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Science and Technology Committee

Investigating the Oceans

Tenth Report of Session 2006–07

Volume II

Oral and Written Evidence

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The Science and Technology Committee

The Science and Technology Committee is appointed by the House of Commons to examine the expenditure, administration and policy of the Office of Science and Innovation and its associated public bodies.

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Publications

The Reports and evidence of the Committee are published by The Stationery Office by Order of the House. All publications of the Committee (including press notices) are on the Internet at www.parliament.uk/s&tcom
A list of Reports from the Committee in this Parliament is included at the back of this volume.

Committee staff

The current staff of the Committee are: Dr Lynn Gardner (Clerk); Dr Celia Blacklock (Second Clerk); Mr Edward Waller (Assistant Clerk); Dr Christopher Tyler (Committee Specialist); Dr Joanna Dally (Committee Specialist); Ana Ferreira (Committee Assistant); Christine McGrane (Committee Secretary); and Jonathan Olivier Wright (Senior Office Clerk).

Previous Committee staff during the inquiry

Dr Anne Simpson (Committee Specialist); and Dr Sarah Bunn (Committee Specialist).

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Witnesses

List of written evidence

List of unprinted evidence

The following memoranda have been reported to the House, but to save printing costs they have not been printed and copies have been placed in the House of Commons Library, where they may be inspected by Members. Other copies are in the Parliamentary Archives, and are available to the public for inspection. Requests for inspection should be addressed to The Parliamentary Archives, Houses of Parliament, London SW1A 0PW (tel. 020 7219 3074). Opening hours are from 9.30 am to 5.00 pm on Mondays to Fridays.

- ITO 42 Partnership for Observation of the Global Oceans
- ITO 29C Supplementary memorandum from the Natural Environment Research Council

List of Reports from the Committee during the current Parliament

The reference number of the Government's response to each Report is printed in brackets after the HC printing number.

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Fourth Report	Research Council Institutes	HC 68–I (HC 979)
Fifth Report	Government Proposals for the Regulation of Hybrid and Chimera Embryos	HC 272–I (Cm 7139)
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Second Report	Strategic Science Provision in English Universities: A Follow–up	HC 1011 (HC 1382)
Third Report	Research Council Support for Knowledge Transfer	HC 995-I (HC 1653)
Fourth Report	Watching the Directives: Scientific Advice on the EU Physical Agents (Electromagnetic Fields) Directive	HC 1030 (HC 1654)
Fifth Report	Drug classification: making a hash of it?	HC 1031 (Cm 6941)
Sixth Report	Identity Card Technologies: Scientific Advice, Risk and Evidence	HC 1032 (Cm 6942)
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First Special Report	Forensic Science on Trial: Government Response to the Committee's Seventh Report of Session 2004-05	HC 427
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Oral evidence

Taken before the Science and Technology Committee

on Tuesday 1 May 2007

Members present:

Mr Phil Willis, in the Chair

Linda Gilroy
Dr Brian Iddon
Chris Mole
Mr Brooks Newmark
Dr Bob Spink
Dr Desmond Turner

Witnesses: **Professor Sir Howard Dalton,** Chairman, Plenary Committee, and **Mr Trevor Guymer,** Secretary, the Inter-Agency Committee on Marine Science and Technology (IACMST); and **Dr Philip Newton,** Deputy Director, Science and Innovation, and **Dr Mike Webb,** Marine Science and Innovation Manager, Natural Environment Research Council, gave evidence.

Q1 Chairman: Good morning. Can I welcome our witnesses to this the first session of the Science and Technology Committee's new inquiry into Investigating the Oceans. With us this morning are Professor Sir Howard Dalton, the Chairman of the Plenary Committee for the Inter-Agency Committee on Marine Science and Technology, Mr Trevor Guymer, the Secretary of the Inter-Agency Committee on Marine Science and Technology, Dr Phil Newton, who is the Deputy Director for Science and Innovation at the Natural Environment Research Council (NERC), and Dr Mike Webb, the Marine Science and Innovation Manager for the Natural Environment Research Council (NERC). Good morning, all of you. Can I start with you, Professor Dalton, and say what is your assessment at the moment in terms of the health of the marine science sector, is it in good health, is it declining, is it increasing, what is your assessment?
Professor Sir Howard Dalton: It has undergone quite a lot of change over the last few years, certainly for the last four or five years. In some areas I think it is doing quite well, in other areas I think it is not doing as well as it ought.

Q2 Chairman: Can you be more precise?
Professor Sir Howard Dalton: I think one area which has concerned us particularly on the IACMST (which is a more convenient acronym for it than saying it at great length) is very much to do with the co-ordination of the activities that are going on within the UK. There is a fair amount of good research and certainly there is a good amount of activity in the area and, largely due to NERC, over the last few years, and their programme, which I am sure you want to talk about, Oceans 2025, it has made quite a big difference to the way in which we are trying to get together to try to co-ordinate activities; but that is only a small part of it. There is a lot more that needs to be done in terms of bringing about much better co-ordination right across the piece. I think particularly that is true, for example, in government departments, where it is deferred to one or two or three, many of which have a strong interest in marine science and technology but which are not as well co-ordinated and functioning as well as I think they ought. One of the problems we have is possibly, in our particular case, that we do not have enough teeth, in IACMST, to bring about many of the changes which I think need to be brought about. We do not have resource, we act there in just an advisory role; we are a catalyst, to try to bring people together, and all that we can do is try to bring people together, tell them what the problems are, tell them what the issues are and rely very much upon them to try to sort it out. I think there are a lot of issues which really we do need to address properly, in terms of co-ordinating and developing the science, and in some areas I think it is going very well, in other areas not so well.

Q3 Chairman: We knew that back in the late 1980s, when this Committee moved from its predecessor; has this been a constant pattern, and why do you think there is this realisation now that we have got to do more?
Professor Sir Howard Dalton: I do not think it is a realisation now, Phil. I think actually, as you say, correctly, it has been with us for quite some time. I just do not think there is the mechanism in place at the moment to be able to address those sorts of issues. We are a very small part of this operation. The IACMST is really a facilitator for activity; we are not sufficiently geared up to being able to resource any activities, we just do not have it. We have a very small resource, funded largely by the Natural Environment Research Council and by subscriptions from our members, but all we can do is point people in the right direction. We are doing things ourselves, we are initiating things and we are telling people largely what they ought to be doing, but that is about all we can do.

Q4 Linda Gilroy: Are its powers and membership appropriate to what you would like to see it do more effectively?
Professor Sir Howard Dalton: I think the membership is okay, there is no problem there, we have all the right people on board; it is a question of

how we can get them to do things. All we can do is facilitate, all we can do is indicate and bring people together.

Q5 Linda Gilroy: Where are its powers, its remit, written out; is that a memorandum?
Professor Sir Howard Dalton: There are terms of reference. Trevor, who is the Secretary, probably would tell you, better than I, what those terms of reference are.

Q6 Linda Gilroy: Are they appropriate to what needs to be done to focus and energise what is going on in the sector?
Professor Sir Howard Dalton: Trevor, maybe you can answer that one, because you know the terms of reference better than I do.
Mr Guymer: Primarily, they are to have oversight of what is going on in marine science and technology in the UK within the international context and to ensure that appropriate co-ordination exists. We have taken that a little further, that when we have seen that we, IACMST, with albeit its limited resources, could provide a useful co-ordination role ourselves then we have taken that on, specific examples are marine monitoring and to do with data and information management. We have set up groups to bring together people from across the community and when we have seen a particularly interesting topic we have set up a short-life working group on that. One of those, for example, was underwater sound and marine life, and that was very successful in bringing together people from across the different sectors who, perhaps, left to themselves, would have continued in parallel tracks, but we have seen a real convergence there; but, with the resources that we have and the remit we have, we cannot tell people to do particular things. One useful thing which perhaps could be done is to have added to our terms of reference that the member departments and agencies should be required to report regularly to the Committee. At the moment really it is much more on a voluntary basis, people volunteer information; we try to encourage them to work together.

Q7 Chairman: Dr Newton, can I ask you this basic question, just to get us going: do you agree with Professor Dalton's analysis of the state of marine science?
Dr Newton: I do agree with his analysis of the state of marine science, yes. I think that definitely there have been significant improvements in the last few years. I agree also with his assessment of IACMST, and what we have done in NERC is try to take some complementary approaches which would be intended to deliver towards the same objectives as IACMST but try to support it in some way, and part of that is the creation of Oceans 2025.

Q8 Chairman: Dr Newton, can I come on to funding. We want to ask you another question, Professor Dalton. In terms of funding, do you feel that the funding for marine science is adequate, is it getting better; is there a difficulty with it, does that limit what you can do?
Dr Webb: To be honest, I find it hard to be sure. Within NERC the marine sciences attract a significant proportion of the funds available, so, in terms of responsive mode, NERC is providing about 20 per cent of its funds in this area. In terms of the strategic marine science programme, Oceans 2025, NERC has been able to increase marginally the amounts of money it has given the new five-year programme.

Q9 Chairman: I am just looking at the funds, you see: terrestrial monitoring, £500 million goes in; marine environment, £36 million. That hardly seems to be a significant investment really. That has come from the Environmental Research Funders' Forum.
Dr Webb: I would agree, there does seem to be—

Q10 Chairman: A slight imbalance there?
Dr Webb: Yes.

Q11 Chairman: It that just historic?
Dr Webb: I am afraid I do not know. I have not seen the Environmental Research Funders' Forum analysis so I do not know what is behind the terrestrial observation from them, but I would imagine it is made up of the Environment Agency and a whole load of other agencies; whereas, in the marine environment, I think, the long-term monitoring, a substantial amount of it is from NERC. I am not sure if that is true necessarily with other organisations.

Q12 Chairman: Professor Dalton, do you share that analysis, that it seems to be incredibly underfunded compared with the work on terrestrial observation?
Professor Sir Howard Dalton: I think there is no doubt about it, it is seriously underfunded, yes, and the figures you quote are quite right; it is an issue that one has in marine science. I think actually what is interesting is that people now are beginning to realise gradually, largely I think through NERC's activities, that the marine environment is extremely important, and particularly as an island we have a great dependence upon understanding and working with the marine environment. There are many issues which need to be addressed right now and the Natural Environment Research Council, and to some extent Defra and some of the other funding agencies, are putting money into it, but I do not think it is enough, judging by the value that the marine environment brings to the economy. We are talking constantly of something around five per cent of GDP, now that is a significant amount of money, and the amount of money that goes into researching that and developing it I think is really a very small part of that and needs addressing.

Q13 Chairman: As far as the Committee is concerned, Mr Guymer, could you tell me, in terms of the priorities which exist currently in terms of funding marine science, do you feel that the different parts of the community have got it right? If you were an agency, rather than an advisory committee, in fact would you be putting money in different areas?

Mr Guymer: Given that marine is rising up the political agenda, and particularly with the potential Marine Bill in sight and the implications for global climate change on the marine ecosystem, I think where there is a real need to have additional resources, which may be a shift of funds, is into the area of monitoring. We have identified that already, but it is a very difficult area because it cuts across all of the different departments and so that single fact makes it very difficult for one department or agency or research council to say "We will pick that up." I think that is the single most important area I would identify where more resources need to be concentrated if the UK is going to be able to underpin its policy in marine better and if it is going to be able to fulfil its commitments on the international scene as well.

Q14 Chairman: In terms of change of priorities, where would you put your money?
Dr Newton: I will answer your question, but I guess the way I look at it is this. About three or four years ago, NERC had a pretty poor understanding of what marine observations we were making, in fact probably in most areas, largely because of the historical fragmentation of our investments, we have about seven different research institutes which, for various reasons, have different agendas. We did a review of our investments in the marine sector and, as a consequence, we understand much better now what we are doing and why we are doing it. We asked our marine institutes, the institutes in which we have strategic marine investments, to set the new proposal, which was Oceans 2025, as a co-ordinated proposal in the context of national and international needs and explicitly to separate out of it the monitoring, the long-term observation, so that we could crystallise that very clearly. In parallel to that, we have got the Environment Research Funders' Forum, which is a forum of all the different funders of environmental research in the UK, and I think that was the report you quoted from earlier. The report which you quoted was trying to say, basically, "Okay, right across the environmental sciences, what do we fund, in long-term observations; we do not understand that very well, across all the funders?" We know that now and, as a group of funders, we have decided to fund a follow-on study, which is trying to move towards a strategic decision-making framework for what sorts of environmental observations we should be making in the long term and what time and space scales. To me, that is the most important thing, that we have identified a process, in investing resources, in trying to answer the question, say, in one or two years' time, about where we should be making the observations. I think that is the way I would like to approach answering that question, rather than sort of the proclivities or limited understandings of any one member.

Q15 Chairman: You are nodding in agreement?
Professor Sir Howard Dalton: Yes, very much, and the observational side clearly is a very important part and it is something which we have been flagging up for quite some time. It is an area where we need these global observation processes in place in order to make sure that we have got a lot of the science in place that we need. We need these observations, for the simple reason that there are a lot of things happening right now. Climate change is a big issue, and going along with climate change issues in the oceans is ocean acidification. The amount of CO_2 which is going into the oceans is causing some serious problems, it is changing the biodiversity in those oceans; we need to understand that better, we need to know what to do about it when we can determine where the real problems are. We have got real problems, as you know, with fish stocks, biodiversity in the oceans, we need to understand that better; flood and coastal management and other areas which are really important that we need to be able to work towards. I think it is a whole number of different areas, all of which are becoming extremely important, which we need to be funding in the future. The question is, there is insufficient resource, I think, to be able to do it. The Natural Environment Research Council are the biggest funders of this. Defra I know fund quite a bit of work in this area, but nowhere near as much as the Natural Environment Research Council. It all needs to be done, and it needs to be done not just from a UK perspective but from a global perspective as well.

Q16 Mr Newmark: This question is a follow-up question, to Professor Dalton. You said that the contribution of marine activities is roughly 5% of GDP. The latest figures that we have go back to 1999–2000, unfortunately, and, I am wondering, currently is it still roughly 5% of GDP?
Professor Sir Howard Dalton: The figures we came up with, in the report which IACMST produced in 2002, indicated that it had gone up to 4.9%of GDP.
Mr Guymer: Yes, and if I could come in there, there was an earlier study done in 1996 and that was 4.8%, and following on the last select committee report by the Lords there was a study done then, so that was 1990, and again that came up with a figure of about 5%; so we think there is some robustness in those figures. What I would add, as a rider, and this may lie behind your question as to why there has not been a study done since, is that getting this information together requires considerable effort in getting the information from the departments, so it is not the kind of thing that one wants to do too often, particularly if you have limited resources.

Q17 Mr Newmark: Is it an art or a science, defining what a marine activity is there?
Professor Sir Howard Dalton: Do not forget also, within that 5%, in those figures of 5% from the 1990s and 2004, was included the contributions from the oil and gas sector. In fact, the oil and gas sector contribution to GDP actually is going down slightly now and therefore we may not have all of the up-to-date figures, which were, when it was measured in 2004, the oil and gas industry was contributing 39% of that 5%, it may well be less than that now.

Q18 Mr Newmark: The figures remain fairly stable?
Professor Sir Howard Dalton: It has been fairly stable.

Q19 Mr Newmark: In absolute terms, it has gone up, so it is roughly £50 billion plus, yes?
Professor Sir Howard Dalton: If you had got the current GDP, it would be about that, yes.

Q20 Mr Newmark: In which case, how much private sector investment is there in marine sciences and research and where is this focused, that is private sector investment?
Professor Sir Howard Dalton: I do not know the answer to that; do you, for private sector investment? We did have some figures.
Mr Guymer: This would have to go across all of the oil and gas inputs, and so forth. In terms of marine-related activities, what we quoted, the £39 billion, as Howard has said, most of that comes from the oil and gas. If you are talking about the research element of it, one of the biggest contributors to that, certainly on the private side, is oil and gas, which contributes to the £600 million turnover, or just over £300 million a year in value[1].

Q21 Mr Newmark: I would think it is the same not just in R&D but I would think the actual investment itself would have to be also oil and gas, I am assuming, yes?
Mr Guymer: Certainly it would be oil and gas. Despite any downward trend there might be, oil and gas would be still significantly the biggest player.

Q22 Mr Newmark: Given the whole issue of global warming and everything else, with respect to marine science, have you noticed any trend with respect to private sector investment going into new areas or new sciences, related specifically to marine science, in terms of new technologies, and so on?
Mr Guymer: So far, I would say that we do not have the evidence on which to say that.

Q23 Mr Newmark: What are IACMST and NERC doing to encourage knowledge transfer in the marine science field?
Dr Webb: From a NERC perspective, knowledge transfer within the Oceans 2025 programme has been seen as a critical element of the programme. The Council took a big interest in what was going on, in terms of knowledge transfer, and so for the first time we will have theme leaders within Oceans 2025. Those people's names will be made available to government agencies, so the government agencies can interact easily with the marine strategic science programme; there will be a number of stakeholder events annually, to encourage the policy interaction that is required.

Q24 Mr Newmark: Is it actually happening? You are saying there is a lot of action to encourage this, but do you see it being followed through, or not?
Dr Webb: Most definitely; this is a critical element of the delivery of Oceans 2025. At the moment there is an implementation plan which needs to be developed for Oceans 2025, then there will be consultation once again with stakeholders before that plan is put in place, so it is taken very, very seriously.

Q25 Dr Turner: Professor Dalton, and Mr Guymer, I think particularly, we are all agreed that the whole field is far too fragmented and underfunded, and the Committee has gone further and argues that the Government needs to behave like a coherent commissioner for marine research. If you could persuade the Government to do anything coherently, what would you want for them, in terms of marine research?
Professor Sir Howard Dalton: We discussed this earlier actually; it is a very interesting point. One of the interesting things that we have discovered, and certainly I have discovered, in IACMST, is the fragmentation that we have, and the way in which marine science is funded in the United Kingdom is still fragmentary. We have got a number of different government departments all putting in various bits and pieces and not necessarily co-ordinating their activities in the way really that they ought to. If you could wave a magic wand and say actually what is going to be the best way, I would try to bring them all together and have some major organisations responsible overall for funding all the various aspects of marine science. At the moment we are beginning to try to get it together but it is still not there and I think it still needs a bit more work to it.

Q26 Dr Turner: Do you think the Inter-Agency Committee itself could be transmogrified into the body to do that?
Professor Sir Howard Dalton: If it were properly resourced, possibly.
Mr Guymer: It is interesting to learn from the experience of marine science and technology in the EC Framework Programmes. In the 1990s there was a dedicated marine science and technology programme called MAST and that was very successful in bringing together different communities across Europe, working together in a much more co-ordinated fashion. It seems somewhat ironic that we have achieved quite a bit in a decade or so while that dedicated programme was running, it is no longer a marine-dedicated programme, we achieved quite a lot there, and yet we do not have any kind of equivalent mechanism which provides that kind of incentive and encouragement for the different parts of the marine science and technology community to come together as a whole across the UK.

Q27 Dr Turner: The relationship between the Inter-Agency Committee and the OSI obviously is not irrelevant, too. How much do you feel that marine activities figure in the thinking of OSI; does it play a role at all?

[1] *Note from the witness:* As noted in previous studies, figures for R&D in the private sector are difficult to access.

Mr Guymer: I think it does, from time to time. OSI are full members of IACMST and therefore they see all of the trends that are being developed. In addition, when we see a critical issue, using Howard's role and access to the Chief Scientific Adviser to the Government, on occasions we have identified crucial elements, and two of them actually are cited in our submission, when we needed to get a UK national contribution to a particular satellite programme. Another one was the Argo profiling programme, where we realised that we were in danger of a lack of coherence, really shooting ourselves in the foot, and so when we have identified specific things we have taken those straight to Sir David King.

Q28 Dr Turner: Is it a two-way relationship?
Mr Guymer: I would say that, hitherto, it has tended to be one way; upwards.

Q29 Dr Turner: Would it be helpful if there was more positive pressure from OSI to encourage the marine contribution?
Mr Guymer: If OSI were to task IACMST with some specific things to do, and we had reasonable resources to do that, I think, based on our experience in our lifetime, we would be very keen to take on those responsibilities and would see it as a valuable service to the community.

Q30 Dr Turner: Do you think that is the way forward?
Mr Guymer: I think it is one way which strongly ought to be considered.

Q31 Chairman: Could I just follow that up and say we have just completed an inquiry into Space, though we have not published yet, so we cannot tell you what the conclusion was, and we have had similar discussions really about whether in fact we should have an agency, and what you have been describing, over the last few minutes, particularly to Des Turner, is an agency. Is that actually what you are asking for?
Mr Guymer: There are many agencies.

Q32 Chairman: I know there are. I think what you are asking for though is to have a specific marine agency actually to co-ordinate all this, to have a central budget and to drive the science, in terms of marine science?
Professor Sir Howard Dalton: Personally, I think that would make a lot of sense. I think it needs some proper co-ordination. It needs the Natural Environment Research Council to push forward the fundamental science which underpins much of what goes on in the marine environment, and they fund that and they do that, and certainly, through the new Oceans 2025, I think that is a very sensible way. There is a whole series of activities, aside from all of that, which, I think, if it were to come under some sort of agency operation, would make a lot of sense, in trying to bring about the co-ordination. We try to co-ordinate, through IACMST, but we are funded very poorly; we report to the OSI, we try to bring people together, we try to tell people what is going to be the sensible thing to do and what is not, we have brought together some very useful information on databases, which was fragmented before. If we had had resource and teeth I think we could have done a lot more.

Q33 Chairman: Do you have any links with the Royal Navy, any links into there?
Professor Sir Howard Dalton: We have few links with the Royal Navy; the MoD are represented on IACMST.

Q34 Dr Turner: Do they ever offer the use of their ships?
Professor Sir Howard Dalton: They are used, yes. The Natural Environment Research Council uses them; we use them down in the Antarctic, I do know that.
Dr Webb: The Royal Navy help support the logistics for BAS down in the Antarctic.

Q35 Dr Turner: Do they tow plankton monitors; do they help with observations?
Mr Guymer: They do help with the deployment of Argo floats in remote areas, and that has included the South Atlantic, so we do have access to those ships when we need to but there is more that could be done in that area.

Q36 Chairman: In terms of a specific relationship, they sit on the Committee but they do not do a lot: yes, or no?
Mr Guymer: MoD are involved in quite an active way in IACMST sub-committees, to do with data and observations, so there is quite a strong relationship there.

Q37 Chairman: Are you going to echo that?
Dr Newton: I wanted just to add that the Oceans 2025 directors met with the MoD in the last couple of weeks and they discussed the possibility of enhancing the use of the Royal Navy and their platforms; it is something which is being discussed actively at the moment.

Q38 Chairman: There is a lot more that could be done?
Dr Newton: Yes.

Q39 Dr Iddon: I want to put a few questions to you on Oceans 2025. Where did the original idea come from and what was the philosophy behind setting it up, and who is involved in it? I know we have got the written evidence but perhaps you would just summarise that?
Dr Newton: In 2004, NERC took the view that, due to various historical events, our strategic marine science investment was rather fragmented, so we approached five of the Oceans 2025 partners and said that we would like them to start thinking about a more co-ordinated approach when it came to the time to renew their proposals. To help with that, we commissioned a review of NERC marine science, all our investment, strategic and blue sky, so that

NERC Council could understand what we are investing in currently and understand why we are doing so, and so forth. That review came out with a number of recommendations, one of which was to ask the Oceans 2025 labs—they were not called Oceans 2025 then, of course—to come into NERC with a much more co-ordinated set of proposals than previously had been the case, where they were much more competitive at the previous round, we wanted something that was a better balance of competition and collaboration. Their response to that, essentially, was to go further than we had asked; we asked for a set of co-ordinated proposals and they said, "No, we can do better than that; we can come up with a single proposal which we will co-ordinate," which NERC Council was delighted with, so they responded very positively to that request. The other difference from the past was, because we had our NERC delivery plan, there were a number of specific targets in that, we specified to Oceans 2025, essentially, "We want you to come back to us with your case for the strategic marine research which NERC should be doing, set in a context of UK and international user needs, but we want the following things to be in it," in our delivery plan, which reflected our strategic priorities. We asked them to develop specific aspects to do with science for sustainable marine bio-resources, deep oceans and some transatlantic monitoring of a large overturning circulation which affects climate; so we specified, which we have not tended to do in the past. I think probably you know the rest; they came up with a proposal and it was seen very positively and funded appropriately[2].

Q40 Dr Iddon: For how long is the programme expected to last?
Dr Newton: It was bid for funds for 2007 to 2012, so it is a five-year proposal, which was what we asked for. In parallel with this, I think you are aware from your previous inquiries that we are reviewing the way that we fund our investments generally, the so-called FAB project, Funding, Allocation and Budgeting, and through that we will be moving to a case where we make investments on more of a rolling basis. Things such as long-term observation facilities, what we call now national capability, we intend funding for longer than a five-year period, generally speaking; then maybe turning over some of our more research-oriented programmes on different timescales. We structured the Oceans 2025 proposal so that it would help in transition into that new way of working, so the way they set up the proposal, in response to an invitation from us, will make it easier to transition into this new way of working. For example, it is very clear, from the proposal and the funded programme, what is the national capability, what is the research programme, where the knowledge transfer is, where the science in society is; we can see all that very clearly. In the past, asking for proposals, we would have had to bundle up all those things together.

Q41 Dr Iddon: Initially £120 million has gone in; presumably that is not new money, it has been shifted from somewhere else. Was that money already being spent on marine science which has just been collected together, or is there new money in Oceans 2025 for marine science?
Dr Newton: NERC Council has a current policy, when an investment in a research centre comes to an end, of inviting a proposal at ten per cent more than level funding plus indexation and then making a funding decision in the context of that proposed work. Oceans 2025 proposal came in at ten per cent over the money the seven component institutions were getting already, so the money it was getting already was already in planning in NERC. In your terminology, that is not new money. They bid for ten per cent more than that, and it depends how you count things, but the increased funding was probably somewhere between about three and a half and six per cent, depending on what you count; so there is an element of additional funds in Oceans 2025 which was not there previously.

Q42 Dr Iddon: Were all the relevant universities involved in the decision-making process, and are they are able to bid for funding from the programme?
Dr Newton: In terms of the set-up, the Oceans 2025 directors, when they were developing the proposal, had an open consultation to try to answer our question of what needed to be in it, and that involved the universities, as well as the various agencies and departments could play a part in trying to shape what was in it. There was that in it, then, Mike, perhaps you can comment on the decision-making process and the SOFI scheme.
Dr Webb: The proposal itself for the new programme was peer reviewed extensively, which included university academics from this country and abroad. On top of that we had a moderating panel which had on it academics from both this country and abroad, and senior directors from institutes from abroad as well. As part of the Oceans 2025 settlement, there is going to be a Strategic Ocean Funding Initiative (SOFI), which will fill the skills gaps, if you like, within Oceans 2025, hopefully with university academics, basically to encourage the collaboration between the universities and the marine centres. That initiative will have about £5 million worth of funding.

Q43 Dr Iddon: When we visited Plymouth, and indeed this is a constant theme of this Committee's investigations in this area, we heard again that researchers are finding it difficult deciding which research council to head their bid, and often are turned away, saying, "No, that's not BBSRC, that's NERC," or, "No, that's not EPSRC, it's NERC," or vice versa. We thought that Universities UK had been set up to squeeze those silos together and make

[2] *Note from the witness:* Dr Iddon asked 'who is involved' in Oceans 2025. I did not answer this. It is; National Oceanography Centre; Plymouth Marine Laboratory; Proudman Oceanographic Laboratory; Scottish Association for Marine Sciences; Sea Mammal research Unit; Marine Biological Association; and Sir Alister Hardy Foundation for Ocean Sciences.

interdisciplinary research much more successful; we are not picking that up in this area either, there seem to be tensions between the research councils. How is this new programme going to get over that?
Dr Newton: In terms of RCUK activities, this problem has been addressed over the last three to six months. But I guess, because changes have been made to the process to avoid the problem of one council coming back to bidders and saying, "No, it's somebody else," we deal with that problem in a systematic way and we tell the proposer basically how we are going to handle it and that they should not have to worry to which research council they submit it. They should be able to put in their proposal and get it dealt with fairly. We have made changes to the processes through RCUK but they will not have filtered back to the community yet, because those changes have been made only in the last three to six months. I would expect, say, if you asked the same questions in six to 12 months' time, that the community would have more positive experiences of the way in which their proposals were handled. There is a system now which decides not only which council would handle the proposal but also, based on the fraction in different remits of the different councils, whether it would be co-funded or funded by one council. This is now clearly laid out.

Q44 Dr Iddon: Are the members of your peer review panel sympathetic to this new idea, are they sympathetic to interdisciplinary research, do they understand it and do they sympathise with the people wanting to do this kind of research?
Dr Newton: Yes, they are, but we put quite a bit of effort into training the panels, because of the way that we run our peer review system now. It used to be with fixed panels of a period of maybe three or four years, but now we have much more of a rolling and large college that we draw on, so every year there are training exercises, and the need to be able to be aware of and how to deal with interdisciplinary proposals is part of that training. We are going to be reviewing the success of the college at some point in the near future and I would expect that to be one of the aspects we would look at.

Q45 Chairman: Can I take you up on an issue that you mentioned in reply to Dr Iddon, and that is the involvement of the universities. Professor Henderson, of Oxford, said to us, and I quote: "The Oceans-2025 document was prepared in secrecy without public consultation nor the open-involvement of marine researchers from the university sector. Requests for draft copies of the Oceans-2025 document were turned down during the writing of this important strategic document." That flies totally in the face of the evidence you have just given to this Committee?
Dr Newton: My understanding is that the proposal was subject to an open consultation. Obviously, we would need to check that as a factual piece of evidence. I do not know if you can help with that, Mike?
Dr Webb: I confirm, that is as I believe it to be.

Q46 Chairman: I am sorry; are you confirming that what Dr Henderson says is right, or what you have just said to this Committee is right?
Dr Webb: What we have said to this Committee is right. I believe the timescales were somewhat compressed, so the amount of time available for consultation with stakeholders was quite small.

Q47 Chairman: Why were they not given copies of the draft document?
Dr Webb: The actual proposal itself. I cannot answer that question. I suspect the reason was that the full proposal itself was not written until right at the last minute. It was a developing document and so the scientists were writing the science case as they went along.

Q48 Dr Iddon: How long was the consultation period?
Dr Webb: I do not know the answer to that, I am sorry.

Q49 Dr Iddon: You are aware that the Government lays down limits for its own consultation processes, which I think is three months?
Dr Newton: Yes. I should stress, just in case it is not clear, we specified that we wanted a proposal as I described from the Oceans 2025 directors; they wrote the proposal, they conducted the consultation, it was not something that we were involved in, which is why we cannot give you direct answers to these questions. To the best of my awareness, it was an open consultation. Certainly I know that a number of government departments and agencies had specific meetings with the Oceans 2025 directors on what should be in it.

Q50 Chairman: As you do not know, could you provide us with a written note on that? It is really quite a fundamental issue, because if universities were not involved in the consultation then that is something perhaps which should have happened?
Dr Newton: Yes, we will provide that.

Q51 Linda Gilroy: I am particularly interested in the interface between health and the oceans and the research associated with that, and it is a pretty new area. I would like to ask you if what you have been saying about addressing the difficulties of research between the different research councils will be addressed there? Certainly it is something which I think is a strong strand emerging in Plymouth between the new medical school and the scientists in the marine science community and I wonder if you think what you have said will address the difficulty of getting these issues onto the medical research agenda?
Dr Newton: Certainly developing capacity in the environment and human health sector is something which is very prominent in the strategy and was one of our priorities in the last Spending Review. As a consequence, we led the development of a cross-council and cross-agency programme, called

Environment and Human Health, which I think invested about £5 million or £6 million, I could check the figure if you needed me to, and basically that is stretched across about eight or nine different funders, again the number may not be quite right but a good number of funders. We have been building capacity and capability in that sector, trying to form the links between the medical researchers, the economic and social and the environmental scientists, and so forth. In specifying what we wanted to see in Oceans 2025, we encouraged them to develop the proposal in the context of current NERC priorities, and, as a consequence, Plymouth Marine Laboratory in particular introduced a theme on marine environment and human health, but unfortunately that did not come through the peer review process in a way which enabled us to be able to fund it. Certainly we were delighted to see the ambition, implementing a new laboratory in that sector, but that particular piece of work we were not able to fund. My colleague mentioned the Strategic Ocean Funding Initiative, which is designed as a way, and there is £5 million, to be able to fund the work which Oceans 2025 should be doing but it does not have the capability to do itself, for whatever reason. This might be one of the areas for which that initiative could be used. We have just made an announcement to use the initiative for another area of Oceans 2025 which did not do particularly well during the funding process, in the area of sustainable marine bio-resources, and we have used the initiative funds we have just talked about, put them against some funds from Defra and CEFAS and from SEERAD (Fisheries Research Services) and from the Northern Ireland Office (Agri-food & Biosciences Institute) to create a sort of cross-partner effort on research policy, in sustainable marine environment resources; so that is another example of the way in which we are trying to fill the gaps, which ought to be in Oceans 2025 but which are not there.

Q52 Linda Gilroy: Do you think that matches up to the challenge which lies ahead, because climate change is as big an issue as I think is emerging on the political agenda; is the science in that interface responding quickly enough, and the funding of the science?

Dr Newton: NERC is in the process of developing its new strategy, which is definitely out to an open consultation at the moment, and we would expect that views which would help us form that opinion, when reflected in our strategy implementation plan, would come through that strategy consultation. It is clearly an area which is prominent in many people's minds.

Q53 Chris Mole: Professor Dalton, earlier on you mentioned the importance of monitoring, global monitoring in particular. What is your prognosis of the UK's capability and effectiveness and what have you been doing to promote UK participation in surveys amongst the Government and research councils?

Professor Sir Howard Dalton: In many areas of science the UK punches very much above its weight. In this area, I think, probably we do not. I think this is an area where we do need to have a much more co-ordinated and sustained effort, in terms of global observation systems. We do make our contributions. I think the problem is that the way in which it has been funded and resourced in the UK is fragmentary. We have had real problems trying to raise sufficient resources in order to be able to play our international part in being able to support and encourage and develop global monitoring systems. I think there is more that should be done. Personally, I believe that we might need again some sort of central pot of resources which addresses this issue. My colleague, Mr Guymer, mentioned the business about Jason-2; that was an issue which we made a contribution towards in the UK, other countries in the world made contributions to it; it was very difficult to persuade different government departments to come up with the money to be able to support that. I think it is rather a sad reflection that often we have to go round with a hat to different government departments asking for contributions to support what are really important, international observational systems. There has to be a stage, I think, where we have got to consolidate that and say, "Actually, this is an important, international contribution that we have to make and we should resource it properly."

Q54 Chris Mole: Mr Willis mentioned earlier the happy juxtaposition of our Space inquiry with this inquiry. How do you think our position as a nation compares with others, with respect to the use of satellite technology for earth observation?

Professor Sir Howard Dalton: We are part of a global earth observation system of systems; we have been engaged in that actively for quite some time now. Certainly while I have been Chief Scientific Adviser at Defra we have been actively attending and being part of all of those various meetings and making an active contribution towards it. As far as the UK is concerned, I think we are not big players, we should be bigger. You heard, of course, I am sure, at the inquiry on Space, that there is a lot of extremely good technical innovation going on in the UK in the satellite business and we ought to be bigger players in that game, I think. At the moment, largely it is coming from other European countries: France, Germany and Italy put a lot more money into that than we do, but they have central government funding to do it. They do not have to go round, like we have to go round, with a hat, asking various different departments to make a contribution; that is not the case in Europe particularly, or in the United States. Though, I must say, the United States, NASA, there is a strong indication that they may well be cutting back significantly on their satellite programmes; they have announced they will reduce it by half by 2015.

Mr Guymer: In terms of earth observation for marine aspects, I think the general agreement around the world is that France has a much more coherent approach to this and has the lead, in many

respects. It has an integrated approach across its industry, which tends to drive the European Space Agency programmes, and its user community; so they build excellent oceanographic satellite instruments and they have the user community bolted into that. The UK, apart from one particular instrument to measure sea surface temperature very precisely, has not tended to go down that route. The UK does have real, leading expertise in small satellites and that is something really which could be exploited much better by the UK. There is a real sampling problem with the ocean, compared with the land, where you have got things changing rapidly, and this can be overcome partially by having constellations of satellites, equipped with suitable sensors. There is a real opportunity there for the UK to carve out a niche, which would be not only in line with UK technology and industry but actually would meet a number of user requirements in the research councils and in terms of meeting policy agendas of Government.

Q55 Chris Mole: What are you doing to try to make sure that happens?
Mr Guymer: We have made that point in helping submissions to that particular inquiry, although IACMST itself did not; we put into that via other bodies. When there are international meetings, we have tried to advance the usefulness of the whole concept of small satellites and take the opportunity there at those conferences as well. It is interesting that, ten or 20 years ago, I remember standing up at a European Space Agency meeting and being shouted down because the concept of small satellites did not fit in with the idea of the big birds which the space agencies wanted to have. I think we have seen a shift of opinion during that time, but it is like trying to turn around a very, very big ship and it is taking time; so it is concerted pressure, not just isolated pressure.

Q56 Chris Mole: Can I ask everyone then what are the known unknowns, where are the gaps in the collection of data, with regard to climate change and biodiversity, as far as the oceans are concerned?
Professor Sir Howard Dalton: In terms of the known unknowns, I think we have got pretty much, certainly on a global scale, most of the basis covered. We know what we need to be looking at and we are doing it; the question is, we do not have necessarily all of the instruments there to be able to do what we want to do. We are measuring sea surface temperatures; we have got floats which are out there measuring a whole variety of different parameters in the ocean.

Q57 Chris Mole: Like Argo?
Professor Sir Howard Dalton: Yes; like Argo. Those things are there, but getting all the measurements right; we are measuring marine circulation, we are measuring a whole variety of different parameters, we can look at the phytoplankton in the oceans from space, we can identify pretty much what is there. We have got all of the sensors in place, except that we do not have enough of them necessarily and the level of detail is insufficient. We have got some pretty broad observational systems, which cover very large areas, but we do not get very much local information. I think the problems really are trying to drill down and get a higher resolution of what is actually going on, because in order to make much better predictions for the future we need measurements of much higher resolution.

Q58 Chris Mole: Is there any more of that sort of detail perhaps with the Royal Navy you might have access to currently?
Professor Sir Howard Dalton: Quite honestly, I do not know the extra role the Royal Navy might play here, because most of the sensing measurement systems are done really quite remotely and, as we have mentioned, there is a whole number of systems out there; the Royal Navy do help.

Q59 Chris Mole: They have got a lot of sea-bed data and stuff like that?
Professor Sir Howard Dalton: Yes, in getting sea-bed data and doing measurements beneath the waters, which is largely to do with contour mapping, a very important part of what we have got to try to do; yes, I am sure they could help out there.

Q60 Chairman: Do you get access to all that data, in terms of sea-bed tracking; because they do a huge amount of work?
Professor Sir Howard Dalton: I am sure those data are available somewhere. I know, for example, when I was down in the Antarctic, the Royal Navy was involved in being able to do contour mapping of the sea-bed and that information is available, yes.

Q61 Linda Gilroy: There is a good link with the Met Office; is there a similar link with the Hydrographic Office, which is an MoD agency as well as the Met Office being an MoD agency?
Professor Sir Howard Dalton: I cannot speak on behalf of the Hydrographic Office. I do not know quite where they fit into this. Maybe you ought to ask them.

Q62 Chairman: We are going to.
Dr Newton: Just to answer your more general question, what are the known unknowns. I guess, from NERC's point of view, for the strategic investments that we make, we find that out by conducting a review of our marine investments and then asking our main strategic suppliers to identify what is required in the national context, then testing that by national and international peer review of scientists and users. We would say, at this moment in time, the known unknowns that we want to know now are in Oceans 2025. We must not be complacent about that; we have got to keep revisiting that question. That would be my overall answer to your question. Because we also fund a lot of responsive mode, blue skies science, then of course we do not feel that we always need to be able to identify things that we need to do in such a specific way. We need there to be mechanisms just for taking excellent proposals in any area of marine science.

Q63 Chris Mole: Can I follow that up by asking you and Dr Webb what guarantees NERC can give for sustained funding for surveys such as the Continuous Plankton Recorder, which we saw in Plymouth, and similar, long-term, because there seems to be enormous value in that long-term analysis of these oceans?
Dr Webb: Phil did tell you about national capability, and the main role for national capability is to ensure that there is sustainable funding for these critical, long-term time series. Of course there will be an element of review but it will be over a much longer time period, so it might be in ten or 12 years' time the time series of, say, the Sir Alister Hardy Foundation for Ocean Science will be looked at; but it is an opportunity as well for that time series maybe to make the case for more money. There will be an element of review and it will be over longer periods of time.
Chairman: That sounded just like the Rumsfeld episode. That was very well done, Professor Newton.

Q64 Dr Spink: Mr Guymer, the Joint Nature Conservation Committee commented that, and I quote: "The paucity of biological data sets is hampering our ability to assess and interpret changes resulting from climate change." You have already said quite a bit about the availability of data sets, but there are massive data sets around the world; do you have sufficient access, is there sufficient exchange of data sets internationally: what is your view?
Mr Guymer: There is an intergovernmental mechanism which is set up, called the International Oceanographic Data and Information Exchange Programme, and that comes under the auspices of the Intergovernmental Oceanographic Commission, which is the competent body, in UN terminology, for this. There has been a real effort, over quite a period of time, to pull together the various national and regional efforts which have been going on.

Q65 Dr Spink: They are organised under UNESCO, are they not?
Mr Guymer: They are, under UNESCO, yes.

Q66 Dr Spink: Is it working, the IOC (not the Olympics but Oceanographic)?
Mr Guymer: I can speak to that, because in addition to my role as Secretary of IACMST I lead the UK delegation to IOC. There is an issue here. IOC has evolved into not only doing the underpinning science but also in developing these operational systems, both in terms of data collection and the data management, and there is a tension, which is growing, between that role and the wider role of UNESCO. Certainly this is a feeling among a number of Member States, and my understanding is that this is going to begin to come to a head. Member States are going to be asked to consider various possibilities about the future of IOC within the UNESCO system; is it best served by being within it, or should there be some alternative. I would contrast the position of IOC with that of WMO, the World Meteorological Organisation, which of course also is a UN body but does not sit under an umbrella body like UNESCO. There is a direct correspondence between marine science and meteorological science and so I think that this whole issue is being pointed up at the moment.

Q67 Dr Spink: Thank you very much for that. It is self-evident, of course, that international collaboration on a subject like oceans is absolutely essential. What are NERC and IACMST doing to promote UK marine research in the international arena?
Dr Webb: At the current time, NERC has large investments in directed programmes which have collaborative elements, so within the Rapid Climate Change Programme, which NERC runs, we have got an array across the North Atlantic, which is funded jointly with the US. The US also provides ship time to support that array and so, with the co-ordinated programme between the US and NERC, we can support a very large observing system which, arguably, the US or the UK, in their own right, could not support. Also though we have investments, for example, we have an observatory on the Cape Verde Islands, it is an atmospheric observatory, with an oceanic observatory, and, through co-operation with the Germans and the US, once again, we are able to put all of the elements in place for that ocean and atmospheric observatory, and hopefully ensure, over the longer term, that remains in place in a part of the world which is very sensitive to climate change, and, with joint funding, hopefully we will keep that going for many years to come. On ships, it is very noticeable, if you look at NERC's Cruise programme, that there is a large amount of co-operation embedded within the NERC Cruise programme. In terms of NERC's barter arrangements, you may or may not be aware that we have exchange arrangements with six partners, and hopefully one more shortly, and that allows for exchange of ship time without exchange of funding. What that allows NERC to do is operate on a worldwide basis, even though UK ships do not generally go out of the North Atlantic, or the South Atlantic, or the Indian Ocean. An example of where that can lead; we funded a large consortium off Sumatra to look at the earthquake zone where the tsunami was generated, it is in a part of the world to which NERC has not sent ships for years, but through these barter exchange arrangements the Germans have provided 130 days of ship time to do geophysics off Sumatra. No money has been exchanged between NERC and the Germans but, in return, an example of what NERC will give the Germans is we will be in the Pacific early next year so we will do a geophysics experiment for the Germans, in return, off Chile. It is a hugely cost-effective way of using these large facilities, and the level of co-operation, I think it is fair to say, has increased markedly over the last five to six years, to such an extent now that I think we can push even further and maybe start thinking about sharing

facilities, be they big ocean observatories or the actual ships themselves. We are really building momentum in this area.

Mr Guymer: I could build on what I said earlier about the Intergovernmental Oceanographic Commission. Recently, it has been conducting a review of its Ocean Sciences programme and the UK has contributed ideas to that. Of course, in contributing ideas to it, we try also to get convergence with the UK national programme as well. We have been feeding very much into that. That is the intergovernmental process, which, as we all know, can be rather a slow process. Some years ago, the partnership in observing the global ocean, POGO, was set up to link the major oceanographic institutions of the world, and in particular to bring the directors and the senior staff of those institutes together to try to facilitate what was happening at the intergovernmental level. The UK was one of the founder members of that. I have attended several meetings to get cross-fertilisation with the intergovernmental process. In both of those ways, those mechanisms, I think we can advance international marine science and make sure that the UK is playing a key role, and I think in those arenas we do punch above our weight; it is not only to do with the financial resources, it is to do with our ideas, our intellectual capabilities.

Q68 Dr Spink: As in many areas, thankfully. Philip, are there any particular concerns regarding our link-ups with the US?

Dr Newton: Certainly, from the links that I am aware of, it is all extremely positive. For the Rapid Climate Change programme, to which Dr Webb has just referred, that involved sort of a strategic partnership, whereby we undertook, researchers on both sides, in both countries, writing complementary proposals, a joint review process, by common reviewers, a joint decision-making panel; it was a very positive relationship with National Science Foundation. Some of that work is funded by NOAA, the National Oceanic and Atmospheric Administration; again, very positive interactions, a lot of good work and funding coming for most of the programme.

Q69 Dr Spink: Is our international collaboration, particularly with the US, getting better, or getting worse?

Professor Sir Howard Dalton: I can answer one part of that, and maybe Phil will want to talk a little bit more about NERC's role specifically. Yesterday, for example, I was speaking in the Royal Society to a meeting which was organised between the UK, the Natural Environment Research Council, and the National Science Foundation in the US, and, in fact, the US sent over to this country, I think, about 15 of their scientists to be actively engaged in this meeting and make some major contributions, all on seas, which is where they are making a major contribution.

Q70 Dr Spink: Why I ask, Howard, is that Plymouth told the Committee that there was decreasing ease with which it was possible to work with colleagues in the USA. I just wonder why?

Professor Sir Howard Dalton: I do not know why, because, in fact, this meeting was organised by Ian Joint, who is at the Plymouth Marine Laboratory; so I do not understand that statement at all. Maybe you have picked up on one person's involvement; but, very often, certainly in my view, we have had quite good relationships with the United States in a number of different areas, particularly in the marine environment. There are major laboratories in the United States which are working collaboratively with us; if you look at Woods Hole, if you look at Scrips, there is a lot of activity going on between the two.

Linda Gilroy: Can I say, Chairman, I looked at that comment and wondered if we had picked that up correctly, because my recollection was that they were saying almost it was easier to collaborate with European and US colleagues than it was with UK colleagues.

Q71 Chairman: Collaborate internationally?

Professor Sir Howard Dalton: I think probably that is true.

Q72 Dr Spink: I am glad you have cleared that up for us, Howard; thank you very much. I phrased my question carefully because I was not at the meeting so I did not hear the comment. There are many facets of research in the ocean; there is impact on climate, there is biodiversity, there is mineral extraction, all of that, there is navigation, there is coastal erosion. Do you find that particular countries have particular areas of specialisation, or that there is easier research in certain areas, easier collaboration in certain areas rather than others? For instance, are we all collaborating very freely on climate but being very protective in terms of fish stocks, for instance? Do you find any differences?

Professor Sir Howard Dalton: Certainly there are areas where there is good international collaboration; on climate change there is no doubt that there is, we are all extremely good at sharing information with each other. It is a global problem and we all contribute dramatically to that. When it comes to things like biodiversity of the oceans as well, there again I think there are very good levels of collaboration. I suspect that we punch well above our weight there also.

Q73 Dr Spink: If I could interrupt you; on the biodiversity, on fish stocks, do you not find that nations get a bit protective about their own fish stocks and they are fishing and exploiting it?

Professor Sir Howard Dalton: Of course; naturally.

Q74 Dr Spink: They do not want to share that data with others, so that they can do what they have to do economically?

Professor Sir Howard Dalton: I think probably you are right, and intuitively I am sure you are. I do not know the detail sufficiently to be able to tell you how

much individual countries become protective about their environment, when it comes to fish stocks. It is a very, very difficult one. I know, in the European Union, there is a lot of debate, as you may well know, and our Fisheries Minister spends a lot of time discussing all of that, but that is wearing my Defra hat and not my IACMST hat. There is a lot of good, shared information and resource, and science is very much like that, as you know; it is very much at the international area, but there are areas where there is probably some limited sharing of information. When you talk about flood and coastal management, that is peculiar to the United Kingdom, we have to work towards that particular goal. When it looks at aggregate mining, again, that is something very much to do with the UK. I think there are areas of research where we collaborate very well, where we need to; in others areas, it is not necessarily very important to do so.

Mr Guymer: There is an interesting issue there which arose with the UN, at its General Assembly, calling for the establishment of a global marine assessment, and probably that is the closest that we will come, in our lifetime, to the equivalent of the IPCC arrangement for climate. The consensus was broken by Iceland, which would not allow this to go ahead if it included living marine resources, which made a nonsense of the whole thing, really. Happily, that has been resolved, to the extent that, although Iceland are not part of that, they have stood to one side; but that is an example where a particular nation's political will and stance can endanger a whole international activity.

Dr Spink: Thank you very much indeed.

Q75 Linda Gilroy: Just on international collaboration, we have talked a lot about Europe and the US, which are the countries which stand out in your minds, outside of those arenas, which if not punching above their weight certainly are making significant contributions in the international collaborations in science?

Dr Webb: My impression is that clearly India and China are up and coming and it is inevitable that there are going to be huge amounts of collaboration in future. I say 'inevitable'. The interactions are starting already through the POGO initiative which Trevor talked about earlier.

Q76 Linda Gilroy: Australia?

Dr Webb: After that, Australia is the one nation which springs to mind, and Japan, of course.

Q77 Chairman: I was particularly interested in this issue of international co-operation, and particularly the use of ships from other nations, not to buy time but to barter time on those. Would it be possible for you to give us a note on that, because we have not got any written evidence on it?

Dr Webb: Absolutely; yes.

Q78 Chairman: Thank you very much indeed, because it was a really interesting comment you made.

Dr Webb: There are a very brief couple of lines in the NERC evidence, but it is a very small amount.

Chairman: Yes; but it was a very interesting point you were making and I think it will be something perhaps to include in our report.

Q79 Linda Gilroy: In some of the evidence we have received, several submissions have mentioned the skills base for marine science weakening to the point where some specialities are being lost, and particularly taxonomy has been mentioned, difficulties with recruiting numerate PhD, post-doctoral staff, as an ongoing problem, and perhaps deep-sea biology. What are IACMST and NERC strategies to ensure that there are the necessary skills?

Dr Webb: I would start by making the point that NERC has tried actively to encourage engagement between its researchers and the university sector, to try to stimulate the younger students to come through to fill some of these gaps. As part of the evidence for that, the Proudman Oceanographic Laboratory has moved from Bidston to Liverpool, within the University of Liverpool; of course, in Southampton University, we have the National Oceanography Centre, which was moved down from IOS, the Institute for Oceanographic Science, at Wormley. Also we have the Sea Mammal Research Unit, which has moved from Cambridge up to St Andrew's University. We have tried to stimulate interest in the marine sciences and attract students to fill these gaps that way. In terms of the skills gap, clearly the research councils are aware there are issues; attracting highly numerate scientists to the environmental sciences is an ongoing issue. In the past, NERC and the Engineering and Physical Sciences Research Council funded an environmental maths and stats programme, which provided £3½ million worth of funding to target studentships at this area and then, hopefully, keep them on this career path, which would allow them then to move on to, let us say, the oceanic modelling, which is another area of weakness which we know about, within that. As part of NERC's emerging strategy, we will be looking to do a gap analysis when it comes to skills and to target these areas in ways which might include, as I said before, the environmental maths and stats course, so specifically target these areas.

Professor Sir Howard Dalton: I could say something very briefly about it, because it is not a major activity of ours in IACMST, we concentrate more on trying to stimulate the activities between given government departments. It was true that the precursor to IACMST, the CCMST as it was in those days, did recognise this as an issue, and that the skills base, even then, was being somewhat eroded, and tried to stimulate industry to try to interact much more with the higher education institutions so that there could be a more active engagement for the universities to have an identification of the sorts of needs that it would have and the skills it would require in the future. That is still an issue and it is still something that IACMST talked a little bit about, but it is not very high up on the agenda, I am afraid.

Mr Guymer: IACMST does engage in some discussions with representatives of industry, and recently we have had the Institute for Marine Engineering, Science and Technology join as full members of IACMST, and talking with them and the Marine Information Alliance we have identified not only that some skills which were needed in the past have declined but also that there are emerging needs, particularly surrounding the area of operational oceanography, where we are not well placed to provide the sorts of skills which industry perceives that it needs. We have been discussing with those bodies how we should address that, probably initially with a working group, which pulls together NERC and those industry bodies, and indeed government departments, the Met Office, to discuss this. What we have done also is have a meeting involving representatives of industry and the National Oceanography Centre, which of course is embedded within a university environment, and specifically we discussed how we might set up an MSc in Operational Oceanography; so those discussions are ongoing. I think those are indicative of the kind of facilitating role which IACMST can play just to help meet the emerging needs. We need to have a better understanding of industry's and government departments' present needs and what they anticipate they are going to be in the next ten to 20 years, and then establish a strategy to meet those.

Q80 Linda Gilroy: The Environment Research Funders' Forum has been doing a review of training requirements; what do you expect to emerge from that?
Professor Sir Howard Dalton: Up to last week I had chaired the Environmental Research Funders' Forum. I have now stepped down from that. One of the things that we were very concerned about was ensuring that the right skills were being brought through the system in order to meet what we perceived, in some areas, as being skills shortages. We are about to commission that report; hopefully that will give us some indication as to where the future needs are going to be. We just have to wait for it to come out.

Q81 Linda Gilroy: What is the timescale on that? Can we have a note, if you are not certain?
Professor Sir Howard Dalton: Yes, I can do that. I am not sure exactly when it will be produced; it should not be too long[3].
Dr Newton: The agreed forward work programme in ERFF, to look at this training issue, is very similar to what is in NERC's draft strategy on training, so NERC is going to play a prominent role in that. The only other area that we have not touched on is education in schools, which is an important part of this. It is not within the research councils' remit but, for example, some of the Oceans 2025 institutions have programmes they run with schools, through Science in Society, to try to raise awareness, and I think RCUK is looking at ways it can interact with the Department for Education and Skills, again to start thinking about how we influence things at the schools level.

Q82 Linda Gilroy: Turning to the research vessels, again we have had some evidence expressing concerns about some of that. I am particularly interested to know what long-term plans NERC has to provide inshore research vessels?
Dr Webb: In the longer term, we have a Capital Programme now for the replacement of *The Discovery*, which is a large, oceanic ship. Through the NERC's barter arrangements I talked about earlier, we have access to a portfolio of other facilities, which includes smaller ships, when the demand is there from the science community and where we have access to what you would call more coastal or continental shelf type ships, through those barter arrangements. The whole idea of the barter arrangements is that we do not need to own every type of facility, and if the French have got smaller ships then why not use those; it is not very far away. One other point to make; through the Joint Infrastructure Funding, NERC awarded the University of Bangor what you would call a coastal and continental shelf ship, called the *Prince Madog*, and that is available as a NERC 'pay as you go' facility. As I understand it, that has availability year on year, so that would suggest, at the moment, that we are meeting the demand. I would suggest there is not strong evidence that NERC is not able to provide access to the ships which the science is demanding.

Q83 Linda Gilroy: When people tell us that the UK research fleet has reduced in size, are you saying that is more than made up for, or made up for, by access to barter or other sources?
Dr Webb: I think there is little doubt that the UK fleet has contracted over the last 20 years. I also think it is true to say that, through the barter arrangement, NERC is optimising the use of those facilities. If you look at the programme now, you will see very little evidence in the Cruise programme of large passages, because NERC is using all of the available time to programme in foreign cruises on its own ships. By doing that, I would suggest that you could say, arguably, if NERC was not involved in the barter arrangements we might need two and a half ships, or three ships, to do what we do currently with two. In terms of science demand, we are meeting all of the demand at the moment, but the demand is high and the pressure on marine planning is high then it may be that over time—

Q84 Linda Gilroy: It will increase with the Marine Bill, assuming that goes through the House, and the marine management organisation?
Dr Webb: Yes.

Q85 Linda Gilroy: Is that an area we should be concerned about and we should be looking at, in terms of our recommendations in this report?

[3] *Note from the Witness:* The report is expected within a few months.

Dr Webb: I find it hard to comment, to be honest. I believe there is capacity at the moment in the UK to charter what we would call more coastal ships. It may be that there is a need for some new resource but I do not know how strong the arguments are for that.

Q86 Linda Gilroy: Is anybody looking at value for money across what is available, at the moment?
Dr Webb: In terms of the NERC fleet, as part of the evidence base which NERC had to build to submit a case to OSI for capital funding for the replacement of *The Discovery*, we had to make a compelling case that we were using our existing facilities effectively and that there was the demand there to use them. I hope that answers your question.

Q87 Linda Gilroy: Is that something to which we can have access, to see what the issues are around that?
Dr Webb: Yes; certainly I can give you the case which NERC made for that facility.

Q88 Chairman: On that note, we will bring this first session to an end. Can I thank you very much indeed, Mr Trevor Guymer, Dr Philip Newton and Dr Mike Webb, and, in particular, could we thank you, Professor Dalton, Howard, for not only this session but for all the help that you have given to this Committee. We understand that you are leaving Defra sometime in the future, so this may be your last appearance before us, and, very, very sincerely and genuinely, can I thank you for being always really a very obliging, very supportive and very informative witness, and we wish you well. Also, could I apologise to the witnesses for Members coming in and out. We do not meet normally on a Tuesday morning, we have rearranged this to meet some other diaries, and there are two other Committees occurring this morning, including the launch of the Mental Health Bill Committee Stage, which Members are on. It was not because they were disinterested in your replies, it was because there were other things going on, and members of the Science and Technology Committee are in huge demand, all over the House.
Professor Sir Howard Dalton: We know that; we are delighted.
Chairman: Thank you very much.

Witness: **Professor Gideon Henderson,** Department of Earth Sciences, University of Oxford, gave evidence.

Q89 Chairman: Welcome to the second panel of this investigation, the Oceans inquiry, and we welcome very much Professor Gideon Henderson of the School of Earth Sciences at the University of Oxford. Thank you very much indeed not only for your written evidence but also for coming as our witness this morning. You probably heard the discussion we had with NERC over marine science. I just wonder whether you feel, as an academic within the university sector, that marine science has got this level of prestige and strength within the university sector that it has perhaps within its institutes: where is the strength?
Professor Henderson: I think I would say that, in broad terms, the strength in the university sector is not as high as in the institutes, and partly that reflects an absence of ready funding routes into those institutes. There are some areas of particular excellence in the university sector, areas where there is very good work going on, certainly in the chemical regime in the oceans but also in other branches of ocean sciences, and that tends to be focused in relatively few universities at present.

Q90 Chairman: What can the university sector offer this whole area of marine science; why do we not just leave it to the institutes?
Professor Henderson: That is a good question. There are two distinct answers to that question. The first one is to do with research and the second one is to do with training. In the research area, I think that, as I said, there is excellence in the university sector which would complement, or perhaps out-compete, work in the institutes at the moment, and those areas should be nurtured more carefully. I think, if there was more ready funding for marine science in the university sector we would find also that those areas of excellence would increase and we would see more university involvement in other areas of marine science, they would introduce competition and additional strength to the research process in marine science in the UK. The training aspect is that obviously the universities are responsible for bringing on the next generation of people who will work in marine sciences, and the active involvement of the universities is an absolute prerequisite if you want to get good scientists to come into marine sciences in the future.

Q91 Chairman: How easy is it for the university sector with marine expertise to collaborate with NERC centres; how close is the relationship?
Professor Henderson: Intellectually, the relationship can be as close as you want it to be, but the problem is always to fund the research that you want to do. At the moment if you want to fund research between universities and the institutes that has to be done through the responsive, non-directed mode within NERC, if you are looking for money within NERC. That limits things, because it is an extremely competitive way of getting money through the NERC system, and obviously most of the marine resources currently are going through other channels rather than the responsive mode. That is set to change in Oceans 2025, with the introduction of SOFI, the Strategic Ocean Funding Initiative, which you have heard a little about already this morning, and I welcome that as a very positive move.

Unfortunately, we have not seen very much information about that. I hope that SOFI will grow and will be as effective as it sounds that it may be.

Q92 Chairman: I can understand, in terms of the competitive bidding for funding, that there is a tension there. The Committee is trying to find out how you collaborate with the institutes directly; do they ever come to you for support, in terms of research work, or do you ever make a joint bid with an institute for a research project? How does that operate, or does that just not happen?
Professor Henderson: I think that it happens; it could happen more, but I think both of those examples that you have made do happen. There is dialogue between the institutes and the university sector and bids are made, but bids are not made generally through the strategic routes within there.

Q93 Chairman: How would you describe the research which is going on within the university sector, in terms of marine science? I do not mean in terms of quality, I am interested in the areas. Which areas are the universities specialising in, which is not happening within the centres?
Professor Henderson: I suppose one area which I would draw out from this morning's discussion, where perhaps there is a little bit of a difference, is that the universities tend to be more interdisciplinary, so there is more work in areas such as climates, for instance, than there is in some of the centres. That means that work where oceanography is a component part of a larger body of research is often pursued at universities and not in the centres.

Q94 Chairman: In terms of funding, other than from the research councils, where are you getting your funding from, where are the other big sources of funding for the university sector?
Professor Henderson: For oceanic research, those other sources of funding are small, basically. We get some money through charitable organisations, the Leverhulme Foundation, other charitable organisations contribute some money, but for marine research the funding opportunities are quite small outside the research councils.

Q95 Chairman: What about the European Framework Programme, so the European Research Council, is that an area of funding which is open to you?
Professor Henderson: Yes; that is true. I would have called that a research council; it depends whether you mean within Britain or whether you mean rather more generally. I think that EU money is available and there are some very successful EU programmes which work in the marine sector and involving university scientists.

Q96 Chairman: Are the European Framework Programmes—if you take Framework 6, for instance, or even the new Framework 7 Programme—separate from the European Research Council; are there programmes available there to bid into?
Professor Henderson: There are; relatively few and they have the problems of the strength, depending on which way you look at it, but the sheer size of the typical consortia that are required at European level, they are normally looking for very large groups of people. That is a good format to do really targeted research in a few areas and I think the EU is very successful at doing that, but it funds very specific areas of ocean marine science.

Q97 Chairman: We heard this morning about the co-ordination of the various bodies involved in marine science. In terms of the university sector, do you tend to work as a group, or do you work as individual silos; how do you co-operate?
Professor Henderson: In a wide variety of ways; it is not a straightforward question to answer. Even within a single research group there will be projects which are internal to that group, projects which involve co-ordination at a local level and a national level or an international level. I think there are very many ways of working. Increasingly, I think what we are seeing in universities is a move towards a system a little more like the American system, where you have active research groups in universities; this has happened, of course, in other subjects, chemistry and physics perhaps, for some time. In the earth and environmental and ocean sciences I think we are seeing a culture developing where there are research groups, they have a particular disciplinary strength in an area, which have a long-standing team of post-docs, students and researchers and technicians. That is more like the American model and enables those groups to interact internationally and nationally quite effectively, in terms of research.

Q98 Chairman: Should we be encouraging that way; do you feel that is an effective way for Government to be encouraging research in this area to continue?
Professor Henderson: I think it is, yes. Many of the problems that we have to face up to in the marine area are big enough and challenging enough that the sort of 'one man and his dog' approach is not very effective at solving them.

Q99 Dr Spink: On the funding side, we have talked about Framework Programmes and the public bodies; you did not mention the sources of private funding. Is there any collaboration with oil companies or companies which are extracting minerals; is there any funding or intellectual co-operation with those organisations?
Professor Henderson: I think, to be honest, I find that a difficult question to answer because of the side of ocean sciences that I work in myself. I am more on the environmental and climate-related side. I think people working on the mineral and oil recovery side do have some interaction with companies. There has been a thematic programme within NERC looking at ocean margins, which I know has generated interest from oil companies and funding from oil companies. Naturally, that comes into only particular parts of the marine sciences.

Chairman: You made some stinging comments about the relationship between NERC and the university sector and I am asking Linda if she will develop some of those.

Q100 Linda Gilroy: On the input to Oceans 2025 and the draft strategy, I think probably you have been observing the evidence we received earlier. Do you want to elaborate on that to the Committee, and in particular there seems to be some uncertainty over how long the consultation period was; have you got a clear recollection of what that was and can you tell us how it looked from your point of view?
Professor Henderson: I cannot answer the specific question. I do not know how long the consultation was. I think probably my written remarks are too strong here. There was, as I discover now, some consultation, but I would like to make two general remarks about that. The first is, that consultation was quite short, it was a compressed timescale, I do not know how long, but I certainly and most people that I spoke to in the university sector were unaware of the consultation. That is in marked contrast, for instance, with the NERC strategy document which is being consulted on now, where there is widespread awareness and discussion in the community about that document.

Q101 Linda Gilroy: Your remarks are set in the overall context of what Brian Iddon said to us earlier, which is that there is a general consultation period, I think it is 12 weeks, three months?
Professor Henderson: I am afraid I do not know the actual number.

Q102 Linda Gilroy: You are familiar with that sort of cycle, so you are phrasing your comments within what you are accustomed to in other consultations; is there a comparison that you are making?
Professor Henderson: I suppose I am, but in particular I am drawing a contrast between Oceans 2025 and other things that I have seen through NERC where the consultation has been more full. The other comment that I would make, and this is, I suppose, the more important of the two, is that the document which was consulted on is the outline document only, which lays out the general purpose of Oceans 2025 and describes the ten themes within it briefly and just the titles of the work packages. From a scientist's perspective, all the science is going on in those work packages; that is where actually you need to see the details to know if the document is going to meet the strategic objectives for the country. There are ten proposals, as I understand it, one for each of those themes, and those documents have never been made available to the wider community, there has been no open access to those. Requests for those documents have been turned down and, as I understand it, those theme proposals are still not accessible to people in the university sector, unless they happen to be a formal reviewer, invited into that process.

Q103 Dr Spink: Could I ask you to tell us, do you think that this was an oversight on NERC's part, on Oceans 2025, or do you think they had some underlying strategy in rushing the consultation or not making it quite as open as previous and subsequent consultations? Do you think that there was a competitive element in this?
Professor Henderson: I think the latter may be true, but it relates to a structural issue here and the fact that this document is describing the science which individuals and research groups want to do within the institutes in the next five years, which naturally they want to have some sort of ownership of and they may be reticent to disseminate those ideas too widely. In another funding route, where there is competition between different proposals, that would seem entirely appropriate, that there was not completely open access, but in a situation like this, where there is no competition, it is not possible for other groups of people to bid for the funding, that seems inappropriate and there should be complete openness of some of that policy.

Q104 Linda Gilroy: Looking to the future on that, in terms of the balance in support of marine research in the universities and the centres, and particularly what we heard earlier about probably substantial underfunding in the marine science sector, what are your observations on that balance and what would you like to see in the future, if indeed it proves possible to expand the commitment of resources to marine science?
Professor Henderson: I think the thing that is missing in the UK at the moment, and which I brought up in my written statements, is that in the university sector it is pretty difficult, if not impossible, to gain access to strategic funding. I think, if there was a more open system in which the universities could bid for either the present pool of resources or an expanded pool of resources, you would see quite quickly universities stepping up, apart from the ones which are already doing some research, you would see additional universities stepping up to do high quality marine research, to fill gaps that are in the strategic goals of the country in marine resources. Just to take an example from this morning, one of the previous panellists mentioned the fact that the UK now is fairly weak in modelling of the oceans and perhaps modelling physical oceanography as well of the oceans, and that is an area where I know there is active interest in the university sector, in my own University and in others, to do more work, but it is quite difficult to tap into the necessary resources at the moment. I think you would find other examples like that and probably in the biological realm as well.

Q105 Linda Gilroy: You have already mentioned the ability of universities to bridge the research councils; is there also a contribution which universities can make there, not just, I think you were mentioning, climate change but also the issue I mentioned earlier about health sciences and the ocean sciences?
Professor Henderson: Certainly, there is. I think that the universities, by their nature, strive to be universal, at least they used to, and they study many

different aspects of the environment, including health sciences and many of the biological aspects of the environment, and I think, in some ways, they are the natural home for some of this interdisciplinary work. I would concur with what we heard earlier this morning, that it can be difficult to work out which research council should be funding your research, and personally I have had this experience and have had conservations with many other people who have had difficulty when you fall between the gaps of research councils. That is something which the universities can do a good job on, but only inasmuch as the research councils move with them.

Q106 Linda Gilroy: From your point of view, irrespective of the balance, are the national facilities provided by NERC adequate?
Professor Henderson: Do you mean, by the 'national facilities', things like provision of ships?

Q107 Linda Gilroy: Yes, and the facilities in the research centres?
Professor Henderson: I am not sure I understand. Are you asking me whether, if I go to the centres, they provide what I need, as a scientist, or are you asking do they provide what the Government needs and the country needs?

Q108 Linda Gilroy: I suppose what I am saying is, are the facilities which are available, which tend to be concentrated at the moment in NERC and its research centres, adequate, in terms of the challenges that we face in the marine science sector, and I suppose it is also about the balance issue again between NERC and the work that is going on in the universities?
Professor Henderson: I would say that they are adequate but certainly that they could be improved. I think the room for improvement is seen if you compare the reputation of UK ocean sciences with that in some other countries, and certainly I would say that other national marine labs have a better reputation than the ones in Britain, at the moment. I think that we have room for improvement and one way to affect that would be to introduce more competition into the system and involve the university sector more.

Q109 Linda Gilroy: Are there particular international examples you would point us in the direction of looking at?
Professor Henderson: I think the two international centres which probably are recognised as being the best, or two of the best, in the world are Woods Hole, which you have heard about, and also Kiel, in Germany, and of the European ones I think the Kiel Institute is probably permanent.

Q110 Linda Gilroy: Is there anything further you would like to say about the input you were able to make to Oceans 2025?
Professor Henderson: In terms of the specific science of Oceans 2025, as I said, I find that difficult. As an example, as far as it goes down in the detail, there is a working package here, called Plankton communities and biogeochemistry; that is to choose just one random one. Plankton communities and biogeochemistry could mean many, many different things; that is an extremely wide remit to describe in three or four words. As a scientist, I am not able to work out how much detail is in the theme proposals, which I have not seen, and it is very difficult for me to comment in detail about the science, as a consequence. That is even more of a problem, I think, in this document, when we look at SOFI, because SOFI, as it is described in here, says simply there will be many opportunities for university scientists to link with this document, and further discussion of that is left for the theme proposals. In the absence of having seen those theme proposals, it is not possible for me to know where those areas of interaction between the university and the research councils are, so I find it difficult to tell you whether this document really covers marine sciences adequately.

Q111 Dr Spink: Did you have any input into it?
Professor Henderson: Yes.

Q112 Mr Newmark: What incentives are there for young researchers to pursue a career in marine science in the UK, financially and otherwise?
Professor Henderson: Perhaps I have a naïve view, from the university sector, but I think interest often is one of the incentives which gets people into the subject, and I think that happens often at university level. People who come in and are exposed to oceanography gain an interest in it, and then, as we heard earlier, there is a lot of activity in the marine realm in the UK so there are many job opportunities for people who are trained at university in ocean sciences and become interested in it.

Q113 Mr Newmark: Has the whole profile of climate change and everything related to that led to far more people suddenly applying to universities, or has there not been that much change?
Professor Henderson: I think it is true to say there has been an increase in particular subjects related to climate change.

Q114 Mr Newmark: In marine courses, specifically?
Professor Henderson: I do not know the statistics on that; there are relatively few courses which are specifically marine, and often those are in the institutes, and I would have to refer you to them for their enrolment numbers. In the subjects related to climate and the environment there has been a modest increase, but there are not actually that many courses offered in the UK in those subjects, particularly not in some of the leading universities, and that is something which I think probably should be addressed.

Q115 Mr Newmark: If there are not that many courses, I am assuming demand exceeds supply so is the quality of people increasing, or is there no change in the quality?

Professor Henderson: I think probably I am not the right person to answer that. I can tell you the specific example of Oxford, and in Oxford we do not teach a specific ocean course, we teach it as modules within two of our courses. One of those is physics, and I think that physics has been a route to get people into oceanography which has been very successful; we need to have highly numerate people coming into the field, as was said this morning. In that area, really it is the quality of the teaching and the research in the university that will inspire students to do it.

Q116 Mr Newmark: Is there a skills shortage of people who actually teach those courses, or not, in your view?
Professor Henderson: No, I do not think there is a skills shortage.

Q117 Mr Newmark: Do you feel that marine science and technology graduates are adequately prepared for post-graduate courses and advanced academic studies?
Professor Henderson: That is a difficult question to answer. I think that some of them are, but it depends on what sorts of students you want to bring into post-graduate courses.

Q118 Mr Newmark: Smart ones?
Professor Henderson: Yes, smart ones obviously, but I think 'smart' these days means numerate as well.

Q119 Mr Newmark: You do feel, to succeed in this particular field, you do need to have good numeracy skills?
Professor Henderson: I think that is true and probably there is a weakness in that area. I think that scientists who have been trained at undergraduate level in this country often are not ending up being sufficiently numerate then to go off and really make an impact in research.

Q120 Dr Spink: Are many of the post-grads from abroad in this discipline?
Professor Henderson: A fair number, yes. I am afraid I do not have the statistics to hand but there is a fair number. That is a number probably I could put my hand on, if you wished.

Q121 Dr Spink: Where are they coming from, Asia or further afield?
Professor Henderson: There is a fairly large number from Asia; we see quite a lot from Australia as well and from America, although the Americans generally want to stay in their country, but there is a certain amount of exchange between.

Q122 Mr Newmark: I guess, having got your education and gone through the whole process, at the end of the day, is there a skills shortage in areas around marine science and technology or not, and, if so, how is that gap being filled?
Professor Henderson: From an industry perspective, I find that quite difficult to answer because I am not in that sector. I can see, from a research perspective, that there is a looming skills shortage and we are seeing subjects which Britain used to be strong in, and again physical oceanography would be a good example, become weaker because fewer people are going into that field. I think, certainly from a research and both a strategic and non-directed research point of view, there is a looming skills shortage in some areas.

Q123 Chairman: Professor Henderson, you sounded very gloomy this morning and your evidence was a little gloomy; do you think you reflect other academics, in other universities, in the marine science area, in your frustrations, particularly with Oceans 2025 and NERC?
Professor Henderson: I do. As I think I said in my document, I became aware of this only quite late in the process, but from informal discussions before writing the document and since, with people, I think there is a general level of frustration about how able we have been in the past to influence NERC strategy in the marine area and to tap into strategic funding, and that is widespread. Many people in my direct field and similar fields feel that we are doing strategically important work for the country but we are not able to tap into funding for that work.

Q124 Chairman: If you had to write a chapter in our report about how to rectify that situation, so you would all be singing and dancing again, what would be the sort of main recommendation you would make?
Professor Henderson: I think the main recommendation is to open up the bidding process for strategic research to involve many more institutes so it is not a closed shop. You cannot break that down to very small projects because it would become too cumbersome, but to enable consortium groups to come in and bid for aspects of the strategic research.

Q125 Chairman: Is it not important to have the strategy first of all, so that, if you like, there is an agreed common strategy which then you can bid for; and that seems to be the bit you are most aggrieved about, that you have not been able to make real inputs into the strategy?
Professor Henderson: I am not sure it is true to say that is the bit I am most aggrieved about; I may be aggrieved about.

Q126 Chairman: One of the things you are aggrieved about?
Professor Henderson: I think it would be much easier to build a strategic consensus if all the people who were interested in marine science thought that they could get some money out of it, at the end of the day. The problem is it is difficult to involve people in the process when they think that they are going to be excluded from the final result. I think you would find it impossible to build a strategic consensus.

Q127 Linda Gilroy: I have one question, which has just occurred to me, about dissemination of research by NERC. How does that look, from where you are standing; are they good at disseminating research, from the universities' point of view?
Professor Henderson: To the public, or to Government?

Q128 Linda Gilroy: I think to people who would be interested in it, in university communities, but to the public as well, if you want to comment on that, because that is important, of course that is important, as well?
Professor Henderson: I think NERC are certainly improving and I think that they are getting pretty good at disseminating to the university sector. I think probably there is still further to go and one way to do it might be to have in universities a formal NERC liaison person who was responsible for making sure that the right people had seen the right documents within the university.

Q129 Linda Gilroy: It is more proactive, perhaps?
Professor Henderson: Perhaps more proactive. It might not be a NERC person, it might be someone from the university who was identified as a liaison person. These days, we get so many e-mails from so many institutes that knowing which are the important ones is difficult, and someone who can help sift that and make sure that the right documents are on the right desks would help the transfer of information, I think.
Chairman: We hope our report will go some way to supporting the work that you do, and indeed the institutes. Professor Gideon Henderson, thank you very, very much indeed for your evidence this morning.

Wednesday 16 May 2007

Members present:

Mr Phil Willis, in the Chair

Linda Gilroy	Mr Brooks Newmark
Dr Evan Harris	Dr Bob Spink
Dr Brian Iddon	Graham Stringer
Chris Mole	Dr Desmond Turner

Witnesses: **Dr Joe Horwood,** Deputy Chief Executive, Centre for Environment, Fisheries and Aquaculture Science (Cefas), **Dr Robin Hensley,** International Partnering Programme Team Leader, UK Hydrographic Office, and **Dr Mike Bell,** Head, National Centre for Ocean Forecasting, Met Office, gave evidence.

Q130 Chairman: Good morning to our special witnesses this morning: Dr Joe Horwood from the Centre for Environment, Fisheries and Aquaculture Science, Cefas; Dr Robin Hensley, from the International Partnering Programme, the Team Leader for the UK Hydrographic Office; and Dr Mike Bell, Head from the National Centre for Ocean Forecasting, the Met Office. Gentlemen, you are very welcome to this evidence session of our inquiry investigating the oceans. Could I ask you, Dr Hensley, to be the chair of your panel and please bring in your colleagues. How do you see the roles of organisations like Cefas, the UKHO and the Met Office in marine science and technology research? What is their principal role at the moment?
Dr Hensley: I will speak about the Hydrographic Office and then I will defer to my colleagues. The UKHO itself does not conduct research. However, we collate data that are gathered and we turn those into products and services, either for the military or for the civilian user. We are not a research organisation but we are a user, a consumer of data. We could have a role in requesting or requiring research to be done where there are gaps within the research, but primarily we are not a research organisation. We just have a database that we manage and use to service our community.
Dr Horwood: We have a fairly clear role. It is very much as a supporter of government and other departments, particularly Defra from which we receive over 70 per cent of our funding, from the Marine and Fisheries Divisions of Defra with its national and international responsibilities. We are engaged in support of obligations, monitoring, research and advice. We have emergency response capabilities which fit in with that. Our research does tend to be very applied to support the needs of the government policy divisions; it tends to be more short term than programmes managed by, for instance, NERC.

Q131 Chairman: It is basically the Government that sets your work programme?
Dr Horwood: All our work, apart from a very small amount which we ourselves do, is done through particular contractual commitments, mainly through Defra. Then about another 25 per cent of that funding is won in competition but it is work that is aligned to the core. We do significant work for the Food Standard Agency in monitoring radio activity, including in the environment, and in looking at the toxins in marine foods. We have a significant portfolio of EU research programmes, which again support the core Defra marine and fisheries programme.

Q132 Chairman: It is virtually all public sector funded?
Dr Horwood: It is but it need not necessarily be. About 5 to 10% of our work is overseas and for other governments.

Q133 Chairman: What is the overall budget?
Dr Horwood: It is presently £43 million.

Q134 Chairman: You say that roughly 5 to 10% comes from the private sector?
Dr Horwood: Having looked at my notes, the figure is at present 4%, with another 4% from the EU, and about 25% is won in competition with other organisations nationally and internationally.
Dr Bell: The primary role of the Met Office with respect to marine science is to use up-to-date marine science and technology to make predictions. There are three timescales for which we make predictions. There are climate predictions, predicting how the climate is going to vary and change over the next 50 to 100 years. There are seasonal forecasts that we make; for example, the cold winter forecast that we made not for last winter but the preceding winter. We also make forecasts of the surface waves, coastal flooding, storm surges, surface temperature currents in the ocean on a short timescale, so just a few days ahead. Obviously to do all of those things, monitoring of the oceans is very important to us. We ourselves play a small role in that.

Q135 Graham Stringer: What is the balance of resources into those three areas of forecasting, as a percentage?
Dr Bell: As percentages, the climate prediction with seasonal forecasting together is just over 50% of those and we spend of the order of £1.8 million per annum on those activities; that is, the marine aspects of those. For short-range forecasting, we spend, as we stated in our evidence, £1.3 million; I think it is slightly more than that at £1.5 million per year on short-range forecasting, which is primarily funded by the Ministry of Defence.

Q136 Chairman: Obviously the whole marine space is used significantly. When I was growing up, it was seen as a major source of food and that was it. It is now used in all sorts of different ways. How is your work changing? How is your workload changing? How would you say the emphasis of your budget changes to meet the changes in the marine environment and the uses of it for things like energy? I would like a comment from each of you.
Dr Bell: Obviously the climate change agenda has increased in importance dramatically over the last ten years. That work is jointly funded by Defra and MoD. It is of course up to Defra and MoD to decide how much money to spend in that area. The seasonal forecasting area has also gone up the agenda recently because it has become more plausible; we can make seasonal forecasts with a useful level of skill. I think that has become clearer over the last five years than it was ten years ago, particularly for forecasting in north-west Europe; for seasonal forecasting in the tropical regions, it has been understood that that has been possible for some time. Operational forecasting has gone up the agenda a lot in the last ten years as well because it is only in the last ten years that it has been seen to be feasible. Surface wave forecasting has been going on for quite a long time. That is well established, and so is storm surge prediction, so the coastal predictions on the basis of which the Environment Agency issues warnings of coastal flooding. That is well established but in some of the other areas, in particular forecasting of currents in the ocean, the technology has only just got to the point in the last ten years where that is coming through as a viable and reasonable thing to do.
Dr Hensley: From the UKHO perspective, it is not as direct as the forecasting function from the Met Office. We support the Maritime and Coastguard Agency discharging the Government's Safety of Lives at Sea regulations, and we do that through the provision of navigational products and services. In order to achieve that, the bathometric survey programme needs to be geared to respond to environmental changes in shipping areas, for example, and areas that have not been particularly well surveyed. One could argue that our role follows environmental change in that respect. It is responding really to the requirements of the needs for safe navigation. In our defence area, again we are responding to the requirements for environmental information and data. There is not as clear a driver as for the Met Office looking at forecasting of, say, storm surges. We respond in that respect. It is not as direct.

Q137 Chairman: Have the technologies changed dramatically?
Dr Hensley: Yes.

Q138 Chairman: Give me an example of where five years ago something you are doing now is totally different from the way in which you were operating five years ago using technology.
Dr Bell: There is one rather good example of that, I think, which is the ARGO system, which is a system of floats which are about the size of a man. They spend most of their time at about 1,000 metres depth within the deep ocean and once every ten days or so they come up to the surface. They go down to 2,000 metres and come up measuring temperature and salinity, then they signal that via satellite to shore. There are nearly 3,000 of these of those floats distributed globally in the water now. This programme was first considered in 1997. I remember very vividly thinking how marvellous it would be if we could really have such a system monitoring the oceans with 3,000 floats with a very good geographical distribution. That data is freely available over the worldwide web. We use it to keep our forecasts on track and close to reality. I think that is one of several examples.

Q139 Dr Spink: Could I ask how that actually works with predictions of temperatures and salinity? What does that enable you to predict?
Dr Bell: Knowing the temperature and salinity of the oceans is important because the temperature and salinity structure drives the currents, together with the surface winds. It is that thermal and density structure which drives the currents. If you want to do things like monitor the thermohaline circulations, this is the circulation that does a lot of the transport of heat from the Equator to the Poles and it is very important in the earth's climate.

Q140 Dr Spink: Had we had that in 1953, would it have enabled us to know sooner about the massive surge in tide and flood that hit the south-east of England, for instance?
Dr Bell: It would not have been relevant to that particular application. Tide gauges are more valuable for that particular application. So, yes, there is an important point there that, in monitoring, you have to be very clear about the purposes of the monitoring.

Q141 Linda Gilroy: To Dr Hensley, you have described how you are focused around providing navigational products and the basic hydrographic activity is to map the bed of the ocean. What proportion of the oceans has actually been mapped?
Dr Hensley: That is a fine question.

Q142 Linda Gilroy: They are not mapped in their entirety, as I understand it, by a long chalk.
Dr Hensley: They are not. I cannot give you an answer in terms of percentage, I am afraid. There is also a question of to what standard they are mapped and whether they are charted and surveyed to International Hydrographic Office standards for navigational requirements or whether it is for environmental purposes. Going back slightly, if I may digress, when I was still but a lowly student, and it is not that long ago, I understand that in the deep sea area that I used to work in there was approximately a football pitch worth of ground, if you like, that had been thoroughly surveyed but that is at least 15 years ago. I do not have the figures for the UK. I am sure we get give you those.

Q143 Chairman: It would be useful if we had those. I turn to you, Dr Horwood, and ask you in terms of Cefas about how your agency has changed and its work has changed to meet the changing use of the marine environment, briefly.

Dr Horwood: May I pick up on one of the technologies for instance which again we share with the Met Office. We have developed over the last few years some offshore wave censors, which have been very helpful in predicting local flooding in the last 12 months. We now have this system of offshore real time data coming in which complements the shore-based gauges. We are looking more and more to remote data collection but the key area for us is really the increasing international interest and international obligations to monitor and keep an eye on the coastal seas. Rather than the wonderful technologies that are coming on board, it is the increasing interest in getting proper baseline information.

Q144 Chairman: Why do you think that we have had evidence given to the committee that Cefas is becoming much more aggressive, much more remote and much less co-operative in terms of the other marine science organisations of late? Why do you think that should have been reported to us? Is it true? You do not look like a very predatory man from here!

Dr Horwood: There are some good things about that. We have been extremely fortunate, and I think the country is quite fortunate, in having agreed a ten-year deal with Defra on our future. We have a ten-year funding programme. This is in the context of the Public Sector Research Establishment report, which said that all the government's research establishments are really at risk from the sustainability point of view. They have attempted to address that but the agreement is for ten years of flat funding. Of course, as you can imagine, at the end of that period, there will be a gap to fill. At present, they are filling 77 per cent; in ten years' time, they will be filling than 60 per cent. We will be looking to wider markets to fill the gap. This is not just to keep people in business. It is actually to keep teams and facilities alive in order to underpin the government. There is an induced financial driver to do this but also it has been enormously beneficial to us. There has been, since the Sixties and Seventies, a contraction in funding for marine research. Our area of interest has contracted and this ability to go out into the wider market has enabled us to do a much richer range of research. A lot of our scientists are much more fulfilled. If you refer to the submission from Oxford University, they have pointed out that some of our institutes might be better if they too were subjected to more competition. There are lots of good things and drivers for competition. The people who we are competing with one day of course are our partners in other complex research projects the next day.

Q145 Chairman: I do not have a clear picture yet as to whether you will drive policy and therefore say to Government, "This is what we need to be doing", or whether you are just simply recipients of government policy and carry it out. Can you tell us briefly where you sit on that continuum between being the driver and being purely the recipient?

Dr Bell: The Met Office's role is to provide impartial, objective, scientific advice on which policy can be based but it is not to enter into the discussion of the policy itself.

Dr Hensley: The policy for data collection for defence is set within MoD. FLEET is the organisation that controls vessels to collect the data that we get. We do have some role at the IHO alongside the MCA but the MCA is responsible for discharging our SOLAS obligations. We are advisory in that respect.

Dr Horwood: We have no exclusive policy role or responsibility. We are essentially a delivery agent but our Defra colleagues see us as partners so that they have an informed customer role. In addition, we sit on quite a lot of high level expert panels at the European level where we are influencing the European policy agenda. We ourselves are not responsible for agreeing any particular set of policies.

Q146 Dr Spink: Dr Hemsley mentioned the MoD. I wondered if he could expand a little on what the MoD's role is in marine science research and technology development.

Dr Hensley: I do not sit in a research organisation, so I cannot comment directly on the way MoD directs its research funds. We are recipients of the data from various programmes that they undertake so that we can turn them into products and services for them. It would be speculation for me if I was to throw that back.

Q147 Dr Spink: Mike Bell, do you have a view on where the MoD sits and how they advise on scientific information?

Dr Bell: There is a research acquisition organisation within MoD which plays that sort of role. They acquire research from us, for example. There is also the DSTL of course, which undertakes a lot of research for the Ministry of Defence.

Q148 Dr Spink: What sort of research is it looking for?

Dr Bell: It is a very broad range of research. I think there are seven pillars under which the research is organised. I perhaps need to check that and send you a written answer.

Q149 Dr Spink: For instance, do they come up with specific projects or do they just come up with problems and ask you to look at how you might design research and technology to solve those problems?

Dr Bell: In our specific case, which might be a good example, the programme of work that we do, which involves some research, is agreed with the MoD customers, with the policy customer within MoD. There is a discussion as to what their priorities are, what our capabilities are and what we could develop

that would be valuable to them. The projects that they drive are worked out in quite a collaborative and constructive way.

Dr Hensley: There is a body called the Co-operative Arrangements for Research in Ocean Science. That is attended by the directors of the NERC institutes and it is co-chaired by one of the NERC directors and an MoD representative. At that level, there is mutual discussion on requirements.

Q150 Dr Spink: Could I turn to the relationship between Cefas and the OSI, Dr Horwood? What is your relationship with the OSI?

Dr Horwood: I have to admit that I do not know whether IACMST is still part of OSI.

Q151 Chairman: You do not know whether it is?

Dr Horwood: I personally do not know; maybe I should. I do not know what the parent of IACMST is but we have a seat on the IACMST. As you have already heard, it is a form of co-ordinating body and it sends information up through the system. We do contribute to the open consultation on framework programmes. Also, via Defra, the OSI have an overall responsibility for the quality of science across government. We see that effect through our science audits and through the review of science in Defra. I would be straining to find any closer contact.

Q152 Dr Spink: It seems to me then that there is not really that much collaboration or contact between you as someone who delivers science in a specific area, the issue of agriculture, and the OSI. That is quite surprising. I would have thought there was very close collaboration to make sure that there are no gaps and overlaps.

Dr Horwood: One area that I missed is that of course they would probably be leading on our response to the framework programmes in Europe, and again either independently or through Defra we would be feeding in our thoughts to that. Our key association is with the parent department to commission specific work. There are lots of areas where we are very much joined up at the European and North Atlantic level.

Q153 Dr Spink: Do the OSI get involved in any quality issues in terms of your research and quality advice delivery?

Dr Horwood: That is only in terms of their remit to overlook the quality of science conducted by government departments as a whole.

Q154 Dr Iddon: It sounds to me as if the bulk of the money for your three agencies comes as a result of programmes rather than as core funding, which you could direct as you wish. Is that correct?

Dr Hensley: UKHO is a trading fund, so we do receive some funding from the MoD in order to turn around the data that they provide to us to provide defence-specific products and services. We use the bathometric data from the civilian hydrographic programme as administered by they MCA and we quality assure those data and turn those into navigational products and services. It is the sale of those navigational products and services that supports the agency.

Q155 Dr Iddon: What about the other two agencies?

Dr Horwood: To my understanding, yes, that is right; we are funded through programmes.

Q156 Dr Iddon: Do you think that is right or would you prefer to have more core funding to develop research ideas, for example? What would you like to do that you cannot do at the moment? Are there any pressing problems?

Dr Bell: I think that the existing arrangements are quite good. I do think having programmes is quite a good arrangement. There are areas where the co-ordination across government is quite difficult to bring marine science through into practical applications. I am thinking in particular, for example, of counter pollution responses to, for example, oil spills, to the co-ordination across government of the requirements for that to bring new marine research through into those operations. I think that the co-ordination there could be improved. It is those sorts of areas where I think there is a gap.

Q157 Dr Iddon: Dr Harwood, what could your organisation be doing if you were not so restricted by programmes?

Dr Horwood: It would depend upon the scale. There is a very significant list of things that needs to be done at sea. We really do not understand how the sea works at all. You might be interested to have a look at the ICES submission to the Maritime Marine Green paper where they have a fairly pithy set of recommendations for activities. One of the key things is to understand how the sea is going to change in response to anthropogenic stresses and annual climate change. We really need to be monitoring it more intensively to understand the natural variation from which we then see signals of change. The first is monitoring; the second is understanding how the sea as a system works. In terms of our internal programmes, likewise, I think our marine environment, and fisheries divisions in Defra, are very supportive of work in thus area. I am sure if they had more from the Treasury, they would be more than willing to invest more in this area. Within our own programmes, we really are a bit constrained to delivering fairly targeted programmes. It would be nice to have a little bit of space within each programme for a bit more innovation and sitting back and thinking.

Dr Hensley: As a trading fund, we are very focused on our objectives. I will not quote those. We are there to provide navigation products and services. One of our objectives is organisational excellence and maximising the benefit of those uses. I do not have any comments to add to those of my colleagues.

Q158 Dr Iddon: Are all government agencies able to bid for their funding and indeed other research council funding or are there some difficulties in that area?

Dr Horwood: There are some difficulties. There has been a recent change in the character of research council eligibility such that my organisation, and I guess the Met Office, are no longer in a position to be given any of the research council funding at all. This is a problem. We can still receive it as subcontractors but the key thing is that as a leader in a programme, you very much can drive a particular idea forward, in competition with everybody else who is competing. We did see that as a bit of a blow. I understand there were representations from the Defra Chief Scientist back to the research council, although I cannot say what the outcome of that is.

Dr Bell: The Met Office under the new rules is not able to apply for money from research councils but I believe that it can take part in projects as subcontractors. In the past, it has been a bit less clear whether the Met Office could take part in, say, NERC-funded projects. There have been projects where collaboration between the Met Office and NERC was obviously very desirable and we collaborated in the projects, but there was difficulty getting funding for the Met Office for that, so we tried to get funding from the Ministry of Defence and that did make it difficult to get the projects started. We were successful in the end, I should say.

Q159 Dr Iddon: Could you each tell the committee, and you have hinted at some of this already but perhaps we could clarify it, how much involvement each of your agencies has with the private sector? Is it important that you bring in a lot of private sector money or not? We will start with the Met Office. You must service a lot of the private sector.

Dr Bell: We do service the private sector. The marine research part of the Met Office has much more contact with the NERC laboratories, which is very strong at the moment. To come back to your question, the Met Office in the marine sector has the Aberdeen Weather Centre, which services the oil and gas industry, particularly in the North Sea. There is a programme within the Met Office to develop commercial products to serve the marine sector in various aspects, like energy, marine renewables and the leisure industry. There is a list of things. It is in fact a fairly small group.

Q160 Dr Iddon: Professor Hensley, how important is the private sector to you?

Dr Hensley: Our remit is to meet the safe navigation requirements of international mariners, so the private sector as a customer of our products is very important. In the paper charting the world, I think the figure is approximately 85 per cent of world vessels in the SOLAS market would carry British Admiralty charts. It is very important that we do meet their requirements precisely in terms of up-to-date information delivered on time of reliable products and so on, so they are very important to us.

Dr Horwood: We obviously serve the private sector as an agent of Defra, for instance with help in licensing and with stakeholders in fisheries. But as direct customers for our services, provided there are no conflicts of interest or they can be managed, we can take on private sector clients. As it has turned out, that really has not to date been a very significant part of our business. The area we seem to be most suited is support to other government departments or even overseas governments or the European Union.

Q161 Dr Turner: The IACMST takes the view that marine science could be better co-ordinated. What is your view on that from the point of view of your agencies?

Dr Hensley: We have a representative on IACMST, so we are party to that. We are involved in that. We are also involved in the Marine Data Information Partnership (MDIP) along with our colleagues within the MoD. As I said earlier, we are not responsible for doing research but we are part of that community. We play our part in that respect.

Q162 Dr Turner: Do you think it could be better co-ordinated? Do you agree with the committee in that view?

Dr Hensley: I do not really have view. I am not sure whether it can or cannot be, to be honest.

Dr Bell: The co-ordination certainly between the Met Office and NERC has improved enormously over the past ten years. The National Centre for Ocean Forecasting is a very good example of that. That is a consortium that has been set up to enable the marine research that is done within the consortium within NERC to pull through more effectively into our short-range forecasting operations. I think there things have improved a lot at working level. That is very important. There is co-ordination with the Met Office down to the use, particularly by government departments, of the information and the forecast predictions that we produce. I have indicated already that there are some areas where that could be strengthened. We set up a stakeholders' group to try to encourage that. That is certainly an area where things could be better.

Q163 Dr Turner: That is within the Ministry of Defence and yourselves, is it not?

Dr Bell: The stakeholder group includes people from Cefas, from HR Wallingford, from BP and MCA, so from quite a wide rage of organisations. The other area I would mention is marine monitoring. Better co-ordination there is really crucial. Some good steps have been taken with the UK Marine Monitoring and Assessment Strategy and the setting up of the policy committee and the sub-committees under that. It needs co-ordination of funding as well as just co-ordination in meeting up to get some common ideas.

Q164 Dr Turner: Some of that long-term monitoring has nearly been lost because of gaps in funding?

Dr Bell: Yes.

Q165 Dr Turner: Dr Horwood, what is your view?

Dr Horwood: There is a great deal of co-ordination that goes on that I guess you need to be able to see to identify the particular weaknesses. The question

was put to us as: you see your work as coming from programmes. Where there are some programmes, these are often aligned to European programmes, and there is a great deal of co-ordination, particularly at the European level because we are essentially an international business. When things happen at sea, we have been used to joining together with other countries for many years. There are key European committees. The International Council for Exploration of the Sea has a key remit to co-ordinate work. The European Science Foundation has a marine board that brings together research councils across Europe. Under the new Maritime Bill, ICES and the European Science Foundation hope to get together to provide even greater co-ordination. Nationally, the devolved administrations and Defra join together to ensure there is a coherent UK programme in fisheries and the marine environment. They are taking the lead on UKMMAS, the marine environmental monitoring programme, which for the first time has brought together national monitoring and includes a review of what resources are needed to deliver that. There is a huge amount of co-ordination that goes on. To me, the weak bit is then the bit from our type of organisation to NERC, the research councils and the universities. There is less coherence there than in some of the other areas where there is very strong co-ordination.

Q166 Dr Turner: You are all basically agreeing with the inter-agency committee's view then that co-ordination is not as good as it might be. There seem to be far too many organisations doing their thing that may or may not be talking to each other and collaborating. It strikes us as somewhat analogous to the situation we found in space science where there is a relatively weak national committee charged with co-ordinating space science, but it lacks clout and it lacks funding. The question there is: should there be a national agency with its own funding and given far more authority? We are wondering whether this applies to marine science as well. We have the example in the US of the National Oceanic and Atmospheric Association as just such a body. What would your view be on the establishment of a comparable body in the UK? Do you think it could improve for instance the overall funding of marine science, which clearly is not enough to do everything that is desirable?
Dr Bell: I think one of the points that you do need to bear in mind is that different organisations have different roles. You have the NERC institutes which are focused very much on marine research.

Q167 Chairman: We are very anxious to get an answer directly to Dr Turner's question. Is an agency a good idea or not?
Dr Bell: I will come on to that. One of the questions is what the scope of that agency would be, what it would actually cover, and whether it would cover the whole of marine research, whether it would cover research through to operations and applications?

Q168 Dr Turner: Assume the answer is yes to that question, then continue please.
Dr Bell: Across the whole thing, I do not think that would be the right thing to do. For the operational work, the Met Office is very good place to do that because of the gearing that you get from the weather forecasting. If you did that work anywhere other than the Met Office, it would cost an awful lot more money. The Met Office has a rather small group of people involved in marine research. That would not be an appropriate place to bring all the marine research institutes. Those need to be closer to the universities.
Dr Horwood: It is not entirely clear that we have a UK strategy for marine research to underpin what we need from the marine side. It would seem sensible that somewhere there is a very high level overview on whether we have the strategy right for UK plc, and whether all the key players are contributing. I do not believe IACMST has worked but I do not know why. Lots of the key players are sitting around that table. Maybe that is the organisation you are talking about. I have to say that there does seem to me to be a fair amount of bureaucracy in co-ordination already. I do not think I would relish a further layer of bureaucracy.

Q169 Dr Turner: Perhaps we might be able to take some layers out. What is Cefas doing to help in promoting collaboration with the marine science community, both nationally and internationally?
Dr Horwood: Internationally, we are involved in major bodies such as ICES, the International Council for Exploration of the Sea; this is an intergovernmental body. I happen to be their President. We have seats on the council. As a body, it tends to be on the more applied side of co-ordinating research rather than blue skies, although clearly there is not a bar to that. Through ICES, we are seeking to join up at the European level. Through OSPAR, the Oslo/Paris Convention, which has responsibility for the marine environment, there are various key groups there where scientists around Europe get together to comment on the quality of the marine environment and its biodiversity. Nationally, through consultations such as that through NERC 2025, we do join and have partners, although they clearly own that process, and at present Defra and the devolved administrations are funding a specific programme to help join 2025 type activities with our fisheries laboratory type activities.

Q170 Dr Turner: Dr Bell, no one would suggest I think that we meddle around with the Met Office because it does an extremely good job. I think you can rest assured on that. Do you think that NERC is doing enough to enable researchers to get the benefit of the Met Office's facilities?
Dr Bell: I think that there is quite a good and an increasingly good working relationship between the Met Office and quite a number of NERC research institutes. We had a NCOF workshop a couple of weeks ago with 50 people present, half of them from the NERC research institutes. I think that there is

good support from the directors of the marine institutes to encourage their staff to work with us. There is good grass roots support. We have a list of 50 small collaborative projects between ourselves and the other members of NCOV, which is really helping to pull their work through into our operations.

Q171 Dr Turner: You are conscious of this issue?
Dr Bell: Yes, we are. I should say that in the climate area as well, and I have been talking about the short-range forecasting of NCOF, there is a committee for UK strategy for climate modelling. There is good collaboration between the Met Office and a number of groups in the development of the components of system modelling; for example, atmospheric chemistry, land surface modelling and carbon cycle modelling.

Q172 Dr Turner: Finally, while I am on this theme, there seems to be a player missing in this country. In the United States, the US Navy actually plays a role in marine science now. Do you think we should get the MoD to get the Navy involved here? They still have a few ships, almost as many ships as they have admirals. They could be asked to tow a few plankton monitors while they are at it and so on. Why is the Navy not involved?
Dr Hensley: May I first pick up on the NERC point? The UKHO provides data for example to the British Oceanographic Data Centre. We do provide our data into the NERC communities through that route. We also exchange data with our NATO partners. We have some work, I hesitate to call it research, for which we will contract some research establishments, such as Southampton, to help us in answering relatively short-term key questions on defence. We do have some links there. With regard to the use of naval vessels, the MoD will set the policy for defence's data collection and FLEET will be responsible for tasking vessels to collect. So if there is a wider question on whether naval vessel could and should be used, I am not the person to answer the question.
Chairman: Are you ever going to have an opinion on anything?

Q173 Dr Turner: These are the opportunities that are not being taken advantage of at present. For instance, we have Royal Navy vessels patrolling in all sorts of parts of the world for other reasons but, while they are doing that, they are not fighting most of the time and they could have a scientist on board making observations.
Dr Hensley: We receive data from the Navy in support of the requirements they have, but I cannot answer on behalf of the Royal Navy, I am afraid.

Q174 Dr Turner: Nobody listens to this. You can be as honest as you like and disagree.
Dr Hensley: I have read the transcripts.
Dr Bell: The Navy does try hard to be supportive of marine research and over the years they have provided a lot of funding for marine research. Some of that funding has dried up a bit in recent years. Robin has mentioned CAROS, the co-operative arrangements for research in ocean science. That is quite a high level group that co-ordinates this and there have been some major programmes which the MoD has supported at the National Oceanography Centre.

Q175 Chris Mole: We have seen some evidence so far about long-term monitoring in areas such as the continuous plankton recorder and the UK tidal gauge network. What sort of long-term monitoring do your agencies support and how do you share that data more widely in other issues to do with securing the funding for that on a long-term basis?
Dr Hensley: From an environmental perspective, we have a database on oceanographic observations; that would be sea water temperature, salinity and so forth. As I have alluded to earlier, those data are released into the academic environment periodically. That would be where we could contribute on that.
Dr Bell: The Met Office maintains a network of moored buoys around the UK continental shelf. It is also the leader of the UK contribution to the ARGO system, so it co-ordinates that.

Q176 Chris Mole: Is the ARGO funding secure?
Dr Bell: No.

Q177 Chris Mole: Do you think it should it be?
Dr Bell: Yes.

Q178 Chris Mole: Is it the Met Office's responsibility to ensure that is secured?
Dr Bell: No.

Q179 Chris Mole: Whose responsibility do you think it is?
Dr Bell: It is across government, so it is the government departments which have been involved in that discussion: Defra, MoD and NERC.
Dr Horwood: On the UKMMAS, they have tried to find out exactly where the UK is in terms of its national monitoring. In the report we did for them very recently, we reported 34 ongoing monitoring surveys covering radiological work, contaminant work and disease—a raft of fish stock assessment monitoring. Again, we made that available through the MDIP website. That is accessible to third parties. We also feed in to the national data storage programme through the National Data Centre and also a range of our data goes to ICES where it is amalgamated at an international level, so you have international fishery surveys and contaminant data being stored there.

Q180 Chris Mole: That is 34 ongoing. I think you hinted earlier there might be some missing. What else should you be monitoring on a long-term basis?
Dr Horwood: If you look at the review that UKMMAS did, they reckon to fulfil the aspirations of that UK monitoring strategy. They would be looking for an extra £22 million a year and they have identified those areas where they would seek to do more, possibly adding to that number.

Q181 Chris Mole: Briefly, could you?
Dr Horwood: I do feel that we do not know enough about the basic state of marine biodiversity and, more importantly, how that is responding to natural variation. The sea is used to seeing very large changes, both cyclic shifts and variability, and until we have that baseline in it will be very difficult to detect changes that we want to attribute to climate change.

Q182 Chris Mole: Dr Bell?
Dr Bell: One aspect of monitoring, which I agree fully with what Joe has just said, one other aspect which has not been mentioned so far is satellite monitoring and the UK contribution to that, which could be significantly stronger than it is.

Q183 Chris Mole: Who should be leading the demand for that?
Dr Bell: Defra have taken on the responsibility for global monitoring for environments and security.

Q184 Chris Mole: GMES.
Dr Bell: GMES, and so that is certainly one of the departments that has taken on responsibility. But there are other departments involved across British National Space Centre that would have some responsibility.

Q185 Chris Mole: We have talked about some of the sharing issues. Some of the data your produce is commercially consumed but beyond that how can the Met Office and UKHO share your scientific data with the wider research community and are there any barriers to preventing people having access to that information?
Dr Hensley: I think from our perspective, other than the barriers which would be where we hold third party data, which we are not at liberty to release from international partners, or if there are defence constraints, for reasons which will be self-evident, there are not the barriers for us releasing data as long as it is consistent with our trading fund status.

Q186 Chris Mole: Have you had a dialogue with the research community about whether there is anything that they think they might take from you that they are not currently doing?
Dr Hensley: We have spoken over some time about some issues, such as observations of the marine mammals and so on and so forth, and we have some work in progress—and I will have to clarify that—with St. Andrew's University on that, where we have put in risk mitigation work for marine mammals, for example; and on the physical side, as I say, we release data out through BODC.

Q187 Chris Mole: Dr Bell?
Dr Bell: It is quite a complex issue that you have raised about access to data and it is a very important one because we rely on data being openly exchanged in real time to do our monitoring and forecasting, so it is actually something that we do want to see progress. For research and development and for making our data available for research and development purposes we would seek to make that data available at cost basis. For other government departments' use our policy is that the data that is produced for our public task should be available to other government departments for their public task, again at an at cost basis. I think those are the principles but you have to bear in mind that there are also issues of funding in making data available; there is also a certain amount of history that things are organised in certain ways and it takes time to move towards more modern methods for data exchange. As Rob has mentioned, there are security issues as well. One of the security issues, for example, from the Met Office's point of view, is that we have to be very careful not to open up our system to hackers because if our system goes down it has very serious repercussions for the country. And that does constrain the way in which we can make data available to others. So there are constraints, apart from the principles which have become clearer recently.

Q188 Chris Mole: Dr Bell, how does the Met Office work with academic institutions in developing forecasting models? I am very much aware that those models have become increasingly complex and need bigger and bigger super computers to cope with each model.
Dr Bell: Yes.

Q189 Chris Mole: As the understanding about the interface between the sea and the sky to those models becomes increasingly important do we have the funding in place to ensure that we have the computing power to crunch those models for the next generation of modelling and forecasting?
Dr Bell: You have asked two questions.

Q190 Chris Mole: I am sorry; yes, I have.
Dr Bell: It is very important to us to take the research that is done in institutions like Proudman Oceanographic Laboratory and Plymouth Marine Laboratory and to pull those through into our system. So, for example, there is an ecosystem model which was developed by Plymouth, which we brought into our operational systems this year and there are other examples of that, and this is why this National Centre for Ocean forecasting was set up, to really recognise that there has been this collaboration going on over the last ten years, and to formalise it and to help to strengthen it. To come on to your other question about whether the computing resources are available, the computing resources to which we have access, to which the Met Office has access are not as large as the resources that are available in some other countries, for example the USA, Japan and, in our case, also France. So that is an issue; that is really quite an important issue.

Q191 Chris Mole: Who is addressing that issue?
Dr Bell: That issue is certainly being addressed by the Hadley Centre in discussions with Defra and MOD. There are also discussions with NERC as to whether we can share computer resources in the future and get better computer resources.

Q192 Chairman: That should be an issue for us really.
Dr Bell: Yes, I think that is an important issue.

Q193 Graham Stringer: Do you ever worry that as your computers get bigger and your models get more sophisticated that you are drawing more and more resources into modelling that actually does reflect as accurately as it could do what is going to happen in 10 years' time, but everybody is very happy with the model because the model is self-consistent? Is that question clear?
Dr Bell: Yes, I think I see what you are driving at. It would be very serious if that were the case but a lot of the science that is done at the Met Office is on the validation of the models and particularly for climate change because it is like a one-shot problem, that you make predictions, say, for 50 years ahead and you do not know until 50 years' time whether they are going to be right. So this issue of validation of the models and ensuring that the science is adequately captured is really at the heart of what we do. One of the ways in which we try to tackle that is that we do forecasting on an every day basis which does test the models, at least in short range, every day. Actually a lot of the errors in the climate models do show up on these sorts of short timescales so that testing of the models is very relevant and the Met Office does seek to work together with the NERC partners because we recognise that we do not have the funding on our own to do all of the necessary validation, and validation and understanding of the models is very expensive.
Chairman: Linda Gilroy.

Q194 Linda Gilroy: These are the concluding questions of the session on marine policy and a few questions to Dr Horwood before turning to the other two. What discussions has Cefas had with Defra regarding the Marine Bill White Paper and how do you expect Cefas to be affected by the proposed Marine Management Organisation?
Dr Horwood: I have a few words on this. We would not comment on our Minister's policy but from our involvement in the activities we are pleased with the Bill. We do see that it seeks to make more coherent the current fragmented management of marine activities at a time when coastal pressures are high and increasing and there is real competition for space. We think the key roles of marine planning, licensing, nature conservation and inshore fisheries are suitably and well aligned; the marine conservation zones will be a very useful new tool. The conclusion was that Cefas should not be a part of the MMO because we would be too big a tail wagging the dog but we do see in whatever form it takes that we would expect to have a very strong relationship with the MMO. At the same time it is very healthy that science is separated from policy and is transparent, so if we were in the MMO or out of the MMO I think people would clearly want to see a separation between a report, advice and subsequent action by the MMO. We are still in discussions about whether particular licensing teams should move from Cefas to an MMO.

Q195 Linda Gilroy: So licensing in relation to fisheries, in relation to . . .
Dr Horwood: No licensing very much in relation to construction and dumping and dredging activities under FEPA, the Food and Environmental Protection Act, and the Coastal Protection Act.

Q196 Linda Gilroy: Presumably that is the response you would be making to the Marine Bill consultation, which closes in early June?
Dr Horwood: As part of Defra we have not gone through the consultation, we are speaking to them directly.

Q197 Linda Gilroy: I think you have given us some indication towards how you would see Cefas' statutory functions changing in response to changing pressures on the UK marine environment, but do you want to say a few more words about that?
Dr Horwood: I think the key thing is the massive changes that are happening at the European level. Previously OSPAR Commission on the marine environment was the big organisation that we, the UK, was serving and looking after. Now we see DG Environment becoming much more interested. We have had the Water Framework Directive come in; the Marine Strategy Directive is now at a pretty advanced stage; we have the Marine Green Paper from the Commission. There will be a much greater European involvement in marine activities, so I guess we will still be serving this core activity but there will be a much greater European dimension to it.

Q198 Linda Gilroy: And the Cefas research in support of policy proposals in the Marine Bill White Paper, such as the Marine Protected Areas, do you see Cefas research and experience thus far feeding into that; and, if so, how does that fit with the position you stated just now, that it should remain outside of the Marine Management Organisation? Would that be an activity that would transfer in?
Dr Horwood: I am not sure how some of these things will pan out but at some point somebody has to decide that area X should go ahead—probably Ministers—and it may be that the MMO then has the job of implementing it. But there will be a body of advice going in to the people who make the decision in the first stage, which I guess would probably not only come from us but a larger range of views would go into any evaluation of a protected area—some scientific, some economic. We have had a strong engagement with advising on Marine Protected Areas over the last several decades, both for fisheries purposes and, for instance, in the marine Natura sites and in protecting specific sensitive habitats.

Q199 Linda Gilroy: Dr Hensley, how does UKHO support evidence-based policy making? For example, what assistance are you giving to Defra to support their marine policy making?

Dr Hensley: We have had input to Defra; we consult; they consulted with us on the Marine Bill. We are a centre of expertise for hydrographic/bathymetric data, so therefore our role would be to provide the definitive picture and what the definitive of the UK shelf would be. We are currently piloting what a data assessment centre underpinning this would be. It was a model that was proposed some time ago and we are now working through the implementation to see how it stands up. We have input into the Data Standards, for example, so we have been providing underpinning information on the quality of seabed and its structure.

Q200 Linda Gilroy: Might that make the data that you collect and the potential for collecting data more widely known to the marine science community?
Dr Hensley: We do not collect data, but we database, analyse and so on and so forth. The data that we have is either available through our website, and for non-commercial academic use it is free; or goes in a GIS framework way through Sea Zone Hyperspatial, so the data is available to the academic community certainly.
Chairman: I am going to have to finish there. I am sorry, we have run over as well, but Dr Horwood, Dr Hensley and Dr Bell thank you very much indeed for giving your evidence before us this morning.

Witnesses: **Professor Andrew J Willmott,** Director, Proudman Oceanographic Laboratory, **Professor Ed Hill,** Director, National Oceanography Centre, Southampton, and **Professor Peter Liss,** President, Challenger Society for Marine Science and University of East Anglia, gave evidence.

Q201 Chairman: I do apologise to our second panel that we have run over. We welcome Professor Ed Hill, the Director of the National Oceanography Centre, Southampton; Professor Peter Liss, President of the Challenger Society for Marine Science and from the School of Environmental Sciences at the University of East Anglia; and Professor Andrew Willmott, the Director of the Proudman Oceanographic Laboratory in Liverpool. You are very, very welcome indeed. If we can be fairly brief and fairly rapid in terms of responding to us. What we are trying to get at is what is your assessment of UK marine science, both in the universities and in the NERC research centres? What are the strengths and weaknesses? Where are we?
Professor Liss: It is a big question and of course the answer is that it is very good in some parts and not so good in other parts, and we could spend the next hour detailing those categories, and I do not think you want that. That strength lies in various places; it lies in the universities, it lies in the NERC research institutes, it relies in other research institutes and agency laboratories, and I think that is one of the questions you have been tackling as to, okay, it is all over the place, is it well-integrated, do people talk to each other, do they use the resources effectively?

Q202 Chairman: And the answer is?
Professor Liss: Again, in part yes, but we could do better. I guess what you want to do is to investigate how we could do better.

Q203 Chairman: Give me an example of where it is really good and where it is not very good?
Professor Liss: I will give you an example that is very good. From personal experience I have very good links with my own research group to NERC laboratories, particularly in Plymouth—we have joint graduate students, we do joint work, we go on cruises together—and that is an example of where it works extremely well between a NERC laboratory and a university laboratory. Where it does not work so well is, for instance, on marine data. I am presently chairing the MDIP group, which has been referred to by one of the previous people. What MDIP is attempting to do is to set a framework for the use of marine data collected in UK coastal waters and marine areas. It is a very difficult job to do because the data is collected by lots of different organisations, and the attempt is to try to get this into a common framework, common standards, recognised data centres which obey those standards and make the data, as far as is possible, available to the whole marine community in the UK and further afield. That difficult job is run by MDIP, which is a professional organisation, which I chair, but is run on an amateur funding basis because we have only 0.8 of an individual who is paid to lead that work. All the other people have day jobs, which they have to do because they are paid to do them and they put time in whenever they can to contribute to the process. I do not think that is a satisfactory way of doing business because data is extremely important, particularly when we come to the MMO and marine protected areas and licensing and all those policy issues—you have to have the data to start otherwise you make wrong decisions even if you have a perfect system.

Q204 Chairman: So it is a curate's egg really.
Professor Liss: Yes.

Q205 Chairman: Professor Willmott, would you agree with that assessment to start with, and where do you see the strengths and weaknesses?
Professor Willmott: I agree with Peter's assessment. The thing I would like to point is that in making the UK science base fit to address issues like climate change, what NERC is trying to do in its new strategy is to remove the barriers which might exist for collaboration between research centres and also between research centres and the university sector. We believe that the most effective way for dealing with issues like climate change is to ensure that we can bring the interdisciplinary teams together so that we do not have any fiscal problems with the fact that one centre has to work in a different five-year cycle

to another. So NERC has been developing a new strategy and a new funding model called FAB with the purpose of producing a more integrated community that is fit to tackle climate change issues.

Q206 Chairman: You did not even involve the universities in the design of that programme, they were not even consultees in terms of Oceans 2025, for instance.
Professor Willmott: With respect there—

Q207 Chairman: That means you do not agree!
Professor Willmott: There was a misunderstanding pedalled by others. Firstly, Oceans 2025 is about a programme which is renewing the funding for a group of laboratories, it is not a UK-wide national marine strategy. If it was that then we would have very wide consultation. It was a science review proposal, so before the proposal there was an overview document that was consulted on widely. The actual development of the research proposals, of course that is a confidential stage because those proposals are going to go out to peer review, and it is understood that the peer reviewers are receiving those in confidence. Now we have gone through that process we are again widely engaging with a variety of stakeholders, both in the university and indeed in the departments like Defra.

Q208 Chairman: All right. I have got you excited anyhow! Professor Hill, do not repeat what we have had, but basically a curate's egg in terms of marine science. Can I pull you in on this issue of coordination between our institution, our universities; is that good enough?
Professor Hill: It is never going to be good enough but it is getting better and we are, I think, on a journey towards better coordination. Despite some of the things that you have heard actually the relationship between the NERC centres and the university community are much better in this particular sector than in some other areas of environmental science, as it has to be said. This is not least because marine science is heavily dependent on massive infrastructure in order to get to the parts of the world that we need to get—ships, but access to data centres and very complex observing systems and technologies. And this can only really be done by a combination of facilities where you have a congregation of that kind of capability combined with a rather dynamic flexible environment that is typically finding universities generating new ideas, but which would be not possible to sustain them long-term without that kind of infrastructure. Where we are really heading is to try to ensure that that clarity of mission between the centres is right, so that we get the best added value as opposed to unnecessary protection.
Chairman: Okay, you have redressed the balance. Bob Spink.

Q209 Dr Spink: Could I ask each of you what the priorities are for marine research, very briefly?
Professor Hill: I can start on that. There is an interesting degree of convergence on this. If you look at the NERC emerging strategy for environmental science, if you look at the EU Framework Programmes, if you look at the strategy produced by the European Science Foundations Marine Board, if you look at the Oceans 2025 Strategic Programme you will see the same things cropping up time and time again.

Q210 Dr Spink: Which are?
Professor Hill: Climate, biodiversity, natural resources including bio resources and energy, the issue of environment and health and technologies.

Q211 Dr Spink: Coastal erosion would not feature in that?
Professor Hill: Yes, the other area is about hazards and adverse human impact.

Q212 Dr Spink: Would the biodiversity include fishing, over fishing, fishing policy? Would it include the impact on spawning grounds or the extraction of minerals, dredging for channels, which is happening in the Thames Estuary?
Professor Hill: That is certainly a key area for research. It is not one where the NERC centres and a lot of the university community have necessarily been particularly active, but there is strength in fishery research in Cefas and in the Scottish equivalent agency. The key issue that has been recognised, though, is that there needs to be a much stronger linkage between fishery science and fundamental environmental science and to get the right relationship there, and that has been the recommendation of a number of bodies. So that is somewhere we are heading.

Q213 Dr Spink: Professor Hill you have answered that very comprehensively, I suspect for all of you, so I will not go through it again unless there is anything that either of you would like to add?
Professor Willmott: If I might add that there is a recently announced bio resources programme which will link laboratories like Cefas, SEERAD and the NERC centres and the university sector, so I think that is a very exciting and promising development in the area of bio resources.
Professor Liss: I think what Ed Hill said is absolutely right, that in this day and age we are not just doing marine sciences, we are doing climate sciences, biodiversity and earth system science, and if you look at the new NERC strategy, which is for consultation at the present time—just finished, I think—those are the sort of things. I am chairing the panel on earth system science and obviously marine sciences come within that and virtually all the other panels have marine sciences. The corollary of that is that there is no centre in NERC Swindon which is called marine sciences—or at least it is hard to define; it is going much more to what are the projects we need to be doing rather than the disciplines we need to support.

Q214 Dr Spink: Professor Liss, since you have the floor, you heard us ask questions that were quite probing on IACMST; what is your view of IACMST? Do you think it is working?
Professor Liss: I am one of the three independent members of it, so in a sense, although I am a member, I take a somewhat more distant view. I think that it works probably as well as it can in its present configuration. It has the departmental representatives on it; it has three independent members and it has a secretariat which is again very small. It has done some useful tasks; it has two data groups, it has a remote sensing group which try to look at UK coordination in these matters—and I have already described the MDIP process—and those are all under IACMST and I think it would be a big loss if they did not exist. We did a review on effect of sound on marine mammals. But we can only do a certain amount. If, for instance, there is a suggestion that the UK should develop a marine strategy which, to my view, we do not have, if we wanted to have such a document—and the US is developing such a document, and you are going to the United States and you may want to look into how the document is and what does it cover, et cetera—I think IACMST is the sort of body that could do that if it had the resources. It currently does not have the resources to do a job as large as that.

Q215 Dr Spink: That is extremely constructive and helpful and we will bear in mind next week your advice. Should the IACMST's role be changed to enable it to discharge its functions and to better coordinate the marine science opportunities more effectively?
Professor Liss: I am not sure you have to change the terms of reference but you do need to get more buy-in from the stakeholders, i.e. government departments and agencies, and if it was doing more work and it had ability to do more work that buy-in would come, I think.

Q216 Chairman: It was set up in 1990 to do exactly the things you are now describing. Quite frankly, if I had had a reference from somebody, which you have just described, I would not appoint them.
Professor Liss: Fair comment.

Q217 Chairman: I think we are very serious about this issue of where is the policy coming from and where is the coordination policy, and we take the very strong comments you made about this coordination. We found that with our space science programme, that you cannot just simply look at the space without looking at the oceans and the atmosphere and the whole things put together. So we are really keen on this idea of where do we go with this organisation in order to make a really effective, dynamic, thrusting, policy-driven world class organisation?
Professor Liss: You need to do two things. You need to get greater buy-in from the stakeholders, and I am not sure how you do that.

Q218 Dr Spink: Can you name the stakeholders you think are not buying-in sufficiently?
Professor Liss: I think what we need to do is to look at the attendance. Some stakeholders are there all the time working for it and other stakeholders are not. I do not want to name names; I do not have the attendance record. Trevor Guymer, who is the Secretary, can give you this chapter and verse; I do not want to say things that might be proved slightly wrong from the data, but there are clearly people who are working very hard for it and some who are not working particularly hard.

Q219 Dr Iddon: What is the second point?
Professor Liss: The second point is it would need to be resourced properly; at the moment it is resourced at a very low level and again the Secretariat at NOC can give you the actual numbers of how much resource goes in, but it is very small.

Q220 Mr Newmark: Do you think that you get adequate funding from government for marine science?
Professor Liss: Maybe one of the directors might answer that; they are spending a lot of money, so perhaps they should answer!
Professor Hill: Are we getting enough? Certainly the science budget has increased.

Q221 Mr Newmark: Is it adequate?
Professor Hill: If you want me to put my neck on the line I would say no. What I would like to see is a times two increase in marine science funding.

Q222 Mr Newmark: Any higher bids?
Professor Willmott: We will not go into the stratosphere with any higher factors. We cannot get heavily involved with things like observatories and perhaps it is appropriate that, say, cabled observatories should be coordinated and funded at a European level rather than the national level; but I do think it is important that we are aware of these large projects, like the observatories pay. I would like a European icebreaker and I would like to see that the UK has some buy-in on those sorts of projects.
Professor Liss: Can I just comment on that because the universities are always bidding it up even higher than the institutes, for whatever reasons? I think a factor of two is about right. Why do I use that as a marker? Because I think the present success rate for responsive mode funding in NERC is less than 20%—I do not know the exact figure but it is below 20%—so only a fifth or less of the proposals, which take a lot of time to write and prepare, are actually successfully funded through the NERC. I think that is too low a number, it should be more like 40%; so that is where I get my factor of times two.

Q223 Mr Newmark: What you are saying is that NERC is not doing enough to give support?
Professor Liss: There is not enough resource. I am not saying they are not doing enough; I am just saying that the amount of money they have had means that the funding is only going to a fifth of the

proposals which are put forward. The other element of that is that it is very difficult to mount a directed programme through the NERC because they require a lot of money for the UK to contribute for international programmes and of course climate science and ocean science are done internationally these days. It is very difficult to put those large sums of money, £10 million or £20 million required for a UK reasonable contribution to one of these international programmes—that is very difficult to do with the present NERC budget.

Q224 Chairman: There is not much left after that?
Professor Liss: There is not; so I think a factor of two would be extremely helpful.

Q225 Mr Newmark: Are there barriers to obtaining funding for interdisciplinary research projects from the research councils? If so, how could these be overcome?
Professor Liss: I think that is always going to be an issue; it has been for years, things fall between the divisions between research councils. It has probably got somewhat better in the NERC because the subject specific committees have been abolished and there is now a college which picks review bodies from within a larger body of people and that should make it easier to fund interdisciplinary studies—I think there is some evidence for that, but it is not very strong.

Q226 Mr Newmark: So going in the right direction?
Professor Liss: Yes.

Q227 Chairman: If we had a single research council would it be easier?
Professor Liss: Possibly. No doubt there would be divisions within that single research council as with the National Science Foundation. I do not know if you are going there.

Q228 Chairman: We were there.
Professor Liss: They have two—they have one for medical research as well. For science and engineering they have one research council, but there are divisions within it and no doubt you can ask questions about how it works across the divisions. I suspect it would not be a lot different. There might be some economies of scale but I do not know.
Professor Hill: If I could comment on that? I think there are pros and cons for a single research council; there are probably some very significant benefits, I would have to say. The issue with marine sciences and marine affairs generally, though, is one word used about them is fragmentation, but there is another word which you can use which puts a different interpretation on it, and that is that marine science is pervasive—you find marine affairs and marine science everywhere. So it is never going to be possible just to find a neat corral of it into one single entity. So the science theme of climate have marine in it. Many issues have marine themes in them. So that is the benefit of marine science, that it is everywhere but it is also its problem, in that it loses its visibility. Within the Framework Programmes in the European Union, for example, in the early days of the Framework Programmes there was a specific marine science programme. But probably rightly the Commission went away from that into much more thematic-based science, in which case marine is in everything and its visibility is lost. One of the benefits of the Natural Environment Research Council, because it is explicitly environment, marine does have a profile in it. Whenever you create a larger entity the risk for us, I think, would be that marine would be more lost in a more general science council than it is in NERC. On the other hand, technologies are very, very important in marine science and the ability for NERC to increase its funding in technology and for us to access EPSRC funding for marine technologies is a very important issue.

Q229 Mr Newmark: Are the UK national facilities, such as our research vessel fleet adequate?
Professor Hill: I can comment as to the person who is responsible for a slice of that research vessel fleet, managing two of the NERC ships. There has been very important investment in research vessels; the Royal Research Ship, James Cook, has just completed her first cruise and embarked on her second cruise, and that was a £40m investment in a state of the art research vessel. There is funding now earmarked for the replacement of Discovery, a 40-year old vessel—

Q230 Mr Newmark: But that is not due to happen until 2011.
Professor Hill: 2011, in fact early 2012 before she comes on stream. The fact that the ship is 40 years' old tells you something about the level of capital investment that has been going on to support these ships. Meanwhile, the research vessel fleet has decreased over the last 20 years from something like five ships down to two—multi-purpose vessels, I am excluding vessels with Antarctic capability from this—and that is the bare minimum. What is also significantly missing though is the research vessel capacity for working shelf seas and coastal seas, where you do not need quite such big teams and you operate on much shorter timescales. It is very difficult to provide evidence for this but I do think that a lot of marine science is partly platform driven. If there is a ship capable of doing it you will find proposals coming in in that area, and because of the lack of capacity of ships for coastal research I think we have seen proposals for coastal science tend to dry up.

Q231 Mr Newmark: You still have not given me a solution, so what other approaches could NERC take to actually increase fieldwork capacity?
Professor Hill: It is difficult in its existing budgets but one option certainly would be to see if one could secure additional funding.

Q232 Mr Newmark: It comes down to money not re-shifting existing funds?

Professor Hill: It is two things. Part of my times two would include increasing the research vessel capacity in shelf seas. We do operate our vessels, I believe at maximum capacity, through things like international ship bartering arrangements, which is very, very effective.

Q233 Chairman: We have heard about that.
Professor Hill: We do less ship bartering within the UK where there are coastal vessels, but there are reasons for that in that the coastal vessels that Cefas and FRS have are pretty much fulltime on statutory responsibilities, and so there is not the spare capacity. So I think there is ultimately an issue about capacity here, and I suspect what could be achieved by bartering in some internal flexibility is rather marginal.

Q234 Chairman: Andrew, did you want to comment on that?
Professor Willmott: Yes. As a coastal seas research lab a great deal of our work is carried out in the Irish Sea and the UK continental shelf. We have access to a vessel called the Prince Madog, based at Menai Bridge. She is 33 metres long and she is okay as long as you do not operate off northwest Europe or the Scottish shelf or in the Celtic Sea where, quite frankly, she is not capable of operating in the inclement weather conditions there. I wondered whether there was capacity to perhaps get access to the Cefas ships, I think that would be a way forward. We are certainly missing a vessel of the size of the Challenger, which was retired in 2002—a 60 metre vessel, which can operate anywhere on the European continental shelf. We have plans with our partners in Ireland to extend our coastal observatory to become an Irish Sea observatory and that will put even greater pressure on us to find a suitable vessel to operate in that larger domain.

Q235 Dr Turner: Do you think the Navy could make any contribution through its residual fleet towards providing platforms for observation?
Professor Hill: The Navy actually does some provide some ship capacity. For example, the first survey of the Sumatran Plate Boundary after the 2004 Boxing Day earthquake was conducted by researchers at Southampton and British Geological Survey from HMS Scott and very successful it was too, so that has happened. HMS Endurance obviously works very closely with work in the southern ocean for the British Antarctic Survey. It is also the case that a lot of the ice thickness measurements made in the Arctic by the Scott Polar Research Institute and others has actually utilised Royal Navy submarines. So the scientists are accessing and using Navy vessels. They are also used as ships of opportunity; they deploy Argo floats, significantly the XBT programmes, so there is a lot of data flowing back into the operational agencies and into the scientific community that are sourced from naval vessels. Is there more that could be done? There probably is. One of the things that we have been doing, for example, is instrumenting ferries with underway sampling systems; we have also gone to container vessel operators who are really quite enthusiastic about operating underway systems like this and also probably the cruise liner business will get into this game as well. But the naval vessels are not particularly operating that. There are some security issues, of course, about giving away in near real time the position of Royal Naval vessels, but I have no doubt some of these could be overcome.

Q236 Chairman: What amazes me—and I think it was the point of Brooks' question here—we can always say, "If you give us more money we can provide more ships", but it is a matter of how do we work smarter, how do we work more coordinated. I am in and out of Killybegs in Ireland on the West Coast of Ireland very, very regularly, and all winter I have seen the fishing fleet just sat there doing nothing because they cannot fish. Yet there are all those ships available, and I am sure that applies in British waters as well. So I throw that into the pot as my idea to help you out! Do you agree?
Professor Hill: We do a lot of that also—already doing it.

Q237 Chris Mole: I wanted to start by asking about the university collaboration and data sharing with Cefas and other government research agencies and how you think that might be improved, and I know we got on to Oceans 2025 just now, but we will come back to that. Do any of you have a view on that?
Professor Liss: I think the situation is not bad for the universities. We tend to not be users of huge amounts of data; we are more engaged in shorter-term process studies, which may not use large amounts of data. I have not heard too many complaints about availability of data from the British Oceanographic Data Centre or Cefas Data Centre, et cetera. I think what the MDIP is to do will make it easier not just for universities, but everyone can get access to the data that presently exists and this phrase "measure once, use many times" is clearly an easy thing to say but rather hard to do but that is the objective.
Professor Willmott: As you know, BODC has the mission of taking raw data, calibrating it and making it freely available for a wide range of users—university based and wider than that—and I think that they have been particularly successful over the last few years in increasing the use of the data because that raw data is freely available. I think that has been critical to the success and the take-up of those data sets. I guess where we must be careful is about proliferation of data centres. I am not totally familiar with what types of data are held at Cefas; I would hope that there is not duplication of data between Cefas and BODC.
Professor Hill: I think data is an important issue. In the scientific community there is a fairly good free flow of data and the data is reasonably accessible for research and development purposes. I do think that there are some fundamental issues around data accessibility, and this is a much bigger picture internationally. Some countries operate a very different philosophy from the UK in terms of data access, which essentially all fundamental data sets

generated by public funds are free. The US has this kind of model. It is not as great as it sounds because it actually does have quite serious implications for data quality. In the UK I do think that there are some serious barriers in the system about being able to fuse certain data sets, not least because some important data—and it is not actually the data as such but the added value information products that are created from those data—are commercially tradable items. Three important sources of those data are the Ordnance Survey, the Hydrographic Office and the Met Office are trading funds and so there is a trade in their added value data products. Other bodies, such as Cefas and the British Geological Survey, whilst not trading funds are operating under increasingly commercial models whereby revenue generation is important. I am not saying that this is a massive problem in terms of accessibility to data for science, but in terms of bodies such as the MMO, who will be critically reliant on key data sets in order, and not just separate data sets, synthesised, fused, overlaid, multi-layered sets, then they will need to be able to access these, and this probably means, under the various models that we have, that there will be a cost implication of that and that the MMO will need to be suitably resources in order to purchase licences for access to this data.

Q238 Chris Mole: There are precursors for planning functions using ordnance survey, where I would imagine there are similar issues. I think we got into the Oceans 2025 important way in which the academic sector had engaged within that and it was whether any of the other two had not contributed to that and wanted to add anything.
Professor Liss: No, I think you have given a fair thrashing to the 2025 process.
Professor Hill: If I could briefly comment on that? I think it has been given a good airing and I think there have been full responses from NERC on the subject. I would say that the only reason we are having this discussion about Oceans 2025 in the Mother of Parliaments is that for the first time a bunch of marine centres got their act together to produce a coordinated programme of research in marine science that somebody had actually heard of, and I think that is quite important. So there are a lot of benefits of Oceans 2025. Are we looking to engage the university community? Absolutely, it is actually built into the programme. Do we want more people on the bandwagon? Absolutely and I am sure that will be happening over the years.
Chairman: You are a great advert for NERC!

Q239 Dr Iddon: Which countries do you slightly envy, or who is ahead of us in the marine science game?
Professor Hill: We are always envious of the United States; they have larger amounts of resources, but they also have other things beyond resources. In Europe, though, the other places that we envy are Japan, who seem to be able to invest large amounts in marine technology. Their science is probably not as strong but certainly the investments in technology and some of the technological innovations that they are capable of doing are truly phenomenal and we certainly envy their access to technology. In Europe I am increasingly looking with envy at Germany. It is investing heavily in marine sciences at the moment. Their institutes seem to be recruiting very strongly and certainly looking to my institute, amongst others, to find talented people, and we find it very difficult to extract German professors from Germany to come to the UK, not least because they are well resourced, they find it easy to access ships and the funding regime does not appear to be as competitive. Also, it appears that their governments are coming to them almost trying to push money at them as opposed to the other way around, and the Germans are really taking it very seriously. I was at a meeting in Bremen just two weeks ago, talking about the European Maritime Green Paper and the President of the Commission turned up to speak about this, as did the German Chancellor, and made a speech talking about the importance of maritime affairs and marine science, so it is very, very high profile.

Q240 Dr Iddon: We are a bit short of time as Question Time begins at 11.30. I will just ask the other two guys, do you agree with that or do you want to add anything to it?
Professor Willmott: I agree.
Professor Liss: I agree with that; Germany is our competitor now.

Q241 Dr Iddon: I have a second question relating to international activity. It is amazing, is it not, that most leading European countries signed up to the EUROCORES process—that is the deep oceans investigation—yet NERC felt that it could not do that. Any clues as to why? Was it a resource issue or similar reason? Are we not interested in the deep oceans?
Professor Liss: To give a general answer, I think there is a reluctance to designate funds to a central pot, as it were. I know that the funds for the EUROCORES are allocated nation by nation but there is a considerable control on that otherwise the process does not work and it is not then coordinated. So I think that NERC was somewhat reluctant to commit to that, particularly without a strong push from the science community, and maybe for that particular programme you talk about the science community did not push hard enough for it. NERC is responsive to communities of scientists banging on their door.

Q242 Dr Iddon: I assume, Professor Liss, that the deep oceans are of interest to you guys?
Professor Liss: Absolutely. I am a surface ocean man myself but we are certainly interested in the deep ocean and I guess that community did not make a big enough push for it or did not want it, or did not see that as a way forward.

Q243 Dr Iddon: So one of our weaknesses.
Professor Liss: Maybe, maybe not; maybe that was not the way they wished the money to be spent and wanted to spend it some other way.
Professor Hill: The centre that I run is the main UK centre for deep sea oceanography and we are pushing very hard on a number of areas where it is very, very important to get major investments. The one that we are pushing very hard at the moment is under the European Science Research Infrastructure—ESFRI Programme—and we are supporting very strongly something called EMSO, which is a cabled deep sea observatory system and we have managed to persuade NERC to sign up to the early stages of the discussions around that.

Q244 Dr Iddon: Andrew, do you have anything to add to what your colleagues have said?
Professor Willmott: No, I do not, thank you.

Q245 Graham Stringer: What incentives are there for young people to take up a career in marine science and technology? How attractive an area is it for young graduates, postgraduates?
Professor Liss: I think it is attractive on a comparative basis. I think young people see marine science as an exciting area and therefore they go into it, more so than they do the more pure sciences, if I can call it that. That does not mean that the situation is ideal because there are clearly many other careers that bright young people can go into with science degrees and which probably pay larger amounts of money or they see the prospect of larger amounts of money, so there is clearly a competition. I think marine science is probably not as badly off as some other areas of science in the UK in terms of recruitment. So the incentive is really that people get interested in it, and that is no doubt what brought us into the subject and brings young people into the subject.

Q246 Graham Stringer: Apart from the intrinsic interest of the seas, is there anything else that you can do to make it more attractive?
Professor Liss: I think a lot of people are attracted to the idea of going on research vessels and conducting measurements of the oceans, observing the oceans, going to Antarctica—these are all very big magnets for young people, as you might expect.
Professor Willmott: Things like the International Polar Year I think provide a good platform for advertising and marine science, for example, through Poles involvement in an IPY project we have the opportunity to send a student and a science teacher to go on board the Canadian icebreaker next winter, so that sort of thing helps. I think the other thing to comment on is that for many undergraduates studying mathematics, physics, they perhaps do not always realise that there are some really very attractive, exciting careers in marine science. I think there is a lack of information to those sorts of people that there is a very large demand for highly numerate graduates in our field.

Q247 Graham Stringer: Is there a skills gap within marine science and technology, in mathematics, taxtonomy and are there any other areas? And what can you do to address that?
Professor Willmott: I certainly feel that we struggle to get expert young people working in ocean modelling, finite element techniques and in certain areas of marine technology. The question then is how do we address that? The research councils do not have a strong remit to work in high schools, although we do have an understanding that we should communicate science to the public, so I guess we have to be, certainly in my centre, more effective at working with the community in raising the profile of what we do, and in doing so making it clear that there are exciting career opportunities for people with skills in engineering, physics and mathematics.

Q248 Graham Stringer: Do we have anything to learn from international comparators about attracting people into this area?
Professor Liss: I will answer a slightly different question: how do we compare with other subjects, for instance, in the UK? For instance, the meteorology community is rather more clever at this than the marine science community, in attracting people because there is a huge amateur field of people interested in meteorology and make measurements in their back gardens, et cetera, and I do not think we have quite exploited that in the marine sciences as much as meteorologists have. So perhaps there are some lessons there for us to learn.
Professor Hill: One of the key gaps is the flow of maths, physics students into our area in the more physical areas of our science. In my reading of it and talking to colleagues overseas, that is a pretty generic problem and certainly one that is faced in the US and in Europe as well. A lot of US universities are populated by students from outside the US, particularly from the Far East who are numerate in maths and physics. So that is a problem.

Q249 Graham Stringer: Professor Liss, what role does the Research Assessment Exercise play in influencing UK marine science? Does it enhance or impair it?
Professor Liss: I chaired the last Panel in Earth and Environmental Sciences and marine sciences was clearly within that, but again the subject matter is not divided in that way. Meteorology, oceanography, geology, all the environmental sciences are within that panel—and the same will happen this time round. So marine sciences have to take their chance, if you like, alongside all the other environmental sciences to try and increase their share of the pot, basically.

Q250 Dr Turner: How do you feel about the significance of the research in the Polar Regions as far as climate change and oceanographic research is concerned?
Professor Hill: As I often say, the Arctic is basically an ocean and it is a very, very important area of research, of direct relevance to Europe and the

United Kingdom—increasingly important. The signs of climate change are most rapid and going to be most pronounced in the Arctic regions.

Q251 Chairman: Why do we spend all our time in the Antarctic then?

Professor Hill: Because the Antarctic is also a very important and significant regulator of the earth's climate—both Poles. But it is true that the relative balance of our investment in Arctic research is much lower, so there is an imbalance. That does not mean we can spend less in the Antarctic because it is a very expensive place to get to and to do research, so we have to see how we can maintain the presence. There are very many significant opportunities and threats relating to the Arctic. By 2070 it may be that the Arctic is ice free in the summer months and when that happens—and of course it may well be significantly ice free much earlier than that, 2050, maybe even 2020—all sorts of things will start happening in the Arctic, driven by market forces—hydrocarbon exploration, fishing and, most importantly, trade between the Far East and Europe with bulk carriers and container ships across the Arctic Ocean. That will already be an area that is very, very stressed through the rapid climate change that has already happened—very stressed ecosystems with a lot of human intervention going on as well. It is really, really important that we understand what is going on there from the environmental point of view, but a huge part of our economy is going to be dictated by what goes on within the Arctic region.

Professor Willmott: Ed has nicely summarised the key reasons for the UK and Europe to invest more effort in understanding the climate change of the Arctic. I think within the UK we do have a considerable group of expertise, albeit spread around the country. I think we can harness the skills that we have for people who already work on the Arctic problems through responsive mode grants—we can harness those in a more effective way under a common umbrella to better address some of these really important questions relating to global change driven by the change in the Arctic. So I think there is a strong case for us over the next ten years to up our game in partnership probably with other European countries, such as Norway and countries like Canada, bordering on the Arctic, to have a more concerted effort in understanding the big changes that are going to occur globally through the rapid warming of the Arctic.

Q252 Dr Turner: What in your view is needed to give the UK the capacity that you clearly feel is needed to ramp up the efforts in the Arctic? Is it simply ships, people? What are the factors?

Professor Willmott: I think we have the intellectual base; we have the people, but I think we do not have the infrastructure to go up there and carry out programmes either in marine environment or working looking at meteorological changes. I think it is a question of, it is expensive to get up there and carry out field programmes and we do not have the capacity, certainly within the UK, to do that at the moment.

Q253 Dr Turner: How many icebreakers should we build and how much?

Professor Hill: I do not think we should do this alone; we should be doing this in partnership, and in Europe particularly. But we must build the relationships and we must build the networks to be able to work in significant partnerships with major collaborators to do it. The UK cannot go alone.

Professor Liss: And there is a European proposal to build an icebreaker vessel—Aurora Borealis, I think it is called—and that proposal has been around for some time but it has not yet led to the vessel. But we must do it Europe-wide.

Chairman: On that positive note we will end this session. Professor Ed Hill, Professor Peter Liss and Professor Andrew Willmott, thank you enormously and my apologies to all of you for the very quick countdown and for you being so cooperative.

Wednesday 13 June 2007

Members present:

Mr Phil Willis, in the Chair

Linda Gilroy
Dr Brian Iddon
Chris Mole
Dr Bob Spink
Dr Desmond Turner

Witnesses: **Mr Ian Gallett,** Executive Secretary, Society for Underwater Technology (SUT), **Dr Lesley Thompson,** Director, Research and Innovation, Engineering and Physical Sciences Research Council (EPSRC), **Dr Ralph Rayner,** Vice President, Institute of Marine Engineering, Science and Technology (IMarEST), and **Mr Richard Burt,** Member, Executive Committee, Association of Marine Scientific Industries (AMSI), gave evidence.

Chairman: Good morning to our witnesses this morning in this evidence session of the major inquiry this Committee has undertaken in investigating the oceans. We welcome this morning Mr Richard Burt, a member of the Executive Committee of the Association of Marine Scientific Industries, Mr Ian Gallett, the Executive Secretary of the Society of Underwater Technology, Dr Ralph Rayner, the Vice President of the Institute of Marine Engineering Science and Technology, and Dr Lesley Thompson, the acting Director for the Research and Innovation directorate of the Physical Sciences Research Council. Welcome to you all.
Linda Gilroy: Before you begin, Chairman, may I declare an interest. I am an honorary officer for the Society of Maritime Industries of which some of these organisations are or may be members.

Q254 Chairman: Thank you very much. I would like to start with a question to Mr Burt, Mr Gallett and Dr Rayner. The European Marine Strategy Green Paper was really quite pessimistic about the decline in maritime science and marine science generally. What is your assessment of the UK's position in marine science and technology in that sector?
Dr Rayner: Is that addressed specifically to the position in Europe?

Q255 Chairman: Both. If across Europe the Green Paper is saying that things are declining, are they declining in the UK?
Dr Rayner: I would say not declining and, at a European level, I would say that operational oceanography is now very alive and well. The moves to coordinate particularly operational oceanography in Europe are well developed and are progressing quite effectively.
Mr Gallett: I would agree with that. On the fisheries side we are probably quite strong as well. We certainly are getting support in our activities from the European Union itself with the developing across European activities and offshore fish farming, for instance.

Q256 Chairman: So, as far as the UK's position within Europe, we are very strong in maritime science.
Mr Gallett: Yes.
Mr Burt: I would totally agree. I think there has been a significant change from individual scientific programmes to coordinating programmes towards operation oceanography. As Dr Rayner says, I think that has been achieved quite well. We have to implement and take that through and I think marine science, in support of operation oceanography, is underpinning quite well.

Q257 Chairman: Mr Gallett, how would you characterise the role of the private sector funding in marine science? We are finding it difficult to get a handle on how much is spent in that area. Can the three of you enlighten us on that?
Mr Gallett: I am not particularly well placed to answer that question but I also find it very difficult to decide how it all fits together. One of the problems I have specifically is understanding the role of the agencies. When the agencies were first privatised, if I may put it that way, when they started having training funds and so forth, they moved from being government bodies which we understood and they are now stalled, in my mind, somewhere in limbo between a proper private organisation and being a government body still.

Q258 Chairman: Can you throw any light on the private sector's contribution in funding terms?
Dr Rayner: The private sector acts as a conduit in respect of linking what happens in research and operational observations to specific uses—so very much as an intermediate user of data and information to create services. It is not really directly engaged in the funding of marine scientific research; it is a recipient of the benefits of that research and the benefits of data and information that are collected from public funds and a user of that information to create secondary products. It is more a flow in the direction of creating useful and useable products for particular sectors than as a sponsor directly of research activity.

Q259 Chairman: Where are the growing trends, then, Mr Burt in this area?
Mr Burt: From the industry perspective, there are two main areas. The one to which Dr Rayner has alluded is the added-value product: once you have gathered scientific information, oceanographic data,

what you do to give added value for UK industry. But right at the front end, the initial stage, is the technology, the instrumentation that you require to gather the data in the first place. You see UK industry dividing into those two aspects. It is very important, I think, at the front end, for academic and UK government agencies to be able to link with the industry in the early days for technology pull through. In many cases industry has developed technologies that it thinks the customer needs, and that is not necessarily appropriate, or, indeed, has allied with technologies being developed in centres of excellence in the UK.

Q260 Chairman: I am sorry, are you saying the industry is developing these technologies that they think the customer wants.
Mr Burt: That is certainly one aspect and the other aspect is working alongside the centres of excellence, where technologies have been developed in the laboratories and the government institutes, and pulling those through. But the disadvantage with the current system is that, more often than not, (a) there is no mechanism to enable early engagement between industry and the centres of excellence, and (b) there are really no formal funding mechanisms to take that through. It is often a question of industry assuming it is making the right liaisons in the first place, and that is down to industry's initiative, and then hoping that it carries the right ones through to the market-place.

Q261 Chairman: Whose role is it to do that coordination? Is it industry's role? Is it the Government's role?
Mr Burt: At the moment it is happening through industry's initiative. Industry is very much looking for the Government to give better links and clarification across agencies because, more often than not, there may well be a technology in one agency that would be very applicable to use by others where commercial products are needed and that cross-agency link is certainly unclear.

Q262 Chairman: Mr Gallett, in terms of looking at the oceans, traditionally things like fishing have been the main exploitation of the oceans. Whilst you have said that fishing was in reasonably rude health—which was a comment you made earlier, as far as the UK is concerned and its competitiveness with Europe—where are the new areas of exploitation of the oceans that we are looking at?
Mr Gallett: If you are talking about industrial exploitation, I think there are several areas. The first one is oil and gas. That is a very strong area and it is one of the things that has often been neglected from a view of a marine world. Most of the UK expertise lies in sub-sea technology. We are now operating, not in the UK itself but using UK people, UK firms, UK expertise, in over 2,000 metres of water, where you are putting a well-head, effectively, on the sea floor and connecting it up which is a major task in that sort of water beds. The area that I see growing dramatically is offshore fish farming. We have recently run a conference, for instance, in Malta on that particular subject. I think it is one of the growth areas. There is agreement around the world, there is a recognition, that the world is going to be short of protein in the near future. There are no more wild fisheries or very little to exploit—in fact those are declining in general terms. The land production of protein is also maximised at the moment. One great thought there is that a lot of it will now become offshore fish farming, where you do not have a lot of problems with detritus and the other problems that are familiar with farmed salmon, for instance, in lochs and fiords.

Q263 Chairman: Do you have anything to add, Dr Rayner?
Dr Rayner: Renewable energy is probably one area that should be included. Offshore sources of renewable energy and marine sources generally.

Q264 Chairman: Is this using the ocean itself, using tidal power?
Dr Rayner: Using tidal power, using wave power, using tidal stream, using the temperature differentials in the ocean, not necessarily as a direct source of power but there are now schemes using cold water from the oceans as an aid to cooling buildings, for example. There are lots of areas which are open for exploitation.

Q265 Chairman: Mr Burt, are there new areas of exploitation of the oceans? Nobody has mentioned health, for instance. I thought that might have been an area using marine products for health and for chemicals.
Mr Burt: There are significant unknowns in the oceans which could be exploited for the health industry. It is very early days and it is really just feasibility studies at this stage.
Mr Gallett: Marine bio-technology is another area of great interest. Some of the mechanisms in the ocean are still unknown but quite a lot of them have perhaps usefulness in the bio-technology area. The main link considered in that is that the source will be the marine bodies but not in great volume. Once you have extracted what you need from it, you can then grow that in a laboratory. In terms of a large-scale resource, probably not; but in terms of new ideas for marine bio-technology, certainly.

Q266 Chairman: Are you all heavily involved, for instance, in the climate change agenda and in terms of what is happening to the deposits of carbon?
Mr Gallett: Yes, very much so.

Q267 Chairman: Is that a growing part of your business?
Mr Gallett: Yes, I think so. Dr Rayner mentioned renewable energy and I was going to mention that as well. It is the key one, I believe, but also another area of interest is the disposal of carbon into the ground through carbon capture and storage. Most of that would go under the sea—not in the sea but under the sea. That is using the same technologies that the oil and gas community has already developed for developing the UK continental shelf, for instance.

Q268 Chairman: Will we ever get the Peterhead project off the ground?
Mr Gallett: A good question, sir. I do not know. Scotland was very annoyed about that when I was up there a couple of weeks ago.

Q269 Chairman: We will leave that hanging. Dr Thompson, future demand for marine technologies. What do you see in research terms? Where is the demand going to come from and how are you going to meet it?
Dr Thompson: Energy is one area where clearly the marine environment has a big part to play, both in energy generation but also carbon storage. We see that as a really important area. Another area is the whole issue of living with environmental change and how we respond to technology to cope with the environmental changes that will come about. There are big opportunities there but also big challenges. They are really the areas we see as most important. The other area is all about transportation, marine transportation and more energy efficient transportation, which is an area where there is a lot of opportunities to improve the efficiency of transportation. Just look at carbon budgets and how transportation contributes to the carbon loading of the world, then there are big opportunities to look at more efficient marine transportation systems.

Q270 Chairman: How well placed is the UK science base and technology base to do that in research terms?
Dr Thompson: It is always very dangerous to say we are very well placed because you do not necessarily know what is happening around the rest of the world. We have some real strengths in the UK but certainly from an engineering and physical sciences viewpoints we have some concerns. One of the areas we are concerned about is the strength in renewable marine energy. While we do have some strengths, we do not think we have enough diversity in the UK, so that is an area where we have just targeted to form a new research group through the science and innovation awards, which was a funding stream we received from the last spending review settlement. There we are looking to fund three lectureships, three post docs and three students to come together to form a new critical mass centre to increase the diversity of researchers and groups that can tackle some of the challenges in marine renewables.

Q271 Chairman: Will that be a co-located group?
Dr Thompson: It will definitely be a co-located group.

Q272 Chairman: Where?
Dr Thompson: It is currently under competition. There are a number of universities that have been short-listed and we will wait to see where peer review says is the best place.

Q273 Chairman: You cannot give us a hint.
Dr Thompson: I cannot give you a hint, but there are some strong universities short-listed.

Chairman: Excellent. We will move on.

Q274 Dr Turner: 1991 saw the establishment of a committee with one of the worst acronyms I have ever come across: IACMST. What effect has this had on the coordination, organisation and funding of marine science in the UK? Has it produced?
Mr Gallett: The problem to me is that if you go back to 1984, when the Lords Select Committee looked at it and, following that, set up the Coordinating Committee of Marine Science and Technology which had a specific coordinating role, that came out and produced a strategy for marine science. On the date you gave, that ceased operating and was replaced by the Inter-Agency Committee, which had far less teeth, far less ability to coordinate. Its role was more to try to arrange for the ability to coordinate. Within its remit I think it has done extremely well but it did not enforce coordination, which the original committee was intended so to do.

Q275 Dr Turner: It lacks any teeth and it lacks any funding, so it is a talk shop.
Mr Gallett: It does more than that. It has achieved quite a bit.

Q276 Dr Turner: What would you all like to see done to improve coordination of the UK's marine science activities? Do you think the IACMST can play a role in it? What needs to be done to that body to make it effective?
Dr Rayner: I think it needs to have more capacity to effect linkages and to enforce linkages. As Ian Gallett has said, the problem at the moment is that it is representative of the different bodies in government but it has no ability to do anything other than talk about coordination as opposed to drive coordination. If I look at the parallel in the United States, in the United States the equivalent of the IACMST has considerably more ability to drive that coordinating process by virtue of having access to more funds which they can distribute.

Q277 Chairman: Which committee are you talking about?
Dr Rayner: It is called Ocean.US and it is a cross-federal agency body that represents all of the US federal agencies that are engaged in any aspect of the oceans.

Q278 Dr Turner: The issue of coordination and, if you like, the advertisement of a strategy and funding cannot be disconnected, can they?
Dr Rayner: No.

Q279 Dr Turner: If marine scientists acted as a coherent body and said, "Here are the things which you think are vitally important right now" would that increase your case for extra government funding and any other funding that you could lever with it?
Mr Burt: We have seen, with the Oceans 2025 initiative, a very good step in that direction but it was a grassroots initiative. From the perspective of IACMST, the coordination, the teeth and the funding are the key points addressed here. I would

say, across agencies, that it is very tempting to think of marine science and technology as research and technology within the Government but a cross-agency intiative very much needs to bring in the industrial link. It needs to build very clear bridges where industry can be incorporated into that because there may well be cases where industry needs to engage early in some of these programmes.

Q280 Dr Turner: I was going to Oceans 2025 because one of the criticisms that certainly the university sector will make about it is it is not inclusive. It did not include them. It clearly does not include the associated industries. Whereas in the US there is a much more cohesive organisation, it is also much more bottom-up, so that scientists' views are really coming through in terms of priorities. Do we need to do something comparable in the UK. If we did that, could we arrive at a situation where, instead having a sum of all the different parts that are going on, we had something bigger and would get more funding?
Mr Burt: Yes, I totally agree. It needs cross-collaborative engagement and it needs engagement between science and industry. You are absolutely right, an overarching clear way forward is fine, providing it is an efficient structure and just has not grown to too large a compass.

Q281 Dr Turner: What sort of form do you think this will take? We got the distinct impression that one of the reasons why things seem to be going quite well in the States is that it is not done on a top-down basis, like an agency like NASA, but it is very much based on a sort of bottom-up approach that comes together. How do you think we could achieve that in the UK? How would you form this organisation? Would you start with the IACMST and reform it and give it a more powerful remit or would you create an equivalent of a NOAA?
Mr Burt: From an industry perspective, although we know IACMST has lacked teeth, in effect, it has brought the key players together over a number of years—and I do include industry and academia in that area. I think you have the core players there engaged within that organisation, so I would say there is a first pass to look at reorganising that rather than implementing something different.

Q282 Dr Turner: So build on what you have got.
Mr Burt: But change it for what we require today.

Q283 Dr Turner: Does anyone want to add to that?
Dr Rayner: I think you can use the links to the professional societies as well, they have a strong role to play in this process. They can help to foster those linkages. One of the problems you have is that, once you start talking about funding for marine science and technology, the beneficiaries of the funding are distributed and they are each vying for their individual sources of funds. There is no collective pot, either at a UK level or indeed at the European level, so there has always been a problem with the marine sector being very diffuse.

Q284 Dr Turner: If it was cohesive, it might be able to argue for a bigger pot.
Dr Rayner: It would but who would be the recipient body for that pot?

Q285 Dr Turner: That is always the problem.
Dr Rayner: That is the problem. You can level the argument but you then have to have clarity as to the way in which those funds would be administered
Dr Thompson: I would like to make a personal comment. Always when you find units of organisation you have to find the right unit for organisation. If you go bottom-up, it has to be something where everybody feels that committing their time is giving them what they need and they get their just return. In my own mind, I am not clear whether an organisation across the whole of marine, if you are trying to do bottom-up, is appropriate, or whether it works in smaller units. An example of a smaller unit with bottom-up organisation is the flood risk management activity, where a whole range of funders and industry and academic groups come together to tackle, as consortiums, some of the issues around flood risk management. That works at a unit where everybody feels they are getting something. If you cover the whole of the marine area and then you look at some of the issues in marines that take energy, there are already other bodies that try to coordinate energy, and so you will end up with interfaces. I think the most important thing is that if you go bottom-up people feel they are making a contribution and they can see some return for their contribution. I am not sure, necessarily, across a diversity of marine, with all the interfaces that marine has, either with other technologies or with other parts of the environment, a single focus on marine would be enough to bring cohesion across the whole of industry, government departments, and the science base. In the UK, people dread—and my own organisation is as guilty of this as anyone—getting entwined in lots of discussion meetings without seeing very positive forward action.

Q286 Dr Turner: That is fair enough. We have quite enough talk shops and different funding pockets as it is. That is one of our problems. We need to do a bit of amalgamation but not necessarily forced amalgamation.
Dr Thompson: I think that is the very interesting thing, if you want to go bottom-up, how you get units that self-assemble because they feel self-interest, rather than being forced down. I think that is sometimes an uncomfortable marriage. We have some examples where we have got self-assembly of self-interested groups and we pull together a consortium of funders, a consortium of companies and of academics to work on specific areas. One area, I would say, is flood risk management. Another area is SuperGen Marine Consortium, where we have industry, NERC, EPSRC, the Environment Agency, the Department of Trade and Industry and a number of academic groups working together for common purpose and making sure that

there is a short transfer of any technology that comes out quickly to companies who will shorten the innovation cycle.

Q287 Dr Turner: SuperGen was essentially a government initiative, was it not?
Dr Thompson: SuperGen was our initiative but it has not stayed as an EPSRC initiatives, it has managed to brigade a consortium of funding partners, a consortium of industry who have come in and added their funding and, now it is on its second round, it has also added on additional academic partners to give what we need for a marine consortium in energy generation.

Q288 Chairman: Dr Rayner, did you want to come in?
Dr Rayner: I wanted to comment on the way in which funding mechanisms can engender cooperation. If I look at what is happening at a European level in terms of operational oceanography, the GMES programme in Europe and the moves towards creating a pan-European capability in operational oceanography have very much been fostered by the fact that there is a fund being administered through the Framework Programme which is bringing together all of the parties. It is the existence of the funding that caused them to come together and, having come together, they are starting to work as a coherent pan-European group (that is, industry, academia and government laboratories working in a team) which is progressively becoming more integrated, but it took the existence of the pot of funding, partial funding, to cause that to happen.

Q289 Linda Gilroy: We have begun to touch on knowledge transfer and I would like to take that a bit forward and ask you to share with us your thoughts on the mechanisms to facilitate marine technology development and their commercialisation. Are they working and how could they be improved?
Mr Burt: From a UK perspective it is quite interesting. First of all, we have to identify where the technologies are. There are many, many technologies being developed in marine science and technology centres in the UK often for extreme applications. Very few of them are what I would call commercial products or capable of being commercially exploited. From the industry perspective we have to do a number of things. We have to identify technology which we can economically evolve into a product which can then be sold commercially around the world and make money for UK industry but, also, we have to produce the products that the marine science and technology organisations do require. That is two different things. From an operational oceanographic point of view, you are looking for sensor technologies, for example, which have to last for long, long periods of time in the environment, doing a number of things with very little human interaction but always giving you good data. That is a clear link into applications for operational oceanography in climate change. But if you are looking at some of the basic research that is being undertaken in the laboratories here to pump-prime that activity, then the type of instrumentation they require is different. The first part of the jigsaw is where we have to identify technologies. From the UK perspective, from a UK company, we have to look at worldwide technologies, just not UK technologies. There may well be something applicable in the US or in Japan that is at a very early development stage which we could licence or enter into an agreement to pull through, so, although the added value is eventually there for UK industry, UK marine science, perhaps, does not benefit because it has not developed that instrumentation route. The financial mechanisms to make that happen are poor, to say the least. There are very little opportunities to get significant funding to pull through technology to the market place. There are DTI schemes, there are NERC schemes, but when we lay these alongside, for example, US schemes, then I think the UK is poorly placed. There are a number of US schemes which are geared to early innovation, fully funded schemes for small spin-out companies to bring product through to the market-place. If we sit here today and look at where the competition is against UK industry, many of our competitors are in the US and many of those have developed into companies using third-party funding, and often 100% third-party funding, to bring them to market-place with a technology and begin trading. In the UK, even if we embark upon the most generous of DTI schemes, it contributes very, very little, if anything, as you enter production and bring products to a commercial realisation, so there are significant overheads for the UK to have to recoup once it starts to sell product. If your competition has no overheads to recoup, you are immediately at a significant disadvantage. I think the funding schemes within the UK to enable technology to pull through are not as advantageous as they could be with competition. The other means of funding is through European schemes, through the framework schemes, but that then fosters collaboration. Collaboration can be good for scientific programmes, technology programmes, and ensuring appropriate technologies are brought to the market-place for that, but it is not always appropriate to collaborate with potential competitors commercially. Single-funded schemes out of a European perspective are not really there, so we have to come back again to look at the UK situation for funding, which again is at a disadvantage to overseas.

Q290 Dr Spink: But you do accept that the sort of funding that they enjoy in the United States would not be possible with EU regulations in this country.
Mr Burt: Yes. But commercially the outcome is to disadvantage us.
Dr Spink: We understand that.

Q291 Linda Gilroy: Mr Rayner, the institute has been very critical, particularly in respect of small and medium enterprises—which very often are what we are talking about, of course. In your evidence you

have said that it is not only ineffective and excessively bureaucratic but, also, it can damage existing businesses with unfair competition.
Dr Rayner: There are three separate elements here. The marine science and technology industry area is a series of small, niche markets. It is not a very large pooled market, so companies tend to specialise in a very narrow niche and what is really required for small companies is helping them to exploit that niche on a wider geographical basis and helping them to create new technologies into those global niche markets.

Q292 Linda Gilroy: Have you seen any good examples of where that happens in the UK? Are any of the science parks, for instance, developed—
Dr Rayner: There is really very little activity directed towards helping small companies to broaden their geographical market. I would go back to something that Richard Burt said about the equivalent position in the United States. In the United States, government agencies, and particularly NOAA, are quite engaged in supporting the activities of small companies in penetrating export markets. It is not surprising, because NOAA is part of the Department of Commerce, that it has a very specific commercial imperative and you will quite often see small, niche American companies being supported in promoting their products by NOAA as a government body. I cannot think of any examples of an equivalent position in the UK.

Q293 Linda Gilroy: Have you seen any evidence of that happening at regional development agency level?
Dr Rayner: Not really, no.

Q294 Linda Gilroy: Or through the science parks? I can think of some, in Plymouth, for instance, fairly modest, where the Tamar Science Park responded at the time to assist some people who lost some of their funding during the NERC streamlining. Do you have any contact with the science parks?
Dr Rayner: A little. I think the difficulty here is making it highly targeted, picking niches—and I know this is a very interventionist approach.

Q295 Linda Gilroy: The one I am thinking of was a niche area.
Dr Rayner: You pick a niche and foster it and then promote it widely internationally. It is very difficult for small companies to do that in their own right. It is very beneficial if they can be supported in doing that—and I do not necessarily mean financial support; I mean support in terms of proximity to markets and making their products and services more widely known.

Q296 Linda Gilroy: Are there ways in which you can think we need to change? Is it a NOAA type organisation or something more at that sort of regional level of economic activity?
Dr Rayner: I think it should be national rather than regional. I find it very difficult to see how it would work at a regional level when you are trying primarily to promote into export markets. That is something that really should be driven at a national level.

Q297 Linda Gilroy: I would comment on that, Chairman, before moving on, that the South West Regional Development Agency has an office in China, so a lot of the activities are happening at that level. Mr Gallett, would you like to comment on that?
Mr Gallett: It is not a main area of interest. I would only note on the regional side that there does seem to be more money available north of the border. Certainly Grampian Enterprise and Scottish Enterprise between them seem to be rather more generous in their support of small companies, particularly in the Aberdeen area with which I am quite familiar.

Q298 Linda Gilroy: Do any of you have familiarity with Wales? I have heard anecdotally that that may be true in Wales as well.
Mr Gallett: I do not have any knowledge about it.
Dr Thompson: It is clearly an area of great concern to us. If we are developing technology and the UK is not making best use of it, then that is a concern for all of us. Within the resources we have, we work very hard to make sure that, where it is appropriate, there are good contacts with companies, so certainly 40% of the research portfolio we support is collaboration with industry. It is harder for small companies to collaborate with the science base, although that does not mean it does not happen. It happens when people have made the right contacts. Increasingly, we are trying to use our own time and effort to try to make sure we go directly to companies and try to look for intermediates that give us the leverage to have those dialogues, to make companies aware of some support they can get through engagement with the science base, but it is much harder than going to talk to the universities that we have, so it takes a lot more time and a lot more resource and, increasingly, finding ways we can work together on some of those things, particularly with things like regional development agencies, is becoming very high on our agenda. We have just reorganised our own internal structures so that we have a defined point of contact with every regional development agency devolved authority and through that agency we are trying to find ways that we can jointly promote companies working in the science base, as well as doing lots of things on a national level working with the DTI.

Q299 Linda Gilroy: It sounds a bit bureaucratic and like quite hard work at the moment.
Dr Thompson: It is hard work.

Q300 Linda Gilroy: Do you agree with the comment made that more of this should be driven from the top down?
Dr Thompson: I think the regional agenda is quite an interesting one, particularly as regional development agencies are no longer looking necessarily to source the science they need from their particularly local area but because they want to

compete globally. That is a very interesting new dynamic in the UK, so we want to work to support it, but I think we are all learning as we go along at the moment. I would not claim that there is an easy mechanism but we all just have to put our shoulder to the grindstone and work at it.
Linda Gilroy: We have mentioned comparisons with the United States but are there any other international comparisons which perhaps might show the way ahead?

Q301 Chairman: Could I come in here because I am getting increasingly depressed this morning. You said in your evidence, Dr Rayner, that the Government is spending £100 million to create spin-off companies and it is ineffective. That is a very, very strong statement to make. We want to see some evidence of that.
Dr Rayner: First of all, it is not my comment. What you are seeing is a collection of comments from the membership of IMarEST.

Q302 Dr Spink: Are you withdrawing from it?
Dr Rayner: I am not withdrawing from it.

Q303 Chairman: You are the Vice President of this organisation.
Dr Rayner: I am, yes,

Q304 Chairman: So you are disassociating yourself from it.
Dr Rayner: No.

Q305 Chairman: Come on, dig the dirt.
Dr Rayner: The problem is making that funding much more targeted at some of these small niche markets and connecting it to companies, small niche companies in the UK that are active in those markets. In some cases, elements of that funding have been internalised.

Q306 Chairman: What does that mean?
Dr Rayner: I mean that it has been used to foster the creation of spin-off companies which are very closely linked to academic institutions and to government laboratories. It has not necessarily found its way to established SMEs.

Q307 Chairman: SMEs were once spin-off companies, were they not?
Dr Rayner: They were in some cases, yes, but not in the marine science and technology sector. Very few of the companies in the marine science and technology sector were spin-off companies.

Q308 Chairman: I am now confused. If we are talking about small emerging companies.
Dr Rayner: They need support.

Q309 Chairman: They need support but you are saying that if they get support the established SMEs do not get the support. Why do we want two lots of support?
Dr Rayner: We want to foster our existing SMEs in niche markets and help them to broaden their penetration of global markets. As I mentioned earlier, it is a collection of small, niche market sectors and we have in the UK a small number of SMEs active in those niche sectors. They are competing with small to medium sized companies in other parts of the world and the market that they are serving is a global market. It is very difficult for companies of that size effectively to create a position in a global market because they are very small scale. The funding should be directed, I believe, towards helping to foster that process, so creating the avenues from academic and institutional research to establish new products and then helping to link the industries, the small industries that are developing those products, to wider export markets.

Q310 Linda Gilroy: Is the support more of how to develop the business plan and marketing plan rather than on the development of the science?
Dr Rayner: Penetration of markets is where the gap is. For a large company, that is relatively straightforward because they already have the established infrastructure to achieve it. They have the local offices; they have the proximity to markets. For small businesses working in niche markets, that is not the case. For a small business to go into a new export market is a very, very significant expenditure. They certainly cannot contemplate doing this on a global scale.

Q311 Linda Gilroy: One of the things you refer to is an unfairness because of the way it works at the moment as between those that emerge from academic and government laboratory settings. What sorts of small businesses that are not supported in that way are struggling to make those leaps into their market?
Dr Rayner: I would say that most of the small businesses engaged in this area in the UK have rarely, if ever, received any support in this area.
Linda Gilroy: What kinds of things are they? I can only think of examples from my experience as a constituency MP of things that have worked and are about to work and therefore it is difficult to know what is not happening.

Q312 Chairman: You are not giving us any examples at all.
Mr Burt: Perhaps I might answer the question from a different perspective. To spin-out companies, SMEs from academia, it is but one important mechanism. The core route is technology transfer from academia to market-place. One route is spinning out SMEs. Another route is to enable that technology transfer to the existing SME base. The existing SME base, as Dr Rayner says, is very small and very niche. If you looked at marine science and technology, and I exclude oil and offshore at this stage, there is probably less than ten or 12 companies in the UK. That is as a result of 40/50 years of marine scientific research. Those companies have matured and are very well placed to identify production engineer technologies and achieve market

penetration to a degree. Certainly penetrating new markets would require assistance. If you take the other model, whereby you identify technology in an academic environment and spin out an SME with it, invariably you spin out an SME primarily based on the science engineers involved in that product. As they move across to industry, they suddenly realise they have no skills in production engineering, no skills in marketing, market penetration and all that goes with the company profile, so they would be asking for different styles of funding from that which an existing SME would. I think there are two different cases there, but the prime driver is: What is the best route for me to bring in technology to the market-place? It can go either of two ways.

Q313 Chairman: Could we hear from Dr Thompson, because this is your job.
Dr Thompson: It is our job. Certainly, as a research council, we work both with the university spin-outs but we also work with existing companies. It is hard to work with small and medium enterprises because they are trying to keep going for tomorrow but there are some really good examples of companies that still work for the science base that are not huge companies. I am not a technical expert in this area but I am trying to pull in some areas. Guidance Control System Limited, which is a company which deals with how you can moor next to an oil rig, started off from quite a small company but it still very strongly engages with the science base. When it has a problem, it goes and tries to find somebody, not necessarily somebody whom they know, but who knows somebody who can help. They have just had a recent link with Liverpool University that has really opened up new markets for them, but that is a company that is attuned and will ask questions. The real issue for the UK is how you can support people to go and do that more often—and that is time consuming. How do you support that? We are trying to use our offices to do it but clearly organisations, like all of us sitting here today, have a duty of care to try to make sure there is that natural ebb and flow of information between the science base and industry. The other thing that industry gives is some really important challenges. If you give the challenges back to researchers, they can lead to some really interesting research. It is not about a one-way flow; it is about pulling it back as well. That is how we absolutely get the ecosystem right in the UK but it does mean a concerted effort in supporting these companies. It is hard, if you are a small company, to go and spend an hour in a university. You are not going to unless you have the support from your regional development agencies, you know what a research council is and you know a way you can get help. The mechanisms are there but it is putting the energy into making sure you can get it going. Working with regional development agencies that have identified particular priority areas is probably a smarter way of going than just blitzing all the SMEs, but clearly you cannot pick off all of the areas in the UK that might need support and then do it all to all of them in one go.

Q314 Chairman: I am less depressed now. Perhaps we could move on.
Dr Thompson: I am not depressed.

Q315 Dr Iddon: Professor Thompson, considering the importance of the oceans concerning climate change, in particular, but earth systems in general, do you think the current level of funding by EPSRC for marine science is adequate?
Dr Thompson: I do not think there is any area in EPSRC's remit where I would ever answer our level of funding is adequate. Within the resources we have, we do the best we can to support high quality science and engineering within our remit and we work hard to try to increase leverage, so working with NERC and working with companies to make sure there is additional funding. Looking to the future, we are concerned that there is an opportunity for working on living with environmental change and that is part of the bid that all of the research councils will be putting into the Office of Science and Innovation for increased funding to enable us to invest more money into that area that is opening up with the development of new technology, with modelling science. Looking to the future, we think that is an important area for investment but we are halfway through the allocation of the science settlement and, until we know how that is settled, we cannot tell you whether we can afford to invest in it or not. But we think it is an important area, and it is a high priority, going forward, for increased funding across research councils.

Q316 Dr Iddon: I have some figures here for 2006–07 and for the two years after that. For the year 2008–09 it shows there is a decline in funding. Is that a temporary figure?
Dr Thompson: It is not a decline in funding. The figures you have are the figures when we submitted the evidence. Clearly for 2008–09 we are currently agreeing new grant proposals that we will fund and that will add to the number. Significant parts of that funding, something like 70%, is through responsive mode. How that will stack up as eventual expenditure, I cannot tell you, so I am much happier to say the figures you have for 2006–07 and 2007–08 are firm figures. For 2008–09 there will be additional grants agreed and additional expenditure put out. It is certainly not an intentional decline and, already, looking at things in the pipeline, I think you will see it go up to the 2007–08 level and it could increase beyond that.

Q317 Dr Iddon: I am sure the Committee is pleased to hear that but, nevertheless, at around £3 million of the £650 million total budget, approximately, it is less than half a per cent, is it not?
Dr Thompson: It is less than half a per cent. It is the money that we are investing in this area, but other priorities come in and that is our current expenditure level. Ideally we would like to be able to invest more money but we have to use taxpayers' money wisely and that is our current level of expenditure on research. In addition to that, we support training in universities and there is probably an additional £0.5

million a year going into supporting masters courses. But that is our research expenditure currently.

Q318 Dr Iddon: We have been talking about supporting innovation and technology and transferring that knowledge. Are you able to put a figure on how much you spend on that at EPSRC or is that difficult?
Dr Thompson: Given the space in which engineering and physical sciences works, separating out knowledge transfer into a separate funding pot does not do it for us, so our research expenditure includes expenditure on KT because it is embedded in everything we do. For instance, I can tell you that a significant number of the grants that make up those values already have collaboration with industry, which adds money to it, so we do not have separate funding schemes. We try to ensure that research and KT happen naturally in trying to encourage it, rather than having a separate pot of money that you access when you have decided you have to have a good KT idea, because it just does not work like that in engineering and physical sciences space. A project was recently approved at Southampton University looking at sensors in partnership with NERC that will go out into the marine environment and sample the water but also sample the marine biological population. That already has three companies working on that project, so we hope that will shorten the innovation circle because they are there watching over the shoulders of the academics. As soon as they see something that they can go and take value and make a new product from, they will be in there exploiting it. That is how we prefer to see it happen.

Q319 Dr Iddon: By the nature of the marine environment quite a lot of the research you have to fund is applied in nature.
Dr Thompson: Yes.

Q320 Dr Iddon: How do you determine the balance between the pure research and the applied research?
Dr Thompson: We do not ever determine that balance in that way. The way we manage our funding levels is that we divide up engineering and physical sciences into a number of technical programmes (so physics, mathematical science, engineering) and the council every year decides a budget that it wants to invest in each of those technical areas. Then, given that 70 per cent of the portfolio is responsive, it depends on the ideas coming in from the academic community that pass quality peer review that we can then afford to fund. So we do not determine it in the way you are suggesting.

Q321 Dr Iddon: It has become very obvious to us that quite a considerable amount of marine science is database collecting. It is absolutely essential to learn about all the earth system.
Dr Thompson: Yes.

Q322 Dr Iddon: Is there a case, because of that, do you think for the EPSRC to put more money into core funding to support those kinds of programmes?
Dr Thompson: With respect, understanding the earth systems is very much the remit of NERC but we have worked with NERC on some areas that would help with that, so the whole E-science programme, which was about how you shared information, how you mined data, was a joint activity with a very strong interaction between EPSRC and NERC. But collecting data to understand earth systems is very firmly footprinted in NERC.

Q323 Dr Iddon: That was just an example.
Dr Thompson: Yes. Clearly we have a very big programme in information and communications technology and a lot of the people that are engaged in that research have strong connections to people in other research environments. This recent project we funded at Southampton comes out of electronic engineering but it is to be able to measure things in the marine environment. That is a joint venture and joint funding between EPSRC and NERC. We provide the underlying knowledge base to do smart information collecting and researching and things, but colleting data from the marine environment when it is to understand earth systems is very much NERC. I would have to look at specific projects. It is very difficult to generalise this discussion—and I am not trying to be obtuse.

Q324 Dr Iddon: You have mentioned NERC but of course some of your programmes are collaborative with BBSRC and of course the Office of Science and Innovation are also important in all of this.
Dr Thompson: Yes.

Q325 Dr Iddon: And many of the marine science programmes are interdisciplinary in nature. How often do you come together with OSI and research councils to discuss future programmes in marine science?
Dr Thompson: I am a member of the Research Directors Group which meets every month. That is all the research directors from all the research councils. The best part of the job we do then is talking about new science opportunities. It is not talking about worrying about small things. We do that monthly and we look at new science opportunities. Clearly, in the run-up to a comprehensive spending review, we have been working very closely together to identify the clearest opportunities for the UK both in terms of scientific excellence but also in terms of ensuring we are tightly linked into better exploitation opportunities to put forward the programme of joint research activities. Energy is clearly a high priority across all councils. Living with environmental change, a high priority. The digital economy, a high priority—because if you just look at how the whole world is changing by the revolution in ICT, we clearly have to make sure that is closely coupled to the economy. Nano-technology are the other example and ageing and healthy living.

They are five examples of where we think it is important to have a large thematic programme. Clearly research opportunities come up all the time from one-to-one dialogues with researchers and so making sure that researchers can come in and can receive a level playing field, whether they are working in core physics or at the interface with BBSRC or another research council, is critically important to us. I spent five years of my life working as EPSRC developed its life-science interface, which was about making sure there was not a gap but wherever possible there were funding overlaps, and understanding where the gaps were and how we might address that to make sure the environment was right for science in the UK. It is second nature now to work with other research councils because the problems of the world do not neatly fit into our administrative structures.

Q326 Dr Iddon: Are you aware that some of the academics make a criticism that where they are doing this kind of interdisciplinary work, sometimes they find it difficult to make the grant applications. They make them for BBSRC and they bounce back and feel that is a NERC opportunity. What are we going to do about that?

Dr Thompson: One of the problems we suffer is people remember past experiences much more strongly than the current situation. If somebody has been bounced between two research councils in the past, they will have a much stronger belief set about that than they will about the current funding environment. For a number of years now, and it was renewed last year, there is a funding agreement across all the research councils which clearly articulates, if you have a research idea across any research council's remit or across two or more, how we will handle those proposals. For EPSRC I watch what happens to cross-council proposals very, very carefully because I think it is important that the UK community does not suffer if it works at an interface. Colleagues in the same position as me in the other research councils do likewise. I think the situation has got much better but clearly we have to be ever vigilant. The other issue we have to then address is the attitude of peer reviewers, because every penny that we invest is invested through peer review judgments and there is nothing worse than somebody who peer reviews, when they write a proposal, being this very broad-minded person, who becomes this very narrow-minded person when they review it who says—and I have to be careful what I say—"This is not good chemistry, so I am going to dismiss it." Encouraging people to be open-minded in the peer review process as well as us making sure we try to provide a level playing field is an absolutely critical thing, going forward.

Q327 Chris Mole: When the Committee visited some businesses in the marine engineering field in the States it was very clear that there was significant US navy funding. What is the role of the RN in funding engineering and science in this area?

Mr Gallett: Obviously the MOD would be funding rather than the Royal Navy itself. When you go to the States it is very striking how much the US Navy is involved at the ground level. From my own experience of the Navy, which is now ten years out of date, we were never quite so close to that. I did work in MOD at times and we worked quite hard to get areas we thought were beneficial to the RN to get those research activities funded but my own experience at the moment is that there is not that much funding around for the sort of things the Navy would probably like.

Q328 Chris Mole: Do they deal with the work themselves if they need it done?

Mr Gallett: Or it just does not get done. As I say, my knowledge of this is somewhat outdated now, I am afraid.

Mr Burt: I do work with the Navy on oceanographic aspects. Certainly the Navy procure oceanographic systems and marine science systems for their own target area of environmental knowledge rather than doing marine science. A few years ago, certainly, there was more marine science and technology undertaken by the MOD and placed with small and medium sized enterprises externally. That really has stopped now. Most of the contractual work that appears from the MOD relating to marine science and technology is in support of environmental mitigation: acoustics and mammals and things like that, and very little is done in what I would call the science of instrumentation for example. If you put acoustics to one side, which is very much a Navy remit, then there is very, very little done outside. Certainly companies I am aware of in the past had a lot more work from that aspect of the Navy than they do now. In fact, we see more innovation for instrumentation, for example, coming out of areas of homeland security than we do from the MOD.[1]

Mr Gallett: Perhaps I could add one more thing. One of the areas in which I am concerned at the moment is autonomous underwater vehicles. These are underwater robots. One of their roles will be to measure the oceans but they are also being used now by all companies to do pipeline survey and do the survey beforehand. From the military point of view, they have a great interest in that for mine clearance and mine hunting. Lots of the funding for that, as far as I can see, has dropped dramatically off over the last few years. Certainly QinetiQ did have quite a bit of funding going through and there is quite an operation still at Bincleaves but some of the activities in which I was engaged through the SUT, my society, have fallen away dramatically and it seems to be from lack of funding.

Dr Thompson: We do not have any direct funding that I can see on our research grant portfolio with the Navy but we do have joint funding with the Defence Procurement Agency.

[1] *Footnote by the Witness:* The MOD has established, through the Research Acquisition Organisation, the "Sensors Tower of Excellence". This serves as an excellent, efficient brokerage forum to match the MOD "Capability Shortfall" in in-water sensors to industry capability.

Q329 Chairman: Could I pick up on Mr Gallett's comment about autonomous underwater vehicles and ask you, Dr Thompson, whilst we understand response mode funding—and thank you very much for your comments about the peer review going across interdisciplinary projects which I thought that was a very useful comment to make—do you ever at any time drive the technology? When we were at MIT we saw superb examples of technologies coming together and being driven, if you like, by research which are not only spin-offs but procurement in private sector companies as part and parcel of really quite sophisticated autonomous underwater vehicles. What do you do in that area, rather than waiting for things to come to you?
Dr Thompson: In areas where we think there is a gap in the portfolio or opportunity, where they are not coming in in the volume or in the type of proposal that we like, we take intervention action.

Q330 Chairman: Could you give me some examples?
Dr Thompson: Four years ago we decided that the whole area of wired and wireless sensor systems was an area where the UK had strengths but we were not pulling those strengths together. We have now invested £16 million in funding large, collaborative projects in partnership with industry in the whole area of wired and wireless network systems, of which some in the marine environment could have come in but did not. We then identified there was a gap. We thought there was a need to stimulate more research more in autonomous systems in the UK, so we issued a call to try to establish an interdisciplinary research consortia in autonomous systems. Unfortunately, when the proposal came forward through peer review it was deemed of not satisfactory quality to be funded, so we took the judgment not to fund it, but now we are working on additional ways and other approaches we can take to try to stimulate more research in autonomous systems in the UK. That is working very closely with defence, because there is already a Defence Technology Centre set up in autonomous systems. We really wanted to put to the two together, so they were complementary, to add even more capability in the UK rather than competing with each other. Unfortunately that one was not funded but I am more comfortable with wanting to take an intervention, deciding the quality is not sufficient and not funding it than funding second-rate research because the competition on our funds is too great.

Q331 Chris Mole: Could I ask all of you what you think the skill shortages are in the marine science and technology sector. What are your concerns for the impact of this, going forward?
Mr Gallett: From the oil and gas industry's perspective there is a huge skill shortage worldwide, not just in the UK. Certainly in all the developments that are happening around the world—bearing in mind this is very much a global industry, it is not just specifically to the UK—there is a crying shortage for skilled engineers.
Mr Burt: From an oceanographic SME Perspective, when you look at the companies that we have been discussing this morning, this dozen or so marine science and technology companies, very, very few are employers of what I would call marine science graduates. If you look at the type of products and instrumentation that people develop, then the requirement is for electronic engineers, software, embedded software, display software programmers and design engineers. Certainly, if you move towards the added-value product side, in terms of data and data display and added-value products, then there will be more of a call for marine science oceanographers in that role.
Dr Thompson: I think there is an area where we did identify a skills shortage in the UK and that was marine energy. That is an area where we tried to take intervention action. We continue to monitor the portfolio. We have a general concern at the number of kids that want to come in and do engineering and physical sciences and that naturally has a consequent knock-on to the people that the UK will be producing in the future. That is a much bigger issue for this Committee here today.

Q332 Chris Mole: Does EPSRC have a specific dialogue with the industry marine sector about the health and future needs of the marine science sector?
Dr Thompson: We spend a lot of time talking to lots of people about skills requirements. It is one of the hardest areas in which to identify needs, so even my own organisation could not tell you the sorts of people we are likely to want to employ in ten years time. Because the market we are in is PhD, whilst there is a PhD training, trying to get companies to give you their needs is very hard. They can identify specific skill shortages and we work on that to try to address that. We have a whole programme of industrially relevant PhD training called the engineering doctorate. We are looking at refreshing the engineering doctorate and clearly part of the dialogue is with industry as to their shortage areas. If we identify shortage areas, we will focus on those areas, but quite a lot of our training is given to universities to try to identify where they have shortages. Certainly we have a number of universities which are running masters courses in marine technology areas in response to employers coming along and saying, "We need masters training in *x, y* or *z*. There are five courses running currently. In Southampton there is one in coastal engineering for climate change which is looking forward. In Newcastle there is a masters' course for marine technology. There are people being trained. Whether they are sufficient and of the right volume is a problem we worry about all the time.
Mr Gallett: A lot of the students undertaking courses do not come from the UK. They are very much worldwide. If you look at the Cranfield course, which is a pure masters' course, there are at least five French students on the current course of about 25 people, and about another five Nigerians.

Q333 Chris Mole: Do other members of the panel think the IACMST is well placed to examine future needs of the skills base for marine science and technology?
Dr Rayner: It has not historically had a strong role in looking at skills requirements. I think you would have to find a way of more actively engaging industry if you were going to go down that route. Yes, if you could create that structure, it would be a good place to start.

Q334 Chris Mole: Is there not a risk that the industry is just sitting around twiddling its thumbs complaining that nobody is turning up?
Dr Rayner: I do not think the industry is doing that at all. I think the industries in this sector are actively seeking to recruit anywhere they can and often outside of the UK, in countries that are generating the skill base in engineering, with numerate scientists, because they have to. They have to fill those positions. But there certainly is not a body that is looking specifically at that issue for the marine science area.
Mr Gallett: Or in the engineering area. The other thing I would say about IACMST is they have certainly funded my society in the past to provide a careers pamphlet for children. We have had that quite a long time and we have kept it going. We run quite a large scale careers thing for people in marine science and technology engineering.

Q335 Chris Mole: Is there a case for teaching more about marine science in what I think we all recognise is a very crowded curriculum already?
Dr Rayner: Yes. It does not receive much attention in the curriculum, certainly not as a science, so there is little awareness amongst school children about the sector. I would very much like to see that position changed. I think there needs to be much stronger awareness of the issues surrounding climate change and the critical role of the oceans in the climate.

Q336 Dr Spink: Following on from what you have said, Dr Rayner, given the public perception of the importance of the oceans in driving climate change, do you think EPSRC's priority, by putting one half of a per cent of their budget in that area, is a problem? Do you think they should readdress their prioritisation?
Dr Rayner: I do not think it is the role of the EPSRC that needs to be looked at here. Indeed, I think one of the issues here is not primarily a research issue; it is more of an operational issue. In one of the earlier comments, a distinction was made between pure and applied research. There is a further area in oceanography and marine science that I think is critically important that is not being addressed and should not be addressed necessarily by the research councils and that is the whole area of operational observations. How do you observe the oceans on a sufficient scale and density to address some of the questions?

Q337 Chairman: If it is not the research councils doing that, who should be doing it?
Dr Rayner: That is the difficulty. It is not clear where that role should lie.

Q338 Chairman: Who do you think it should lie with?
Dr Rayner: It possibly could lie with an existing operational body like the Met Office. To some extent, the Met Office already does occupy, in part, that role. I would go so far as to say those sorts of observations are so critical to understanding climate change that they should be regarded more as critical infrastructure in which nationally and globally we need to engage in effectively. Perhaps we do need a new body, perhaps at a European level, to engage in that whole area.

Q339 Dr Spink: That leads me neatly into datasets observation. Of course they are important not just for climate change but for fish stock management and the commercial exploitation of minerals and so on and so forth. I am coming on to datasets. The Oceans 2025 mission statement reveals that we face three closely related challenges. They say that the first is to know the rules of ocean behaviour. The second is to be aware of what is happening: we need to keep track of the many changes that are already occurring. The third is basically to find knowledge-based solutions based on the first two, which are the datasets. That establishes, I hope, the importance of the global datasets, not just for this country, of course, but for the world. First of all, which are the most important gaps in our knowledge of the oceans on which we are trying to establish data?
Mr Burt: The gaps really are going to be twofold. One is the long-term datasets for climate change and certainly the gaps in specific parameters are going to be geographically dependent. In some areas certain parameters will be more important than others. The second aspect is the technology that can enable you to fill those gaps.

Q340 Dr Spink: Which are the geographical areas where you think there are gaps at the moment?
Mr Burt: For example, if you are making deep ocean measurements for long-term climate change monitoring, there are going to be different types of measurements you would make, for example, in coasts and regional cities. There has been a significant targeting at the moment for the deep ocean programmes, the TOGA programme, the ARGO programmes, which are building upon long-term datasets, which is good. Certainly there are gaps in biological oceanography. There is a lot of emphasis on physical oceanographic datasets, which are very, very important, but, once those are becoming established, how the biology varies upon that is very, very important and that clearly leads to two areas. One is CO_2 uptake—which everybody is very keen to look at these days—and resulting ocean certification. Both of those are very early in their stages of knowledge.
Mr Gallett: I think there are two issues here. One is gaps in types of observation, so areas where, perhaps, sensor technology is not capable of making observations we would like to make, and then there

is the issue of lack of continuity in routine observations. I think oceanography is going through a fundamental transition with the science at the moment, in that operational oceanography is a relatively new activity and there are huge problems with continuity of observations. Most observations in the oceans have their origin in research projects and research projects are generally short lived, so we get snapshots of the way the ocean behaves from a particular perspective and then that snapshot may cease. I see the biggest problem here is how do you ensure that certain key observations are made continuously and made consistently. This is not research. It may underpin research but it is not research. It is a fundamentally different activity and it needs to be managed and operated in a different way. At the moment in the UK, and I would say at an international level also, the mechanisms properly to underpin the funding of those regular routine observations are not well established and so what tends to happen is that we have a stop-go sort of situation. We will have some observation capability in place, whether it is space based or in situ within the oceans, and then that observational base will suddenly reach the end of its life and there has been no attention paid to proper continuity. Clearly, if we do not get the basic long-term observation correctly undertaken we will not be able to understand properly the way in which the oceans drive climate. That is one half of the equation. The other half, as Richard has said, is that there are gaps in terms of the types of observation that we are able to make and they are embedded in the research area because there are some things we would like to be able to observe routinely that we cannot observe routinely at the moment because the technologies to do so are not sufficiently developed. There are two different areas here that I think need to be addressed. One is bringing up to speed the technologies that are needed to fill gaps in the types of parameters that are being measured. The other is creating mechanisms at a national and a global level which properly ensure the continuity of routine observation of the oceans.

Mr Gallett: One of the other things that we do suffer from is that we have packets of data scattered around the place. Quite often they are not being joined up, they are not being utilised. The MOD has quite a lot of data that it is very unhappy to release because perhaps it might reveal operational activities of vessels. I do not know to what extent in recent times those have been looked at again but there is an awful lot of data being held by the MOD through their hydrographic office in areas which probably other people have not been working on. There are other packets around in some of the other research places as well that have not been brought into the fold.

Q341 Dr Spink: Added to the problem of inadequate funding and technical knowledge and a lack of coordination, you would say, is protectionism—probably for fairly sound security reasons.

Mr Gallett: Yes.

Q342 Dr Spink: What do you think is the significance of the Global Ocean Observing System?

Mr Burt: From a scientific point of view, it is very well proven, and I think its significance is very clear. Also there are two other key aspects. It is global, so that it does act as an overarching coordinating activity for marine science and technology, but, also, from a commercial aspect for companies that will participate in it. Again, that is companies from developing technologies to giving added value to data products. There is one interesting aspect of the Global Ocean Observing System which is yet to be addressed. We have alluded to that today. That is the significant change in the technologies that are needed to achieve the data products that you require. If you were to look around at worldwide technologies, instrumentation products that are being used for Global Ocean Observing Systems, they all invariably have their roots in scientific programmes. A simple instrument for measuring temperature in the oceans, salinity in the oceans, all have their roots in scientific programmes, where a scientist may take some equipment to sea and make a measurement. Very few, if any, are designed for what we would call long-term operational deployments. At the moment you have a very large number of observing systems using scientific equipment and then a significant part of their budget, for example, would go towards maintaining that system. It is a little bit like having a very, very expensive racing car you want to use a few days a week. It is so expensive to maintain. Whereas the technology input required is to develop instrumentation and technologies that will last for many months or years in the ocean environment and report good data continuously. That may be seen as a very good topic for research, but if you then sit and think about how many different oceanographic regimes there are around the world, all inputting to a Global Ocean Observing System, it gives you an idea of the size of the project. For example, if you wish to measure a given parameter in the Thames Estuary or in the Solent, you may use a totally different technology for the same parameter from that you would use in the Arctic or in the surf zone or in the middle of the Pacific. There is a huge opportunity for assessing the types of different technologies that you require and applying those to the most suitable regime, even though at the end of the day they are all giving you the same information: the temperature is *X*. There is a significant opportunity and it is an opportunity that is not being addressed at all[2]. The European aspect of the Global Ocean Observing System, EuroGOOS, has identified this many years ago as a technology gap that is required to be filled and it has looked, within the European context, at where it can obtain this information. It cannot fund initiatives but it can identify and act was a catalyst to try to get things

[2] *Footnote by the Witness:* In the USA, NOAA has established the Alliance for Coastal Technologies to specifically address the technology requirements for long term marine measurements in the coastal zone.

done. Certainly up to this stage, it has not been successful in doing that. Many, many workshops and discussions that I have been directly involved in have tried to achieve this technology gap in trying to fill it but at the moment the consensus is still that we continue to use scientific instruments and maybe adapt, whereas in the long term adapting is too expensive. You need to design again from the grassroots.

Q343 Dr Spink: We saw in the United States a couple of weeks ago instruments that were dropped in the ocean and left there to operate over a number of years, a decade perhaps, that bob up from time to time, release their data and go back down. Is that technology not shared around the world for everyone to use?
Mr Burt: It is a well known programme. All the technology requirement came out of the US and the technology development to meet that came out of the US as well.

Q344 Dr Spink: Hence your earlier comment about the US being more effective in start-up, seed corn funding.
Mr Burt: Absolutely. The US did provide full funding for the manufacturers of the sensor technologies on those particular buoys, to produce instruments which are designed for that use. Certainly at the time of requirements for sensors on those buoys, the American pull-through of technology was far better than it was over here. We had full visibility of it but it was not economic to pull it through.

Q345 Dr Spink: Do you think the UK's participation in the GOOS project and its long-term viability are sound and becoming more secure as we get more political understanding of the need for these datasets or do you think they are at risk in any way because of short-termism?
Dr Rayner: Clearly, the Global Ocean Observing System is an absolutely critical component of the overall earth observation system and there is a well-formulated plan for how the Global Ocean Observing System should be created. Necessarily and by definition it is a global endeavour but it relies on effective participation of individual nations to perform a routine programme of observations. The UK's participation is not particularly strong. There have been several recent instances, in fact, where the UK has reduced its level of participation. You mentioned the ARGO programme specifically in your earlier comments.

Q346 Dr Spink: In fact there are some people in the industry who believe the UK should double its financial participation in this project.
Dr Rayner: And should engage perhaps at a different level.

Q347 Dr Spink: Would you explain that.
Dr Rayner: At the moment the representation to the Global Ocean Observing System is through IACMST and it is funded through the research councils. I would argue again that it is not a research council function. It is so fundamental to our understanding and routine monitoring of the planet that it should receive much more attention and perhaps be elevated to a different position.

Q348 Dr Spink: An operational department like the Met Office or something.
Dr Rayner: Yes.

Q349 Chris Mole: Who should operate that?
Dr Rayner: At the moment the only organisation I think in the UK is positioned to do that is the UK Met Office. But of course it is not funded to do so.

Q350 Dr Spink: What part has the Marine Climate Change Partnership had to play in addressing the gaps in our scientific knowledge of the oceans?
Mr Burt: In terms of our scientific gaps, I do not know, but, in terms of technology applied to it, I am not aware that we have had any pull-through yet.
Chairman: Is that across the board? Yes. Okay.

Q351 Dr Turner: I would like to ask some brief questions about international collaboration and organisation. There are many international and European organisations involved in the governance of the oceans. Do you feel, Dr Rayner, that the UK is adequately represented at the international level in UNESCO and the other bodies like the IOOC and the International Maritime Organisation?
Dr Rayner: It is certainly represented. I would ask the question of how the position of the UK is determined in some of these bodies. Who briefs representatives? How do they decide what position is taken when they attend those sorts of fora?

Q352 Dr Turner: In other words, should our representation be more forceful?
Dr Rayner: I would say yes, it should be.

Q353 Dr Turner: What impact do you think better representation or more effective representation could have on our own marine science and policy development?
Dr Rayner: It would be more informed by what is going on in other countries and what is going on at a global level.

Q354 Dr Turner: How serious a deficiency do you think this is?
Dr Rayner: I would say it is a relatively serious problem. It is very difficult to understand or even to see if there is a process for how UK position is determined in those bodies.

Q355 Dr Turner: Do you all feel this to any degree?
Mr Gallett: It is outside my field.
Dr Thompson: It is outside mine.
Mr Burt: I would agree totally.

Q356 Dr Turner: There is a European Marine Strategy Green Paper, what impact is that going to have on the UK?

Dr Rayner: If it forms the basis for the Maritime Directive it will have quite a specific impact on the UK, in that the UK will have to enact legislation appropriate to that Directive. Formulated in the right way, it will create some coherence and it will raise this whole issue to a higher level.

Q357 Dr Turner: It is a reasonable expectation that a Green Paper will lead to a Directive. Do you feel that the Green Paper as published is good or bad for us?
Dr Rayner: I think it is good for us.

Q358 Dr Turner: If the Directive follows that, you will be quite happy.
Dr Rayner: Because I think it will create a focus for the maritime sector which is currently lacking.

Q359 Dr Turner: Could I ask you all finally to comment on how well the UK collaborates internationally with the development of marine technologies?
Mr Burt: Let me try to answer that with two examples. One is the well-known European framework programme which, by its necessity, forces collaboration or otherwise you do not participate. Certainly in previous years there has been a significant dip in what I would call SME participation. It was very, very positive and then, as the funding mechanisms became less attractive, fewer and fewer SMEs participated. In the current round now, framework 7, it is a lot better. It is early stages but there is more funding for SMEs at a greater percentage level, which is good, and also there is a stronger role that SMEs are expected to perform within the projects so there is less opportunity to undertake research for research's sake. With collaboration, you have to outline explicitly how your technology pull-through will happen. I think that is good. The second example is if we look across the water—dare I say again—to the United States, to look at what is happening there. There are opportunities for UK companies to license technologies from the US and to develop those—again, coming back to our funding models, perhaps at our expense—then launching them on to the US market. I think UK companies do as good a job, if not a better job, at technology pull-through than US companies. Whereas US companies have more opportunity, I think we can do a better job, but it is beholden on the individual companies to go over to find the perfect technologies and bring them back.

Q360 Dr Turner: Do you have any shining examples to show how this has been operating or could operate?
Mr Burt: Yes. I have a very good example. Our particular company has licensed the technology that came out originally from the Brookhaven Laboratory. That was assessed by a number of our US competitors, who deemed that it was too difficult to procure and to bring to market-place. Through our links with the UK laboratories, they identified us as a candidate company, we went over there about five years ago, licensed the technology, brought it over here using our money and, I would say, some DTI money at that stage, managed to bring a product to market-place which is still a world leader and the second generation is about to appear. We are quite happy to enter into royalty agreements and commercial exploitation agreements.

Q361 Chairman: What is the name of that product?
Mr Burt: That particular product is known as FASTtracka.

Q362 Dr Turner: What does that do?
Mr Burt: It is a fast repetition rate fluorimeter for monitoring the photosynthetic reaction of chlorophyll in the water.
Chairman: I thought it was!

Q363 Dr Turner: Being a scientist, you knew instinctively! It can be done but it clearly there was more that could be done.
Mr Burt: Yes, and the initiative rests with the company.

Q364 Dr Turner: It also sounds, from what you are saying, that there are less licensing opportunities arising out of British laboratories than from the US. Is that a fair comment?
Mr Burt: There are an awful lot of opportunities both sides. You certainly see more opportunities of products appearing out of US laboratories now and coming on the market-place than you are in the UK.

Q365 Dr Turner: Is that a function of the scale of US laboratory operations or a difference in approach?
Mr Burt: It is a difference in approach. As I am sure you can imagine, there are many, many technologies being developed which are great for scientific purposes but not suitable for commercial exploitation. The market is not big enough and what have you. Certainly in the US some organisations . . . For example, if you look at Monterey Bay Aquarium Research, where the funding is not government at all really—it comes straight out of the Hewlett Packard Foundation and they can spend their money on all sorts of prosaic things where it does not have to be part of a long-term programme—that lab is probably responsible for spawning four, five, six technologies which have appeared on to the market-place in as many years and has achieved significant revenue for those companies.

Q366 Dr Turner: Do you think there will be an advantage to UK plc to mimic these approaches?
Mr Burt: Commercially, I think we either have to mimic or better the approach. We do not want to be disadvantaged.

Q367 Chairman: Thank you very much. Could I ask you for, literally, a one-word answer. In terms of organisation of marine science and its interface with commercial operations, do you feel the equivalent of a NOAA in the UK would be an advantage?

Dr Rayner: Yes.
Mr Burt: Yes.
Mr Gallett: Yes.
Dr Thompson: I am not qualified to comment.
Chairman: On that note, could I thank Richard Burt, Ian Gallett, Ralph Rayner and Lesley Thompson. Thank you very much indeed.

Wednesday 4 July 2007

Members present:

Mr Phil Willis, in the Chair

Dr Evan Harris
Dr Brian Iddon
Chris Mole
Bob Spink
Dr Desmond Turner

Witnesses: **Dr Sharon Thompson,** Senior Marine Policy Officer, Royal Society for the Protection of Birds; **Dr Malcolm Vincent,** Director of Science, Joint Nature Conservation Committee, **Professor Ian Boyd,** Sea Mammal Research Unit, University of St Andrews; and **Dr Tom Tew,** Chief Scientist, Natural England, gave evidence.

Q368 Chairman: Good morning and I first of all apologise to our witnesses for a slightly late start this morning; we have been somewhat flexed by the changes in the Government's structure and we needed to have a discussion about that. This is not quite the last of our oral evidence sessions on investigating the oceans because we have the Minister and NERC to come but it has been a fascinating subject. We welcome four very distinguished scientists to start with on the first panel: Dr Sharon Thompson, the Senior Marine Policy Officer for the Royal Society for the Protection of Birds, Dr Malcolm Vincent, the Director of Science at the Joint Nature Conservation Committee, Professor Ian Boyd from the Sea Mammal Research Unit at the University of St Andrews and last but by no means least Dr Tom Tew, the Chief Scientist for Natural England. Dr Tew, I ask that you chair your panel and you can deflect questions if you cannot answer them.
Dr Tew: I can certainly try.

Q369 Chairman: I will begin with you, Dr Tew, and ask you, why do we know so little about the biodiversity of the oceans?
Dr Tew: Clearly, there are significant challenges to do with the difficulty of getting information but I do not think that those challenges are insurmountable and, for me, the issue is largely around the way research has been structured, funded and integrated, or rather the lack of structure, function and integration. As end users, we are finding all kinds of instances where we simply have a paucity of data to do what we need to do to protect the environment.

Q370 Chairman: Whose fault is it then?
Professor Boyd: May I answer as a practising scientist and one who has to deliver the data. I think that there are some very specific challenges within the marine environment. It takes a lot to get to first base there, a bit like working in the polar regions. A large investment is required; it is a very complex dynamic system. As a result of that, our knowledge base in the marine environment is much, much poorer than it is for the terrestrial environment.

Q371 Chairman: Where are the huge gaps?
Professor Boyd: I think that some of the biggest gaps are just, what is there and where is it? We only know that for very specific coastal regions. The deep oceans are largely a mystery to us, for example, and the microbiology in the oceans is something that is only just being unfolded.

Q372 Chairman: During this inquiry, witness after witness has told us that the deep oceans are absolutely crucial to the future of the earth and the planet.
Professor Boyd: It is a matter of having the logistics to get to the deep oceans. They are a very, very difficult and complex part of the planet to reach.

Q373 Chairman: So, it is logistics rather than a failure of science to appreciate the significance of the deep oceans?
Professor Boyd: I would say so. I think science has always said that the deep oceans are very important; certainly in the recent past it has said that the deep oceans are very important. It is also key skills as well. If we are not practising in those areas, we are not bringing on key skills as well. That is fundamental too.
Dr Tew: However, those logistics do not apply to the inshore and near shore and, even there, we have a great paucity of information on where biodiversity is, what value it represents to us as the human species and what the effects of human impacts are. Data are missing on all of these issues. I think the driver is that the marine environment is largely hidden from public view. The glories of the marine environment and the plight of the marine environment are largely hidden and, for instance, we are sleepwalking towards a situation where we might not even get a Marine Bill and, if we get a Marine Bill, we might not have proper duties and proper mechanisms. I believe that the drivers there are lack of public engagement.

Q374 Chairman: Dr Vincent, why does it matter? Why is it important?
Dr Vincent: At the moment, in terms of biological data, we have about 10 to 15% of what we actually require to take any practical action to regulate human activities in relation to the UK continental shelf waters. So, while we have fairly good data in relation to the geophysical side, particularly the substrate, the topography bathymetry, knowledge of the seabed biology is quite meagre. When we are actually trying to manage major human impacts such as fishing, such as energy, such as aggregate extraction, we are actually more able to determine

whether these are likely to have a severe impact or not[1]. We do not know what is there and we do not know what the effect of human activity is having on it as a generalisation and that is why it is important. In answer to your previous question, I think that there has been a major shortfall in the systematic survey of even UK continental shelf waters down to, say, 500 metres, let alone the continental shelf or the deep oceans, and I think that is a major problem for us in the UK.

Dr Thompson: From our point of view, we would agree. If we could use a comparison with terrestrial survey work at least from the point of view of birds, we feel that for a long period of time the Government have had the advantage of organisations such as ourselves who have used volunteers to go out and collect that information for free and that is something that we want to do; we want to help that process along saying where we think sites need to be protected, but we are not in the same situation offshore to be able to do that. It is very expensive to go offshore and, as a charity, we cannot do that. We think, agreeing with Dr Vincent, that we need to have systematic surveys offshore including inshore as well as the deep oceans.

Q375 Chairman: With the huge emphasis we have seen in climate change certainly over the past five years—since I have been in Parliament the emphasis has gone up massively—has that had a positive or negative effect in terms of what is happening with the seas and the oceans?

Dr Thompson: As far as protecting it, I think it has been a bit of both. What it has brought up on the agenda is the fact that climate change impacts are not only happening on land, they are happening in the marine environment and that we need to look after our environment and climate change has certainly brought that to the fore. On the flipside, what has tended to happen is, with such a direct focus on climate change and reducing the impacts of that, we have forgotten that we also need to protect biodiversity as well and remembering that a lot of this biodiversity and the functions of the marine environment actually help us mitigate against climate change impacts. So, it is trying to get that balance between renewable energy, for example, but not damaging those systems that actually help us already.

Q376 Dr Turner: Dr Vincent, I have listened to your comments about the clear lack of knowledge for our marine ecosystems on the continental shelf and I am particularly interested in offshore renewable energy and am quite appalled by the inordinate delays that occur in the consenting process for offshore development of either offshore wind farms or even the first commercial trans(?) turbine. It has taken an enormous amount of time and it has clearly been impeded by the lack of knowledge for the ecosystems and indeed almost the cynical feeling that it was a wonderful excuse to get companies to take over research to fill the gaps in somebody's knowledge. Do you think it is essential that we actually have a concerted effort to get to grips with these ecosystems in order that we can rationalise this whole process?

Dr Vincent: I think the instances which you gave, the renewable energy and the wind turbines, are instances where innovative technology took the scientific community, in biodiversity sense, a little by surprise, so there was not enough lead-in time to prepare to gather the information we needed to answer the environmental questions that were posed. In relation to the turbine in Strangford Lough, for example, we really do not have a great deal to go on in order to evaluate the likely damage of that turbine, ditto the wind turbines in the inshore and offshore zone. There is only a certain amount of evidence available to us to determine whether or not that is going to be a bad thing. There will inevitably be some circumstances whereby innovative technology will simply take us by surprise. However, our lack of basic understanding about what is there, as has been said before, and about how ecological processes work in the environment will always need to be resolved. Fishing will continue in some form and other human activities will continue in some form, so there is a basic systematic need for knowledge as to what is there and how it is going to be impacted by different activities.

Q377 Dr Turner: Let us go back to the Strangford Lough example because it is a good one. It nearly did not happen because of fear of what turbines would do to the seals which I am fairly convinced was totally unfounded because seals are far too smart. It is totally ironic because the local horse mussel population had been rendered extinct by totally unregulated fishing and most of the marine damage on our offshore waters has been done by fishing, not by renewable energy installations which are by and large a method which is benign and, as to the concern about seals in Strangford Lough, what is most affecting the seal population there is climate change because habitats and species are moving north. Are marine biologists in this sort of context keeping a proper sense of proportion?

Dr Tew: We have a seal expert here.

Dr Vincent: I would like to respond on the horse mussels. I think that the damage was entirely predictable in Strangford Lough; it would inevitably have had that result and should have been more strictly controlled.

Professor Boyd: I am not sure if I should admit to this but I am advising the company that is putting the turbines into Strangford Lough and Environmental Heritage Services in Northern Ireland.

Q378 Dr Turner: We can have a talk afterwards.

Professor Boyd: I think that there were some misconceptions in what you say about, for example, climate change and changes in the seal populations. We do not know that. Seal populations are changing in that area and they are changing in Northern Britain in general. That may be a natural dynamic process. When Marine Current Turbines turned up in my office to ask what the effect was going to be on

[1] *Note from the witness*: "if we have good data".

seals, my honest answer as a scientist was that I could not say because, as Dr Vincent said, this is a new technology and we have no previous experience of it. My advice was that we have to go ahead with this anyway but let us take a step-by-step approach and let us come to some sort of conclusion about what the impacts might be and let us try to mitigate along the way. I think that was a sensible measured approach to it and that is what is happening.

Q379 Chairman: I did not really follow that but I am sure that you and Dr Turner can have a chat with a cup of tea afterwards. All of you have mentioned the issue of collecting data and making sure that we have good, reliable datasets and in fact one international census, the Census of Marine Life, is in an attempt to try to catalogue much of what is happening. What part does the UK play in that and how effective is it? Can anyone pick that up?
Professor Boyd: In the next session, you will have Professor Graham Shimmield talking to you and he is Chairman of the European Census of Marine Life, so it would be much better if he answered that question.

Q380 Chairman: You sound like a politician!
Dr Tew: In terms of English and UK approaches, the 2005 State of the Seas report *Charting Progress* was almost entirely unable to put any kind of measures on any of the things that you would want to use as indicators. I think that it is a strong indicator of the paucity of data out there at a national level.

Q381 Dr Harris: I want to ask you about issues to do with conservation, SACs, planned SACs and the planned MPAs and under the new Bill. We have heard in evidence concerns that the research base to accurately allocate criteria to develop these areas is not adequate. Who is responsible for doing the research required or judging whether it is sufficient and is the system working well heading towards the proposals for MPAs and SACs?
Dr Tew: For SACs, the duty is upon the Government to designate these sites under European legislation and it is a government responsibility. There is good news here because the Government have recently set aside considerable funding for SAC survey particularly for reefs and sandbanks. So, it is not all good news but the Government are responding to the need for more information. It is the forward look in terms of the MPAs which is the more worrying with no, as we have just said, coordinated or integrated view on habitats and ecosystems offshore.
Dr Vincent: There are ways of coping. There is a tendency to translate practices on land to sea in terms of the Government's thinking about the sorts of data that you need. As Professor Boyd has said, in actual fact, that is unreasonable in many respects. It may be that we have to change the way that we think and be prepared to accept rather lesser data in support of measures at sea than on land. We have just got ourselves into a sort of mindset about the sea. In relation to MPAs, it is possible for us to use the geophysical data to actually pinpoint probable areas that are likely to be rich in biodiversity terms and then target those for survey. So, we do not necessarily have to survey the entire continental shelf and adjacent waters in order to be able to come up with a suite of ecologically-coherent sites. There are other ways of doing it.
Dr Tew: I think that we might compare ourselves with the Irish who have just launched a £70 million survey over ten years to provide exactly the kind of information which they need and again the point is, if there is not duty to come up with MPAs in the Bill, this is exactly the kind of issue which will again confound the problem and it is why we only have one marine nature reserve in England after 26 years.
Dr Thompson: I agree with everything that has been said before. One of the areas that we focus on is the SPAs for seabirds and this is an area where we have long been saying that the data is old and there are gaps in it, that it needs to be updated and that there needs to be a systematic survey to update that to get us to the next stage to be able to designate those sites. As well as designating sites so that they protect the biodiversity interest, I think that it cuts across to the issue that was brought up before in relation to the activities that take place at sea. If we do not know where the important sites are, every time an activity takes place, whether it be considered good renewable energy or something bad, it is always going to run into the problem of, is this site important for biodiversity or not? You are reaching that conflict on a site-by-site basis rather than having a better overview of what is happening at sea.

Q382 Dr Harris: You are saying that there are gaps in the knowledge base for this but who is responsible for filling that? You said in your earlier answer that the Government have a role but the Government would say that there are research councils and it is for them to decide how to spend their money to this aim.
Dr Thompson: I think that something on such a strategic level is going to benefit UK industry as well as meeting our national energy/national conservation objectives. It needs some strategic lead at least from the Government. We have had a series of strategic environmental assessments for offshore oil and gas in particular which have been surveying the whole of the UK continental shelf, but they have tended to focus on very specific issues that will, I suppose, bring the benefits for that industry itself, particularly oil and gas, and that started back in 1999 and I think that probably all of us there said that we needed more of the biological/biodiversity information as well. However, funds get prioritised and we feel that maybe there should be more funds put towards the conservation element of where we are actually going to move forward in that.

Q383 Dr Harris: Is it the words "long term" that scare funders because it has to be a commitment to the collection of long-term datasets or is it actual research into specific species that is missing from the system in order to designate these areas or both?

Dr Thompson: I am not entirely sure. Maybe more from a personal point of view, I would say that the marine environment is a new frontier that has been forgotten until now and we are only beginning to really look into it and hopefully, as more activities do take place there, people will understand the issues more and more funds should be put towards it.

Q384 Dr Harris: I am trying to work out what is stopping this happening.
Dr Vincent: Could I turn the question back and say that there is a certain lack of clarity, at least I am not very clear, as to which minister is responsible for marine science in the sense that the portfolio seems to shift backwards and forwards between the Defra Minister and what was the Office of Science and Innovation and it is not clear to us who in fact the relevant marine science minister is. If that could be clarified, then their responsibility could be to address cross-governmental objectives which would actually help direct the future marine science funding into those areas in order to meet those objectives and I think that there is a lack of clarity there.
Professor Boyd: I think that there are probably two different issues being confused here in terms of the science delivery. There is a process of documentation of distribution and abundance of biodiversity to put it very broadly, but there is also the process of understanding why it is there and how it changes. In other words, it is the underlying mechanisms. Those two aspects are often delivered from two different directions. The research councils tend to deal with process, why is it there and how is it changing. The government departments have more traditionally dealt with the documentation process/monitoring process. Of course they are not mutually exclusive, but I do think that we need to join the two up an awful lot better than we have in the past because the reasons why everything is there are very important to being able to predict what the effects of climate change might be for example, or the introduction of turbines or whatever it might be. So, there are those two mechanisms and I think that they are dealt with quite differently within—

Q385 Chairman: I thought the Interagency Committee for Marine Science and Technology did all that. I thought that it was their job and then to advise the Government accordingly.
Professor Boyd: I think that is—

Q386 Chairman: It has been a huge success since 1990.
Professor Boyd: It is a job that they are trying to do. I am not directly involved with IACMST except as a member of a subcommittee on marine noise and I think that works very well. So, from my perspective, that works well. In other parts of it, I do not see the joined-up-ness happening.

Q387 Dr Harris: Finally on the issue of conservation, unless anyone has a burning comment to make, if we take mammals, they are generally considered to be the best study of species in the marine environment. As far as you are concerned, are there still gaps that need to be filled before we can designate sites for conservation? There will always be some but are there significant gaps?
Professor Boyd: Some species of marine mammals are very well studied but some are almost not known to us at all. There may in fact be some species out there that we do not know exist yet.

Q388 Dr Harris: The Loch Ness Monster, for example?
Professor Boyd: That would be a reptile, it would not be a mammal!

Q389 Dr Harris: You know that!
Professor Boyd: I think that there is a lot more that needs to be done even for marine mammals and that there are major gaps there, as I have indicated. In my response on the turbine issue, we were unable from first principles to be able to provide a coherent answer to that question and that reflects a lack of basic understanding of how these animals operate on small scales within the marine environment.
Dr Tew: I think that we are searching for a national framework. A national marine policy statement is what is promised in the Bill that provides an overview. The marine environment has to provide us with so much: it has to provide us with renewables and fish and biodiversity. Where is the balance between the Blue Sky research in the deep sea and the applied research in near shore? Who sets the framework for that?

Q390 Chairman: Oceans 2025 has done it.
Dr Tew: Oceans 2025 was an excellent start as a NERC initiative but again it failed to deal with the bigger picture. In response to Dr Turner, industry collects fantastic data but it is not coordinated. We are reactively dealing with each case on a case-by-case basis and that is why it takes time to deal with it. There is no proactive integration.
Dr Thompson: You were asking about conservation and I think we have all admitted that there are gaps in the data. At the same time, I think we would also caution about not protecting anything or putting any management tools in place until we know everything because we are never going to know everything.
Chairman: We mentioned the marine protected areas earlier and I know that Dr Turner has some questions around that.

Q391 Dr Turner: It seems clear to me from your evidence so far that if you were asked to set out a designated marine protected areas as will undoubtedly come assuming that the Bill comes as we expect, you do not have the knowledge base to be able to say where they should be and I also get the feeling that you see a conflict between marine protected areas and use of offshore regions for energy production. I put it to you that in fact there could be a synergy there because you prohibit all sorts of damaging activities, notably fishing. How would you people like to see the network of such areas set out? How would you go about it?

Dr Vincent: I do not think that we need to have comprehensive knowledge in order to deliver that objective. I think that we can do it. I think that we have sufficient information to be able to identify broad scale habitats across the continental shelf and adjacent waters on the basis of this type of the seabed. I think that we can then match that information with available information on human use of the area because human use of the area, for example trawling, will give us an indication of how damaged it is likely to have been. We can then select areas from those kinds of information which will give us a representative sample of protected areas of the different habitat types which have had relatively little disturbance and then we can focus survey over the next ten years to identify sites from that sample. I think that it is perfectly achievable within the next 10 years.

Q392 Dr Turner: Do you want to wait ten years?
Dr Vincent: It can be done progressively over the period of ten years. The point about particularly representative types of habitat is that they do not have to be the best examples, they just have to be good undamaged examples and they will maintain characteristic biodiversity. Provided that they are protected and provided that they are not damaged to start with and providing that you have a suite of different types of them relatively close to each other so that they are not too far apart and can support each other, then that will do the job.

Q393 Dr Turner: There are a number of provisions in that answer. Do you actually believe that there are areas of the seabed in our offshore waters that have not been damaged?
Dr Vincent: That is an unknowable thing. What we can identify are areas that we know are being relatively intensively fished and we can probably set those to one side. So, we can look at the remainder and select from those and investigate those.
Professor Boyd: I would like to respond to that. I think that there are quite significant areas which are undamaged. Fishing tends to go to the very traditional areas and some recent surveys, for example, in the sea of the Hebrides have suggested that there are some quite pristine areas there—these surveys have been carried by the Scottish Association for Marine Science—and I would expect that that might happen in other areas. If we were to be able to survey the shelf seas appropriately, I think that we would find pristine areas.
Dr Thompson: I also think that there is an issue there. There are some areas, particularly around the coast, where we could probably go out tomorrow and say, "We think that there are important species or habitats here and they could do with protection", but the burden of proof is to prove scientifically that this site requires to be protected. That is why we keep coming back to the science. You could go out and say, "We will protect a couple of sites and see how it goes", but we are not in the situation of being allowed to take that approach which is why we keep coming back to the science.

Q394 Dr Turner: What sort of area of our offshore waters would you expect to be covered by MPAs because obviously the sea moves, the fish move, mammals move, everything moves? How big would you want an MPA to be? What percentage of our inshore waters do you think should be covered should be covered from there? Should we take Evan's favoured line of precautionary principle and say that, until we know more, we should protect more?
Dr Thompson: I quite like that one! I think that going down the line of percentages can be quite dangerous because we are trying to set the criteria of how much needs to be protected before we know what needs to be protected and where and how much of it we have. I know that there are lots of percentages flying about. I think that what we need to do is to protect enough to meet our conservation objectives and make sure that we maintain functioning ecosystems that deliver those services that we get from it, whether it be food or climate regulation.

Q395 Dr Turner: We legislators are going to have to move before you have all that data and it will take years to get all that data. We are going to have to set out a map and say, "That is it" in about a year's time.
Dr Thompson: I think as legislators we are asking you to put the legislative tools in place that will deliver that and then we should progressively put sites in place. As a conservation NGO, we want it faster and sooner rather than a long time in the future. What we are saying is that we want to see the Marine Bill now and what we want to see in the Marine Bill is an effective system for designating sites that puts a duty on people to designate and can actually manage those sites once they are in place.

Q396 Chairman: May we ask everyone if they agree with that analysis because Dr Turner's point is really crucially important to us.
Professor Boyd: I am not sure that I necessarily disagree with it but I think I can add to it. In the short term, we have to come up with mechanisms and you are absolutely right about that. We actually do know more than we let on a lot of the time—

Q397 Dr Turner: Do not be coy with us!
Professor Boyd: We can use indicator species. For example, OSPAR is already moving down this track of trying to provide ecological quality objectives using indicator species. There are dangers with that in that you might choose the wrong indicators. After subsequent research, you might find that it is not the best way to go. In general, if we use upper trophic level animals in the marine system and if you are protect them, you are protecting the system that they support and this would go for seabirds or marine mammals and some marine fish as well. I think that some of the mechanisms which we already have in place have the potential to provide the kind of process that you are looking for.

Q398 Dr Turner: It seems to me that, in logic, there has to be a minimum size for an MPA to be of any great value because, if it is too small, the effects of

what is going around it are going to possibly swamp its ecosystem. The other point is, if we protect an MPA, what is the degree of protection? Would you be prepared to see, for instance, turbines being put in an MPA because you might well find that several of your most interesting sites ecologically happen to coincide with the richest energy sources? We have all sorts of competing priorities here.
Dr Tew: The conservation community are very alive to potential win-win scenarios. We are also alive to different possible mechanisms where you have highly protected marine reserves which are really left to recover in a completely pristine state and MPAs where they are of a variety of sustainable uses. The concept that MPAs are exclusively just for nature conservation is an old-fashioned one and the conservation community is very alive to the win-wins. I think that we are all agreed on two things. One is that the process must be based on science. You cannot simply draw random lines out at sea on no good evidence because, as Malcolm says, there is much evidence there already and particularly if we can start to integrate. The other thing that we are all agreed on is that we want to proceed with all possible haste because industry suffers from uncertainty just as much as conservationists suffer from uncertainty. So, the balance is driving the process forward and getting these areas as large as is necessary on the best possible sites and I do not think that picking 25, 30 or 40 per cent is a helpful way forward.

Q399 Dr Turner: I come back to my first point that we cannot wait for more science before designating these areas, we have to make a start with the knowledge base that we have.
Dr Tew: At the moment, the marine environment is more or less totally unprotected and there is a crisis going on out at our seas and we need to do something about that as a nation.

Q400 Dr Turner: So, you would argue that we cannot wait.
Dr Tew: Yes.

Q401 Dr Turner: Finally for me, the Marine Management Organisation is going to have a multiplicity of rules. Do you see it as primarily a regulator or provider of science and data? How do you see it? Do you see it as a determinant of marine spatial planning and use?
Dr Tew: The devil is going to be in the detail but, broadly speaking, we are happy that the MMO should deal with all of those functions. We in Natural England see there being a clear difference between what we do and what the MMO might do and we think that there is a need for an independent nature conservational adviser to sit outside the MMO and we think that we should be monitoring the protected areas. However, given that the key is for integration, I think that the MMO should have as many integrative powers as possible.

Q402 Chairman: Is there general agreement with that?
Dr Vincent: I think I would see the foremost value of the MMO being as a planning authority. I think everything falls out from that.

Q403 Chairman: Dr Thompson, you gave an indication that you wanted to see Parliament set down the rules by which marine protection areas would be decided.
Dr Thompson: The legal powers to create and manage marine protection areas, yes.

Q404 Chairman: You expect Parliament to do that and to do that very clearly, and then the sciences applied to that framework in order to decide the actual areas themselves?
Dr Thompson: Yes. There is probably a two-stage approach on the science. One is determining the criteria for the species and habitats and then picking the sites and then developing the management plans.

Q405 Chairman: But you are clear that it should be on the basis of the science that the sites are applied and that Parliament should be the framework within which to work?
Dr Thompson: Science as in the knowledge we have as the starting process, yes.
Dr Tew: This should not be a political decision, this should be a decision based on science which is why we think that Natural England should be the confirming authority as well as the proposing authority.
Chairman: There are no political decisions made in Parliament!

Q406 Dr Iddon: I want to look at this question of coordination of policy and research which we have referred to throughout this discussion so far. I would like to ask all of you, are we clear about our national priorities in this area of marine policy and research and who establishes those national priorities?
Dr Tew: I think that the answer is generally, "No, we are not clear" and a national marine policy statement should indeed set out those priorities for the nation.

Q407 Dr Iddon: Who should make it?
Dr Tew: The Government.

Q408 Dr Iddon: Which part of the Government?
Dr Tew: Defra.
Professor Boyd: I think that there are differences between Scotland and England in this area and certainly, in my experience, I interact very differently as an advisor with the Scottish and English process and policy is being made differently in the two sectors.
Dr Thompson: I think there are also objectives and priorities that we sign up to through Europe and other international conventions and it is making sure that we marry up our research to achieve those objectives at the end stage, but I think we are probably moving more towards that process than we have historically.

Q409 Dr Iddon: We do share our seas of course with the continent and with Ireland and to a degree across the North Sea. Let us look at the European dimension and the European Marine Strategy Directive for example. How do current research programmes support emerging policy in that direction? Do you think we are having our fair share of input into that directive or not?
Dr Thompson: I could not really answer from a research point of view. From the point of view of how we go about achieving those objectives in the end, hopefully if our aspirations for the Marine Bill are realised, the legislation that we are putting in place should deliver the Marine Strategy Directive's aspirations. As an NGO and having the luxury of this, we would like to see more cross-border working and delivery of marine strategies on what we call a biogeographical regional seas approach, so ignoring our political boundaries and working at the scale of, say, the Irish Sea or the North Sea which are coherent management units on an ecological scale. How far down that route we get in political terms we have yet to see.

Q410 Dr Iddon: Does anybody have any comments on the EU directive?
Dr Tew: No, I just note the report that came out of the Commission last week which was that 90 per cent of EU fish stocks are over fished beyond their maximum sustainable yield. CFP is not even delivering sustainable fishing, never mind sustainable use of the environment.

Q411 Dr Iddon: Do any of you think that there is a need for the proposed European Marine Observation and Data Network, the other aspect of the European directive? It has not registered yet.
Professor Boyd: I think that it depends what it looks like.
Dr Thompson: I think it is, do you want to go down the route of everybody putting their data into one place and having to collect it in the one way versus sharing data and making sure that it is available to all users and I think that, as far as we are concerned, as an end user, as long as the data is collected, processed and made available so that we, as end users, can use it, that is probably the most valuable thing that we want from data.

Q412 Dr Iddon: Wherever we have been, we have picked up criticism on the way that research grants are allocated in this area. For example, we launched this inquiry in Plymouth and the scientists who were present in that room at that time said that it was difficult to understand to which research council one should apply for a grant. How do you think we should organise research in this area? Do you think that it is organised well at the moment or do your scientists have trouble knowing to whom to go for the grants?
Professor Boyd: Maybe I should respond to that question. There is confusion on occasions but I cannot offer a hard and fast solution to it. I think that whatever system you put in place, however we divide the cake, there are going to be things that fall between the cracks and there are a number of issues that do fall between the cracks but I think that is inevitable with what system you have in place.
Dr Vincent: I would like to say a word on the knowledge transfer aspect which we touched on earlier, which is that we are finding this a major problem issue in that we believe that there is a great deal of data out there in academic institutions which we cannot use and the reason why we cannot use it is because it is not in the public domain and the reason why it is not in the public domain is because the scientists wish to retain possession of it in order to generate peer review papers from it. We have two major problems: one is that we cannot get hold of the data because they will not release it; the other is that, for many of us on the operation and policy formulation side, even peer reviewed papers are a difficult way of obtaining knowledge transfer in the sense that we do not have the time in order to do the literature searches and in order to get the answers which are already out there. So, there are two major problems. Approaches which make research undertaken with public funds conditional on the environmental data obtained using those funds to be put in the public domain within, say, two years at a completion of a project or something, some reasonable period, would be a huge benefit to us because on many occasions we have approached universities and academic institutions and have simply not been able to obtain the data which they have. In relation to the other aspect of knowledge transfer which is about what you do when you know that the information is out there in papers, I think that there needs to be some better infrastructure in order to be able to collate information, particularly on key policy issues, and make it more available to the wider user.

Q413 Chairman: Who should do it?
Dr Vincent: I think that probably it could well be within academia but I think that it would need to be publicly funded. There is no such thing as a free lunch. Some kind of centre for the provision of the collation of reviews on key policy questions could be funded by the Government. The Government could determine the key policy questions which they wanted addressed—these are in the short term; we are dealing with existing knowledge here—and then the centres for collating information could then undertake those reviews and place them in the public domain. I think that that kind of structure would be perfectly satisfactory.
Dr Tew: We are end users rather than parts of the research community so, in terms of the grant processes, it is not appropriate for us to comment. We would like to see a thematic approach to how research is organised, so that there is actually some coordinated discipline in terms of the distribution of the resource or the value of the resource or the human impact. That is number one. Number two is, frankly, we would like to see more funding going into marine research. At the moment, I think there is a concern that the Blue Sky, deep ocean climate change acidification agenda which is very big and topical at the moment perhaps threatens the near

shore applied research and that is what we are most concerned about. Both are extremely valuable; there should be more money going into both. Spending £40 million a year on marine monitoring compared to £500 million in the terrestrial environment is not appropriate.

Professor Boyd: I would like to come back on data because I am a data supplier rather than a user. I think that there is a very fundamental problem here because it often is not just a matter of, say, putting data up on a website to allow people to come in, download it and use it. Data needs to be interpreted and, however that data is used, there will almost certainly be an interactive process between the producers and suppliers of the data and the users of the data and we need to find a mechanism that allows that to happen much more smoothly than it does at the moment. We have a mechanism in the marine mammal sector to allow that to happen in the UK which comes out of a rather quirky piece of legislation that came up in 1970, the Conservation of Seals Act, and I personally think that that is a model by which could work in the future in a much wider scale. Nevertheless, there is this fundamental problem that just making data available does not mean that it is useable.

Q414 Dr Iddon: My final question is again concerning coordination. I think we are getting the feeling from our four witnesses this morning that coordination is not good in this area either in policy information or for the research that is necessary. If you had a clean sheet of paper, would you reorganise coordination of policy and research or would you make the existing mechanisms work? The Chairman has mentioned IACMST which is a fairly recent organisation. Can we make those organisations work or do we have it all wrong?

Dr Vincent: It may well be that that committee needs a much greater policy steer or support from ministerial level.

Q415 Dr Iddon: From Defra or NERC?

Dr Vincent: As I said earlier, I think that the relevant marine science minister portfolio needs to be clearly established. I would be quite happy for it to be in Defra but that is not for me to say. That ministerial policy steer could then direct the committee, under its terms of reference, to carry out functions and charge it to do so. At the moment, the committee does a lot of useful work; it has an excellent chair and excellent secretariat, but it behaves a little like a committee.

Q416 Chairman: Steady!

Dr Vincent: What it needs to do is behave a little more like an implementing organisation that is going to carry out a particular remit.

Q417 Dr Iddon: You are asking for clear lines of responsibility.

Dr Vincent: Yes.

Dr Thompson: I think the point to add is that policy often changes a lot faster than the period of time that grant research is given out for. So, there can sometimes be a mismatch of what the grant money is being given out for and what maybe a new policy might be. I think that a greater policy steer would be useful.

Dr Tew: I think that that is exactly the question that Parliament should be debating as the Marine Bill goes through and I think the MMO, properly set up, is the place to do that, the integration and coordination.

Q418 Chris Mole: We have touched across commercial exploitation in some of the questions already and Dr Tew, I think you said that you were looking for a win-win situation wherever possible. Is that a view that everyone shares? It is difficult not to, really!

Dr Thompson: We all want as many win-wins as possible but, as we have also said, there is virtually no protection at all in the marine environment. So, to manage expectations, I think it is probably fair if I said as well that there, at least, have to be a few situations where somebody might have to be negatively impacted. It would be unfair of me to say: "Oh, it will all be fantastic and everybody will win-win"; it will not. However, I think there is also misapprehension that every marine protected area, particularly in the case of renewables, stops wind farms. That is not the case.

Dr Vincent: Can I just add to that to say that what we badly need are really usable sustainable development tools which enable us to evaluate the economic side, the wellbeing side and the environmental side in order to make sensible decisions in relation to the environment. At the moment I do not believe we have those tools; we have a system whereby an initiative comes up, via the marketplace very often, and then it is assessed against an environmental appraisal of some kind. I would rather see the development of a series of tools which would actually foster initiatives which would support sustainable development—in other words, those things which deliver to the economy, deliver to the wellbeing and do not damage the environment. I do not think we have that yet.

Q419 Chris Mole: You want to see these tools in the Marine Bill?

Dr Vincent: No, I think cross-cutting science should help deliver those tools, because I think we are five years away from having them, and I think we are going to struggle until we do have them.

Q420 Chris Mole: Which economic sectors do you think are most likely to cause environmental harm to the oceans and marine life?

Dr Thompson: The last OSPAR Quality Statement Report (I am trying to remember what QSR stands for) in 2000 did acknowledge that fishing was the most damaging activity in the North East Atlantic, but I think that is probably in many ways relating to the fact that it covers most of the marine environment. Until, I suppose, relatively recently there were very few other activities taking place there, but it is probably the most pervasive.

Dr Tew: There is no doubt that fishing has been the most damaging. In terms of offshore renewables, a couple of points: one, offshore renewables are going ahead. There are wind farms out there being built and they are going through the proper process. Number two, the major conservation bodies do have a very keen eye on the integration of a longer-term view of climate change and the need to provide renewables with short-term damage, and the processes that are in place at the moment are to do with adaptive management. So build your offshore wind farms in phases, monitor what is going on and then make informed decisions about how they may or may not be expanded. You might find that the effects on birds, for instance, are a lot less than you feared. Thirdly, there is a big need for innovative research into mitigation; for instance, turbines that collapse at certain times of the year when they see geese coming towards them, because there is a radar on top. There are all sorts of innovative ways to reduce the impact that industry can have on the environment.

Q421 Chris Mole: Are there any circumstances in which interests such as the oil and gas industry can actually aid science and conservation?
Professor Boyd: There are some examples of the oil and gas industry, in particular, taking their responsibilities in that respect very seriously. They have just set up what they call a joint industry programme with 15 partners in it—these are international oil and gas companies—to study the problems of the noise that they generate on marine life. I believe they have allocated something like $13 or $14 million to that over the next three years for research, and that is fundamental, peer-reviewed research that will produce outputs in the scientific literature. So there is evidence that they are taking that very seriously. I suspect that other users of the marine environment are beginning to do that as well.
Dr Thompson: I would add that, coming back to the view of needing a systematic survey and research process offshore, we have certain sympathy with industries that they are having to go out and find the information. They are finding the important congregations of species or important habitats and then we are saying: "Those need to be protected". That is why we are saying we want to frontload that process, and this is where the Marine Bill will, hopefully, come into its own by having marine planning and site protection measures. Once we know where the important sites are it reduces the pressures on industry and helps us make sure that the marine environment is managed properly as well.

Q422 Chris Mole: What about leaving things behind. We did have some scientists suggest to us that when you take an oil rig away you should leave what is below the surface there because, actually, you get some ecological hotspots that have developed new features of the oceans.
Dr Thompson: From my point of view I would caution about that being the thin end of the wedge of using the sea as a dumping ground—suddenly everything is an artificial reef. There are stories of places like Japan where, basically, old buses, trains, tyres—everything—are chucked off a cliff and: "Oh, it's an artificial reef now". So I would caution against that.

Q423 Chris Mole: But if it contributes to biodiversity?
Dr Tew: There are often very natural, properly functioning, properly, naturally, deporporate (?) eco-systems on the base of the seabed and just dumping an oil rig because you get some more—although technically it increases biodiversity it is not a proper approach to managing the seabed. A couple of points I would make about the oil and gas industry—

Q424 Chris Mole: Can you expand on what your concerns are about that? If it does increase biodiversity.
Dr Thompson: It is a different biodiversity from the one that was there. There is a certain perception that just mud or just sand is not very interesting and what you want is lots of anemones on hard surfaces. All it is a different eco-system providing different services. So we need to be, I suppose, cautious about what biodiversity it is that you are trying to get—just increasing the different—

Q425 Chris Mole: What exactly is the danger in that? What is the problem?
Dr Vincent: I think it is very hard to answer your question as a generality.

Q426 Chris Mole: We were quite surprised to hear scientists working on a European hotspots project saying this to us.
Dr Vincent: It is foreseeable. For example, if you wanted to have a series of MPAs for reef organisms across a part of the coast that is normally sediment, there would be a gap in terms of their transport, colonisation, so that in fact you would actually welcome the establishment of an artificial reef as a stepping stone in terms of colonisation routes, but you would have to look at the whole issue of disposal in the round, as to where the balance of advantage is. So it is quite difficult to respond to your question as a generality.
Dr Tew: Can I make a couple of positive comments about the oil and gas industry? One is that the quality of the seabed seismic research they do is fantastic, and that is allowing the nation to map the seabed. The second is I think there is great potential in terms of carbon sequestration and carbon storage out under the seabed, and the oil and gas industry has a huge role to play in that, and could be very positive.

Q427 Chris Mole: What about the biotechnology exploitation of marine life? What do you think we are going to see coming out of that in the near future?
Professor Boyd: This is not my specific area of expertise, but what I see of it is that there is huge potential sitting there to develop new chemicals that

have a wide variety of applications from food technology right the way through to medicine. I think we are only just beginning to open that box. There are a lot of small, spin-out companies now bioprospecting, essentially, and some of them will not succeed but some certainly will find some very, very interesting molecules that will be very useful to us.

Dr Thompson: However, again, I suppose I would caution: on the one hand, over-exploitation could mean that we are losing these important properties before we have even discovered them, but biotechnology in itself will be a further form of exploitation and we must ensure that we have proper management and control mechanisms in place before we open up the frontiers and go forth, so that we can still continue to meet our conservation objectives and ensure that we halt the loss of biodiversity by 2010—another objective that we have to meet. So we would say regulation.

Chairman: At that point, I really have to call a halt. Can I just say you have been an absolutely splendid panel this morning. It has been an absolute joy to listen to you; you have given us some very frank answers. It has been absolutely superb. So can I thank Dr Sharon Thompson, Dr Malcolm Vincent, Professor Ian Boyd and Dr Tom Tew.

Witnesses: **Professor Alan Rodger,** Head of Science Programmes, British Antarctic Survey, **Professor Graham Shimmield,** Director, Scottish Association for Marine Science, **Professor Bob Dickson,** Centre for Environment, Fisheries and Aquaculture Science, and **Professor Andrew Watson,** School of Environmental Sciences, UEA, Royal Society of Chemistry, gave evidence.

Chairman: We welcome our second panel this morning and, again, apologies for starting slightly late. We welcome Professor alan Rodger, the Head of Science Programmes from the British Antarctic Survey, Professor Graham Shimmield, the Director from the Scottish Association for Marine Science, Professor Bob Dickson, the Centre for Environment, Fisheries and Aquaculture Science, and Professor Andrew Watson from the School of Environmental Sciences at UEA and the Royal Society of Chemistry. Welcome to you all. Can I ask you, Professor Rodger, to chair your panel, in case there are any disputes as we go through?

Dr Iddon: Chairman, may I just declare an interest in that I am a Fellow of the Royal Society of Chemistry and one of their Parliamentary advisers.

Chairman: Thank you very much indeed. Can I ask Dr Turner to begin the session?

Q428 Dr Turner: How much do we already know about the changes that have occurred in the oceans as a result of climate change? How firm do you think the predictions are for the future?

Professor Rodger: Why do I not start off in the southern hemispheres, is the first question. I think we know quite a lot about the southern hemisphere oceans but the uncertainties are very significant in a whole host of areas. The uncertainties relate to carbon drawdown, about how much there is, how fast it is, where it is going, the biological roles in there—even the physical processes. I think we are uncertain about the way the ocean interacts with ice shelves and, therefore, has a fundamental effect on sea level, and then I think we have serious big questions, too, in terms of the way in which climate change is affecting the eco-system. That leads on to sustainable use of the southern oceans for biological bioresources. Those would be my three big topics. So we have a long way to go, I think, before we can give you predictions that are as robust as a scientist would wish.

Q429 Dr Turner: However, BAS has made an impressive start, I think it is reasonable to say. Clearly, the world has two poles.

Professor Rodger: Indeed.

Q430 Dr Turner: We do not really seem—at least not from a UK point of view—to have made the same effort with the North Pole. Do you think there is an equivalent corpus of knowledge about the North Pole, because we need both ends of the system?

Professor Dickson: I think that used to be the case. When the world's biggest ocean experiment set out—the World Ocean Circulation Experiment—it set out to cover the world-ocean and establish its role in climate and establish a baseline against which future change would be seen. It only went as far north as the Iceland/Scotland Ridge, and then when the Arctic Climate System Study started up a little bit later it, to study the Arctic Ocean from the same points of view, it unaccountably, only went north of Fram Strait. So the answer I would have given you ten years ago would have been "not much" in the north. Since then we have put together something called the Arctic and Subarctic Ocean Flux Study designed to put all that right. We have discovered quite a lot since then. We now have measured almost all of the ocean fluxes that connect the Atlantic and the Arctic. They could not be measured before; we can now, the technology has advanced (with a couple of exceptions). Now we have discovered that the processes were connected latitudinally between the Atlantic and the Arctic, and it was quite a surprise how diverse was the connectibility of the processes. The third thing we discovered was how extreme the changes have been as our records lengthen. There are still things that we have to do as we go into the polar year, but I think we see our job now—and we have just done it in ASOF (Arctic and Subarctic Ocean Fluxes)—as to re-sharpen what the cutting edge questions now are. So we have learned a lot. We have learned, even, how to question what the questions were and before the IPY to re-pose

these. So I think the answer now is we have quite a lot of information that we would not have been able to answer you on before.

Professor Shimmield: I think Bob is absolutely right, and I think he has described well our advances in the physical domain in the way in which the oceans are operating at the higher northern latitudes. Our knowledge of the way in which some of the biology and eco-systems are responding to those changes, and the way in which the biogeochemistry of the ocean is operating, is less well advanced, and it is a major thrust under the International Polar Year to address that. Of course, that brings in the whole dimension of human activity in the Arctic and the rate of change there. Before I move off I would say one other way that we look at the history of the oceans is the palaeo-oceanographic record—the history of the oceans—as recovered from deep-sea sediment cores and the like. In that area the UK is world leader in trying to help develop our comprehensive understanding of certain modern changes in the ocean in this historical and geological context.

Q431 Dr Turner: If you guys are not actually yet prepared with confidence to make a statement encapsulating the relationship between the oceans and climate change, can you identify the sort of knowledge and major questions that need to be settled before you can?

Professor Watson: I would say that the interaction of the climate with the ocean circulation is critical, because it feeds into the issues of the chemistry and how the ocean takes up carbon dioxide. Incidentally, that uptake of carbon dioxide is extremely important because it has slowed the rate of climate change, which we do not understand well—we do not understand how long it will continue, whether it is increasing or whether it is decreasing; we have some evidence that it is decreasing. This interacts with the ocean circulation, in particular, on our own doorstep, the overturning circulation of the Atlantic, which is fed by the currents coming down from the Arctic Ocean over the Iceland/Scotland Ridge. That is a critical area which we have to understand. This involves modelling the ocean circulation, but, also, the biology and the chemistry of the ocean, and that requires big computers, which is the reason why we are not further forward than we might otherwise be.

Professor Rodger: There are some serious difficulties in all sorts of areas; for example, in sea ice. We know the stories of Arctic sea ice disappearing but, also, in the Antarctic, it is a critical issue from the point of view of acting as a lid on that ocean interface, that energy transfer between the ocean and atmosphere. Indeed, what we are seeing now is some beginnings of changes in sea ice in the Antarctic that have not been reported before. Therefore, mesoscale structures as well are changing. So all things are changing on all timescales, and it is really difficult at this juncture to give you accurate predictions, because it is the interaction of scale sizes as well as the biogeochemistry, as well as the atmosphere that, I think, is demanding, these higher resolution computer models that have just been described.

Q432 Dr Turner: Do you think that the current programmes ordered by NERC and the EU are asking the right questions, from your point of view? Do we need any change of direction—any shift in emphasis—in our research programmes? Especially as the 2025 programme, for instance, leaves out the universities. Do we need to widen that programme?

Professor Shimmield: First, on Oceans 2025, what we have set out there is building on existing work, particularly in the Arctic region, and linking across to the work of the British Antarctic Survey. I should say that is only a first step and, currently, as we are sitting here, a group known as the Polar Sciences Working Group is helping to develop this further within the readjustment of NERC's overall scientific strategy, which will encompass the broad range of funding, both to institutes and to university sectors. So it will address both aspects. That working group is also looking at infrastructure aspects to support the scientific programme and to set priorities, and will report very shortly. In the context of my knowledge base within the Arctic, then the European/UK interaction at all levels is quite strong—it is certainly led by some key institutions—but there is a broad diversity of scientists taking part in those initiatives, and the International Polar Year has been a strong catalyst in grouping people into clusters and setting the priorities accordingly. I think we should be quite proud of the way we are going forward at this moment in time. Resources are still a limitation, though.

Professor Watson: I would say that we do need to be careful. Oceans 2025 only covered, as you say, the NERC institutes. There are places in the universities—my own group is one of them, which is, for instance, doing long-term observations on carbon dioxide in the Atlantic Ocean. It is not funded by NERC, it was never funded by NERC, and it is completely left outside of that structure. There is no mechanism, actually, in the UK for funding those kinds of long-term observations—none that I know of; we have to go to Europe to get funding for that. That can be quite dodgy, too. So I think there are large areas that have been left outside, certainly, of NERC. You would naturally look to the NERC to do some of this co-ordination, and I think that they have, to a certain extent, left out sections of the community. In the area of ocean acidification—I should say that I was asked here by the Royal Society of Chemistry who gave evidence to you on ocean acidification—there is comparatively little work being done within Oceans 2025.

Q433 Dr Turner: I think you have identified an area which has been pointed out to us by several previous witnesses where there is a problem in maintaining long-term monitoring as opposed to specific, immediate research projects. However, without the monitoring we will not have a framework in which to

place whatever other knowledge we get. Would you agree that that is something which urgently needs to be addressed?

Professor Watson: Yes, I think so. NERC has done something on this, with its Oceans 2025, but, as you rightly say, it only is a subsection of the community and it is not very well co-ordinated with the rest of the community. We see no real mechanism for them to do that.

Professor Rodger: Perhaps I could say a little bit (I should, perhaps, declare an interest being funded by the Natural Environment Research Council) in the sense that they are changing the way in which they operate, the way in which things are being funded, into different categories, one of which is national capability. This is a regime whereby things like long-term monitoring and survey of the oceans will have much more clearly-defined activity and principles by which they are decided. So I think there is a seed-change, if you like, and that seed-change, if I can go back to your earlier question, is also trying to build the links between the university system and the institutes, which have in the past been less well-integrated. However, I think things are changing quite markedly, and the evidence I would give you is that there is money in Oceans 2025 to work specifically with the universities, and the number of joint grants NERC is awarding between institutes and universities is increasing.

Q434 Dr Turner: So there are hopeful straws in the wind, at the very least. Clearly, ocean sciences have benefited, to a degree, from the political attention to climate change. Are you worried that this might take over completely and distort ocean science so that it only looks at climate change and not anything else?

Professor Dickson: I do not think so. I think we need more observations of the northern seas—which used to be a data dessert. The reason for my slight spluttering about your earlier question, is that we are actually producing this week a 750-page book called *The Role of Northern Seas in Climate*. So it is not that we are bashful about saying what we have learned—

Q435 Dr Turner: Can you send us copies?

Professor Dickson: I will certainly send you a copy—with a bill!

Q436 Dr Turner: I do not want the bill!

Professor Dickson: The second question you asked was: are we asking the right questions? I think the second output from that sort of study is to re-hone the questions. Certainly the EC effort, the biggest one on the oceans that we know of is Damocles. It costs something like 25 million euros over the next four years or so, of which the EC is producing about 17. All the other institutions involved are providing matching funding for this, including the UK, Norway and others. So the question they focus on is the central one: what is the state and fate of the Arctic sea ice? All sorts of other "oceans role in climate" issues will come up as they study that. It is important not to be too prescriptive when you define the first question, the central question, that a big programme like this will answer. I think we have got the question right: is the Arctic perennial sea ice going to disappear in late summer, and if so, when? What will it do to the earth's climate? In many ways the peripheral observations that we have to arm that with go back to the 100-year time series that we have at certain places, and forward to the observations that we have only just learnt to make. So we have a continuum between the 120-year time series, which are rare but, nonetheless, important, and the ones where a technique has been so wanted, so needed but only just available that we have hardly any time series of it at all. I think if that is the question then we are getting there. Of course, looking at variability is a hard thing to do.

Q437 Chris Mole: You may feel that you have answered this to an extent already, in which case do not repeat yourself. Is the balance of funding between monitoring and basic research right then? We have limited pots of money, but if NERC has any increases where should it direct it?

Professor Rodger: I will answer that, in the first instance. I think we know quite a lot about the surface of the ocean—we do very well from space—but we know remarkably little about under the water, to be perfectly honest. We are at a cusp, I believe, in the sense that there is new technology out there that has been around for a few years. The UK has not yet invested heavily in this area.

Q438 Chris Mole: Gliders?

Professor Rodger: Gliders, towed systems, buoys, more moorings, very clever moorings—ones that do not yet operate in sea ice, unfortunately. In general, there is a lot more technology around there, and whether you call that research or whether you call it long-term monitoring, I will leave as an open question, but it is absolutely essential to get more understanding and more measurements throughout the ocean profile. This is the part of the planet that is least well understood in many ways, and least well measured. That is what I would spend my money on, if you like—if I had money today.

Professor Shimmield: I think the monitoring programmes will get more for your money as well by integrating with other nations, approaching this in an international co-ordination effort. Clearly, there are good examples in the past—we have heard about some of them today—and there are more planned in the future, and I think the activities of the Global Ocean Observing System and how that integrates across into regional activities is something that is important. The UK then has to play a leadership role in determining both the course of those programmes and the investment, and ensuring that all the parts of government that needs the aspects of monitoring (we were hearing about that in the earlier session this morning) really derive maximum benefit, and that is where the co-ordination is required.

Professor Watson: I would say that to a certain extent the difference between research and monitoring is decreasing. What is happening is, to a certain extent, the era of the single investigator—the

one man and his post-doc kind of research grant—is less important when we are dealing with global climate change. Increasingly, we are having to do large, co-ordinated programmes. Sometimes they involve long-term monitoring for decades, but they almost always involve periods of monitoring of four or five years. There is a need to make the funding structure better able to promote that kind of—

Q439 Chris Mole: Are you concerned about the sustainability of monitoring? One man for five years on a research grant can do some very good work, but if you really need to see the trends—is that something that concerns you?
Professor Watson: Yes, it is. I think that NERC, for instance, is always torn between being a research council and running its institutes. When one looks at the countries that do this well, the United States with NOAA[2], Japan with JAMSTEC, they have dedicated agencies that do this monitoring, and if we had not got, for instance, NOAA's measurements going back over decades (they funded Keeling[3] for many, many years) we would know precious little about the global environment.

Q440 Chris Mole: Should we charge the Met Office or Proudman, or somebody, with having a long-term monitoring role?
Professor Watson: I think it would be a good idea to have an agency that had that role, yes.

Q441 Chris Mole: Do others share that view?
Professor Rodger: I accept there is a need for long-term monitoring, I accept there is a need to do it in an integrated way, but whether you need a separate organisation is one that I am less convinced by. It is about integration. As I have said to some of you before, the earth is an integrated system and exactly which box you draw there are always going to be people on the edges of that box or outside that box.

Q442 Chris Mole: Is it not a problem that things keep just falling off the monitoring list if there is not somebody charged with doing it? We nearly lost SAHFOS a while ago.
Professor Dickson: The point you made is an interesting one about whether monitoring is mindless monitoring or whether it is research. In many cases, and you used sea gliders in the example, we are waiting for sea gliders that will work under the ice and within the shelf, for example. We are waiting for sea gliders that will go all the way to the ocean floor—they do not at present. So these are very intense research efforts that are going on necessarily in only a few places. The ones we use come from Seattle. That is a whole new research topic just now and eventually it will be used for monitoring.

Q443 Chris Mole: I think, Professor Watson, you touched on the numerical climate change modelling. We are talking about gliders and buoys and things; you can buy an awful lot of them for the super-computing power we need to get a step-change. Where is the balance there? Do we need that super-computing power tomorrow or should we spend the money on buoys and gliders?
Professor Watson: Moore's law states that computer power doubles every 18 months, or something like that, but what we actually need is to be able to run a model at eddy-resolving, which is 10 km resolving, for 1,000 years with the full ocean physics and chemistry and biology, and we still need to wait for, probably, 20 years of Moore's law doubling before we will get there. You asked for the balance: it is certainly true that with the current modelling—the Argo programme, for example, has dramatically increased the usefulness of the short-term modelling that we are doing, so that was very well worth spending. There are some other areas where we certainly need to spend more on monitoring, and that will come before the computing. However, the computing is desperately important.

Q444 Chris Mole: We have been world-leading, have we not?
Professor Watson: We have been.

Q445 Chris Mole: Are we about to lose that?
Professor Watson: I do not think so. My impression is that we are still very good. In the oceans in particular there has been something of a hiatus and the new model that the Hadley Centre will be using shortly is actually a French model—for which we have to swallow our pride! It is a good model. In general, we are doing very well.

Q446 Chairman: Just before we leave the super-computing, we heard from the previous panel, and we have heard this on a number of our inquiries, about the lack of super-computing capacity in the UK. Do you feel—and this is just a question outside this brief but it clearly affects it—that UK, either through STFC or some other body, needs in fact to actually concentrate on that issue of providing super-computer capacity in order for us not to have simply the large climate change models but models for all sorts of other areas as well? Is this a weakness in British science or are you not able to answer that?
Professor Rodger: All areas of science are benefiting from high degrees of super-computing. It is one of the things that Britain has been, traditionally, excellent at, in high-resolution super-computing. It is one of the things that we can hold up as a flagship. What it offers us is the integration, often, and that is a very powerful activity, that you can bring data and theory together.

Q447 Chairman: I am not arguing against this.
Professor Rodger: I would argue that you could use more super-computing across the board in science.

[2] *Note from the witness*: "NOAA: The US National Oceanic and Atmospheric Administration."
[3] Note from the witness: "Keeling: CD Keeling, responsible for the first monitoring of atmospheric carbon dioxide."

Q448 Chairman: I just wanted to know whether it is actually holding us back—the lack of super-computing power and availability. But you do not believe that is the case.
Professor Rodger: We need multiple runs, for example, in the environment rather than a single run; we do not have the resources to run as many multiple, high-resolution runs for as long as we would wish at the current time.

Q449 Chairman: Okay. Thank you very much indeed. Professor, Shimmield, you spoke earlier about partnerships and co-ordination, and it has been a feature of this inquiry that there are a very significant number of partnerships—in fact, often, too many to mention. We have got the Marine Climate Change Impacts Partnership, the Marine Environment Change Network and the Office for Climate Change. Do they make a ha'ppeth of difference and do scientists actually get very much involved with them?
Professor Shimmield: You are right to identify a range of partnerships and arrangements. Going to the next level down you will see where some of the differences are; some are more focused on the impact of biodiversity in the coastal systems as a consequence of climate change; some are more directed at climate change consequences on the human populations and coastal zone management. I think what you may be alluding to is the need to have some better integration between these activities. They probably show the breadth and pervasiveness of understanding climate change impact across the marine and terrestrial environment.

Q450 Chairman: How effective are these partnerships? How involved are you?
Professor Shimmield: I think they have been quite effective in producing some of the new status reports that are coming out; we are able to see in a more holistic way some of the inter-annual variability in climate change impacts, particularly on shelf seas around the UK. That is one definite benefit that has come out of some of the partnerships.
Professor Watson: I am from a university and, at the coalface, fairly well down the food chain here, but I would have to say that many of these do not make a lot of difference at the practical level of the day-to-day doing of the research. The best ones are those which do involve, from my perspective at least, the people who are actually doing the research and not simply those that are talking about it and doing reports.

Q451 Chairman: Which ones?
Professor Watson: For example, the IGBP (that is the International Geosphere-Biosphere Programme) which has a Committee that sits nationally, and there is the GER Committee (Global Environmental Research Committee) that sits under the auspices of the Royal Society. Those Committees are very useful; they organise meetings, for example, that one may go to.

Q452 Chairman: I will move on briefly. Do you think that NERC does a good job in co-ordinating the whole of climate change science including work on the oceans?
Professor Rodger: NERC, well, who is going to answer this question?

Q453 Chairman: Professor Rodger, you are a good advocate for NERC.
Professor Rodger: Thank you very much for that. NERC in the past has taken a different role in the sense that it has often seen itself as a funding agency. Under its new Chief Executive it is definitely trying to be more directed, more focused, and therefore there are particular activities where there is an attempt to do much more co-ordination, much more addressing the critical question. So in the new strategy you will find "climate change" and then under there you will only find six or seven key questions that are to be addressed, so I think again we are at a point of change where we are going to be more integrated and more directed at addressing the key questions that are relevant not only to the UK but internationally, globally.

Q454 Chairman: Any other comments?
Professor Dickson: The funding of the Hadley Centre by Defra is one major strength in the UK and I must say that when we look at, for example, the NERC programmes in the ocean in the north for the IPY, they are done in collaboration with the Hadley Centre effort, as is the remote sensing of ice freeboard in University College London, so the thing I like about it is that there are a number of departments and agencies who are all well aware of each other's abilities and the need to feed back and forth in an iterative way between observations and modelling, so I wouldn't say it is just NERC.

Q455 Dr Spink: Chairman, can I just take us on to the next question. On specific programme funding such as the global ocean observing systems and climate variability programmes, should these be funded direct from NERC, would that improve them, or should they come through specific programme fundings?
Professor Rodger: Again I think we go back to what we said; I do not think it matters as long as it is done.

Q456 Chairman: With respect, Professor Rodger, that is not satisfactory, is it, because unless somebody takes ownership of it—
Professor Rodger: --- unless somebody takes ownership of the question—

Q457 Chairman: --- then it could easily slip off the radar here.
Professor Rodger: Going back to your question then, I think Defra has to take a significant responsibility for defining the problem and then encourage NERC and make sure NERC and the other organisations carry out the requirements.

Q458 Dr Spink: So there needs to be better co-ordination then?
Professor Rodger: Yes.
Professor Watson: I would say that I very much welcome NERC's new strategy on which there has been widespread consultation, but historically I would say NERC has not done a great job of co-ordination—as Alan says perhaps they are going to change because of that. The problem is, as I say, that NERC is very focused on its own institutes and it does not necessarily know what is happening in the community as a whole which is quite a lot larger than the institutes. There is a reorganisation of government science and the universities now coming together under a new department.

Q459 Chairman: Do you support that?
Professor Watson: I certainly would. I think that that is a good idea and perhaps an opportunity to get this co-ordination across the piece a little better than it has been done in the past.
Chairman: Okay, on that note I will pass to you, Brian.

Q460 Dr Iddon: These are all questions for you, Professor Watson, because you came to give evidence on carbon dioxide and acidification this morning. What do you think we ought to be doing across the world to improve our knowledge of absorption of carbon dioxide and its effects?
Professor Watson: We need to properly understand how much carbon dioxide is going into the oceans. There is a canonical figure that has been around for literally decades. With new research—some of it just published jointly between the British Antarctic Survey and the University of East Anglia two weeks ago—we now realise that the Southern Ocean, for example, is changing quite rapidly the rate at which it takes up carbon dioxide. We have new research in the North Atlantic suggesting that the North Atlantic also is changing very rapidly. So largely in ignorance we thought that oceans took up carbon dioxide at a uniform rate year on year and we now realise that that is not the case. We need to put in place—this is globally—an observing system that will tell us how rapidly CO_2 is being taken up by the oceans. In some places that is in place. In the North Atlantic it is being done using commercial ships of opportunity and this is funded by the European Union at the moment under Framework VI as a demonstration project and it has worked extremely well. We can see that we can do this using commercial ships of opportunity. It is difficult and it would be very helpful if the shipping companies had some slight incentive to help us because at the moment they will move their ships at a moment's notice, and this can be quite annoying if you have spent six months putting instrumentation in and then the ship goes off to the other side of the world. So there is something there which governments, I think, could do. If they got one per cent off their port duties for example for helping scientists that would be useful. But we do need to put in place a global observing system and that will involve satellites, in situ observations, the co-ordination of the different methodologies, and computing too. The UK has begun to do that. We have projects that are going in that direction. The NERC has a centre which does that for example. However, we have to expand this to the global ocean and quite quickly. In general, there has been little support again from the UK to do this kind of work. It has been done (insofar as it has been done) through Europe which co-ordinates some of the other European countries, but they are only funding a demonstration project so this will stop in a year or so.

Q461 Dr Iddon: There are about 3,000 Argo floats in the sea now. Have we missed a trick? Could we have adapted those to give you the data that you require?
Professor Watson: It would be lovely if one could put a carbon dioxide sensor on the Argo floats and get the carbon dioxide information. Unfortunately, we cannot do that, the technology is not there, when the float goes down the sensor falls to pieces, but you can put oxygen sensors on such floats and that would be extremely useful to knowing how the biological system is working.

Q462 Dr Iddon: Briefly, which instrumental techniques are you relying on?
Professor Watson: We are relying on these commercial ships of opportunity with CO_2 instrumentation that were originally developed by Plymouth Marine Laboratory and Defra and are now being used worldwide. We are relying on satellites to get measurements of ocean colour and temperature, et cetera, and we try to integrate that with computing.

Q463 Dr Iddon: Obviously normal partition will occur between the air and sea and carbon dioxide and the other gases, but are there other major features like sea churn, currents, temperatures that affect the levels of uptake in specific areas?
Professor Watson: Absolutely. The temperature affects carbon dioxide uptake very dramatically so if the temperature of the oceans begins to increase the rate of uptake decreases. The overturning circulation, so the rate of mixing basically, of the ocean also affects this, and finally the biology of the oceans is very important in this. We can monitor all of those things, for example biology can be monitored from space and the temperature can be monitored to a certain extent from space. Mixing is a little more difficult but by using high-resolution models and the Argo floats we can get some information on that.

Q464 Dr Iddon: Do we know if there are huge variations between the surface and the bottom of the deepest oceans? What kind of distribution of carbon dioxide occurs?
Professor Watson: There is a distribution that is in general terms understood, but there is more carbon dioxide at the bottom of the oceans for example because biological fluxes take it down—it is called the biological pump—to the bottom, so in general

terms that distribution is understood but near the surface it can change rapidly and that of course is the bit that is of interest for uptake over, let us say, shortish timescales of a decade or even 100 years. The deep ocean turns over so slowly that it is less significant.

Q465 Dr Iddon: Briefly, what would be the main effects of increasing acidification if we had another 100 years of uptake at the rate of the past 200 years where more than half the CO_2 emitted has been absorbed?
Professor Watson: Many organisms do not seem to function so well as the acidity of the oceans increases. Those are particularly organisms that calcify, that is to say they produce calcium carbonate, and a huge range of marine organisms do that. They find it more difficult to do it as the CO_2 increases. Those organisms include corals for example, which are already under stress caused by rising temperatures. They include also plankton which are so numerous that they form much of the rocks on which this city is built for example and which are therefore important just because of the sheer fluxes that they produce. We know from experiments in labs for example that these organisms can find it difficult to calcify if you increase the carbon dioxide concentration. What we do not know is whether we can extrapolate those experiments to the real ocean to a relatively slow increase taking 100 years, although they may adapt and may have no trouble but we suspect not, so a lot of the marine biologists are quite concerned about the long-term effects of acidification and little is known.

Q466 Dr Iddon: Apart from stopping producing as much CO_2 by burning fossils fuels, which we are attempting to do worldwide, are there any other ways we can mitigate the effects of acidification?
Professor Watson: Locally, for example around the coral reef if the coral reef is having problems with the acidification, you might add calcium carbonate or magnesium carbonate to the area and that would probably help the organisms. However, for the seas as a whole, for the open ocean, well, people have discussed geo-engineering type scenarios where you grind up vast quantities of calcium carbonate rock and throw it into the ocean, but you would have to grind up about the area of Sussex every year in order to have any real effect. We are putting so much carbon dioxide into the atmosphere that I think most people who look at this think it is just not practical.

Q467 Dr Spink: This is obviously a double-edged sword. Is the international community confident about the level of ocean CO_2 absorption that would be optimum for the health of the planet overall, not that we can, as you have just explained, do much about it other than stop burning fossil fuels? Are we confident about the optimum level?
Professor Watson: If you ask about the optimum level of $C0_2$ absorption you have to balance two things. If you leave the carbon dioxide in the atmosphere then it builds up more quickly and you get quicker climate change. If it goes into the oceans you get these effects of acidification. I do not think there is any consensus about what the optimum level is other than most scientists in this area would strongly support decarbonising industrial economies as quickly as possible.

Q468 Dr Spink: So that is the bottom line?
Professor Watson: That is the bottom line.

Q469 Dr Harris: I know you have touched on this already but I want to ask about the balance between Antarctic and Arctic work in pure terms of poles. Do you all accept that there is a need to improve, comparatively speaking, the amount of work and resource going into the Arctic as opposed to the Antarctic and, if so, how would you do it? What are the mechanisms for increasing the funding and capability in the Arctic?
Professor Rodger: There is a fair amount of resource already going into the Arctic. What you do not see effectively is that resource as a coherent body such as you do have through the British Antarctic Survey going to the other pole. We have already heard about a significant number of EU activities that are going on where the UK is playing a leadership role, so it is not as much a question necessarily of resource but being more integrated to some extent which I think is a much more important activity. I will leave my Arctic colleagues to say some more.
Professor Dickson: The IPY coming up has given us a huge impetus to add more and more co-ordinated work in the Arctic and from the submitted 1,500 or so expressions of interest something called the Integrated Arctic Ocean Observing System, the science plan for which I have got here, was thought up and designed specifically for the IPY. The reason for doing such a thing is because a pan-Arctic effort like this is not only possible but it is larger than any national funding agency would aspire to, so this had to be done before the announcements of opportunity were made by, for example, NSF, the Research Council of Norway, and NERC, so that was done. There is going to be on a scale that we have not had before an integrated Arctic Ocean observing system for the IPY of which the big European effort Damocles will be the European half, so I would say that although we by no means have covered all the bases in the Arctic it is becoming much better co-ordinated, and the IPY has given us the incentive to do that.
Professor Shimmield: I entirely agree with Bob and, as I said in an earlier remark, we are moving strongly forward on the biological and chemical aspects of the Arctic work as well. I think that is also done both in collaboration across the UK university network but also very strongly with the Scandinavian effort and Norwegian effort. I should say that is permeating right through into the education sector as well. There are now joint education programmes

for the universities in the Arctic and UK universities and the University of Svalbard, which is an international organisation for training both at undergraduate and postgraduate level, so we are seeing, I would say, in the last five years a dramatic shift in the way in which Arctic research and Arctic marine research is being carried out.

Q470 Dr Harris: Do either of your colleagues working in the frozen north look jealously on the resources and reputation of the BAS? There must be pangs at least?
Professor Shimmield: Yes clearly there are. Some of the infrastructure that is available to deliver the effort in the southern hemisphere is only available at a modest level in the north.

Q471 Dr Harris: So it is not all about co-ordination, there is a resource issue?
Professor Shimmield: For instance, as you have heard in previous discussions, the availability of full icebreaking vessels in the high north to conduct marine research, and that would clearly need to be done, I think, at a European co-ordination level now.

Q472 Dr Harris: You are not looking bashful at all, Professor Rodger?
Professor Rodger: Only that the *James Clark Ross,* which is one of the best ships that NERC owns, for doing marine research, has 60 days allocated to doing other things other than looking south and some of that is spent in the north, but it is not an icebreaker and it can only deal with one to one and a half metres' thickness of ice.

Q473 Chris Mole: I think everybody knows about the rainforest. Are people really aware of the role of the seas and the oceans in climate change? Do you need to do more to engage with the public to understand acidification? They might know a bit about the thermal haline pump and all of that but should you be doing more?
Professor Rodger: Yes. Let me just say that one of the ways to engage is the education side, but always to inspire youngsters you want something unusual and out of the way and I would have suggested that the deep sea with all its peculiar animals is one way to inspire, so instead of necessary looking at dinosaurs I would really like to see this generation of youngsters focus on the fantastic biodiversity that you get within the ocean and particularly the deep ocean.

Q474 Chris Mole: Anybody else?
Professor Watson: I would have to say that the British Antarctic Survey is one of the best at doing outreach. In general, I would absolutely agree. I think that we do not do enough outreach. Again it is rather a question of funding and time. There are many calls on one's time and it tends to be that is relatively far down the list because there is not enough time. It would be helpful if for example the NERC did more centrally to co-ordinate with the various things that they are funding. That would be helpful from a university point of view where we generally do not have the resources to do that.
Chairman: On that note I am going to bring this session neatly to an end and to thank Professor alan Rodger, Professor Graham Shimmield, Professor Bob Dickson and Professor Andrew Watson for their time this morning. Thank you very much indeed.

Monday 16 July 2007

Members present:

Mr Phil Willis, in the Chair

Mrs Nadine Dorries
Linda Gilroy
Dr Brian Iddon
Chris Mole
Dr Desmond Turner

Witnesses: **Jonathan Shaw MP,** Parliamentary Under Secretary of State, **Professor Sir Howard Dalton,** Chief Scientific Adviser, Department for Environment, Food and Rural Affairs, and **Professor Sir David King,** Government Chief Scientific Adviser, gave evidence.

Q475 Chairman: Could I offer a particularly warm welcome to our three witnesses this afternoon on this, the penultimate session of our inquiry investigating the oceans, one of the excellent cross-cutting inquiries which the Science and Technology Committee are involved with. Our three witnesses this afternoon are Jonathan Shaw, the Parliamentary Under Secretary of State for Defra. Could we not only welcome you, Jonathan, but also congratulate you on your appointment. We are delighted for you.
Jonathan Shaw: Thank you, Chairman.

Q476 Chairman: Professor Sir David King, the Government Chief Scientific Adviser, welcome again, Sir David. Last, but by no means least, Sir Howard Dalton, Defra's Departmental Chief Scientific Adviser, and you are always welcome to our Committee.
Professor Sir Howard Dalton: Thank you, Chairman.

Q477 Chairman: I wonder if we could move on quickly and perhaps ask you, Jonathan, who is the Minister for Marine Science?
Jonathan Shaw: I am the Minister for Marine Science. The IACMST reports to me, so I am the Minister for Marine Science in terms of Defra's responsibility.

Q478 Chairman: The division between DIUS and Defra, are you conscious of where the responsibility for one begins and the other one ends?
Jonathan Shaw: DIUS, I am not sure—
Professor Sir David King: The Department for Innovation, Universities and Skills.
Jonathan Shaw: Chairman, in preparing for this inquiry I asked the officials to prepare me a list of acronyms for this particular area and there are 48, so I have got a crib sheet.

Q479 Chairman: We will not use another acronym for the whole afternoon. I expect all my colleagues to give the full titles.
Jonathan Shaw: You are a better man than I am, Chairman!

Q480 Chairman: The serious question is that we do now have a new Department for Innovation, Universities and Skills and I just wonder if you see a conflict or a division between Defra and, indeed, the new department in terms of marine science.
Jonathan Shaw: There should not be a conflict, Chairman. Sir Howard chairs the IACMST, which is independent, but nevertheless he is the Chief Scientist for Defra. The work that we have seen undertaken has been collaborative with many organisations coming together to provide science evidence on which a policy can be formulated. The starting point was *Safeguarding our Seas*, which I am sure the Committee are familiar with. There are other examples which I will perhaps come on to during the evidence where there is collaboration. The IACMST is the catalyst that identifies particular areas of research that are required and obviously the research institutes undertake their research as well, and they do come together. Perhaps if I can just highlight an example of where that has happened, and where that has happened well: the monitoring arrangements. This chart, which we will provide the Committee with, highlights 350 different programmes of where there is monitoring taking place in the sea and that is undertaken by a range of different organisations, but it is brought together and collated—

Q481 Chairman: By Defra.
Jonathan Shaw: By Defra. It was the work of the IACMST that drew attention to the fact that it was very disparate and it is absolutely vital that we do have this monitoring that takes place. It is now brought together, not just for England but for the devolved authorities as well.

Q482 Chairman: We will come on to the Inter-Agency Committee for Marine Science and Technology a little later but, Sir David, I wonder do you see any real divisions between Defra and the Department for Innovation, Universities and Skills, which will henceforth be called DIUS?
Professor Sir David King: In respect of marine science?

Q483 Chairman: Yes. Is there a conflict anywhere?
Professor Sir David King: I see it rather clearly. In 2003 Sir Howard took over from me as Chairman of the Inter-Agency Committee and at that point as well the officials moved to Defra and I saw it as

becoming a full Defra responsibility with the ministerial responsibility in Defra. Now, of course there are many government departments involved, as there are in many other issues such as climate change, but the practice of giving key responsibility to one department exists right across government, so I do not see the conflict with that.

Q484 Chairman: Can I tell you why I have asked the question. Currently IACMST actually reports to OSI and OSI is moving lock, stock and barrel into the new department. That was the confusion. You are now saying that has changed and it is going to report to Defra.
Professor Sir David King: I believe in practice this has been the case. We have a member from the Office of Science and Innovation, as it was, and DIUS as it is now, on that Inter-Agency Committee but the chairmanship and the official responsibility now lies with Defra, and I believe has done since 2003. Your question means that we need to go away and make sure that the reporting lines are absolutely clear. As Chief Scientific Adviser on issues like this I would always pass initial responsibility to the Departmental Chief Scientific Adviser, for example, leaving myself a position of challenge so that I can come in not having been fully involved.

Q485 Chairman: It is not a trick question, it is just trying to get clarification, please do not think that. Sir Howard, the committee itself thinks it reports to OSI, not to Defra.
Professor Sir Howard Dalton: It does. It believes it does.

Q486 Chairman: It believes it does.
Professor Sir Howard Dalton: We need some clarity here but I think there is an issue about clarity and that is a problem at the moment.

Q487 Chairman: It is as this is the key organisation that, if you like, co-ordinates marine science.
Professor Sir Howard Dalton: It is quite true. If you go to the Inter-Agency Committee on Marine Science and Technology website you will see that the Inter-Agency Committee on Marine Science and Technology reports to the Office of Science and Innovation. It is true, and Sir David is absolutely right, I took over the chairmanship of the Inter-Agency Committee on Marine Science and Technology in 2003 from his department and have been chair of that ever since. I act, in a sense, as an independent chair of IACMST because on that committee sits representations from each of the major government departments, including Defra, so I purely and simply serve as its chairman and will continue to serve as its chairman, despite the fact that I shall no longer be formally associated with Defra when I leave government in September, and will continue being the chairman of IACMST for one year at least thereafter. That emphasises that I have an independent role as a chairman but we in Defra and the OSI, or DIUS—the Department for Innovation, Universities and Skills—need to be clear about what the reporting lines are and I think there is a slight fuzziness there and we need to get that resolved.

Q488 Chairman: Could I just ask you, Sir Howard, whether the committee actually produces an annual report? Does it present it to Defra or to OSI?
Professor Sir Howard Dalton: The Office of Science and Innovation. We have a report.

Q489 Chairman: The report goes to OSI?
Professor Sir Howard Dalton: Yes.

Q490 Chairman: So it does need clarification and you are going to do it, Jonathan.
Jonathan Shaw: In preparing for the evidence session this afternoon from some of the submissions of the previous evidence that has been presented to you I spotted that there was perhaps the need for clarity and, coming new to the job, that is something that I am going to do. It is very helpful that the Committee has highlighted this point because as we move forward the lines of accountability and reporting are very important. We have got an enormous amount of work ahead of us with the Marine Bill and it is right that we get this in place. Yes, I will get on and do it.

Q491 Chairman: Minister, you mentioned the Marine Bill. Everybody's eyes lit up at that point. When are we going to get the Marine Bill?
Jonathan Shaw: I have read *The Guardian* today and some other colleagues have as well. We are committed to the Marine Bill. We anticipate seeing a draft Bill early next year and in our manifesto it was stated that we would introduce that Bill. We have got a lot of work to do.

Q492 Chairman: It was not in the Queen's Speech, that is what concerned us.
Jonathan Shaw: It was referred to in the written statement. The Prime Minister did not say in his oral statement but there was reference to it in the written statement. It will be the first type of legislation anywhere in the world, so the world will be looking at us. We will have a blank canvas within which to paint the new planning and regulation of our ocean. It is absolutely vital that we get this right, both in terms of the science and also, very importantly, the co-operation with the devolved authorities, which *The Guardian* did not refer to.

Q493 Chairman: We are not responsible for *The Guardian*.
Jonathan Shaw: You are not, no.

Q494 Chairman: Not yet!
Jonathan Shaw: In terms of responding to that.

Q495 Chairman: Can I just lead on from that because the Committee, as part of this inquiry, and we think it has been a very significant inquiry into marine science—

Jonathan Shaw: And very timely.

Q496 Chairman: ---visited the United States and three weeks ago we were in Portugal. Both Portugal as a small country and the US as arguably the largest country involved in marine science have comprehensive national strategies and we have not. Why is that, do you think? Are we going to put that right? Do we need one?
Jonathan Shaw: I referred earlier to *Safeguarding our Seas* and that started off the process and there was the follow-up charting our progress. What is vital is that good science informs the way that we shape policy. These documents lay out what the Government's intention is. As I say, we have the Marine Bill as well and that will bring in proper regulation and planning arrangements, which do not exist at the moment. It is a bit like on the land, is it not, where there is a myriad of different organisations and responsibilities but we have got a blank canvas. There has been good work in progress.

Q497 Chairman: But they are not national strategies, are they, the documents that you have referred to, they were part of a strategy rather than a whole strategy.
Jonathan Shaw: Do you mean in terms of where—

Q498 Chairman: A comprehensive set of priorities which the UK marine science, marine industries, are working towards.
Jonathan Shaw: We have strategies to deal with marine life, we have strategies to deal with ensuring our coastal waters are clean, we have strategies in terms of climate change and the effect that is having upon the marine life and the effect it is having on our oceans. By way of inspiration, we also have a strategy for marine monitoring under UKMMAS. We are making steps in the right direction.

Q499 Chairman: I think we are trying to make the point that this is an important area to pull together rather than have a division.
Jonathan Shaw: I agree with you, Chairman, and you highlighted in your first points about reporting between different committees in terms of how they disseminate evidence and how they encourage research that is needed in order to shape that overall strategy. There is work in train and we need to do more.

Q500 Chairman: I will just ask one last question. The clerk and I were down in Southampton last week looking at the Oceanographic Centre and we came away having met a number of the scientists there who felt that there was a need for a champion for marine science. Sir David, I wonder have you met a champion for marine science during your time as Government Chief Scientific Adviser, and who is that person?
Professor Sir David King: The champion is sitting to my left and would be Sir Howard Dalton, in my view.

Q501 Chairman: Sir Howard, you have been named as the champion. Will you continue to be the champion when you have left government?
Professor Sir Howard Dalton: I am sure my successor will be happy to accept the mantle of being champion for it, and it is absolutely right in many respects that Defra should take some sort of leading role here and we would be happy to embrace that. It is important that strategically we get something together which from our point of view brings together the science, well structured and well organised, so that it can feed into the policy process. We need a proper marine strategy, you are absolutely right, and in order to do that it is essential that we get the science right. My role on IACMST is to try to bring together all those people in the UK who have a need for, and are involved in, marine science, particularly in the monitoring area, the research area, understanding fisheries, understanding everything that is going on in the marine environment, which has been rather poorly researched. I told you this when I last gave evidence to this Committee. I think it is right that we do it and we do it properly. In terms of developing a proper science base for that, I think Defra is probably as good as anybody else in order to do that. IACMST is purely and simply a vehicle for bringing people together and to understand what the issues are, it is not the one that sets the programmes up in the first place, it advises different government departments on what to do.
Chairman: I will bring Des in here because we would like to follow that up.

Q502 Dr Turner: I do not know who wants to take this one but having been in the job for two weeks Jonathan ought to be able to account for the deficiencies in the last 50 years! Anyway, the Lords Select Committee looked at marine science 20 years and they described the areas as "under-funded and fragmented". Nothing seems to have changed very much over the last 20 years because all of our witnesses have told us the same story, so why are we in this position?
Jonathan Shaw: I am not sure that is right. There will be a number of important areas to improve upon but in terms of funding, it is science that spends around £26 million and the Committee has been provided with a breakdown of the areas within the evidence that we submitted. There is also the science and marine science that goes from the Research Councils and you will be aware that there has been a significant increase in funding to the Research Councils. In terms of money and fragmentation, I would point to the example of MariFish. It is about us being more collaborative with other countries as well so we can use our resources with other countries. Defra have led MariFish, which is a collaboration of 13 countries with a whole series of different programmes, and that has been very successful. We are able to work with others and to use the resources available to us in a smarter way. In terms of how the UK stands up comparatively, and we will provide the Committee with a league table, we compare pretty well in terms of other European

countries. I accept that there is bound to be a case of needing to do more. In terms of you saying that things have stayed the same for the last 20 years, I think that I could point to examples which would refute that, although not necessarily entirely.

Q503 Dr Turner: It is a pity that the marine scientific community does not see it that way. There are also reservations from the IACMST themselves because they do not seem to think that it is really fulfilling a proper co-ordinated and strategic role and it certainly does not have any actual powers. It does not have funding powers, it is a talk shop. Do you think that its powers should be increased? Should we consider moving to a formal agency like NOAA in the United States? We seem to have a situation where we have got some very, very good marine scientists at work and the reputation of British marine science stands very high in the world but they are having problems with inconsistent support, shall we say, which if you are looking at it from a strategic point of view, especially the monitoring programmes, would have been better avoided and many of these programmes have only been saved by the skin of their teeth by charitable finance. Do you think that we should be doing something with the IACMST? God, I hate that acronym, I can never my tongue round it

Jonathan Shaw: I know what we are talking about.

Professor Sir Howard Dalton: We can use MST as an abbreviation if that helps.

Jonathan Shaw: Another one!

Q504 Dr Turner: Should we do anything?

Jonathan Shaw: The opening questions from the Chairman highlighted an issue for me to look at in terms of the reporting and accountability and who is in the lead. That is probably the first thing that I need to do. In terms of whether the committee that we are talking about needs teeth and whether it needs to be an agency, I am not in a position to be able to make a proper assessment of. In terms of whether it is just a talking shop and does not do anything, the example I have just referred to of the 300 programmes of monitoring did not happen until the Committee was set up. It was through the Committee's work that people were brought together to ensure that all of that monitoring and those programmes then fed into Defra so we can have a good idea of what is happening on the sea bed. There is an example of where the Committee has provided an important function. The point the Chairman raises is something for me to look at. In terms of whether it needs teeth or money, et cetera, that will be something for me to consider. I hope that I will be able to consider that when I receive a copy of your report which will be very helpful

Professor Sir Howard Dalton: Getting back to your question at the beginning, which was a fair one about the funding situation, that is absolutely clear. Historically the funding in the marine environment has been much poorer than it has in the terrestrial environment.

Q505 Chairman: In your evidence you said it was £2 million under-funded.

Professor Sir Howard Dalton: I gave you the figure in my evidence and that has not changed. What has changed is the realisation that we need to fund it better and it is an important and valuable resource for the UK. When you think about the programme that we talked about before, Oceans 2025, which is a NERC funded research initiative that Defra are teaming up with and other funders are getting involved with, I think it is a major step forward in trying to develop the science that underpins everything to do with the marine environment. There is a very important initiative and we must not lose sight of that. Where IACMST fits in all of this is an interesting and valuable question and it is one for the Minister to contemplate on because we need to think now what the role of IACMST ought to be. You are absolutely right. It has been a talking shop. It has been a vehicle for us to be able to think seriously about what we are trying to do, what different government departments are doing in order to address the issues. Maybe it needs some teeth. Maybe it does need a resource base that we can throw at this and say, "We think more money ought to be put in there and we have it to give you." That is a possibility. I would not want to presume any more than saying this is something we need to think about but it is certainly something for the Minister to contemplate.

Professor Sir David King: This may be an occasion when you find you have three different opinions before you. I personally think that we have rather over stressed the Inter-Agency Committee and its position in the discussion. The Department for the Environment, Food and Rural Affairs is the right department to take on full responsibility for the marine environment. The full responsibility lies with that department, including the possibility to coordinate activities with other government departments. Coming back to the responsibilities of Jonathan, I think they lie within the Department. At the same time, I do support what Sir Howard in the sense that we have not, despite being a maritime nation, fully recognised the importance of marine science in the overall picture. As we move forward through this century, I think we will have to change that quite dramatically. If we look at the marine situation, we have biodiversity issues, water quality issues, impacts from climate change—by that I mean warming oceans—impacts from carbon dioxide levels increasing which means acidifying the oceans and we have major issues, I believe, around the food chain beginning with plankton. All of this impacts heavily on the way we move forward through this century. We will have to have a much greater focus of attention on marine science as we move forward.

Jonathan Shaw: One of the first questions I had for officials was obviously about how much money we were spending and where the shortfalls were. There are shortfalls. They have prepared me a chart of the different areas where we are spending now and where we see the shortfalls. I can very happily provide the Committee with that. It talks about sea

birds, data assessment project management for productive seas, litter, noise, a whole range of different areas.

Q506 Chairman: That would be useful for us.
Jonathan Shaw: You will get it all from me. It is much better that you have all the information. The government has to make decisions about how much we spend and whether we will be able to meet all the shortfalls. We will probably not but it is important that the Committee have that information so that they can provide the most accurate report.

Q507 Linda Gilroy: I was very pleased to hear Sir David's comments about the recognition that is growing for marine science. I think I am right in saying that marine science and technology—it is one of the things we have learned, the interconnection and the importance between the two—is something like a £14 billion industry in Europe. It is a growth industry and it is one where the UK in many fields has a lead. I would just challenge you to look at whether it really is appropriate for it to be sited in Defra, that the champion we were trying to identify should be sited in Defra and not perhaps in DIUS or whatever.
Professor Sir Howard Dalton: When you look at that £14 billion, you have to ask yourself who is generating it. A lot of it is oil, gas and marine engineering which in a sense fit probably much closer into that department than Defra. The fishing side of it is relatively small, although it is a very important part of the livelihood and wellbeing of the nation. It is important to think about where the major activities are from that point of view. I am not trying to shove it away to another department essentially but it might be more realistic to think about where the major resource earners are in that context.
Professor Sir David King: We just have to bear in mind that the DTI no longer exists. I think the department Sir Howard has just referred to is Business Enterprise and Regulatory Reform, not DIUS.
Jonathan Shaw: In Defra's defence, Defra leads on sustainable development so it is appropriate that there is an umbrella that looks after the sea. I think it should remain where it is given all the work that has been undertaken.

Q508 Dr Turner: Oceans 2025 is going to need lots of good collaboration between Defra's institutes and NERC's institutes. Are you happy that this is going to work well? Are we going to get some symbiosis between all these different institutes?
Jonathan Shaw: Yes. At the moment there is a sustainable marine bioresources programme which is funded jointly with NERC, in the region of £700,000. It is happening and it needs to continue to happen. Yes, I am confident that that will be the case.

Q509 Dr Turner: Marine science is becoming increasingly relevant to climate change. Defra contains the Office for Climate Change. Is the marine science community being brought into the work of the Office for Climate Change?
Jonathan Shaw: It is. This is the marine climate change annual report card which sets out very clearly and succinctly where we are, what could happen and how confident we are about that prediction. That includes a whole range of different organisations and contributors. I am very happy that the collaboration is taking place. We have a very high level of contributors to this report card which is a good document and sets out where we are. It also includes NGOs and the devolved authorities and Guernsey and Jersey, for example. Yes, people are working together on climate change.

Q510 Dr Turner: There is a whole host of Defra led initiatives going on. Are you satisfied that there are not too many of them so that they are not going to trip each other up? Is each of them being adequately funded?
Jonathan Shaw: I have talked about the programmes in terms of the monitoring that is happening. Getting the most out of the resources that we are putting in is absolutely essential but I do not think we should just be looking at it from a UK perspective. It is obvious that marine life, pollution and such matters do not recognise borders so it is essential that we have collaborative arrangements, particularly with our European partners. That is an important part of the way ahead, how we use our resources. I will provide a very bold statement about how much we are investing and where we think the shortfall is so that you will have that clear picture.

Q511 Dr Turner: You have clearly come to the realisation that there is some under-funding in marine science. Do you think it is drastically under-funded? How optimistic do you feel about its level of funding under the comprehensive spending review?
Jonathan Shaw: What I hope we will see more of is collaboration between the Committee so that we know what we are talking about and the Research Councils, particularly NERC. There has been some work and Oceans 2025 is an important part of that, but we need to see more of that going forward. We need to be able to answer the big questions as to what is happening out there. What is climate change going to do in terms of impacting on marine life, not just within our immediate area but in the oceans around the world and how they all feed into each other? That is big research which we need to do in terms of the Foresight Programme looking forward but within that we need more applied science as well. I hope that we do see more discussion and collaboration. I have been advised that perhaps on the one hand the Committee and the IACMST and NERC have not had a lot of collaboration in the past. Oceans 2025 is an encouraging development and we need to see more of it.

Q512 Dr Turner: You carefully skated around the question about funding.

Jonathan Shaw: There will always be demands upon funding. Is the level of marine and scientific research going to get to the same level as terrestrial research? That would be a huge leap and I do not think that is likely. We will have to see what comes out of the CSR but it is reasonable for me to say that we need to use our money in a more collaborative way with other countries and I also think we need to see greater use of the significant resources that have gone into the Research Councils.

Professor Sir Howard Dalton: The Minister is absolutely right that we have to get our priorities sorted. There is an issue over funding for marine science. I agree with that. If you look at the amount of money that we were putting into the marine environment research spend in 1994, it is the same as it is today in real terms. Therefore, it is less. You ask yourself: are you doing the same amount of research? We are being quite innovative in realising that there is less money available than there was. We do need to work very closely with our partners on it and the Minister is quite right in saying that what we have to find ways of doing is to team up with as many people as we can so that we do not all start doing the same sort of things. Working with our European partners has been very important. Working with the Natural Environment Research Council is a very useful and helpful way forward. We have to be more careful in the way in which we spend our money. You ask any scientist, "Are you spending enough money on your particular project?" any scientist will say, "No, we can always spend more" and we can. What is being clever is being able to do the right sort of science at the right time with the same amount of money. That is really what the challenge is for us and we try to do that.

Jonathan Shaw: We do compare well with other countries as will be illustrated with the information that I will provide to the Committee.

Chairman: Can we ask Sir David the same question? The real issue here is that throughout this inquiry we have been impressed by witness after witness, both the other side of the Atlantic and here, who have made the significant point that the research into what is happening in our oceans is absolutely fundamental to the future of this planet. Therefore, to hear that we will make the resources go a bit further perhaps is not the exciting response we need. We need someone to fight for this.

Dr Iddon: We are not even touching the deep ocean. We are talking about research on the continental shelf largely at the moment.

Q513 Chairman: Sir David, triumph. This is your opportunity.

Professor Sir David King: I want to respond by reminding everyone that there are two forms of government funding that we are talking about. One is the Research Council funding which is pushing the frontiers of knowledge. The other is government funding which is advising governments on policy decisions. They have different intents and different contents. At the same time, in the best of possible worlds, they pull in similar directions and I think this is an example where things are moving in a way that synergises these two aspects of the work. We had a discussion about Oceans 2025. That is a NERC led project. If you read their 2005 to 2008 projected work, you will see that it is right up there as one of the projects they plan to fund with increased funding. Within NERC there is a very clear understanding of the reason why we need to fund marine science more heavily. For example, the Exeter meeting on the impacts of climate change held at the beginning of our presidency year of the G8, a big, international meeting. I was present throughout that meeting and I can attest to the fact that it was the British marine scientists who led the way on this new area of concern which is what is climate change doing to our oceans. It was British scientists, funded very largely by the Met Office and NERC who were leading the way in terms of developing areas of science that needed exploring. This question of acidifying the oceans really became apparent through British work from Portsmouth and Southampton that was presented at that meeting. On the one hand we do have excellent research and I personally think that NERC has a chief executive and a council that are focused on trying to moved as quickly as possible into these critically important areas. From the point of view of the government department, there is much to be done in taking that research and converting it into policy advice. For example, we look at the movement of plankton, plankton being the beginning of much of the food chain. If Arctic plankton is moving north and we are seeing data showing 1,000 kilometre movement north, a different variety of plankton is moving up to replace it around the British Isles. What are the consequences for the marine food chain but also for the land based food chain, both in terms of cod stocks and fish stocks generally, because the fish larvae eat the plankton; but also in terms of bird populations, because the birds feed off the ocean reservoir as well? All of this feeds directly into Defra's responsible area in terms of the fisheries of the United Kingdom but also in terms of the environment. The Department has a very clear responsibility and, as time moves on, it really needs to look very carefully at the level of funding and see that it is appropriate to the needs.

Q514 Chris Mole: The Minister referred to applied science and Sir David was talking about some of the products of a particular scientific project. I am not sure whether these are some of the 350 projects mentioned earlier but Sir David referred to monitoring plankton and that is part of building up a long term picture about what is happening in the ocean, along with measuring acidity, salinity, temperature and all of those data sets. Whose responsibility is it to ensure that we have that continuous monitoring? Is that something that is going to sit with Defra? Has it been with the OSI in the past because of the project funding approach? Who is going to get hold of that and say, "We need this information on a continuous basis in order to properly inform our public policy in this area"?

Professor Sir Howard Dalton: One of the things the Minister referred to early on and the one thing that we and IACMST have been very concerned about are marine data, what we do with marine data, where they go, how are they being properly used and can it be properly used in the future. There have been something like, when we started to look into this business, 350-odd data sets all out there, all over the place in different forms, all of which were necessarily important if we want to understand what is going on in the marine environment. Through our Marine Data Information Partnership initiative from IACMST, an activity that IACMST got engaged with, we said, "Let us try and put all this together so we have a proper system." We funded that with some money that came from NERC particularly in order to be able to set up a very small team of people to bring all that information together. We in Defra and many other organisations around the UK collect data together and put them all down so that they can be thoroughly used. The MDIP partnership has been responsible for pulling those data together and making them available in a form that everybody can then use. Defra funds an awful lot of this activity in what we call the non-R&D side of the budgets which is to do with monitoring, understanding what the fish stocks are, understanding what is going on in the environment, doing the sort of measurements that Sir David talked about in terms of CO_2, acidification, salinity measurements, funding a whole load of activities out there for monitoring the marine environment which is an international activity. It is not just a UK activity.

Q515 Chris Mole: Who should be pulling it together on an international basis?
Professor Sir Howard Dalton: There are people who are pulling it together on an international basis. We have this global observation system for the ocean, GOOS. There is a number of internationally coordinated activities to look at the marine environment and that is part of it. We pull our weight by looking at the activities around the UK.

Q516 Chris Mole: Does that mean our contribution towards ensuring that things like the ARGO floats are going to be there and replaced when they drop off the system?
Professor Sir Howard Dalton: That is an issue that I am concerned about. I am concerned about the funding and deployment and the continued funding and deployment of ARGO floats, which are playing a very important role globally, where the UK should be making a contribution to the international activities. We struggle every year to get money for it.

Q517 Chris Mole: There is no worry that that will not continue?
Professor Sir Howard Dalton: I am worried that it may not continue. We need to ensure that government, if it wants to involved in all of this, funds it properly and does not give us a situation every year where we have to go cap in hand, trying to raise money for it.

Q518 Chairman: The question that we would like an answer to is: whose responsibility is it? You have mentioned that Defra have pulled this together and the Committee are very supportive of what has been achieved there. In terms of some of the long term, continuous plankton records, NERC is doing that but it is doing it on a cycle by cycle basis.
Professor Sir Howard Dalton: It is funded by Defra but it is done through SAHFOs, the Sir Alistair Harding Foundations.

Q519 Chairman: In Plymouth?
Professor Sir Howard Dalton: That is right. Defra funds it and Defra has taken on board the responsibility for ensuring it is continued.

Q520 Chairman: It would be better if Defra took on responsibility for all the recording, do you think?
Professor Sir Howard Dalton: Probably. It is very useful for Defra to have some sort of element of control over what is going. IACMST which I chair has to go to a variety of different departments to get bits and pieces on this and I think it is good for somebody to pick it all up.

Q521 Chris Mole: That would be a new funding structure, a new approach to saying, "This is monitoring information" as opposed to scientific project based research?
Professor Sir Howard Dalton: We need a strategy for bringing all of that information together under one roof. I cannot disagree with that. I think it is sensible.

Q522 Chris Mole: Would Professor King endorse that?
Professor Sir David King: Absolutely. That should be closest to the department where the policy is most heavily involved.
Jonathan Shaw: In terms of bringing together organisations, I referred to *Safeguarding the Seas*. That brought together 60 organisations in the UK. Defra did that. Certainty of funding is very important for this. We have just agreed a ten year funding for CEFAS, which I know Chris Mole has visited recently in Lowestoft. There is commitment to long term funding to provide the certainty that science needs.

Q523 Chris Mole: We discovered in another inquiry that DfES has the lead on global monitoring for GMES.
Jonathan Shaw: Global Monitoring and Environmental Security.

Q524 Chris Mole: DfES has the lead on that?
Jonathan Shaw: CEFAS? Who are you talking about?

Q525 Chris Mole: Defra. There is some question about whether there was enough commitment to earth monitoring in general through satellite technology. Do you have concerns that we are maintaining as much earth observation from space as we should be?

Professor Sir Howard Dalton: I think I also gave evidence to your space committee that talked about GMES, Global Monitoring and Environmental Security. We did have some concerns again that we were not necessarily playing as full a role in being able to make contributions to it as we ought. There is this issue within Europe about *juste retour* in terms of satellite technology for GMES. If the UK is not making its contributions sufficiently large, UK industry begins to fall down a bit there. It is a bit like all of these monitoring systems. They get more and more sophisticated every year. They get better and better technology and usually you would like to see the technology getting cheaper but more often than not it does not. It is important that we try and pull our weight as far as GMES and satellite monitoring are concerned and that is an important part of that.

Q526 Chris Mole: I was not going to return to the funding question but we have raised even more demands there. Everyone has highlighted the imbalance in terrestrial and is not the answer to shift some of the money within the department on terrestrial monitoring of the environment to the oceans? It is 87 per cent of the biosphere and a huge amount of our biodiversity as well. Is that what we should be doing, Minister?
Jonathan Shaw: Each area of research is very important, whether it is on terrestrial or marine. We look forward to the Committee's conclusions and we will consider funding as we go forward. We are not alone in terms of how we compare to other countries. We are pretty good. With the determination for more collaborative work, we can undertake the type of work necessary to get the answers. That will then feed into policy, whether that is of an Oceans 2025 type or in terms of the stuff that Defra does, if it helps influence us when we are making decisions on fish stocks, or whatever.

Q527 Chris Mole: It was a vain stab on my part.
Jonathan Shaw: I cannot announce today that we will be cutting one stream and moving it over to marine research.
Professor Sir David King: It does seem to me that there is something critically important here. As we move forward over the next 10, 15 or 20 years, the pressures on our environment will continually increase. I am talking about pressures on the marine environment and the land environment. Our population globally will continue to increase. The climate change issues are an additional strain to all previous strains. At the same time, science has become capable of handling these extremely complex issues with very clear outcomes. That means that a government that is going to use the best scientific advice is going to do it in the best interests of its own population and more broadly. The basic message I want to get through is that it is going to be tough leaving Defra to say, "Now we have this new challenge we will just switch our resources onto another challenge that is arising." We need to look at the global funding. I do not think we can find a way round this just by saying, "Shift your budget around." Look at it globally and see the nature of the challenges that Defra particularly is faced with.

Q528 Chris Mole: Professor Dalton, just now you were talking about better coordination of a lot of the monitoring and measurement work. What steps have been taken to ensure that all the data output from publicly funded operations is available to researchers? I think it is important that we ensure that we do not get duplication or people are not having to do work twice. Specifically, are you confident for example that the mathematic data that comes from the Hydrographic Office is not degraded before it gets into the scientific arena?
Professor Sir Howard Dalton: I cannot give you a 100 per cent guarantee, but I can tell you that we are working very hard to ensure that all the information through our Marine Data Information Partnership operation is making those data that we get available to everybody. The whole point of this was that we wanted to get as much information into the system to make it as freely available for researchers to access so that the work can be done very effectively. You have to accept sometimes that some of those data are difficult to get because there is a commercial need to maintain and keep them. In a sense, it is not going to be a perfect data set but what we are trying to do is say to everybody, "Look, you put all that information into the system. You will get an incredible amount of information back." That is all we can do. We are making it available for everybody else. Anybody who wants to sign up and give us data gets access to the system that we are allowing. There is a multiplier. If you put data in, you get a heck of a lot more data out. We are putting it in a form that is accessible to everybody because when you look at data sets from a whole variety of different situations, they all have to be deconvoluted and restructured so that it makes sense to everybody. That is an issue that we are working on and that is why we have a management team to do it.

Q529 Chris Mole: There is no risk that bits of agencies that are asked to operate in trading functions are going to end up charging for things that academics really cannot afford?
Professor Sir Howard Dalton: I would hope not. I cannot guarantee it because you cannot hold a sword over people's heads and say, "You must give us those data." It is very difficult for us to ensure that but we are trying to do things for the good of the marine community. That is the way it works.

Q530 Chris Mole: Does the Minister need to talk to his defence colleagues about the information we get from some of their agencies?
Professor Sir Howard Dalton: He might.

Q531 Chairman: When we were on the *James Cook* with scientists there, they said they often find it more difficult to get data from UK based operations than they do from operations the other side of the world. I think it is an issue which we need to have a clear policy on. You have stated that publicly funded

research data should be available within a timescale which allowed researchers to be able to do their initial investigations and to write their papers, which seems perfectly reasonable. You are nodding in accordance with that?
Professor Sir Howard Dalton: Absolutely. I agree with that 100%. I do not think those data should be kept secret. I really think it is important for the community and for UK plc to have access to them and for other people to have access to them, because they also in turn can give us their information. It is not just UK based. We are working with our European partners on this and that is an important part of the 19 centre organisations that Defra has been organising which the Minister referred to at the beginning, which I think is playing a very important role in us working with our partners to get as much information out of them as possible.
Jonathan Shaw: We will look at that and send the Committee a note on how quickly we get research information out.

Q532 Chairman: Would you like to make a recommendation?
Jonathan Shaw: It is something that you have found from your trip on the *James Cook* and if these things come up we want to answer those points.

Q533 Chairman: It was not a trip, Minister. It was a research visit.
Jonathan Shaw: You are correct. Thank you for putting me right.

Q534 Dr Turner: When the Marine Bill finally arrives, it is going to propose setting up a chain of marine protected areas. This is already looking a little problematic because of the deficiency of data. It is difficult to be truly certain as to the areas that most need protection. Can you tell us a little about how you see the designation of marine protected areas being done and how big is the coverage? What sort of conservation measures do you envisage?
Jonathan Shaw: You are right to point out that within the Bill there is going to be this opportunity. In terms of me defining how large they are going to be and how many there are going to be, with all matters in this area, we will develop that. We will not say there are going to be 15 or 20. We need to see how they progress and what type of information they provide for us. It will be about trying to preserve stocks. It is unlikely that they will be able to preserve fish stocks because obviously they do not recognise non-fishing areas. It would be good if they did but, for other crustaceans and other forms of marine life, there will be fishing and no extraction of minerals within those areas. That will then provide us with important information as to whether that has a positive effect upon oceans and marine life.

Q535 Dr Turner: You have a target of getting this network of MPAs in place by 2010 which only gives you three years. There is not time to get a significant amount of data to decide where to designate. How will you cope with that? Is there a sensible case for saying, "Let's have sufficiently comprehensive coverage and collect data later"?
Jonathan Shaw: My presumption would be that there will be a range of different areas that we would cover within our coastal shores to provide information on a range of different species.
Professor Sir Howard Dalton: We do have extant marine protected areas. Lundy. Skomer.

Q536 Dr Turner: About three square kilometres?
Professor Sir Howard Dalton: You are pretty close, yes, 3.3. Those are areas where of course there is substratum corfal growing and therefore with crustaceans particularly we can look at those but there is a bigger issue. We are doing an awful lot of monitoring of the seas in order to be able to look at what is happening to fish populations: whiting, cod, herring and so on. We will almost certainly have to come up with protected areas in order to allow those stocks to recover. It is important that we understand what is going on in the whole food chain in order to be able to understand best how we are going to be able to stimulate and allow those stocks to recover and develop a viable, profitable fishing industry.

Q537 Dr Turner: It is my understanding that the thing is meant to be based on the ecosystem approach. Unfortunately we do not sufficiently understand those ecosystems at the moment to be precise about designating areas but equally, if we have not designated some areas, we probably will not be able to understand the ecosystems. There are some conundrums to be resolved here. It is going to need some funding. Will that be in place?
Jonathan Shaw: I have just been handed some inspiration. I am advised that there has been a lot of work that has been undertaken in the network areas already. We can provide the Committee with an up to date report of what work has been undertaken. What we intend is by 2012 to have made substantial progress in completing our network by designating additional European sites, bringing the total of fully marine sites into the territorial sea adjacent to England and the UK offshore area to around 30.

Q538 Chairman: In terms of these marine protected areas, it is not clear to me what it is we are trying to achieve and how we get the balance between commercial exploitation of the seas, which is absolutely crucial—we had figures earlier about the commercial benefits of the oceans as far as Europe is concerned—and the need to do good science. Are we going to have marine protected areas which exclude the science or are they going to simply exclude commercial activity? How do we decide the balance between the two?
Jonathan Shaw: In the White Paper it says that by 2020 we want to develop a network of effectively managed sites comprising European marine sites, including highly protected sites. We want to conserve enough rare, threatened and representative species and habitats to maintain and improve

biodiversity and ecosystems whilst covering as small an area as possible. It sets out what our intention is for these sites.

Professor Sir Howard Dalton: Marine protected areas in this context have to be thought of in terms of what you are going to do with them. You are absolutely right. We are not going to be exploiting these particular areas. We are not going to be fishing these areas because if you do that then the whole thing gets screwed up anyway. What we need to do is good quality science that helps us understand what is necessary in order to regenerate the populations of stock that can then ultimately be fished in the future. The reason behind producing these protected areas is that we can get into them and understand what is going on from a scientific perspective.

Q539 Chairman: Can I put a scenario to you? If you put an offshore wind farm three kilometres square, where clearly commercial fishing cannot take place for very obvious reasons, could that become a marine protection area as well? Can you have these two functions going on at the same time, where you can develop a specific site but have a commercial activity as well which is not in conflict?

Professor Sir Howard Dalton: Commercial other than fishing? You have something there. I do not know to what extent offshore wind farms affect the marine environment. We are doing work on trying to understand a bit better what is going on there. It was quite interesting that IACMST produced a report on underwater sound and the effects it has on marine populations. It is quite significant and important. You do get transmission of underwater sound from wind farms. There is an effect there. It may well be a bit more difficult if we are going to try to understand better what is going on in the marine environment. Possibly we need as little commercial interference in those areas as possible.

Q540 Linda Gilroy: There was a strong perception amongst the marine science community that a good proportion of the protected areas would be like Sites of Special Scientific Interest on land. Presumably from what you are saying there is no danger that that will be let slip? I have been lobbied by my very large local community to express some concerns that this might not even appear in the Marine Bill, which I am seeking to offer reassurances by other means is not the case. Can you offer the Committee that assurance?

Professor Sir Howard Dalton: No, I cannot offer the Committee that assurance. What I can do is ensure that my ministers understand that that could be a potential problem.

Q541 Dr Turner: There is a very clear possibility that some of the areas which you most want to protect are also areas—for instance, they may have very good tidal streams—that are very desirable for development from the point of view of tidal stream energy, for instance. Do you see a conflict?

Professor Sir Howard Dalton: If you are talking about something like the River Severn—

Q542 Dr Turner: I am not talking of barrages.

Professor Sir Howard Dalton: What are you talking about?

Q543 Dr Turner: For instance, the tidal stream turbine which is waiting to be installed in Strangford Lock right now.

Professor Sir Howard Dalton: I do not know. It is a perfectly reasonable question to ask and as a scientist I say why not just get the evidence. Let us evaluate that and look at what is going on. What is the impact of that? Then we can make a sensible decision. Unless an environmental impact assessment had been done prior to that, which would help inform it, you will not get the information you need to put it in and do all the measurements, again a very good case to be made for us getting the science right so that we understand what the implication might be for other places.

Jonathan Shaw: One of the purposes of the Marine Bill will be that planning will be at its heart. With all of the potential conflict, we need to get the proper planning and regulations in place.

Q544 Chairman: We have heard a lot of evidence during this inquiry about blue biotech or marine biotechnology. I wonder what the government's policy is towards marine biotechnology and where we are going?

Professor Sir David King: I am going to defer to Sir Howard on this one because you are referring to exploiting the biodiverse systems that still exist in our oceans for potential economic benefit.

Q545 Chairman: Or even for soaking up more carbon dioxide or using plankton.

Professor Sir David King: These are areas that all need to be explored, but I defer to Sir Howard.

Professor Sir Howard Dalton: The answer is yes, we are engaged with our partners. It is not the sort of thing necessarily that Defra has a direct, immediate role in. We do work very closely with the Natural Environment Research Council and there is a programme on microbial biotechnology in the marine environment. Indeed, I spoke at one of their conferences very recently on how one could think about exploiting marine systems for biology. Take for example the experiments that Craig Venter has been doing in Bermuda, where he has been looking to identify what sort of organisms are out there in the marine environment. On one major fishing expedition he identified something like several thousand new microbial species about which we know absolutely nothing. That is a very good example, it seems to me, of using science proactively to try and understand what they are doing. What NERC has done very cleverly is look at a whole number of organisms that they have isolated from the marine environment and asked the simple question: do they do anything interesting that we know nothing about? The answer is yes, they do. In a number of cases they are producing pharmaceutical compounds which no other organism on this planet, as far as we can tell, is able to produce. There is an example of exploitation there. We are understanding

better how various genes are transferred between one organism and another and that is also making a big difference.

Q546 Dr Iddon: The Foresight Marine Panel was set up in the 1990s and disbanded. What did we learn from that exercise?
Professor Sir David King: It was set up in the 1990s, shortly after the original Foresight Programme was established. The question is?

Q547 Dr Iddon: What did we learn from that exercise?
Professor Sir David King: The Foresight Programme that was established in the mid-1990s was a very different beast from the one that we have now. What we learned was a matter of very broad ranging knowledge, who was the marine science community, who should be pulled together, what sort of research was already being done and how was the industry interacting with that. There was a very broad learning process. Interestingly, after the Office of Science and Technology stopped the programme, it continued. It had a life of its own and continued for a few years. Clearly, the people within the Foresight Programme felt it was worthwhile to keep connected. Much of the outcome has gone into both the industry and the Research Councils in terms of current work.

Q548 Dr Iddon: It made a number of important recommendations like campaigning to improve public awareness of the marine environment and the science, leading roles for three Research Councils, the formation of government departmental strategies for marine technology. What are we going to monitor in terms of whether those recommendations have been carried out or not and have been effective or not?
Professor Sir David King: I am sure the Minister will explain to you that these have been largely taken on board by Defra.
Jonathan Shaw: In terms of improving the quality of marine water, that has happened. Where there still are problems they are probably for historic reasons in estuaries. We do not pollute the sea in the way that we used to. Man's behaviour is causing other problems in terms of global warming. Elsewhere, I am thinking about the target we have by 2015 to ensure that our fish stocks are at a sustainable level. That was agreed in Johannesburg. That again is an international agreement. There is a great deal of awareness of that. So many people are employed within the marine industry and related industries. It is in the region of 450,000 people. There is awareness. Take blue flags. People are aware of cleaner beaches these days, at a very practical level. We want to open up coastal footpaths and coastal areas. We have made some strides but in terms of monitoring whether we are making sufficient progress, this Committee is doing Parliament's job for it in making sure that we are held to account.

Q549 Dr Iddon: Could I ask Sir Howard about the European Commission and the Framework Seven Programme in particular, but also the Marine Strategy Green Paper? What input are we putting into one and what are we getting out of the other? Marine science does not seem to play a very large role in the Framework Seven Programme. Am I wrong?
Jonathan Shaw: We are pleased that marine and maritime have connected. Defra has made contributions to the consultation which has concluded now. We are not expecting any legislation to come forward this year. It will probably come forward next year. Some of the things that we want to do in the Marine Bill we think will be unlikely to get agreement in Europe. What we want to do in the Marine Bill is to be at the forefront of marine legislation and inform Europe as they draw up legislation.
Professor Sir Howard Dalton: I am not familiar with the contribution that comes out of the Framework Seven programme on the marine environment. I ought to know it but I do not. We certainly interact with Framework Seven largely through our Centre for Environment, Fisheries and Agriculture Science Centre because that is an important part of where we interface.

Q550 Dr Iddon: Perhaps somebody could write to us.
Jonathan Shaw: I am informed that our memo to the Committee highlights our involvement.

Q551 Dr Iddon: On research, as you have heard, the Committee has visited the *James Cook*. I did not go but I gather it is a pretty impressive vessel and also very costly. We have also heard that the number of vessels in our fleet for research at sea or on the continental shelf and in the deep sea has reduced over the past year. Whilst we are talking about collaboration with Europe, are we planning to build more ships or are we going to plan to collaborate more within the European Union for exploration?
Jonathan Shaw: The *James Cook* cost in the region of £25 million. That was a substantial capital investment and we hope we get a good return on that investment and the research undertaken. I am pleased that the Committee has been on that important fact finding mission, not a trip of course. In terms of whether we are going to extend the fleet, I am not aware. The collaboration point is well made. I know that in previous evidence you asked whether the Royal Navy were involved in some of that research work and I understand that they are. We will make use of all the resources at our disposal. We are developing new technologies that enable us to record information in some of those buoys.
Professor Sir Howard Dalton: CEFAS and NERC both have ships. It is important that you recognise that if you have ships you want to be using them all the time. You do not want them docked up too much. We are trying to dovetail our research requirements with the Natural Environment Research Council and with other people who need access and the use of those ships. That is very important. The whole idea is to ensure that we are all

getting the maximum amount of activity out of those. We cannot afford to have them in dock for too long.

Q552 Linda Gilroy: Whose responsibility is it to monitor and address skills shortages in marine science? Where do you think the key skills shortages are?
Jonathan Shaw: Defra commissions research. One of its principal bodies is CEFAS. We have a ten year funding agreement with them. That ensures certainty. We have collaboration arrangements. Where there are shortfalls, people are recruited internationally as happens a great deal with science of this nature. In your own constituency, obviously as you are aware, we have the Plymouth Laboratory. We have very highly regarded institutions. People want to come and work in them so I think we are reasonably well placed. Our marine science base is well regarded. It has not been highlighted to me since taking over this job that there are particular shortfalls.

Q553 Linda Gilroy: It has been highlighted in various sessions with us that there are shortages. The Proudman for example told us that the UK skills base for marine science is not healthy, particularly in the area of marine physics. Other witnesses have identified shortages in everything from mathematicians, oceanographic and ecological modellers, molecular biologists, environmental geophysicists and taxonomists. There is also concern about the recruitment of young people into marine science and whether the opportunities are well enough known.
Professor Sir Howard Dalton: All the disciplines that you mention are quite well served in the United Kingdom but not necessarily for the marine environment. In other words, if you look at the molecular biologists, the physicists, the mathematicians, they tend not necessarily to move into the marine environment when it comes to applying the work that they do, but I agree that there is a shortage in certain areas, particularly in terms of taxonomy, ecosystems analysis and also probably in terms of modelling. It is a question really of trying to attract the existing individuals who have skills in those areas to apply them to that particular discipline.

Q554 Linda Gilroy: How? Given the importance that I think we are agreeing should be attached to the future of marine science, how can we up the ante on that?
Professor Sir Howard Dalton: I have just come back from a BBSRC meeting, on which I also sit, where skills shortages have been identified for laboratories such as the Babraham Institute, which feels that it needs a lot more people who understand mathematical modelling. This is now an area which is moving up the agenda for an awful lot of science disciplines. How do you attract people? You put resources into it. You make it an interesting area for people to want to go into. You talk about career structures for people and that is the way you get people to move into those areas. What attracts people to these things is exciting and interesting science. If the science is interesting, needs to be done and is valuable, people will move into it.

Q555 Linda Gilroy: Given the importance of climate change, how can we ensure that people are aware at the stages they are making their decisions and also that the money is right in research as compared with other attractions that there might be, particularly for mathematicians and modellers?
Professor Sir Howard Dalton: I do not necessarily think it is Defra's job to do that. The Research Councils have a very important role to play. Universities have a very important role to play there in terms of trying to stimulate activity in those areas. There is quite a number of courses that are going on in a whole variety of different university departments in these sorts of areas. I think about Bangor, Plymouth, York and all the courses that they put on. Newcastle puts courses on in these areas. St Andrew's puts on some really good courses in these areas. There is a number of different universities that are all trying to stimulate activity there across the piece. Why people get concerned that there are not enough people out there filling the gaps that they perceive is because sometimes these are highly specialised areas that have some difficulty in attracting an individual or group of individuals to those particular areas.

Q556 Linda Gilroy: Is it also because of lack of continuity of funding and security which we talked about earlier? In particular, CEFAS has complained that lack of funding for salaries and continuity of research is hindering their ability to recruit good scientists. Do you accept that that is a problem?
Professor Sir Howard Dalton: Yes.

Q557 Linda Gilroy: Any advances on what we have already discussed in how that could be put right?
Professor Sir Howard Dalton: The way in which you get scientists engaged in these sorts of issues is to pose some very interesting and fascinating problems that they want to work on and in such a way that there is a career structure associated with them too. Once you have both of those in place, you do not have a problem. There is a whole load of areas of science where we have no problem in recruiting people. That is because they are challenging, interesting areas of science and they are at the cutting edge of what is going on.
Jonathan Shaw: If the ten year funding is not as much as people want that is a shame but in terms of providing certainty, if projects can be undertaken and completed, that is a positive development. I am pleased you have raised the question because it is a very interesting point.

Q558 Linda Gilroy: Finally, a couple of questions on raising awareness first of all amongst school children on learning related issues and then the wider public. What research has been conducted into wider public awareness?

Professor Sir Howard Dalton: As far as school children are concerned, I think they are being served pretty well these days. If I think about the laboratories for which I had former responsibility within Defra and I look at CEFAS, I think they are an exemplar in this area. Particularly for example in Weymouth, one of the CEFAS laboratories there brings in lots of school kids. They spend time there, getting engaged in some of the projects and activities there.

Q559 Linda Gilroy: Who pays for those programmes?
Professor Sir Howard Dalton: We do.
Jonathan Shaw: We want to see more collaboration with universities and schools. The government set that out within the last Education Act. The recent references to a curriculum change concentrated on climate change and part of that should be about how climate change is affecting sea life. We have published *The Marine Fisheries Science Yearbook*. I think you have all seen a copy. I have brought you all a copy if you have not. That sets out some of the work undertaken by Defra in a very informative and clear way. There were 226,000 length measurements and 24,500 samples taken of age determination of fish, so huge amounts of work are being undertaken which informs our policy.

Q560 Linda Gilroy: Does it inform the wider public?
Jonathan Shaw: Information is disseminated. It has to happen in the first place. Do the public understand that there is an issue in terms of the amount of fish and cod in the North Sea?

Q561 Linda Gilroy: That is the question we are asking. We have had a very short inquiry on science centres and there is a group of science centres that I would draw to your attention, normally known as marine aquarians, but there are displays in other science centres as well relating to climate change, the oceans, fish, et cetera. When we were in the United States we came across a programme called Sea Grant. I do not know if it is one you are familiar with but I would certainly recommend it as something to look at because it is a programme which funds the States to do a whole variety of public awareness and education of school children amongst that, which I think has produced some quite exciting results and includes the support of some marine aquarians.
Professor Sir Howard Dalton: The other CEFAS laboratories do get actively engaged in it and for example in Plymouth, where the aquarium is and where you have the MBA, the PML, the university all together in one place, they do a seriously good amount of work, working with the local community and with school children. That s a good way of being able to stimulate it. I know it goes on in other university areas. I know St Andrew's carried out a lot of work in that area.

Q562 Linda Gilroy: Is there scope for having a coherent approach towards that or do you think you already have a coherent approach?
Professor Sir Howard Dalton: The various institutions are conscious that they need some sort of future life blood fed into them. They recognise the value associated with getting to kids at school age because stimulating them at that sort of stage can be critically important in later years. I know from my own experiences how stimulated I was by those sorts of activities going on in schools and I think that is a really important area.
Jonathan Shaw: We have not done enough. The funding disparity reflects that. I hope that with the Marine Bill, when we have eight or nine million people who are members of environmental NGOs, all of those organisations getting their members to lobby Members of Parliament to support this important piece of legislation, that will raise awareness of the importance of our actions.
Chairman: On that note, can I assure you, Minister, that we will also be raising awareness through our humble efforts. Can I thank the Minister, Jonathan Shaw, Parliamentary Under-Secretary of State at Defra? Thank you very much for coming at such short notice. We very much value your contribution. Thank you again, Professor Sir Howard Dalton, Chief Scientific Adviser at Defra. As ever, it has been a pleasure to listen to you and, in his absence, Sir David King.

Monday 23 July 2007

Members present:

Mr Phil Willis, in the Chair

Linda Gilroy
Dr Evan Harris
Dr Brian Iddon
Chris Mole
Dr Desmond Turner

Witnesses: **Professor Alan Thorpe,** Chief Executive, and **Dr Phil Williamson,** School of Environmental Sciences, University of East Anglia, Natural Environment Research Council, gave evidence.

Q563 Chairman: This is the final evidence session of our inquiry *Investigating the Oceans*. We welcome today Professor Alan Thorpe, Chief Executive of the Natural Environment Research Council, and Dr Phil Williamson of the Natural Environment Research Council and the University of East Anglia. I apologise for starting this session slightly late. You have probably gathered that there are some issues regarding the future of the Committee and we want to deal with one or two of those, which means that we are in an even worse mood than we normally are! Alan, we have enjoyed this particular inquiry very much indeed; it has been a very useful inquiry to us. We note that you have a strategy 2007-2012, the NERC strategy, and we wondered where marine science and technology fit into that whole strategy. What emphasis and prominence has it got?

Professor Thorpe: The new strategy is quite a break from the past in that we have a combination of science themes that are cross-cutting. We have seven, which include climate change, earth system science, biodiversity, et cetera; so they cut across all the disciplinary areas and are thematically based, as the name suggests. We also have a clearer focus on the funding that we give for maintaining national capability in core disciplinary areas in environmental science. We are going to put a clearer emphasis on maintaining and developing that national capability, and marine science, atmospheric science, earth observation are amongst the disciplines on that axis. We will be looking at both maintaining the marine science and technology capability overall, and that obviously is largely but not exclusively delivered by the marine centres, via the Oceans 2025 Programme; but marine science also appears in the thematic research programmes that cut across. In terms of research programmes, marine science is in many of these themes, as you can imagine.

Q564 Chairman: Are you confident that NERC is addressing the right issues in terms of sponsored science in regard to marine science? The community feels that perhaps it is not getting its fair share. They would say that, I know, would they not; but it is important. There is a feeling that in the past there has been too much emphasis on climate change and that that has dominated over other aspects of marine science. Is that fair?

Professor Thorpe: It is a big question. The issue of whether there is sufficient funding going into marine science is one, of course, of prioritisation, and NERC Council is responsible for making that prioritisation. The new strategy is very clear in terms of its strategic goal, so it is very mission driven, and it is to deliver what the Council feels are the major priorities in the environmental issues that we are facing. Climate change is undoubtedly one of the main issues that we are all having to face, but the strategy—when it is published in September—focuses on environmental change, which includes not only the impact of climate change but the many other ways in which the environment is changing around us, and we have to cope with those changes. I would say that whilst climate change remains one of the central drivers for environmental change, there are many others as well, and they do come out in the new strategy, I feel. I am very confident and content with the new strategy, which, by the way, has been consulted on quite widely. We had an open consultation on the strategy and had a lot of inputs. It has attempted to reflect the priorities that the scientific community, which helped us write it, are interested in and feel are at the forefront. I would say that the new strategy recognises the importance of climate change but is much more holistic and wider than that. It is definitely focused on providing the scientific evidence to address the environmental issues that society and the economy face. That is an unashamed focus of the new strategy.

Q565 Chairman: Phil, in terms of marine science and ocean science research, do you feel that NERC has got the balance right?

Dr Williamson: I think it has got to compete with the other areas of science and the other interests there. But within all of the seven themes in the new strategy there is a very important marine element there. In the totality of marine science there is not much that one misses out from that; all of the main features are there.

Q566 Chairman: So you are happy that they are being properly addressed. Let me take one area where concern has been expressed to us, and that is about the Arctic. There is a great deal of work, obviously, in terms of marine science, which concentrates on the Antarctic as being the main source—and, to be fair, we were very impressed with what we saw in the British Antarctic survey; but would you accept that we are not doing much in the Arctic and that we need to change our priorities in that area?

Professor Thorpe: Perhaps I can pick that one up.

Q567 Chairman: Do you disagree?
Professor Thorpe: No. Well, let's see what I say, first! I do not disagree with what you said. NERC Council has recognised that particularly as a driver for climate change the Arctic is a key indicator of climate change. We expect the impacts to be large. We have made a start on investing more in research in the Arctic in the IPY—but it has been recognised by NERC that we need to rebalance and invest more in Arctic research. We have a polar study going on to isolate the priorities for the future, both Arctic and Antarctic, and Chris Rapley and Duncan Wingham are leading that. That will provide a focus on the key priority areas. We are also looking at the opportunities to collaborate with other countries in Arctic research. Many other countries are active, and we need to work with them where appropriate. We absolutely accept your point, but the new strategy recognises, and the Council recognises, that we need to do more.
Dr Williamson: From the Oceans 2025 perspective, then there is Arctic work, particularly by the Scottish Association for Marine Science (SAMS) but also with the Proudman Oceanographic Laboratory that has an Arctic programme. There may not be a dedicated Arctic research institute, but nevertheless there is work going on. Ten years ago you could have made that comment and it would have been fair enough to say we had neglected the Arctic, but I do not think that is the situation now.

Q568 Chairman: You have mentioned Oceans 2025. There is a concern—and this applies to a lot of the scientific community—that we do have the year off and then suddenly it is the year after where people say, "Where is the funding?" How confident are you that we can maintain funding for Oceans 2025 up to 2025 and beyond, or is it just—
Professor Thorpe: I am very confident because, as I have said, with the new strategy we have specifically identified the national capability to do environmental science that we think is enduring and long term. Quite a bit of that is marine science capability, but not just marine science. Therefore, the need for research vessels, for maintaining long-term data sets and the need for expertise to innovate in those, are things that the new strategy is clear we have to invest in in the long term. We will not only make that commitment, but we recognise that increasingly the question moves away from whether we need to have marine science capability to let us make sure that we are running it effectively and efficiently and innovating it. It is not a question of whether we need it, but how we can do the best job on it. That recognises the importance of maintaining long-term capability. It is not just in marine science but in the main disciplinary areas.

Q569 Chairman: It seems to me at any rate that the pressure on NERC funding for research will increase dramatically as there is a greater understanding of the needs to get to grips with climate change and the environmental impact of that, which hits your research council. I know that it hits them all but it hits yours head on. Is marine science likely to be a casualty if you have a limited budget with greater pressure on it?
Professor Thorpe: I do not personally feel there is any special reason why marine science should be a casualty of that. Of course, I could do nothing but agree with you that there is a great need, and there will be a greater need in the future, for environmental science research to underpin what society will need to do in the future. There will be increasing pressures on the NERC budget. Of course, we are making what we feel is a strong case in the spending review for our budget to go up; but no doubt there will still be much greater demand than we can fund. I do not see myself any reason why marine science should do disproportionately badly in that. It is recognised—and you can tell from the Oceans 2025 exercise—that marine science in the UK is very high-quality, and the peer review of that proposal made by the Marine Labs was very highly reviewed by the international community. You probably heard that from your visits to Woods Hole, et cetera. The UK community in marine science is very highly regarded. As you know, NERC is very focused on funding the highest quality, highest priority research; so there is every reason to suppose that marine science will do very well in the future, within the constraints of our overall budget.

Q570 Chairman: We were impressed when we were in the States and indeed in Lisbon as to how highly regarded was marine science, though there are a few caveats to that. In terms of Oceans 2025, when I was in Southampton recently I got a different view of Oceans 2025—that this was the way in which the research institutes were divvying up the programme between now and 2025 and it was about them rather than about the whole strategy. Can you tell us what is the truth about that?
Professor Thorpe: This is a very important point, and I think everybody is clear about this actually. Oceans 2025 is the name given for our core strategic investments in marine science that maintains the national capability to do marine science; it does not represent the totality of the funding that we devote to marine science, nor does it represent a holistic marine strategy. It absolutely focuses on the funding to maintain those centres' contributions to NERC's overall portfolio, and particularly to maintain the long-term capability to do environmental science, which the whole community can then utilise as well as those laboratories. It was never intended to be the total strategy for the UK's marine science investments. It is an important part, but only a part.

Q571 Chairman: Phil, why do you think universities did not understand that?
Dr Williamson: I think there are two or three reasons. Ten years ago, NERC did have a marine science strategy and it had an atmospheric science strategy and an earth science strategy, and that is the way it was structured. So when a document comes along that says "strategic programme in marine science" then for some people who are not fully

familiar with it, it might look as though NERC has gone back to dividing things up into marine, atmospheric and terrestrial. There is that possible confusion. Also, because Oceans 2025, for better or worse, tried to raise its profile and tell the wider community of what it was doing and what it was trying to do, it might then have suffered from a perception that it was more comprehensive than it really was. It is no more or less than the bid from the marine research centres, but the difference being that instead of having seven separate bids they came together as one co-ordinated bid.

Q572 Dr Iddon: I think that is the clearest statement we have had of Oceans 2025, quite frankly, ever since this investigation started. Other countries—and I name the USA and Portugal as examples, have "holistic"—as you used the word—national marine strategies. Now you are saying that we have not got one of those. Do you think that we should have?
Professor Thorpe: This is an important and complex question. It depends, for me, on what you mean by "marine strategy". For NERC we are talking about research components; and a marine strategy for the UK could incorporate science, it could incorporate policy et cetera.

Q573 Dr Iddon: Can I explain how I see it? I see it as used for transport, for energy supply, for recreation, the gaining of minerals particularly oil and gas, the gaining of food supplies, collection of data sheets and research and development. I personally—and I think the Committee might endorse my view—feel that all of that should be part of a holistic marine strategy. That is what I mean.
Professor Thorpe: NERC's contribution to that would be in the scientific research component of that strategy. My perception is that there is indeed not a holistic marine strategy in the way that you described it. NERC is clear about its investments in marine science, and why it is doing it and what it is hoping to achieve from it. Of course, NERC is not the only research funder of marine research in the UK, and there are various mechanisms for aligning and discussing strategies between the different research funders of marine science. I know that you have been discussing those, such as the IACMST, and to a degree also the Environment Research Funders' Forum. These are fora where there is read-across between the strategies of different research funders. You would expect me to say this, but I fundamentally believe that NERC investments in marine science are coherent and fit into NERC's overall strategy, but I absolutely take your point that the wider picture in the UK in terms of marine strategy is perhaps a more complex and confused picture.

Q574 Dr Iddon: My question was: would it be beneficial to the nation if we had a holistic marine strategy?
Professor Thorpe: I think it would be—the answer must be "yes".

Q575 Dr Iddon: Who do you think should draw that up, now that you have fallen into that?
Professor Thorpe: Clearly, one has to start at government level and where the driver is from a government policy point of view for a marine strategy to feed into that. There is a Defra Minister who has marine affairs within his wider portfolio. One might have imagined that beneath that a marine strategy would feed into such a minister, and a body like ERFF or IACMST could orchestrate the scientific component, and perhaps have a wider feed into that policy area. I suspect that the linkage I have just described could be improved operationally within the UK.

Q576 Dr Iddon: Obviously, NERC would have an important role to play.
Professor Thorpe: I would be happy for us to play such a role.

Q577 Dr Iddon: You mentioned IACMST as being a possible organisation to draw that together in a holistic way. We have some evidence that they have certain disadvantages and weaknesses and lack of powers, if you like. What, in your view, would IACMST have to become if it were to be powerful enough to do what we have just discussed?
Professor Thorpe: One should be aware of what it could not be and what it could be. It is clearly a place where one can align strategies and bring strategies of the member organisations together. It is not going to be a place where you can command resources of all of those organisations, but you can helpfully bring together a holistic strategy of what those organisations want to do. The key to me, to make it effective, is that it needs to have a strong feed into the policy and ministerial lead. I am not sure that that is the case. I do not personally sit on the Committee, although NERC does, but I am sure that that would provide the focus, if there were a strong flow-through of that holistic strategy into the ministerial portfolio. Phil might be able to comment on whether that pull-through is there.
Dr Williamson: At the moment, not much information goes further up. It can be described as a talking shop because views are exchanged and information is collated sometimes, but it does not necessarily drive any major decision-making processes.

Q578 Dr Iddon: Do you think the United Kingdom needs the equivalent of the US National Oceanic and Atmospheric Administration?
Professor Thorpe: This is another interesting question. In many respects, of course, we have parts of NOAA already, and it is called the Met Office. The Met Office is not purely a meteorological agency; it takes responsibility increasingly for operational ocean forecasting and observations to some degree. It is not a complete oceanographic institution but it has clearly got an operational oceanographic component. One can see the Met Office as playing a key role in a UK analogue to NOAA, and I think the Met Office is a very effective organisation in that regard. We interact on the

forecasting via the National Centre for Ocean Forecasting, which is both the Met Office and the NERC institutes. There is the possibility of having such a structure. You can look at NOAA within the United States and ask the question how effective that has been in terms of overall coordination, and there are challenges there within NOAA. For NOAA's total budget there are challenges. Just recently there have been difficulties about the earth observation component and the lack of funding for it. The head of the Hurricane Centre has just departed because of issues about under-funding of earth observation for oceanography. It is not without its challenges even if there were a NOAA. One could imagine the advantages of bringing a wider remit of organisations like the Met Office to look more holistically at ocean operational activities, because at the moment it is very narrowly focused in that area. There may be an opportunity there.

Q579 Dr Iddon: You are saying that the Met Office is doing some of what NOAA is doing, but by no means enough.
Professor Thorpe: Precisely.

Q580 Dr Iddon: In that NOAA brings the air and the sea together in tackling climate change. Do I interpret that correctly?
Professor Thorpe: Yes. The Met Office, because of the Hadley Centre being in the Met Office, brings together the relevant disciplines for climate change prediction and research. The Met Office is quite focused in its ocean-forecasting component. It has a very specific customer in the Navy for that, and it is probably not as broad in terms of the kinds of forecasting it produces as NOAA does; but Phil might know more about that.
Dr Williamson: NOAA includes the fishery responsibility, fishery management, so any UK equivalent of NOAA would then have to take under its umbrella the fishery laboratories in the UK and Scotland; and that is quite a major issue, bringing all of that under one area.

Q581 Chairman: Would that be a good thing?
Dr Williamson: Potentially. Any reorganisation causes some extra costs and resources, and restructuring does not come cheap. It would take several years before any efficiency gains came through.
Chairman: The reason I chipped in there was that when we went to BAS, and when we were in the States, we saw significant amounts of evidence which showed that it was fishing that had done so much harm to the seabed and that you could not have a proper marine science policy unless fishing was part and parcel of it. That is why we are looking at this area.

Q582 Dr Iddon: Here, it seems to be treated in a quite separate box to everything else to do with the sea.
Dr Williamson: If I reply personally, I very much agree, but it is not just a UK problem; it is also on a European scale that the fishing activity and management is distinct from the environmental activities; and so it has to be put back together in the UK and on a European scale. It is putting fishing in the environmental perspective—the climate change issues, the biochemistry, the biodiversity and the biotechnology—and all those links could potentially be improved.

Q583 Chairman: We have not got a cat in hell's chance with the current IACMST, have we?
Professor Thorpe: It depends what you require. IACMST can be a place where the whole range of marine, including fisheries, can share strategic overview; but if you are talking about an agency or an operational activity, that is quite a different thing from the way IACMST is set up.

Q584 Chairman: Would you prefer there to be an agency? Can we put that on record?
Professor Thorpe: I do not think I said that! I agreed with Brian, and I think Phil did, strongly, that there is a correct perception that there is a split in some sense between the fisheries side and the rest of marine science into environmental science, and we would benefit from bringing them together. I referred to the Met Office being the operational agency that links best on the environmental science of ocean forecasting. It is a more complicated question to ask how to bring in fisheries operationally together, but certainly I agree that it would be advantageous to have a more holistic view.

Q585 Linda Gilroy: To what extent do you expect the Marine Bill to act as a prompt to that happening?
Professor Thorpe: That is difficult to answer.
Dr Williamson: There is not a great deal of science implications for NERC in the Marine Bill, which is essentially about planning and management aspects. It may require a science input and it does require data and the background information, but the Marine Bill does not deal with the major step-change that is being discussed in this Committee.

Q586 Linda Gilroy: But it will have an impact.
Dr Williamson: Yes.
Professor Thorpe: Yes. In many respects the structural elements of the Marine Bill like marine protected areas and marine management organisation et cetera are structures that we would want to have a strong link with to make sure that the research evidence base fed into those activities. Our view about the Marine Bill is that we need a good feed of research evidence into the consequential structures that are set up. It is more difficult for NERC to comment on other aspects of the Marine Bill.

Q587 Chris Mole: We have been struck by the importance of various decadal-scales, datasets for informing change in relation to the climate or other aspects of the environment. Do you think NERC has the balance of funding right between core scientific research and some of the sustained ocean observation activities that are necessary to provide that sort of data?

Professor Thorpe: Again, it is an area that we have talked about on this Committee in other contexts on many occasions, and it is something we have to keep a focus on. NERC's position is quite clear: we are driven by the science priorities that we have. Often, to deliver the science that we want to do requires long-term data sets. Where we feel we need those long-term data sets and they do not exist, NERC is happy to invest in long-term data sets. For example, NERC Council took the view that to understand the thermohaline overturning circulation, as part of that system we had to monitor in the Atlantic, and we set up a monitoring system, and we are in that for the long-term. That was a science-driven need, to have long-term monitoring. A very much more tricky thing—and this comes up in earth observation a lot—is where research monitoring and instrumentation is set up, perhaps with NERC funding, and is then translated into operational long-term use. The hand-over of funding for that from the purely research to the purely operational, where NERC finds it much more difficult to invest long-term, is troublesome. It is not just in marine, but that is true in a number of areas. The only counter to that, I would say, is that we have all recognised that it is a difficulty, and there are a number of places, particularly the Global Environmental Change Committee and the Environment Research Funders' Forum, where specific studies are being done at the moment to look at monitoring holistically and to look at the hand-over from research into operational monitoring. I would not underestimate the difficulty, because, as I have said in the Committee before, the amount of monitoring that is necessary of environmental change that is going on is very great, and the resources we have to do it are limited. We are having to focus and prioritise, and that is extremely difficult to do.

Q588 Chris Mole: What are the kinds of agencies picking up those operational observations and how do we smooth that hand-over?

Professor Thorpe: I suppose an issue is that there is a wide range of agencies contributing to that monitoring. We have probably mentioned a number of them here. Defra clearly has a role; the Met Office has a role in sustained observations. A number of operational agencies can and do play a role. Even those operational departments and agencies are struggling to a degree to find the large resources needed to maintain observations. Just as an example, again in the earth observation area, the sustained observing that is needed for meteorological and ocean forecasting from space is a considerable burden on Europe, within Eumetsat and within the Met Office contribution to that. I know that Defra feels this acutely in terms of its contribution. We have discussed before various programmes like Global Monitoring for Environment and Security where a number of agencies need to come together to sustain that funding; and it is quite difficult to make sure that they do indeed come together; and the UK plays the dominant role, which I think it needs to play.

Q589 Chris Mole: What has fallen off the table during those hand-overs? Where are the gaps between what we should be monitoring currently and . . .

Dr Williamson: I do not think we have lost anything serious in the last five years, but it has been tough holding it all together. The problem is that there is no shortage of new things that we ought to be monitoring and measuring and that come up through the science, through NERC, that start as a time series of three years, then it is five years and then there can be very awkward decisions: do they get another five years from NERC and another five years after that, or is there a hand-over time? Some things have European funding and some of them have different agencies. Sometimes NERC pays for half and Defra pays for half, and we keep things going on that basis. It is getting harder all the time, in that the number of additional changes now that we feel we ought to have a handle on and that we ought to know about—ocean acidification, the plankton changes, the hydrographic changes—the value of having a time series is that you do not stop for five years, put them to one side and then come back again. All the time, the number of commitments is increasing, and that is a headache.

Professor Thorpe: We have been close to the brink on a number. On Jason, which is a satellite altimeter of the ocean we were close to not making the right contribution, although we did in the end—nationally. GMES is another example where the UK would benefit from having a more coherent approach. At the last Space Ministerial we had difficulties with GMES, which were well reported. The ARGO float programme is another area where it has been a challenge to maintain the level of investment across a number of agencies and to make sure that the UK plays its role, because it is part of a global network. I would say we have been close to some difficult points, but we have just about managed to hang on. It shows that we would benefit from an improved co-ordination.

Q590 Chris Mole: Are you working with Government departments to ensure open access to all publicly-funded data sets for all scientists?

Professor Thorpe: We are. NERC-funded data collection is made available via the British Oceanographic Data Centre. We have put quite a bit of investment into making sure that our data is made available, and that our researchers have access to international data sets as well. My feeling is that researchers anyway in the UK have pretty good access to data sets from NERC-generated projects but also world-wide. I am sure there are problems somewhere.

Dr Williamson: There are some problems, but on the whole the academic researchers can get round most of those. The problem is that some scientific institutions have funding trading status and are obliged to sell their data wherever possible and make money. The Met Office is not supposed to give it away, but NERC scientists have access routes to it; but for people in universities there are problems on

the marine side, and within NERC we cannot always get hold of the data we want on marine surveys or other information like that.
Professor Thorpe: The fisheries information, where there are elements of commercial in confidence, can be difficult to access from labs that are not within NERC.

Q591 Chris Mole: MODs—is some of the data—
Dr Williamson: Or just not available!

Q592 Chris Mole: What is the position on ready publication of data?
Professor Thorpe: Ready in the sense . . .

Q593 Chris Mole: About having it available in a timely manner.
Professor Thorpe: We get a very rapid access of data that is taken in the field, often in real time of course; but usually the researchers will have a period of time—for example those who have been on a research cruise, where their particular project has been accumulating data, they will have a relatively short period of time to look at their own data, so to speak, to quality-control it, et cetera. We try to reduce that to a minimum.
Dr Williamson: A lot of data is available online. For the Cape Verde Ocean Atmosphere Observatory, the data is there on the day that it arrives. Others are within six months or a year. For any NERC-directed programme they will have a data policy that says, "Within a year you will have banked your data and done the quality control and you will make it available"; and the programme produces a CD at the end of it, and any reasonable request is met at whatever stage.

Q594 Dr Turner: If you are undertaking a funding allocation and budgeting project, presumably it is a fundamental change to your whole accounting and financial control procedures. What effect will this have on long-term research projects, and particularly how will it affect research cruises? We have learnt that it takes several years just to do the planning phase of these projects.
Professor Thorpe: We brought in this project, with a rather opaque title I am afraid, but it represents NERC being clearer about how it allocates its funding streams to—as I mentioned earlier—the national capability to do environmental research, which includes the marine laboratories and vessels, and the research programmes that utilise that capability. We have now, under this project, made clearer what the funding streams are and how we will review them, performance-manage them and evaluate their outcomes. One of the changes will be that part of the research funding that is currently allocated to our centres will come together with previously thematic funding into one pot called research programmes, and that will be bid for across the community, both by research centre scientists and academics within universities. This is a way for us to encourage collaboration between university researchers and our research institutes. We are going to bring this in over the next few years. Oceans 2025 was very much designed with this new way of allocation in mind, so they have been quite clear about the components of Oceans 2025 that are there for the national capability part and the parts that will be within the research programme component. Another aspect of this is that we will have theme leaders for each of the seven science themes. They will be scientists in the community who will act to bring together the community in each of the themes, like biodiversity, to make recommendations to our science board on investments. There are a number of associated changes that this project will bring in, but it is all described quite clearly in our new strategy that will be published in September.

Q595 Dr Turner: We have heard criticism that FAB has some short-term funding cycles but that these are not really appropriate to marine science projects. How do you answer that?
Professor Thorpe: The research programme element will be in the form of quite a large set of individual programmes that might run between three to five years, but they will have a finite lifetime. The research vessels, for example, come under the national capability component, where we will essentially have a much longer-term horizon on the funding. This change will give a greater security of long-term support for that capability to do the science. In many respects, this signals a greater long-term commitment for NERC on that underpinning requirement.

Q596 Dr Turner: Will all these changes have any effect on your ability to encourage inter-disciplinary research, particularly linking physical ocean science with biological sciences?
Professor Thorpe: The whole structure of the strategy is there specifically to encourage and facilitate multi-disciplinary environmental science. The fact that we have a thematic structure that cuts across the disciplinary areas shows that we are looking to bring the disciplines together to address these environmental issues. I would say that the strategy is multi-disciplinary at its core. Of course, that is at a higher level than the individual components of the marine community, which are the ones you mentioned; but with the multi-disciplinary opportunities that the community will see in these research programmes there will be very great encouragement to work across the marine physics/chemistry/biology boundaries. That is signalled very strongly in the strategy.

Q597 Dr Turner: So you can guarantee there will be no funding gaps that multi-disciplinary projects can fall into, can you?
Professor Thorpe: "Guarantee" is a strong word! We are going to enable. One of the journeys that NERC has been on for quite a significant time—and Phil has reminded us that if you go back ten or fifteen years, NERC was very much sub-divided into the disciplinary areas. There was a sub-strategy for marine, atmospheric, et cetera. Under the previous Chief Executive, and I am following through on that, we are taking much more of an earth system

approach, recognising that many of the problems we are dealing with, like climate change, involve all of those disciplines. We need to bring those together, so we are very strongly encouraging cross-centre and centre-to-university collaboration in the new strategy.

Q598 Dr Turner: Do you have any interaction with the other research councils? Are there any fringe areas where you meet?
Professor Thorpe: We again address this in the new strategy and the new spending review with an initiative that we are particularly excited about called *Living with Environmental Change*, which brings together all of the research councils. We have now ten departments or organisations on a partners board to look specifically at the problem of environmental change to society, bringing together natural science, engineering, economics and social science, et cetera. I am quite excited about this initiative for the coming spending review. It is very much where we need to be because even NERC on its own cannot tackle these environmental questions; it has got to be done in conjunction with others. That is a vehicle where we will strongly improve our ability to work across, with the other research councils but also the policy departments and other users.

Q599 Chairman: Natural England gave us evidence that it was difficult getting multi-disciplinary research. When we asked BBSRC, which you would expect to be a significant funder of the main biological science research council, they said to us: "We did not co-fund any marine science research jointly with other research councils between 2002–2003 and 2006–2007." That seems to fly totally in the face of what you have just said to Des Turner.
Professor Thorpe: It is partly in the realisation that environmental problems have to be multi-disciplinary that we are introducing this new initiative, which I think will be a large opportunity to bring together not just the biologists but economists, social scientists, et cetera. This is seriously difficult to do, so I think BBSRC were right to point that out. In the past we have not stepped up to the plate on this, so I absolutely accept that now is the time to do multi-disciplinary science; but the challenge of it is enormous. We have been having strong dialogue with the Economic and Social Research Council to make sure that natural science on climate change is reflected with really good social science of understanding whether the public wants to take up the mitigation adaptation solutions. These are real research questions and we have not had effective mechanisms, or mechanisms that are as effective as they should be, to do this multi-disciplinary exercise. I am hoping that, with a great deal of effort and resources we are going to substantially have a vehicle for this in the future, which is what *Living with Environmental Change* is about.

Q600 Linda Gilroy: Research vessels: do NERC's international barter arrangements weaken the case for the UK to fund its own new vessel and equipment purchases? Are barter arrangements the best way by which to provide UK marine scientists with the facilities they need in the future? What is the relationship between the traditional way of doing things and the emerging way of bartering?
Dr Williamson: Bartering helps make more efficient use of the vessels you have got. It is certainly no substitute. For any barter arrangement there is always a pay-back time, but what that enables is that if the UK has a research vessel in the Pacific Ocean and then another country wishes to do a follow-on cruise in the Pacific, or vice versa, it means there is less time moving ships around the world, and that they are more effectively used. It has an efficiency gain for the use of the vessels, but it does not mean that you do not need to have your own fleet. It does require co-operation and planning. It adds on 5 to 20 per cent efficiency, but it does not substitute for having your own vessels.

Q601 Linda Gilroy: There have been concerns about *Discovery* and its reliability and whether it can continue to contribute effectively to the bartering arrangements. Are those concerns likely to be met with the new vessel in time to maintain that balance of contributing towards bartering?
Professor Thorpe: We are moving as rapidly as we can to replace *Discovery*. We are starting our procurement of the replacement. There is no doubt that the existing *Discovery* has had some technical difficulties. It is quite an old ship.

Q602 Linda Gilroy: It is to be retired in 2011.
Professor Thorpe: Yes. We will have the replacement in time for that. We are trying to make sure that we align where *Discovery* is used so that it is not put under undue pressure and that it doesn't go into seriously difficult waters when severe weather occurs. We are trying to design the cruises so that it is most effective in delivery. We have got in place the replacement process, and we are going forward with it as fast as we can.

Q603 Linda Gilroy: You are categorically saying there will be a ship in time to replace it because there seems to be a perception out there that you are not.
Dr Williamson: I am not aware of it.
Professor Thorpe: There is every intention to replace *Discovery* on that timescale, and we are starting the procurement project now. I was unaware. I think the perception might come from the fact that the existing *Discovery* had some technical problems because of its age, so we have some concerns; but obviously the solution to that is, as I have said, to put it less at risk by putting it in places where it is not so stressed but also to spend money to make sure that it is repaired so that it can continue until 2011.

Q604 Chairman: When we were in Southampton last week we heard that there were significant problems with the new *James Cook*, technical problems, which may mean that it will have to come out of service. That is a worry if a brand new ship is having problems and indeed *Discovery* is only being used in selected environments.

Professor Thorpe: The *James Cook* is a very good vessel. It is cutting-edge. It has a wide variety of capabilities, and in many of those capabilities we are pushing the envelope. You would not expect a new vessel to have other than some issues to deal with. We have one in particular at the moment to do with one particular instrument. We are not quite sure but we are doing some technical assessments.

Q605 Chairman: This was on the front of the bow. There is a major problem with bubbles, which meant you can not get accurate readings, which seems to be a fairly—

Professor Thorpe: It is one instrument. It is hypothesis at the moment. The hypothesis is that the bubbles are interfering with this instrument as it looks down to the ocean floor. We are doing quite a bit of work to look at this and we can certainly minimise it by reducing the shedding of bubbles. Nearly all the other instruments are working really well. I do not want you to feel this is the only thing on there.

Q606 Chairman: No, I am picking up the point that if you are using *Discovery* in limited environments and the *James Cook* has got to go into dock—and that is the impression we were given in Southampton, that it may well have to go back to the shipyard in order to have modifications—that would leave us very exposed in terms of capability.

Professor Thorpe: We have no plans to leave the community exposed in terms of capability. We are doing the preparation work to understand the problem, and it is too early to say what the solution to that problem will be. We do not foresee that it is a major issue and that there will be major difficulties in meshing its work in with the *Discovery,* which we are doing all the time. This is not untypical of any research vessel at the cutting edge. You would expect that some instruments would require adjustments so that they are working most effectively. It is really within that scope that you are seeing those problems.

Q607 Linda Gilroy: To what extent is the availability of ships meeting the need through bartering arrangements? Is the availability through bartering adequate for the UK, and what discussions has NERC had with Government laboratories such as Cefas and the Ministry of Defence regarding bartering and their role in that?

Professor Thorpe: We do have significant arrangements with the Navy. We are very grateful to be able to use *Endurance* for Antarctic work, and at the time of the tsunami we were able to use *HMS Scott*, so there is perhaps limited opportunity in terms of the type of ships available but we have had great benefit from using Navy ships, particularly *Endurance*. That is something that has been a good UK story.

Q608 Linda Gilroy: That presumably is for use within the UK science community rather than part of the wider bartering?

Professor Thorpe: I would have said "yes". In terms of UK capacity, there is no doubt that there are other ships. There is a ship, for example, at Cefas. How utilised that ship is I am not sure. There are perhaps opportunities there, but in terms of the international bartering arrangements.

Dr Williamson: Because of the heavy demand on ships, we are talking about chartering rather than bartering, and chartering is when you buy in the time on other people's research vessels without necessarily saying, "I will borrow time on your vessel and you can borrow time on mine in a future year" For the next two or three years the NERC schedule is pretty booked up, so any additional demand on that would not be solved by a bartering arrangement unless some of that might be re-configured. But then we have to talk in terms of the full economic cost of buying in time on other people's research vessels, and that is expensive.

Q609 Linda Gilroy: Going back to the question on how far all of that is meeting the needs of the research community, is it a good fit?

Professor Thorpe: My impression is that it is a good fit. We have a very full programme. You might say, hearing that, that perhaps there is demand out there that we are not satisfying. There is a match here between capability of being able to do cruises and the number of highly rated proposals that get funded. There has to be a matching between those two. There have been times in the past where NERC ships have been under-utilised, but that is not the case now; they are fully utilised and with the highest quality proposals. It is a hard question to know how much demand there is that we are not supporting. All of the high rated proposals that we support are getting ship time.

Dr Williamson: Sometimes they have to wait a year or two. Oceans 2025 has a five-year cruise programme, but that might be a six-year programme because of some slippage.

Q610 Linda Gilroy: There is certainly no over-capacity?

Dr Williamson: There is no under-use. Every month is provisionally booked for the next two years ahead.

Q611 Linda Gilroy: With the sort of things we have been hearing about the scope for marine science to contribute more, that presumably has implications for vessels. When we went to Rhode Island we heard about some proposals for the use of a commercial fleet for scientific purposes. Is that something that NERC would view favourably? Is it something that you are already supporting?

Professor Thorpe: We have already started, but we are contemplating an extension of making measurements on the commercial fleet of the more routine variety. This is something that has happened in the past, and we are having active discussions now to extend that, so we see great opportunities there. The atmospheric community has been doing that with respect to planes and even soundings in the atmosphere from ships for a number of years, so the

merchant fleet is an opportunity for making certain sorts of measurements, and we are certainly exploiting that.

Q612 Linda Gilroy: SAHFOS has been doing it for many years and has a track record.
Professor Thorpe: Yes, absolutely. We see the opportunity there and we are certainly happy to pay for that because we see it as a good adjunct to the science.

Q613 Linda Gilroy: Where would NERC direct any increases in funding for capital investment in marine resources, were they to be available? You do not have a long wish list obviously at your fingertips! I am sure some of the scientists might have.
Professor Thorpe: There will be members of the community, I am sure, who might feel that we could use another ship. We have two—of course we have the BAS ships as well—that are particularly focused for ocean-going, for the main oceanography, but I am sure there are those who think that we could use three. NERC is not just a marine funding agency; we have to look across all of environmental science. We would certainly have aspirations on capital spend if we had more across the whole of NERC, and we have to prioritise. We are in the position, whatever our budget is, of having to prioritise. An example of where we are particularly stressed at the moment outside of our direct observations is on computing, where the marine community came through very strongly in Oceans 2025, and more widely, that there is a great demand for increased computing power to utilise the observations that we are making with the ships and to feed it into the climate change question. Therefore, for NERC as a whole, we absolutely do have a wish list of capital expenditure but it is one that has to be prioritised and, as you can tell, there are various diverse calls on that funding. My impression is that we probably have about the right level of marine vessel capability at the moment.

Q614 Chairman: Including coastal vessels?
Dr Williamson: For coastal vessels we have access to the *Prince Madog*. I am not sure who owns it but it is managed on behalf of the University of Wales and we have time on that. There is the potential for having collaborative work with Cefas Lowestoft and the marine lab at Aberdeen and using their vessels but there has not been very much developed in that area.

Q615 Linda Gilroy: You seemed to express an uncertainty just now as to what capacity there might be with Cefas as to vessels to offer.
Dr Williamson: They do have potentially some time available. They have made offers for saying, "Here is an opportunity", but then you have to line up a research group to take advantage of that opportunity and that takes time and one does not always get it in place.

Q616 Linda Gilroy: But, as we have been hearing in some of the evidence submitted to us, that in terms of coastal management issues climate change particularly is one of the areas of mitigation as well as understanding what is going on. Might that be something that should be more clear on your horizon for capital resourcing in the medium term?
Professor Thorpe: I think a strong case could be made for that.

Q617 Linda Gilroy: Is scientific use of large resources such as the submersible ISIS being undermined through insufficient availability of technical personnel to support the technology? This was something that the members who visited Lisbon seemed to pick up.
Professor Thorpe: We are rather in a different place at the moment in being very impressed with the measurements that ISIS have been taking and seeing what great potential it has.

Q618 Linda Gilroy: But the comments that we have picked up are that it has got huge potential which is not currently being dedicated.
Professor Thorpe: Because of the lack of technical support?

Q619 Chairman: Half the time it is in dock because you have only got one set of crew to manage it, so therefore it can only be at sea for literally half the year, if that, because there is not sufficient flexibility in staffing and technical support to be able to have it at sea longer. Were you aware of that?
Professor Thorpe: Not specifically, but, again, it is not just a question of availability of the instrument, in this case the remotely operated vehicle, and the technical support. It is the availability of proposals that are supported and funded by NERC to carry out that science. There is a balancing act between the two.

Q620 Chairman: Chicken and egg, is it?
Professor Thorpe: It is, yes, but it is always a balancing act. In terms of the overall utilisation of the ships, never mind the particular instrument, it is a matter of balancing the proposals that the community submit that are highly graded, and it is possible from year to year, for example, that insufficient proposals are submitted of high enough quality to utilise a particular piece of equipment. That does happen and we would encourage the community to come forward with many proposals that will get supported, and if that is the case we would, I think, again via our national capability portfolio, hope to support those. I would say that probably the issue here is the matching of the high-quality proposals with the utilisation.

Q621 Chairman: I do not think that was the point though, was it, Linda?
Professor Thorpe: I was not aware there were technical support issues.

Q622 Linda Gilroy: I had the impression that there were calls on it to be used but it could not be used.
Professor Thorpe: I can certainly find out for you. I was unaware of that.

Q623 Dr Iddon: Our last batch of questions are relating to our relationships with Europe, within the EU. Of course, they have just concluded their consultations on the EU Maritime Policy Green Paper. How does that lie with respect to NERC's priorities? Do you find there is a lot of agreement or a lot of disagreement? Can you comment on that?
Dr Williamson: The Maritime Policy Green Paper does cover the whole range of maritime issues. The marine subset of NERC interest is only a component of that, but the comments and the input that the NERC-funded centres have given on that Green Paper have been favourable, saying that it is going in the right direction and that it is just the sort of thing that we ought to be doing, that the key issues that have been identified on a European scale give a very good congruence matched to our national priorities and interests, and that we think we could play a major part in taking that forward. There are some specifics within the Green Paper on which I do not have all the information, but on the whole we are supportive and helping to take it forward.

Q624 Dr Iddon: So it is not going to cause you guys in NERC to alter your current priorities to any large extent?
Professor Thorpe: In terms of the scientific agenda there is good convergence between Europe and what the European Commission are thinking about and NERC. The NERC Executive Board, which is my senior team, met in Brussels a month ago and it was exactly to discuss this question of how aligned was NERC strategy with priorities that are emerging in the Commission, both in the Framework Programme and in other funding initiatives like infrastructure. We had a very good discussion with senior Commission officials about this and we felt on both sides that there was increasingly a very good convergence of the scientific agenda. I think the UK has shown that in the past by being very effective at winning European funds. I would have said that the convergence on the science direction is pretty good. Of course, there has been discussion about better co-ordination, as we were discussing earlier, within the UK and across Europe as a whole, and this recent Aberdeen Declaration that emerged across the European groups in ocean science again is a welcome addition to getting better co-ordination and recognising the fact that we can do better.

Q625 Dr Iddon: I was coming to the Aberdeen Conference, which, of course, was held in June with 200 delegates present, as I understand it. Are you also saying that the Aberdeen declaration "A New Deal for Marine and Maritime Science" would not cause you to change your priorities either to any great degree?
Professor Thorpe: I think we could contribute and align to that cross-Europe initiative quite well. I am not saying we will not change as a consequence of dialogue across Europe but I am saying that I do not see substantial difficulties in adjusting and aligning our programme such that it fits into a European agenda. Indeed, there were members of the UK community that were instrumental in drawing up the Aberdeen Declaration.

Q626 Dr Iddon: You have just mentioned the Framework Seven Programme, so there is another investigation on international developments in science which we are about to publish. We have detected that some research councils, maybe not yours; I am not going to ask you that, are not really promoting Framework Seven Programmes among their community. There are difficulties, of course, and full economic costing is one. What does NERC do to promote knowledge of and urge being into the Framework Seven Programmes?
Professor Thorpe: We have an international section in Swindon and the head of that is Ruth Boumphrey who has a very good track record in engaging in the dialogue of the design of Framework Programmes as they are being discussed by the Commission and she is part of—and I cannot give you the name of it—but the group that involves the UK national representative which comes from Defra. She has been quite instrumental in making sure that the UK scientific community's priorities influence the design of the upcoming calls for the Framework Seven Programme, and, of course, our office in Brussels, UKRO, is an important conduit for that. On the other hand, when opportunities have been decided Ruth takes a role with our international section in informing the UK's environmental science community of those opportunities and also our research institutes so that they are well positioned to take those opportunities on board. I think the UK environmental science community has been very effective at winning research monies from the European Framework Programme.

Q627 Dr Iddon: Do you encourage people to go beyond your priorities in bidding for those monies as well as, obviously, bidding within your interests as well?
Professor Thorpe: Absolutely, and, of course, the main instrument for that at the moment is the European Research Council, which is essentially a responsive mode blue-skies approach, and we wait to see how effective that is going to be. That is an area where, unconstrained from our particular strategic priorities at the moment, researchers can put in proposals. Of course, we are concerned, as a number of others are, that the demand on the European Research Council is going to overwhelm it, but I would imagine the UK community will want to substantially get involved in that.

Q628 Chairman: We have heard a lot during this inquiry and again today about co-ordination, both with a UK base and European international bases. One of the things that struck us when we were in Southampton was that, for instance, there was a very impressive international drilling programme and NERC were funding scientists for that and there was clearly some very high quality science going on, but the issue was really about them using the data thereafter and being able to process the data into a

format that was available then to other scientists and that seemed to be the really big sticking point. Are you aware of that? What plans have you to deal with that? It is pointless getting the good science if we cannot use the results.

Professor Thorpe: Absolutely. The Integrated Ocean Drilling Programme is one of NERC's flagship programmes that we contribute to. I should say it is an international programme. We have two forms of funding for the Integrated Ocean Drilling Programme. One is the UK's national subscription to it, which allows us access to those cruises and those data, and we contribute at the right level for the UK, and NERC takes that responsibility, but also we have a UK IODP directed programme that NERC funds so that those data can be utilised, so it is exactly answering your question, that we have a specific research programme focused on enabling the research to be done with the data. That is of a finite size, of course, but nonetheless it has been incredibly productive and some of the outputs from the previous phase of the Integrated Ocean Drilling Programme have been among some of the highest cited journal papers that NERC has funded. I am pretty confident that we have supported both the subscription to get ocean drilling and access to it but also the attendant research. Of course, there is also the opportunity for researchers in the UK to bid for research to use those data via our normal responsive mode schemes but we do have a specific pot of money for research with that programme.

Chairman: Okay. On that positive we will draw this session to an end. Dr Phil Williamson, Professor Alan Thorpe, thank you very much indeed for giving evidence.

Written evidence

Memorandum 1

Submission from the Gardline Group

COST SAVING FOR GOVERNMENT RESEARCH VESSEL OPERATIONS

1. Executive Summary

Marine science is a costly exercise, however utilisation of the private sector will significantly improve value for money without compromising either quality or quantity.

We would appreciate your consideration of the approach embodied within this email that would lead to significant reductions in operational costs for the vessels operated by the Natural Environment Research Council (NERC), the British Antarctic Survey (BAS), CEFAS and others.

As an owner and operator of 10 large ocean going survey vessels we have a substantial capability in vessel management, marine data collection, interpretation and ocean science in general, providing such services to both public and private sector clients.

It is our view that the private sector could operate government research vessels for *circa* 20% less than current practice. The reason for this bold assertion is that we have studied the available cost structure from publicly available sources and we know what it costs to run our own vessels, five of which were previously UK government owned.

Our experience and understanding ranges from the provision of vessels under charter to NERC in the early 70's eg RV Researcher, to the purchase of the "Charles Darwin" in 2006—now renamed RV Ocean Researcher and operated by Gardline.

2. Cost Saving Basis

One of the main costs associated with marine science is that of vessel operation. Savings can be gained from attention to the following:

(a) Increase in available days at sea. Government survey ships are typically on task for 200 days, yet similar commercial vessels operate for 280–300 paid days. This increase in activity could mean reducing the fleet or utilising the vessels for other work so that the day rate, and therefore costs, when on task are reduced.

(b) Generous sea going allowances are paid to civil service scientists and technicians, and although some form of "time at sea payment" is appropriate in the case of CEFAS for example an additional £100/day or £60/day exchange for an extra day of leave applies, ie a 10 day trip will generate an extra £1,000 or 10 days leave plus £400.

(c) Vessel crewing—"Charles Darwin" and "Discovery" have a crew of 22, where commercial vessels performing the same task would have at least five crew less—and with duplicated crews to provide relief this equates to a saving of 10 crew per ship.

(d) The vessels can be used for paid commercial or government survey operations to generate income in between scientific activities.

(e) If incorporated as part of a commercial fleet then (i) onshore support can be provided appropriately and 365 days a year, and (ii) vessel manning can be optimised, particularly to fill gaps between projects, rather than what we can deduce as being two crews allocated per ship, busy or not.

3. Background and Experience

3.1 This email is an initial introduction and can be further developed with operational details as required, however the opportunity for say 30 minutes to discuss our suggestion with the committee at a date to suit would we believe be a valuable contribution.

3.2 The commercial sector operates within a competitive environment to the highest safety standards providing service globally and continuously, without the constraints of pre-arranged external schedules, in what can truly be described as a demanding environment. This capability if applied to the operation of government research vessels will unquestionably provide substantial savings.

3.3 The commercial sector including Gardline has developed in depth, technology and experience over recent decades as a result of increased spending for hydrocarbon exploration, intercontinental telephone cables, oil and gas pipelines; plus governments from many countries have developed their Exclusive Economic Zones with regional hydrographic surveys, environmental monitoring, sand and gravel extraction, offshore wind farms, fisheries science and enforcement etc.

3.4 A list of Gardline vessels and their current operations (29 December 2006) is detailed below to illustrate operations undertaken. Of marginal relevance is the fact that the Gardline Group is a privately owned British company, of more importance is that research vessel experience from the poles to the tropics has developed over the past 35 years.

Name	*Location*	*Activity*
Sea Explorer	North Sea Danish Sector	Geotechnical survey
Sea Profiler	Great Yarmouth, UK	Dry dock
Ocean Endeavour	Indonesia	Hydrographic survey (exploration)
Ocean Seeker	North Sea UK Sector	Geophysical survey
Sea Trident	Congo West Africa	Geophysical survey
Sea Surveyor	North Sea German Sector	Geophysical survey
Tridens	North Sea UK Sector	Geophysical survey
Ocean Researcher	North Sea UK Sector	Pipeline route survey
L'espoir	On passage to Singapore	Mobilisation for hydrographic survey
Triton	On passage to Australia	Mobilisation for Australian Government charter

4. High Cost of Government New Build

We note that the cost of the newly acquired (Norwegian built) RV James Cook is £36 million, which is greater in value than the entire 10 ship fleet of Gardline vessels which undertake virtually the same work with greater productivity. This vessel is an expensive resource and should, in our view, be used as efficiently as possible.

5. Request for Commercial Tender

We request that consideration is given to putting UK Government research vessel operation and data collection out to commercial tender as demonstrable capacity exists and undoubted cost savings will apply.

6. Invitation to Visit—Information Gathering

Although we would not expect an immediate response we would be pleased to take members of the Committee to sea for a day, or if inappropriate a visit to Great Yarmouth to view the facilities, support services available and vessels if alongside.

December 2006

Memorandum 2

Submission from the United Kingdom Hydrographic Centre

1. The Maritime Environment Information Centre (MEIC) at the UK Hydrographic Office:
   (a) Is a repository for marine environmental data collected by the Royal Navy—we process raw observational data, build and manage databases.
   (b) Provides the information which the RN needs to enable commanders to understand their operating environment—we analyse data, both our own and data acquired from external sources. The results of such analyses are used to compile a range of products that are distributed to RN units.
   (c) Has a global remit with particular emphasis on regions of operational interest.

2. The Marine Environment Information Centre's major contribution to marine science is to manage a significant volume of data. Part of that process is to periodically release batches of data to the wider science community. Our data is delivered to the British Oceanographic Data Centre, the National Oceanographic Data Centre (US) and, in the case of marine life observations, to Duke University in the US for dissemination via the OBIS website.

3. Data may also be made available to support specific research projects such as marine mammal habitat preference modelling (Sea Mammal Research Unit, St Andrews University).

How marine science is being used to advance knowledge of the impact of climate change on the oceans

4. Any impact on climate change studies is incidental. Certainly the release of old data is useful in climate change studies but the data has rarely been gathered with that use in mind.

Organisation and funding of UK marine science in the polar and non-polar regions

5. The MoD collaborates with various scientific institutions such as the National Oceanography Centre for the Sumatra seabed survey, Scott Polar Research Institute for under ice measurements and St Andrews University for marine mammal studies. MEIC is peripherally involved in such projects in being the repository for data collected and supply supporting data. MoD has also been asked to submit evidence and would probably be better placed to present evidence about such activity. The NERC/MoD Joint Grant Scheme for funding research has been significant in terms of funding for marine science and is currently an issue for research organisations who find it difficult to secure funding from NERC by this route. UKHO is represented in CAROS (Cooperative Arrangements for Search in Ocean Science) a joint NERC/MoD group chaired by MoD, DI-ICSP.

The role of the UK internationally and international collaboration in marine science

6. MEIC does have some standing internationally in defence marine science due to the RN's global interests, our position within NATO and various bilateral arrangements. Activity is largely data and product exchange.

Support for marine science, including provision and development of technology and engineering

7. We do play a small part in the delayed mode quality control of Argo data but I would assume that MoD's contribution to its funding is much more significant in this context.

Use of marine sites of specific scientific interest

8. MEIC supports the RN Sonar 2117 project. S2117 is a computer decision aid whose purpose is to provide command guidance on the minimisation of the environmental impacts from use of sonar. Our support is primarily in the provision of underlying data sets on the distribution of marine mammal species and other relevant oceanographic information. We are also responsible for providing geospatial data describing the locations of marine management areas of all designations including Sites of Special Scientific Interest.

January 2007

Memorandum 3

Submission from Professor Sir John Lawton, Chairman, Royal Commission on Environmental Pollution

1. These are my personal views. The Members of the RCEP have not considered the matter. I have not provided a summary (as requested) because the submission is very brief.

2. The Committee will, I assume, have received evidence from the Natural Environment Research Council on the role of NERC and its associated Wholly-Owned and Collaborative Centres. (The Wholly Owned centres are: British Antarctic Survey [BAS]; British Geological Survey [BGS as a partner in the International Ocean Drilling Programme—IODP]; National Oceanographic Centre, Southampton [NOCS]; Proudman Oceanographic Laboratory. The Collaborative Centres include the British Oceanographic Data Centre; Plymouth Marine Laboratory [PML]; Scottish Association for Marine Science; Sea Mammal Research Unit; and several laboratories within the Earth Observation Centres and the NERC Centres for Atmospheric Science). Some of NERC's Services and Facilities Laboratories also support UK marine science.

3. NERC currently has four ocean-going research vessels, two run through BAS, and two through NOCS. The BAS ships are available for non-BAS work, particularly in the northern hemisphere summer.

4. This is a complex landscape, but just because it is complex does not mean that it is not fit for purpose. The landscape has evolved over many years, in response to changing demands, budgets and scientific opportunities. For example, during my time as CE of NERC we considered the economies of scale that might be achieved by running all four ships through one operation. We abandoned the idea because at that time there were no obvious economies of scale. Operational planning for use of the BAS ships has to be intimately tied to the overall planning of BAS operations, two, even three years ahead. Logistics demand his has to be done within BAS; if it is not, the evidence suggested that there was scope for considerable confusion and duplication of effort.

5. Generalising, each Wholly-Owned or Collaborative Centre has a distinct scientific role, with very little duplication of effort or expertise. Where there is apparent duplication, it is usually for very good scientific reasons. But of course there is always room for improvement. The creation of NOCS during my time as CE was partly to provide this very large, "flagship" laboratory with a leadership role across the UK marine laboratories, not as a "takeover bid" but on a "first-among-equals" basis. It is for others to judge whether this role has been fulfilled.

6. Overall, UK marine science is in excellent shape. Over the last decade we have done, and continue to do, world-class science in, for example:

- The development of Remotely Operated Vehicles (ROVs)—Autosub.
- Monitoring the Themo-haline Circulation through the RAPID programme, of fundamental importance in understanding the impacts of climate change on the UK.
- Carrying out pioneering work on sea surface—atmospheric coupling through the SOLAS Programme.

NERC will, I am sure have given you many other examples.

7. One measure of this success is the number of international collaborations involving NERC-funded UK marine scientists. Major examples include the RAPID programme (co-funded with the US National Science Foundation and other European partners) and IODP. World-class scientists from other countries do not actively seek collaboration with second division players. UK marine scientists play in the premier league.

8. Against this positive background, during my time at NERC (and no doubt continuing) there was severe competition for funds to support marine science in the UK. Marine science is generally expensive (as are most other areas of NERC science), and with other major calls on NERC's budget, we had to make some difficult choices. For example I had at least two requests to fund the provision of new inshore research vessels by good UK laboratories. No doubt the science they would have carried out would have been excellent, but NERC did not have the funds to support these bids. (This is not a problem unique to marine science in the UK. Tough decisions about priorities apply across the remit of NERC).

9. As I left NERC the rapidly increasing price of oil was causing problems for BAS and for the running of our other two ships. The deployment of all four vessels was already extremely efficiently scheduled, with little or no capacity to make "efficiency savings". NERC overall had therefore to find ways of supporting these vessels by cutting other operations. I am not privy to the current situation, but continuing high oil price will be a constraint of UK marine science operations, unless additional funds are forthcoming.

10. NERC was due to review its marine laboratories after I left in April 2005. Key questions are whether the current configuration and number of marine-related laboratories is still fit for purpose, and whether reconfiguration would be cost-effective? I have not seen the outcome of the review, and do not know the answers to these questions. Unless things have changed dramatically, my best guess is that reconfiguration (mergers, closures etc) are unnecessary at this time, and doubtfully good value for money.

11. An alternative question is whether it would be desirable to expand the UK's marine science capability, for example by building on the existing cluster of marine laboratories in Plymouth (the university, the Marine Biological Association, PML and the Sir Alastair Hardy Foundation). At one level this is an attractive notion. As always, the question is where will the money come from, and what else in NERC's potential portfolio won't get done if they fund this expansion?

January 2007

Memorandum 4

Submission from the Fisheries Research Service

1. Fisheries Research Services (FRS) is the Scottish centre for research on fisheries aquaculture and the aquatic environment. It is an Agency of the Scottish Executive Environment and Rural Affairs Department (SEERAD) and supports policy and stewardship of living aquatic resources. More details on the aims and objectives of FRS can be found on our website (www.frs-scotland.gov.uk) where we have recently published our Report and Accounts 2005–06[1].

[1] Link to Report and Accounts 2005-2006 http://www.frs-scotland.gov.uk/FRS.Web/Uploads/Documents/report%2006all.pdf

2. Although FRS has a very clear focus on the research and monitoring requirements of the Scottish Executive, and to that extent inshore waters up to 12 miles, FRS contributes scientific expertise to the research and monitoring which underlies the advice produced on the wider marine environment and marine issues. In part this is achieved through close collaboration with the Scottish Environment Protection Agency (SEPA), Scottish Natural Heritage (SNH) and Scottish marine institutes such as the Scottish Association for Marine Science (SAMS) in Oban. In addition, we have forged partnership agreements with several Scottish Universities and are active in developments around a "virtual" Scottish marine science group. However, FRS also contributes actively to, often Defra led, UK-wide commitments and to UK-wide research and monitoring collaborating closely with the Centre for Environment, Fisheries and Aquaculture Science (CEFAS) and other UK-wide institutes. FRS is fully engaged with the UK Marine Monitoring and Assessment Strategy and contributes to UK input to the International Council for the Exploration of the Seas, providing both delegates and Chairs for the various working groups and committees. FRS further provides scientific expertise as part of the UK representation to the Oslo and Paris Commission (OSPAR).

3. FRS operates two research vessels, the ocean going FRV *Scotia* and the smaller FRV *Clupea*. Both ships are used extensively as part of the marine fish stock monitoring which, together with our market sampling and fish discards programme, contributes to the annual fish stock assessments.

4. FRS undertakes research in a range of areas including the effects of climate change, indicators of change in the health of fish communities, understanding the spread of sea lice, design of fishing gears, the biological response of fish to contaminants and the development of disease, the hydrography of the waters around the UK, the use of molecular probes to identify phytoplankton, the modelling of fish stocks and much more. Some examples of the research undertaken at FRS are presented FRS information leaflets electronic links for which are at Annex 1 to this letter*. Although much of this research is funded by SEERAD, some of these programmes are funded by organisations such as the Natural Environmental Research Council; an example is the recently completed programme on marine productivity which had a focus in the Irminger Sea. A current NERC programme running at FRS is the multi-centre research on fish toxicogenomics which is lead from the University of Birmingham. Services to customers other than SEERAD account for approximately 14% of FRS' total budget. In addition to NERC other customers include the European Union (EU), the Food Standards Agency (FSA), other Government Departments, and public and private sector organisations.

5. A large proportion of the research and monitoring undertaken by FRS scientists is published in the peer-reviewed literature. However, FRS also produces a series known as "FRS Reports" which can be accessed via our internet site. Finally, FRS contributes to international publications. An example of this is the ICES Cooperative Research Report on Ocean Climate, the Scottish data coming from the FRS produced Scottish Ocean Climate Status Report.

6. FRS contributes significantly to our wider understanding of the seas around the UK and the animals that live within these waters. If the Committee would like further information on the activities of FRS then I will be happy to provide this.

January 2007

Memorandum 5

Submission from the Centre for Environment, Fisheries and Aquaculture Science (Cefas)

SUMMARY

1. The scope of marine science provided by Cefas for Government customers is briefly outlined in this document. Cefas is an Executive Agency of Defra and we provide research, monitoring and advisory services on marine environment protection and the use of marine resources to support a number of Government Departments.

2. Funding at Cefas is largely directed at science in UK coastal waters and is typically supported by Defra and other Government funders on a programme by programme basis. This funding model is changing following a 10-year agreement with Defra to ensure a sustainable future for Cefas. We are also able to access overseas income competitively (including from the EU) to match and extend Defra funding for work in the global oceans and seas.

3. Our view is that the UK in general and Cefas in particular plays a major role in shaping the international agenda for marine science and provides a significant contribution to understanding the impact of human activity on marine ecosystems.

4. In a global competitive market for skills of marine scientists, Cefas is able to attract excellent scientists from an increasingly diverse community, but our ability to retain them depends on our future ability to provide a suitably challenging and rewarding environment for marine science to thrive.

* (Not printed)

Cefas Contribution to Marine Science

5. The Centre for Environment, Fisheries and Aquaculture Science is an Executive Agency of Defra. Our role is to provide Defra and other Government Departments with advisory, research and monitoring services in the aquatic environment. We have around 530 staff based in laboratories in Lowestoft, Burnham on Crouch and Weymouth. Our origin was the MAFF Directorate of Fisheries Research and as such we have more than 100 years of history in marine research. Our focus is on fish stocks management, the impacts of human activity on the physical, chemical & ecological environment and protection of fish health. Around 75% of our funding is from Defra, but in our Agency status we are actively engaged in providing services to a wider market and we work with the DTI, the Food Standards Agency, the EU and a large number of other customers in the UK- and foreign-public and private sectors.

6. This submission should be read in conjunction with the Defra memorandum to this Committee that lists the policy drivers for undertaking science in the marine environment and their role in meeting this need. Cefas delivers the majority of the science evidence base in support of Defra requirements and for the sake of brevity we have not repeated the same information here. We would highlight our unique contribution to their programmes of marine environmental protection, marine biodiversity, water quality, fisheries management and flood and coastal management, all of which are seen as key elements in sustainable use of the seas.

7. We partner more than 100 different academic and research institutes both in the UK and around the world to deliver our mission. We also publish around 150 peer-reviewed papers in scientific journals each year based on our research programmes. In this regard we have a broad perspective on the state of marine research both in UK waters and the major oceans of the world including the Polar Regions.

8. We use our research vessel, the Cefas Endeavour, to monitor the state of the seas and provide information on the impact of a broad range of human activities from energy exploitation, diffuse chemical and nutrient inputs, dredged material disposal to fisheries and the impact of fishing. We have developed novel technologies to measure oceanographic parameters remotely from fixed moored buoys and seabed landers where these are not available in the wider market. Our current research programmes are directed to understanding how human activities act in combination on ecosystem function and the limits on use of goods and services from the sea. The scope of this work is mainly focused on the shelf seas around the UK, but our contribution to work in the polar seas is listed later under the climate change section.

9. More information on our activities may found on the Cefas web site[2], which contains amongst other material our Annual Report and Accounts and a full list of Cefas publications.

Organisation and Funding of UK Marine Science in the Polar and Non-Polar Regions

10. Recognising the strategic partnership between Defra and Cefas and the ongoing requirement for science services, Ministers have recently supported a 10-year funding agreement to ensure the sustainability of Cefas science. The contract will allow for the development of new laboratory facilities and merging of two laboratories to retain the critical mass of skills that Defra will require for the future.

11. Cefas is also able to access a number of funding streams to support our science activities. Defra currently procures services from Cefas by Memorandums of Understanding for R&D and non-R&D activity. Pressures on Defra budgets have resulted in a focus on UK coastal seas rather than work in the polar regions.

12. Although the Universities have benefited from recent increases in funding for the best academic establishments, the funding lines for other research activities (particularly those in the polar regions) have been put under severe pressure due to Government spending constraints. The relevant rules have changed recently leaving Cefas unable to access Research Council funding. There is a disconnect between blue-skies activity and a more directed approach to making the best use of marine resources and protecting the environment. The NERC community have attempted to address this issue in the recent "Oceans 2025" programme that aims to be more policy relevant, but there is still an impasse of free funding flow, and therefore information, between NERC and other Government laboratories that impedes better integration. It is noteworthy that of more than 500 current Cefas contracts only two are directly funded by NERC. Other initiatives such as the Environment Research Funders Forum (ERFF) also attempt to join up the community effort, but the evidence of well-integrated programmes is sparse.

13. The recent change in EU accounting procedures to require 25% rather than 50% matched funding makes EU research funding now more accessible to Cefas. We are actively working with Defra to align Defra R&D with EU bids to maximise collaborative pan-European marine science.

14. The recent OSI review of science in Defra[3] underlines the need to strengthen the sense of a Defra science community and ensure a strategic approach to planning and coordination of science. We are working closely with other Defra Agencies and the Inter-Laboratory Forum (a consortium of six Government Agencies bringing together the skills of 9,000 scientists) to invest jointly in future programme

[2] www.cefas.co.uk

[3] (http://www.dti.gov.uk/science/science-in-govt/works/science-reviews/review/defra/page24808.html

development. At a Departmental level the Fisheries and Marine Science Customer Group brings together the management of marine programmes across the UK and the Chief Executive of Cefas, with sister agencies in Scotland and Northern Ireland form the Management Group of Directors to ensure joined up working between the devolved administrations.

15. Current activity in joining up monitoring activity in the UK regional seas via the Defra led UK Marine Monitoring and Assessment Strategy (UKMMAS)[4] is a good step in the right direction of better-integrated observational science. A cross-departmental policy grouping (the Marine Assessment Policy Committee, MAPC) leads the activity and brings together many institutes engaged in long-term marine monitoring. Information gathered by MAPC suggests that marine monitoring is underfunded by £22 million p/a if it is to deliver the full range of measurements needed to deliver the UKMMAS vision.

The Role of the UK Internationally, and International Collaboration in Marine Science

16. Recent global agreements on sustainability shape the changing approach to environmental management. Cefas' work supports delivery of the global conventions such as the Convention on Biological Diversity, World Summit on Sustainable Development and Convention on Control and Management of Ship's Ballast Water and Sediments. Regionally the OSPAR Convention for Protection of the Marine Environment of the North Atlantic and Bergen Declaration elucidate the same management philosophy for our regional seas and provides a driver for much of the science at Cefas. The key messages that come out of these forums are the Oceans Initiative to develop a cross-cutting approach to regional oceans and coastal ecosystem management; development of management frameworks supported by indicators; and actions to reduce hazardous substances, combat eutrophication and conserve biodiversity.

17. European regulations are following the same trend and provide a clear legislative backdrop for the detail of Cefas science. Examples here include the new basic regulation of the Common Fisheries Policy and associated requirements, revisions to the fish disease control regulations (91/64) and the implementation of the Water Framework Directive. The Green Paper "*Towards a future Maritime Policy for the Union: A European vision for the oceans and seas*" will set the scene for sustainable use of the seas and provides for a strengthened approach to protection and preservation through the proposed European Marine Strategy Directive. The emerging directive sets the goal of achieving Good Environmental Status by 2021 and will require significant innovation in assessment and monitoring as well as in marine natural resource management. The strengthening of European institutions will have an effect on the dynamics of science delivery in support of management but a key focus will be co-operation at a regional scale.

18. Shared international use of marine resources, particularly fish has always fostered a joined up approach to management of marine systems. Cefas has been a key player in the International Council for the Exploration of the Sea (ICES) since its' formation at the turn of the last century and our deputy director is the current president. We also provide science advice in management forums such as various EC committees, OSPAR, the London Convention and International Maritime Organisation.

19. Collaboration on marine science has been greatly facilitated by EU research contracts aimed at joining up the European marine science community. This is happening at a number of levels and the programme EFARO is a good example of bringing together senior scientists and directors of EU fisheries institutes to share resources, advise the EU Commission on future science needs and set up collaborative research programmes. At a working level there are also a number of Networks of Excellence that Cefas is involved in, including EUR-OCEANS[5] which has an overall objective to achieve lasting integration of European research organisations on global change and pelagic marine ecosystems and the relevant scientific disciplines. The network brings together 66 institutes in 25 countries. Cefas is presently involved in more than 30 European programmes.

20. We also lead the development of the integrated Arctic Ocean Observing System) Science Plan (Prof. R. Dickson,CBE 2006)[6] that was endorsed in 2006 by the International Council for Science Joint Committee for the International Polar Year as one of its "coordination proposals".

Support for Marine Science, Including Provision and Development of Technology and Engineering

21. Support for particular areas of marine science have changed markedly during the last 20 years. We have seen reduced funding for research vessel based work on oceanography and productivity of the seas. Large open-ended monitoring programmes fell out of favour and have only recently seen limited renewed interest for long-term data sets in the context of climate change. Funding for mariculture in England and Wales was largely discontinued in the 1990's and work on the impacts of hazardous substances peaked in the 1990s.

[4] (http://www.defra.gov.uk/Environment/water/marine/uk/science/monitoring.htm)

[5] http://www.eur-oceans.eu/

[6] Dickson RR 2006. The integrated Arctic Ocean Observing System (iAOOS): an AOSB-CliC Observing Plan for the International Polar Year. *Oceanologia* 48 (1) 5–21.

22. Technological advances have largely been driven by private sector requirements such as in oil and gas exploitation and more recently in the renewables sector. Recent advances in molecular technologies in the marine sector are largely spin-offs from medical research. Our need to develop our science and technology ahead of Departmental Funding has been met by a "seedcorn" investment programme partly sponsored by Defra and partly by returns generated from wider markets income when necessary. Cefas has invested seedcorn funding to develop technologies to make remote measurements eg nitrate in marine systems and to introduce latest molecular technologies. Individual customers for our work rarely take the long view of developing such technologies.

The State of the UK Research and Skills Base

23. Biological sciences benefit from attracting a large number of undergraduates to some very good universities in the UK. Cefas is able to recruit high calibre biologists at the postgraduate and postdoctoral level. Where we find it more difficult to recruit is highly numerate scientists with modelling and statistical skills and in attracting experienced scientists at the highest levels in the organisation. There is a two fold problem; firstly with the amount of funding available for scientists salaries and secondly for the continuity of funding for long-term research that will deliver government needs in marine science and climate change science and provide a well-planned career path for scientists.

24. The mix of nationalities working for Cefas has altered markedly over the last 10 years and the workforce is more mobile with higher turnover rates. This brings many advantages in terms of international networking and joining up the science base, but has the disadvantage for the UK that many marine scientists regard their workplace as global rather than local and they are more ready to move for increases in salary.

Climate Change Impact—The Role of Marine Science

25. Cefas recently re-organised our science into thematic areas of work to give more emphasis on developing tools to assess the impact and develop methods to mitigate the effects of climate change. The principal research objective of the Climate Group is to understand the effects of climate variation and change on species, communities and ecosystems and the consequences for humans, in order to improve environmental management. Our strength in this area is the long-term data sets we hold on fisheries and ecosystem change.

26. Activities in hand at present include managing the Marine Climate Change Impacts Partnership (on behalf of partners led by Defra), leading an ICES working group on the effects of ocean acidification, participation in the Marine Environmental Change network, refocusing our Fisheries R&D programme to examine in more depth the effects of the environment on fisheries, and aligning our current environment monitoring programmes with climate change measurements, eg pH change.

27. For polar seas Cefas has maintained a system of current meters in the deep sea east of Greenland since the 1980's measuring the flow of cold dense water out of the Arctic region that plays a fundamental role in the global ocean circulation and climate. These measurements form a component of the largest ocean-observing system in the hemisphere, the Arctic-Subarctic Ocean Flux study, which was instigated and is currently chaired by Cefas. Such studies allow us to map out and quantify the freshwater flux out of the Arctic, which is thought to modulate the thermohaline circulation of the World Ocean and provides us with an understanding to support prediction of future climate change.

28. Cefas is also participating in EU integrated project "Damocles" by running an array of instruments that measure the properties and volume of the water leaving the Arctic system in the coastal waters of Greenland for the first time. In collaboration with German and Norwegian researchers the increased discharges of technetium-99 from Sellafield have been used to examine the variability of transport pathways and rates to the Arctic and contributed to the development and validation of ocean transport model.

January 2007

Memorandum 6

Submission from the Proudman Oceanographic Laboratory (POL)

Executive Summary

Global warming is creating changes in the Arctic that are likely to have a global impact. The UK has a number of small research groups with a strong track record in Arctic research and POL recommends that they are coordinated to address the impact of Arctic climate change on the climate of Northwestern Europe.

POL welcomes the modest real terms increase in funding for strategic marine research announced by the NERC at the launch of Oceans 2025.

Although Oceans 2025 is a five-year programme, the NERC is only committing funding for the first two years due to the uncertainty surrounding the outcome of the comprehensive spending review. A real-term cut in years three to five of the programme would seriously undermine basic research aimed at improving the predictability of climate models and assessing the impact of climate change on the UK.

POL continues to be concerned about barriers preventing cross-council funding of marine research. Collaboration between NERC research and collaborative centres has been hampered by their mode of funding and POL welcomes moves to address this through the NERC Funding, Allocation and Budgeting project. Collaboration between CEFAS and NERC is also lacking and this is holding back research progress in the areas of marine bio-resources and marine spatial planning.

POL is concerned that recent budget cuts at Defra and the EA could reduce investment in the UK tide gauge network which underpins the storm and flood forecasting at the Met Office.

Long-term ocean monitoring ranging from remote sensing to ARGO floats is funded by a number of organizations and the situation is unnecessarily complicated. Funding for long-term monitoring of the oceans is also insecure.

Similarly, the current divided responsibilities between several organizations for Earth Observation have an adverse impact on global environmental monitoring capability in the UK. POL struggles to recruit well-qualified physicists and mathematicians trained in the UK and we frequently recruit from overseas.

What can be done to make a career in marine science more attractive to scientists trained in these fields?

POL is concerned that there are no funded programmes to protect the health of marine SSSIs. Data collected by Crown Estates on marine SSSIs should be deposited in the British Oceanographic Data Centre to facilitate its wide dissemination in the marine science community.

Introduction

POL welcomes the opportunity to submit evidence to this enquiry.

Organisation and funding of UK marine science in the polar and non-polar regions

1. An increase in funding and better organisation for polar marine research is needed. In recent years it is apparent that the Arctic is a barometer for the rapid climate change we are experiencing. Feedback mechanisms operating between the atmosphere, cryosphere and ocean and are responsible for the dramatic year on year decrease in Arctic summer sea ice that we are witnessing. The consequences of global warming are most starkly revealed in the Arctic, where warming is greater than elsewhere on the planet. One likely consequence of Arctic warming will be to impact on the strength of the global thermohaline circulation due to an increase in freshwater run-off from glacial melt. Thus, climate change in the Arctic can be viewed as the "engine room" for driving global climate change. In view of the extreme climate sensitivity of the Arctic, the likely global impact that it will create and the sensitivity of UK climate thereto via the thermohaline circulation, we believe that the UK should be at the forefront of research aimed at developing regional (including Arctic) climate prediction models.

2. The British Antarctic Survey (BAS) provides the leadership for UK research in the Antarctic. However, BAS is not in a position to provide similar leadership for Arctic research. The ships that BAS uses are ice strengthened and have only modest ice breaking capability. To reach the interesting regions in the Arctic basin during periods when sea ice is forming requires an ice breaker. The science programmes that BAS conducts in the Antarctic leaves very little time to deploy their ships and planes in the Arctic; usually 4 months at most during the Northern Hemisphere summer. We require data from the Arctic throughout the year and it is unlikely that BAS will be able to deliver it.

3. Other UK institutions with a track record of running Arctic field programmes are the Scott Polar Research Institute (SPRI) and the Scottish Association for Marine Science (SAMS). In recent years SPRI has reduced activity in the physical sciences. SAMS does not have a research vessel capable of operating in the Arctic. However, SAMS has a long track record of collaborating with Arctic nations, in particular the Norwegians. Collaboration provides SAMS with access to the Arctic.

4. The picture in the UK for developing regional Arctic climate prediction models is somewhat brighter, with the Hadley Centre, BAS, the National Centre for Atmospheric Sciences (NCAS), the Centre for Polar Observation and Modelling (CPOM), the National Oceanography Centre (NOC) and the Proudman Oceanographic Laboratory (POL) all having capability in this field. There is an urgent requirement to coordinate the modelling capabilities of these centres under the umbrella of a new UK initiative, the Arctic Climate Prediction Programme, say.

5. April 2007 marks the launch of the International Polar Year (IPY).The recent NERC IPY funding initiative was very small (order £5 million) for polar research. A project that plans to collect and analyse data from the Polar Regions will typically cost £2 million upwards. Thus, the NERC IPY funding initiative supported two major projects only. Although the UK has not committed a great deal of ring fenced money to the IPY, UK based scientists are involved in a large number of IPY-approved projects led by scientists based overseas.

6. Recently the NERC approved funding for a new strategic marine science programme called Ocean 2025. Seven marine laboratories in the UK will be collaborating on this programme and the Executive Board of this programme will be submitting evidence to this inquiry. The overall five-year funding envelope for Oceans 2025 exceeds the current NERC strategic funding to the seven participating marine laboratories by approximately 4%. POL welcomes the planned increase in NERC strategic marine funding, and is one of the laboratories that can look forward to a real-term funding increase.

7. Until recently the funding for NERC centres and surveys inhibited research collaboration between the laboratories. In fact, the centres and surveys were competing against each other for strategic funding. NERC's Funding Allocation and Budgeting (FAB) review promises to create a funding environment that enables centres/surveys to collaborate; POL welcomes this.

8. There are also unhelpful barriers for funding marine science between research councils. For example, offshore engineering is mainly funded by EPSRC which POL is prevented from bidding for.

9. Looking beyond the NERC the issue of funding for marine science is of concern. Defra funding cuts are a major problem for UK marine sciences. Persuading Defra to fund long-term monitoring is always an uphill struggle, and the situation is likely to become more challenging with Defra's funding cuts. POL is also concerned about the longer term funding of the UK tide gauge network by the Environment Agency (EA). Defra funding cuts filter through to the EA. POL has run the tide gauge (sea-level) network for many years supported by Defra. About two years ago the funding of the tide gauge network was transferred to the EA, and now their funding constraints may well jeopardise the future funding and development of the network. We must stress that long-term monitoring of environmental fields (eg temperature and salinity of our coastal seas) provides a vital benchmark for assessing the impact of climate change. Long time series provide an invaluable method for assessing the predictive capability of climate prediction models. There is a generic issue that as observing and predicting systems progress from research to ongoing operational status, beneficiaries should be identified and assume corresponding shares of the funding responsibility.

10. Funding constraints at Defra have also inhibited collaboration between the NERC and CEFAS. There is the potential for a major advance in marine ecosystem management through closer collaboration between CEFAS and the laboratories participating in Oceans 2025.

The role of UK internationally, and international collaboration in marine science

11. The UK takes the lead in RAPID and is a big player in WOCE. Although ring fenced funding for IPY has not been large, UK scientists are involved with almost half of the IPY-approved projects. UK sea level science is excellent and its profile should be raised further on the international stage. POL hosts GLOSS (The Global Sea Level Observing System), an IOC/UNESCO funded programme. The UK also has a high participation rate in EU framework proposals. We believe the UK should be taking a stronger lead in many international (eg IOC) programmes and not leave it all to the US (as most countries do!). There should be a clear line of responsibility for funding global programmes like CLIVAR, GOOS etc. and not leave it to the fate of individual science proposals like Oceans 2025. There is a lack of scientific administrative support in the UK which prohibits our scientists in getting involved in the leadership of international programmes. The leadership of large international programmes carries a significant administrative overhead that most UK laboratories cannot easily accommodate.

12. Without large ships the UK cannot participate in international marine science. POL welcomes the imminent arrival of the RRS James Cook and the planned funding to replace the RRS Discovery. However, the cost of building new ships continues to rise rapidly and we are concerned that there will be insufficient funds to build a vessel with capability similar, if not greater, than the RRS Discovery. The UK enters into a barter arrangement with countries that run ocean going research vessels. This arrangement is only possible if the UK can continue to offer berths to international scientists on its own ocean going research vessels. The challenge for the UK Government, and in particular the NERC, is to develop a long-term funding model to support large-scale infrastructure such as aircraft and ships. To conduct cutting-edge environmental science it is vital to have access to these types of facilities.

13. Earth observations play a fundamental role in monitoring our planet, but there is insufficient funding for processing and archiving remote sensing data. The NERC subscribes to ESA for science but not for monitoring. The UK needs to get its act together regarding all aspects of space research. Present divided responsibilities have an adverse impact on global environmental monitoring capability in the UK. There are a number of organisations with responsibility for space research such as the BNSC, EPSRC and Defra. It is unclear to us what the roles and responsibilities of each of these organisations are in space research. A proper strategy for space research, including who is responsible for funding the processing and archiving of remotely-sensed data is urgently required.

Support for marine science, including provision and development of technology and engineering

14. Oceans 2025 has made a significant step forward in funding marine technology. In POL our proposal for marine technology has been fully funded, enabling us to further develop the Liverpool Bay Observatory and to develop state-of-the-art telemetry systems for sea level data. There is however a caveat to this good news. Oceans 2025 funding has been confirmed for the first two years of the five-year programme only.

Funding for years three to five is dependent on the outcome of the CSR 2007. Technology development is, by its very nature, long-term and costly. If funding for years three to five of Oceans 2025 is reduced in real terms then this will have a disproportionately large adverse impact on the technology theme. Marine technology development also provides opportunities for commercialisation. The time-scale for developing a new instrument and then conducting the trials required to reach the stage where commercialisation is a real prospect is typically five to 10 years. Until recently strategic marine science funding from the NERC was five years at most. The FAB review proposes that "national capability" within NERC centres and surveys (such as marine technology) be funded on a longer time-scale, such as 10 years. POL welcomes this proposal.

15. Apart form the NERC there are few bodies willing to fund marine technology. Better collaboration with EPSRC may benefit technology funding. At present the UK is weak in developing and deploying "big *in situ* technology" such as robots, deep sea submersibles and autonomous under water vehicles. Sea floor observatories, particularly of the cabled type, are talked about, but nothing happens. We believe that the UK is missing out by not getting involved with "big technology".

16. Attracting skilled engineers into careers in marine technology is a major challenge. The UK does not train a large number of engineers, and the most able tend to pursue more lucrative careers than we can offer in the marine laboratories. At POL we have had modest success in running an apprentice scheme where we train technicians "in house". However, leadership for marine technology development requires physicists, material scientists and engineers trained up to postgraduate level and at POL we struggle to appoint such people, mainly due to non-competitive salaries.

State of UK research and skills base underpinning of marine science

17. The UK skill base for marine science is not healthy, particularly in the area of marine physics which is at the heart of the research conducted at POL. POL requires highly numerate scientists and engineers, usually trained to postgraduate level. POL always seeks to recruit the best person for a given post and in a many cases this results in recruiting from abroad. The question is what will happen to UK (marine) science if the supply of skilled scientists from overseas dries up? POL believes it is strongly in the interests of the UK economy to train and retain scientists and engineers. The status of scientists and engineers in the UK is not high and the salaries they command are significantly less than in many other professions. We have a shortage of role models in science and engineering that young people can be inspired by. High schools struggle to attract teaching staff trained to degree level in science and engineering. Mathematics and physics graduates are desperately required in the teaching profession. The Research Councils are aware of these problems but the debate is to what degree they should become involved with addressing the problems at high school level. Universities are perhaps better placed to address the problems with attracting well qualified scientists in the teaching profession. Information for young people about the skills required for a career in marine science is often inaccurate. For example, it is not made clear that certain fields in marine science require graduates in mathematics and/or physics.

Use of marine sites of special scientific interest

18. There are a number of marine SSSIs which have already been identified. Unfortunately, there is very little funding available to monitor such sites with the goal of determining whether they are under threat. Further, there is a lack of a single point of contact for data obtained through monitoring. We would like Crown Estates to make data they collect available via the BODC.

January 2007

Memorandum 7

Submission from the Royal Society of Chemistry

The Royal Society of Chemistry (RSC) welcomes the opportunity to contribute to the House of Commons Science and Technology Committee's consultation Investigating the Oceans.

The RSC is the largest organisation in Europe for advancing the chemical sciences. Supported by a network of 43,000 members worldwide and an internationally acclaimed publishing business, our activities span education and training, conferences and science policy, and the promotion of the chemical sciences to the public.

This document represents the views of the RSC. The RSC's Royal Charter obliges it to serve the public interest by acting in an independent advisory capacity, and the RSC is happy for this submission to be put into the public domain.

Executive Summary

— Manmade emissions of carbon dioxide (CO_2) are causing the oceans to become more acidic.

— To-date, the oceans have absorbed approximately half of the carbon emitted into the environment by mankind.

— The ability of the oceans to continue to absorb carbon dioxide is not well understood; current carbon levels and changes in global temperatures may have a significant effect.

— Increasing carbon acidity could have a significant impact on many marine organisms, specifically calcifying organisms and larger aquatic animals. The effects of ocean acidification on these, and other organisms, is not completely known.

— The deep oceans have been suggested as potential storage sites for carbon.

— Much research is needed before the viability of deep ocean carbon storage can be evaluated. The effect of such schemes on the oceans, at a local and global scale, and on deep ocean life has not been determined.

Introduction

The Royal Society of Chemistry is concerned about the impact of human activity on oceanic ecosystems. One of the foremost problems is the acidification of the oceans. This arises as a result of increased carbon dioxide (CO_2) absorption by the oceans as a direct result of an increase in atmospheric CO_2 levels caused by human activity such as the combustion of fossil fuels, agriculture, deforestation and cement production.

The deep oceans have also been suggested as a suitable environment for storing carbon dioxide as a means to mitigate climate change. Many of the scientific questions regarding this are also closely associated with the absorption of carbon dioxide by the oceans and its subsequent acidification.

Ocean Acidification

The RSC fully endorses the 2005 report by the Royal Society entitled "*Ocean acidification due to increasing atmospheric carbon dioxide*" in its scientific evaluation of ocean acidification, its discussion of related socio-economic impacts, and its recommendations for future research and governance.[1] The issue of oceanic acidification has also been discussed by the Intergovernmental Panel on Climate Change (IPCC) in its 2001 Climate Change report.[2] The following section highlights some key aspects of ocean acidification.

There is now wide-spread acceptance that carbon dioxide (CO_2) released into the atmosphere through human activities is having a negative impact on global climate. Since pre-industrial times the atmospheric level of carbon dioxide has risen from about 280 ppm to about 380 ppm today, and it is still rising. This increase in atmospheric CO_2 levels does not account for all manmade carbon emissions; over half of total CO_2 emissions produced in the last 200 years have been absorbed by the oceans.[3]

The concentration of carbon dioxide (CO_2) in the oceans directly correlates to that in the atmosphere. When atmospheric CO_2 levels rise then there is a concurrent increase in that absorbed by the oceans. When CO_2 dissolves in the oceans it combines with water to form carbonic acid, H_2CO_3, which in turn dissociates to form carbonate ions, HCO_3^-, and hydrogen ions, H^+. Further ionisation of HCO_3^- leads to the formation of carbonate ions, CO_3^{2-}, and H^+. It is the generation of hydrogen ions, or protons, that leads to the lowering of oceanic pH, ie the ocean becomes more acidic. The composition of dissolved inorganic carbon (DIC) in the ocean typically comprises aqueous CO_2 (1%, including H_2CO_3), bicarbonate ions (3%) and carbonate ions (CO_3^{2-}, 8%). These ratios will vary according to local conditions including, primarily, temperature and up- welling of CO_2-rich deep water. Over the past 200 years the average pH of the oceans has dropped by 0.1 pH units (a 30% increase in H^+).

The oceans act as a carbonate buffer, which has, to date, been highly beneficial to mankind in minimising damage ocean acidification caused by high levels of CO_2 emissions. The decrease in ocean pH is therefore less than would be expected for the quantity of CO_2 absorbed. However, as increasingly large amounts of CO_2 become absorbed in the oceans then their ability to act as a buffer is lessened.

Currently the quantity of CO_2 absorbed by the oceans per year is two Gt (Gt = gigatonne; one Gt = 10^9 tonnes). For comparison, a fully laden supertanker weighs approximately 250,000 tonnes. As oceanic carbon dioxide levels increase, this rate of absorption will drop. Increases in average global temperature will potentially lead to increased vertical stratification (decreased mixing), thus decreasing the amount of CO_2 that can be absorbed (it may also decrease the flow of nutrients). If CO_2 emissions continue as at present then the pH of the oceans is predicted to drop by approximately 0.5 units by 2,100, corresponding to a three fold increase in H^+ ions since pre-industrial times. Importantly, reversing current changes in ocean pH could take tens of thousands of years, ie it is essentially irreversible in our lifetimes. This is because oceanic mixing between surface and deep waters, which is required in order to bring up ocean sediments to buffer acidity changes, is a very slow process.

There is the potential for ocean acidification to have a significant impact on aquatic life. The greatest detrimental effect may be felt by those organisms that produce structures made from calcium carbonate ($CaCO_3$). Calcifying organisms include molluscs, corals, echinoderms, foraminifera and calcareous algae. The calcium carbonate produced by these organisms is used in external and internal structures, and in one of two forms: calcite or aragonite. Crucially, calcium carbonate will dissolve into seawater if the surrounding concentration of carbonate ions (CO_3^{2-}) is not high enough. It also becomes more soluble at lower ocean depths as a result of decreasing temperature and increasing pressure. A "saturation horizon" can therefore be defined; in waters above this depth $CaCO_3$ does not dissolve but below this depth it does. Currently calcifying marine organisms live above the saturation horizon, however, lowering the pH of seawater will result in a decrease in the concentration of CO_3^{2-} and the saturation horizon will be elevated closer to the ocean surface. Aragonite is more soluble than calcite, and its saturation horizon is closer to the ocean surface than it is for calcite.

The acidification of the oceans may also have an impact on non-calcifying organisms. Most photosynthetic organisms, such as phytoplankton, obtain inorganic carbon from dissolved CO_2 or bicarbonate ions. As it is an active process then increases in dissolved inorganic carbon is likely to have only a small effect on photosynthesis and, in turn, on growth rates. The effect of increasing dissolved carbon concentrations on non-photosynthetic organisms is less well-understood, although it is anticipated that they will respond to increased CO_2 concentrations.

Larger oceanic animals may also be adversely affected by increased CO_2 concentrations. The respiratory system of such animals relies on obtaining oxygen from water, in which it is present in only very low levels. This is also accompanied by removal of CO_2, to a much lower level than that required by land mammals. Large aquatic, water breathing mammals are therefore highly sensitive to the concentration of carbon dioxide in the oceans; increased CO_2 can lead to acidification of bodily tissues and fluids.

There is also some concern that ocean acidification will have a direct impact on the availability of nutrients and the presence of toxins in the aqueous environment. The modification of ocean chemistry could have significant impacts on sea life. In the oceans metals can either be in complexed or free dissolved forms; the latter is considered to be toxic. Decreasing the pH of the oceans is anticipated to result in an increase in the concentration of free metals. Predicting the impact of this change is highly problematic though, with the role of trace elements in aquatic biochemical processes still an area of ongoing research.

Key questions that may need to be addressed include:

- How will CO_2 absorption by the oceans be affected in the future by current absorption and by increased global temperatures?
- Do climate change models need to be addressed with regards to changes in rates of CO_2 absorption?
- To what extent will calcifying organisms be affected at current CO_2 levels and at future projected levels?
- What research needs to done to identify the effects of ocean acidification on non-calcifying organisms?
- How will ocean acidification affect the ratio of complexed to freely dissolved metals in the oceans, and what impact will this have on aquatic organisms?
- What effect will ocean acidification have on the availability (concentration, speciation etc) of nutrients such as phosphates, silicates and ammonium ions.
- Will the corrosion of ship hulls be adversely affected by increased ocean acidity?

Deep Ocean Storage of Carbon Dioxide

Carbon capture and storage has been proposed as a means to decrease the quantity of carbon dioxide emitted by human activities, thus helping minimise the impact on global climate. Using deep oceans as repositories for carbon dioxide has been proposed and a detailed study of this concept has been carried out by the IPCC and is included in their Special Report Carbon dioxide Capture and Storage.[4]

The two main concepts include "dissolution", in which CO_2 is injected at depths of 1,000 m or more and the CO_2 subsequently dissolves, or by "lake" deposition in which CO_2 is injected onto the sea floor at depths of greater than 3,000 m where it is anticipated that, being denser than water, it would form a lake and dissolution would be delayed.[5] Both schemes rely upon the slow mixing of ocean water of differing depths.

There is general agreement that carbon stored by this method would remain isolated for several hundreds of years, although not permanently. Fractions stored at greater depths will be retained for longer periods of time, and this can be extended further by the formation of solid clathrates or liquid CO_2 lakes.

The environmental effects of such schemes remain poorly understood. As dissolution of CO_2 progresses the acidity of the ocean would decrease, as outlined in the previous section. If the quantity of CO_2 injected was limited to only a few Gt then significant perturbations in ocean chemistry would only occur locally. Injection of hundreds of $GtCO_2$ would likely result in measurable changes over the entire ocean volume.

Although life is perceived to be sparse at such ocean depths, the effects of such high levels of CO_2 could have significant implications for what benthic (floor dwelling) organisms are present. There are suggestions that such organisms, and deep ocean microbial populations, may be highly susceptible to changes in CO_2 concentrations and pH.[6]

A third option is the conversion of carbon dioxide into bicarbonates or hydrates. This has the potential of minimising the impact on pH and avoid the need for prior separation of CO_2. However, wider environmental impacts include the use of large amounts of limestone and the need to require large material volumes.

A final option is to sequester carbon in crop residue and place large bales of biomass into the alluvial fan areas of the ocean basin. This could result in rapid burial of the bales into silt on the sea floor, and therefore the biomass could be stored for a long time.

Although deep ocean storage of carbon dioxide must be considered, there are many questions that need answering in order to be able to judge its viability.[7]

- Is deep ocean storage economically viable, environmentally safe and socially acceptable?
- What are the legal ramifications of injecting CO_2 into the oceans?
- How will CO_2 interact with water and ocean sediments at such extreme depths?
- What effect will high levels of CO_2 have on organisms living on or near the ocean bed?
- Will the stratification of the oceans be affected by current CO_2 emission and global warming and what effect will this have on potential deep ocean storage?

The RSC does not feel that sufficient data exists presently on this subject. Until these key questions are addressed satisfactorily then the RSC cannot condone deep ocean storage of CO_2.

January 2007

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[4] Intergovernmental Panel on Climate Change Special Report on *Carbon dioxide Capture and Storage*, Chapter 6 Ocean Storage. http://arch/rivm.nl/env/int/ipcc/pages_media/SRCCS-final/IPCCSpecialReport onCarbondioxideCaptureandStorage.htm

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[7] Intergovernmental Oceanographic Commission of UNESCO, *Watching Brief: Ocean Carbon Sequestration*. http://ioc.unesco.org/iocweb/co2panel/CaptureStorageOcean.htm.

Memorandum 8

Submission from the Royal Society for the Protection of Birds

Executive Summary

- This response focuses on the use of marine sites of special scientific interest, and the impact of climate change on UK seabird populations.
- There are serious shortcomings in the current marine nature conservation framework. Progress on the designation of marine Special Protection Areas in UK waters (required by EU legislation) is unacceptably slow, and hampered by inadequate data.
- The UK's nationally important marine wildlife needs better protection, and the forthcoming Marine Bill must include provisions to identify and designate Nationally Important Marine Sites, some of which will be highly protected, with all damaging activity prohibited.
- There is evidence that warming of UK waters is changing the food web, creating food stress for certain seabirds, adversely affecting their breeding success and survival, and ultimately reducing population sizes. The strong dependence of many seabird populations on sandeels, whose abundance is declining, appears to be a key pressure point.

— The Danish-led industrial sandeel fishery must not aggravate the depletion of local aggregations of this species on which breeding seabirds depend. There is a strong case for maintaining indefinitely the closed area for sandeel fishing off the east coast of Scotland/north-east England.

— The geographical spread of comprehensive research into climate change impacts on seabirds should be widened beyond the current relatively circumscribed area of Scottish North Sea coast to include other UK coastal regions. This should be accompanied by full integration of seabird research efforts into the Natural Environment Research Council-led Oceans 2025 programme.

— The RSPB is a member of Wildlife and Countryside Link, and the UK partner of BirdLife International. Both have responded separately to this Inquiry, and we fully support their responses.

The RSPB

1. The RSPB is Europe's largest wildlife charity, with more than one million members, and we manage one of the largest conservation estates in the UK, comprising 200 nature reserves. We are part of the BirdLife International partnership, a global alliance of independent national conservation organisations working in more than 100 countries. The RSPB's policies are based on detailed and comprehensive scientific research, and we have considerable expertise on the operation of terrestrial and marine ecosystems, and the factors governing bird population trends.

The use of Marine Sites of Special Scientific Interest

2. The RSPB, working with other NGOs through Wildlife and Countryside Link, is campaigning for better management, protection and conservation of important marine assets. We therefore welcome the proposals for a Marine Bill, and we responded in detail to the Government's Marine Bill consultation last summer. Although we were disappointed that there was no draft Bill in the 2006 Queen's Speech, we are heartened by the promise of a Marine White Paper this spring, and hope to see a full Bill in the 2007 Queen's Speech. This must deliver strong measures for nature conservation—if it does not, it will be a squandered opportunity.

3. The RSPB is concerned about serious shortcomings in the current marine nature conservation framework.

4. The identification of marine Special Protection Areas (SPAs), required by the EU Birds Directive, is crucially important to the conservation of seabirds of European importance, but is far from complete: to date, only one true marine SPA has been designated in UK waters.

5. The European Court of Justice (Case C-6/04, *European Commission vs United Kingdom*, 20 October 2005) has confirmed that the EU's Birds and Habitats Directives apply within the territorial waters and the continental shelf and superjacent waters of the UK. The Court also required the UK to implement surveillance requirements for habitats and species of Community interest, necessary in order to determine whether the UK is meeting its conservation obligations under the Habitats Directive.

6. Among other things, this means the Government must now identify, designate, monitor and manage a complete network of European protected areas to meet the requirements of those Directives in the marine environment: SPAs for birds and Special Areas of Conservation (SACs) for other habitats and species of European Community interest. Robust and comprehensive surveillance data will be essential to underpin decisions on both the identification and long-term management of these sites.

7. The Joint Nature Conservation Committee (JNCC) has responsibility for surveying and identifying potential marine SPAs to recommend to government for designation. JNCC has identified a three-element approach to this work, which we broadly support: (1) seabird breeding colony SPA extensions; (2) inshore aggregations of non-breeding waterbirds; and (3) offshore aggregations away from the coast at any time of year (eg foraging seabirds from breeding colonies).

8. Elements 2 and 3 are the most challenging, requiring substantial additional survey and analysis to ensure that the resulting marine SPA network is fit for purpose, identifying sites that reflect the most important areas for seabirds in the pelagic environment.

9. We are particularly concerned about JNCC's heavy reliance on European Seabirds at Sea (ESAS) data for element 3. Our concerns centre on the comprehensiveness of survey coverage in both spatial and temporal terms, essential to ensure we protect the right places. Much of the ESAS systematic survey data is at least 10 years old, with more recent data tending to be gathered in a patchy or ad hoc fashion, mainly from the outcomes of developers' project-specific environmental impact assessments. Given the strong evidence of a climate change-induced "regime shift" in the North Sea (see later section on climate change impacts on seabirds), data will become obsolete faster. Therefore, we doubt that the existing ESAS database adequately reflects current seabird distribution or the location of important concentrations.

10. In addition to these concerns, JNCC timetable estimates for completing this work vary from 2011–17, dependent on resources. Our concerns over the adequacy of available survey data leave us sceptical about the ability to meet even the 2017 timescale and deliver a coherent marine SPA network that complies with

Birds Directive requirements. Even if this timescale were met, it would mean completion of the UK marine SPA network some 36 years after the Birds Directive came into force. This is unacceptable, both in terms of marine conservation obligations and the UK economy.

11. The Government must carry out an ecologically-driven assessment of the work needed to identify, designate and monitor a marine SPA (and SAC) network within a timescale that fits as closely as possible with its international commitments to implement a marine protected area network, ie by 2010. This would benefit both conservation and the economy, by providing greater certainty over the location and protection of our most important marine protected areas, such that they are fully taken into account in planning the future management and use of the sea.

12. Even when complete, however, the Natura 2000 network of SPAs and SACs will not offer sufficient protection to the full range of important marine species and habitats, to the UK's nationally important marine biodiversity or to the marine ecosystems that underpin so many goods and services. We are pleased that the UK's commitment under OSPAR (protection of the marine environment of the North-east Atlantic) to designate a well-managed, ecologically coherent network of marine protected areas (MPAs) by 2010 has also been identified as requiring new legislation through the Marine Bill. However, this legislation must also ensure proper protection of the UK's nationally important biodiversity. We are therefore calling for the designation, protection and management of Nationally Important Marine Sites (NIMSs) throughout the UK's marine jurisdiction.

13. To safeguard these sites, features and processes, the RSPB is calling, through the Marine Bill, for a new mechanism for the designation of a network of OSPAR MPAs and NIMSs, including provisions to create highly protected areas where all damaging activities would be excluded. This mechanism would replace the existing inadequate legislation on Marine Nature Reserves.

14. A network of sites should be designated to protect, conserve and secure the recovery and enhancement of vulnerable (rare, threatened or otherwise sensitive) species and habitats. Such a network should include geological and physical marine features, and ecological and geomorphological processes, as well as ecosystem structure and functioning. Sites must represent the full diversity and geographic range of species and habitats found in the territorial waters around England, Scotland, Wales and Northern Ireland, throughout UK waters and to the limits of the UK continental shelf, and throughout EU waters and the OSPAR maritime area.

15. New legislation must also include a duty, not just a power, to designate sites. The Statutory Nature Conservation Organisations (SNCOs) should be responsible for determining, on a purely scientific basis, site selection criteria (with a duty on the SNCOs to select sites according to agreed criteria, based on a regional seas approach). Social and economic considerations must not influence decisions about site identification, selection and designation. The impacts of the designation of sites on socio-economic interests should be considered through the preparation of management plans, with the engagement of stakeholders. These would ensure that any socio-economic activities within or affecting an MPA would take place within the context of its conservation objectives.

16. To secure effective management of sites, there should be a combination of both direct (ie proactive site protection management tools) and indirect (ie through the licensing of marine activities) controls over activities affecting (or potentially affecting) MPAs. There should be a strong presumption against activities that would have significant detrimental effect on MPAs.

17. Scientific data and information are required to identify, select and designate all forms of MPAs. Such data provides vital information on the location of particular species and habitats, their status, and which human activities they are sensitive to. Good data and information are also necessary to ensure an effective management regime is put in place for each designated site. Finally, there should be a requirement to monitor the status of the features protected by the site to determine whether the management plan is achieving its objectives.

18. Although marine science (survey and research) in the UK is among the best in the world, there are still gaps in our knowledge. We lack adequate coverage of data on both a spatial and a temporal scale for many species and habitats in UK waters. Our knowledge of the location and status of mobile marine species such as cetaceans and seabirds is even poorer. As noted above, these data gaps have already resulted in delays to the designation of marine SACs and SPAs. In addition, the Government's current reliance on industry surveys, carried out for environmental assessment purposes, must end, as it leads to conflicts and delays to projects when developers discover important wildlife at their chosen sites.

19. However, there is a view that, until we know which are the best sites for a particular feature, and where they are, no sites can be designated for that feature. If the same thinking continues, there will almost certainly be long implementation times for any new site protection mechanisms proposed through the Marine Bill. The knock-on effect would be that the UK would fail to meet its commitments to achieve targets for networks of protected sites, such as those under the Birds and Habitats Directives and OSPAR.

20. Data must be collected to fill existing gaps, with resources made available for that purpose. Where data does exist, resources should also be provided to ensure it is analysed as quickly as possible, and then made public. This is the information required to enable fully informed policy and management decisions regarding the designation of all types of MPAs to protect our marine natural resources and wildlife properly.

21. Delays in identifying, designating and protecting important marine sites leave them vulnerable to damage and destruction by human activities. Society cannot continue to use the absence of a complete data set and absolute knowledge of the UK's seas as a justification for negligence in providing improved site protection for marine wildlife.

The Impact of Climate Change on UK Seabird Populations

22. The UK holds internationally important seabird populations, including over 90% of the world's breeding Manx shearwaters, over 70% of northern gannets and 60% of great skuas. We therefore have a special responsibility to protect them from adverse impacts. Many seabird populations have prospered over the last century, with the cessation of hunting, improved colony protection, and the creation of a gratuitous food supply through discards from fishing vessels. However, particularly on the north and east coasts, some species have declined substantially in the last two decades. There has been an increasing incidence of years in which black-legged kittiwakes, arctic terns and arctic skuas have struggled to find enough fish to feed their young.

23. A recent census of kittiwakes breeding on Shetland, for example, showed declines of nearly 70% (37,000 pairs) between 1985–88 and 1998–2002. In 2004, kittiwakes suffered their worst breeding success on record all along the North Sea coast as far south as the RSPB seabird colony at Bempton (Yorkshire), with widespread chick starvation. Breeding success of guillemots also suffered badly in Scotland, many not even attempting to breed. Productivity of several seabird species continued to be below average in many areas in 2005 and 2006, and in both years failures spread to the west coast, particularly Scotland and Northern Ireland.

24. In spring and summer, many of these birds are highly dependent (often $>90\%$) on sandeels as prey for themselves and their young. There is some empirical evidence that sandeel recruitment (likewise cod recruitment) is reduced by poor planktonic feeding conditions due to warm winters. We already know that, since the mid-1980s, rising sea surface temperatures (SST) in the North Sea have profoundly changed ('regime shift') the assemblage and spatial distribution of plankton on which larval fish depend for survival and growth. There is, therefore, a strong presumption that climate change is creating food stress for certain seabirds, adversely affecting their breeding success and survival, and ultimately reducing populations.

25. The strongest evidence for this linkage comes from long-term demographic work by the Centre for Ecology and Hydrology (CEH) on kittiwake populations on the Isle of May (Firth of Forth), where warm winters depressing sandeel prey abundance and quality have been invoked as a key factor in the birds' poor breeding success. Winter survival of adult kittiwakes was also lower after warmer winters, and this is likely to compound population declines.

26. Poor breeding success was also linked to sandeel extraction by the Danish-led fishery on the Wee Bankie (Firth of Forth) in the 1990s. The relentless and unsustainable rate of decline (6% per annum) of kittiwake populations in this region (South-east Scotland) from 1989–2005 led to the establishment (by the EU Fisheries Council) in 2000 of a closed area for sandeel fishing stretching from North-east Scotland to Northumberland. In the first ever use of a seabird as a proxy for the status of a fish stock, threshold values of kittiwake breeding success were used as criteria for the establishment and lifting of this particular closure. The area has been closed continuously since 2000, and remains so today.

27. Reversing the adverse effects of warm winters will—at best—be a very slow process, and CEH scientists have therefore argued that, as a precautionary measure, the current closure of the commercial sandeel fishery should remain in place "indefinitely", to safeguard the kittiwake population in the hinterland. The RSPB strongly supports this recommendation.

28. Since 2004, the Danish fleet has been subject to a new set of harvesting rules for sandeels, such that the main regulating tool is not now a blanket Total Allowable Catch, but a level of fishing effort predicated on the strength of sandeel recruitment (which is monitored annually, right up to the traditional start of the sandeel fishing season in spring). Since the inauguration of this new regime in 2005, fishing effort has been curtailed, with adverse knock-on effects on industrial fish processing capacity in Denmark. Accordingly, Denmark may well argue for the lifting of the closed box off eastern Scotland in order to increase its fishing opportunities for sandeels.

29. The RSPB therefore continues to urge the UK Government to be vigilant and to resist any request from Denmark to lift the ban on purely socio-economic grounds. Rather, Ministers must support indefinite closure, in view of the continuing decline of the kittiwake population in the region.

30. According to the Marine Climate Change Impacts Partnership (MCCIP) Annual (2006) Report Card, "While no direct link has been shown between SST increases, low sandeel biomass and poor seabird breeding performance, the circumstantial evidence is compelling". However, useful as this is as a broad framework, and although seabirds (as top predators) have manifest value as indicators of marine ecosystem status, the mechanisms underlying these trophic (ie food chain) linkages are likely to be complex and subject to high levels of uncertainty. Detailed research is required to identify these mechanisms, to differentiate between and give due weight to human (eg sandeel fishing) and environmental drivers (eg long-term change in SST), and ultimately to predict and mitigate change.

31. There is therefore a need for multi-disciplinary work to address, coherently and strategically, the monitoring of seabird populations, climate change, oceanography, plankton community dynamics, fish stocks and commercial fisheries. Such a programme will be invaluable in predicting the impacts of projected changes in climate on the marine environment, and providing the evidence base to underpin policy-making and design of monitoring programmes. Initial efforts in this direction have already been made by JNCC, with the inauguration in 2005 of the multi-disciplinary Seabird Monitoring Programme Liaison Group.

32. For this work to be successful, however, certain conditions must be met. Firstly, while there has been a traditional focus on the North Sea, which must be maintained (it is one of the best-studied regional seas in the world, with high-quality data sets and long time series), effort must also be spread across a range of UK waters. This would allow capture of responses to a variety of anthropogenic influences, such as fisheries, and fundamental differences in oceanography (bathymetry, hydrography etc). Only by working across a range of locations will we be able to gauge and understand the causes of variation in seabird performance across sites and years, and predict long-term impacts on populations.

33. Secondly, there is a growing need to integrate the efforts of different research agencies to facilitate the linkages between different trophic levels and to combine these with expertise in oceanography and climate. A significant step in this direction has been made with seven prestigious UK Marine Centres recently joining forces to seek funding from the Natural Environment Research Council for a coordinated strategic research programme, Oceans 2025. This strategy will pursue a number of research themes highly relevant to the Committee's Inquiry, including "Climate, ocean circulation and sea level", "Biodiversity and ecosystem function" and "Integration of sustained observations in the marine environment".

34. The creation of this consortium is a huge step forward in addressing the need for coherence between disciplines. However, the role of seabirds in the ecosystem is a glaring omission from this new integrated structure, and all the more surprising because due weight is given to the role of other top predators through the inclusion of the Sea Mammal Research Unit. An obvious way to redress this would be to include in Oceans 2025 CEH's internationally important work on the mechanisms and processes linking seabird population status and behaviour to diet and the marine trophic structure. Oceans 2025 would benefit greatly from the great strides this group is making in unravelling the impacts of climate change on UK seabird populations. For its part, CEH's synergy with the seven other Marine Centres in Oceans 2025 organisations would be of immense benefit in progressing this vital seabird work.

January 2007

Memorandum 9

Submission from Birdlife International

Executive Summary

- This submission concentrates on the UK's input into three international fora: the United Nations Food and Agriculture Organisation (FAO); the Agreement on the Conservation of Albatrosses and Petrels (ACAP); and the Regional Fisheries Management Organisations (RFMOs).
- As a Member State of FAO, the UK must meet its international obligations on behalf of its Overseas Territories, as prescribed in the FAO International Plan of Action ıSeabirds (IPOA-S).
- The UK should also lead on the development of a European Community Plan of Action, which should be initiated as a matter of high priority, particularly given repeated assurances by the European Commission that they intend to propose and legislate for such a plan.
- The UK is a critically important Party to ACAP, which is currently largely dependent on voluntary funds contributed by Parties in addition to budget contributions. It is vital that through DEFRA, the UK continues to contribute funds to ensure delivery of effective conservation action by ACAP.
- The effectiveness of the UK's input to ACAP would be greatly enhanced by the active engagement of Defra Fisheries Division, in addition to the Defra Wildlife Division.
- A range of steps should be taken by the UK Government to increase the capacity and ability for UK Overseas Territories (OTs) to participate fully in ACAP. These include: investigation of the feasibility of an appropriate level of fishery protection (patrols); part funding of an OTs coordination post based in the Falklands Islands; and provision of facilities and resources to enable remote OTs to participate fully in ACAP related activities in the UK and overseas.
- It is critical that the UK, as a member of the top five RFMOs (in terms of overlap between seabird distribution and longline fishing effort) attends and is proactive at key meetings of relevant RFMO scientific committees and bycatch working groups. Only by engaging pro-actively in this way will the UK influence upcoming initiatives to address seabird bycatch in key RFMOs.
- The UK should include bycatch experts within its RFMO delegations, and ensure the highest standard of scientific input.

Introduction—The Global Seabird Programme

1. BirdLife International was formed in 1994, reconstituted from the International Council for Bird Preservation. The organisation is a global Partnership of NGOs which work together to achieve the shared mission "to conserve wild birds, their habitats and global biodiversity, by working with people towards sustainability in the use of natural resources". The NGOs in 103 countries that form BirdLife International together represent the leading global network focusing on the conservation of birds and biodiversity. The Partnership is the world's foremost scientific authority on birds, and the network provides information on conservation and development issues to many governmental and inter-governmental institutions worldwide.

2. Given that seabirds often travel vast distances across the oceans, including the high seas, their protection cannot be addressed by national measures alone. To address the need for a coordinated international approach to seabird conservation, in 1997 BirdLife International established the BirdLife Global Seabird Programme. While the programme addresses a broad range of issues, its main coordinated focus to date, highlighted by BirdLife's "Save the Albatross" Campaign, is seabird mortality caused by longline and other fisheries. In broad terms, the programme focuses on local, regional and international advocacy to raise awareness of the issue within the fishing industry and wider community and to facilitate implementation of onboard mitigation measures to reduce the level of seabird mortality.

3. Seabirds are killed as bycatch in fisheries around the world, but the UK has a critical role to play in the conservation of albatrosses and petrels, as the UK Overseas Territories (OTs) of the Falkland Islands, South Georgia and South Sandwich Islands, and Tristan da Cunha are collectively home to more than 30% of the world's albatross populations. This includes seven species, including two endemic to Tristan da Cunha. Some albatross populations in South Atlantic OTs are the most rapidly declining in the world.

4. Bycatch of seabirds in longline fisheries occurs when birds, attracted to the bait set on the longline hooks, get caught on those hooks, dragged underwater and drowned. Each year, more than a billion hooks are set by the world's longline fleets, killing at least 300,000 seabirds, including about 100,000 albatrosses.

5. Largely as a result of this mortality, the albatross family (*Diomedeidae*) has the highest proportion of species under threat of global extinction of any bird family. Currently, 19 of 21 species are classified as globally threatened, seven of which are listed as Endangered and two as Critically Endangered. The proportion of albatross species threatened with extinction increased from around 30%–90% between 1994 and 2004. The ecology of albatrosses (a decade to reach breeding age and infrequent successful breeding thereafter) renders them particularly susceptible to increased adult mortality. The level of albatross mortality in both regulated and unregulated longline fisheries is causing dramatic declines in breeding populations. This poses the risk that populations of several of these iconic species will become extinct in the near future, unless international policy instruments translate into concerted action, in particular the widespread adoption of proven mitigation measures by the world's longline fishing fleets.

United Nations Food and Agriculture Organisation

6. In 1996, an IUCN-The World Conservation Union resolution called for concerted action to reduce seabird mortality in fisheries. This led to the development of an FAO International Plan of Action for Reducing Incidental Catch of Seabirds in Longline Fisheries (IPOA-Seabirds), formally adopted by the FAO Committee on Fisheries (COFI) in February 1999. As a voluntary instrument, the IPOA sets forth a range of actions that states [b1]should take in order to reduce seabird mortality, primarily through each developing a National Plan of Action-Seabirds (NPOA-Seabirds).

7. The Falkland Islands is the only UK OT to have an adopted NPOA-Seabirds. The development of this plan was funded by the RSPB and undertaken by Falklands Conservation (the BirdLife Partner in the Falkland Islands). BirdLife is currently negotiating with the Government of South Georgia and South Sandwich Islands to conduct a FAO Assessment (as prescribed by IPOA-Seabirds) of the three South Georgia fisheries (Patagonian toothfish, icefish and krill) to determine the need for an NPOA-Seabirds.

8. The UK also has an obligation as a member of the European Union to support the development of a European Community Plan of Action -Seabirds (a generic NPOA-S covering the range of longline fisheries deployed by EU Member States). This would address the issue of seabird bycatch in Community Waters and external waters (other than UK OTs) where the UK has interests. The European Commission first mooted such a plan in 1999, but has since failed to galvanise the political will to take the issue forward, despite including this goal in annual workplans and strategies on a number of occasions.

9. The UK can and should lend powerful support to the development of such a plan: UK fisheries and wildlife agencies have extensive experience in developing and implementing ecosystem-based management expertise in fisheries managed by the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR). This experience, particularly in the South-West Atlantic, means that they are well placed to lead in the development of a European Community Plan of Action-Seabirds for both their domestic and external (distant water) fleets. This should be undertaken as a matter of high priority, particularly given repeated commitment by the EU to develop such a plan.

THE AGREEMENT ON THE CONSERVATION OF ALBATROSSES AND PETRELS

10. International concern over the plight of the albatross led to the negotiation of the Agreement on the Conservation of Albatross and Petrels (ACAP), which came into force in 2004. This agreement was drafted under the auspices of the Convention on Migratory Species (CMS) to provide an integrated approach to conserving Southern Hemisphere albatrosses and petrels. The species to which ACAP applies currently include all Southern Hemisphere albatrosses and seven species of petrel.

11. The stated objective of ACAP is to achieve and maintain a favourable conservation status for Southern Hemisphere albatrosses and petrels by addressing both land and at-sea based threats. The success of the Agreement will be largely dependent on the number of coastal states (ie, those with breeding populations of albatrosses and petrels) and key longline fishing states that accede to the Agreement and act on it.

12. Currently, 10 countries have ratified the agreement: Argentina; Australia; Chile; Ecuador; France; New Zealand; Peru; South Africa; Spain; and the United Kingdom (on behalf of metropolitan UK, the Falkland Islands, South Georgia and South Sandwich Islands and British Antarctic Territory). Of these, only Spain is a solely "fishing" state, without jurisdiction over any land-based populations of ACAP species. Brazil has signed the agreement and indicated that it will ratify in the near future.

13. Through the input of the British Antarctic Survey (BAS), Defra (and the Joint Nature Conservation Committee (JNCC)) and FCO (Polar Regions), the UK has played a critical role in influencing and shaping the scientific agenda of ACAP. This is particularly evident in the development of the work programme (through the first ACAP Science meeting, chaired by Prof. John Croxall, BAS establishment of Working Groups, formulation of key resolutions, and through a member of the UK delegation (Dr. Mark Tasker, JNCC) being appointed the inaugural Chair of the Agreement's Advisory Committee, which is the scientific and technical body of the Agreement).

14. In addition to its budget contributions, over the last three years the UK has contributed considerable voluntary funds (2005-£70,000, 2006-£10,000 and a commitment to contribute a further £50,000 in 2007) to help deliver action on the early stages of the Agreement's work programme, and also to sponsor developing country delegates to attend meetings. These contributions have been critical in helping the fledgling Agreement to deliver conservation action and engage with Parties, Signatories and Range States, during the early stages of the Agreement when budget limitations could have greatly restricted its impact.

15. BirdLife commends these contributions, and feels strongly that continued contributions on this scale are essential to the successful delivery and expansion of the Agreement's work programme, particularly as the focus shifts from land-based issues to encompass at-sea threats (primarily bycatch) facing albatrosses and petrels.

16. To maximise the influence and effectiveness of the UK's input into the agreement, it is essential that, in addition to the current engagement of Defra Wildlife Division, Defra Fisheries becomes actively involved in the Agreement. The input of the Fisheries Division will be critical to addressing the complex issues surrounding fisheries-related seabird mortality.

17. UK Overseas Territories

A meeting (funded through the FCO Overseas Territories Environment Programme) of representatives of all relevant OT Governments, NGOs and other stakeholders was held in the Falkland Islands in March 2005, focusing on the responsibilities and obligations of parties to ACAP, and seeking to identify priorities for the management and conservation of albatrosses and petrels in South Atlantic OTs.

18. Among the key priorities agreed in the report of the meeting was a recognition that Illegal Unreported and Unregulated (IUU) fishing is of paramount importance for OTs, particularly Tristan da Cunha, where no effective fishery protection regime exists, and without which there is potential for substantial bycatch of ACAP listed species by IUU vessels. An appropriate fisheries protection regime is also essential to protect the fish stocks of the region and to support the economy of these islands through increased licence revenue from regulated fisheries. The UK government should investigate the feasibility of an appropriate level of fishery protection (patrols) to ensure that Tristan seabirds and fish stocks are protected and to help support the economy of the islands.

19. The report also advocated that Defra, as the UK lead department for ACAP, must become proactive in engaging all stakeholders for OTs, not least to ensure that realistic timeframes are established for data and information transfer and timely input into UK ACAP preparation meetings.

20. The need for a full-time post based in an Atlantic Overseas Territory (and managed by JNCC, UK), most likely the Falkland Islands, was another priority of the report. This would coordinate communications and input (including data collection and transmission) of the Atlantic OTs into ACAP processes and initiatives.

21. BirdLife International see this coordination post as one of the highest priorities for the UK, to ensure that it continues to lead the way with the scope and quality of input into the Agreement. BirdLife understands that Defra, the FCO and JNCC have committed financial resources to establish this post in the near future, and we hope to hear definitive confirmation of this soon.

22. Finally, the report recognised the importance of effective communication between the OTs to ensure knowledge exchange and efficient collation and transfer of data and information to feed into ACAP processes and initiatives. This is particularly critical in the case of Tristan da Cunha, where only a limited and unreliable channel of communication exists.

Regional Fisheries Management Organisations

23. Regional Fisheries Management Organisations (RFMOs) are the bodies responsible for the management of high seas fisheries and highly migratory fish stocks. As such, they have a central role to play in the conservation of albatross and petrel species, managing a number of the fisheries that are known, or likely, to be killing significant numbers of albatrosses and petrels each year.

24. On behalf of Atlantic OTs, the UK is a member of three of the top five RFMOs (CCAMLR, the Indian Ocean Tuna Commission (IOTC) and the International Commission for the Conservation of Atlantic Tunas (ICCAT)), in terms of the overlap between their areas of jurisdiction and albatross and petrel distribution. The UK is also, through the EU, a member of the remaining top two RFMOs (the Western Central Pacific Fisheries Commission and the Commission for the Conservation of Southern Bluefin Tuna). As such, the UK has a key role to play in the management of UK flagged vessels fishing in these waters and in shaping the agenda of the EU's position within these RFMOs.

25. The role of UK scientists, fisheries managers and fishermen is internationally recognised as being critical in reducing seabird bycatch in the CCAMLR area, which cover Antarctic and sub-Antarctic waters. CCAMLR has pioneered a suite of measures to reduce seabird bycatch, including technical measures (eg night setting, streamer lines, line weighting) and operational measures (eg closed seasons and 100% observer coverage) that, when used in combination, have created a truly "seabird friendly" fishery in some of the most critical areas for threatened albatrosses and petrels.

26. As a result of implementing these measures, in the 2006 fishing season not a single albatross was caught by legal longline vessels operating in CCAMLR waters, a remarkable achievement of international will and concerted action.

27. The UK recently announced funding of £60,000 for an assessment of the impact on seabirds of longline fishing within ICCAT waters. This will be a significant step toward to further understanding and mitigating seabird by-catch in longline fisheries in the Atlantic Ocean, which will assist in halting the rapid decline of many albatross and petrel populations in Atlantic OTs. It is hoped that this contribution by the UK will also set an example that will stimulate similar assessment in other key RFMOs.

28. It is now important that the achievements of CCAMLR and the ICCAT assessment are replicated in other RFMOs, as 84% of albatross distribution is outside CCAMLR waters. UK representatives have attended IOTC and ICCAT scientific meetings in 2006. The UK can further contribute to this end by continuing to attend and be proactive at key meetings of relevant RFMO scientific committees and bycatch working groups, by including bycatch experts within its delegations and ensuring the highest standard of scientific input. This will help the UK influence data collection protocols, the development of observer programmes and information on the spatial and temporal overlap of seabirds and fisheries.

29. BirdLife International would be happy to provide the Committee with any further information required.

January 2007

Memorandum 10

Submission from the School of Ocean and Earth Science, Southampton University

THE INTERNATIONAL MARINE PAST GLOBAL CHANGE STUDY (IMAGES) AND IMPORTANCE OF FUTURE UK SUPPORT FOR RESEARCH ACTIVITIES ADDRESSING PAST OCEAN AND CLIMATE CHANGES

Executive Summary

It is well-known that the Earth's climate system is defined by complex interactions between oceans, atmosphere, land and ice sheets, and the mechanisms involved in potential future climate changes can be revealed by studying the past. The UK currently supports world-class research in palaeoceanography—*the quantitative study of ocean history*—investigating ocean and climate interactions at a range of scales throughout the global ocean. In this evidence we highlight the importance of ensuring continued UK sponsorship for the International Marine Past Global Change Study and the critical need for structural and substantive support in this fundamental area of climate change research.

SUBMISSION

1. The UK hosts a very active and vibrant research community who study records of ocean change on timescales of decades to millennia and the evolution of past climates. This "palaeoceanographic" community seeks support for its participation in the International Marine Past Global Change Study (IMAGES), for research on past ocean and climate interactions.

2. Research on climatic variations during the last few glacial-interglacial cycles has provided many fundamental insights into the rapidity, magnitude and processes leading to past climate perturbations. It is well understood that the Earth's climate system is defined by complex interactions between oceans, atmosphere, land and ice sheets. Due to their massive heat capacity, the oceans provide a "long term memory" for the climate system, but recent advances in ocean and climate research have shown that the ocean Meridional Overturning Circulation (MOC), and with it the warm currents that sustain our temperate climate, can be highly variable with direct implications for the stability of global climate. Records from marine sediment and polar ice cores are of particular importance in documenting the dynamics of the MOC, its sensitivity to variable forcing, and its consequences for climate on regional to hemisphere-wide scales. These palaeo-archives provide compelling evidence for sustained periods, within the last 10s of thousands of years, of dramatic climate oscillations involving many sudden (within a decade) and substantial (up to 15 degrees C) shifts in the global climate system. Insights such as this, obtained from palaeo-studies, have played a crucial role in the development of current NERC flagship thematic programmes (i) Rapid climate change (RAPID) and (ii) Quantifying and Understanding the Earth System (QUEST).

3. It is clear that detailed studies of past climate variability are essential to inform us about magnitudes, rates, and sensitivities of the variability inherent to the climate system, and of the processes driving that variability. Modern monitoring and modelling studies, which aim to assess potential future climate change, cannot deliver without the context of a sound understanding of past natural climate variability. Deep-time studies of, for example, ice-free greenhouse climate states in the distant past can be performed only through the Integrated Ocean Drilling Program (IODP). The increases in both temporal and spatial resolution required to resolve processes of abrupt climate change during the last few glacial-interglacial cycles can most effectively be achieved through international marine science consortia such as IMAGES.

4. The international structure of IMAGES ensures optimum access to international facilities for all participant nations. A key example is access to ship-time on vessels from the various participant nations best equipped for taking long high-volume sediment cores, which is a major benefit for the UK in the current transition period to its new research fleet. This transition period has led to significant cancellations of sea-going expeditions on the UK vessels and there is a long backlog of awarded sea-going programs to be dealt with. Hence, strategic participation in international consortia offers an important means to ensure progress in the UK natural research agenda. IMAGES has made particularly good use of the French research vessel *Marion Dufresne*, which has a high-volume giant coring capacity that is unique in the world.

5. The international IMAGES programme was established in 1995, with strong input from the UK, in order to respond to the challenge of understanding the mechanisms and consequences of climatic changes using oceanic sedimentary records. IMAGES forms the marine sediment research component of Past Global Changes—International Geosphere Biosphere Program (PAGES-IGBP), and is also supported by the International Council for Sciences, Scientific Committee on Oceanic Research (SCOR). As a founder member of IMAGES, the UK continues to participate actively in the full range of its activities. This includes the incumbent IMAGES Executive Committee chair (Prof E J Rohling, NOCS).

6. The major goal of IMAGES is to foster international co-ordination of collaborative scientific programmes aimed at collection and interpretation of high quality palaeoclimate data from the global ocean. It aims to understand the role of marine processes in the Earth's climate system during the past million years at timescales relevant to human life and societal development.

7. IMAGES priority scientific objectives are currently:

- To describe and understand the role of ocean circulation in past climate changes.
- To describe and understand the role of marine biogeochemical cycles in past climate changes.
- To describe and understand the impact of past ocean changes on continental environments and the development of human civilization.
- To develop novel methods to better quantify the key processes that define the role of the oceans in past climate changes.

8. To further these aims, IMAGES organises sea-going sampling missions, thematic and regional working groups, workshops and conferences. The focal point of IMAGES activities is formed by working groups (WG). Organised around specific scientific questions or themes, working groups allow an international consortium of scientists to focus questions and ideas, develop a plan, and marshal the required operational resources, thus working together towards a successful, internationally supported, strategy to address the topic.

9. Original IMAGES priorities for coring expeditions primarily concerned areas of high biological productivity, hydrographic frontal regions, ocean margins, and areas of active deep-water transport and their associated sediment drifts. Project development by the WGs has enabled IMAGES to systematically visit many of the original target areas while maintaining a flexible approach for response to emerging

challenges. Examples of successful past WGs include those that led to coring expeditions involving or led by UK scientists, such as the WEPAMA effort to core the Western Pacific Margins and the HOLOCENE WG on sub-centennial scale climate change. Results of the UK participation in this latter WG and associated coring have recently led to significant new insights into climate variability during the present (Holocene) interglacial period (eg Rohling and Pälike (*Nature*; 2005) Ellison *et al* (*Science*, 2006)). Through the operation of the WG system, IMAGES can identify major scientific objectives and it accordingly prioritises and facilitates coring operations under international coordination. The critical aspect of international cooperation enhances the returns that any individual participating nation may expect in terms of ideas development, material recovery, analytical approach, and training of Early-Stage and Early-Career researchers.

10. A major initiative for the next five years is concerned with millennial- to sub-centennial scale variability of the Antarctic Circumpolar Current and the ensuing Atlantic-Indian water transports, including surface transports and deep water flow in order to assess the linkage of the Southern Ocean, both in terms of its thermohaline circulation and biogeochemical inventories, with millennial perturbations to the MOC and global climate. The Southern Ocean WG includes UK scientists from Cambridge, Cardiff, Edinburgh, NOCS and UEA. Other initiatives focus on the role of variations in the water exchanges between ocean basins on the global heat budget (eg, Pacific-Indian through-flow through the Indonesian Archipelago) and on variability in both the intensity and spatial extent of the tropical monsoons. The success of IMAGES coring campaigns relies on its unique capacity to recover very long Giant Piston Cores and large volume Kasten Cores. These are targeted at critical time-coverage in high accumulation settings and yield sufficient sample volume for the wide range of analytical techniques that are crucial for well-described and quantitative reconstructions of climate/ocean change.

11. The main achievements of IMAGES to date include over 150 international refereed publications, support of PhD students, 13 sea-going missions, 700 sediment core operations, 800 participants from over 70 institutions from the 26 participating countries (see: http://www.images-pages.org/home.html). All IMAGES related information and data are archived for public access at the World Data Centres for Marine Environmental Sciences (WDC-MARE, Bremen, Germany) and for Palaeoclimatology (Boulder, USA). IMAGES actively encourages, promotes and supports the participation of early-career scientists in its full range of activities, for example with ship-board opportunities, access to infrastructure, integration with research initiatives, and participation in workshops. Notably, ship-board opportunities are provided through the "Floating Universities Programme", one of which has been organised through the UK IMAGES community.

12. Funding for IMAGES activities has to date been achieved through a combination of subscriptions/ donations from member countries and collective contributions of participating scientists in cruise campaigns. Currently participating countries include: *Australia, Canada, Chile, People's Republic of China, Denmark, France, Germany, Iceland, India, Indonesia, Italy, Japan, Mexico, the Netherlands, New Zealand, Norway, Portugal, Russia, South Africa, Spain, Sweden, Switzerland, Taiwan, Tunisia, UK and USA.*

13. Given its past track-record in fundamental research on climate change, and in sustaining the essential internationalisation of climate change research, the UK should ensure that it continues to support the IMAGES programme and the broader data-driven research on past ocean and climate change in a structural and substantial manner, as part of a strategic funding programme. This would perfectly complement deeper-time initiatives through IODP as well as modelling studies, to deliver an essential broad-based understanding of the magnitudes, rates, and processes of climate change. Structural support to the UK's participation to IMAGES, and to data-driven palaeoclimate research in general, will enable the UK to continue to "punch above its weight" in this critical discipline for understanding global climate change.

January 2007

Memorandum 11

Submission from the Plymouth Marine Laboratory

Executive Summary

(i) There is a rich diversity of funding for marine science and a complex array of providers of strategic marine science. By and large the current structure works well, and the recent co-ordination of NERC strategic marine science is a very welcome development. However, there is a need for a review of the relationship of the fisheries laboratories and the rest of the sector.

(ii) PML, together with its partners in the Plymouth Marine Sciences Partnership (PMSP) represents one of the largest groupings of marine science and technologists in Europe. Research is carried out ranging from blue-skies molecular biology through to applied renewable energy technologies. Plymouth science also contributes strongly to UK policy.

(iii) The UK has a very strong reputation internationally in marine science and leads in many sectors. The UK also has a strong leadership role in the EU.

(iv) The skill base in the UK in most areas of marine science is extremely buoyant, although some sectors are relatively under-represented, eg mathematics. However, PML itself has not had difficulty in recruiting in the more numeracy related areas. However, a four-year PhD programme is now almost mandatory, given the poor preparation now provided by most first degrees.

(v) Whilst the current SSSI designations are of relatively minor importance for UK waters, the marine protected areas proposed in emerging legislation are crucial for the sound management of the UK.

(vi) Marine science is playing an increasingly important role in understanding the workings and future of the Earth system. Marine questions are of key importance in most of the critical problems facing humankind in the early 21st century. These include: climate change, sea level rise, ocean acidification, maintenance of biodiversity and sustainability; food production and human health and well-being. A strong UK blue-skies and strategic marine science research base is essential for the economy of the UK and its leadership in world affairs.

1. The Plymouth Marine Laboratory (PML) welcomes the opportunity to comment.

2. PML is an independent marine environmental research institute. It is a registered charity and a company limited by guarantee. PML was formally a wholly owned centre of the Natural Environment Research Council (NERC). PML became independent in 2002 and is now a Collaborative Research Centre of NERC and an OSI recognised public sector research establishment.

3. PML welcomes the Committee's decision to hold an enquiry into marine science. The oceans are increasingly being recognised as a key component of the Earth System and are intimately linked to many of the greatest pressures facing humankind in the early 21st century, namely: climate change; sea level rise; ocean acidification; biodiversity, and food supply.

4. PML's comments below represent a primarily "PML-centric" view since wider issues have been considered in the NERC consolidated response.

Organisation and Funding of UK Marine Science in the Polar and Non-Polar Regions

5. PML receives funds from a variety of sources, for example, NERC, Government Departments (eg DEFRA, DTI). More commercial funding is also available, although this is primarily focused on specific problem solving for the sponsor. PML has also received some funds from research charities, eg the Leverhulme Trust.

6. A particular limitation currently is the apparently arbitrary way in which organisations are eligible for funding. For example, PML is unable to bid for responsive mode funding from the Engineering and Physical Sciences Research Council, despite having a well developed capability in some of the areas of interest to that Research Council. Similarly, PML has found it extraordinarily difficult to obtain funding from the Biotechnology and Biological Sciences Research Council, although there are signs that this route is opening up somewhat.

7. A particular concern of PML is the lack of funding at full economic cost (FEC). Clearly this is not unique to PML and there are welcome signs that some funders are moving toward full cost recovery mechanisms. PML remains concerned, however, that it might be many years before all funders agree to support research at full economic cost and perhaps not at all in the case of some charities.

8. A particular frustration is that some funding schemes or multidisciplinary projects working at the interface of, for example, two Research Councils, frequently face "double jeopardy" in the decision making. For example, in recent years, PML has identified research which has secured funding from the MoD which has not been successful in obtaining funding from NERC. In these cases, the same grant mechanisms have been used to assess these strategic projects as blue-skies projects. By their very nature, the strategic projects have a problem solving, near market element which would not "score" highly using the normal blue-skies mechanisms. There is a need for a review of such schemes. Similarly, research at interfaces needs to be able to satisfy two (or more) Research Councils, at which point, it is relatively easy for a particular Council to decide not to support a piece of work if it has received funds from elsewhere. A review of how to deal with interdisciplinary science is long overdue.

9. A particular local issue facing PML (and other NERC funded strategic institutes) currently is the proposed adoption of a new funding and allocation model being developed by the NERC. In essence, this should provide a more transparent mechanism for funding. It is also intended to open up funding to more competition. Whilst this is to be welcomed in principle, the potential consequences could be damaging if taken to its logical limits. PML supports these developments and is helping in their development; nevertheless, they do represent some considerable uncertainty.

10. Within the context of the wider organisation of science, there is a need to address the role of the fisheries institutes relative to the other strategic research institutes. There is a perception, in part justifiable, that organisations such as CEFAS are gradually shifting their focus and becoming more aggressive

competitors. PML's anecdotal experience is that CEFAS was more collaborative in past years. Overall, there is certainly a need for a wide review of the fisheries laboratories and Research Council institutes in supporting UK-wide marine science.

11. PML is a founding member (and currently chairs) the Plymouth Marine Sciences Partnership (PMSP), which comprises: the Plymouth Marine Laboratory; Marine Biological Association; University of Plymouth; Sir Alister Hardy Foundation for Ocean Science; National Marine Aquarium. Together this Partnership represents one of the largest collections of professional marine scientists and technologists in Europe. The PMSP represents a considerable resource for the UK and has expertise ranging from molecular biology, blue biotechnology through marine diversity and sustainability to coastal protection and marine renewables. The PMSP is currently engaged in an ambitious project to co-locate many of its activities on one site as part of a major regeneration project in Plymouth with support from (amongst others) the South West Regional Development Agency.

Role of the UK Internationally and International Collaboration in Marine Science

12. The UK generally has an excellent track record in international collaboration and in many sectors, the UK is either the leader or second only to the USA in marine research.

13. In this context, PML also has a very strong reputation. PML hosts the International Project Office for GLOBEC, a major IGBP project concerned with marine bioresources, and was the host site for the early development of the IMBER International Project Office (now re-located to France). PML also hosts the national programme office for the Atlantic Meridional Transect programme (AMT) which has provided a platform for numerous international researchers. Together with its other PMSP partners (see para 11) in Plymouth, PML has recently supported the Secretariat of the international programme partnership for the Observation of the Global Ocean (POGO), a subscription organisation comprising all the major research organisations worldwide which exists to promote collection and sharing of marine data and to develop capacity in developing nations.

14. PML hosts a number of international researchers at any one time, including EU Marie Curie Fellows. Approximately 25% of PML's staff and students are of non-British nationality.

15. PML is a major contributor to EU framework activities. For example, PML is either a member or leads on three marine related networks of excellence. The EU is PML's third most important supplier of funding, contributing approximately 20% of funding (variable year-on-year).

Support for Marine Science, including Provision of Technology and Engineering

16. PML does not have a specific technology and engineering division. Rather, PML develops technology in partnership with external companies in response to the need of specific research projects. In this way, PML has been responsible for introducing marine sampling technologies, which are in use throughout the world. For example, a current project for which DTI funding is being sought involves a local communications company and will entail the development of self-contained instrumentation to measure the concentrations of CO_2 in seawater and the atmosphere and deployed on ocean-going ships of opportunity.

17. PML represents a considerable national resource in the form of research infrastructure available, for example, to the UK Higher Education Institute community. Such support includes: use of inshore research vessels; seawater experimental mesocosms; world-leading capability in ecosystem modelling and satellite remote sensing. These facilities are available for both professional researchers and research students (the latter currently numbering about 30) at no or little cost.

State of the UK Research and Skills Base Underpinning Marine Science and Provision and Skills to Maintain and Improve the UK's Position in Marine Science

18. The UK has a world-class capability in Marine Science across virtually all disciplines.

19. PML has particular strengths in marine biology and chemistry, remote sensing—particularly ocean colour—and marine optics and ecosystem modelling.

20. At any one time, PML is host to approximately 30 research students registered at a variety of universities around the UK, all of which are rated at either RAE or alpha 4 or 5. A particularly notable achievement has been the success of the AMT project (see para 13), which has supported the PhDs of 69 students, with more to come.

21. Collectively the PMSP represents a major resource in providing training and the development of the skills base. For example, the University of Plymouth alone has of the order of 1,500 students registered on various marine courses. One of the areas in which it is difficult to recruit is that involving the more numerate sciences. Overall this appears to be true; however, PML has been fortunate in having been able to recruit strong, highly numerate candidates for recent computer modelling and remote sensing positions. We are not sure why this has been the case and the numbers have been relatively small—five in the past three years; however, our experience is positive.

22. Similarly we have not had any difficulty in recruiting good analytical chemists, although all our recent recruits have had previous industrial experience.

23. In our experience, undergraduates entering PhD programmes are less well prepared in some basic skills than their peers of say 10 years ago. We rarely recruit PhD students directly from an undergraduate degree; most have some form of further training or experience, with many having obtained an MSc or MRes. A four-year training from bachelor to doctorate is now virtually essential given the relatively poor preparation provided by a typical first degree, even from the top-class universities.

The Use of Marine Sites of Special Scientific Interest

24. It is not clear what is meant by this. The current SSSI scheme is restricted essentially to terrestrial systems, although there are some important coastal and salt-marsh SSSIs. The scheme does not apply to fully marine sites.

25. PML has experience of the coastal areas which are important habitats and rich in biodiversity. These coastal/salt-marsh areas are important for coastal protection and are very vulnerable to human development and disturbance and global change. The latter includes: increases in sea level; storminess; floods and ocean acidification. For example, research at PML has demonstrated that the biological consequences of warmer or colder than average winters have profound effects on the population of animals in the salt-marshes and mud-flats, which in turn changes the ability of these areas to withstand the consequences or floods, for example. These types of areas will almost certainly behave in ways that probably cannot be predicted.

26. The important related aspect to the topic of SSSIs is the question of fully marine protected areas (MPAs)—perhaps the forthcoming equivalent of SSSIs. The proposed Marine Bill has MPAs as a central tenet to the management of the marine domain and PML is a strong and enthusiastic supporter of this idea. Some form of very serious protection of an appropriate mosaic of protected areas is the minimum requirement of these vital, yet hugely sensitive, areas. It is also crucial to understand that these areas provide a huge and previously unquantified economic benefit to the UK amounting to many £billions in goods and services.[7]

How Marine Science is Being Used to Advance Knowledge of the Impact of Climate Change on the Oceans

27. This is a huge subject and has been only partially covered by the NERC consolidated statement.

28. The key points here relate to some fundamental features of the ocean:

- They are a massive "flywheel" with regard to temperature—they are slow to warm-up but also slow to cool down. Thus the oceans moderate temperatures.
- The composition and biology and chemistry of the oceans control and are controlled by the atmosphere. For example, climate is intimately regulated by biological processes occurring in the ocean.
- Ocean circulation is relatively ephemeral and can change quite rapidly.
- 75% of the surface of the planet is influenced by the ocean-atmosphere interface. This is only a few millionths of a metre in thickness, yet we know very little about the biology, chemistry and physics of the layer. For example, we are now discovering a whole new microbial flora in this area which can probably influence the role of exchange of gases between the atmosphere and ocean. The virtually ignored process of ocean acidification—ie the process whereby the oceans are becoming more acidic because of the absorption of human produced CO_2, is now recognised as a problem of huge global significance. Predictors suggest that, by the end of the 21st century, whole marine ecosystems may have disappeared. This is not alarmist; the chemistry is very well constrained, the biology less so, but nevertheless fairly robust. For example, coral reefs may well not be able to grow significantly under the lower pHs predicted.

29. Coastal regions are all under threat from a variety of challenges, including climate change and human development (something like 50% of the world population lives within 50 km of the coast).

30. UK Marine Science is active in all these (and other) key areas identified above. PML is particularly involved in studies on ocean acidification, the climate regulation provided by the oceans, biodiversity and sustainability issues and, increasingly, the state of the marine environment and its influence on human health.

31. Whilst the importance of the oceans in the areas above is becoming more prominent, the realisation of the precarious state of this planet with respect to the oceans is very poorly known. For example, enormous numbers of people worldwide are dependent upon the oceans as their only source of protein. This is under serious threat from, for example, sea-level rise; acidification, harmful algal blooms and habitat destruction. Endless other examples could be given. Yet, despite the widening understanding, appropriate resources are

[7] Beaumont N, Townsend M, Mangi S, Austen M C (2006) Marine Biodiversity. An economic valuation. Building the evidence base for the Marine Bill. Defra, London, July 2006.

not flowing into the area. This is in marked contrast to, for example, space travel and particle physics. I have the highest regard for these latter areas; however, humankind faces genuine threat in the next few decades. We need to address these issues as a matter of priority. Our science is capable of significantly more in the way of delivering predictions and solutions for the future, but it needs appropriate support.

January 2007

Memorandum 12

Submission from the Challenger Society for Marine Science

Executive Summary

1. In this submission from the Challenger Society we stress the following items relevant to the questions asked by the Inquiry:

- The wide range in predicted global warming (2.5–7.0°C for 750 ppm CO_2) is in large part due to lack of understanding of the two-way interactions between the ocean and climate.
- There is no UK national strategy for marine sciences and few mechanisms for integrating the activities of the many contributors.
- Long-term marine observations are vital but difficult to maintain through lack of continuing funding.
- There is concern about the size and viability of the UK research vessel fleet.
- The UK should continue to play a leading role in marine science internationally.

Introduction

2. This submission is made by the President of the Challenger Society for Marine Science (CSMS), based on inputs from several members of the society's Council. There was, however, insufficient time to consult with all CSMS members, and their individual views may differ from those provided here.

3. The CSMS is a UK-based learned society, founded over a 100 years ago. It currently has about 500 members drawn mainly from the academic and institute marine research communities. Information on its role and activities is given at www.challenger-society.org.uk.

4. Professor Liss is one of the three independent members of the Inter-Agency Committee for Marine Science and Technology (IACMST) and chairs its Marine Data and Information Partnership (MDIP) and its Marine Environmental Data Action Group (MEDAG). In addition, he recently chaired the IACMST group which reported on "*Underwater Sound and Marine Life*". He chairs the Royal Society's Global Environmental Research Committee and was a member of the Society's recent Working Group on ocean acidification. He has served on the Natural Environment Research Council (NERC) and chaired the Scientific Committee of the International Geosphere-Biosphere Programme (IGBP).

5. This submission is based on the bulleted foci of the inquiry, prefaced by a section covering the Select Committee's interests on how marine science is being used to advance knowledge of the impact of climate change on the ocean.

Ocean-climate Interactions

6. Future climate change will undoubtedly affect the ocean, altering temperature, circulation patterns, sea level, ocean acidity and the distribution, abundance and productivity of marine life. However, the ocean will also affect the rate and scale of future climate change. Marine research must cover both aspects.

7. The importance of the ocean-climate linkage is shown by the uncertainty range in the global equilibrium temperature rise resulting from CO_2 stabilisation at 750 ppm (from 2.5–7.0°C: IPCC 2001; a similar range is understood to be included in IPCC 2007). Whilst even the lower end of the range has severe implications, it could be tolerable; in contrast, the upper end of the range would be disastrous for most life on Earth (except for microbes). It is not possible here to cover all the reasons for these uncertainties in the climate models, but very many involve gaps in our understanding of the ocean—arguably the most important part of the Earth system with regard to climate change. In particular:

- The ocean acts as a huge reservoir of heat: there is more heat energy in the top 5m of the sea than in all the atmosphere. This slows the rate at which the atmospheric temperature is rising—but to a poorly determined extent. Warming of the ocean interior increases ocean volume, hence driving sea level rise—probably the most devastating (and unstoppable) single economic consequence of climate change.

— Melting of Arctic sea-ice is occurring more rapidly than predicted by current climate models; this has a strong positive feedback (accelerating warming), since seawater absorbs 2–8 times more heat from sunlight than ice.

— The ocean is the prime source of water vapour to the atmosphere, driving the whole hydrological cycle—and hence determining the global pattern of floods and droughts. Sea surface conditions are critical in this regard; they depend on ocean circulation as much as local weather, and both are altering as the climate changes.

— The ocean also has indirect effects, via chemistry and biology, on the formation of clouds. There are many uncertainties in how the extent and type of clouds will alter as the world warms. For example, a recent paper in *Science*[8] showed that areas of high marine biological production underlie areas of enhanced cloudiness due to the emission of gases such as dimethyl sulphide and isoprene, formed by biological processes in the upper ocean. Thus, in order to predict future cloud type and coverage we need to know much more about what controls marine biological activity, by phytoplankton, bacteria and other microbes.

— As well as emitting climatically-important gases, the ocean is a major "sink" of man-made CO_2, taking up 30–40% of what we add to the atmosphere (by burning fossil fuels etc). How this "service" that the ocean provides will change in the future is of critical importance, affecting the urgency—and severity—of policy decisions. We don't yet have detailed answers, but it is likely that enhanced stratification and lowered seawater pH (due to these very CO_2 inputs) will negatively affect the ocean's ability to take up CO_2.

8. The above are only a selection of the poorly-understood ways in which the ocean affects climate and vice versa. They illustrate the many uncertainties- and research problems—involved. Given the serious potential social and economic implications of climate change,[9] it is clearly imperative to narrow the uncertainties in the mutual two-way interaction between the ocean and climate.

Organisation and Funding

9. UK marine research is carried out by a wide variety of organisations. These include government departments, agencies and associated bodies (eg Meteorological Office, Centre for Environment, Fisheries and Aquaculture Science (Cefas), Fisheries Research Service (FRS), MoD/QinetiQ), NERC-funded laboratories, university departments and industry—mostly having different funding streams, little coordination between them, and no overall national strategy. Given the magnitude of the tasks outlined above with regard to climate-related research (let alone other aspects of ecosystem dynamics, eg related to fishery management), this would not seem the optimum way to arrange things.

10. In the universities, where much of the cutting edge marine research is being done, there is an almost complete lack of national coordination or overall marine science strategy, made worse by NERC's abolition of its marine research grant committee some years ago (noting that NERC is the major funder of university research in this area). There are signs that the recently reconfigured National Oceanography Centre (NOC) at Southampton is now beginning to take on a national leadership role; however, this has not been forthcoming in the past.

11. A positive example is "Oceans 2025", the recently approved research programme for NERC marine Centres, where a joined-up, well-coordinated approach is central. However, although this is designed and approved in principle as a five year programme,[10] my understanding is that funding is currently only assured for the first two years.

12. IACMST is a forum that is intended to promote coordination between government department and agency research programmes (not the university sector). In my view, it has been only partially successful in this role because the component bodies are primarily focused on their own (policy-driven) research agendas. They are often unwilling to contribute to the bigger picture—which may be more about new research ideas than immediate policy issues.

13. However, IACMST has been successful at horizon scanning for new policy-related research areas (eg the effect of sound on marine mammals). It has also run several useful action groups concerned with global observing systems and data issues (MEDAG and MDIP). In particular, MDIP is specifying and designing the data system to support the multi-use of UK marine data ("measure once, use many times" concept), that is directly relevant to marine spatial planning.

14. Several other countries appear to have better arrangements for coordination of their marine activities than exist in the UK (eg France, USA). In the UK, there is no equivalent in the marine realm of the operational role the Met. Office plays in basic data gathering, atmospheric forecasting and relevant research (although much oceanography is required for this). The merits of having a UK "Wet" Office might usefully be considered by the Select Committee under this inquiry. The Marine Management Organisation discussed

[8] N Meskhide and A Nenes (2006) Phytoplankton and cloudiness in the Southern Ocean. *Science 314,* 1419–23.

[9] Stern Review on economics of climate change, HM Treasury, 2006. Online at www.hm-treasury.gov.uk/independent_reviews/stern_review_economics_climate_change/stern_review_report.cfm

[10] NERC press release, 10 January 2007. Also "Oceans 2025 Overview", online at www.oceans2025.org

in the Marine Bill Consultation document could form the starting point for such an organisation. An alternative model is the US National Oceanographic and Atmospheric Administration that has responsibilities for many aspects of *both* marine and atmospheric affairs.

International Role

15. UK marine scientists have played, and continue to play, substantial roles in internationally-organised global change programmes relevant to marine research. Further, NERC is currently funding the International Project Offices for three such marine-oriented activities: the World Climate Research Programme's "Climate Variability and Predictability" (CLIVAR, at NOC), and the IGBP's "Global Ocean Ecosystem Dynamics" (GLOBEC, at Plymouth Marine Laboratory) and "Surface Ocean—Lower Atmosphere Study" (SOLAS, at UEA).

16. In addition, NERC funds the Planning Office for the International Polar Year (at British Antarctic Survey), which also covers much oceanographic research, and the European Office for IODP (Integrated Ocean Drilling Program) at Cardiff University.

17. Provision of the project offices described in paras 15 and 16 is highly commendable since it gives the UK a strong leadership role in what is planned and executed worldwide, with many benefits to both the UK community as well as to individual scientists who can participate in projects much larger than they or indeed the UK could mount alone.

18. In Europe, UK marine scientists also play substantial roles and the EU Framework Programmes provide real opportunities for us to lead and participate in larger marine (field and modelling) studies than national funding alone will allow.

19. Funding constraints do, however, limit the involvement of UK scientists in global marine programmes. In the past NERC has been able to devote substantial resources to its science contribution to international projects such as the World Ocean Circulation Experiment (WOCE) and the Joint Global Ocean Flux Study (JGOFS). The current NERC budget makes it difficult for this to happen at the scale required. For example, although significant funding was awarded for SOLAS work, it was subsequently reduced (due to an overall funding shortfall in NERC), and there are currently no directed funds for national participation in either the CLIVAR, GLOBEC, IMBER (Integrated Marine Biogeochemistry and Ecosystem Research) or GEOTRACES projects. This means that to take part in international activities under these projects, scientists have to individually obtain responsive-mode funding from NERC, a system that makes it very difficult to coordinate UK participation.

Support

20. Long-term observational records are a vital part of ocean studies but are often costly and have proved difficult to maintain on a continuing basis. For example, the 75-year survival of the Continuous Plankton Recorder (CPR) survey has been fortuitous—having been very close to closure on many occasions. The new NERC marine research programme "Oceans 2025" attempts to address this but, as noted above, even that funding is not yet committed beyond the next two years.

21. IACMST has developed a list of long-term observational needs. From that list, two examples are:

- funding of satellites for marine measurements [noting the many problems a couple of years ago in assembling the UK contribution to the 2nd Joint Air Sea Interaction experiment (Jason) mission]; and
- placing the UK's observational programme into ocean CO_2 measurements onto a sounder footing (noting that the UK has no programme for making CO_2 measurements in the atmosphere!).

However, it has proved impossible to date to find a funding mechanism for these studies or even a route by which to request new funds, for example via a bid in a Comprehensive Spending Review. Without them we will struggle to quantify changes occurring in the ocean as a result of climate change.

22. An issue of concern to many marine researchers is the availability of suitable ocean-going research vessels. A few years ago NERC reduced its general purpose, non-polar fleet by a third and *RRS Discovery* is now close to the end of its effective life. In the past year, three research cruises (each of ~one month duration, involving 20–25 researchers and a total investment in excess of £1 million) have been either abandoned or postponed for a further year or so due to severe technical problems with this vessel. A new research ship (*RRS James Cook*) has recently been delivered, to replace *RRS Charles Darwin* but there has been a gap of nearly a year, resulting in a backlog of nearly 20 approved but unscheduled field-based projects. Replacement of *RRS Discovery* is, I understand, timetabled for 2012, but in the meanwhile there is greatly reduced capacity. It would seem that this can only be solved by chartering non-UK ocean-going research vessels for at least six months per year (if available), but NERC could not easily find the resources for such action.

23. A closely-related problem is the limited availability of research ships for studies in coastal and shelf waters. With the reduction in the NERC fleet and with Cefas and FRS Aberdeen now possessing only one suitable vessel each, we have lost significant capacity for near-shore work. This is arguably as important as

open ocean studies for detecting the effects of climate change—for example, changes in river flow, flooding and sea level are likely to deliver more nutrients and sediments to coastal waters, hence affecting planktonic and benthic biodiversity, fishery productivity etc. For these reasons, we need to *expand* monitoring and research in coastal and shelf waters, the opposite to the present direction of travel.

Research and Skills Base

24. Overall the UK currently seems to be viewed from abroad as an exciting and reasonably well-funded place to do research. Thus, recruitment into academic posts in marine science in the university sector is relatively buoyant: senior and more junior appointments of high quality have, and are being, made. There have, however, been retention problems at some institutions and in some key science areas.

25. Student recruitment (at both undergraduate and postgraduate, PhD level) into marine sciences suffers from the endemic shortage of students wanting to study science in the UK. However, it would appear that the problem is not as severe in the marine area as in the pure sciences due to the considerable public interest in the subject. Furthermore, it is significantly easier to find excellent students in biology than in physics and mathematics.

Sites of Special Scientific Interest

26. The concept and role of marine Sites of Special Scientific Interest (SSSI) is inherently different from that on land. Whilst littoral and benthic habitats of particularly high conservation value can be mapped and boundaries drawn, there are still many dependencies and interactions with much larger spatial areas. Enforcing regulation of controls in the marine environment is also more complex, due to the many stakeholder interests, local, regional, national and European/international.

27. Fragmentation of research responsibilities in this area (between English, Scottish and Welsh conservation bodies, fishery laboratories and NERC) is acute. The poor science base may not be the only factor responsible for the lack of UK marine SSSIs, but it has certainly contributed to it.

28. More ambitious plans for marine reserves and Marine Protected Areas (MPAs) have been developed overseas, with relevant research effort.[11] Proposals for a nationally-integrated research initiative on sustainable marine bioresources, that could cover the role of MPAs in promoting fishery recovery, have been under discussion between NERC, Defra and the Scottish Executive for several years, but there has been very great difficulty in securing funding for such an initiative, despite its political importance.[12]

January 2007

Memorandum 13

Submission from the UK-Integrated Ocean Drilling Program Steering Committee

UK MEMBERSHIP AND PARTICIPATION IN THE INTEGRATED OCEAN DRILLING PROGRAM

Executive Summary

1. This submission highlights the importance of continued UK membership of the Integrated Ocean Drilling Program (IODP), an essential marine infrastructural resource for the wider UK ocean and Earth science community. Scientific ocean drilling is the marine equivalent of the "Hubble Telescope" and is one of the most successful major international collaborations in the history of science. IODP is the only mechanism available for accessing the continuous sedimentary records essential for understanding past changes in the Earth's climate and how climate is maintained. The research on the cores recovered by the drilling and experiments and observations in the drill holes are also important for understanding the tectonic processes that shape the surface of the Earth and give rise to the major seismic and volcanic geohazards that threaten billions of the global population.

2. To ensure that the UK receives the greatest return from its subscription, and that science questions of greatest relevance to the UK are targeted by the IODP, it is imperative that appropriate enabling resources be available, preferably at levels equivalent to the investments made by comparable economies (eg, Germany, USA). Such funds are necessary for UK scientists to direct campaigns for ocean drilling, undertake the highest quality post-cruise research on the samples recovered, and to train the next generation of physical and biological scientists in environmental fields of increasing societal relevance.

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[11] eg J Sobel and C Dahlgren (2004). *Marine Reserves: A Guide to Science, Design and Use.* Island Press.
[12] Prime Minister's Strategy Unit (2004). *Net Benefits. A sustainable and profitable future for UK fishing.*

Scientific Background

3. The oceans regulate climate, cover the formative features of plate tectonics and preserve a high-resolution archive of the last 180 Ma of Earth history including its climatic evolution. Analysis of marine rock and sediment cores recovered by scientific ocean drilling has been central to most of the important advances in understanding of our planet's dynamic and inter-related systems with far reaching implications for the Earth and environmental sciences. UK scientists initiated and lead many of the fields in which ocean drilling provides the main platform for furthering our understanding of the Earth system.

4. Key among these are:

(a) The verification of Plate Tectonics—the primary Earth cycle that shapes our planet, and controls the location and occurrence of earthquakes, volcanoes, critical metal and hydrocarbon resources, and geohazards.

(b) Development of the field of Palaeoceanography, where through the analysis of layers of ocean sediments, we are able to understand and reconstruct past climate, patterns of ocean circulation and chemical, physical and biological responses to changing environmental conditions.

(c) Demonstration of orbital forcing of climate caused by subtle but predictable changes in the Earth's spin and rotation around the Sun.

(d) The rapidity and severity of past climate change.

(e) The variation of past oceanic circulation patterns.

(f) The recognition of climate extremes in past Earth history particularly during periods of high atmospheric CO_2 that are useful for better understanding future climate scenarios.

(g) The significance of "black smokers" and how hydrothermal exchanges between the solid Earth and the oceans provide a major control on global geochemical cycles.

(h) The discovery and dynamic nature of gas hydrates and their roles as resources, geohazards and possible agents for rapid climate change.

(i) Fluid flow associated with active faults.

(j) The formation of the ocean crust at the mid-ocean ridges—a process that has resurfaced more than 60% of our planet over the past 200 million years.

(k) Discovery of the deep biosphere, hitherto unknown microbial life forms that live deep within ocean sediments, at the temperature and chemical extremes of the life envelope. These previously unsuspected communities have the potential to answer questions about the origin of life on our planet and are possible sources of new organic compounds of great interest to the biotechnology and pharmaceutical industries.

5. Drilling and resulting research have shown how sensitive the surficial environment is to solid Earth processes, biogeochemical interactions and a whole series of internal feedbacks. However, we have yet to gain a sufficient knowledge of the underlying physics to identify the driving mechanisms, the dominant feedbacks and the relationships between mass fluxes, chemical states, physical states, and biological communities. As a consequence, the Earth and environmental sciences are now poised to make fundamental advances in understanding critical Earth processes. These include topics of immediate environmental concern to mankind, processes that control the location of vital natural resources, as well as the governing dynamics of our planet.

6. Experience has shown that many of the oceanographic records essential to understanding the Earth system can only be recovered by scientific ocean drilling. However, the construction and operating costs for drill ships and other coring platforms are beyond the means of individual nations and this has lead to more than 30 years of successful international scientific collaboration initiated by the Deep Sea Drilling Project (DSDP, 1968–83) and the recently completed Ocean Drilling Program (ODP, 1985–2003). The new Integrated Ocean Drilling Program[13] (IODP, 2003–13) represents a major expansion for scientific ocean drilling both in the scope and sophistication of the technology and in the breadth and structure of the international collaboration involved in running the program. The fundamental purpose of the IODP is to drill into the seabed to collect samples and carry out experiments to further scientific research on the Earth, its evolution and environment. The new technologies available through the IODP now make it possible to recover drill cores from nearly all marine environments from very shallow to deep water, from open ocean to ice-covered polar latitudes, in regions of significant gas hazard or instability and from great depths (up to 7,000 m).

Key Objectives of IODP

7. The major science areas identified by the Initial Science Plan of the Integrated Ocean Drilling Program[14] are:

Environmental Change, Processes and Effects;

The Deep Biosphere and Sub-seafloor Ocean;

Solid Earth Cycles and Geodynamics.

[13] See http://www.iodp.org

[14] Available from http://www.iodp.org/isp/

8. There is growing recognition within the UK of the importance of the problems of rapid climate change and the sensitivity of Earth's climate to a number of interdependent atmospheric, oceanic and solid Earth processes.

However, our knowledge of the processes and consequences of climate change and the computer modelling essential to predict future climate remain under development. IODP will provide the required spatial coverage of high resolution records of climate proxies capable of resolving the leads and lags and hence causality in patterns of change (eg, in particular levels of CO_2 and global temperatures).

Critical among these will be the nature and relative timing of changing oceanic circulation patterns, changes in sealevel, and the role of bio-geochemistry. Other first-order environmental concerns which require study by deep ocean drilling are the stability of the vast deposits of methane stored as solid gas hydrates in sediments and processes in seismogenic zones of collisional crustal plate boundaries. Over 1 billion people and key elements of the global economy are in close proximity to subduction zones that have been the loci of all known great tsunamogenic earthquakes (eg, Boxing Day, 2004 Sumatran quake and other historic earthquakes greater than 8.5 magnitude on Richter Scale). By drilling and installing monitoring and sensor arrays within these zones we will better understand the mechanisms of stress build-up and release in these systems perhaps leading to the identification of precursor warning signs of large, destructive events.

9. Deep sea drilling also provides the direct sampling and *in-situ* borehole experiments essential to investigate a whole series of fundamental geodynamic, geochemical and biological processes on Earth. Drilling is the only satisfactory way to investigate ocean ridges where determination of flow of melt in the mantle and solid-earth—ocean geochemical exchanges have proved difficult to quantify. The installation of seismometers in ocean boreholes will provide the global coverage essential to exploit computational advances in 3D seismic imaging of the Earth. The ability to site instruments in the oceanic sub-surface will also make an important contribution to planned sea floor observatories for monitoring key environmental parameters. Problems as fundamental and diverse as generation of Earth's magnetic field by the core and mechanisms of lithospheric deformation, require high resolution sedimentary records, only recoverable by deep ocean drilling, to provide the critical time-series information necessary for their solution. The discovery of a huge and previously unknown microbial biomass active in deep sediments has implications that span a whole-range of Earth science topics including evolutionary biology, formation of oil and gas, global geochemical fluxes and climate.

UK Membership of the Integrated Ocean Drilling Program (IODP) and the Significance to UK Science

10. Participation in IODP allows UK scientists to influence the science planning and benefit directly from more than $1.5 billion investment in drilling platforms and their operation by the USA, Japan and Europe. UK scientific engagement in the IODP is enabled through membership of the European Consortium for Ocean Research Drilling (ECORD) comprising 16 European nations plus Canada. ECORD is a partner in IODP alongside the US National Science Foundation (NSF) and the Japanese Ministry of Education, Culture, Sports, Science and Technology (MEXT). Science is prioritised in the IODP through the peer-review of proposals to tackle specific science questions. This proposal system is open to all researchers be they from universities, industry or government institutions. IODP then co-ordinates the deployment of a spectrum of drilling platforms for the recovery of sediments, other rock-types and fluids from all marine environments.

11. Technological developments since the final cruises of the Ocean Drilling Program (2003) include the construction of a riser drill ship by Japan, and use of mission-specific platforms that provide completely new capabilities for scientific ocean drilling by UK-IODP's European consortium. Of particular benefit to the UK is the use of mission specific platforms that enable sampling of previously inaccessible targets such as shallow water (coral reefs), or polar regions. Improvements in riserless drilling will allow good recovery of fractured hard rocks for the first time. Riser drilling with circulating drilling mud will allow drilling in poorly consolidated and over-pressured rocks, areas of hydrocarbon hazard and deep holes. Also important are developments in borehole technology that allow separation and sampling of different formation fluids, making proper sub-seafloor hydrological investigations possible. The technological developments in deep ocean drilling coincident with oil exploration in ever deeper and more difficult water has lead to growing and beneficial collaboration with industry both nationally and internationally (eg, the UK-IODP Industrial Liaison Panel[15]).

12. Participation in previous drilling programmes has given UK scientists influence over drilling strategy far in excess of the UK financial input. At a point where we face urgent problems in the prediction and mitigation of climate change the UK must maintain its involvement in an international programme which will provide information on a whole range of critical Earth Science processes. Assessment and prediction of the environmental impact of our technologies and the coupled problems of finding and exploiting natural resources will be the major challenges faced by society over the 21st century. The results of deep sea drilling

[15] http://www.bgs.ac.uk/iodp/UK_ILP.html

provide key information to enhance our ability to tackle these problems. UK involvement is essential if the UK is to continue its influential role in the international environmental debate such as implementation of climate change mitigation (eg, Kyoto Protocol).

13. Involvement in IODP will also be critical to the development of emerging research areas. Prime among these is biogeochemistry because we now recognise that biological processes control many of the feedbacks which maintain oceanic and atmospheric chemistry and we use biologically moderated element and isotope ratios in fossils, as well as organic molecules, as the key proxies for the past physical and chemical states of the oceans. The UK has an enviable research record at the forefront of the biological sciences and UK scientists lead in the discovery and investigation of the deep biosphere, in the development of proxies for palaeoceanography, and in the identification of the key phytoplankton that export carbon from the ocean surface. A high proportion of new appointments at UK Earth and Environmental Science departments have research interests which relate to biogeochemistry and participation in IODP will be necessary for this investment in people to realise its full potential.

14. IODP topics of immediate importance to UK science include:

(a) ocean climate dynamics;

(b) ocean biogeochemistry and the carbon cycle;

(c) Arctic ocean: control on climate and ocean circulation;

(d) the deep biosphere;

(e) gas hydrates: stability, dynamics and potential consequences;

(f) magnetic field and the geodynamo;

(g) oceanic seismic arrays and oceanic sub-surface observatories; and

(h) ocean Ridge processes: mantle melt flow, crustal construction and hydrothermal fluxes.

15. IODP drilling will make fundamental contributions to other important areas of Earth sciences research that both involve UK scientists and impact UK science through the complex interdependence of Earth systems. Most significant will be research on the seismogenic zone at subduction zones, but drilling will also put important constraints on the processes of extensional and compressional continental deformation, on large igneous provinces and their potentially catastrophic environmental impacts, asteroid impact sites such as the Chicxulub crater at the Cretaceous/Tertiary boundary, and oceanic mass wasting events on ocean islands or the continental shelves that can be responsible for major tsunamis.

16. The IODP, when it reaches full capabilities in 2007, will be able to carry out drilling to depths of six or seven kilometres below the seabed in nearly all of the ocean basins and in most geological environments. To do this it will mount three types of expeditions:

(a) Non-riser drilling by the refurbished US drill ship, the *JOIDES Resolution*,[16] scheduled to resume drilling in late 2007.

(b) Riser drilling using the new Japanese ship, the *Chikyu*,[17] scheduled to begin operations in late 2007.

(c) Mission-specific platform expeditions mounted to access otherwise inaccessible locations by ECORD.[18]

17. The NERC UK-IODP Directed Science programme makes these essential IODP facilities available to the UK community through its subscription to ECORD (~US$5.9M/yr). The UK played a major role in the establishment of the ECORD consortium of 16 European countries and Canada. Science support is currently provided through an enabling programme (£3.5 million for 2004–08) that funds UK scientists' involvement in drilling expeditions, their participation in the IODP and ECORD science peer review committees, liaison with industry and the attendance and organisation of IODP-related conferences and workshops. New to this enabling support programme is the ability to fund marine site surveys. Such surveys are mandatory for the development of a successful drilling proposal, as detailed knowledge of the sub-seafloor targets, usually from remote geophysical observations such as multi-channel seismic reflection surveying, are critical to the safety and success of the drilling expeditions. UK scientists are engaged within IODP through the development of drilling proposals as well as through research on the drill cores recovered, at an intensity that far exceeds (~4 times) the UK's financial contribution to the international programme. The regular submission of successful drilling proposals by UK scientists allows them to guide the IODP to undertake projects of the greatest relevance to UK environmental science priorities and to deliver on key government research areas including ocean climate dynamics, rapid climate change, extreme, climates, biogeochemistry and the carbon cycle, gas hydrates, and geohazards.

[16] See http://iodp.tamu.edu/publicinfo/drillship.html
[17] See http://www.jamstec.go.jp/chikyu/eng/CHIKYU/index.html
[18] See http://www.eso.ecord.org/expeditions/msp.htm

SUCCESSES OF PHASE I OF THE IODP (2003–06)

18. Drilling expeditions in the first phase of the IODP (2003 to 2006) are providing information for research into (1) mechanisms of rapid climate change, particularly in the North Atlantic and the Arctic, (2) a very high resolution record of sealevel and climate change since the last glacial period, (3) movement of fluids through sediments, the associated sub-seafloor biosphere and gas hydrates, and (4) the mechanisms of lithosphere formation and the drivers of ocean-hydrosphere geochemical fluxes. Spectacular drilling successes of the initial phase of IODP include:

(a) the mission-specific expedition to the Arctic, which made the first deep research drilling in the Arctic basin and has revealed the magnitude of Arctic climate change and sea ice evolution over the last 50 Ma;

(b) the first deep hole in intact oceanic crust to reach lower crustal gabbros which will provide information on the inter-related magmatic and hydrothermal processes that govern solid earth-ocean geochemical exchanges; and

(c) the first complete coral record of the last deglacial sealevel rise from a site far from ice sheets and tectonic disturbance.

19. The success and importance of the on-going UK-IODP Directed Science Program to the UK environmental research community can be judged by:

(a) the number of high profile papers published as a result of the programme (eg, 24 papers in the highly competitive scientific journals *Nature* and *Science* from 2004 to 2006);

(b) the involvement in IODP of all the research active university geoscience departments as well as the major NERC institutes and collaborative centres;

(c) the large number of UK scientists involved in formulating and implementing new drilling proposals;

(d) the active effective involvement of UK scientists in the science advisory structures of IODP and ECORD;

(e) the uptake of grants and research support in the UK programme;

(f) the success of IODP initiated and sponsored conferences in publicising both opportunities in the programme and the results of recent ocean drilling; and

(g) the role of IODP expeditions in the training of the next generation of UK environmental scientists through shipboard participation and cutting edge PhD topics.

20. The IODP makes a significant contribution to the UK science strategy including providing national and international scientific leadership and supporting a world class environmental science community. It makes essential contributions to the priority areas of climate change, biogeochemical fluxes, resources, geohazards and research training. Membership of the Integrated Ocean Drilling Program is an essential component of the UK's marine infrastructure.

To enable UK scientists to maintain and further develop their leadership of scientific ocean drilling, the subscription to IODP should be complimented by a science support package of similar scope to the investments presently made by our major international oceanographic partners (eg, Germany, USA).

January 2007

Memorandum 14

Submission from the Inter-Agency Committee on Marine Science and Technology (IACMST)

Given the time available, it has not been possible to consult all our members as fully as we would wish. Therefore, not all organisations within IACMST necessarily agree with all of the views expressed below. Many members have submitted individual responses, as is the norm.

EXECUTIVE SUMMARY

Following a brief description of IACMST, the submission outlines the importance of the oceans. In addressing the areas requested by the Committee, particular emphasis has been placed on: the need for continuing (and strengthening) coordination across all of the UK marine science community; the urgent need for new mechanisms to fund sustained measurements that meet a wide range of user requirements; minimising barriers to the exchange of data, especially financial transfers between government agencies; developing better mechanisms to ensure consistent UK delegation inputs to intergovernmental bodies; find more flexible ways of participating in the infrastructure of large international satellite and *in situ* programmes; the need for better identification of future skill requirements and the strategies to deliver them; and transferring the scientific knowledge of ocean acidification to policy making.

A key general point is that the Government needs to behave as a coherent commissioner for marine research across all its departments. We also consider that the brief of IACMST may need to be changed from one of coordination to actively driving forward an updated version of the strategy first developed in CCMST 1990, a seminal report produced by the Coordinating Committee on Marine Science and Technology (IACMST's predecessor) which itself was formed as one of the outcomes of the last Select Committee inquiry into marine science (by the Lords) in 1985–86.

Brief Introduction to IACMST

IACMST is a Government committee reporting to OSI through its Chairman, Sir Howard Dalton, Chief Scientific Adviser to Defra; it had its first meeting in September 1991. Primary responsibilities are broad oversight of Marine Science and Technology (MST) activities within and beyond government agencies and to ensure the existence of adequate coordination mechanisms. Its membership is drawn mainly from government organisations and it depends on developing consensus views to carry out its work. Where appropriate, some of the achievements of IACMST, as well as the problems it has identified, are included in the main body. Further information is contained in the Annex*.

The Importance of the Oceans

1. Even though the centre of gravity of the climate change debate has shifted towards mitigation and adaptation, especially in the light of the Stern report, the uncertainties over the extent of the warming, the changes in extreme weather, and the regional variations in climate change are however still very large. Improved scientific knowledge of these aspects of climate change is vital to enable cost-effective planning of appropriate adaptation measures. The oceans are a key component of the climate system strongly influencing the timing and distribution of climate change and variability, eg El Niño, the effect of North Atlantic temperatures on European winter weather patterns, and the moderating influence of the Atlantic conveyor and its potential vulnerability to global warming. The oceans themselves also respond to the climate. Increased take-up of atmospheric CO_2 is leading to ocean acidification with consequences for the marine ecosystem, further sea level rise (which is inevitable regardless of any action to reduce emissions) threatens coastal environments with huge economic implications and observations of regime changes in the ecosystem have been related to long-term changes in sea temperatures. Although these and other issues have been identified, there is still much that needs to be learnt about the processes involved through long-term observations and modelling in order to reduce uncertainties in prediction.

2. Even if climate change were not a matter for concern, there are many other reasons why marine science is important for the UK. The increasing competing requirements for use of the waters around the UK and Europe and the desire to safeguard its ecosystem make sustainable development a key item on the political agenda. The intention to place a Marine Bill before Parliament and the present consultation on an EU Maritime Policy are evidence of this. The following topics, all mentioned in the 1990 CCMST Report, are highly relevant in justifying why the UK needs a vibrant marine science activity today: environmental protection including living resources (some to meet statutory and regulatory obligations), exploitation of resources including sea floor, defence, requirements for technology and spin-offs. Another very significant growth area is operational oceanography, ie routinely disseminating and interpreting measurements for forecasting and other purposes, as already done in meteorology.

Organisation and Funding of UK Marine Science in the Polar and Non-polar Regions

3. There is a need for continuing and strengthening coordination across all of the UK marine science community. Marine science and technology (MST) responsibilities are distributed widely across Government departments, agencies and NDPBs. Within any one of these, MST may be distributed across a number of different parts of the organisation. Several coordination mechanisms exist but many suffer from being identified too closely with individual departments. The developments noted in paragraph 1 and paragraph 2 imply an even greater need for coordination and were recognised in *Charting Progress* (2005). An excellent example of a programme designed to achieve greater internal coordination in strategic marine science is NERC's Oceans 2025 programme which has just been awarded nearly £120 million over five years.

4. IACMST's role is independent of any department but its membership extends across all departments having MST interests (see Annex for further information on the responsibilities and activities of IACMST). It is therefore able to provide distinctive cross-departmental views. Its remit includes "to ensure that there are satisfactory arrangements for the co-ordination of national and international MST activities". It should be noted that this does not mean that IACMST must do all the coordination, but it does have an important role in ensuring that adequate coordination exists where required. In some cases IACMST has carried out the coordination itself (eg UK contributions to the Global Ocean Observing System, marine data and information activities). However, discussions are underway exploring the transfer of some of these

* (Not printed)

responsibilities to a new body arising from the Government's marine stewardship commitments; the organisation of marine science in the UK is not static. IACMST also sponsors studies into topics that would benefit from cross-departmental approach, eg underwater sound and marine life.

5. Given the total investment in MST (~ £600 million in 1999–2000), the resources available for coordination across UK policy, industry and research communities are modest and this is one of the limitations on what can be achieved. IACMST activities are funded through a combination of a two-person secretariat funded by one member agency (NERC), a central government pot of ~£50K per annum and annual subscriptions for annually approved programmes from a few of the member agencies. Coordination for research itself has been rather well supported, eg by NERC.

6. Overall funding for marine science. Carrying out marine science, especially in the open ocean, can appear expensive. The capital cost of research ships with multi-disciplinary capability in hostile environments is a few tens of million pounds each; running costs including technical support add several million more per ship. However, the vessels have a lifetime as a research platform of 20 years or more and still have a market value beyond that so it is important to apportion the large one-off costs over a long period. In an era when satellite oceanography and computer models have come of age, ships are still essential to provide data for validation and the additional information needed by users. Over the last few years, several of the UK's research vessels have been replaced as they reached the end of their useful life and it is important that sufficient funding is earmarked to maintain this resource in the future.

7. At the time of the last Select Committee inquiry, as recorded in the CCMST report, the NERC marine centres were midway through a period of retrenchment with a 37% reduction in staff over six years. CCMST recommended that there should be consolidation about this smaller base. It would appear that Oceans 2025 marks another period of consolidation in order to sustain a more limited range of activity to meet funding constraints.

8. The Government is committed to the concept of evidence-based policy making which in the present context means making best use of good science. IACMST has identified this as an important issue meriting further study and highlighted it in its response to the Marine Bill consultation where, at that stage, it was difficult to see how the feed-through of marine science into policy would work. There are several issues: the paucity of scientific knowledge on which policy decisions necessarily have to be made; the transfer mechanism itself; and the resources needed to carry it out. Also, the current preference to focus research funding on the HEI sector and then provide further funding to them for Knowledge Transfer may not be the most appropriate model for the marine sector.

9. There is an urgent need for a new mechanism to fund sustained measurements that serve UK-wide interests in a cost-effective way. This has emerged from the requirement to systematically monitor the health of our seas, to conduct operational oceanography and to carry out research into the role of the oceans in climate. It is encouraging to see that NERC has recognised this problem and devoted one of the themes in its new Oceans 2025 programme to long-term observations. However, there is an over-reliance on short-term research programmes to provide the longer-term data. Notable progress towards an integrated approach to monitoring has been made by establishing the UK Marine Monitoring and Assessment Strategy (UKMMAS) and IACMST has identified, justified, and costed the priority observations needed for the UK contribution to the Global Ocean Observing System which have now been incorporated into the wider UKMMAS resource requirements. However, a fundamental difficulty—initially identified by IACMST when it sought to ensure that the UK was contributing appropriately to the Jason-2 satellite altimeter mission and the Argo profiling float programme (see paragraphs 13 and 14)—is that the present UK funding system is not well-suited to funding cross-departmental contributions to observing programmes. Also, the criteria for monitoring national needs are different from those used in the evaluation of research proposals where observations are needed to meet specific, short-term research objectives. IACMST has provided the methodology for conducting a cost-benefit assessment to establish the value of maintaining or stopping long-term monitoring programmes. The seriousness of this issue has been recognised by UKMMAS, the Environmental Research Funders' Forum (ERFF) and the Global Environmental Change Committee. ERFF has highlighted a major difference between the funds allocated to monitoring the terrestrial UK environment (£500 million) and those allocated to monitoring the marine environment (£36 million).

10. Compared with other types of data for both terrestrial and marine environments, data on the biological resources of the seabed, and some components of the water column, are very sparse for the UK continental shelf and adjacent oceanic areas. This deficiency, which is a major constraint on biological resource mapping, is a major strategic issue for UK marine science and one which is currently under consideration by UKMMAS.

11. Much progress has been achieved during the last 20 years in seeking to minimise barriers to the exchange of data but new challenges have emerged. IACMST established and coordinated a network of marine data managers (MEDAG) and developed inventories, catalogues and products as agreed by member agencies. It has provided a key interface in to European and international data management. Recently it has moved beyond the traditional oceanographic parameters of temperature, current, etc to consider issues associated with photographic and video records. A study was also completed for Defra on the future needs for marine data and information and this led to the formation of the cross-UK Marine Data and Information Partnership (also hosted by IACMST) in 2005. MDIP is building the framework for marine

data stewardship in the UK in which data collected by any organisation can be managed in the long term. It will, along with MEDAG, be asked to also meet the more specific needs associated with the development of the UKMMAS and the monitoring metadata required by ERFF. A key issue is the accessibility and interoperability of datasets held by government-funded organisations. In order to maximise the investment of public money the philosophy should be to "collect once, use many times"; this is a principle underpinning the UKMMAS. However, although this is a simple concept, in practice the way that Government activities are structured and funded, including the establishment of Trading Funds, can easily hinder rather than advance such an approach. There are also some examples of where ownership of IPR is compromising what can be delivered in terms of inter-agency working and is a major disincentive for commercial organisations to propose innovative solutions to problems.

The Role of the UK Internationally, and International Collaboration in Marine Science

12. The main international body for marine science in the UN system is the Intergovernmental Oceanographic Commission of UNESCO. The UK lead is delegated to NERC (the lead on other marine-related activities is taken by appropriate government departments, eg International Maritime Organisation (DfT) and International Council for the Exploration of the Sea (Defra/SEERAD). The UK has been an active participant in the formulation and execution of many IOC activities, including the development of the Global Ocean Observing System, the International Oceanographic Data and Information Exchange committee and, following the Indian Ocean tsunami, in some aspects of the development of warning systems for tsunami and other ocean-related hazards—although it was disappointing that the UK did not respond more positively to UNESCO's request for technical assistance in developing the Indian Ocean Warning System. Several IOC members states are becoming increasingly uncomfortable that the IOC sits in UNESCO. This is also an issue for the UK as the priorities of DfiD (which is the UK lead for UNESCO) are not compatible with the growing operational oceanography agenda of IOC. The IACMST Secretariat has an additional function as the UK's IOC Office and this helps with coordination. Also, the present chairman of IOC, provided by the UK, is the former Secretary of IACMST and this enhances useful liaison.

13. This raises the issue of how the UK develops better mechanisms to ensure consistent inputs by its delegates across international bodies. Adequate briefing mechanisms exist for most of the delegations but many are *ad hoc*, as indeed are arrangements for liaison between the delegations. Much of this stems from the very limited resources available (cross-membership of the different briefing groups helps but is time consuming and often has to be arranged at short notice because of the late availability of documents produced by the international bodies). FCO, assisted by IACMST, are developing plans to improve overarching aspects of coordination.

14. Hosting by UK of international project offices. The strength of the UK in the ocean sciences has ensured that it provides international leadership, influence and partnership within International programmes—notably those of the World Climate Research Programme (WCRP) and the International Geosphere Biosphere Programme (IGBP)—and has allowed NERC to fund and manage four International Project Offices (IPOs): WCRP's Climate Variability (CLIVAR) and World Ocean Circulation (WOCE) projects; IGBP's Global Ocean Ecosystem Dynamics (GLOBEC), and the Surface-Ocean Lower-Atmosphere Study (SOLAS). The Met Office also hosts the Project Offices for the Global Ocean Data Assimilation Experiment (GODAE) and the Global High Resolution Sea Surface Temperature Pilot Project (GHRSST-PP). The coordinating function of these offices is vital for the efficient conduct of very large programmes, involving many different countries and organisations. The support provided by the UK is much appreciated by the international community and helps to raise the international profile of the hosting institutes. In addition, through hosting these IPOs the UK is able to help set the scientific agenda of these international projects to maximise their value for the UK.

Support for Marine Science, Including Provision and Development of Technology and Engineering

15. Application of satellite remote sensing has matured over the last 20 years to the point where it is now regarded as an indispensable tool for most marine science, particularly when combined with *in situ* observations and numerical models. As stated in paragraph 9 continuity of data is a vital issue, especially with regard to satellite altimetry because of its demonstrated capability to measure changes in sea level rise and ocean currents at regional to global scales to unprecedented accuracies. Specific challenges are: how to maximise the benefit to the UK from participation in Global Monitoring for Environment and Security (GMES) and to ensure that the UK can take advantage of very cost-effective arrangements for participating in non-ESA satellite programmes that are of relevance to marine science. For the latter, the UK found it very difficult to contribute its modest share of the Jason-2 altimeter mission costs, despite intervention by the Government Chief Scientific Adviser. The UK should also consider investing in constellations of small satellites. This would overcome some of the sampling problems associated with observing the oceans and may also open up new possibilities for UK industry.

16. Autonomous *in situ* systems are vital for many applications. A major success has been the Argo profiling float programme in which the upper ocean is measured every few hundred kilometres every 10 days. The target figure of 3,000 floats has almost been achieved. Marine scientists across the world have been

mobilised into deploying the floats and analysing the data from them. The UK has played a significant role but IACMST remains concerned about long-term funding from the UK. It is noted that UK industry is not involved in float manufacture. However, a strong link between UK scientists and industry has led to the pioneering Autosub system which has recently demonstrated its ability to operate under ice shelves as well as in the open ocean.

The State of the UK Research and Skills Base Underpinning Marine Science and Provision and Skills to Maintain and Improve the UK's Position in Marine Science

17. In its 1990 report, CCMST highlighted the difficulties in training and retaining sufficient scientists and technologists. They recommended that HEIs should interact more strongly with potential employees to determine the demand. Many of the same comments still hold today. Apart from the general difficulty of persuading the brightest students to pursue a career in science, there are particular problems in trying to recruit into the numerate disciplines. Also, the development of operational oceanography and its projected rapid growth has raised new requirements spanning government and industry; a scoping study for an MSc in Operational Oceanography has recently been completed. This is an example of where training provision is lagging behind employer needs. IACMST is discussing with bodies such as the Institute of Marine Engineering Science and Technology how to identify these and similar future needs and what strategies should be implemented to meet them; we suggest more effort should be focused on this issue.

Use of Marine Sites of Special Scientific Interest (We Have Assumed This Is Broader Than Formal SSIs Which Are Limited to the Intertidal Zone)

18. A coordinated approach to the designation of Marine Protected Areas (MPAs) is important and this should be based on good science supported by the necessary funding. MPAs can also serve as a benchmark series of sites which can be compared with other marine areas to help determine the effect of human impacts and natural changes, and provide a resource for education, training and research.

How Marine Science is Being Used to Advance Knowledge of the Impact of Climate Change on the Oceans

19. There have been significant changes since the last Select Committee report. Links between the marine science community and the Met Office have grown over the past 20 years and are now considered to be very good. The Met Office has become *de facto* the UK agency for Operational Oceanography and the formation of the National Centre for Ocean Forecasting, a joint activity of the Met Office and several NERC marine centres, has been a very encouraging development. In order to fully exploit this new collaborative framework the partners will need to ensure that they commit adequate resources to the venture. A similar model could be used to further strengthen links between the Hadley Centre, a world leader in climate research and prediction, and UK marine centres undertaking climate-related programmes. We note that Defra has become the lead government department for climate change and the Defra-led Office for Climate Change needs to give attention to integrating the contribution of the marine science community. As a contribution to the International Polar Year, NERC and others have also funded two large marine consortiums to look at the impact of changes in the Arctic climate on the oceans (one related to gas hydrates).

20. Measurements made using the Continuous Plankton Recorder over the last 75 years indicate that major biological changes have taken place in the plankton in the seas around the British Isles over the last few decades correlated with increases in sea surface temperature. A northerly movement of warm water plankton and a parallel retreat of cold water plankton to the north are clearly evident and some plankton species are observed earlier in the season. Because changes in the North Sea observed from the mid 1980s have been so marked they are referred to as a regime shift. A key point is that it is only the length of the observation period that has allowed such interpretation of the changes.

21. Although some of the increased atmospheric CO_2 due to human activities is taken up by the ocean this ameliorating effect comes at a price: ocean acidification. Research has shown that changes have already occurred and, if emissions of CO_2 continue to rise as predicted, it is projected that the pH of the oceans will by 2100 have fallen to a level that has not existed in the oceans for many millions of years. This will have important consequences for the ecosystem. More research is needed to understand the processes and feedbacks in order to reduce uncertainties about the future. In particular, there is little evidence of observed pH changes in UK coastal waters, partly due to the natural variability of the region. Also, IACMST is of the view that a synthesis of published studies and consideration of policy implications by a cross-sectoral group, as done for underwater sound, would be valuable.

January 2007

Memorandum 15

Submission from the Joint Nature of Conservation Committee

Executive Summary

The JNCC's main conclusions are:

- Government needs to develop and implement an overall strategy for publicly-funded marine science, both in relation to UK waters and also overseas;
- funding for UK marine science needs to be increased, but also needs to be rebalanced to address major shortfalls, notably in relation to biological resources and the effects of human impacts;
- international collaboration in marine science should be promoted and be provided with enhanced support through international funding mechanisms;
- new technologies, including remote sensing technologies, have the potential greatly to facilitate marine research, and their development should be supported;
- a combination of both traditional and new skills will be required to supply future needs for marine science;
- the ability to access scientific results needs to be considerably improved, and techniques for assessing confidence in their use for policy and operational purposes developed and implemented;
- all publicly-funded marine data should be held electronically to agreed standards and placed in the public domain;
- marine protected areas provide a wide range of ecosystem services and are a resource for education, training and research. Their value is increased when they are strictly protected;
- the paucity of biological datasets is hampering our ability to assess and interpret changes resulting from climate change.

Introduction

1. The Joint Nature Conservation Committee (JNCC) provides advice and information to ministers and other persons on matters for or affecting nature conservation in the UK as a whole and also in relation to nature conservation outside the UK. JNCC is a Committee of the Council for Nature Conservation and the Countryside, the Countryside Council for Wales, Natural England and Scottish Natural Heritage and discharges its functions on behalf of those organisations. JNCC's ability to carry out its statutory functions is dependent on the availability of marine data and scientific information.

Organisation and Funding of UK Marine Science in the Polar and Non-polar Regions

2. Marine science in the UK is funded by a range of bodies, notably including the research councils, Government Departments, public agencies, private sector companies and non-governmental charitable institutions. It is carried out by research council centres, Government and non-governmental laboratories, Government agencies, universities, industry and commercial companies under contract.

3. Government policy includes using investment in research as one means of securing the United Kingdom's future competitiveness and growth as a world economy and also as a means of helping to alleviate world poverty. However, there are other societal needs for research. These include the need to monitor the status of biodiversity and geodiversity in the UK and elsewhere, and of identifying the causes of trends, and the means of addressing them. More generally, research is needed to provide the information necessary for human activities to be carried out in a manner which will produce benefits while avoiding harm.

4. The doctrine of scientific excellence (usually determined by academic peer-review) continues to be a powerful determinant in relation to where marine science and research funding is directed (including in relation to NERC's important Oceans 2025 programme), and, in practice, marine science and research follows the funding. Often, too little consideration is given to formulating the society-relevant questions that research should be designed to answer. Government intends that the formulation of its policy should be evidence-based, yet too often this objective is undermined by lack of data.

5. So far as JNCC is aware, no overall objectives for publicly-funded marine science have been promoted by Government, nor is there any over-arching strategy for publicly-funded marine science. This is likely to be due, in large measure, to the manner in which research funding has developed and evolved in the UK over time, but the lack of central direction and co-ordination of publicly-funded science has the potential to lead to duplication of effort, lack of collaboration where this is desirable, gaps in research endeavour, and research funds being allocated with insufficient regard to national priorities.

6. In the absence of a central strategy, major research funders have developed their own strategies. While such initiatives are commendable and can be considered as complementary, they also have the potential to be divergent and insufficiently connected.

7. Current publicly-funded UK marine research is largely focussed on oceanographic studies, mainly through NERC funding. In comparison, and also when compared to the UK terrestrial environment, data on the biological resources of the seabed, and some components of the water column, for the UK continental shelf and adjacent ocean areas, are very sparse. Systematic surveillance of marine biodiversity in UK continental shelf waters is currently poorly developed (the Continuous Plankton Recorder programme undertaken by SAPHOS, and the commercial fish stock monitoring by CEFAS and FRS being notable exceptions), with the result that it is currently very difficult to assess the status of, and trends in, marine UK biodiversity or to give a quantitative assessment of the impact of human activities on this. Defra have recently instigated the development of a UK Marine Monitoring and Assessment Strategy to improve coordination and direction of scientific endeavour in this area.

8. While funding for environmental science and research in the marine environment is low compared with the terrestrial environment, existing expenditure partly relates to past, rather than current or future, priorities and needs to be rebalanced. While overall funding provision for marine science needs to be increased, it also needs to be used more efficiently, including through the redirection of resources, and greatly enhanced collaboration, eg in the use of vessels.

9. In summary:

— Government needs to develop and implement an overall strategy for publicly-funded marine science;

— research funding for UK marine science needs to be increased but also rebalanced to address major shortfalls, eg in relation to biological resources and the effects of human impacts. Enhanced collaboration between those commissioning research needs to take place.

The Role of the UK Internationally, and International Collaboration in Marine Science

10. The geographic location of the UK and its overseas territories has had a considerable influence on the direction of its marine science work. Inevitably, marine science effort has been focused on the UK continental shelf area and on the adjacent waters of the north-east Atlantic. Outside this "home" area, the UK also undertakes considerable research in the south Atlantic and in the waters adjacent to the Antarctic Peninsula; this reflects its responsibilities and historic involvement in the Overseas Territories in the south Atlantic and in the British Antarctic Territory. In contrast, UK research is less developed in other areas, for example in the Arctic Ocean and the tropical seas, notwithstanding that these areas are under considerable environmental pressure, including as a result of climate change.

11. The UK is party to a range of international Multilateral Environmental Agreements which require research to be undertaken and for appropriate levels of research collaboration and information exchange between parties. However, so far as we are aware, there is no overall UK guidance or strategy in relation to the disbursement of UK publicly-funded marine science resources internationally, either in relation to the UK continental shelf, the various Overseas Territories, or elsewhere, nor any particular mechanism for allocating research expenditure or effort in accordance with policy priorities, with the range of international treaty obligations, or in relation to environmental pressures.

12. Marine research is expensive, and financial, technical and expertise requirements encourage collaborative working, and the EU's financial instruments encourage such collaboration. Current habitat mapping projects are financially supported through such instruments and require international collaboration. For example, the HABMAP project in the southern Irish Sea (www.habmap.org) and the Marine European Seabed Habitat mapping project which involves the continental shelf areas of the UK, Ireland, Belgium, Netherlands, and adjacent waters of France (www.searchmesh.net) were both grant-aided under the EU's INTERREG programme.

13. Many marine issues are international in nature. Scientific collaboration is essential in relation to marine monitoring, and the implementation of marine policy and international treaty obligations. For example, initiatives to develop spatial planning in the UK marine environment will require cross-border working with other states when the responsibility for individual seas (eg the North Sea and the Irish Sea) are shared between the states. We would like to see marine science highlighted as a special case for international funding opportunities (eg through EU and other funding mechanisms).

14. In summary:

— Government needs to develop a strategy for supporting marine science outside the UK, including identifying priorities for funding in terms of geographical location, international commitments, and environmental pressures. Indicative resource levels should be identified to guide the apportionment of science resources as between the UK and overseas;

— international collaboration in marine science should be promoted, and be provided with enhanced support through international (including EU) funding mechanisms.

SUPPORT FOR MARINE SCIENCE, INCLUDING PROVISION AND DEVELOPMENT OF TECHNOLOGY AND ENGINEERING

15. Because of the scale of the marine environment and difficulties of researcher access, technological innovation and development is proving of the utmost importance. Technological developments such as GPS, remote sensing technologies, electronic tagging and satellite tracking have greatly facilitated the marine life sciences. For example, multi-beam sonar has proved invaluable for seabed habitat mapping. Mapping, surveillance and monitoring, both of the state of the marine environment, and of human activities, and the effect of those, on the marine environment, will be key areas for future innovation. Consequently, we welcome and support the continued investment in the development of new and improved marine technologies.

16. New technologies also have the potential for benefiting biodiversity through, for example, improvements in fishing gear designed to cause less harm to the environment or to wildlife (eg the use of "pingers" to reduce incidental take of dolphins and porpoises by fishing gear).

17. In summary:

— because of the scale of the marine environment, and because of access difficulties for researchers, new technologies, including remote sensing technologies, have the potential greatly to facilitate marine research, and their development should be supported.

THE STATE OF THE UK RESEARCH AND SKILLS BASE UNDERPINNING MARINE SCIENCE AND PROVISION AND SKILLS TO MAINTAIN AND IMPROVE THE UK'S POSITION IN MARINE SCIENCE

18. Key marine skills for the future will encompass a range of traditional and current skills, together with new skills required to develop and use new technologies, including remote sensing technologies, and to handle, analyse and interpret the data provided by those technologies. In addition, environmental factors (eg ecosystem services), will, increasingly, need to be considered in economic and societal terms, requiring greatly enhanced inter-disciplinary working.

19. We remain concerned about the current loss of taxonomic expertise in the UK in relation to marine taxa. Universities need to continue to train people with marine taxonomic skills, and taxonomic institutions (eg museums) need to be supported to enable them to carry out a taxonomy function effectively. Traditional taxonomic techniques will need to be supported by new and different skills, eg DNA sequencing.

20. Knowledge of how natural ecosystems function, how different organisms contribute to that functioning, and how organisms relate to physical and chemical factors and the changes in those, are major areas for the future development of marine science. Critical components of this functioning will be micro-organisms. Many of these organisms have not been described and the total diversity of marine micro-organisms is likely to be very considerable. New techniques and approaches will need to be developed to help advance this area of marine science.

21. Marine skills and expertise have a strong tendency to become localised in research institutes, within marine industries, and within marine departments in universities, and are not as accessible to marine regulators and managers, and their advisers, as is desirable. The ability of scientists to keep up to date on the results of marine research is quite variable. Generally, the wider the field of expertise, the more difficult this becomes. For those wishing to use science for policy formulation, or for operational purposes, accessing research conclusions presents a major challenge.

22. To assist the process of knowledge transfer, a number of actions are desirable, for example: (a) the establishment of standard UK systems for enabling access to research information in both the scientific and "grey" literature (the principles and strategy set out in the Research Councils UK position statement on access to research outputs are commended see www.rcuk.ac.uk/access/statement.pdf), (b) where research is critical to policy formulation or operational action it needs to be accompanied by a well-resourced communications plan that develops understanding of the user audience (eg www.relu.ac.uk/about/CommunicationPlan.pdf), (c) the development of an appropriate infrastructure for conducting systematic reviews on topics important for policy formulation or operational action, and (d) all marine data collected with public funds should be held electronically to agreed formats and standards and placed in the public domain within specified timescales.

23. Research results are rarely 100% comprehensive or certain in relation to supporting policy decisions or operational action. For this reason, techniques need to be developed which will enable an assessment of confidence to be provided, so as to help determine the level of risk involved in determining policy or action based on the available science.

24. In summary:

— a combination of both traditional and new skills, (eg in relation to the handling of remote sensing equipment and data, and of new taxonomic techniques) for marine science in the future will be required;

— the ability of non-specialists to access scientific results needs to be considerably improved through providing electronic access to results, more effective communication of results, and infrastructure provision for reviews on important topics;

— all publicly-funded marine research data should be held electronically to agreed standards and placed in the public domain;

— techniques for assessing the degree of confidence of using scientific conclusions to address policy and operational questions are needed.

Use of Marine Sites of Special Scientific Interest

25. Under current legislation, marine SSSIs normally extend seawards only as far as low water mark. Marine SSSIs are selected primarily for the contribution they make to the conservation of UK biodiversity and geodiversity. The legislation provides these sites with substantial protection from human impacts.

26. In addition to SSSIs, similar levels of protection are provided by statutory marine nature reserves (MNRs) (only three established to date) and European Marine Sites (established under the EU Habitats and Birds Directives). European Marine Sites can only be established for a limited number of marine habitat types and species, and the Government's intention is to provide powers under a future Marine Bill to afford protection to a much wider range of habitats and biological communities, and also to important geological features. These areas (and those referred to above) will: (a) provide refuges for vulnerable wildlife, (b) serve as reservoirs of biodiversity capable of "seeding" into adjacent marine areas, (c) provide genetic and ecological support to marine biological populations more widely, (d) contribute functionally to the ecosystems of which they are part and also to the sustainable use of the marine environment, (e) serve as a benchmark series of sites which can be compared with other marine areas to help determine the effect of human impacts and natural changes, and (f), provide a resource for education, training and research. In general, the value of these sites for scientific purposes can be expected to increase with the degree of protection afforded to them, and, to achieve this range of benefits, a proportion of these sites will need to be afforded strict protection (eg from all extractive or development uses). Areas subject to such strict protection are sometimes referred to as "highly protected areas".

27. A considerable amount of research is currently undertaken on protected sites. For example, both Lundy and Skomer MNRs have been the subject of long-term monitoring studies and also studies into the response of biological communities to the cessation of fishing activities and, in the case of Skomer, to the effects of a major oil spill.

28. In summary:

— Marine Protected Areas provide a wide range of services, including to biodiversity and ecosystem conservation, the sustainable use of natural resources, and as a resource for education, training and research. Their value to both conservation and science is increased when they are strictly protected.

How Marine Science is being used to Advance Knowledge of Impact of Climate Change on the Ocean

29. The Marine Climate Change Impacts Partnership (MCCIP) has been set up specifically to assess the potential impact of climate change on the marine ecosystem by drawing on the expertise of leading UK scientists. In November 2006, MCCIP launched its first Annual Report Card (ARC) and summarised current understanding of how our oceans are changing. This highlighted that long-term and widespread datasets are central to our ability to model changes with a high degree of confidence, as exemplified by the ocean temperature, sea level, continuous plankton recorder, seabird and intertidal species data.

30. The marine temperature and plankton records over the last 20 years have shown an increase in sea temperature of about 2°C in the North Sea, Irish Sea and English Channel. The mid-1980s witnessed a change in the composition of the plankton as warm water species expanded their range in the seas around southern and central Britain, while cold water plankton withdrew northwards into the sub-Arctic, north of Shetland. There are concerns that, as a result of changes in plankton composition, the productivity of sandeel populations may decline, and lead to a consequent decline in seabird populations. The low breeding success of kittiwake breeding colonies in some areas of northern Britain in 2004 and 2005 may be a result of such changes.

31. In summary:

— the paucity of biological datasets and a limited understanding of ecological processes is hampering our ability to predict and interpret ecosystem scale changes as a result of climate change.

January 2007

Memorandum 16

Submission from Gardline Environmental Limited

USE OF THE PRIVATE SECTOR TO DELIVER COST EFFECTIVE MARINE SCIENCE

1. Executive Summary

It is widely recognised that the marine environment contains huge resources of economic significance as well as supporting marine food webs that are of global significance in maintaining our climate. Many of these processes are poorly understood but are likely to dominate political and economic policy in the coming decades. Research in the marine environment is of particular importance to the UK where our Exclusive Economic Zone (EEZ) includes resources of enormous economic importance such as oil and gas, as well as fisheries and resources of conservation significance that require protection under the EU Habitats Directive and other legislation. Thus the importance to the UK of properly funded and organised research to our environmental and economic future has to be recognised, and the Select Committee on Science and Technology's efforts on this are applauded. For too long, research has been organised almost exclusively from within the public sector with scant regard for value for money.

Although the UK scientific community has for many years sustained an internationally recognised expertise in Marine Science, research effort in this field is expensive in terms of manpower, ships and equipment. To sustain our leading international expertise in Marine Science, and to meet the economic and management requirements of the UK under the forthcoming Marine Bill, as well as the UK's response to major global issues that will affect our coastline in the coming decades, two fundamental issues must be addressed:

(a) Marine Science needs to be funded effectively. Without this the marine scientific community cannot provide the necessary robust science for Government and Industry to make informed decisions on how our marine resources can be managed in a sustainable fashion whilst at the same time meeting the conservation requirements of a changing global climate.

(b) Funding to Marine Science needs to be managed cost-effectively. It is acknowledged that funding will always be constrained, however, proper management will ensure that the maximum amount of quality information is obtained from the available funding to ensure the delivery of the goals as outlined in (a).

This submission suggests ways in which these two items may be addressed. It briefly discusses the present funding of marine scientific research and goes on to suggest alternate means of funding. It also addresses the issues of cost management and how a wider use of the private sector in all facets of marine science would result in better value for money.

In this submission it is assumed that "marine science in the polar and non polar oceans" also includes seas, territorial and coastal waters.

2. Organisation and Funding

Funding for marine science must be increased, particularly with regard to identification of seabed resources that may require conservation and management in relation to infrastructure and other developments in the UK Exclusive Economic Zone. In particular, seabed mapping has been achieved in sufficient detail in only relatively small areas of the UK's seabed and requires major investment to meet the requirements of the Marine Bill and the EU's Habitat Directive.

Currently there is no coherent funding strategy to support the long-term requirements of marine resource management in the seas and oceans that are of economic significance and in the national interest of the UK. Some work is funded through the Research Councils (notably the Natural Environment Research Council: NERC). National funding is also directed through the Department for Environment, Food and Rural Affairs' (Defra) R&D programmes, as well as through specialist research initiatives such as the Aggregate Levy Sustainability Fund (ALSF) which is directed towards how aggregate mining on land and at sea can be managed in a sustainable fashion. Funds derived from a levy on the offshore renewables industry are managed through the Collaborative Offshore Wind Research into The Environment (COWRIE) programme that is administered through the Crown Estate. Like the ALSF, this programme has been developed to assist in our understanding of how UK commitments to increase renewable sources of power can be achieved sustainably in UK waters.

Other programmes are funded through international collaborative initiatives including the Mapping European Seabed Habitats (MESH) programmes in Irish waters and in the North Sea, the Channel Habitat Atlas Resource Map (CHARM) funded through the EU Interreg II programme, and the INFOMAR programme.

These National and international collaborative programmes deliver significant benefits for UK Policy and management advice. However, there is neither a strategic overview managing the research that is currently carried out under the wide variety of funding sources nor are these programmes generally required

to meet objectives that have been defined in a coherent fashion to meet UK Policy objectives. The difficulty of matching long-term requirements of marine research and short-term funding imposed by arbitrary limits imposed by Financial Year management from Government is also widely recognised.

There is clearly a case for a Marine Forum to guide and oversee the research requirements for the UK in the coming decades, and to ensure that this work is funded on a sufficiently long-term basis that facilitates the studies that are required to manage and sustain marine resources of economic and political importance to the UK. This would provide a sound science-base to UK policy in response to major global issues that will affect our coastline in the coming decades.

3. European Funding

Historically, UK public sector research bodies undertaking marine science have been slow to draw on the wide range of EU funding available. This may be due in part to a general reluctance to fund projects through the EU or simply due to the sometimes onerous task of supplying the relevant information for grant application and subsequent award.

The private sector is much more successful in drawing down EU money for a wide range of services, including product development, as demonstrated by the Advanced ROV package for Automatic Mobile Investigation of Sediments (ARAMIS) and SEABEE EU funded projects which included the UK private sector and other EU research institutes, marketing and development initiatives and even research programmes. This is most likely because some organisations rely heavily on this type of funding but also because the private sector is more used to the submission of detailed technical and commercial documents to acquire work and, in this case, funding.

Therefore, by inviting the private sector to undertake or manage a greater portion of the marine science work in polar and non polar regions it is likely that there will be a larger volume of EU funding available to the marine science sector. This case would be strengthened if the submissions for funding submitted by the private sector were to be supported by UK research or other public sector bodies.

4. Cost Effective Management of Research Assets and Programmes

In marine scientific research the biggest drain on funding is the offshore vessel. This is ably demonstrated by the CEFAS research vessel Endeavour, which is purported to cost in the region of £17,000 to £22,000 per day to operate and cost £24 million to build, and the newly acquired James Cook which cost £36 million to build.

These vessels will join a European public sector research vessel fleet that is already oversupplied. A fleet where each individual EU member state, and each research institute within it, feels the need to have its own, dedicated resource. In addition to the costs associated with the initial build and the subsequent loan and depreciation on these assets, there is also the huge duplication of base facilities required to keep these vessels at sea or, in many cases, alongside for a large part of the year.

Given that there is a finite pool of money available for marine science research as a whole, these costs limit the total amount of research that can be done. Clearly it is therefore very important to make sure that these costs are as low as possible, consistent with the money being well spent to maximise the quality of the science undertaken.

Compare this to the private sector of the UK marine industry where there are upward of 20 vessels that could undertake marine scientific research work in polar or non polar regions operated by a number of companies. While some of these vessels would not fall into the same category in terms of technical excellence as the Endeavour and the Cook, many would be more than capable of undertaking the research programmes required and as an aside it should be noted the entire Gardline fleet of 10 ocean going vessels costs less than the purchase price of the James Cook alone.

In addition to the basic costs of the vessel, there are also the resources to operate and support a fleet of vessels. Clearly, the cost per vessel is drastically reduced when it is combined in a fleet consisting of a number of vessels and this still does not take in to account the significantly higher costs of public sector manning over private sector manning, as well as the more effective operation of private vessel fleets as opposed to public vessels.

Therefore, by involving the private sector in either the supply of research vessels or the operation of the existing fleets, the research institutes and public bodies can reduce the costs of the "tools" required to undertake the work, and so release some of the funding for more detailed and prolonged studies. This is already an approach that has been implemented by EU member states, for example Briese Schiffahrts GmbH and Company KG, a privately owned company, operates a number of the German research vessels and indeed SMIT operate the Endeavour on behalf of CEFAS.

5. The Role of the UK in Marine Science

The UK has been the leader of marine science both in the public and private sector for many years and it is a position we still hold today.

The main driver for development and innovation within the private sector has been the strong offshore oil and gas market. The technology and expertise that has been developed over the last 35 years in this sector is now exported world-wide and the UK is seen as a centre of excellence for offshore exploration and development.

A focused partnership between the public and private sector, funded through innovative solutions such as Public Finance Initiatives, would enable the UK to retain its reputation as a leader in marine science. This would also enable it to build on the expertise of both sectors to offer assistance, guidance and indeed acquisition of marine research programmes on an international basis. However, this will only be achieved if the partnership is mutually beneficial and if any private funding for such projects is transparent and managed effectively.

6. Development of Technology

By its very nature, the private sector is a highly competitive environment where clients and companies alike are constantly looking to differentiate between service providers and where evermore demanding technical solutions offer combined efficiencies of cost and schedule. This breeds a supply chain that is constantly reviewing how it undertakes its operations, how they can be improved and what new technology is available to realise cost savings and maximise market share and profit. The marine science market place is no different.

There are myriad examples that could be supplied but one of the most significant in marine science in recent years is in the development of systems able to undertake seabed stills photography and video imagery. These are not Remotely Operated Vehicles (ROV) which have been widely used for many years but units specifically designed for use in marine environmental research. In the past two to three years technology has moved along at pace from analogue to digital and increases in picture quality, definition and the depth capabilities of such systems. Whilst the private sector has embraced these developments, a number of issues including funding, running costs and lack of knowledge of the latest technologies available have restrained the public sector and research organisations. As a result, outdated systems are being employed on research programmes, resulting in poor data quality, slow acquisition speeds and resultant cost implications.

The private sector with its higher utilisation of newly developed systems can offer the marine science community better quality data with the resultant improvement in the strategic decisions based on these data, and in all probability with little or no overall increase in cost. In fact, it is more likely that such technology will significantly reduce the length of research programmes and save costs that could be employed on additional programmes.

Conversely, there are systems and technologies that have been developed either exclusively by, or in close association with, the public sector or research institutes. However, rather than offer this equipment to the private sector and thereby promote better practice through better technology (and also recovering some of the costs of development, construction and maintenance) use of these systems is so restricted or prohibitive due to inflated charges that they remain unused within the organisations. The result is that research and development within these organisations is reduced because funding is limited and there is little or no return on developed systems. Often the private sector then goes on to develop systems that supersede the publicly funded systems. Examples of this would be the (Wide-Angle Seabed Photography (WASP) system developed by the then Southampton Oceanography Centre that has been surpassed by modern systems and the Sediment Profiling Imagery (SPI) camera system at CEFAS that would have real benefit and great potential if it could be used more widely in the private sector.

7. UK Research and Skills Base

The issue of the reduced number of suitably trained marine scientists available to public and private sector organisations and in particular the lack of support for the training of marine scientists was recently raised in the House of Lords.

This is clearly an industry-wide concern and an issue that will have a major impact on the ability of the UK's to deliver our own marine research programmes and our standing within the marine science international community.

For many years the public and private sectors have supported student placements, student sabbaticals, and gap-year employment. However, when it comes to taking these individuals to the next level of their professional rather than academic training then the process becomes much more difficult.

There is a case for the public and private sector to work much more closely in the future to meet the industry's training needs. There are a number of ways that this could be achieved but in essence two concepts are at the core. Firstly, that either the public or private sector offer and receive funding for more vocational training following the completion of formal academic training. Secondly, that the private sector employ personnel who obtain training from the private sector but who also have designated roles within the public sector or research bodies.

The first option is attractive because it offers a discrete mechanism for staff training, which then can be apportioned funding, or operate on a commercial basis. The second option enables the public and private sectors to co-operate and spread the costs of both staff employment and training whilst enhancing the links between the public and private sectors: it would also go a long way to enhancing the joined-up thinking required to develop cost and time effective strategies for the delivery of crucial marine science research to address issues such as those surrounding climate.

8. Use of Marine Special Areas of Conservation (SACs)

It should be a major consideration of the Committee that coastal and territorial waters are the location of both the greatest productivity and the greatest pressure on the marine environment from a wide range of factors including resource removal, global warming, pollution and recreational use.

The UK has an obligation under the EU Habitats Directive to conserve and sustain the biodiversity of the marine ecosystem. This is implemented through the identification of "Special Areas of Conservation (SAC)" in UK coastal waters.

The main issue with regard to the identification and management of marine SAC's relates in many ways to all the items detailed previously in this submission. There is not enough funding presently available to effectively delineate Special Areas of Conservation let alone to monitor the impact of other legitimate users of the seabed. Recent plans to map the UK's marine candidate Special Areas of Conservation (SAC's) were severely curtailed due to overspill from the Department for Environment and Rural Affairs (Defra) farm subsidy budget overrun.

In addition, the funding that is available is not being effectively employed with poorly targeted surveys or surveys which overlap with other programmes, thus duplicating effort and expenditure. It should be considered that private sector research carried out on behalf of oil and gas exploration companies in UK waters could provide a wealth of as yet untapped information on seabed habitats, often where no other information exists.

If SAC's are to be identified and managed then significant additional funding will need to be employed. The alternative is a series of "white elephants" around the UK that have limited scientific value and alienate a raft of potential users whose access to these areas is restricted through a lack of understanding of the potential impacts.

9. Conclusion

In summary, more funding is needed for the research that will underpin our marine policy over the coming decades. It is realised that this will always be limited, so it beholden on all of us in the marine sciences to ensure the best use is made of this funding. The UK private sector should have a major part to play in the coming decades, not only in drawing in and potentially providing additional funding, but also in effective management of research facilities and funding. Only with the private and public sectors working with one another will we ensure that we have a marine environment that is suitably protected but also is well understood and effectively utilised by a wide range of potential users.

January 2007

Memorandum 17

Submission by the Society for Underwater Technology

1. Executive Summary

The oceans and seas play a very important role in the weather, climate and wealth of the UK. These all depend on research, measurement and the distribution of data to be effective in modelling physical and biological ocean systems for operational and longer term predictions. This is now particularly important in view of climate change and the mitigation of its causes and affects. Despite identification of the fragmented nature of its provision in 1985, and again in 1990, the organisation of marine research, technology and affairs is still lacking an over-riding strategy and is spread amongst many agencies.

2. Introduction to Society for Underwater Technology

The Society for Underwater Technology (SUT) is a UK learned society with Branches world wide. It is dedicated to the exchange of learning and knowledge in and between all sectors where technology is used in the underwater environment. As such it is not sector specific or representative of any trade. Its members are drawn from academia, industry and government with interests as diverse as archaeology, fish farming, renewable energy and oil and gas exploration and production. The views expressed here are not necessarily representative of all our members but have been culled from consultations amongst the relevant technical committees of the Society.

3. Background to UK Marine Science and Technology Organisation and Funding

In 1985 a House of Lords Select Committee investigation revealed that UK marine science and technology (MST) was fragmented and under-funded. This led directly to the creation of the Co-ordinating Committee for Marine Science and Technology (CCMST), tasked to develop a strategic framework for UK MST. This important document was produced in 1990. However, in 1991 the Committee was replaced by one which had less executive authority, the Inter Agency Committee for MST (IACMST). This was charged with the general co-ordination of government and agency activities in the MST area. Within its terms of reference, it has done a very good job, but a Parliamentary Office of Science and Technology (POST) report (No 128) noted in 1999 that "the current arrangements appear to be a long way from those envisaged in 1990". It raised concerns about the level of funding, the balance between fundamental and applied research, the commercialisation of publicly funded science and the ability to provide appropriately specialised graduates. It also raised further concerns about the mechanisms for Government support and the role of its Departments in this area.

4. Importance of the Oceans

4.1 The oceans play a vital, controlling, role in the weather and climate system of the earth. They are a major source of food and, more recently, oil and gas and other minerals. It is known that a large additional gas resource lies under the deep ocean in the form of hydrates, but how to exploit this without causing a major environmental catastrophe is not at well understood. The impact of global warming, and the part the oceans play in the mitigation of increasing CO_2 is also not yet well-enough understood. We know more about the surface of the closer planets than we do about the deep ocean, as well illustrated by recent television programmes which routinely find large creatures there previously unknown to science.

4.2 On a more parochial note, 95% of the UK's trade goes by sea, the maritime sector is worth about £35 billion (larger than aerospace and agriculture put together) and the UK seas are rich in both hydrocarbon and renewable energy resources.

4.3 Understanding the oceans and their environment is a key to the future of mankind, both from the perspective of climate change and that of the sustainable exploitation of its living and non-living resources. [For example, with the continuing increase in world population, it is anticipated that the requisite increase in protein for food will come from the oceans.]

4.4 The polar seas are unique, but are also an integral part of the interlocking world oceans and form part of the driving force for the world's ocean circulation system. At the other end of the scale, coastal and estuarine processes are very important to the life and health of the nation.

5. Organisation of UK MST

The UK has, historically, been a leading practitioner of marine research, but this has been spread over many agencies and departments. For example, on the Research Council side the leading two are EPSRC and NERC, but there is also the Biotechnology and Biological Research Council for marine-based biotechnology. Many Government Departments have an interest: DTI (hydrocarbons and renewable energy), Defra (fishing, fish farming and the environment), MoD and DoT (shipping) to name but a few. Despite IACMST's best efforts there still appears to be a lack of co-ordination in marine matters between the Departments. For instance, it is notable that the Marine Bill, the precursor of which has recently undergone public consultation, is driven by Defra but excludes the oil and gas and renewable energy areas (DTI) and defence (MoD). It appears to concentrate solely on environmental matters, but suggests that Marine Spatial Planning (MSP) would be worthwhile. However, to be effective, MSP would need to engage with all users of the UK's seas and, if some of the main ones are not included, it is difficult to see how this would work. In ant case, underlying MSP is the requirement for marine scientific data so that informed decisions can be taken. Collecting and analysing this will be no trivial task.

6. Marine Measurements and Data

6.1 As the preceding paragraphs have shown, the understanding of the oceans and seas on both a global and local scale is of great importance to the UK as a nation, both in the long term and the short. However, the measurement and research effort required is fragmented. There are major international programmes in which the UK could or should play a part. Of particular interest is Global Ocean Observing System (GOOS) that will be the marine component of the proposed Global Earth Observing System of Systems (GEOSS), the call for which is supported by the G8. However, the requisite network of ocean observatories in and adjacent to UK waters, and in areas of interest to the UK, is not yet in place. This will reduce the value of the other data being collected, with the UK lagging behind other nations in its commitments to both the GOOS and the GEOSS.

6.2 Marine measurements, physical and biological, are required on many time and space scales to provide information on which to base Environmental Assessments, both with regards to local impacts and to strategic scale activities. They are of vital use in the prediction of the impacts of climate change, such as the increase of flood risks, changing global weather patterns and ocean acidification, and in modelling how we might mitigate these.

6.3 It should also be remembered that users of these data and measurements do not always come from the government laboratories and agencies. There are many companies providing services to a wide range of user communities and who have need of this input data. There is a need to ensure that our scarce resources are well spent and well co-ordinated in the gathering of this data, which can then be made available to the full range of user communities.

7. Technology

7.1 The sustainable exploitation of the oceans requires the development of suitable technology. Conventional subsea oil and gas exploration and extraction technologies are well advanced, but these (and the experience in developing tem) are needed in other areas that are now of increasing importance such as offshore renewable energy and offshore fish farming. Renewable energy from the sea has huge potential for the UK, both for its own consumption to displace carbon technologies, as the UK has one of the best wave and tidal climates in the world, and for export. Offshore fish farming could potentially solve the world's forthcoming shortage of protein, as inshore fish farming has major drawbacks, and wild fisheries and terrestrial sources have reached the limit of their viability.

7.2 Such developments need the UK's marine technology research base to be working in a co-ordinated way. This would not only be good for the UK, for example in terms of combating global warming and its effects, but also in exploiting a large export market. However, the research involved has to cross sector boundaries to be effective.

January 2007

Memorandum 18

Submission from the Biosciences Federation

Executive Summary

The UK is widely recognised as having made strong long-term contributions to the marine sciences across the globe, as befits a fundamentally maritime nation. Our maritime research base has in recent years benefited from the deployment of new (often at least partly automated technology and from the added focus and immediacy provided by high-level research questions, most notably gauging climate change. However, the Federation believes that the UK's marine sciences remain seriously under-funded and surprisingly disconnected, reflecting a lack of overall coordination and an under-appreciation of our true depth of ignorance regarding the composition and dynamics of oceanic ecosystems. This in turn partly reflects the continuing long-term decline in organismal biology, which has most drastically affected the university sector, thus eliminating the source of fresh UK-trained recruits needed in these critical research areas. Such expertise, appropriately networked, is required especially urgently to develop less crude models of ecosystem responses to climate change. The Federation especially highlights the increasing failure of the UK's funding bodies to adequately support long-term research programmes in general and those relating to environmental monitoring (including taxonomic underpinning) in particular. Although our success in marine sciences should be assessed primarily at the international level, it is equally important to ensure that the UK's own marine research network is properly integrated and self-sustaining.

Biosciences Federation

The Biosciences Federation (BSF) is a registered charity (No 1103894) that was established in 2002 as a single authority representing the UK's biological expertise, providing independent opinion to inform public policy and promoting the advancement of the biosciences. The Federation is actively working to influence national and European policy and strategy in biology-based research (including funding and the interface with other disciplines) and in university and school teaching. It is also concerned with the translation of research into benefits for society, and with the impact of legislation and regulations on the ability of scientists to operate effectively.

The Federation brings together the strengths of 44 member organisations (including the Institute of Biology) and 42 additional affiliated societies. This represents a cumulative membership of over 70,000 individuals, together covering the full spectrum of biosciences from physiology and neuroscience, biochemistry and microbiology, to ecology, taxonomy and environmental science.

The Federation thanks the following for their substantial technical contributions to this document:

Dr Louise Allcock (Queen's University Belfast/ Linnean Society);

Professor Richard Bateman (Biosciences Federation/ Systematics Association);

Dr Anthony Fletcher (Leicestershire Museums/ British Lichen Society);

Professor David Mann (RBG Edinburgh/ British Phycological Society);

Professor Graham Underwood (Essex University/ British Phycological Society).

Preamble: Clarification of Terms and Remit

This [is an] inquiry into marine science in the polar and non-polar regions

1. The Federation finds the precise phrasing of this statement intriguing. While recognising that there is understandably a strong interest in the relevance of the polar seas to climate change, there can be few more integrated systems than the world's oceans; ultimately, the dichotomy implied by this statement between polar and non-polar regions is artificial. We would not, for example, wish to see vital research into polar seas promoted at the expense of consideration of home waters; it is comparisons between different biotas and environments that are in general likely to prove most informative.

2. In addition, it is important to define the extent of the marine realm. We here take a broad definition, including any terrain periodically inundated by tides or frequently affected by wind-borne sea spray. Our decision reflects the high ecological impact of salt, and the fragility and vulnerability (eg to pollution and development) of many of the ecosystems that characterise the intertidal and supralittoral zones.

Organisation of UK Marine Science

Organisation (and funding) of UK marine science in the polar and non-polar regions

3. We welcome recent initiatives to improve connectivity between the UK's marine research organisations, such as the focusing of climate collaborations on the British Antarctic Survey (BAS). Nonetheless, in our view, the remaining centres of oceanic research in the UK remain undesirably poorly networked, often perpetuating research foci that owe more to historical constraints than to national or international priorities. We therefore suggest that an independent review of the UK's marine biology would be timely, analogous to that recently performed by the Freshwater Biology Association and NERC on behalf of the UK's freshwater ecology base (*A review of freshwater ecology in the UK,* December 2005). NERC's own crucial role in resourcing the bulk of the UK's marine science, in both the universities and the institutions, also merits periodic reappraisal.

4. In addition, we suggest that benchmarking against global leaders in the field of marine sciences (eg Scripps Institution of Oceanography, La Jolla; Woods Hole Oceanographic Institute; Alfred Wegener Institute (AWI), Bremerhaven) would help to highlight strengths and weaknesses to their UK equivalents, and indicate where additional resources could most usefully be deployed in the immediate future.

We discuss funding issues below, under "Research and skills base".

Contribution of the UK to International Collaborations

The role of the UK internationally, and international collaboration in marine science

5. Although modest grants for brief exchange visits are relatively easy to obtain, surprisingly, there is at present no clear route for obtaining matching funds from the major UK funders (notably NERC) to develop substantive collaborate with other major global partners (eg the USA's National Science Foundation). For example, for the International Polar Year, each country independently funded its own contribution. Any planned research programmes between countries could be initiated only by successfully passing two independent proposals through at least two independent funding systems; this "double jeopardy" approach

to funding offers very low probabilities of success. Similar situations currently exist within the ESF and other bodies supporting international collaboration. It is difficult to envisage how a genuinely global challenge such as climate change can realistically be addressed at a national level. The Federation therefore recommends that recent genuine advances in international cooperation at the policy level are now matched by corresponding advances in cooperative research funding.

6. UK marine scientists recognise the importance of international initiatives and working groups (eg IGBP initiatives such as SOLAS and IMBER); they are also aware of the damage done to our international competitiveness in cases where we choose not to participate (often due to inadequate resourcing). The UK is most likely to benefit when it is a full partner in the initiation of international programmes, but at present, establishing such programmes is extremely time consuming and necessitates extensive lobbying; this in turn requires substantial career-time investment by key individuals. Greater consensus on prioritising global issues, and determining the best methods of addressing them, is required. Also, better coordination is desirable, supported by formal recognition of the essential contribution of those key individuals that protects their ongoing research careers (for example, the Research Assessment Exercise gives minimal reward for international coordination).

Technological Support

Support for marine science, including provision and development of technology and engineering

Note: We assume that funding aspects of "support" have been covered by earlier questions, and that this is therefore essentially a technological question.

7. The Federation recognises the technical advances that have allowed automation of much of our marine data collection. Examples include remarkable data on productivity in the open ocean from remote sensing (NERC has wisely developed excellent satellite capability), a range of initiatives focused on autonomous buoys, and AUTOSUB.

8. Nonetheless, it remains critical for the UK to maintain a top-class research fleet. Although this has made vital contributions to global marine science, it presently suffers from a combination of technical failures and under-provision of cutting-edge technology. At the time of writing (January 2007) cruises have once again been cancelled due to mechanical problems with RSS *Discovery;* such cancellations can seriously undermine grant-funded projects and damage the careers of associated fixed-term researchers.

9. Each of our research ships requires provision of a full range of technical capabilities (eg swath bathymetry, ice-breaking capacity) so that technical issues with single ships do not cause disproportional and/or long-term disruption to research programmes. At present there is very limited flexibility if a particular ship becomes unavailable. Together, these factors threaten our competitiveness at an international level.

10. The Federation therefore recommends that funding of the UK fleet is revised, and that its remit is expanded to include more speculative projects and those that add to baseline data on biodiversity. If properly resourced and managed, this would allow adequate support of both short-term and longer term research projects. In addition, the nature, location and usage of other items of expensive technology sought in order to enhance the UK's oceanic sciences needs to be carefully reviewed, preferably in collaboration with our international partners.

Research and Skills Base in the UK's Marine Science

The state of the UK research and skills base underpinning marine science, and provision and skills to maintain and improve the UK's position in marine science

11. We will address these issues in particular detail, as they reflect broad concerns already identified by the Federation as being of especially high priority within the UK's biosciences base (indeed, we are anxious to see the Science and Technology Committee directly address these issues via an explicit enquiry). Specifically, we wish to highlight:

(a) the erosion of the research, education and skills base in whole-organism biology in general and taxonomy in particular, especially in the university sector; and

(b) the present unwillingness of virtually all funding bodies to support the long-term research projects that provide essential data-sets for enabling science such as taxonomy and environmental monitoring.

That little effort is presently being made by government to remedy these widely recognised declines appears to us extraordinary in the wake of valid concerns expressed the House of Lords Select Committee review of the UK's systematic biology base (*What on Earth,* 2002) and the unprecedented political impact of the Stern report on climate change (December 2006).

Research Base

12. Long-term data gathering has proven especially vulnerable to funding cuts (often management-driven) through the last two decades. Arguments commonly offered in an attempt to justify such decisions include: (a) sufficient knowledge has already been gathered, (b) these are "stamp collecting" exercises rather than hypothesis-testing science, (c) only hypothesis-testing will bring external funding into the organisation, and (d) the expertise needed to maintain such programmes is no longer available. Yet, for example, gathering time-series data (especially those of phytoplankton, so critical for nutrient cycling), offer the strongest available biotic signals documenting climate change. The Continuous Plankton Recorder (CPR) in particular has highlighted substantial changes in marine populations due to temperature changes and regime shifts, and similar patterns have been found in the freshwater data-sets from Lake Windermere. Indeed, the much-discussed closure of the Centre for Ecology and Hydrology's Windermere labs remains widely viewed as an astonishing risk for NERC to elect to take with an internationally renowned long-term monitoring project—one that provides an essential yardstick for its marine equivalents. Similarly, NERC elected to close long-term data collection at the Marine Biology Association in the 1980s, though fortunately the CPR team made redundant from that programme was later resurrected as SAHFOS.

13. This problem is compounded by the fact that new initiatives are much more readily funded than ongoing projects. For example, it is far easier to obtain funds for establishing a database than for populating it with data, analysing those data, or archiving the outcomes.

14. The increasing pre-eminence of grant-winning in the RAE has all but expunged enabling research (eg taxonomy and biodiversity assessment) from the university sector, leaving it in the hands of a few research institutes and a few remaining marine/oceanographic laboratories. For example, botanical taxonomic expertise (and, to a degree, training) has become concentrated in the Natural History Museum and the Royal Botanic Gardens of Kew and Edinburgh, and even then relatively little of their research has a marine focus. Moreover, each receives the bulk of its funding from a different government department (DCMS, Defra, SEERAD), discouraging strategic cooperation. Connectivity between these organisations and the HE sector is particularly desirable, but the potential is weakened by the current paucity of organismal researchers in the university system. Remedying this damaging asymmetry is a high policy priority for the Federation.

15. It is still often argued that the majority of species in the oceans have already been described, and so can be identified with relative ease. This has been an extremely damaging myth, as it has been used as a key argument in favour of downgrading (indeed, virtually abandoning) exploratory sampling of the kind pursued by *Challenger* and its noteworthy successors.

16. Thus, many of the projects designed to understand the functioning of oceanic ecosystems—an essential pre-requisite for addressing climate change—are obliged to collect data at worryingly coarse levels of resolution. Both crude functional categories and higher taxa (eg families, genera) are artificial entities that consequently are unlikely to share similar genetic (and thus ecological) properties. Analyses that focus on the species level or below (eg on particular genotypes within species) are far more likely to generate reliable information, not only on the species themselves but also on the critical inter-specific interactions that are the crux of oceanic communities (eg the planktonic microalgae and their protistan parasites and grazers, which have a profound role in carbon cycling).

17. Even a knowledge of the number of species present in an oceanic ecosystem (for example, gathered via increasingly automated DNA bar-coding technology) will not allow adequate understanding of climate change without understanding the inherent properties of those species. For example, several species of northerly distribution might be replaced in UK waters by corresponding species of more southerly distribution; the overall biodiversity of the ecosystem would not have changed, but its degree of integration and likely responses to further climate change would probably be significantly altered.

18. It is also important that lacunae in our current knowledge of particular ecosystems are identified, so that informed decisions can be taken as to whether they should be rectified. For example, at least for relatively poorly known taxonomic groups such as lichens and microalgae, there is recognition that the coastal supratidal (lichens) and subtidal (algae) zones are less well understood than the intertidal coastal zone and the plankton of the deep oceans. They are estimated to be especially biodiverse in the UK, and to be rich in rare and/or endemic species, though data remain weak and the subtidal zone remains a particular challenge to detailed, quantitative sampling. As well as intrinsic biological interest, these zones have practical relevance with regard to coastal land use (eg tourism, fish farming).

Skills Base

19. Arguments that enabling research disciplines such as taxonomy and environmental monitoring are not directly hypothesis testing have led to near-complete withdrawal of responsive-mode grant funding from these areas, particularly from the UK's research councils. This greatly reduced the number (and increased the average age) of research practitioners in these areas, which has in turn eliminated qualified academics available to train students. Students then found such courses taught be active researchers unavailable, and

simultaneously recognised that finding employment in organismal biology was becoming ever more challenging. Consequently, the UK now faces a dearth of such individuals coinciding with a greater need for them in high-priority research areas such as climate change. To some extent, the collapse of our "informal apprenticeship" in organismal biology can be remedied by important organismal biologists trained elsewhere, but their mean residence time in the UK is relatively low. What is clear is that reversing this negative feedback loop will require (a) far more commitment than is currently being shown and (b) a minimum period of a generation (ie 20 years).

20. The downstream consequences of these skills gaps can be profound. For example, the British Lichen Society reports that only five tenured comparative lichenologists remain in the UK: one in the university sector and four in the museums/botanic gardens sector. Only one of these individuals primarily studies coastal habitats. The bulk of the UK's lichenological research is now conducted by unfunded amateurs and retired professionals, with some support from a handful of independent consultants.

21. Biology-oriented students passing through the increasingly prescribed route of GCSE—A-level—BSc are not exposed to the practical skills that are essential for planning or conducting marine work in general and its organismal (ecology and systematics) aspects in particular. Even at undergraduate level, laboratory exercises are increasingly mass-produced or virtual, and field courses have become less frequent and less challenging. The main drivers of these changes are minimising staff and other costs and, to a lesser degree, increasingly stringent Heath and Safety constraints, rather than lack of demand from students. The consequences of these "rationalisations" are that UK-trained students are not only surprisingly ignorant about the biology and diversity of organisms but also of the techniques and technology used to study them. Even simpler skills such as use of a compound microscope can no longer be expected. Hence, postgraduate courses in these areas are now obliged to provide introductory courses in skills such as morphology and anatomy that would have been taken as read two decades ago. Employers in growth areas such as environmental impact assessment and ecological microbiology also routinely complain about the low skills base of applicants.

22. Consequently, researchers desiring practical training rely increasingly heavily on independent (and generally under-resourced) organisations such as the Field Studies Council and Marine Biology Association, and on learned societies such as the British Phycological Society. The importance of these courses is given even greater emphasis by periodic closures of marine laboratories and field centres (eg the closure of the Port Erin Marine laboratory by Liverpool University).

23. Overall, there is a clear need for a properly funded national or preferably international (at least EU-wide) strategy to develop and maintain taxonomic expertise across the range of marine organisms. At present, there is no coordinated strategic planning.

Marine Sites of Special Scientific Interest [SSSIs]

[The] use of marine sites of special scientific interest

Note: We find the wording of this statement ambiguous, being unclear whether the committee is questioning the value of establishing marine SSSIs or simply asking whether they are of practical use or benefit to the UK. We also note that this is a narrower topic than the others identified by the Parliamentary STC.

24. It is not widely known that SSSI status can extend only to the intertidal region, and therefore is not applicable to the vast majority of the marine environment. The marine environment is instead protected primarily by Special Areas of Conservation (SACs). Although three "marine reserves" have also so far been designated (Lundy, Skomer and Strangford Lough), the level of protection afforded by marine reserve status is far below that afforded by SSSI status (eg it does not even prevent trawling activity, which is demonstrably highly destructive to the benthic fauna).

25. While recognising that much of the British coastline has been scheduled at a European level under RAMSAR or SAC, we note that the protection offered by EC designation is much weaker than that provided by the UK's SSSI status. Furthermore, there are insufficient funds to monitor, assess and report on the SACs already designated, nor for the agencies responsible for SACs to collaborate with specialist researchers whose input is desperately required to facilitate our knowledge and understanding of these often fragile ecosystems.

26. Species lists for most SSSIs, SACs and marine reserves cover only a small proportion of the major groups of organisms present (for example, lichens figure in the species lists for only one coastal NNR, Bardsey Island). Moreover, if species are not specifically mentioned when a site is scheduled they are, by definition, excluded from the management agreement, and individual site schedules are difficult to rewrite when new species are found.

27. Even when species lists have been compiled, our knowledge of the biological properties of most of these species remains rudimentary. In many cases their mating systems have not been documented, their larvae described, or their means of dispersal determined. Such ignorance confounds attempts to assess the conservation needs of individual species.

28. Extending the discussion to ecological interactions, information on connectivity and ecological functioning of the biotas of particular reserves is even poorer, to the extent that it is not yet clear whether the current conservation designations are likely to have any useful impact in the longer term. Funding for long-term monitoring and for collaboration with specialist researchers outside the agencies are essential to reverse this situation.

29. In summary, the value, "use" and long-term health of the UK's marine SSSIs, SACs and marine reserves are likely to depend heavily on the larger scale research that is discussed under earlier topics (and that is presumably the main theme of this inquiry).

Climate Change as the Pre-eminent Driver of Current Oceanic Studies

[The inquiry] will include study of how marine science is being used to advance knowledge of climate change in the oceans

30. The Federation can only applaud the greatly increased profile accorded by the scientific and especially the political communities to climate change issues during the last few months. We recognise that the UK has some major internationally renowned centres in this area (eg Environmental Sciences at UEA, Tyndall Centre, Southampton Oceanography Centre), and that key funding bodies such as NERC have taken responsibility for much of the relevant research in the UK.

31. The Federation has listed under earlier headings several specific actions that it believes are critical to making successful the UK's attempts to understand, predict and ultimately manage climate change. Future research will need to be based on far better resolved data. We place particular emphasis on determining the organismal composition of phytoplankton communities world-wide, though with a specific responsibility for documenting their composition in British waters.

32. We would, however, end on a cautionary note. The growing focus on this topical, socially and economically relevant, and increasingly well-funded research area should not be allowed to further distort the UK's marine research base. Vigour and cohesion can be achieved only by maintaining various critical balances—between organismal and molecular, evolutionary and ecological, macroscopic and microscopic, nearshore and deepwater, applied and blue-skies. Imbalances and asymmetries that have developed through the last two decades have helped constrain the speed and impact of the UK's response to climate change.

January 2007

Memorandum 19

Submission from the University of Plymouth Marine Institute

Profile

The University of Plymouth Marine Institute is a multidisciplinary institution incorporating some 160 researchers covering a wised range of interests. Our work is focused on catchments to coastal seas where the primary impacts of economic development are felt. We are one of a very few institutions in the country that undertake studies of coupled social and ecological systems in the marine environment as well as providing science for resolving many practical problems in our shelf seas and estuaries. We have over 1,500 students enrolled in marine-related course and as such are one of the largest providers of marine education in Europe.

The Concern

We are acutely aware of the high quality of current research on the oceans and are pleased to contribute to it in close association with our partner institutions in Plymouth and beyond. We recognise that this is quite poorly funded in comparison with other developed countries (eg Germany, the USA) and that this has required a focus on excellence in order to maintain international standing. However, we are concerned that inadequate attention is being given to the need for more joined-up thinking in research that will meet national and international needs for managing human activities and rationally protecting and exploiting marine systems. This is partly a consequence of the disciplinary nature of our research councils and fragmentation of governance of the UK and Europe's marine environment.

Both globally and locally, marine resources are largely exploited close to their biological limits and often beyond them. There are increasing pressures on seabeds as a source of raw materials or from destructive fishing practices and there is strong early evidence of ocean acidification, the "globalisation" of species and occurrence of harmful algal blooms. Most of these issues are not new to science and our understanding of them has improved dramatically in the past decade. More worrying though is that this scientific knowledge has not been translated into effective action to correct these problems.

There has been a growing realisation that this failure of governance is associated with deficient information on how human and ecological systems are coupled. Again this reflects the disciplinary nature of our knowledge base with social and natural science compartmentalised and using distinct technical language and approach. In order to bridge the gap, numerous bodies nationally and internationally have adopted a new management paradigm—the "ecosystem approach"—that proposes the management of human activities within the context and spatial and temporal limits of a coupled social and ecological system.

Despite this major step forward in thinking, our institutions, including research bodies, have been slow to provide the knowledge base to underpin it and apply it to today's problems. Funding for interdisciplinary science, whether "big picture" or small scale, is relatively poor, perhaps because such science is considered second grade, not well received (or classified) in the academic Research Assessment Exercise and falls between research council stools (there are some smaller interdisciplinary programmes).

In this sense, we compare very unfavourably with countries such as the USA or Sweden, where interdisciplinary science is often prized. Unsurprisingly, much of the emerging knowledge base on how to develop and implement joined-up approaches is coming from these countries and, generally speaking, the best publications (eg in *Nature* and *Science*) are driven by these scientists. We are helped in the UK by having positions in international panels that provide access to peers from leading institutions but it is unfortunate that our own capacity in this field is comparatively weak.

A similar situation emerged for renewable energy technologies. A lack of investment in R & D in the UK has led us to be trailers rather than leaders. Hopefully this situation will change with the development of the Wave Hub in Cornwall. This development has already triggered new research capacity that our own institute is beginning to benefit from.

The Context of the Inquiry

In the UK, international collaboration is essential for the development of our work. Without this we would have little or no interdisciplinary capacity.

As providers of graduates to fill the UK's skill base we are keenly aware of the need to be innovative. We value the link between research and training that is at the core of our university system. We are currently engaged in co-developing a new marine research centre in Plymouth where four institutions (The University of Plymouth Marine Institute, The Marine Biological Association, the Sir Alister Hardy Foundation for Ocean Science and the Plymouth Marine Laboratory) will co-locate in order to improve the impact of their research and provide a better bridge between training and research at all levels. We are often frustrated that there is such limited funding to enable skills progression to take place. We are desperately short of funding for PhD students and it is at this level that we are seeing slippage in excellence in comparison with other countries.

The point concerning marine sites of special scientific interest is very important to us. As part of the ecosystem approach (and of the UK's commitments to the WSSD/Johannesburg process), we should be developing a network of marine protected areas in order to protect global biodiversity and encourage sustainable use of the sea. This has not occurred despite clear scientific evidence of the benefits (undisputed benefits to biodiversity). It is very difficult to understand long term processes around the coasts of the UK because of the intermittent nature of the research effort; valuable time series have been lost because of shifting high profile research interests. Furthermore, research on these sites has rarely integrated human and natural sciences. We need a consistent monitoring system, advised by scientists and stakeholders working together and communicating their findings to the public. This is also one facet of practical implementation of the ecosystem approach where university-based research could have a key role in the future.

The University of Plymouth Marine Institute would be happy to discuss the issues summarised here in greater detail and we are pleased that this inquiry is taking place.

January 2007

Memorandum 20

Submission from the Department for Environment, Food and Rural Affairs

Executive Summary

1. This memorandum outlines Defra's role in supporting marine science. Specifically it details Defra's need for scientific evidence in support of its marine-related policies. It also covers: our organisation of marine science and the scope and content of our programmes; our role in science co-ordination and collaboration; and our support for the skills base. Reference is made to climate change and marine reserves, two topics highlighted by the Inquiry.

2. Defra takes the UK lead and has a major interest in a significant number of international, European and national marine-related policy areas. Defra's policies are evidenced-based and science plays a key part in providing that evidence and in meeting statutory assessment and monitoring requirements.

3. Defra is a major supporter of marine science, spending approximately £26 million annually. Monitoring the marine environment helps Defra maintain an up-to-date assessment of the state of our seas and the effectiveness of our management policies. Research helps interpret the results of our monitoring programmes and assists us in adopting and developing appropriate management measures.

Defra's Role in Marine Science

Background

4. Our seas provide us with valuable economic, social, environmental and cultural benefits. The marine area offers an important potential source of renewable energy and our seas and coastline are enjoyed by tourists and residents for holidays and recreation. They are also home to many important species and habitats. The seabed contains important sources of minerals, including aggregates which are used by the building industry, and there are oil and gas reserves that contribute significantly to our energy requirements. The seabed may in the future be used for carbon capture and storage. The UK has an important sea fish industry with one of the largest fishing fleets and fish processing industries in Europe. An IACMST publication estimated that marine-related activities in total contributed approximately 5% of the UK's GDP.[19]

(Appendix 1 provides a list of acronyms).

Policy drivers

5. The Government has principal stewardship responsibilities for this important resource. The Marine Stewardship Report *Safeguarding our Seas*[20] sets out our vision for managing and protecting the sea as an important ecosystem and how we plan to achieve clean, safe, healthy, productive and biologically diverse oceans and seas. Delivering this vision requires regular updates of our knowledge on how the seas function and how they are impacted by human activities. Charting Progress[21] sets out our current knowledge on the state of the seas. The proposed Marine Bill[22] will help develop and implement the necessary regulation and planning regime for the sustainable use and protection of our seas, coasts, estuaries and marine wildlife.

6. Within the context of this vision, Defra takes the lead or has a major interest in a significant number of international, European and national marine related policy instruments, all aimed at managing human activities in order to protect marine environment (Table 1).

7. For the marine environment, a key policy objective is to have arrangements in place which demonstrate the extent to which our seas and coasts are achieving good environmental, ecological and chemical status. This is necessary to meet obligations under the OSPAR Convention, the Water Framework Directive and those emerging under the European Marine Strategy Directive which is currently under negotiation.

8. At the 2002 World Summit on Sustainable Development at Johannesburg (September 2002), the EU, and member states, committed to maintain and restore fish stocks to levels that can produce the maximum sustainable yield by no later than 2015, and to establish representative networks of marine protected areas by 2012.

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[19] A New Analysis of Marine-Related Activities in the UK Economy with Supporting Science and Technology. D Pugh and L Skinner. IACMST Information Document No 10, August 2002.

[20] *Safeguarding our Seas Report. 2002.* http://www.defra.gov.uk/environment/water/marine/uk/stewardship/index.htm

[21] Charting Progress An Integrated Assessment of the State of the UK Seas. 2005. http://www.defra.gov.uk/environment/water/marine/uk/stateofsea/chartprogress.pdf

[22] Marine Bill http://www.defra.gov.uk/environment/water/marine/uk/policy/marine-bill/index.htm

9. Defra therefore has many significant and wide-ranging policy responsibilities within the marine area. Our national and international policies are evidenced-based and marine science plays a key part in providing that evidence. Our science programmes, and the other evidence we draw on, contribute directly to decision making, including licence consents for human activities in the sea, fisheries management and the development of EU legislation. For these reasons we need high quality, credible science which the Department, our stakeholders and the public can have confidence in.

Defra's Organisation and Support of Marine Science

Background

10. Defra's science programmes encompass both monitoring and research. Monitoring the marine environment helps the UK maintain an up-to-date assessment of the state of our seas and the effectiveness of our management policies. Research helps interpret the results of our monitoring programmes and assists us in developing appropriate management measures, and interpreting their effectiveness. In addition to funding the more specific policy related science, we also commission strategic research which helps us understand long-term variability in the marine environment and the concept of sustainability.

Science supported by Defra

11. Defra is a major supporter of marine science and annually spends approximately £26 million on marine-related science. Table 2 sets out the extensive scope and content of our programmes. Specific project details and research results are available online.[23]

12. For *marine environment* our research and monitoring programmes allow us to assess progress towards our vision of clean, safe, healthy, productive and biodiverse seas.

13. For *marine biodiversity* science is helping to underpin measures to promote strong, healthy and resilient marine ecosystems.

14. For *water quality* the reduction of diffuse water pollution from agriculture and other sources through mitigation will help to improve and protect the quality of inland waters, which will be benefit coastal and marine regions. Under the Water Framework Directive, measures advised by science will be developed for each river basin district to ensure that good ecological status is achieved and maintained.

15. For *fisheries management,* our aim is a fishing sector that is profitable and supports strong local communities, managed effectively as a full part of coherent policies for the marine environment. Our science programme enables us to assess the status of the stocks, understand key biological attributes such as migration, and the impact of fisheries measures.

16. For *flood and coastal management* Defra has a joint programme of research with the Environment Agency that includes work on the physical behaviour of estuary and coastal systems, related management approaches and their social, environmental and economic impacts.

17. For *climate change,* Defra supports a programme of research to increase our understanding of current climate change and its possible future evolution, including projections of sea-level rise, ocean heat uptake, thermohaline circulation and sea ice coverage. Defra also has a long-term commitment to international ocean monitoring programmes, which measures sea temperatures and salinity, and is a major funder of knowledge transfer through MCCIP.[24]

Programme development and quality assurance

18. Defra commissions marine science for the principal purpose of providing evidence to policy development. A number of measures have been adopted by Defra to ensure the science programme is fit for purpose, robust, of good quality, and delivers the necessary evidence. These measures include:

— In 2004 Defra embarked on a comprehensive Evidence and Innovation (E&I) review aimed at defining its science strategy for 2005–08.[25] A key part of the process involved science budget holders setting out their Statements of Need, describing strategic policy priorities, evidence needs and innovation opportunities.[26] E&I helped identify future evidence needs, and the potential for collaborative working.

[23] Defra's Research Projects http://www2.defra.gov.uk/research/project—data/Default.asp

[24] MCCIP UK Marine Climate Change Impacts Partnership http://www.mccip.org.uk/

[25] Defra's Evidence and Innovation needs: Sustainable marine environment http://www.defra.gov.uk/science/how/documents/PDFs%20in%20Parts/Part%20II%20in%20sections/17.pdf

[26] Sustainable Marine Fisheries Statements of Need http://www.defra.gov.uk/fish/sea/index.htm provides an example.

— Individual research programmes are usually reviewed every three to five years, a process involving external experts to help us assess programme progress and set future priorities.

— There is a vigorous process of peer review, including evaluation of project proposals and final reports. Open competition in some research areas helps widen our contractor base.

Future challenges

19. The E&I review identified a number of key science requirements and challenges which the department will need to address in the coming years. Our knowledge of the marine environment as a whole is still far from complete. We need to enhance our understanding of ecosystem structure and functioning and its vulnerability to human impacts and climate change.

20. Priorities for further science are wide ranging covering biology, ocean processes, socio-economic impacts, new technologies and data management. We need to develop appropriate marine ecosystem indicators, map marine habitats, develop risk analysis frameworks, extrapolate impact from the individual to the population level and assess social and economic costs and benefits of alternative policy options.

21. To fully comply with increasing demands for evidence, the UKMMAS[27] states that there needs to be an additional £22 million per year spent on sustained marine observations by UK Departments, Agencies and industry. We acknowledge that Defra's current marine science budget is not sufficient to meet all these needs.[28]

National and international collaboration and partnerships

22. Budgets are finite and collaboration with other funders within the UK and internationally is given a high priority by Defra. Examples of significant collaboration include:

— *Charting Progress*, co-ordinated by Defra, drew on scientific evidence from nearly 60 organisations across the UK. Following on from this, Defra has taken the lead on two UK-wide collaborative partnerships on marine data (MDIP)[29] and on understanding climate change impacts (MCCIP).

— Within the UK other government departments, devolved administrations and agencies also have an important role in developing marine policy. They similarly require scientific evidence and Defra collaborates closely with these science funders, including DTI, EA, MCA, NE, and JNCC.

— Defra acts as UK co-ordinator to the European GMES[30] programme. A significant part of this programme involves remote sensing of our seas using satellites.

— On behalf of other departments, devolved administrations and agencies, Defra leads on the development of the UK Marine Monitoring and Assessment Strategy (UKMMAS). This new strategy aims to shape the UK's ability to provide the evidence to fulfil our vision. Linked to this the Fisheries and Marine Science Customer Group, involving SEERAD, DARD NI and Defra meet annually to review departments' priorities for science in relation to fisheries and marine environment priorities and programme co-ordination.

— Research Councils, including NERC and ESRC, support high quality, strategic research which is potentially of use to Defra and we are seeking to further develop our links with Research Councils to enhance uptake from their programmes into policy. For example as part of NERC's Oceans 2025 programme Defra, NERC and SEERAD are developing a collaboratively funded programme "Sustainable Marine Bioresources". We are also working with NERC to safeguard long-term evidence collection.

— Internationally, Defra is an active participant in the European Commission funded ERA-NET (European Research Area Network) scheme. For example we co-ordinate the MariFish ERA-NET project which brings together the funders of marine fisheries research from 15 countries whose total annual spend on science exceeds €100 million.[31] Other relevant ERA-NETs in which Defra is involved include AMPERA on accidental marine pollution, BIODIVERSA on biodiversity and Defra also co-ordinates the CRUE project on flood management.[32] Through these ERA-NETs Defra is able to access results emerging from research funded across Europe, and participate with our European partners in jointly funded projects.

— Defra encourages its contractors to participate in Commission funded research programmes. For example in 2006 Cefas, an agency of Defra, was involved in over 30 Framework Programme projects, all of which received matching funds from Defra. Projects involve collaboration with many other research institutes. For example a project evaluating management tools involved 28 partners from more than 10 countries.

[27] UKMMAS http://www.defra.gov.uk/Environment/water/marine/uk/science/monitoring.htm
[28] MAPC Reference paper 3.8 "Delivering the UK MMAS resource requirements". November 2006.
[29] MDIP http://www.oceannet.org/MDIP/
[30] GMES http://www.GMES.INFO/
[31] MariFish ERA-NET website http://www.marifish.net/
[32] CRUE ERA-NET website http://www.crue-eranet.net/

— Defra is an active participant and supporter of key international bodies such as ICES and OSPAR. Output from our science programmes provides evidence to these bodies, helping for example with the adoption of new detection and analysis techniques for pollutants and production of the overall Quality Status Reports. Our Agency scientists work jointly with those from other member states in the fish stock assessment process, leading to the setting of annual quotas.

Defra's Support for the Marine Science Skills Base

23. Defra's support for the marine science skills base arises from its commissioning of science, as summarised in Table 2, rather than through the direct funding of training schemes. Evidence is procured from a wide contractor base, including Defra's Executive Agency Cefas (Centre for Environment, Fisheries and Aquaculture Science), NERC's Marine Centres, universities with marine-related science teams, and consultancy companies.

24. Recognising the special role that Cefas has in the provision of science, Defra announced a plan in June 2006 to secure the long term sustainability of the agency. Under this plan Defra will fund Cefas at broadly current levels, in nominal terms, for at least 10 years. Plans also include the development of a new fit for purpose laboratory facility. Defra will benefit from the continued access to high-quality scientific services to support government policy development and maintenance of skills.

25. A wide range of science skills are needed in order to provide the necessary scientific evidence for policy purposes. For example our assessment of ecosystem change arising from natural or anthropogenic disturbance involves biologists, chemists, physicists, statisticians, geologists, engineers and socio-economic specialists. Skills in geographic information systems, ecosystem analysis, acoustic habitat mapping and stable isotope analysis all contribute to a more comprehensive understanding of ecosystem functioning. Climate change modelling provides prediction of future change, both globally and regionally and information on the changes we can expect in the marine environment in the future.

26. As an intelligent customer for science, Defra also has in-house scientists who manage the science programmes and ensure that there is a comprehensive interpretation of the results and uptake into policy. Good interpretation and communication skills are needed by staff members to disseminate results to other stakeholders and the wider public.

Marine Sites of Special Scientific Interest

27. The Committee's inquiry includes a focus on the use of marine sites of special scientific interest (SSSIs). SSSIs are one of a number of tools that can be used to protect marine habitats and species and contribute to the attainment of healthy, functioning and resilient ecosystems. There are currently no entirely marine SSSIs in England or Wales although there are a number of intertidal and estuarine SSSIs extending below the high water mark.

28. Special Areas of Conservation (SACs) have been designated to afford protection to marine species and habitats of European importance. As yet there are no entirely marine sites but Defra withits conservation agencies is actively pursuing a programme to address this. Two sites, Lundy and Skomer, have been designated as marine nature reserves (MNRs) under the Wildlife and Countryside Act in England and Wales.

29. Thecollection of baseline data and the monitoringof marine sites provides invaluable information on the diversity of our marine habitats and species, how they function and the effectiveness ofprotected areas as a conservation measure. For this reason Defra hasfunded monitoring at the Lundy site over a number of years and this is providing a practical insight into how an area closed to fishing helps protect vulnerable species and habitats.

30. On a more general point, Defra also has an interest in the role marine protected areas (MPAs) could play in commercial fish stock recovery. In 2005 we funded a review of MPAs in temperate North Atlantic waters which concluded that MPAs are a valuable tool for the preservation and enhancement of certain critical habitats and site attached shellfish and finfish populations, but are less effective for mobile species.[33]

Climate Change Impact—The Role of Marine Science

Policy drivers

31. Defra is taking a significant lead internationally in identifying the potential impact that climate change is having on our planet, and the need to adopt appropriate mitigating measures. The high priority given to climate change by the UK Prime Minister in his leadership of the G8 (January to December, 2005) and the European Union (July to December 2005) has ensured that climate issues remain high on the

[33] Marine Protected Areas for Management of Temperate North Atlantic Fisheries. C Sweeting and N Polunin, University of Newcastle Upon Tyne
http://defraweb/fish/science/pdf/mpareport-northatlantic.pdf

political agenda and climate change is now firmly established as a political priority, both domestically and globally. The detailed impacts of climate change on marine ecosystems is not yet clear and this area of research is being given high priority by Defra.

The role of marine science in understanding and predicting climate change

32. As with all elements of Defra's policy, science provides the evidence on which to base future developments of climate change related policies. Many aspects of our interpretation of marine science will need to take into account the potential impact of this "environmental driver". Accurate up to date information needs to be available to decision makers, managers and stakeholders, as a fundamental basis for decision making.

33. To help provide the necessary focus Defra leads the Marine Climate Change Impacts Partnership (MCCIP). The aim of MCCIP is to provide a co-ordination framework for the UK. It will enable the transfer of high quality evidence on marine climate change impacts, and related advice, to policy advisors and decision-makers. MCCIP (see footnote 28) will act as a focal point for evidence and enable the UK to plan for the challenges and opportunities presented by the impacts of climate change in the marine environment. The first example of this is the Annual Report Card launched in November 2006. MCCIP must draw on the output from a vast array of R&D and modeling for its impact assessment and will act as a knowledge transfer mechanism.

34. One impact of increasing carbon dioxide concentrations in the atmosphere will be increasing acidification of the oceans. At the global level this needs to be modelled and predicted, and Defra is in close contact with the Plymouth Marine Laboratory (PML) who lead work in this area in the UK.

35. In order to predict future climate and reduce the uncertainties in projections, it is necessary to understand the role of the Earth's oceans in the global climate system. Defra funds an £11 million per annum research programme with the Hadley Centre. Ocean modeling is an important component of the state-of-the-art climate model which is being developed and run to inform policies to address climate change.

36. Ocean observations are important for the detection, monitoring and attribution of climate change and the validation and the validation and further development of models. Observations funded by Defra include instruments on the satellite ENVISAT[34] (for measuring sea surface temperatures with the accuracy necessary to detect climate change) and ARGO,[35] a global network of profiling floats funded by over 20 nations worldwide. The UK component of ARGO is provided by Defra and other UK partners.

CONCLUSIONS

37. This memorandum sets out Defra's considerable interest, investment and reliance on marine science. Key summary points made in this paper include:

- That we have many significant and wide-ranging international, European and national policy responsibilities within the marine area.
- Our policies are evidence-based and science plays a key part in providing that evidence.
- We are a major supporter of marine science spending approximately £26million annually. In addition we draw on the evidence emerging from programmes supported by other funders as a key part of our evidence.
- Our science programmes encompass both monitoring and applied and strategic research.
- There are many future challenges in the marine area and collaboration with other marine science funders is a priority.

We look forward to contributing further to the Science and Technology Committee's Inquiry as appropriate, and the Committee's Recommendations.

January 2007

Table 1

LIST OF MARINE POLICY INSTRUMENTS OF INTEREST TO DEFRA AND/OR OTHER GOVERNMENT DEPARTMENTS
(Refer to Appendix 1 for a list of acronyms)

International	*EU*	*National*
OSPAR	Shellfish Waters Directive	Conservation of Seals Act
IMO Ballast Waters	Shellfish Harvesting Directive	Consents Licensing

[34] http://www.esa.int/esaEO/SEMWYN2VQUD_index_0_M.html?sfgdata=4%20ENVISAT website
[35] http://www.argo.net/ ARGO website.

International	*EU*	*National*
IOC-GOOS	Bathing Waters Directive	Countryside and Rights of
UN Framework Convention on	Water Framework Directive	Way Act
Climate Change/Global Climate	European Marine Strategy and	Environment Act 1995
Observing System (UNFCCC/	proposed Directive	Control of Pollution Act
GCOS)	European Maritime Green Paper	Coast Protection Act
Safety Of Life at Sea (SOLAS)	and proposed Maritime Strategy	Wildlife and Countryside Act
WSSD	Birds Directive	Proposed Marine Bill
Bergen Declaration	Habitats Directive	
ASCOBANS	ICZM	
ACCOBMAS	EU-GMES	
Bonn Convention	SEA Directive	
CBD	INSPIRE	
Bern Convention	Nitrates Directive	
Ramsar Convention	Dangerous Substances Directive	
MARPOL	and Titanium Dioxide Directive	
UNCLOS	Urban Waste Water Treatment	
IWC	Directive	
NASCO	Common Fisheries Policy	
CITES		
The London Convention		

Table 2

DEFRA'S MARINE SCIENCE PROGRAMME

Programme Title	*Summary of programme scope*	*Indicative budget 2006–07*
Sustainable Marine Fisheries R&D	Impact of fishing on the marine ecosystem and appropriate mitigating measures. Environmental variability and climate change affects on fisheries productivity. Modelling tools to support strategic and tactical fisheries management decisions.	£3.0 million
Fish and Shellfish Stock Assessment, Monitoring and Management Advice	Monitoring programmes to assess the status of commercially important stocks for fisheries management. Joint research with the industry on commercial fish catch rates and developing more selective and environmentally friendly fishing methods.	£9.0 million
Sustainable Marine Environment R&D	Research potential impacts of human activities on the marine environment, provide understanding of ecosystem functioning and develop tools and techniques to achieve better marine and coastal management.	£4.8 million
Marine Monitoring and Management Advice	Provision of scientific evidence (monitoring, assessment) and advice relating to environmental protection, including meeting OSPAR and licensing requirements.	£5.6 million
Coastal Flood and Erosion Risk Management R&D	Studies of coastal sediment processes for morphological prediction, beach management and design of coastal management structures, including economic, social and environmental impacts (part of the ongoing Joint Defra and Environment Agency R&D programme on Flood and Coastal Erosion risk).	£0.4 million
Estuary Flood Risk Management R&D	Studies of estuary morphology, sediment movement, economic, social and environmental impacts (part of the ongoing Joint Defra and Environment Agency R&D programme on Flood and Coastal Erosion risk management).	£0.5 million
Wildlife and Countryside R&D	Research on marine biodiversity and habitats to underpin marine nature conservation policy development, including the Marine Bill, Special Areas of Conservation (SACs) and Special Protection Areas (SPAs).	£0.8 million

Programme Title	*Summary of programme scope*	*Indicative budget 2006–07*
Climate	Long-term measurements of sea surface temperature (SST) and salinity for climate models, including; Projections of sea-level rise, ocean heat uptake, thermohaline circulation and sea ice coverage; Producing a risk assessment of rapid thermohaline circulation change; Work on observations of sea surface temperature; Modelling ocean biogeochemistry and its impact on the global carbon cycle.	£2 million
Water Quality Research R&D	Developing operational models to forecast failures of faecal indicator organism limits in designated European Bathing Waters. Impacts of Intermittent discharges on microbial quality of shellfish flesh. Testing of Cost-effectiveness Methodology in Coastal and Transitional Waters.	£0.2 million

APPENDIX 1

List of Acronyms

ACCOBMAS
Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and contiguous Atlantic Area

ARGO
Array for Real-Time Geostrophic Observations

ASCOBANS
Conservation of Small Cetaceans of the Baltic and North Seas

CBD
Convention on Biological Diversity

CEFAS
Centre for Environment, Fisheries and Aquaculture Science

CFP
Common Fisheries Policy

CITES
Convention on International Trade in Endangered Species

DARD NI
Department of Agriculture and Rural Development of Northern Ireland

Defra
Department for Environment, Food and Rural Affairs

DTI
Department of Trade and Industry

EA
Environment Agency

ENVISAT
Earth Observation Spacecraft

ERA-NET
European Research Area Network

ESRC
Economic and Social Research Council

FMSCG
Fisheries and Marine Science Customer Group

GCOS
Global Climate Observing System

GMES
Global Monitoring for Environment and Security

IACMST
The Inter-Agency Committee on Marine Science and Technology

ICES
International Council for the Exploration of the Sea

ICZM
Integrated Coastal Zone Management

IMO Ballast Waters
International Maritime Organisation

INSPIRE
EU Directive on spatial information

IOC-GOOS
Intergovernmental Oceanographic Commission—Global Ocean Observing System

IWC
International Whaling Commission

JNCC
Joint Nature Conservation Committee

MAPC
Marine Assessment Policy Committee

MARPOL
International Convention for the Prevention of Pollution from Ships

MCA
Marine Coastguard Agency

MCCIP
UK Marine Climate Change Impacts Partnership

MDIP
Marine Data and Information Partnership

MNR
Marine Nature Reserves

MPA
Marine Protected Area

NASCO
North Atlantic Salmon Conservation Organisation

NE
Natural England

NERC
Natural Environment Research Council

OSPAR
The Oslo and Paris Convention for the Protection of Marine Environment of the North-East Atlantic

PML
Plymouth Marine Laboratory

SAC
Special Areas of Conservation

SEA Directive
Directive on the Assessment of Certain Plans and Programmes on the Environment

SEERAD
Scottish Executive Environment and Rural Affairs Department

SOLAS
Safety Of Life at Sea

SPA
Special Protection Area

SSSI
Sites of Special Scientific Interest

SST
Sea Surface Temperature

UKMMAS
UK Marine Monitoring and Assessment Strategy

UNCLOS
United Nations Convention on the Law of the Sea

UNFCCC
UN Framework Convention on Climate Change

WSSD
World Summit on Sustainable Development

Memorandum 21

Submission from the Wildlife and Countryside Link

Executive Summary

(i) Wildlife and Countryside Link is campaigning for comprehensive marine legislation, to provide better protection for marine wildlife and effective management of our seas. One of Link's key priorities for the forthcoming Marine Bill is that it should provide for the designation of a representative network of Nationally Important Marine Sites, including some that would be afforded the highest level of protection, for biodiversity conservation and recovery.

(ii) In submitting this brief response Link wishes to highlight that there is currently no adequate system in place for the designation of nationally important marine wildlife sites. Besides their primary purpose—biodiversity conservation and recovery—we believe such sites have an important role to play in improving our understanding of our marine environment. We also briefly outline the need for improved survey and data management to support the development of a protected area network.

Introduction

1. Wildlife and Countryside Link (Link) brings together the UK's leading voluntary organisations united by their common interest in the conservation and enjoyment of the natural and historic environment. This submission is supported by the following Link members: Marine Conservation Society, RSPB (Royal Society for the Protection of Birds), The Wildlife Trusts, WWF-UK, Whale and Dolphin Conservation Society, Buglife—the Invertebrate Conservation Trust, the Herpetological Conservation Trust, and Marine Connection.

2. Link has been campaigning for many years for comprehensive legislation to achieve better protection for marine wildlife and effective management of our seas. We were therefore delighted at the Government's commitment, in May 2004, to develop a draft Marine Bill. We have engaged closely with the development of the Bill so far, and await the Government's detailed proposals in the promised White Paper, due in March 2007. Link's key priority for the Bill is that it should provide new legislation for protection of marine wildlife, primarily through the designation of a representative network of Nationally Important Marine Sites (NIMS), including some that would be given the highest degree of protection, excluding all damaging human activities to ensure biodiversity conservation and recovery.

3. In submitting this brief response, we wish to address the final bullet point in the Committee's call for evidence, "use of marine sites of special scientific interest". In particular, we wish to highlight that Sites of Special Scientific Interest (SSSIs) are a terrestrially-based designation, generally extending to the limit of

local authority planning jurisdiction (which is usually Mean Low Water Mark), although a few existing sites extend beyond this limit. Adequate legislation to protect nationally important nature conservation areas (equivalent to SSSIs) at sea does not currently exist. We believe that NIMS and, in particular, highly protected sites, also have an important role beyond their primary purpose—that of biodiversity conservation and recovery—in enhancing our understanding of marine ecosystems and the pressures acting on them.

4. Link is calling for a comprehensive Marine Bill which provides a new framework for the sustainable management of human activities in the marine area in addition to specific provisions for nature conservation. We were pleased that Defra's consultation document on a Marine Bill (March-June 2006) touched upon all the key elements that Link has been campaigning for: managing marine fisheries, licensing marine activities, planning in the marine area, and improving marine nature conservation.

5. A number of terms (and associated acronyms) are used in this response, in reference to different categories of marine protected area. "Marine Protected Area" or "MPA" is used as a generic term.

Current Legislation and Commitments

6. In the UK there are currently two types of MPA designation: national Marine Nature Reserves (MNRs) under the Wildlife and Countryside Act (1981), and European Marine Sites (EMSs)—the latter covers marine Special Areas of Conservation (mSACs) and marine Special Protection Areas (mSPAs), designated under the EU Habitats and Birds Directives respectively. Unfortunately, experience has shown that these tools alone cannot ensure the conservation of biodiversity and sustainable management of our seas.

7. Only three MNRs have been designated throughout UK waters in the last 25 years, in large part due to shortcomings in the relevant legislation and associated guidance (Link Marine Bill Bulletin 9—Marine Nature Reserves: Lessons we must learn). The Government recognised that this approach has not been successful in a 1998 Consultation (*SSSI—Better Protection and Management*. A DETR consultation).

8. EMSs can be designated to protect specified marine nature conservation features of European importance, but do not cover the full range of important marine features found throughout the UK and European seas. Link also has concerns about the level of protection afforded to EMSs in practice. In addition, the designation of EMSs in UK waters has not yet been completed. At present there is limited funding for marine biological surveys to be undertaken to inform the designation process, and legislation is still not in place to provide for designation of EMSs beyond territorial waters (12 nautical miles), in spite of EU member states' commitment to complete the marine Natura 2000 network by 2008.

9. As a Contracting Party to the OSPAR Convention for the protection of the marine environment of the North East Atlantic, the UK has committed to designate an ecologically coherent network of well-managed MPAs by 2010. Representative examples of all the broad marine habitat types should be included, as well as areas with exceptional biodiversity, rare, threatened or declining species, and aggregations of mobile species, otherwise "important" species, areas of ecological significance, and particularly sensitive and/or natural areas. The Government has recognised that new legislation is needed to enable it to fulfil this commitment.

10. Work was undertaken through the Irish Sea Pilot study conducted as part of the Government's Review of Marine Nature Conservation, and is ongoing through OSPAR on how to design an "ecologically coherent network" of MPAs. Within such networks MPAs should be mutually supporting, ie populations of species in one area should be capable of supporting, and be supported by, populations in other areas, and all features should be represented at a number of sites. A particular challenge will be designing both individual MPAs and networks that can be responsive to the changes that are brought by climate change. This would mean, for example, protecting site features that move inshore or north as sea levels rise and temperatures increase.

The Marine Bill

11. Through the recent Consultation on a Marine Bill (March–June 2006) and subsequently, Defra has set out its commitment to developing legislation for a new system of MPAs to protect nationally important marine biodiversity and to allow the Government to meet its commitment under OSPAR. Link supported the list of functions of these MPAs set out in the Marine Bill Consultation (Defra 2006):

(a) protecting areas of threatened species and habitats to help ensure that biodiversity is not lost as a result of widespread damaging activities;

(b) protecting areas of representative species and habitats to help ensure that they do not become threatened as a result of human activities; and

(c) providing some relatively unaffected areas of high biodiversity value to support the structure and functioning of the wider marine ecosystem.

12. We are anxious that this new legislation should avoid shortcomings apparent in the protection of both MNRs and EMSs and will continue to engage with Defra as further detail of their proposals emerges through the proposed White Paper. In particular, we believe that the new MPA legislation must allow some sites to be designated as highly protected—that is, areas where all damaging activities are excluded.

13. These highly protected marine areas would essentially provide breathing space for marine habitats and wildlife to exist in conditions that are as near to the unexploited state as possible, helping to maintain biodiversity-rich areas, or allowing biodiversity to recover at previously impacted sites. Zones given this high degree of protection within NIMS, for example, could be an important tool in the achievement of conservation objectives. As part of a coherent network of MPAs, highly protected zones or sites will help to support the wider marine ecosystem, buffering or moderating the effects of human activities outside the network and increasing the resilience of marine ecosystems, for example in the face of climate change. They have been recommended as a means of underpinning conservation and protection of marine ecosystems, for example by the Royal Commission on Environmental Pollution.

14. Highly protected sites have been proven to aid recovery of threatened biodiversity and biomass in tropical and temperate marine habitats, and have also proved important as areas of scientific study (eg Scientific consensus statement on marine reserves and protected areas, *NCEAS,* 2001). The only currently highly protected area in English waters—the Lundy Island Fisheries No Take Zone—was set up in 2003. After only 18 months, three times more lobsters of landable size were found in the No Take Zone compared to fished areas. This difference was highly significant and was repeated the following year (http://www.english-nature.org.uk/news/story.asp?ID=745).

15. Monitoring and scientific study of marine protected areas, particularly highly protected areas, would enable us to improve our understanding of marine biodiversity and ecosystems. Further, these highly protected sites could be used as reference (or control) areas for study of how various pressures impact on marine biodiversity, and thus help to inform regulatory decisions in the longer term. They would also allow information to be gathered about environmental changes, such as those linked to climate change, identified by the UK administrations' Charting Progress report as one of the two greatest threats to the marine environment, the other being fisheries (Defra 2005). However, it would be important to ensure that any scientific research beyond monitoring of the status of an MPA was agreed as part of the MPA designation and management process, and did not impact negatively on the site.

Data Requirements

16. The UKSeaMap project (www.jncc.gov.uk) undertook broad scale habitat mapping for the whole of the UK marine area based on the concept of using seabed geology and sediment types to determine marine landscapes, and as such provides an important information source to help guide the identification of important seabed habitat types that may qualify as MPAs. However, precise knowledge of the distribution of marine habitats and species at the finer scale is much less comprehensive. In many cases, the provision of new or up to date scientific information has depended to a large extent on the data collection exercises undertaken for the Environmental Impact Assessments (EIAs) prepared on behalf of developers, or Strategic Environmental Assessments undertaken on behalf of government departments. For example, investigations linked to proposals for development of wind farms have discovered internationally important aggregations of seabirds, with significant implications for the licensing process. MPAs should provide the backbone of a marine spatial planning system, representing important information about the environment for marine industries targeting locations for development.

17. Resources are needed for a much more systematic survey approach, to build on the broad scale data already available, gathering the full range of necessary data and information about seabed habitats and associated species as well as aggregations of species such as fish and marine mammals and those species that depend on the sea for survival such as seabirds. The Marine Nature Conservation Review finished prematurely in 1998 and initiating new surveys to continue this work would enable gaps in marine wildlife data to be filled. We are pleased that government has committed to filling in marine biological data gaps in the establishment of the Data Archive for Seabed Species and Habitats (www.dassh.ac.uk). There is a need to ensure that all relevant scientific data is made available to support the development of MPA networks and Marine Spatial Plans, and regulatory decisions taken within the context of these plans. A new "Marine Management Organisation", expected to be introduced through the Marine Bill, could have a leading role in data collation and management, and advising on science requirements to underpin policy and management.

18. Link is happy to provide further information on any of the points highlighted above, and has a range of Marine Bill Bulletins that cover specific issues regarding our views on the need and benefits of site protection in the marine area.

January 2007

Memorandum 22

Submission from the British Antarctic Survey (BAS)

The Southern Ocean: The Vital Role of The British Antarctic Survey

Introduction

1. The Southern Ocean is of global importance. It regulates the temperature of all the world's oceans and contains unique marine living resources. To deliver UK-relevant science on these topics, the British Antarctic Survey cooperates with other national and international programmes to tackle pressing scientific problems related to global climate change and exploitation of biological resources. The Committee's attention is drawn to the world-class scientific contribution made by the UK, the mechanisms employed to deliver credible scientific advice to HMG for foreign and domestic policy, and the capacity and value for money provided by the British Antarctic Survey (BAS) in undertaking Southern Ocean research. This document describes why and how the UK should continue to develop Southern Ocean science into the future.

2. The importance and value of the Southern Ocean to the UK motivates the British Antarctic Survey's research on climate change and the Antarctic marine system. The increasing pace of environmental change means there is greater need than ever for investment in this research and for long-term monitoring of this marine system. For the UK to continue to project excellent science into the Southern Ocean, provide reliable scientific evidence for policy makers and lead scientific, commercial and political affairs in the region it must be recognised that:

- Southern Ocean research is interdisciplinary by nature and best undertaken by an organisation like BAS, where the essential disciplines in marine science are housed together;
- Continuity is vital. BAS has a strong and unique record of research and long-term monitoring in the Southern Ocean and this must continue for the UK to maintain its leading role in the region;
- Issues are moving rapidly in the Southern Ocean and the UK must be poised to exploit scientific opportunities. For example we are entering a new phase of exploitation of Antarctic krill (*Hansard* 15 January 2007: Column 508) which must be managed on the basis of sound scientific evidence that BAS will provide.

3. This paper should be read with those from the Natural Environment Research Council and the Foreign and Commonwealth Office since they are closely linked. This paper also contains evidence that is related to written evidence provided by the Foreign and Commonwealth Office to the House of Commons Environmental Audit Committee Inquiry on trade, development and environment.

Background

4. The Southern Ocean surrounding Antarctica seems remote but is highly relevant politically, socially and economically to the UK. It is a critical cooling element in the oceanic thermohaline circulation system, refrigerating 40% of the world's oceans and regulating regional and global climate. The Southern Ocean contains probably the largest unexploited marine protein resource. It also has fragile ecosystems and exceptional biological diversity that, because of its isolation, is unique on the planet. Yet, as the global climate changes, so does the Southern Ocean. It is the location of one of the world's fastest warming regions—the seas around the Antarctic Peninsula—and change here is attributable to the effects of human activity. It encircles Antarctica, the coldest continent and the largest reservoir of ice in the world, which, if it were all to melt, would raise sea level by up to 60 metres.

5. There has already been extensive environmental change in the Southern Ocean and more is expected:

- Surface water temperature in the vicinity of the Antarctic Peninsula has increased by more than 1°C over the last five decades and continues to rise.
- There have been profound impacts on the marine system including a probable 80% decrease in the amount of Antarctic krill in the last three decades—this is a critical food source for whales, seals, penguins and albatrosses as well as for some commercially exploited species of fish.
- There have been major changes in the balance of top predators over the last 200 years due to sealing, whaling and fishing.
- The Antarctic krill fishery targets resources with potential to provide high quality protein and high-value nutritional supplements for human consumption and feed for aquaculture. However, unless the krill fishery is managed on the basis of sound scientific advice there is potential for massive damage to the Southern Ocean ecosystem.
- Many Antarctic marine species, especially the "cold blooded" ectotherms, are physiologically and genetically unique. This makes them especially vulnerable to environmental change—it has been shown that many are unable to tolerate a temperature increase of only 2°C. Studying them is of wider relevance as species elsewhere also have to adapt to a warmer world.

International perspective

6. The Southern Ocean and Antarctica are too large and remote for any single nation to tackle all the scientific issues involved, so effort is coordinated through the international Scientific Committee for Antarctic Research (SCAR). Nations cooperate to carry out research on the effects of global climate change on the Southern Ocean, increasing our understanding of the consequences for the UK, Europe and the rest of the world. The size of the UK scientific operation in Antarctica is second only to the USA and through BAS the UK has national capability to provide international scientific leadership in the Southern Ocean. This is achieved by combining, in one institute, a critical mass of diverse scientists and by using assets to maximum effect over many years in a planned programme. Scientific expertise and leadership, as well as first class polar logistics capability, enables BAS to provide the national focus for polar science undertaken by the wider UK science community.

Fundamental science in the Southern Ocean

7. BAS provides the UK with fundamental science relevant to current pressing global concerns. It does this through a highly developed national capability, which includes advanced computer facilities for high resolution modelling of the interactions between the Southern Ocean, the atmosphere and the Antarctic ice system. BAS has an excellent record of delivering scientific advice to Whitehall and providing scientific evidence on which policy is based.

8. BAS's interdisciplinary science integrates physical and biological oceanography, including fisheries-related ecological research, with work on the atmosphere, climate, glaciology and geology. It includes research on Southern Ocean biodiversity, evolution and adaptation at all levels cells to ecosystems. It tackles problems concerned with the formation, circulation and mixing of water masses that regulate ocean temperature and maintain stability. UK research is exploring the likelihood of collapse of the ice shelves and the dynamics of the West Antarctic Ice Sheet. This is vital for understanding sea level rise and assessing the threat of flooding to low-lying land in the UK and elsewhere, including Britain's Overseas Territories.

9. BAS also provides the logistic capability to project into the Southern Ocean UK research on the natural oceanic plankton production processes that remove carbon dioxide from the atmosphere and the acidification of the oceans by excess carbon dioxide. This has particular relevance to the Southern Ocean because of its ecological sensitivity and productivity. Where BAS does not possess specific scientific skills it collaborates to ensure strategic direction and leadership are maintained in the UK research community.

British Antarctic Survey capability in the Southern Ocean

10. BAS provides the UK's logistic capability in the Southern Ocean including two ice-strengthened research vessels and four shore-based research stations. It provides the intellectual leadership to tackle interdisciplinary research problems and holds unique long-term data sets, in some cases spanning decades, recording environmental change in the Southern Ocean. It carries out year-round, shore-based marine science, including biological and oceanographic monitoring. The data provide a unique resource for understanding long-term variability and change. BAS has the capacity to integrate remotely sensed oceanographic data from satellites with data collected at sea. It links together new marine science technologies for large-scale data collection and possesses a world-class ability to integrate information from different sources. It houses state of the art computing facilities for data processing and modelling.

11. A new era of ocean science is dawning in which use of research vessels for data collection in the oceans is being enhanced by new in situ technologies including remote unmanned systems such as moorings, drifters and gliders. These provide synoptic data at relatively low cost and are currently being introduced into Southern Ocean research by BAS scientists. These will link with similar systems deployed by other national programmes. More of this will be needed in the future, as environmental change gathers speed.

12. BAS provides training for the next generation of British marine scientists, equipping them with specific skills for Southern Ocean research.

Science into policy

13. The British Antarctic Survey has a strong record of delivering scientific inputs to HMG policy. These include:

- Antarctic Treaty (including a recent initiative to develop Marine Protected Areas in the Southern Ocean).
- Commission for the Conservation for Antarctic Marine Living Resources (CCAMLR)—the first international organisation to adopt an ecosystem framework for fisheries management providing a model for fisheries management elsewhere, including European waters.
- Management of the fisheries in waters surrounding the South Atlantic Overseas Territories (South Georgia and the South Sandwich Islands).

— Agreement on Conservation of Albatrosses and Petrels (ACAP)—part of the Convention on Migratory Species (CMS).

— Wider policy areas such as the Intergovernmental Panel on Climate Change and ozone.

14. A recent major issue has been the catastrophic decline of albatrosses in the Southern Ocean. BAS research data has provided scientific evidence to develop policy leading to substantial reduction of mortality in Antarctic waters. This has attracted much attention from the scientific and conservation communities including the Royal Society for the Protection of Birds.

Conclusion: the Future of Marine Science in the Southern Ocean

15. BAS science in the Southern Ocean is linked to the new Oceans 2025 programme of UK based, marine science funded by the Natural Environment Research Council. Through BAS, the UK will lead Southern Ocean science through the International Polar Year (2007–08). It will also lead beyond this milestone through international programmes including European initiatives.

16. The environmental issues identified here are of rapidly increasing importance to the UK and other nations, as the Stern Review has highlighted. We can already observe the impact of global climate change on world food security, global biodiversity, ocean circulation and sea-level rise. This will be one of the fastest growth areas for scientific research over the next decade and beyond. BAS research in the Southern Ocean provides a critical element of the Natural Environment Research Council's spending review programme "Living with Environmental Change".

17. The UK must maintain strong scientific leadership in Southern Ocean science where it has unique assets and extensive experience. BAS needs the investment of resources to enhance its capability to provide the best scientific advice to inform UK policy. It requires a critical mass of intellectual leadership, to ensure the nation's capacity to meet the challenges ahead and the ability to capitalise on future opportunities provided by new initiatives and new technology.

18. BAS is crucial to maintaining the UK's position in the science and governance in the Southern Ocean and to capitalising on the scientific, commercial and political opportunities in the region.

19. BAS will be happy to provide further evidence, or to amplify any of the points in this paper.

January 2007

Memorandum 23

Submission from the Marine Biological Association of the United Kingdom

Executive Summary

The Marine Biological Association of the UK is concerned about insufficient and fragmented funding and organisation of marine science in the UK, which may erode the leading role of Britain in Europe and worldwide. Welcome steps have been taken to reverse fragmentation (eg the Oceans 2025 programme of the Natural Environment Research Council [NERC] laboratories). While UK marine science benefits from the diversity of organisations carrying out marine research, each with particular and unique attributes, it is important to foster and maintain their coordinated activities through well-organised, consistent funding mechanisms. This is particularly the case for sustained observations essential to manage marine resources in a rapidly changing world and to contribute towards models of global environmental change enabling forecast of future states.

Background and Sources of Information

1. The Marine Biological Association (MBA) is a Learned Society established in 1884 with over 1,000 members. It has run a Laboratory in Plymouth since 1888 where 60 staff now work. MBA staff have been at the forefront of investigations into the biology and oceanography of our seas since establishment. The results of the recent (2004–05) Science and Management Audit (SMA) undertaken by NERC concluded that MBA science was mainly outstanding with some excellent. The account of the SMA (http://www.mba.ac.uk/PDF/SMAbackground.pdf) gives more information about the MBA, (see also the rest of the MBA website for general information www.mba.ac.uk).

2. The MBA welcomes the opportunity to contribute to the Select Committee inquiry. In the following submission, we draw especial attention to the importance of whole organism science in an ecosystem context including support of environmental protection and management, and the importance of long-term studies. The need to maintain a spread of expertise across a range of institutes and to knowledge transfer is emphasised.

3. The MBA draws the Committee's attention to NERC's recent Marine Review conducted in 2005 following the Science and Management Audits of all the NERC Marine Centres. CEFAS science has also been recently reviewed. This evidence may be of value although it is not fully available in the public domain.

4. The MBA has contributed to the development of Oceans 2025 which we believe is a sound and well-considered approach to NERC-funded UK marine science for the next five years involving all the NERC funded marine research institutes (see separate collective response by the Oceans 2025 Directors).

Organisation and Funding of Marine Science

5. The MBA comments refer only to British and non-polar European waters. Marine science is organised under different sectoral and funding umbrellas: statutory-driven science and monitoring delivered by government departments and their agencies (eg FRS Aberdeen, CEFAS, EA, SEPA), strategic science largely funded by NERC via institutes and collaborative centres, and the university sector which derives funding from a variety of sources, particularly for blue skies responsive mode funding from the Research Councils. Thus there is considerable overlap on this spectrum from pure to very applied science and knowledge transfer. Whilst there has been progress towards a more coordinated approach to marine science (eg Oceans 2025 by the NERC laboratories) more integration across the sector as a whole would benefit scientists and funders by reducing unnecessary competition and duplication of effort. A more coherent approach would enable major issues to be addressed in the most cost-effective way. Government departments commissioning research, rather than letting competitive tenders, may be more appropriate in some areas, such as long-term sustained observations, pollution studies and fisheries management.

Role of the UK Internationally

6. The UK is widely acknowledged as being second only to the United States in marine sciences. However, a more coherent approach to funding has led to countries such as Germany, France and the Netherlands challenging the UK's lead role in Europe in certain sectors.

7. The competitive nature of British science does mean that UK scientists do well when bidding for European Framework funding because of extensive experience in grant writing and tendering. There is a risk that marine scientists in the UK spend too much time competing for funding rather than writing leading edge papers.

Support for Marine Science and Technology

8. There is some fragmentation of coverage in support of research in marine science and technology. Although the NERC supports most responsive mode (blue skies) and strategic research (eg the Oceans 2025 programme), there are also other funders. The Engineering and Physical Sciences Research Council (EPSRC) funds important areas such as coastal engineering and basic research relevant to marine science and technology. The Biotechnology and Biological Sciences Research Council (BBSRC) is responsible for biotechnological research and there is a risk that important developments in the use of products and genes from the great diversity of marine organisms is being neglected as it is in an interface area between NERC and BBSRC. Aquaculture research and development has suffered similarly. Research on the evolutionary and basic biology of marine organisms (eg genetics, development, behaviour) is also compromised by BBSRC's focus on model organisms (ie fly, worm, yeast, Arabidopsis) eschewing the comparative approach. Recent changes in eligibility of different organisations for responsive mode funding may further lead to missed opportunities as a result of instructions to Research Councils by the Office of Science & Innovation. NERC have been very catholic and inclusive in their interpretation of these instructions in contrast to BBSRC who have excluded some leading organisations from direct responsive mode funding, although this is under discussion at present.

9. Considerable funding is also available from Government departments and agencies for policy-driven science. This diversity of funding sources enables much applied research and knowledge transfer.

The State of UK Research and Skills Base

10. We are concerned that whole organism science and especially the science needed to support marine environmental protection and management is in decline and that the retention of both taxonomic (including alpha taxonomy and identification) and survey skills needs to be addressed.

11. Much of the concern about human impacts on our seas relates to inshore areas and undertaking surveys and maintaining monitoring programmes must rely on teams of experienced ecologists working on the shore and from small vessels. We see a reluctance to undertake whole organism ecological surveys such as the Marine Nature Conservation Review of Great Britain which was finished prematurely in 1998. Broad scale mapping projects are important but conservation action requires information on the species and habitats (as biotopes) present in the seas around Britain. Gaps in knowledge need to be filled.

12. There is also expertise in many small coastal laboratories or university departments with strong marine biological expertise. We are concerned that Defra seems over-reliant on the ex-fisheries laboratories as their "traditional" source of information from whom to commission survey work.

13. There is a shortage of oceanographic and ecological modellers in the UK. There are also difficulties in recruiting scientists with particular skills such as molecular biology, and environmental geophysical sciences. As a consequence many research laboratories have a high proportion of non-UK scientists, although this reflects the open door policy of the UK scientific community to European and international scientific integration.

Use of Marine Sites of Special Scientific Interest

14. We find the reference to "marine sites of special scientific interest" confusing as SSSI is a statutory designation that is rarely used for and is not designed to protect marine features. However, we do feel that marine protected areas (mpa's) could provide scientists with the opportunity to study marine ecosystems that are as close as possible to natural conditions (reference or control sites) as well as protecting threatened and important features. With the prospects of a Marine Bill with spatial planning at its core, provisions for mpa's should be made. Identifying those mpa's should use criteria developed by the recent Review of Marine Nature Conservation (RMNC) and not rely on provisions for the Habitats Directive which is poorly developed for marine habitats and species.

15. Research that will help to manage and protect important features for marine natural heritage is often indicated in Biodiversity Action Plans, although many "worthy" species do not qualify because of "insufficient information" predominating in the selection procedure. A new tranche of Biodiversity Action Plans is in preparation at the moment, supported by the RMNC "Nationally Important Marine Features" list. This time around, we need any commitments made by research councils to undertake research to be fulfilled as they were not in the last tranche.

Climate Change on the Oceans

16. Concerns about climate change impacts have "re-vitalized" interest in long-term biological and oceanographic data sets—many of which were closed-down in the mid 1980s to make way for marine science that was more fashionable at the time. There is a strong case to ensure both the maintenance of existing schemes and the establishment of new schemes that will help us to understand the rate at which our seas are changing and to what extent those changes are the result of human activities. There is particular need to separate broad scale low-amplitude global change from regional and local impacts. The work being undertaken needs to be shared and complementarity is important—networking and agreeing to collaborative projects through groups such as the Defra Marine Environmental Change Network are essential. Sustained observation is at the core of the Oceans 2025.

17. Monitoring is not sufficient in itself. Process-based studies integrating molecular and cellular mechanisms through to whole ecosystems are required in order to forecast future environmental states and enable adaptional approaches to dealing with climate change.

Knowledge Transfer

18. We feel that knowledge transfer from the science community to policy advisors and to industry is not as strong and well-structured as it could be. Obviously, there is skill needed in getting complex concepts across to non-scientists but that needs to be done; not least because there is a danger of duplication and therefore unnecessary expense. The Marine Climate Change Impacts Partnership is an example of good practice. The UK, however, does far better than its European neighbours in transferring information from academic and government scientists to policy makers.

19. We draw the attention of the Committee to the leading work that has been undertaken in the UK to provide the structures and criteria that are essential in cataloguing our very varied seabed environment and establishing criteria to identify protective measures. That work has been undertaken especially under the auspices of the Joint Nature Conservation Committee and has been highly influential in establishing common classifications and approaches to protection in Europe and the north Atlantic. The UK should continue to lead within Europe on knowledge transfer related to marine environmental protection and management.

January 2007

Memorandum 24

Submission from Professor Gideon Henderson, University of Oxford

A CALL FOR INCREASED INVOLVEMENT OF THE UNIVERSITY SECTOR IN UK MARINE RESEARCH

Executive Summary

This paper expresses concern that both agenda-setting and funding of UK Marine Research is overly focused on the NERC research centres and does not sufficiently involve the university sector. This focus is explicit in NERC marine sciences policy, but does not allow NERC to best meet its overall strategic goals. This focus impairs the ability of the UK to recognize strategically important research, and to conduct this research. It weakens the UK's international standing as a country involved in marine research. And it limits the training of the next generation of marine scientists, hindering future prospects of UK excellence in marine science.

Main Text

(i) UK Marine Reseach funding is largely administered by the Natural Environment Research Council (NERC). A large portion of this funding is spent in seven UK marine research centres. These centres bid directly to NERC for their funding in a system from which the university sector is excluded. The most recent bid has resulted in the £120 million Oceans-2025 initiative which outlines strategic marine research for the UK over the next five years.

(ii) Point 1 of the executive summary of the Oceans-2025 document states: "NERC has national responsibility for supporting science concerning the Earth system. To fulfil this remit, NERC funds issue led strategic research in its Centres and associated bodies, and curiosity-driven 'blue-skies' research, mostly in universities but also in its own organizations". This statement explicitly excludes UK universities from involvement in issue-led strategic marine research. If pursued effectively, this policy would prevent any NERC funding for strategic research from going to the university sector.

(iii) In truth, research into strategically important areas such as climate change and sustainability does occur in the university sector, but must be funded from limited "blue-skies" funding (which is intended for less strategic issues), or from a small number of focused NERC Thematic Programmes which cover only some of the strategically important areas. In the future, a small portion of strategic funding (7.5% of funding in seven of 10 themes) will also be available to the universities through Oceans-2025. While this is a step in the right direction, it represents a small fraction of UK marine funding, and is explicitly for collaboration with the centres, leaving them in control of the direction and realization of the research.

(iv) The university sector is excluded not only from strategic funding, but also from setting of strategic goals. The Ocean-2025 document was prepared in secrecy without public consultation nor the open-involvement of marine researchers from the university sector. Requests for draft copies of the Oceans-2025 document were turned down during the writing of this important strategic document. The resulting document has therefore not had direct input from those with marine expertise in the university sector. In addition, university scientists planning other marine research (for instance within the NERC thematic programmes) were unable to ensure that this research was complementary to that contained in Oceans-2025. This lack of involvement of university researchers limits the scope and quality of NERCs strategic marine research spending.

(v) Exclusion of the university sector from significant portions of UK marine research also has a major impact on the training of future marine scientists. Lack of funding to the university sector inevitably leads to a smaller number of active university researchers. Although most of the NERC marine centres have connections to a university and are therefore able to offer training and education, none of these universities is amongst the internationally high-ranked UK research universities. Many of the most intellectually gifted students are attracted to these high-ranked UK universities so, as marine research has decreased at these universities, so has the quality of newly trained marine scientists in the UK.

(vi) Lack of competition for strategic research funding harms the overall quality of marine research in the UK. The major research centre—The National Oceanography Centre, Southampton—has a reputation a long-way behind that of its US equivalent—the Woods Hole Oceanographic Institute (WHOI). Researchers at WHOI continually have to prove the high quality of their work by competing with researchers from other sectors for funding. Lack of such competition in the UK means that NOCS has no such competitive edge.

(vii) In summary, I argue for a revision to NERC policy. Scientists at UK universities should be more actively involved in setting marine science strategy in the future, and should be able to bid on an equal footing to researchers at the NERC centres for funding to pursue this strategic research. In a small number of areas the centres are the natural home of marine work (eg long-term monitoring, maintenance of large ships and similar infrastructure). In most research areas, however, the universities have complementary

expertise. Allowing them to compete for UK marine research funding to a much greater degree would improve the overall quality of UK marine research, and enhance the education and training of the next generation of UK marine scientists.

(viii) These are my personal views, but I believe they are shared by other marine scientists in the university sector. The activities of the Select Committee inquiry have not been widely advertised in the community and I have only very recently learned of today's deadline. As a consequence I have not had time to seek formal endorsement for these views from scientists at other universities. From past discussions, however, I expect that marine researchers in other leading UK research establishments would share many of the opinions expressed in this document.

January 2007

Memorandum 25

Submission from the Scottish Association for Marine Science (SAMS)

1. The Scottish Association for Marine Science (SAMS) welcomes the opportunity to comment.

2. SAMS is a learned society, a Collaborative Centre of the Natural Environment Research Council, an Academic Partner of the UHI Millennium Institute and a charitable company limited by guarantee, with its registered office is at the Dunstaffnage Marine Laboratory. The mission of SAMS is to improve understanding and stewardship of the marine environment, through research, education, maintenance of facilities and technology transfer. It is governed by an elected Council (the members of which act as Directors) according to its Memorandum and Articles of Association. Council delegates many of its duties to the Director of SAMS, who runs the organisation with the aid of the Executive Group, which includes the Deputy Director, SAMS' Company Secretary and the SAMSgroup Financial Controller.

3. The SAMSgroup is the structural framework in which the Council of SAMS coordinates the activities of SAMS, as a charitable research and educational organisation, with those of its wholly-owned subsidiaries; and pursues their common interests and objectives. These subsidiaries are SAMS Research Services Ltd (SRSL) and the European Centre for Marine Biotechnology Ltd (ECMB) each of which has a special niche in the strategy which focuses on the marine environment. All of these activities, however, are complimentary to the objectives of SAMS. SAMS manages over 120 staff, representing a growth of over 100% from 1996. Current growth rate is approximately 10% compound per annum. In 2006, the annual turnover of the SAMSgroup was nearly £8 million.

4. This submission is prepared by the SAMS Director: Professor Graham Shimmield FIBiol FRSE, Scottish Association for Marine Science.

General Comments

5. SAMS operates as an independent research and education institution supported by several key stakeholders—NERC, the Scottish Funding Council (SFC), and the Scottish Executive (through the Enterprise network). As such it has to be flexible and adaptive to rapid changes in policy and funding from these organisations. However, its governance (Board of Trustees) and membership guarantee total independence and impartiality of evidence on marine affairs, and a scientific remit that is global in nature (SAMS has and is working in every major ocean basin of the world). As such, its academic credibility and reputation is of international significance and is the envy of many smaller countries.

6. With the increased responsibility of environmental affairs under devolution, the role of SAMS in Scottish marine strategy is increasingly important. It is our opinion that there is increasing pressure to ensure that the reserved role of the Research Councils is satisfactorily discharged under the devolved environmental agenda of the UK. SAMS' core strategic funding from NERC has decreased in real terms year on year for the past 10 years, whilst its involvement with the regional development agenda (and especially Highlands and Islands Enterprise) has increased.

7. This submission should be read in conjunction with the "Oceans 2025" submission from the joint marine directors which gives more of the history of the NERC funding and strategy for SAMS.

The Organisation and Funding of UK Marine Science in the Polar and Non-polar Regions

NERC core strategic research organization and funding

8. NERC funding through the core strategic mode has been vital for the long term programme of SAMS research despite the regular changes in delivery mode. Since 2001, SAMS has operated as a single management operation with both NERC and SAMS employees. Oceans 2025 represents increasing collaboration with our sister laboratories. The core programme will now represent about 28% of the total scientific activity of the Association, with the remainder funded through NERC responsive mode, Europe, the SFC (QR mode), government agencies and departments and commercial contracts to SRSL.

9. On 10 January 2007, NERC announced that, to deliver key strategic scientific goals, it will fund a new "Oceans 2025" research programme. This programme is designed by and will be implemented through NOCS, PML, SAMS, SMRU, POL, the MBA and SAHFOS, and will address, at a national scale, the challenges of a changing marine environment. Oceans 2025 will receive approximately £120 million from NERC over five years. Under this new programme SAMS will receive about 25% less funding than for the previous six years of strategic funding as a combination of peer review, and application of Full Economic Costing. Significantly, all work on environmental impacts of aquaculture and algal bloom dynamics will not be funded via this route.

10. NERC funding also contributes to the UK Culture Collection for Algae and Protozoa, and the NERC Facility for Scientific Diving, both hosted at SAMS. Both national facilities are unique, providing good examples of how combining resources (the Freshwater Collection was moved from Windermere to Oban) can provide a better facility. The CCAP is the second largest collection and biodiversity repository of its kind in the world.

Other Partnerships

11. Initiatives such as "pooling" amongst Scottish HEIs will allow strategic science objectives to be addressed. SAMS is playing a key role in "Marine Science Scotland" allowing a more coordinated approach to be carried out using the skills of research institutes, HEIs and the government agency (FRS, Aberdeen). The Director of SAMS is an independent member of IACMST and the Association recognises the benefit of linking government departments and agencies with the marine science providers. In Scotland, an advisory group, AGMACS (Advisory Group on Marine and Coastal Strategy) has been created to help communication on national policy.

Arctic marine research

12. SAMS has had Arctic polar interest right back to its founding days when William Speirs Bruce was conducting hydrographic surveys around Svalbard at the turn of the 20th century. Bruce was a founder of the Scottish Oceanographic Laboratory, which later merged with the Scottish Marine Biological Laboratory under Sir John Murray. For the past six years, NERC strategic funding has supported a range of polar studies in the European Arctic. To this, SAMS has added its role in many major EU programmes which it has coordinated (GREENICE, SITHOS), and is part of the new Integrated Project, DAMOCLES. SAMS is the only UK partner in the Marine Laboratory at Ny Alesund, Svalbard, and has dedicated funding for a 10-year contributions to this facility.

13. With International Polar Year, and an increasing awareness of Arctic issues, we believe that the coordination provided by NERC (through Dr Tracey Henshaw) could be augmented by a physical coordination and logistics centre, akin to the support provided by BAS for their own and HEI operations in the Antarctic. SAMS experience in Arctic polar oceanography, and its close links with all the European Arctic marine science organisations (eg the Norwegian Polar Institute), make the option of considering SAMS in this role a viable possibility.

THE ROLE OF THE UK INTERNATIONALLY, AND INTERNATIONAL COLLABORATION IN MARINE SCIENCE

14. The USA is the dominant world leader in marine science and oceanography, with a strong tradition in military support (Office of Naval Research) for the science. In Europe, organization of marine science among the three FP6 Networks of Excellence is bedevilled with a high administration overhead. Nevertheless, UK marine scientists are sought after as international partners, and all the marine institutes host major programmes and Project Offices. SAMS supports the European Census of Marine Life PO, and hosts the IP on an Ecosystem Approach to Sustainable Aquaculture (ECASA).

15. Over the past few years Arctic marine science coordination is improving. SAMS was a founder member of the EU Integrated Infrastructure Programme—ENVINET working in the European high Arctic. From this network has spawned our co-coordination with Norway and Canada on the IPY cluster examining Arctic marine ecosystems (PAN-AME). Regular student exchanges and sabbaticals are organised with our Norwegian colleagues in Tromso and Svalbard (UNIS—the University of Svalbard).

16. The UK needs to continue its role in major international programmes, currently RAPID and SOLAS are examples, but also regain the initiative to lead such programmes as happened during the Joint Global Ocean Flux Study (JGOFS). We believe that more investment in our scientific leaders and directors, rather than at the funding agency level is required. An example where the NERC-based decision ran counter to both international and national expectation was in the EUROCORES (ESF) programme on the deep ocean (EURODEEP). The UK is not a participant, whereas all the other major European countries have signed up. Issues over the use of national facilities (vessels and ROVs) should have been sorted out with the scientific community.

SUPPORT FOR MARINE SCIENCE, INCLUDING PROVISION AND DEVELOPMENT OF TECHNOLOGY AND ENGINEERING

17. NERC requires a new ship to replace the RRS Discovery, which at the time of this submission, is unserviceable (again). The RRS James Cook is a very welcome replacement to the Charles Darwin, but the UK research fleet has reduced in size. More use of smaller capable vessels for shelf seas work, and investment in autonomous instrumentation and remote observation is one way to maintain our field capability.

18. Marine technology is priority strategy at SAMS and one that links directly to the Knowledge Economy strategy in Scotland, receiving support from the Enterprise network. To the traditional engineering skills (we have international expertise in satellite communications technology, sea ice drifters and underwater profilers), we can now add marine biotechnology and a growing business cluster exploring for novel compounds in marine organisms (The European Centre for Marine Biotechnology business incubator concept). Molecular biology and genetics of marine organisms requires expensive and major investment in analytical facilities. Cross-collaboration across Europe (eg Marine Genomics programme) is one way to address the low level of investment in this growing field in the UK. Laboratories like PML and SAMS offer the intellectual capability but lack the major funding investment in the new sequencing techniques.

19. Recruitment and retention of engineers and biotechnologists in these fields in problematic on standard university pay scales. As metrics advance to discriminate high quality innovation and application in these fields, then the funding flow should enable appropriate salary rewards to be made. In a recent recruitment round at SAMS we found that a geochemical technician at the Woods Hole Oceanographic Institute is paid the same as a junior Professorial chair in a UK university!

THE STATE OF THE UK RESEARCH AND SKILLS BASE UNDERPINNING MARINE SCIENCE AND PROVISION AND SKILLS TO MAINTAIN AND IMPROVE THE UK'S POSITION IN MARINE SCIENCE

20. In common with other science subjects we are experiencing the problems of a lack numerate skills in recruitment of PhD students and post-docs. We also recognize the need to maintain expertise in marine taxonomy, but find that obtaining the research funding to sustain this skill is very hard indeed. In the past two years, we have lost substantial knowledge in deep sea biology and taxonomy, and despite an international search, have found it hard to recruit even at professorial level.

21. As mentioned above, technologists and engineers need to be provided with rewards and promotions commensurate with their professional qualifications, which can be difficult in an academic career structure.

22. SAMS is providing the only BSc Honours degree in Marine Science in Scotland. Nevertheless recruitment is quite difficult, in part due to the delayed award of university title to the UHI Millennium Institute.

THE USE OF MARINE SITES OF SPECIAL SCIENTIFIC INTEREST (SSSIS)

23. The marine context is probably the EU designated Special Areas of Conservation (SACs). Such sites provide an opportunity to understand whether our understanding of ecosystem response to man's influence is correct. Designated species and habitats allow the testing of management plans and engage key stakeholders and the public. Areas closed to fishing allow research into impacts and recovery times for the marine environment. Some areas (eg military ranges) have been closed for decades (an example is the Raasay underwater range in the Minch) and now provides unique example of the underwater habitat undisturbed by bottom trawling.

January 2007

Memorandum 26

Submission from the Biotechnology and Biological Sciences Research Council (BBSRC)

1. BBSRC welcomes the opportunity to respond to the Science and Technology Committee's inquiry "Investigating the Oceans". BBSRC is the principal UK funder of basic and strategic research and research training in the non-clinical life sciences at universities and research centres throughout the UK, including the BBSRC -sponsored institutes (see http://www.bbsrc.ac.uk/about/pub/policy/institutes.html for details). The Council also promotes knowledge transfer from research to applications in business, industry and policy, and public engagement in the biosciences. (See http://www.bbsrc.ac.uk/about/pub/policy/strategic.html for BBSRC's Strategic Plan, which outlines the Council's key objectives in fulfilling these aims).

2. Although marine biology is at the periphery of BBSRC's interests, the Council does have some interest in supporting research into marine organisms where this will allow study of interesting biological processes. Study of the marine environment does not fall within BBSRC's remit, except in studying the interactions between the marine environment and marine organisms. Three areas in which BBSRC has some interest in marine biology are:

— There is potential for biotechnological exploitation of novel processes in the marine environment (eg novel chemistries for bioprocessing; novel enzymes from hyperthermophiles and hyperbarophiles from deep-sea vents). Access to marine organisms and the necessary equipment for their subsequent exploitation is desirable and the UK has some activity in this area.

— There are increasing problems of maintaining the health of farmed fish against bacterial, viral and parasitic infections. Given the economic benefit of fish farming in some regions, we anticipate increased BBSRC-supported work on fish health in veterinary schools and the Roslin Institute.

— There is interest in understanding the effects and the mechanisms of control of agricultural run-off into catchments and subsequently to the marine environment. This is being studied through inter-institutional collaborations with BBSRC-sponsored institutes (eg the Institute of Grassland and Environmental Research (IGER) and the University of Wales Aberystwyth, UWBangor and CEH Bangor).

January 2007

Memorandum 27

Submission from the National Oceanography Centre, Southampton

1. The National Oceanography Centre, Southampton (NOCS) welcomes the opportunity to provide evidence to this inquiry. NOCS has also contributed to the responses provided by the Natural Environment Research Council (NERC) and to the joint response from the Directors of UK Marine funded laboratories collaborating in the new Oceans2025 strategic research programme.

2. The National Oceanography Centre, Southampton (formerly Southampton Oceanography Centre), is a collaborative Centre owned by the Natural Environment Research Council (NERC) and the University of Southampton. NOCS is based at a purpose-built waterside campus in Southampton, and is home to some 520 research scientists, lecturing support and seagoing staff as well over 700 undergraduate and postgraduate students. A statement of the NOCS mission is provided in Annex 1.

Executive Summary

3. The key points that we draw to the attention of the Committee in this submission are:

— The growing awareness of the key role of the oceans in the climate system and in relation to natural resources.

— The need for greater capacity (ships) to sustain UK sea-going marine science.

— The strong participation of the UK in international marine science.

— The challenge we face in terms of recruiting and retaining key staff from overseas competition (particularly Germany).

— The tendency for progressive "self organisation" of marine science (nationally, within Europe and globally) around the key focus of developing sustained ocean observing systems.

— The major opportunity to engage science and wider society through the medium of the oceans.

Background

4. The marine environment is fundamental to earth system processes and to developing solutions to pressing societal needs. The oceans cover 70% of the earth's surface and 97% by volume of its biosphere. The upper 10 m of the oceans have as much mass per unit area as the whole of the atmosphere and the upper few hundred meters of the ocean contain as much heat. Because the oceans are the cradle of life on earth, biodiversity is greatest there (the only environment on earth in which all phyla are present). Ocean sediments are the library of past changes on earth, and so hold vital clues to the future. The ocean is the largest reservoir on earth of mobile carbon and is the earth's principal solar heat store, regulating both day-to-day weather and climate. The human population is growing fastest in coastal regions and sea level rise poses the single greatest threat resulting from global climate change in the 21st century.

5. The oceans are fascinating and inspiring with insatiable public appetite and interest in the sea. The oceans thus provide a natural common medium for the engagement of wider society with science.

6. Fundamentally, Marine Science is

- interdisciplinary in nature but critically dependent on key skills from core science disciplines (mathematics, physics, chemistry, biology and engineering);
- concerned with processes operating over a vast range of space- and time-scales (local to global; milliseconds to millennia);
- heavily reliant on national and international collaborations;
- critically dependent on major infrastructure and logistics support (eg ships, satellites) required to operate in the oceans;
- technology dependent (most major advances in marine science have stemmed from new technologies enabling new measurements to be made);
- has a strong imperative (particularly in relation to climate change) to undertake sustained (decadal timescale) observations over ocean-basin and global scales; and
- increasingly viewed within a wider Earth System context (consisting of ocean, atmosphere, cryosphere, land surface, deep earth interior), with growing interest in the couplings between the ocean system and other earth system components.

1. *How marine science is being used to advance knowledge of the impact of climate change on the oceans*

7. Given that the issue above is of particular interest to the Committee, we have set out in Appendix 2 a series of key research challenges that form part of the developing NOCS science strategy that we expect to publish in autumn 2007. Our strategy will address the key science challenges of strategic importance to the UK, European and global communities over the next 20 years. This encompasses the broad canvas of ocean and earth science.

8. We concentrate in Appendix 2 on the challenges most directly related to the marine science remit of this inquiry. In particular it is noted that the Oceans are not merely impacted upon by climate change but in many respects the oceans regulate or control key processes involved in climate change. This is because the oceans are both a major store of heat and carbon and also play a key role in transporting these around the planet.

2. *Organisation and funding of UK marine science in the polar and non-polar regions*

Organisation

9. The organisation of marine science in the UK has been described in the collective response of the Directors of the NERC funded marine Centres and in the submission by NERC.

10. A diverse set of ownership and governance arrangements exist within the Marine Research Centres. Nevertheless, there is strength in this diversity and the Centres work together cooperatively and in a coordinated way at the strategic level (eg development of the Oceans 2025 Programme www.oceans2025.org)

11. The National Oceanography Centre, Southampton, as part of its refocused mission, has been given an explicit remit by NERC to act to facilitate coordination of marine science in an impartial and inclusive manner.

Funding (NERC)

12. The major funder of marine science in the UK is the Natural Environment Research Council (NERC) which supports marine science through a variety of funding mechanisms ranging from studentships to responsive mode standard grants, consortium grants and strategic research programmes. NERC also supports major science infrastructure and facilities (eg ships, the national marine equipment pool, High Performance Computing) in support of the whole science community.

13. Within the context of paragraph 5 above, the ability of the UK to remain at the leading edge of marine science is crucially dependent on NERC's ability to be able to:

- continue its funding for innovative, curiosity driven "blue-skies" research by individuals and small teams through standard research grants—but crucially also to continue to complement this by long-term, big-team approaches to funding science (through strategic programmes, directed programmes and consortium grants). These complementary approaches are particularly important for Marine Science where wider critical mass and support through major infrastructure is key;

— support continued development of critical mass and facilities in the spread of key marine science disciplines within the UK, including through support for Marine Research Centres such as NOCS. No serious player in the field of oceanography world wide attempts to do so through reliance on its University sector alone and major oceanographic institutions are a feature of most of the major oceanographic nations;

— to contribute to nurturing the health of core disciplines (particularly mathematics and physics) essential to marine science, and to promote cross-over/conversion of students from these disciplines into marine science;

— Marine Science *per se* does not feature within the National Curriculum for schools and so awareness of the subject is low in terms of undergraduate recruitment. We note that marine science topics offer significant opportunities to "bring to life" core science disciplines at School level. In particular, at NOCS we have developed resources for ready use in the classroom in support of science classes (eg Oceans4Schools; classroom@sea);

— support funding for programmes of sustained scientific observation as part of national science capability and to find better ways to recognise and develop more effective synergies with the activities of operational observing agencies within the context of global scale ocean-observing networks;

— develop more strongly its approaches to support and facilitate participation of UK scientists in major international programmes including the European Framework Programmes;

— continue investment in major capital infrastructure and facilities for the support of marine science (particularly research ships); and

— increasingly recognise that the scale of investments in major infrastructure required over the coming decades (eg cabled sea-floor observatories) will require cooperation at the European Level such as envisaged by the European Strategy Forum on Research Infrastructures (ESFRI).

14. There is increasing recognition that there needs to be a shift of focus of marine science towards the Arctic Seas where responses to climate change are expected to be most pronounced and where the impacts (ice melt, changes in marine ecosystems, and the opening of new exploitation opportunities/risks in Arctic waters) will have most immediate impact on the UK. The International Polar Year (IPY) provides an opportunity to begin this refocusing. The UK will need to develop its particular contribution in this field of research where other nations have more experience and resources.

15. The issue of ocean acidification has risen rapidly up the scientific and policy agenda, representing "the other half" of the anthropogenic CO_2 emission problem. Whilst changes in pH can be predicted with considerable accuracy, the impacts of these changes in the marine environment (particularly on marine ecosystems) remain uncertain but potentially very severe. Consequently we encourage a greater shift of funding resources towards this issue in future. We note that the importance of ocean acidification has emerged from the field of palaeooceanography. This field of science is making profound impact on our understanding of the earth system.

16. Other important sources of funding for Marine Science are through the European Commission through its framework programmes, from UK Government Departments and from industry (particularly offshore hydrocarbon and related businesses). In terms of the EU Framework programmes Marine Science is not an explicit topic but is viewed as a cross cutting issue pervading many topic areas.

3. *The role of the UK internationally, and international collaboration in marine sciences*

17. NOCS believes that continued membership of large international research programmes in earth and marine science is vital. A selection of some of the international projects in which NOCS participates is provided in Apnex 3. Some of the most highly significant participations by us are described below.

18. NOCS involvement and leadership within the Integrated Ocean Drilling Program (IODP and the former ODP), the world's largest earth and ocean science research programme, involving more than 20 countries (budget $<$£1,000M), is among the most significant from any institution in the world. NOCS has provided 4 Co-Chief Scientists and 21 others have sailed as shipboard scientists on a range of drilling cruises. Leadership is also demonstrated by significant involvement in 20 drilling proposals currently under evaluation by the IODP science advisory structure. One proposal has led to a scheduled drilling leg, and five others on which NOCS scientists are leading proponents are highly considered with a strong chance of success. NOCS scientists have co-authored 11 Nature and Science papers from this ODP/IODP work since 2004. UK involvement in IODP is facilitated by membership of the European Consortium for Ocean Research Drilling (ECORD) together with 15 other European countries and Canada. UK scientists are engaged within IODP through the development of drilling proposals as well as through research on the cores recovered, at an intensity that far exceeds ($\sim$4x) the UK's financial contribution to the international program. This enables scientists to direct the IODP to undertake projects of the greatest relevance to UK environmental science priorities and to deliver on key government research areas including ocean climate dynamics, rapid climate change, extreme, climates, biogeochemistry and the carbon cycle, gas hydrates, and geohazards. It is essential that the UK maintains its commitment to IODP.

19. The increases in both temporal and spatial resolution required to resolve processes of abrupt climate change during the last few glacial-interglacial cycles can most effectively be achieved through international marine science consortia such as the International Marine Past Global Change Study (IMAGES). To enable continued leadership of the UK to continue in the critical data-driven disciplines working towards an understanding of abrupt global climate change, it is imperative that the UK continues to support the IMAGES programme and the ensuing research in a structured and substantial manner, as part of a strategic funding programme. This would complement deeper-time initiatives through IODP as well as modelling studies, and will deliver an essential broad-based understanding of the magnitudes, rates, and processes of climate change.

20. NOCS participates in numerous EU Framework Programmes and networks of excellence. Notable is the Hotspot Ecosystem Research on the Margins of European Seas (HERMES) Integrated Programe which is coordinated from NOCS and consists of 45 partners including nine small companies across 15 countries (one of the largest Marine Science projects in Europe) Funded by the European Commission, HERMES brings together expertise in biodiversity, geology, sedimentology, physical oceanography, microbiology and biogeochemistry so that the generic relationship between biodiversity and ecosystem functioning can be understood. Study sites extend from the Arctic to the Black Sea and include biodiversity hotspots such as cold seeps, cold-water coral mounds and reefs, canyons and anoxic environments, and communities found on open slopes. These important systems require urgent study because of their possible biological fragility, unique genetic resources, global relevance to carbon cycling and susceptibility to global change and human impact.

21. The UK hosts a significant number of International Project Offices (IPO) for major international programmes. At NOCS the most significant of these is the IPO for the CLIVAR Programme (Climate Variability and Predictability) which is part of the World Climate Research Programme (WCRP). The hosting of International Project Offices provides the UK with visibility and influence internationally. We believe such activity should be viewed as integral to the leadership role that the UK seeks to provide internationally in science and the environment. Hosting of IPOs usually requires some degree of subsidy by the host nation/institution and NERC continues to be generally supportive of the hosting of IPOs.

22. NOCS is a member of a number of bodies in which Marine Centres are represented institutionally at international level. These include:

- The Partnership for Observation of the Global Ocean (POGO) which is made up of over 25 of the world's leading Oceanographic Institutions (of which NOCS was a founding member). POGO is playing an increasingly prominent role in making the case for in situ ocean observations to be incorporated into and viewed as essential to the Global Earth Observing System of Systems (GEOSS) being developed under the auspices of the Group on Earth Observation (GEO).
- The European Science Foundation (ESF) Marine Board. A recent report (November 2006) of this Board "*Navigating the Future III*" provides an excellent synthesis of perspectives on marine science and technology in Europe (www.esf.org/marineboard)
- NOCS together with IFREMER (France) are associate members of KDM (the German Marine Science Consortium).
- The University of Southampton is a founder member of the Worldwide Universities Network (WUN)—a partnership of leading institutions in the UK, US, China and Europe, which are committed to working together in research and education in rapidly moving areas of global significance. Currently around 80 groups are engaged in collaborative activity, including joint research, joint distributed learning courses and staff and student exchanges across many different subject areas. Postgraduate researchers can participate in these activities and may seek funding for research visits to the University's international partners through the WUN Global Exchange Programme. NOCS is a site at which WUN distributed seminars may be viewed, enabling audiences to interact internationally.

23. NOCS hosts the secretariat for the UK delegation to the Intergovernmental Oceanographic Commission (IOC) and the current President of the IOC is a retired member of NOCS staff (Dr. David Pugh).

24. Staff within NOCS have worked on aspects of maritime territory delimitation for a number of years and, along with the United Kingdom Hydrographic Office, provide all technical advice to Her Majesty's Government on limits to UK waters. Of particular interest to coastal states is the determination of the outer limits of the continental shelf where it extends beyond 200 nautical miles from baseline, defined according to Article 76 of the UN Convention on the Law of the Sea (UNCLOS). NOCS runs an annual international training programme for representatives of nations wishing to develop their maritime territory.

25. In terms of developing future international collaborations, we have a number of links with China (both Universities and Research Institutions). Most of these are in the form of information exchange visits, though we have several PhD students from China. We would welcome the opportunity, however, to develop more substantive project links in due course.

26. As part of our role to manage the NERC multipurpose oceanographic research vessels (RRS James Cook and RRS Discovery) we participate in international ship-time barter arrangements.

4. *Support for marine science including provision and development of technology and engineering*

Support for Marine Science

27. We welcome

— the investment in the recently delivered multipurpose research vessel RRS James Cook which replaces RRS Charles Darwin;

— the announcement in autumn 2006 by Government of the earmarking of funds for replacement of the aging RRS Discovery by a new vessel in 2011.

28. The investment in a second ocean-going multipurpose research vessel to replace Discovery is essential to maintain the UK's position in oceanography, particularly in research relating to the ocean's role in the climate system. The UK's ownership of these vessels provides significant leverage through international ship barter arrangements giving UK scientists global reach and making for very efficient deployment of research vessels.

29. We are, however, concerned that a fleet of just two multi-purposes research ships (plus the Antarctic/polar vessel James Clark Ross) represents the minimum research ship capacity for the UK and that high-quality science demand is outstripping ship capacity.

30. There is concern that coastal and shelf sea marine science is currently compromised by lack of a research vessel since NERC's multi-purpose fleet was reduced from three to two ships when RRS Challenger was taken out of service in 2002. The Fisheries Agencies FRS Aberdeen and Cefas do have vessels with coastal sea capacity but these are difficult to access by the wider NERC science community on account of their full commitment to statutory monitoring duties.

Development of technology

31. NOCS has major capability for technology development and deployment at sea. The NERC Marine Sector Review of 2005 identified the need to maintain critical mass in technology development across the UK.

32. As part of Oceans 2025 NOCS has secured significant additional investment in its technology programme and ensured that technology is more coordinated across the NERC Marine Centres.

33. Nevertheless the UK investment in marine technology remains relatively low compared to other nations, particularly Japan, USA, France and Germany.

Future Infrastructure

34. Future Marine Science will depend heavily on major infrastructure for sustained observational networks (eg cabled sea-floor observatories) which the UK science base will not be able to support in isolation.

— It is essential, therefore, that the UK rapidly engages with initiatives in Europe that afford the opportunity to work collaboratively to share the costs of such infrastructure. For this reason NOCS is keen that the UK engages in the European Strategy Forum on Research Infrastructures (ESFRI). Of the 35 projects currently on the ESFRI roadmap we are particularly interested in EURO-ARGO (European contribution to the global profiling float programme) and EMSO (European Multidisciplinary Seafloor Observatory).

— It is important that science funders (eg NERC) and operational agencies (eg Met Office) work more closely together on global ocean observing systems. There is currently a gulf between operational funding for observational infrastructure and that for science. However, as science moves to sustained observation as a key tool in addressing decadal-scale change, the observing infrastructures will increasingly need to be developed with dual science and operational use in mind. Many parts of the global ocean observing system (eg Argo) continue to be supported by research funding which is unsustainable long term. The problem is common to many countries but there is an opportunity for the UK to take a lead in finding a solution to this problem which is a significant barrier to developing a sustained ocean observing system. The Intergovernmental body (Group on Earth Observation, GEO) is a promising forum for taking this issue forward. However GEO operates by voluntary means at present. Whilst the UK (via Defra) supports as a priority its immediate statutory and international obligations in coastal waters (eg requirements via OSPAR), its commitment to contributing to the international effort global observing appears more fragile.

5. *The state of the UK research and skills base underpinning marine science and provision and skills to maintain and improve the UK's position in marine science*

35. NOCS through the University of Southampton is the leading UK institution in the education of the next generation of physical and biological scientists in ocean and earth system science.

36. We have recently diversified our marine science Masters (MSc and MRes) provision. We now offer courses in Marine Resource Management, Marine Environment and Resources, Marine Science, Policy and Law, Ocean Remote Sensing, Engineering in the Coastal Environment, Marine Geology and Geophysics, as well as our well-established MSc course in Oceanography. We have concentrated new Masters courses in areas of strategic skills shortages in the UK. While numbers are increasing, we feel that research councils need to be more responsive to supporting new Masters courses with studentships in order to accelerate the supply of skilled graduates. In general in marine science we feel that the number of Masters studentships offered by research councils to support students in marine science is inadequate.

37. One particular issue of concern at undergraduate level in ocean and earth science is the absence of recognition by HEFCE of the extra costs of fieldwork which is essential to train scientists of the future. Organisations that accredit degrees in relevant disciplines (Geological Society of London and IMarEST) require a fieldwork component to degrees. This fieldwork is essential to ensure the continued supply of graduates for industry as well as PhD students with the correct skills. The current funding regime results in fieldwork in ocean and earth science being squeezed, and this is something that HEFCE needs to rectify.

38. There is a complete absence of applications from Masters students from new-accession states to the EU, and we wonder whether the UK Government should provide an enabling programme in marine science.

39. There are currently 161 PhD students enrolled within the Graduate School of NOCS (85 UK, other EU 35, Non-EU 21) and on average 30–35 PhD students graduate each year. We have relatively few students from outside Europe, and while there are large numbers of high-calibre international students that we would like to recruit, finding funding for these students remains a major issue.

40. A key current problem in the UK marine science community is the recruitment and retention of scientific staff at all levels. There is substantial competition from German and American research institutes. These institutes are much better funded than in the UK generally and are becoming increasingly aggressive in their targeting of individuals within UK institutions and NOCS in particular.

41. Retention and recruitment is difficult mainly because of the gulf in funding between marine science funding in Germany and the UK. While on an individual basis, salary supplementation is possible, it is not possible under the current system, to guarantee adequate access to science ship time. This issue needs to tackle this urgently if marine science and technology is to continue to be competitive.

6. *Use of marine sites of specific scientific interest*

42. Taking this to include also marine protected areas nationally and internationally, we are concerned that deep water trawling continues to destroy sites where there is still not a full understanding of what these sites contain and their scientific and ecological importance.

43. Of particular concern is the destruction of deep cold water coral reefs. The EU funded HERMES project is an international, multidisciplinary research programme coordinated by NOCS which is investigating Europe's deep marine ecosystems and their environment (see paragraph 19). These important systems require urgent study because of their possible biological fragility, unique genetic resources, global relevance to carbon cycling and susceptibility to global change and human impact.

44. We are also concerned that this implication of designation of sites, as set out in the Marine Bill consultation might actually inhibit the undertaking of research in these sites, perhaps by prohibiting the operation of research vessels or platforms in particular areas or at specific times. Full access for well planned scientific research needs to be built in to the designation and operating conditions on a site by site basis.

Conclusions

45. The oceans are a key regulator of the Earth's climate system and have a crucial role to play in the provision of natural resources (energy, minerals and food).

46. The need for much higher levels of national and international collaboration and coordination in marine science is becoming progressively evident. Over and above the long-standing tradition of scientific collaborations, there is evidence of progressive institutional "self-organisation" or the Marine Science Community at

- UK national level (eg the Oceans 2025 research programme, National Centre for Ocean Forecasting).
- European level (ESF Marine Board, KDM).
- International level (POGO).

47. This "self organisation" trend (which is largely focussed around the challenge of sustained global ocean observing) perhaps points to a weakness in existing institutional structures for coordination. An important UK initiative in this regards has been the formation of the National Centre for Ocean Forcasting (NCOF) which is a consortium of the Met Office, and four NERC-funded institutions (NOCS, POL, PML and ESSC). This seeks to develop more rapid uptake of ocean modeling advances into operational simulation systems.

48. We emphasise the following areas of risk to the UK's international competitiveness in Marine Science

- the crucial importance of maintaining research ship capacity to sustain the UK's international competitiveness in marine science. The NERC fleet has progressively reduced from five to two multi-purpose research ships (excluding Antarctic vessels) over the past two decades. Two ocean-gong multi-purpose ships in minimum capacity and will struggle to support high quality science, especially in the face of the strategic need for ocean research in the coming decades;
- the challenges of recruitment and retention of key staff against stiff international competition (particularly Germany at present). The UK is viewed as a source of intellectual capital and favourable funding arrangements (including infrastructure) make other countries quite attractive. There have been successes recruiting into the UK from overseas. However, aspects of the German system in particular (eg pension arrangements), tend to lock academics into that system making them difficult to recruit into the UK;
- the UK will need to improve the agility of its research funding to enable it to make the necessary step changes in marine research required to address the increasingly growing recognition of massive impact of the oceans on global earth system and the opportunities for natural resource solutions to be found within the marine environment; and
- the need to rapidly evolve processes (and UK and international institutions if necessary) capable of sustaining long-term, multi-user programmes of in situ ocean observing which are at risk through over-reliance at present on research budgets to maintain them (even within operational agencies).

49. NOCS welcomes this timely inquiry into Marine Science by the House of Commons Science & Technology Committee and extends an invitation to the Committee to visit the National Oceanography Centre as part of its deliberations.

January 2007

Annex 1

THE NOCS VISION AND MISSION

50. The formation of the *Southampton Oceanography Centre* (now NOCS) in 1994 was a visionary move which enabled a major critical mass of marine science expertise to be brought together in a single location with excellent facilities and raise the international visibility of UK marine science.

51. The refocused vision of NOCS from 2005 builds on this with a view to using NOCS more fully as a vehicle for providing a wider enabling role for the UK science (see "The vision" http://www.noc.soton.ac.uk/nocs/mission.php)

52. The vision is for NOCS to be the national focus for oceanography in the UK with a remit to

- achieve scientific excellence in its own right as one of the world's top five oceanographic research institutions;
- deliver a diverse mission, which ranges from managing the national research vessel fleet and other major facilities, to programmes of strategic research for NERC, and academic research and education in ocean and earth sciences in support of the University's mission; and
- facilitate greater coordination of marine science in the UK and internationally and to provide major services and facilities to the wider science community in an inclusive and impartial manner.

53. The NOCS mission encompasses:

- research (basic, strategic and applied);
- major ocean technology development;
- sustained ocean observation;
- managing international science programmes;
- promoting enterprise and knowledge transfer;
- providing advice to Government, business and charities;
- promoting engagement between science and society through outreach; and
- working with the wider science community to provide strategic leadership, coordination and facilitation for the whole of the UK marine and related earth sciences.

Further details may be found on our website www.noc.soton.ac.uk

Annex 2

DEVELOPING NOCS SCIENCE STRATEGY

CHALLENGE 1: *How and why has climate changed through Earth History? What are the lessons from this palaeo-record for 2050 and beyond?*

54. Under this challenge we want to understand the patterns, rates and causes of change in atmospheric CO_2 levels over geologic time; the consequences of changes in palaeo CO_2 levels for ocean temperature, sea water acidity and oxygenation; the processes (and feedbacks) in addition to CO_2 change (eg, ocean circulation strength and mode) that control (amplify) rapid changes in climate; the impact of these past changes on continental ice volume (sea level), biogeochemical cycling and global biodiversity.

CHALLENGE 2: *Will the Atlantic meridional ocean circulation slow down as a result of anthropogenic climate change?*

55. The present Atlantic Ocean circulation carries warm upper waters northward through the Atlantic, the waters gradually cool on their journey northward giving up heat to the atmosphere; in the subpolar and polar regions the surface waters become cold enough and salty enough to sink to the bottom forming cold deep waters; and this cold deep water returns southward through the Atlantic. This circulation is called the meridional overturning circulation (MOC); its size is estimated to be about 17 Sv and it transports 1.3 PW of heat northward, heat that is given up to the atmosphere leading to the equitable climate of northwestern Europe.

56. There is a clear need for observations of the Atlantic MOC and how it is changing over time. Recent analysis of five hydrographic sections suggested that the MOC at 25(°N has slowed by 30% over the past 50 years.[36] But how variable is the MOC on seasonal to interannual time scales? Is the 30% slowdown within the range of natural variability? Has the change been gradual as suggested by models or was it abrupt, occurring over a decade or less? It is essential to establish a baseline measure of the MOC strength and its seasonal to interannual variability to put wide-ranging and longer time series of Atlantic observations into an overall context of Atlantic (and global) climate change.

57. Recent results from the NERC RAPID Programme have shown the necessity to acquire data with sufficient temporal and spatial resolution (4D) in order to be able to extract long term trends from short term variability. In particular it demonstrates the needs for continuous measurements (long term observatories) and the development of autonomous survey.

CHALLENGE 3: *How will the biodiversity of the oceans alter with a changing climate?*

58. The Palaeo record clearly shows how species have changed with climatic conditions and we expect the same to be true in the future and there are implications for organisms both in the upper water column and the deep ocean. What will be the responses of biota (eg coral reefs) to ocean acidification?

CHALLENGE 4: *What long term measurements of ocean systems are needed to follow climate change and to make predictions more robust?*

59. The long term ocean stations in the North Pacific (HOT) and Atlantic (BATS), and zooplankton collection (SAHFOS) have demonstrated how patterns of ecosystem change in the surface ocean can emerge from high quality long term records. The RAPID programme has shown the potential to follow important changes in heat fluxes at an ocean scale. Additionally, continuous records are the only way to effectively assess the impact of episodic events such as plankton bloom events that may account for much of the C flux at a particular site. Therefore there is a need for collection of long time series data, with station locations and sampling/data collection strategies need to be carefully optimised, and there is scope for international cooperation.

CHALLENGE 5: *What are the links between surface ocean biogeochemical and physical processes and the deep ocean with respect to production, storage and fate of climatically important materials?*

60. The production of organic C and biogases in the upper ocean are anticipated to have important impacts on atmospheric gas concentrations (eg carbon dioxide, dimethyl sulphide and halocarbons). Vertical transfer to deeper long residence time waters of organic carbon (the biological pump) and carbon dioxide physically dissolved at the surface, through mixing and vertical particle transfer will remove carbon from the atmosphere and upper ocean. Key biogases produced in the ocean and released to the atmosphere are proposed to have important feedbacks on climate so knowledge of their production and fate is essential.

[36] Bryden, H L, Longworth, H R and Cunningham, S A 2005 Slowing of the Atlantic meridional overturning circulation at 25N. *Nature, 438, 655–657. (doi:10.1038/nature04385).*

CHALLENGE 6: *What models are required to effectively describe the ocean system for predictions to be made, and for interfacing with models of atmospheric and terrestrial systems?*

12. Presently the challenge is to integrate ocean physics models with models of biology at increasing resolution in order to provide more rigorous predictions of the behaviour of the ocean system. Mesoscale processes have been identified as important and hence the need for higher resolution. Models of atmospheric inputs of gases and particles to the ocean, and release of climatically important gases, need to be effectively interfaced with models describing the atmosphere and terrestrial components of the planet. There is an increasing need to incorporate the role of shelf seas/coastal oceans in larger-scale modelling.

CHALLENGE 7: *What are the current and projected changes in sea-level, and what will be the regional effects of sealevel change and what are the socio-economic impacts?*

62. Sea-level change is important since it would directly affect coastal regions. In addition, it has an often overlooked impact on inland flood hazards, since sea-level rise elevates the base-level of rivers. The melt-water influxes into the oceans that cause sea-level rise can also affect oceanographic circulation, and hence heat-transport to high latitudes (notably NW Europe). It is therefore imperative that we develop an understanding of both the longer-term history of sea-level change and its modern variability—including the various processes that govern regional and global sea-level change—to underpin evaluations of the large-scale impacts of global (greenhouse) climate change. We especially need to constrain the magnitude and rate of potential global ice-volume reduction and hence sea-level rise. There is a need to be able to translate global predictions to local scales to be used by government to plan and prepare for environmental change.

CHALLENGE 8: *What controls deep ocean biodiversity?*

63. Although originally thought to be of low biodiversity, the deep ocean is now known to be very biodiverse, this diversity composed of species in the small macrofaunal and meiofaunal size range. Such biodiversity is supplemented by the very different faunas found at, *inter-alia*, hydrothermal vents and cold seeps. Our knowledge of this biodiversity is increasing but ecosystem functioning is still imperfectly understood, particularly at temporal scales. Recent studies of the Atlantic have shown large regime shifts but we can only speculate as to their causes. Deep-sea technology has now advanced sufficiently that, for the first time, experimental manipulations in the deep ocean are now possible. This provides an important opportunity to address fundamental questions relating to the functionality (trophic, respiratory, reproduction and competition) in deep ocean ecosystems.

CHALLENGE 9: *How can we understand microbial biodiversity and processes in contrasting ecosystems?*

64. Microbes are central to ecosystem processes. Their genetic biodiversity is immense yet their tiny size means "out of sight is out of mind". Recent research has identified physiological functions and genes that code for these functions. Many functions are strategically important; for instance, genes for nitrogen fixation, and other uniquely prokaryotic aspects of the marine nitrogen cycle, are now known to be diverse, originating from several different bacterial and archaeal groups. We do not know the implications of this and we do not know how these relate to similar processes in other ecosystems. Is there a common phenotypic or genotypic microbial diversity across terrestrial, freshwater and marine ecosystems?

CHALLENGE 10: *What are the major geological natural hazards facing the global community? What are the controls on their location, frequency and character? Which if any of these can we usefully predict? How can we estimate occurrence probabilities and magnitudes for risk/hazard assessment?*

65. The growth of mega-cities, particularly in Asia, means that the first natural event causing over a million deaths due to a large earthquake or Tsunami in the next 30 years is now highly likely. We need to invest in the science to tackle the questions related to earthquakes, tsunami, continental slope slumping and volcanic hazards. NOCS believes (and as also articulated in the Natural Hazards Working Group report chaired by Sir David King in response to the 2004 earthquake and tsunami) that hazard assessment is necessary for the implementation of early warning systems, that we must understand the threats and processes underpinning these hazards, and that greater support is needed to improve scientific methods used to assess risk.

CHALLENGE 11: *Can Geological CO_2 sequestration be achieved on the scale required to make a significant contribution to the global carbon budget, and how do we monitor it?*

What is a sustainable energy budget for the earth? What are the implications for human society?

How do we responsibly exploit geological energy resources?

How do we improve hydrocarbon exploration methods? How do we improve recovery from known oil and gas resources? How do we better exploit geothermal energy? How should we exploit coal resources?

Annex 3

SELECTION OF INTERNATIONAL RESEARCH PROJECTS IN WHICH NOCS IS PARTICIPATING

Acronym	*Project*	*International Aspect*
ANIMATE	Atlantic Network of Interdisciplinary Moorings and Time-series for Europe	Part of Oceansites network
BIOTRACS	BIOtransformations of TRace elements in AquatiC Systems	EU Marie Curie Action
CARBOOCEAN	Marine carbon sources and sinks assessment	EU Integrated Research project
CAVASSO	CArbon VAriability Studies by Ships Of Opportunity	EU
ChEss	Biogeography of deep-water chemosynthetic ecosystems	Census of Marine Life (CoML) field programme
EUR-OCEANS	Global change and pelagic marine ecosystems	EU Network of Excellence
Ferry Box	Real-time monitoring from Portsmouth to Bilbao	Component of EU Ferry box programme
HERMES	Hotspot Ecosystem Research on the Margins of European Seas	EU Integrated Research project (NOCS is the Coordinator)
marbef	Marine Biodiversity and Ecosystem Functioning	EU Network of Excellence
PAP	Porcupine Abyssal Plain observatory	Part of Oceansites network
SERPENT	Scientific and Environmental ROV Partnership using Existing iNdustrial Technology	Industrial network
SOLAS	Surface Ocean Lower Atmosphere Study (NERC)	Component of International SOLAS
MOMARnet	The Sumatra Consortium Project MOnitoring deep sea floor hydrothermal environments on the Mid Atlantic Ridge	Indonesian collaboration Marie Curie Research Training Network
EURODOM	European Deep Ocean Margins	Marie Curie Research Training Network
EUROSTRATAFORM	European Margin Strata Formation	EU Framework 5 (completed)
SEISCANEX	Re-using seismic data	EU Framework 5 (completed)

Memorandum 28

Submission from the Met Office

EXECUTIVE SUMMARY

1. The Met Office makes significant contributions to marine science in the areas of climate change research, seasonal forecasting, short-range ocean forecasting and marine measurements. The National Centre for Ocean Forecasting was established in 2005, as a consortium involving the Met Office and four of the leading marine research institutes funded by NERC, in order to strengthen the exploitation of marine science. Measurements are indispensable for marine science and for monitoring and forecasting the ocean for a wide range of purposes. The Met Office participates fully in the international collaboration and coordination of marine science and has a leading role in the coordination of ocean forecasting both globally

and within Europe. The Met Office develops ocean models as components within Earth System models and has a policy to encourage the NERC community to contribute to the scientific content of these models and to use them for scientific experiments. The strength of the UK marine science base has important impacts on the training of staff recruited and the collaborations in the parts of the Met Office exploiting marine science. The Met Office Hadley Centre assesses the likelihood and impacts of changes in the North Atlantic thermohaline circulation and the impacts of climate change on coastal flooding on the North West European shelf.

Organisation and Funding of Marine Science Within the Met Office

2. The oceans store much larger quantities of heat than the atmosphere. Ocean surface temperatures affect short-range weather forecasts, sub-surface temperature anomalies influence seasonal variations in the weather, and absorption of heat by the ocean is expected to delay global warming. Up-to-date knowledge of the state of the marine environment affects the safety and effectiveness of marine operations and is required to protect the marine environment. The Met Office exploits the results of marine research for all of these reasons.

3. As part of our research into climate change, the Met Office develops and validates ocean and sea-ice models for climate change simulations. We assess the surface temperature variability and trends, ocean heat uptake, sea-ice coverage and the probability and impact of a rapid slowing of the thermohaline circulation in the North Atlantic over the next 100–200 years in these climate simulations and seek to constrain the simulations using historical observations. We also study sea-level rise in higher resolution regional climate change models and model the biogeochemistry of the ocean and its impact on the global carbon cycle. The Met Office's seasonal forecasts also depend on the ocean sea-ice models developed for climate simulations. Defra, MoD, the European Commission and the Environment Agency provide in total some £1.8 million per annum to support this work.

4. The Met Office also develops systems which are used to make operational[37] forecasts of the "weather in the oceans" out to five days ahead. The quantities forecast include: heights of surface waves; heights of tides and storm surges; sea-ice concentrations and velocities; and the temperatures, salinities and velocities of the ocean. The systems generate high resolution forecasts for areas of particular interest (eg the waters around the UK) and most of the systems also generate coarser resolution global forecasts. Funding for the development of these systems is some £1.3 million per annum and is largely provided by MOD. Other contributors include the European Commission, the Environment Agency, the Department for Trade and Industry and the European Space Agency.

Co-ordination with NERC Funded Groups—the National Centre for Ocean Forecasting

5. The Met Office leads the National Centre for Ocean Forecasting (NCOF). NCOF was launched in March 2005 with a mission to establish ocean forecasting as part of the national infrastructure based on world-class research and development. The initial members of the Consortium are the Met Office and four research institutions: the Environmental Systems Science Centre (ESSC), the National Centre for Oceanography Southampton (NOCS), the Plymouth Marine Laboratory (PML) and the Proudman Oceanography Laboratory (POL).

6. The vision for NCOF is to enable joined-up research, development, operational production and exploitation of ocean forecasts for a wide range of purposes. The research institutes contribute to the validation and development of the systems and benefit from the operational exploitation of their research and from access to the measurements, forecasts and modelling systems generated by NCOF. The Met Office produces the operational forecasts, evaluates their accuracy and contributes to the scientific and technical development of the systems. It benefits from the scientific expertise of the research institutes.

Other National Co-ordination

7. DEFRA is leading the development of a UK Marine Monitoring and Assessment Strategy which will be owned by a high-level Marine Assessment Policy Committee (MAPC), of which the Met Office is a member, and implemented through a set of sub-committees. This strategy and set of committees is intended to address the requirements of all government departments.

8. In addition, national interests in marine affairs are co-ordinated through the Inter-Agency Committee on Marine Science and Technology (IACMST) which maintains an overview of marine activities across Government. Some 14 Government departments or agencies, including the Met Office, are members of IACMST. It encourages links between Government and the national marine community, as well as international links.

[37] Operational meaning that the forecasts are produced by the Met Office routinely and without fail every day (and more frequently if necessary) and that their quality is monitored and assessed.

9. IACMST has two action groups to which the Met Office contributes, its GOOS[38] AG (Global Ocean Observing System Action Group) is the UK national GOOS co-ordinating committee and its MED AG (Marine Environmental Data) Action Group is concerned with improving access to marine environmental data.

10. The GOOS AG is charged with coordination of marine observation programmes operated by the UK and with improving the co-ordination, development and application of operational models of the shelf seas around the UK. The GOOS AG also works to improve co-ordination of UK input to the GOOS programme. In future the work of GOOS AG is expected to be absorbed by MAPC and its sub-committees.

11. The Met Office works to improve the accessibility and availability of UK data by contributing funding towards the activities of MED AG. The group, together with the Marine Environmental Data Co-ordinator, forms the UK Marine Environmental Data Network which has set up the OceanNET web site (www.oceannet.org) as a portal to data and information about the marine environment.

Role of the Met Office in International Collaboration

12. The marine science community devotes significant resources to international collaboration and coordination of its resources. The Met Office strongly supports this work and leads the coordination in several areas. We chair the North West Shelf Operational Oceanography System (NOOS)[39] and the Services Programme Area of the WMO/IOC Joint Technical Commission for Oceanography and Marine Meteorology (JCOMM).[40] We run the Global Ocean Data Assimilation Experiment (GODAE)[41] Project Office and co-chair the International GODAE Steering Team. We also run the Global High Resolution Sea Surface Temperature (GHRSST) Project[42] Office and chair the GHRSST Science Team.

13. The Met Office contributes actively to the IPCC (Intergovernmental Panel on Climate Change), providing probably the largest contribution to the Scientific Assessment Working Group, including the role of oceans in climate change. The Met Office also hosts the Technical Support Unit for the Impacts and Adaptation Working Group.

Met Office Involvement in the Provision and Development of Technology and Engineering

14. The Met Office develops complex models of the Earth System which are used to make weather forecasts, seasonal forecasts and to simulate the Earth's climate and changes in its climate. These models include separate model components to simulate the atmosphere, the oceans, sea-ice, land vegetation and other components of the environment. The components are coupled together to form an Earth System model. The development and maintenance of these software systems is a major and technically demanding engineering task. The Met Office has a policy to enable NERC staff to contribute to the scientific development of these models and to have access to them for scientific experiments and evaluation.

15. Marine and ocean observations are essential information needed to produce weather and ocean forecasts, and provide an important part of the climate record. These observations rely heavily on the use of technology (platforms, sensors and communications) in order to be able to operate reliably and autonomously at sea. Continued engagement in the appropriate international fora is necessary in order to ensure that the Met Office is able to exploit the latest developments. The Met Office, for example, manages and leads the UK's contribution to the international Argo programme. This revolutionary new observing system is designed to monitor the temperature and salinity structure of the global oceans to a depth of 2,000 metres. It was initiated in 1999 and over 30 countries have contributed to the system. It presently consists of nearly 3,000 profiling floats distributed throughout the world's oceans.

[38] GOOS is intended to be a permanent global system for observations, modelling and analysis of marine and ocean variables needed to support operational ocean services worldwide. GOOS is co-ordinated by the Intergovernmental Oceanographic Commission (IOC), World Meteorological Organization (WMO), United Nations Environment Programme (UNEP) and the International Council for Science (ICSU) and is being implemented by national and international facilities and services, including the Met Office.

[39] NOOS is an operational oceanography organisation operated by participating partners from the nine countries bordering the extended North Sea and European North West Shelf (Belgium, Denmark, France, Germany, Ireland, Netherlands, Norway, Sweden, and UK), collaborating to develop and implement ocean observing systems for the NWS area, with delivery of real time operational data products and services.

[40] The WMO/IOC Joint Technical Commission for Oceanography and Marine Meteorology (JCOMM) is an intergovernmental body of experts, which provides the international, intergovernmental coordination, regulation and management mechanism for an operational oceanographic and marine meteorological observing, data management and services system.

[41] Through co-ordinated international effort, the aim of GODAE is to facilitate the provision of regular, comprehensive information on the state of the oceans for the benefit of the scientific community.

[42] The purpose of the GHRSST project is to develop an operational demonstration system that will deliver a new generation of global coverage high-resolution (better than 10 km and ~6 hourly) sea surface temperature products. GHRSST data products will be derived by combining readily available but complementary satellite and *in situ* observations in real time to improve, amongst other things, spatial coverage, temporal resolution and SST product accuracy.

State of UK Research and Skills Base

16. The post-graduate training in marine science provided by UK research laboratories is of significant importance to the Met Office. Most of our staff recruited in the last 10 years have benefited from such training. The majority of our scientific collaboration is with UK groups, although we are increasing our collaboration with other European countries (notably France).

Impact of Climate Change on the Oceans

17. The Met Office Hadley Centre produces projections of future climate change for the 21st Century and beyond. These include changes in the deep ocean circulation and properties (eg the North Atlantic thermohaline Circulation). More detailed scenarios are currently being developed for the European shelf seas, for assessment of impacts on coastal flooding, ecosystems, sediment transport. These scenarios will be fed in to the UK Climate Impacts Programme (UKCIP) and UK Marine Climate Impacts Partnership (MCIP), both of which have strong engagement from potential users of marine climate change information.

January 2007

Memorandum 29

Submission from the Natural Environment Research Council (NERC)

1. The Natural Environment Research Council (NERC) is one of the UK's eight Research Councils. It funds and carries out impartial scientific research in the sciences of the environment. NERC trains the next generation of independent environmental scientists. Its three strategic research priority areas are: Earth's life-support systems, climate change, and sustainable economies.

2. NERC's research and collaborative centres are listed in Annex 1. Details can be found at www.nerc.ac.uk. Annex 1 also defines the term "the marine centres" as used in this memorandum.

3. NERC's comments are based on input from the British Antarctic Survey (BAS), the British Geological Survey (BGS), the Centre for Ecology and Hydrology (CEH), the National Oceanography Centre Southampton (NOCS), the Plymouth Marine Laboratory (PML), the Proudman Oceanographic Laboratory (POL), the Sir Alister Hardy Foundation for Ocean Science (SAHFOS), the Scottish Association for Marine Science (SAMS), the Sea Mammal Research Unit (SMRU) and Swindon Office staff.[43]

Executive Summary

4. Marine science makes a major contribution to meeting NERC's strategic aims, and comprises a significant proportion of NERC's responsive research. Following a review of the marine research sector in 2005, NERC Council invited the marine centres[44] to develop a single coordinated strategic marine research programme. The centres' proposal, "*Oceans 2025*", has recently been approved, and the new programme will particularly strengthen collaboration with other bodies and support for long-term monitoring. NERC invests heavily in providing facilities (including infrastructure such as ships) for marine research, and in supporting research studentships in marine science. It participates directly and/or through its research centres in a range of national, European and international marine research and monitoring coordination initiatives and programmes, including ship sharing. NERC expects marine science to have a high profile in its new strategy, and will continue to engage stakeholders in its strategic marine research planning , not least to ensure the relevance and uptake of its research outputs. Several examples are given of the contribution being made by NERC marine science to our understanding of the interaction between climate change and the marine environment.

General Comments

5. NERC welcomes the Committee's decision to hold an inquiry into marine science in the polar and non-polar oceans, and the Committee's implicit recognition of the importance of marine science in improving our understanding of climate change.

6. Marine science makes major contributions in all three of NERC's current strategic priority areas, and will retain its importance when NERC's new strategy is adopted. It is also the basis of a significant proportion of NERC's responsive research projects. Many of NERC's marine science outputs find application in regulatory activities and policy making, for example in fisheries, flood-control and

[43] NOCS, PML, POL and SAMS are submitting detailed individual responses to the inquiry, as is BAS to cover its Southern-Ocean interests. The marine centres are also submitting an *Oceans 2025* memorandum.

[44] See Annex 1.

environmental protection. NERC also encourages commercialisation or other industrial application of its marine research and associated technology—see for example the Blue Microbe Knowledge Transfer Network.[45]

The Organisation and Funding of UK Marine Science in the Polar and Non-polar Regions

NERC research funding

7. NERC and its research and collaborative centres and associated marine research organisations have played a central role over several decades in, respectively, the funding and execution of marine science.[46] NERC also funds marine (and related) research in universities additional to those which host the collaborative centres; and in its Earth Observation (EO) Centres of Excellence.[47]

8. Scientific research funding falls into three categories:

— *Responsive research* is funded through grant schemes for scientists who propose ideas for projects independent of a directed call from NERC. Marine investment though these schemes averaged approximately £6.8 million per annum from 2000 to 2004, amounting to 16–22% of NERC's total responsive-mode budget over this period. The investment was higher in the second half of the period because of the introduction of consortium awards (multi-institute grants over £1 million), of which a further four have been awarded in the past year (Annex 2).

— *Directed programmes* (approximately £5–10 million per programme, generally over five years see Annex 3) address NERC's strategic priorities; they are theme-based and often link universities and NERC centres; some are co-funded by other organisations. NERC has run up to 12 programmes with a marine component since 2000. These include RAPID, a £20 million investment over seven years that aims to improve our ability to quantify the probability and magnitude of future climate change.

— *Centre programmes:* NERC funds strategic research programmes at its research and collaborative centres. Some funding information is available in NERC's Annual Reports.[48]

9. The strategic programmes of the marine centres are discussed in detail below (see *Oceans 2025*). Some information about the marine science in BGS and CEH is given at Annex 4, and BAS Southern Ocean science is discussed in BAS's separate submission. Annex 5 provides details of the relevance to NERC's marine science of the EO centres (especially the Centre for Observation of Air-Sea Interactions and Fluxes), and of the programmes of the European Space Agency (ESA).

The Oceans 2025 research programme

10. Until recently, the marine centres developed separate research programme proposals. However, following a review of the marine research sector in 2005, NERC Council invited them to develop a single coordinated strategic marine research programme. In response, the seven centres submitted a proposal for "*Oceans 2025*" in 2006 (see Annex 6). This programme reflects the national need for a more coordinated and cost-effective response to the challenges of a changing marine environment, and for greater support for long-term monitoring.

11. In late 2006, NERC awarded approximately £120 million to *Oceans 2025* over five years,[49] which represents a modest uplift in total spend in this area. The strategic nature of the programme will enhance the research capabilities and facilities available for marine science, and *Oceans 2025*'s new Strategic Ocean Funding Initiative (SOFI) opens up funds for universities and other partners to bid for, where the skills required are not available within the *Oceans 2025* consortium.

12. Reaching agreement on a coordinated, cooperative and cross-disciplinary research programme of the scale and complexity of *Oceans 2025* is an important step. The coordinated approach from the marine centres, with cooperation and input from other government agencies and departments, should allow the UK to further strengthen its record in national and international collaboration in marine science. *Oceans 2025* will be critical to developing sustainable solutions for the management of marine resources, including food and energy, not least in the face of climate change.

13. The *Oceans 2025* programme complements and integrates with the BAS research programme, and BGS's 2005–10 research programme, which contains a key marine element (focused on the seabed and subsurface).

[45] www.bluemicrobe.com

[46] Annex 1 lists NERC's research and collaborative centres and the marine research organisations in receipt of Grant-in-Aid.

[47] www.nerc.ac.uk/research/sites/collaborative/eo/

[48] www.nerc.ac.uk/publications/annualreport/

[49] The funding for the first two years at this level is assured; the level for subsequent years is contingent on NERC's 2007 CSR settlement.

Other marine research coordination in the UK

14. Beyond *Oceans 2025*, NERC's directed programmes also provide significant opportunities for national research coordination. Most are managed by a Steering Committee, of scientists and research users, and involve a full-time or part-time Science Coordinator. Responsive consortium projects are smaller but involve "internal" management to achieve coordination between participating research groups.

15. NERC works with the other research councils (especially the Biotechnology and Biological Sciences Research Council (BBSRC) and the Engineering and Physical Sciences Research Council (EPSRC)) to ensure coordination of research funding, including in interdisciplinary areas. Examples relevant to marine science include research into renewable energy technology, which is being addressed by the UK Energy Research Centre under the cross-Council "Torwards a Sustainable Energy Economy" programme; research into socio-economic aspects of climate change by the cross-Council Tyndall Centre, eg examining the contribution of marine transport to carbon dioxide emissions and the management of coasts in response to sea-level rise; joint funding of the Flood Risk Management Research Consortium (FRMRC);[50] and interaction between BBSRC's Institute for Grassland and Environmental Research and CEH regarding the impact of agricultural run-off on the marine environment.

16. NERC has bilateral discussions with relevant (including devolved) government departments and agencies and is making broad stakeholder engagement a priority in developing its new strategy. NERC engagement with other national bodies with marine research interests is also facilitated through the Environment Research Funders' Forum (ERFF) and the Inter-Agency Committee on Marine Science and Technology (IACMST).

17. NERC is also involved, through NOCS, PML, POL and the Environmental Systems Science Centre (another NERC collaborative centre) in the National Centre for Ocean Forecasting (NCOF),[51] a partnership with the Met Office.

18. NERC and *Oceans 2025* are represented on the Government's Marine Assessment Policy Committee, which is leading the development of the UK Marine Monitoring and Assessment Strategy (UKMMAS). The Committee is supported by the Marine Assessment and Reporting Group (MARG) and three evidence groups involving NERC's marine centres.

19. The BODC is a member of the Marine Data and Information Partnership (MDIP), a partnership of public and private sector organisations working to provide harmonised stewardship and access to marine data and information, and so facilitate improved management of the seas around the UK.

The Role of the UK Internationally, and International Collaboration in Marine Science

20. NERC participates, directly and through its research and collaborative centres, in European and international marine research activities in a number of ways. Further details are provided in Annex 7, but some activities are mentioned below.

21. NERC takes the UK lead in the main United Nations body for marine science, the Intergovernmental Oceanographic Commission (IOC) of UNESCO, and participates in many IOC activities, including the Global Ocean Observing System and the International Oceanographic Data and Information Exchange Committee. The UK is also involved in international coordination of marine science via bodies such as the Scientific Committee on Oceanic Research (SCOR)—eg SAHFOS is represented—and the international Scientific Committee for Antarctic Research (SCAR)—where BAS is a member.

22. NERC hosts several international project offices (IPOs), eg those of the International Geosphere-Biosphere Programme's Global Ocean Ecosystem Dynamics (GLOBEC) and Surface-Ocean Lower-Atmosphere Study (SOLAS) programmes; and the International Polar Year (IPY). Through hosting these IPOs, and the involvement of researchers in international planning and coordination, the UK is able to help determine the agenda of these international projects, greatly enhancing their national value.

23. NERC also leads, coordinates or is a partner in various European Union networks of excellence and projects. Among them is MarinERA, a project funded by the EU Framework Programme 6 that brings together the leading Marine RTD funding organisations in 13 European Member States to improve the coordination of national and regional RTD activities. NERC is also a partner in the international Global Sea Level Observing System (GLOSS), and the Partnership for Observation of the Global Ocean (POGO).

24. Through its directed programmes (Annex 3) NERC attracts international interest and collaboration. For example (i) US funding agencies are supporting the RAPID programme's observing system with matching funding of approximately £5 million; and (ii) the UK SOLAS programme has obtained German co-support for an international ocean-atmosphere observatory on the Cape Verde islands.

25. NERC also funds the UK's subscription to ESA's environmental science programmes and missions (see Annex 5). Within the current suite of existing and planned satellites, there are a number of instruments designed to provide important oceanographic data which scientists at NERC's Earth Observation Centres of Excellence (soon to become the National Centre for Earth Observation) are well placed to exploit.

[50] www.floodrisk.org.uk

[51] www.ncof.gov.uk/index.html

26. NERC's marine facilities (see below) make a significant contribution to international collaboration. Over the past five years, 50% of NERC's research cruises have involved collaboration with international scientists, from 49 institutions and 17 countries. NERC is also heavily involved in ship-time bartering,[52] which has grown markedly since 2000 to a point where NERC now exchanges approximately 200 barter days per year.

International Polar Year (IPY)

27. Marine science in both polar regions will get a big boost during the International Polar Year, which is a global science programme focusing on the Arctic and Antarctic from March 2007 to March 2009. It comprises over 200 projects, with thousands of scientists from over 60 countries examining a wide range of physical, biological and social research topics. Total expenditure will exceed $2 billion. The UK is contributing to 40% of these projects, and British marine scientists from NERC and elsewhere are participating in 33 international marine projects as part of this IPY effort. They include polar ocean monitoring, circumpolar studies of marine ecosystems, and polar gateways.

Support for Marine Science, Including Provision and Development of Technology and Engineering

28. NERC invests considerable funding in developing and providing platforms and technology for marine science, as well as in the infrastructure of its centres. In particular, it provides funds for: the maintenance and replacement of three research ships, the National Marine Facilities Division (NMF)[53] at NOCS, the National Facility for Scientific Diving, High-Performance Computing (HPC), airborne research facilities, Arctic and Antarctic bases, the new Centre for Earth Observation Instrumentation (jointly with DTI), ESA's environmental science missions, and several marine-related research programmes with a technology-development component. NERC also owns and provides the majority of funding for the BODC, hosted at POL.

29. Details of some of these are provided below; information on satellite-based research capabilities is provided in Annex 5. There is also further information about the research facilities available to scientists on NERC's website.[54]

Ships

30. NERC has two dedicated research ships, which are operated by the NMF. In June 2000, NERC changed its policy on the access procedures to these ships, resulting in a significant increase in ship-time usage. In turn, NERC significantly increased the operational funding from 2004–05 to allow both ships to be operated at full capacity. NERC schedules on average ca 550 science days at sea per annum to meet the requirements of highly graded responsive and directed-programme research, and demand for ship-time is expected to remain at current levels.

31. One of the ships, the *RRS James Cook,* will enter into scientific operation at the end of February 2007 to replace the *RRS Charles Darwin.* The *RRS James Cook* was built at a cost of £40 million, funded by NERC and the DTI/OST Large Facilities Capital Fund.[55] The procurement process followed consultation with the UK marine science community and thorough consideration of research requirements. The other dedicated research vessel, the *RRS Discovery,* was originally built in 1962 and underwent major conversion in 1992 to maximise its operational flexibility. The ship will be at the end of its scientifically useful life in 2011, and a joint NERC/Large Facilities Capital Fund funding bid of £60 million for a replacement was approved in 2006.

32. The NMF supports approximately 30 cruises per year, 20 of which are on the NERC research vessels. The Division also manages the National Marine Equipment Pool (NMEP), which consists of a wide range of equipment available to the UK marine science community, with an asset value of over £20 million. NERC provides £0.8 million per year to maintain and enhance this equipment.

33. NERC also supports the *RRS James Clark Ross* operated by BAS, and uses the *RV Prince Madog* operated by VT Ocean Sciences, and, as mentioned above, is involved in ship-time bartering arrangements.

[52] www.nerc.ac.uk/research/sites/facilities/marine/ofeg.asp
[53] www.noc.soton.ac.uk/nmf/
[54] www.nerc.ac.uk/research/sites/facilities/
[55] www.nerc.ac.uk/press/releases/2004/20-jamescook.asp

Aircraft

34. NERC operates two airborne facilities that can contribute to marine research. *The Airborne Research and Survey Facility* (ARSF) has a Dornier aircraft, leased prior to 2006 but then purchased for approximately £1.4 million to ensure the ongoing capability of the ARSF. The aircraft can be used for remote sensing of, eg algal blooms, and will be involved in campaigns in Iceland and Greenland during IPY. The BAE 146 of the *Facility for Airborne Atmospheric Measurements* (FAAM) can support research into ocean-atmosphere interactions.

Polar bases

35. NERC leases part of the Ny Ålesund International Arctic Environmental Research and Monitoring Facility, Svalbard, Norway[56] to house the NERC Arctic Research Station, which is managed by BAS.[57] Please see the separate submission from BAS regarding logistical capability (research stations and ships) in the Southern Ocean.

Technology development and engineering

36. A key theme within *Oceans 2025* is Technology Development. This has three main research units: Enabling technology for ocean telescience, Development of instruments, platforms and measurement systems, and Towards an optimal observing network. The theme involves scientists from SAMS, POL and NOCS. NOCS has the largest technology R&D team supporting UK marine science in its Underwater Systems Laboratory, which was responsible for developing Autosub, a long range, deep diving, autonomous underwater vehicle, whose design was licensed in 2001 for use in the oil, gas and undersea cable markets. The vehicle is now in the NMEP for use by the marine science community.

37. Through BGS, NERC develops technology for subsea drilling and sampling, and the BGS Marine Operations team is recognised as a world leader in development and management of marine drilling techniques. Its equipment is vital to many international research projects studying offshore mineralisation, marine geohazards, frontier exploration and evidence for past climate change.

38. NERC also supports technology development through its directed programmes, for example: Autosub Under Ice (in which NERC spent nearly £3 million on developing Autosub and its associated monitoring technology) and the SeaSense LINK programme, details of which are presented in Annex 3.

The British Oceanographic Data Centre (BODC)

39. The BODC[58] acts as a national facility for storing and sharing marine research data, and puts the UK amongst the world leaders in marine data management. NERC recognises the importance of long-term monitoring and the maintenance of long-term data sets, not least in the context of understanding the impacts of climate change on the marine environment.

40. Nearly 10,000 data variables are held in the BODC database, containing biological, chemical, physical and geophysical data that are used not only by NERC's research and collaborative centres, but also by many other groups in the UK in universities and stakeholder institutions, such as the Met Office, Hadley Centre and Natural History Museum, and by groups in many international institutions.

THE STATE OF THE UK RESEARCH AND SKILLS BASE UNDERPINNING MARINE SCIENCE AND PROVISION AND SKILLS TO MAINTAIN AND IMPROVE THE UK'S POSITION IN MARINE SCIENCE

41. Oceanography and earth science are two of the seven strongest areas of UK research in the environmental sciences. Bibliometrics analysis (using the ISI's Science Citation Indices) shows that in the environmental disciplines the ocean sciences make a major contribution; the UK is second only to the USA, and closing the gap.[59] For example, for sea-going science the UK has eighteen research groups in university departments graded 5 and 5* in the RAE, and four NERC-funded world-class marine research institutes (as recently judged by peer review).

42. NERC continues to support marine science national capability through its funding of research and collaborative centres, in particular through the *Oceans 2025* programme.

43. NERC funds many PhD studentships in marine science, and approximately 50 of these students are currently conducting research projects involving active participation in research cruises; in a typical year up to 350 scientists, engineers and students gain research training and experience on NERC's research ships.

[56] www.npolar.no/nyaa-lsf/

[57] www.antarctica.ac.uk/BAS_Science/Arctic/index.html

[58] www.bodc.ac.uk/

[59] Source: UK environmental science review report for the Environment Research Funders' Forum.

44. NERC intends to work closely with ERFF's planned review of the training needs that will be required to support environmental science in the UK (to meet academia, policy and commercial end-user needs). Without pre-judging the outcome of this review, specific sub-discipline areas which have recently been highlighted by NERC as areas of possible skills shortages requiring investigation include: taxonomy; physical oceanography; mathematical modelling; and deep-sea biology. In addition, NERC's data on studentship applications suggest that there is a tendency for below-average numbers to apply for studentships classified as mathematics/modelling; earth science; engineering; and physics, although biology, especially topics of research on birds, fish, vertebrates and invertebrates, remains well subscribed, as does polar science.

The Use of Marine Sites of Special Scientific Interest (SSSIs)

45. Marine SSSIs extend only to the low water mark, and are not a major feature of NERC's marine science, except in CEH's work on seabirds (see Annex 4). NERC's marine science is more connected with Marine Protected Areas (MPAs), for example Special Areas of Conservation (SACs). The Joint Nature Conservation Committee (JNCC) is responsible for defining offshore SACs (more than 12 nautical miles offshore), whereas the Countryside Council for Wales, Scottish Natural Heritage, Natural England and Northern Ireland Environment and Heritage Service are responsible for nearshore areas. NERC research centres work closely with these organisations to provide underpinning information and research. SMRU[60] provides the fundamental information used to define SACs for marine mammals, and this is likely to move from coastal into offshore regions that support particularly rich communities of marine organisms.

46. The absence of detailed national seabed maps based on modern techniques such as multibeam, and marine-penetrating LIDAR (for use in nearshore areas where there are restrictions on access for ships) is a major hindrance to sustainable development of our UK marine resources. Surveys funded by the conservation bodies are a vital but small part of the overall UK effort in marine mapping. In addition to NERC-funded research, other important information is collected by the MCA (Maritime & Coastguard Agency), the DTI (through the Strategic Environment Assessment programme), port authorities, the oil industry, marine renewables industry, marine aggregates industry and fisheries research organisations. NERC research institutes are in an excellent position to bring this vital information together to maximise its use for sustainable development of our marine resources and underpin multi-disciplinary research in the marine environment.

How Marine Science is being Used to Advance Knowledge of the Impact of Climate Change on the Oceans

47. Many NERC research programmes, under all three of NERC's strategic priorities (not just climate change) contribute to our knowledge of the impact of climate change on the oceans. However, NERC's overall portfolio reflects the fact that *the impact of the ocean on climate change* is equally important. Indeed, in considering system behaviour and future conditions (both involving feedbacks), with implications for energy policy and sustainable economic development, the two aspects are inseparable.

48. Several examples of NERC-funded studies relating climate change and the marine environment are provided in Annex 8. They concern: sources, sinks and transport of carbon within the Earth system; interactions between biodiversity, ecosystem function and climate change (including links between plankton survival and fisheries); adaptation of marine species to climate change, and conservation options; the prediction of future climate change; the role of the Atlantic's overturning circulation (and the possibility of a weakening of the Gulf stream); the world's ice sheets and potential sea-level rise; links between climate change and ocean-related natural hazards and disasters; implications for coastal-zone management and coastal defence; indirect impacts through marine renewable-energy developments; the exploitation of gas hydrates; and the potential for undersea carbon sequestration.

49. One of NERC's principal concerns is to improve our ability to predict the probability and magnitude of climate change and its effects, at the regional scale. Past climate data are being used to test and improve climate models to take account, for example, of climate feedbacks. Research is covering all marine environments, from the deep ocean to the coastal zones, and is bringing together observations made *in situ* and by satellite. NERC's new strategy is expected to highlight, among other things, the importance of research into ocean acidification, improved climate models, and gas hydrates as a potential energy source, and to emphasise an interdisciplinary Earth-system science approach.

January 2007

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[60] NERC has a statutory responsibility to monitor British seal populations (as required under the Conservation of Seals Act 1970). It discharges this through its sponsorship of SMRU.

Annex 1

NERC Research Centres

British Antarctic Survey (BAS)

British Geological Survey (BGS)

Centre for Ecology and Hydrology (CEH)

Proudman Oceanographic Laboratory (POL)*

NERC Collaborative Centres

Centre for Population Biology (CPB)

National Centre for Atmospheric Science (NCAS)

National Institute for Environmental eScience (NIEeS)

National Oceanography Centre, Southampton (NOCS)*

Plymouth Marine Laboratory (PML)*

Scottish Association for Marine Science (SAMS)*

Sea Mammal Research Unit (SMRU)*

Tyndall Centre for Climate Change Research

[Earth Observation Centres of Excellence]

Centre for Observation of Air-Sea Interactions and Fluxes (CASIX)

Centre for Observation and Modelling of Earthquakes and Tectonics (COMET)

Centre for Polar Observation and Modelling (CPOM)

Centre for Terrestrial Carbon Dynamics (CTCD)

Climate and Land Surface Systems Interaction Centre (CLASSIC)

Data Assimilation Research Centre (DARC)

Environmental Systems Science Centre (ESSC)

Marine Research Organisations in Receipt of Grant-in-Aid

Marine Biological Association (MBA)*

Sir Alister Hardy Foundation for Ocean Science (SAHFOS)*

* The term "the marine centres" in this memorandum refers to the centres marked with an asterisk. They are centres whose focus is marine science. As indicated in paragraphs seven and nine, many of the other centres listed in this annex also conduct marine or marine-related research.

Annex 2

Marine Consortium Grants

Atlantic Meridional Transect (AMT) Consortium (2002–06)

A consortium designed to analyse annual and longer-term variability in ocean ecology and biogeochemistry (especially linked to plankton populations and the turnover of organic matter) in the context of climate change.

ECOMAR Consortium (2006–09)

Ecosystems of the Mid-Atlantic Ridge at the Sub-Polar Front and Charlie Gibbs Fracture Zone

A project investigating how physical and biogeochemical factors, including topography, currents and organic input, influence the distributions and structure of deep-sea communities, focusing on the fauna of the Mid-Atlantic Ridge (MAR).

PAIN CONSORTIUM (2005–09)

"Next Generation" Unstructured-mesh Ocean Global Circulation Modelling

A project to build a next-generation ocean global circulation model that has more detailed resolution than existing models. It will be capable, among other things, of resolving flows simultaneously on global, basin, regional, and process scales, and will have a wide range of applications in oceanography, climate change, flood defence, pollution and contaminant dispersal, the analysis of water quality and the sustainability of fisheries.

WILLIAMS CONSORTIUM (2005–09)

Transport and storage of nutrients, carbon and heat in the subtropical North Atlantic ocean

This interdisciplinary consortium is addressing how the climate system is controlled in the subtropical North Atlantic Ocean by looking at the transport of heat, nutrients and carbon. The survey will complement RAPID- and AMT-supported surveys, and the three datasets will be analysed together. The controlling processes will be identified by taking targeted biogeochemical observations and their wider impact assessed by integrating circulation and biogeochemical models.

Chemosynthetically-driven ecosystems south of the Polar Front: biogeography and ecology (2008–12)

The consortium will study four contrasting chemosynthetic ecosystems in Antarctica south of the Polar Front. Analysis will compare the hydrothermal and seep chemistry of the four sites, determine the phylogeography of species, and examine the food web processes. The study will determine whether colonisation of vents and seeps, in these most isolated of chemosynthetically-driven ecosystems, is driven by oceanographic or tectonic processes or whether any site is, instead, host to completely isolated evolution.

Subduction zone segmentation and controls on earthquake rupture: The 2004 and 2005 Sumatra earthquakes (2006–11)

The Sumatran earthquake of December 2004 was the second-largest earthquake on record. The growing populations in regions prone to great earthquakes make it a matter of urgency to study the processes that control them. The Sumatran earthquake is the first to which modern geophysical tools can be applied, so offers a unique opportunity for such study. The consortium will examine the influence of plate boundaries (which divide tectonic plates into segments) on the spread of earthquakes, asking what determines whether an earthquake stays within one segment of plate boundary (and remains relatively small), or jumps across barriers between segments (to become a large earthquake).

DIMES: Diapycnal and Isopycnal Mixing Experiment in the Southern Ocean (2008–12)

One of the most important elements of ocean circulation is what scientists know as the "meridional overturning circulation" (MOC). This term describes the cooling and resulting sinking of surface water masses in high-latitude regions, their journey through the deep ocean and their eventual warming and return to the surface, after many decades or centuries. The MOC is important to climate because the water masses involved in this long circuit through the ocean carry with them heat, CO_2 and other significant substances such as plant nutrients, which in this way are distributed around the planet and locked away in the deep ocean for long periods of time.

Perhaps the stage of the MOC that puzzles scientists the most, and one of the most serious challenges to the reliability of climate simulations, is the return of deep water masses to the surface. To achieve a breakthrough in this problem, the consortium will directly measure mixing processes in the Southern Ocean and their effect on ocean circulation. These measurements, together with others, will help to answer several key questions.

Dynamics of gas hydrates in polar marine environments (2007–09)

Almost half of the Earth's carbon is stored in gas hydrates and related shallow gas deposits. Numerical models predict that this reservoir is highly mobile and that escaping gas has a significant potential to accelerate climate change by releasing as much as 2000 Gt of methane over a short period of time. As methane is a potent greenhouse gas it would cause further global warming. Arctic gas hydrates are particularly vulnerable to future climate change. The consortium aims to quantify the present amount of gas hydrates through seismic methods, to measure current methane flux from the seabed to the atmosphere, to detect the effects of postglacial warming on the gas hydrate system, and to predict the effect of a range of future temperature changes on the gas hydrates. This information will allow a detailed assessment of the mobility of Arctic gas hydrates and significantly decrease the uncertainties involved in climate modelling.

Annex 3

NERC'S MARINE-RELATED DIRECTED PROGRAMMES[61]

Recently completed programmes

Autosub Under Ice (AUI) [£5.86 million; 2000–06]

The primary objective of the AUI programme was to investigate the marine environment of floating ice shelves with a view to advancing the understanding of their role in the climate system. This entailed developing Autosub and associated world-class monitoring technology to allow access to this previously inaccessible environment under the ice.

Coupled Ocean-Atmosphere Processes and European Climate (COAPEC) [£4.85 million; 2000–05]

The goal of COAPEC was to determine the impact on climate, especially European climate, of the coupling between the Atlantic Ocean and the atmosphere, including the influence of the El Nio—Southern Oscillation on this coupling.

Environmental Genomics [£16.5 million; 2001–06]

The Environmental Genomics programme aimed to exploit existing and emerging genomic knowledge and technology to advance and test evolutionary and ecological theory, and so provide a better understanding of ecosystem structure and function.

Marine & Freshwater Microbial Biodiversity (M&FMB) [£7.0 million; 2001–05]

The aims of the M&FMB programme were (i) to improve our understanding of aquatic microbial biodiversity in the context of community interactions and ecosystem function, and (ii) to investigate the potential for biotechnological exploitation.

Marine Productivity [£6.5 million; 1998-2005]

The main aim of the Marine Productivity programme was to develop coupled modelling and observation systems for the pelagic ecosystem, with emphasis on physical factors affecting zooplankton dynamics.

Ocean Margins LINK [£4.5 million; 2000–05]

The UK together with Ireland shares an ocean margin over 1,500 km in length containing valuable oil and gas reserves but the economic benefits of this huge area have not yet been fully determined. The multidisciplinary Ocean Margins LINK programme aimed to improve geological understanding of ocean margins.

The SeaSense LINK [NERC funding of £1.5 million, DTI funding of £0.8 million; 1996–2003]

A collaborative programme designed to support innovative pre-competitive R&D of marine sensors. The programme targeted a growing market need for improved sensors for monitoring and managing the marine environment, and aimed to adapt and transfer sensor expertise developed by non-marine industry sectors and the science base, and create strategic links between the science base and industry.

Current Programmes

Flood Risk from Extreme Events (FREE) [£6 million; 2005–10]

The FREE programme is researching what causes and propagates floods, so helping to forecast and quantify flood risk, and will inform society about the likely effects of climate change. It is bringing together researchers in the hydrological, meteorological, terrestrial and coastal oceanography communities in an integrated research programme for the first time. It recognises and complements existing research and development programmes such as the Flood Risk Management Research Consortium (FRMRC)2.

[61] Funding levels are for total programme, not just the marine element. Further details are available at www.nerc.ac.uk/research/programmes/.

Integrated Ocean Drilling Programme (IODP) [£3.5 million; 2004–08]

The IODP is a major international research programme, primarily funded by the USA, Japan and a consortium of European countries. NERC, through BGS, is the lead agency in managing the operation of the European contribution, and has successfully led the first ocean drilling programme to core sediments beneath the ice near the North Pole. The results of this project are underpinning international science on the climate history of the Arctic region. Overall, IODP aims to provide a better understanding of plate tectonic processes, Earth's crustal structure and composition, environmental conditions and life in ancient oceans, and climate change. NERC funds many UK scientists to participate in this global science project and it is seen as an important part of the training programme for marine scientists.

Post-Genomics and Proteomics [£12.0 million; 2003–07]

This programme will focus on the application of integrated genomic and/or proteomic approaches to answering environmental questions in specific science areas of strategic importance to NERC and the UK.

Quantifying and Understanding the Earth System (QUEST) [£21.0 million; 2003–09]

The primary objective of QUEST is to achieve a better qualitative and quantitative understanding of large-scale processes and interactions in the Earth System, especially the interactions among biological, physical and chemical processes in the atmosphere, ocean and land and their implications for human activities.

Rapid Climate Change (RAPID) [£20.0 million; 2000–07]

The major objective is to improve our ability to quantify the probability and magnitude of future rapid change in climate, with a main (but not exclusive) focus on the role of the Atlantic Ocean's thermohaline circulation. Funding to continue the programme beyond 2007 has been identified, inter alia, as part of Theme 10 ("Integration of Sustained Observations in the Marine Environment") of Oceans 2025.

UK Surface-Ocean/Lower Atmosphere Study (UK SOLAS) [£10.3 million; 2003–09]

The main aim of the UK SOLAS programme is to advance understanding of the mutual interactions between the atmosphere and the oceans, focusing on chemical exchanges that affect both ocean productivity and atmospheric composition and climate.

Annex 4

(a) British Geological Survey (BGS) Marine Research

The outline work programme is subdivided into four settings. The "foundation and strategic work" is based primarily on fundamental 3D mapping and modelling and the "processes and applications" represents the value-added 4D and broader multi-disciplinary areas.

SETTINGS	*Foundation and strategic activities: data collection, and modelling the 3D sedimentological and geological framework*	*Processes and applications activities: modelling 4D processes and evolution under climatic, oceanographic and anthropogenic drivers*
Estuaries and associated alluvium	Survey and model generation of estuaries including the Thames and Clyde, collation of data on other estuaries (including international)	Modelling of estuarine morphological and habitat change and anthropogenic and biogeochemical land-sea fluxes (with POL, CEH, SAMS, HEIs)
Open Coast from the back of beach or cliff to wave base	Survey and model generation of "hard" and "soft" coasts with contrasting oceanographic climates, collation of data on other open coasts (including international)	Monitoring and modelling of erosion rates, changing sediment supply and biotopes across coast profiles (with POL, The Tyndall Centre for Climate Change Research, CEH, HEIs)
Continental Shelf from wave base to shelf break	Survey, data collation, and high-resolution model generation of shelf "landscapes" (including international). Physical modelling of shelf Quaternary deposits	Evolved modelling of marine habitats (with SAMS, Department of Agriculture and Rural Development Northern Ireland, Joint Nature Conservation Committee, UK Hydrographic Office, Maritime and Coastguard Agency, HEIs), Quaternary climatic feedbacks, evaluation of geohazards.

SETTINGS	*Foundation and strategic activities: data collection, and modelling the 3D sedimentological and geological framework*	*Processes and applications activities: modelling 4D processes and evolution under climatic, oceanographic and anthropogenic drivers*
Continental Margins from the shelf break to deep-ocean toe of slope	Survey, data collation and model generation of continental margins (including international), such as Hatton Bank and Rockall	Modelling the relationship between tectonics and climate, geohazards, shelf-margin biogeochemical stores (including hydrates) and fluxes (with POL, NOCS, HEIs)

(b) Centre for Ecology and Hydrology (CEH) Marine-related Research

Marine-relevant research is conducted mainly under CEH's programme on Biodiversity and Population Processes, within the Coastal Seas Ecology Group,[63] and is focused on seabird ecology. Some of the research is addressing the question of how seabird populations may be affected by climate change, both directly and through changes in the marine environment such as reduced food supply.[64]

Annex 5

Earth Observation Research Related to Marine Science

NERC provides the UK's subscription (~£34 million per annum) to the European Space Agency's (ESA) environmental sciences programmes, namely the Earth Observation Envelope Programme (EOEP) and Envisat/ERS operations, and a share of the UK's subscription to the general budget, covering more cross-cutting functions (administration, technology development, archiving, at around £7 million per annum). NERC also contributes, with Defra, DTI and the MoD, to phase one of the Global Monitoring for Environment and Security Space Component Programme (GMES SCP, £2.2 million over three years).

ESA's EOEP represents NERC's primary means of procuring new satellite missions. EOEP mainly funds the development and operation of innovative Earth Explorer science missions, providing EO data in support of environmental science covering a broad range of scientific subjects.[65] The scientific objectives of EOEP, as identified in the ESA's Strategy for EO,[66] are substantially similar to those of NERC. NERC also supports the operations of ERS-2 and Envisat, both carrying a wide range of instruments monitoring various components of the Earth's environment.

The Envisat and ERS satellites carry a number of instruments which provide oceanographic data, such as the radar altimeter profiling the sea surface, an advanced along-track scanning radiometer measuring sea-surface temperatures, and the medium resolution imaging spectrometer capturing data about biological activity of the oceans.

Scientists in NERC's Earth Observation Centres of Excellence have extensively used these data. The Centre for Observation of Air-Sea Interactions and Fluxes (CASIX) focuses on improving our understanding of how air and sea interact and measures the transport of carbon dioxide between sea and air on a global scale. This will improve our knowledge of ocean circulation models and the ocean carbon cycle in general. The Centre for Polar Observation and Modelling (CPOM) focuses on investigating processes of the Earth's polar climate in the atmosphere, cryosphere and oceans, combining models and satellite and in-situ data.

Approved (but not yet launched) ESA Earth Explorer missions of particular relevance to the oceans are the Gravity Field and Steady-State Ocean Circulation Explorer (GOCE) focussing on measuring the Earth's gravity field and modelling the geoid; the Soil Moisture and Ocean Salinity (SMOS) mission designed to observe soil moisture over the Earth's landmasses and salinity over the oceans; and CryoSat, investigating the extent to which global climate change is causing the polar ice caps to shrink, with potentially significant impacts on ocean circulation.

[63] www.ceh.ac.uk/sections/bpp/Coastal.htm

[64] www.ceh.ac.uk/sections/bpp/Seabirdsandclimatechange.html

[65] See www.esa.int/esaLP/ASEWGWNW9SC_LPearthexp_0.html and www.esa.int/esaLP/ESADQ0UHN6D_LPfuturemis_0.html for further details on the approved and candidate Explorer missions respectively.

[66] See http://esamultimedia.esa.int/docs/SP-1234.pdf for ESA's Strategy for EO. A follow-up document—"The Changing Earth—New Scientific Challenges for ESA's Living Planet Programme"—is available at http://esamultimedia.esa.int/docs/SP-1304.pdf

Annex 6

The Oceans 2025 Strategic Marine Research Programme

NERC Council, in response to a review of NERC's marine sector in 2005, called on the seven institutions* currently doing strategic marine research for NERC to collaborate and provide a more coordinated programme of work that meets NERC and UK's strategic needs. The *Oceans 2025* strategic marine science programme is a response to this call, and Council, at its November 2006 meeting, applauded both the positive response by the seven institutions and the quality of the proposal.

Oceans 2025—Key Facts

- Designed and implemented by a partnership of seven marine science institutions*.
- NERC funding to ca £116 million (plus large capital) spread over five years (2007–12); funding for the first two years at this level is assured, and the level of funding for subsequent years is contingent on the outcome for NERC of the 2007 Comprehensive Spending Review.
- The programme is composed of 10 science themes, one of which embraces long-term observation programmes.
- Each science theme within Oceans 2025 is composed of work packages delivered by different institutions, with their work coordinated across the theme.
- *Oceans 2025* includes two national facilities (the Permanent Service for Mean Sea-Level, and the Culture Collection for Algae and Protozoa), as well as the British Oceanographic Data Centre.
- The institutions will open up about 7.5% of their research programme budget (ca £1 million/year) to competition amongst NERC-eligible organisations, through calls for proposals aimed at delivering specific elements of the strategic research programme (the Strategic Ocean Funding Initiative; SOFI).
- A management board of the directors of the seven *Oceans 2025* institutions will assure programme delivery. Existing management/coordination resources within the institutions will be enhanced by a cross-cutting science coordinator role (to be appointed).

The creation and delivery of *Oceans 2025* produces scientific and organisational opportunities and challenges. In particular, knowledge transfer with stakeholders will benefit from a single programme.

Council has asked the Oceans 2025 directors to consider opportunities to increase further the effectiveness of delivery of NERC strategic marine science over the long-term.

An overview of the *Oceans 2025* programme is at http://www.oceans2025.org/

* Proudman Oceanographic Laboratory, National Oceanography Centre, Plymouth Marine Laboratory, Scottish Association for Marine Science, Sea Mammal Research Unit, Marine Biological Association, Sir Alister Hardy Foundation for Ocean Science.

Annex 7

Examples of NERC Marine International Collaboration

(a) *International collaboration through NERC Directed Programmes*

Marine and Freshwater Microbial Biodiversity (M&FMB)

M&FMB dramatically raised the profile of UK aquatic microbial research at an international level. International cooperation included work with JAMSTEC (using the Japanese submersible Kaiko); the Institute of Microbiology, Bergen (with sampling from a Norwegian research vessel); and biochemical and pharmaceutical studies at the University of Tubingen, Germany. The species inventory studies at Priest Pot involved Spanish, German, French and Russian research groups, and a comparable coastal analysis was carried out at Nivå Bay, Denmark.

Marine Productivity

The GLOBEC International Project Office has been hosted at PML since 1999, with initial funding from the budget of the Directed Programme Marine Productivity. Marine Productivity fieldwork in the northern North Atlantic used GLOBEC contacts to develop collaborations with US and Icelandic groups for data exchange, and with Canadian groups to arrange direct participation in their research cruises.

RAPID

RAPID initiated and set up a working collaboration with the National Science Foundation (NSF) in the USA to co-design and co-fund the MOC monitoring system. Joint review and evaluation of proposals took place, which led NSF to invest a further £5 million in studies complementary to the RAPID funded MOC monitoring studies. The National Atmospheric and Oceanographic Administration (NOAA) is also contributing in kind, in terms of observations and ship time.

RAPID issued a Joint international AO for proposals involving researchers in the Netherlands, Norway and the UK. The Netherlands Organisation for Scientific Research (NWO) and Research Council of Norway (RCN) agreed that the scientific scope of the funding call be focused on the scientific objectives of the RAPID programme. A total of €4 million was made available to promote cross-national projects in the area of rapid climate change research. RAPID has also resulted in links with the Max Planck Institute for Meteorology, Hamburg.

UK SOLAS

This programme has obtained German co-support for an international ocean-atmosphere observatory on the Cape Verde islands, and US support is under negotiation.

(b) *International collaboration through NERC Research and Collaborative Centres/Grant-in-Aid Funded Organisations*

BAS

BAS participates in the international Scientific Committee for Antarctic Research (SCAR).

Much of BAS's work has international implications, for example in policy making. One practical example of BAS science in action, with immediate benefits, is the provision of sea-ice information, in real time, to vessels in Antarctic waters. The impact of BAS science on policy can be seen in the Census on Antarctic Marine Life, in which BAS are playing a lead role. The BAS science research vessel *RRS James Clark Ross* will contribute in the Arctic during IPY, as will the NERC research station (managed by BAS) at Ny Ålesund. Further information about Antarctic marine science is in the separate submission from BAS.

BGS

BGS is a member of MESH (Mapping European Seabed Habitats), an EU project studying techniques for underpinning ecosystem mapping and evaluation. This is a key step in understanding the distribution of marine ecosystems and developing a policy for the sustainable use of marine resources and defining special areas of conservation. BGS works closely with the Joint Nature Conservation Committee (JNCC), the Centre for Environment, Fisheries and Aquaculture Science (CEFAS) and other agencies in this area, and is working to develop a new integrated approach to modern seabed mapping. BGS also receives support through the aggregate levy for this work.

MBA

The MBA is the coordinator of two EU projects (Marine ecosystems regulation and Functional Genomics of the Algae), a member of both the Marine Genomics and Marine Biodiversity and Ecosystem Functioning Framework 6 EU networks of excellence and a partner in 15 EU projects.

NOCS

NOCS leads HERMES (Hotspot Ecosystem Research on the Margins of European Seas), one of the new EU Integrated Research Projects. It also directs ChEss (ChEss: Biogeography of Deep-Water Chemosynthetic Ecosystems) one of 10 pilot projects within the worldwide initiative Census of Marine Life. The aim of ChEss is to determine the biogeography of deep-water chemotrophically-driven ecosystems and to understand the processes driving them.

NOCS also participates in several other European and international projects (see NOCS submission).

NOCS hosts the International Project Office (IPO) of the World Climate Research Programme (WCRP) study on Climate Variability and Predictability (CLIVAR); and until recently also hosted its World Ocean Circulation Experiment (WOCE) IPO.

Two members of staff work full time on, and several others contribute as necessary to, the NOCS applied research programme dealing with governance of the world's oceans, UNCLOS.

PML

PML is part of three EU Networks of Excellence: the Marine Biodiversity and Ecosystem Functioning network (MarBEF), the EURopean OCean Ecosystems ANalysiS network (EUR-OCEANS) and the "Marine Genomics Europe" (MGE), and hosts the International Project Office of GLOBEC (Global Ocean Ecosystem Dynamics).

POL

POL has expertise in sea-level science (global and regional) and in ocean dynamics as revealed by a geodetic perspective (sea level and bottom pressure). Earth observation expertise focuses on altimetry and space gravity. Also major expertise in physical oceanography of coasts, shelf seas and ocean margins, and in the development of advanced coastal ocean hydrodynamic models (coupled to ecosystem models with PML). Marine technology expertise is focused on sea-level measurement and coastal sediment physics (via Coastal Observatories).

POL plays a key role in the Global Sea Level Observing System (GLOSS—a programme of UNESCO's Intergovernmental Oceanographic Commission IOC), and hosts the (world-wide) Permanent Service for Mean Sea Level.

SAHFOS

SAHFOS receives funding from and collaborates with scientists from Australia, Canada, Denmark, Faeroes, France, Iceland, Ireland, Netherlands, Portugal, South Africa and the USA. It is a member of EU Marine Biodiversity and Ecosystem Functioning network (MarBEF) and the EURopean OCean Ecosystems ANalysiS network (EUR-OCEANS) Networks of Excellence. It is a member of the international Partnership for Observation of the Global Ocean (POGO). SAHFOS also runs a subsidiary laboratory in Canada.

SAMS

SAMS has impressive Norwegian and Swedish collaboration appropriate for the Northern Seas Programme. It has developed particularly close links with the Norwegian Polar Institute, and also has good relations with European partners in the Arctic. It is hosting the IPO and Project Officer for Euro Census of Marine Life, 2005–08.

Annex 8

MARINE SCIENCE AND CLIMATE CHANGE

Climate change is one of NERC's three current strategic priorities, but questions about the impacts of climate change on the marine environment (and vice versa) are being addressed under all three priorities. Examples of questions being investigated by NERC-funded researchers are given below.

STRATEGIC PRIORITY 1: EARTH'S LIFE SUPPORT SYSTEMS

What are the sources, sinks and transportation processes of carbon within the Earth system?

The ocean contains around 95% of the world's mobile carbon. Small changes in either annual inputs of carbon dioxide (CO_2) to, or outputs from, the ocean result in much larger changes in atmospheric levels, with consequent implications for climate change. Studies of the dynamic behaviour of ocean circulation, chemistry and biology are critical to reducing uncertainty in global climate modelling.

The build-up of CO_2 in the oceans has made surface waters more acidic than they have been for millions of years. Ocean acidification is likely to continue, and NERC expects to make the study of its effects a priority in the Earth-system-science approach in its emerging strategy.

NERC marine carbon processes work extends from remote satellite modelling studies, to determine large-scale ocean dynamics, through to experimental sea-going studies, to sample in specific areas and interfaces. These studies encompass the coast and open ocean examining both the upper ocean and sea bed processes. The most relevant are included in the programmes of CASIX, PML, SAMS and NOCS.

What is the role of biodiversity in ecosystem function, and what are the consequences of biodiversity loss on ecosystem processes, particularly those involving micro-organisms?

Work is being carried out to assess how changes in biodiversity can be detected and measured together with studies on what functional consequences would result from change. These studies extend from the genetic level to whole organisms, such as marine mammals, and cover a broad geographical scope extending to the polar regions.

The M&FMB programme has contributed significantly to this area, as are programmes at BAS, MBA, PML, SAMS and SMRU. Long-term surveys carried out by SAHFOS have shown dramatic changes in the pelagic systems of the North Atlantic in recent decades, with northerly movement of cold-water plankton without their replacement by warm-water species.

STRATEGIC PRIORITY 2: CLIMATE CHANGE

How has the climate changed in the past, and how will it change in the future? How can we separate natural climate change from that caused by the activities of humans? Will long-term gradual change predominate, or can we expect to see abrupt climate change at the regional scale?

Much work has been carried out on oceanographic variability and the interactions between the atmosphere and oceans in order to better understand the role that they have in governing the variability of the Earth's climate. Current research is now seeking to establish the probability and magnitude of future climate change, and to determine past climate change by looking at palaeo data records. Studies have also focused on both natural forcing functions and anthropogenic influences on climate change. These include work on processes originating in the Antarctic and the sensitivity of the global climate system to them, and work in the Arctic as an area of sensitivity in which marine processes are crucial to understanding short term (sub-decadal) impacts.

The RAPID and COAPEC directed programmes, and programmes at BAS, CASIX, SAMS and NOCS are particularly relevant.

What is the role of the Atlantic's overturning circulation in regulating climate? What are the causes of, and changes in, the variability in the North Atlantic oscillation?

In addition to the work undertaken through centre programmes (NOCS, SAMS) on the circulation in the Atlantic, key components of both the RAPID and COAPEC programmes have focused on the Atlantic overturning circulation. Examples of issues that have been examined are: the role of air-sea forcing, the role of sloping topography, the role of salinity, balancing of heat and freshwater budgets, heat transfer and storage, variation in these processes and their impact on the global climate. BAS work in the Antarctic has examined how the dense water masses in the Antarctic influence the global ocean circulation.

What are the physical, chemical, geological and biological consequences of climatic perturbations on the world's ice sheets?

The primary objective of the AUI programme is to investigate the marine environment of floating ice shelves with a view to advancing the understanding of their role in the climate systems, and together with core programme work undertaken by BAS the knowledge base in this area has been greatly expanded.

What are the biological and geological feedbacks on the climate system in response to climate change? How will natural climate-erosion feedback be modified by climate change, and what will the impacts be?

In order to provide greater understanding of the climate system, work is being undertaken from the microbial to ecosystem level. Modelling studies are being carried out in conjunction with this work towards determining the impacts of variations in the climate system as a result of climate change.

The UK SOLAS directed programme, and programmes at MBA, PML and SAMS are particularly relevant.

What are the past-century trends in European and UK mean and extreme sea-levels? What are the causes of sea-level change and can we accurately predict the changes from a combination of climate and geodynamic models?

Studies are being undertaken not only to evaluate past trends in mean and extreme sea level, but also to compare these measurements to climate and geodynamics models in order to establish how well they perform. Developmental research is being undertaken to improve the current techniques of sea level monitoring, which should provide greater understanding of sea level change. This type of work extends from the European to Antarctic climate, where work is being conducted to establish the history of ice sheets and subsequently use this information in ice-sheet simulation models.

BAS, BGS and POL programmes are particularly relevant.

How strong is the link between climate change and natural hazards and disasters, such as storms, coastal erosion, floods, landslides and drought?

Interdisciplinary work, from estuaries and coasts to the deep oceans, is being undertaken to examine how the different processes in the marine environment that contribute to climate control may be linked to natural hazards. This work includes topics such as sediment dynamics and coastal defence, and ocean-atmosphere interactions.

Whilst submarine landslides and similar geological events can occur independently of climate change, it is possible that climate-change-related changes in sediment stability (eg related to gas hydrate release) could increase the probability of tsunami-generating events.[67]

The COAPEC directed programme, and BGS and PML programmes are particularly relevant.

How will terrestrial and marine species adjust to climate and environmental change, especially within the fragmented land uses of Europe? How can conservation practices assist the process of adjustment?

Underpinning research is being conducted in order to provide a greater understanding of marine ecology—towards establishing those factors that may limit and control population dynamics and distribution. From this base, work is now being undertaken to try and predict how marine species may be impacted by both natural and anthropogenic changes in their environmental conditions. The implications for ecosystem functioning are being considered.

The Marine Productivity directed programme, and programmes at MBA, NOCS, SAMS and SMRU, and the AMT consortium, are particularly relevant.

What are the impacts of climate change on continental shelves, and what are the implications for coastal-zone management?

Through direct measurements and modelling methods, changes in the continental shelves, as a result of climate change, are being investigated. Part of this work is focused on establishing how this may impact upon costal defences, which will be essential in determining the implications for coastal zone management. Ecological impacts of and habitat creation by sea defences have been investigated to inform environmentally sensitive design.

BAS, BGS, MBA, PML, POL, and SAMS programmes are particularly relevant.

STRATEGIC PRIORITY 3: SUSTAINABLE ECONOMIES

What are the environmental, economic and social impacts of renewable energy sources in terms of their complete generation cycles, including power source, infrastructure, and site impacts?

Through collaborative work POL is seeking to develop models that can demonstrate the impacts of anthropogenic activities such as the establishment of offshore renewable energy operations. The SAMS artificial reef programme contributes to our understanding of artificial ecosystem creation and manipulation required for the foundations of offshore windfarms and tidal barrages. Work on the physics of tidal jets in fjords is being used to assess the potential of tidal barrages in sea loch systems.

What are the environmental risks of exploiting gas hydrates as an energy source? What is their role in large undersea slumps, which could result in dangerous tsunamis, as well as climate variability? What scope is there for under-sea carbon sequestration?

Work is being carried out on gas hydrates towards assessing them as a hazard and potential energy source. Together with work on habitat mapping, and improvements in prediction (for exploration) and reservoir characterisation, the understanding of marine geohazards and their potential impacts are becoming better understood.

The Ocean Margins LINK directed programme, BGS and NOCS programmes, and the new "Dynamics of gas hydrates" consortium are particularly relevant.

Through BGS and PML, NERC is also assessing the appropriateness and potential impact on the marine environment of under-sea carbon sequestration.

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[67] Natural Hazard Working Group (2005) *The role of science in physical natural hazard assessment.* Report to UK government, OST, 42 pp.

Memorandum 30

Submission from the Engineering and Physical Sciences Research Council (EPSRC)

1. The Engineering and Physical Sciences Research Council (EPSRC) is responsible for promoting and supporting basic, strategic and applied research within its remit for the benefit of the UK. The EPSRC mission is:

- to promote and support, by any means, high quality basic, strategic and applied research and related postgraduate training in engineering and the physical sciences;
- to advance knowledge and technology, and provide trained engineers and scientists, to meet the needs of users and beneficiaries thereby contributing to the economic competitiveness of the United Kingdom and the quality of life of its citizens; and
- to provide advice, disseminate knowledge, and promote public understanding in the fields of engineering and the physical sciences.

2. The EPSRC currently invests around £650 million a year in the science base for research and training in engineering and physical sciences with a view to ensuring that the UK will be prepared for the next generation of technological change.

3. The EPSRC welcomes the opportunity to respond to this Inquiry. Further details on EPSRC activities are available at www.epsrc.ac.uk.

Organisation and Funding of UK Marine Science in the Polar and Non-polar Regions

EPSRC research funding

4. EPSRC supports marine science where there is a strong engineering or physical science element. EPSRC also supports coastal marine research and some areas of underpinning physical science of relevance to marine science. The following research areas are covered in this memorandum:

- Coastal and waterway engineering: research on coastal and waterway structures, coastal and waterway management, coastal defences (both "soft" and "hard" defences), beach replenishment, estuarine engineering, reservoir and dam engineering and hydrodynamics (including action of currents and waves, sediment transport, mixing processes, and coastal, estuarine and river dynamics and offshore hydrodynamics).
- Fluid dynamics: involves the study of fluids (solid, liquid or gas) moving around structures. It includes techniques covering computational fluid dynamics (CFD), finite element analysis. This is relevant for the study of water flow around marine structures.
- Marine engineering: involves the interaction between the oceans and marine structures, both mechanical effects and hydrodynamic interactions. Also includes the design of Marine craft and structures.
- Marine Energy: involves the research of wave and tidal energy systems. Most work in this area is done by the Supergen Marine Energy Consortium.

5. Due to the nature of marine science, much of the research EPSRC supports interfaces with the remit of other research councils, such as the Tyndall Centre for Climate Change Research (EPSRC, NERC and ESRC) and the UK Energy Research Centre (EPSRC, NERC and ESRC). It should be noted that the aforementioned programmes have some marine science but are mainly focused at broader environmental and related issues. Please also note that NERC is submitting its own evidence to this inquiry.

Funding mechanisms

6. The main funding mechanism for marine-related research is responsive mode, which allows novel, blue skies research ideas to be submitted by researchers on any research area within EPSRC's remit for peer review. Applications are judged in competition on the basis of scientific excellence, independently refereed by experts nominated by the applicants and by EPSRC.

7. Some marine research is also funded through managed activities which are usually specific to key technology themes, such as the Sustainable Power Generation and Supply Programme. EPSRC also supports the Flood Risk Management Research Consortium (FRMRC www.floodrisk.org.uk), which includes research into coastal defences and flooding.

Current EPSRC marine science research spend for financial years 2006–07, 2007–08 and 2008–09:

Financial Year	*Total annual marine science spend*
2006–07	£3,138,849
2007–08	£3,519,717
2008–09	£2,966,241

Please note that the above list is for current grants only. Grants to be announced and planned future activities are not included.

THE ROLE OF THE UK INTERNATIONALLY, AND INTERNATIONAL COLLABORATION IN MARINE SCIENCE

8. International collaboration is taking place in most of the large research projects in this area. The Tyndall Centre specifically seeks to inform international climate change policy. The Marine Supergen consortium also has close links with Eire, France and the Netherlands within the EU, as well Japan and the US. It is currently making links with China. UKERC has strong international links and represents UK energy, including marine energy, at such organisations as the OECD. EPSRC has also recently provided assistance to the Foreign and Commonwealth Office Global Opportunities Fund under their Flooding and Coastal Defences call.

SUPPORT FOR MARINE SCIENCE, INCLUDING PROVISION AND DEVELOPMENT OF TECHNOLOGY AND ENGINEERING

9. The current total spend value of the EPSRC portfolio in marine science for this financial year and the next is shown above. Current project commitment is £12.6 million, £3.3 million commitment for coastal engineering and £9.3 million commitment for marine engineering. Most of this support is made through the responsive mode, However, £2.6 million is directed through the Supergen Marine Energy Consortium which is part of a directed call for renewable energy generation research.

Please note the total funding does not include the £2 million contribution that EPSRC makes to the Tyndall Centre, as only part of this funding goes to marine science activities.

10. EPSRC has recognised the importance of marine energy research and has proposed that marine renewable energy be nominated as a subject for a Science and Innovation Award in the next call. The purpose of Science and Innovation Awards is to secure strategically important research areas that require capacity building in the UK. They are large, long-term grants (typically £3–5 million over five years) supporting staff in a research group, with commitment from the host Higher Education Institution(s) to continue support after the end of the grant.

11. The Tyndall Centre for Climate Change Research is funded by NERC, EPSRC and ESRC. The Centre's total budget for the second phase of funding is £5.677 million over three years. The Centre's purpose is to research, assess and communicate from a distinct trans-disciplinary perspective, the options to mitigate, and the necessities to adapt to, climate change, and to integrate these into the global, UK and local contexts of sustainable development. Tyndall's Sustainable Coast Programme addresses the vulnerability of the coastal regions to increased sea levels, changing storms and other climate changes by developing integrated methods for analysing adaptation options for the sustainable governance of coastlines. The total expenditure in this theme is expected to be in the region of £613k over the life of the current funding phase. More information on the Tyndall Centre can be found on their website, http://www.tyndall.ac.uk/index.shtml. Specific information on the Sustainable Coasts Programme can be found here:

http://www.tyndall.ac.uk/research/programme5/programme5.shtml

Supergen Marine Energy consortium

12. The major EPSRC activity in marine energy is the Sustainable Power Generation and Supply Marine Energy research consortium. Information on the specific activities can be found on their website www.supergen-marine.org.uk. The Marine Energy Consortium is a £2.6 million (commitment) project headed by Professor Robin Wallace at the University of Edinburgh and involves Heriot-Watt University, Lancaster University, Robert Gordon University and the University of Strathclyde. It is closely collaborating with 27 energy companies, including large companies such as Siemens, QinetiQ, and Scottish and Southern power, as well as many small renewable energy companies.

13. The Marine Energy Consortium funding has recently been renewed and will bring the Queen's University Belfast into the consortium. Funding will increase to £5.5 million (commitment) for the next phase of work that will run from the 1 October 2007 to the 31 September 2011. The programme includes work on: device arrays and how these will influence local and regional environmental conditions; radical design approaches, which take into account new philosophies of design guidance; ensuring that numerical and physical design support is consistent and robust; the challenges posed by design in mixed tidal and wave

environments; system control in complex non linear and evolving environments; the complex challenges posed by fixing, mooring and recovery of marine systems; the economic challenges posed by the variable and intermittent nature of the marine resource; the sparse information available to predict and assess the long term reliability of marine energy systems and how an increased understanding of all of these issues can be best disseminated within the stakeholder community.

14. The UK Energy Research Centre is supported by EPSRC, ESRC and NERC. It was set up in 2004 to be a centre of research, and source of authoritative information and leadership, on sustainable energy systems. UKERC organises its networking and research activity under six related themes:

— Demand Reduction.
— Future Sources of Energy.
— Energy Infrastructure and Supply.
— Energy Systems and Modelling.
— Environmental Sustainability.
— Materials for Advanced Energy Systems.

And four functions:

— Technology and Policy Assessment.
— Meeting Place.
— Research Register.
— Energy Data Centre.

The State of the UK Research and Skills Base Underpinning Marine Science and Provision and Skills and to Maintain and Improve the UK's Position in Marine Science

Marine research in UK universities

15. The main universities with strength in marine engineering are the University of Strathclyde, the University of Edinburgh, Southampton University, the University of Newcastle and Imperial College London. Many other UK universities have capability in this area also. It should be noted that most of the universities strong in marine engineering are in the traditional shipbuilding cities. Many of these have transferred their skill to serve the offshore oil industry. Additionally many of these universities have now acquired capability in marine energy generation research.

Skills base

16. As with many scientific disciplines the supply of undergraduates in this area is of general concern. Undergraduate courses are of course outside the remit of EPSRC. However it does impact on the provision of suitable candidates for the post graduate research and training, which is our remit. Marine research capacity related to energy is a specific concern to EPSRC—hence its consideration for inclusion in the next round of S&I awards.

Links to other relevant UK groups

17. EPSRC is represented on both the Aerodynamics National Advisory Committee (ANAC) and the Hydrodynamics National Advisory Committee (HNAC) that reports to the ANAC. The HNAC is undertaking a roadmapping exercise into marine engineering capabilities in the UK. The HNAC has input into the DTI marine sector technology plan that can be seen on the link below.

http://209.85.135.104/search?q=cache:wARS0cfJY_YJ:www.dti.gov.uk/files/file21438.doc+hydrodynamics+national+advisory+committee&hl=en&gl=uk&ct=clnk&cd=1

Use of Marine Sites of Special Scientific Interest

18. EPSRC-supported research would not ordinarily involve the use of SSSIs. The academic study of these areas would fall mainly under the BBSRC or NERC remit.

January 2007

Memorandum 31

Submission from the Directors of the NERC Funded Marine Laboratories

Executive Summary

This response, made jointly by the Directors of the UK Marine Research Centres who receive strategic funding for marine science from the Natural Environment Research Council (NERC), highlights the importance of understanding our oceans and the role they play in the global earth system. We note the increasing emphasis on more integrated approaches to policy making at National and EU level. We welcome the increasing trend (in which we are a driving force), for the marine science community to self organise and coordinate, nationally and internationally as we strive to address the major research and observation challenges that cannot be undertaken by a single institution or even nation on its own.

We comment on the organisation and interaction of the marine science community in the UK, and the positive benefits that we anticipate will arise as a result of our coordinated approach through Oceans 2025. We express the need to continue to support a full range of research from individual "blue skies" activity to strategic research and the need for sustained support for specialist infrastructure, technology and platforms, including ships. The need to collaborate internationally, and opportunities for the UK to take a leading role are highlighted. We draw attention to issues concerning availability of sustained funding for ocean observations which is currently drawn from the research base and we highlight a wider need to address the anticipated weaknesses in the state of the UK research and skills base.

The Oceans 2025 Marine Directors Forum

1. This collective response is made by the Directors of the UK Marine research Centres who receive NERC strategic funding for marine science:

- National Oceanography Centre, Southampton NOCS, Director Professor Ed Hill,
- Marine Biological Association MBA, Director Professor Steve Hawkins,
- Plymouth Marine Laboratory PML, Director Professor Nick Owens,
- Proudman Oceanographic Laboratory POL, Director Professor Andrew Willmott ,
- Sir Alister Hardy Foundation for Ocean Science, SAHFOS, Director Professor Peter Burkill,
- Scottish Association of Marine Science SAMS, Director Professor Graham Shimmield, and
- Sea Mammal Research Unit SMRU, Director Dr Ian Boyd.

2. Our submission is tailored in particular respect of the new NERC Strategic Programme Oceans 2025, which we will be undertaking collaboratively between 2007 and 2012. Oceans 2025 will address the key science challenges, embracing knowledge transfer to the wider stakeholder community, and provide the basic underpinning to ensure that the best UK science is available to protect our marine environment. Further detail on the Oceans 2025 programme may be found in Annex 1.

The Importance of the Oceans

3. The marine environment is the subject of growing public interest. The oceans are integral to the regulation of our planet as the major reservoirs of carbon and heat, and so understanding our oceans is key to better prediction of future climate scenarios. We also expect that the largest impacts on people arising from climate change will be the increased exposure to flood risk from the sea.

4. There is a progressive international trend towards more integrated policies for maritime activities and the marine environment (eg Australia's Ocean Policy; Canada's Oceans Act 1997; USA's Oceans Act 2000). The European Commission is presently consulting on broad-ranging Maritime Policy Green Paper. The Marine Thematic Strategy Directive (intended as the environmental pillar of the proposed Maritime Policy) is presently being negotiated. In the UK, the proposed "Marine Bill" is part of the Government's response to this wider call for a more integrated approach to marine regulation which has for some time been perceived as complex and confusing. A move towards an "ecosystem-based" approach to management of human activities in the marine environment is a common thread through all proposals. This demands a robust scientific underpinning if it is to be achievable and defendable.

5. The fundamental context for management of the marine environment is global change, including climate change as the Stern review has highlighted. In the 21st century marine science is fundamentally concerned with decadal scale variability (and science integral to sustained observing on these scales) and its

interaction with shorter and longer time scale phenomena in the larger earth system. There is consequently strong interest in the interfaces between the ocean and other parts of the earth system (eg land-ocean, atmosphere-ocean and ice-ocean interactions) and the need to be much more in tune with changes taking place so we can rapidly assess their significance and adapt and respond accordingly.

6. Within this context the key roles for science are three fold:

— gain deeper understanding of fundamental earth system processes (so we know what is going on);

— develop better prediction and scenario testing systems (models) and sustained and properly specified global and regionally observing systems—so we are more continually aware of changes in the earth system—and can predict what might happen next; and

— inform and guide public policy, regulation and management and help find the innovative solutions and opportunities to live and do business in a changing world;

7. The key roles for marine science in helping formulate practical policy and regulations such as those under consideration in the UK and Europe include:

— identifying and filling key knowledge gaps;

— investigating the non-linearities (possible "tipping points") in the marine system;

— contributing to developing a definition of "good environmental status" that is more than just a "value judgement by society" and one that can be turned into a sound basis for effective monitoring and assessment and recognises the inherent variability in natural systems;

— designing, optimising and reviewing the effectiveness of monitoring programmes;

— developing novel technologies for reliable measurements in the parts of the marine system that matter;

— providing the techniques to include the fourth dimension (time) into marine spatial planning systems;

— developing next-generation modelling and simulation tools for marine spatial planning and ecosystem based management;

— putting the marine system in its wider earth system context with better knowledge of the key earth system interfaces; and

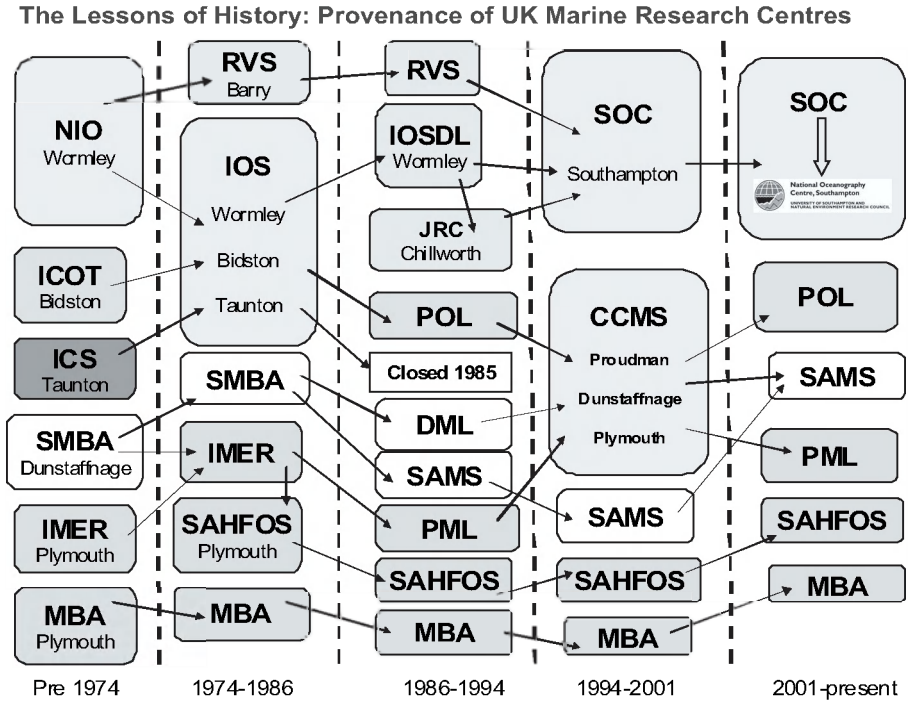
— horizon scanning, evaluating and rapidly communicating to policy-makers new knowledge (eg ocean acidification was not fully appreciated until a couple of years ago);

Detailed Response to Questions Raised by the Inquiry

1. *Organisation and funding of UK marine science in the polar and non-polar regions*

Organisation

8. The present configuration of the NERC funded marine research centres is the product of three previous alignments of these institutions (summarised in simplified form in diagram1 and further detailed in Annex 2). This present configuration of marine research centres has existed for only a relatively short period (since 1 April 2001) and resulted in particular from the break up of two former major distributed centres (Institute of Oceanographic Sciences, IOS; and Centre for Coastal and Marine Sciences, CCMS), though some institutions have been in existence for over a century (MBA and SAMS) and are themselves learned societies. The Sea Mammal Research Unit (SMRU) has specific responsibility for delivering NERC's commitment to advise Government about the management of marine mammal populations under the terms of the Conservation of Seals Act 1970.



9. It is fair to say that if starting with a blank sheet we would not necessarily recommend the organisational outcome as now presented. Nevertheless, there have been important benefits achieved in reaching the current position:

- a set of stable ownership models has been established;
- greater clarity has been injected into the funding arrangements of these centres and the national facilities they host;
- the institutions are financially stronger and a number of the infrastructure issues have been addressed [though some remain]; and
- the diversity of ownership models has widened funding opportunities and drawn a wider diversity of stakeholders into support of strategic marine science.

10. We do not see a case for further large scale organisational changes at the present time. The current structures give a base on which to further improved collaboration and coordination. This is being tackled from the science funding perspective particularly by synchronising the NERC strategic funding of the various institutions through the new Oceans 2025 programme which will make planning and collaboration between ourselves much easier than now.

11. We were pleased that NERC Council in December 2006 allocated Oceans 2025 approximately £120 million over five years, representing a modest uplift overall, though this is not distributed uniformly across the areas of science or our respective institutions, and there are some areas where we will need to seek other funding providers to maintain and develop specific capabilities. NERC Council recognised the immense value of this new coordinated approach. Professor Sir Howard Dalton, Chief Scientific Advisor to Defra in his press comment noted that "Government departments and agencies must also rise to the challenge of working closely with Oceans 2025 as it evolves, to ensure that this tremendous opportunity [to use ocean research findings to protect and sustainably manage and develop our seas] is taken."

12. Reaching agreement on a coordinated, co-operative research programme of the scale and complexity of Oceans 2025 is a very important step. The programme will start in April 2007 and we are currently addressing the implementation issues and the challenges to develop a truly multidisciplinary ocean science community in the UK. As a part of this we intend to continue our interaction as Marine Directors through the establishment of a UK Marine Directors forum:

- To facilitate in an inclusive way the strategic coordination and delivery of NERC's strategic marine research programmes, in particular but not exclusively linked to Oceans 2025.
- To develop collective approaches within the marine science and technology community for issues of common interest.
- To provide where appropriate a single voice to stakeholders on key policy initiatives.
- To champion UK marine science and adopt coordinated and concerted approaches to its promotion at an international level through media, international representation and presence at key meetings etc.

13. Each of our centres undertakes collaborative research projects with a range of centres of academic excellence within the UK, Europe, and internationally through a wide range of funding mechanisms. This will be further facilitated under the Oceans 2025 initiative where we have allocated some 7.5% of the direct research funding to a new Strategic Ocean Funding Initiative (SOFI). This will open up strategic funds for universities and other partners to bid for. Further details of the links between our Centres and with other institutions, with Universities and with industry are given in Annex 3.

FUNDING

14. NERC's response to this consultation addresses the range of programmes and mechanisms it supports. These range from blue skies research grants to strategic programmes and support for knowledge transfer. It is critically important that the requirement for strategic long term funding is fully recognised because progressing the science of decadal scale changes in the ocean and earth system requires sustained multiyear observing programmes and infrastructure and the availability of national capability with sufficient critical mass. Oceans 2025 draws out very clearly the contribution to national capability made by our sustained observing programme and research infrastructure. The latter is integral to our science challenges, which fundamentally concern understanding decadal-scale variability in the earth system. We are greatly encourages that NERC increasingly recognises this need and hope that it will continue such support in future. However the issue of supporting long term observational capacity is not just a NERC or even a solely UK issue (see Paras 27,28).

15. NERC has generally supported strategic funding in its Centres through rather rigid five-year funding blocks. This has had the tendency to:

(a) inhibit joined up strategic programmes if these are on different timelines,

(b) expose Centres to the risk of 5 year funding levels being dependant on the state of available NERC funds at the time of bidding.

16. Through Oceans 2025 we have overcome much of the first difficulty through aligning much of the strategic marine programmes. NERC is moving to new arrangements for strategic funding through its proposed "Funding Allocation and Budgeting" (FAB) mechanism. This should in principle allow Centres to bid at difference stages for strategic funds and make joint bids across centres (eg BAS and NOCS) much easier in future. The ability to take a more integrated approach to science delivery will help the marine research centres contribute most fully to NERC's Earth System Science agenda. We are already engaged in contributing to the development of the future NERC strategy and playing an active part in helping NERC formulate its Comprehensive Spending review submission.

17. The Science Management Audits for each of the centres undertaken in 2004–05 found high quality science in all of the Centres with a high degree of differentiation between then and little or no evidence of duplication. Oceans 2025 has further confirmed this through its explicit coordination of the strategic science in these centres and its transparent approach and distinct division of funding packages into themes, enforcing us to operate in a complementary way at the strategic level. The individual Centres however will continue to compete openly for responsive mode grants and other contracts. Consequently we believe the system is appropriately tensioned with a balanced mix of collaboration and competition.

18. Across its funding portfolio NERC has an active programme of activities to stimulate knowledge transfer, building on research already undertaken. However there is an ongoing perception within the community that NERC's peer review system is systematically biased against grant proposals that involve industry. We believe that this is an area where NERC might take a more positive and proactive approach through guidance to applicants and members of its Peer Review College as well as fostering a greater understanding of the needs of interdisciplinary research.

19. One area where we feel that more could to be done to facilitate linkages is in the area of fisheries research. The NERC funded marine centres do not have an established tradition of working closely with CEFAS laboratories. To an extent this may reflect the division of responsibilities between NERC as a sponsor of academic and strategy research and DEFRA whose responsibility as the Government body with ownership of CEFAS and need to produce short term research directly to support policy, specifically fisheries related.

20. However the increasing integration of policy to encompass the sustainable management of the marine environment (as being driven by the UK Marine Bill and EU Green Paper on Maritime policy) requires underpinning scientific evidence on longer timescales. It also calls for greater collaboration and a need to avoid any tendency for duplication of activities between CEFAS and the NERC Centres where one or the other has a particularly strong existing capability. A better course of action in future may be for CEFAS to draw on the capacities of NERC Centres when bidding for projects rather than maintain or establish new teams in house.

21. We are concerned about the proposal inherent in the Defra consultation on a Marine Bill that seeks to establish a Marine Management organization (MMO). Detailed comments were given in our individual submissions to the Defra consultation. The UK Government needs to retain flexibility in delivery of the information/ science to underpin marine spatial planning (for instance the methods and technology for UK

deep waters will be very different to that for shelf seas and the coastal zone). Combining the role of both regulator and science/knowledge provider in one organization could lead to conflicts of interest. The MMO must be able to contract out scientific research and data gathering to a variety of specialist organizations.

22. In Scotland this agenda is being addressed the Advisory Group on Marine and Coastal Strategy. SAMS and SMRU are playing a key role in the debate on a Scotland Marine Act.

National and International Coordination—Recent Developments

23. Both nationally and internationally there is an increasing trend in the marine research community toward self organisation. This is manifest in the UK through the Oceans 2025 proposal as a first significant step forward. At EU Level the European Commission has long been an important funder of collaborative marine science projects under its EU Framework programmes and UK institutes play leading roles. The European Science Foundation's Marine Board, whose members represent both science funders and research institutions, is taking an increasingly proactive role in highlighting the contribution that marine sciences can make to the policy agenda. In November 2006 it published its Position paper no 8 *Navigating the Future III*. This provides a comprehensive overview of the key challenges and opportunities for scientific progress.

24. Internationally POGO, the Programme for Observation of the Global Oceans, a forum for Directors of the world's major oceanographic institutions instituted originally by the UK and USA, is facilitating a coordinated approach to ensure that the world oceanography community joins together to play its part in the establishment of global earth observing systems, including supporting effort in capacity building in less developed nations.

25. To further facilitate the UK's contribution NOCS has established a National Marine Coordination Office with a small team charged with assisting the Marine Directors to deliver national vision and the remit of the Marine Directors forum. Organisationally this Coordination office also encompasses the Secretariat for the Interagency Committee for Marine Science and Technology which seeks to coordinate marine science interests across Government Departments (See separate IACMST submission).

26. Within the UK new mechanisms to stimulate the rapid pull-through of research to operational activity are also being developed. For example the National Centre for Ocean Forecasting (NCOF) is a strategic partnership between the Met Office and the Proudman Oceanographic Laboratory, Plymouth Marine Laboratory, National Oceanography Centre, Southampton and the Environmental Systems Science Centre at Reading whose mission is to establish ocean forecasting as part of the national infrastructure, based on world-class research and development. http://www.ncof.gov.uk/index.html. This allows us to capitalise on the UK's world-leading position, working within a wider, coherent UK/EU ocean/climate modelling strategy in which NERC can now fully engage.

The Role of the UK Internationally and International Collaboration in Marine Science

27. International collaboration in ocean and earth sciences is essential and in many areas the UK scientists play a major role, for instance in the development of the Global Ocean Observing systems and in our contributions to the international Panel on Climate change. It is intended that the Oceans 2025 programme, which underpins our scientific contribution to a number of international ocean observing commitments will also provide a vehicle for other nations to have improved visibility of the UK research activities, leading to greater collaboration and infrastructure sharing.

28. Under the umbrella of Ministerial commitments, nations have adopted a 10 year plan to put in place a Global Earth Observation System of Systems (GEOSS). The purpose of GEOSS is to achieve comprehensive, coordinated and sustained observations of the Earth system, in order to improve monitoring of the state of the Earth, increase understanding of Earth processes, and enhance prediction of the behavior of the Earth system. Ocean observation systems will play a critical role in delivering GEOSS and the UK has committed to internationally coordinated observation activities. However the present UK funding system is not well-suited to funding cross-departmental contributions to observing programmes. Also, the criteria for monitoring national needs are different from those used in the evaluation of research proposals where observations are needed to meet specific, short-term research objectives.

29. It is important therefore that science funders (eg NERC) and operational agencies (eg Met Office) work more closely together on global ocean observing systems. There is currently a gulf between operational funding for observational infrastructure and that for science, with an over reliance on short term research programmes to provide long term datasets. However, as science moves to sustained observation as a key tool in addressing decadal-scale change the observing infrastructures will increasingly need to be developed with dual science and operational use in mind. Many parts of the global ocean observing system (eg Argo) continue to be supported by research funding, which is unsustainable long term. The problem is common to many countries including the US and Europe, and was the subject of shared concern at the January 2007 POGO meeting. There is an opportunity for the UK to take a lead in finding a solution to this problem which is a significant barrier to developing a sustained ocean observing system.

SUPPORT FOR MARINE SCIENCE INCLUDING PROVISION AND DEVELOPMENT OF TECHNOLOGY AND ENGINEERING

30. Technology and observations are fundamental to ocean science—to provide the basic measurements and to serve as the "chief source of ideas". Fundamental to our ability to make observations is technology, in the guise of new instruments and platforms. While there has been tremendous progress over the last two decades in our ability to tackle the problems of sampling the oceans' space-time continuum, the identification, understanding, and prediction of many interdisciplinary oceanographic processes remains as elusive because we do not have the tools to make necessary observations and measurements.

31. Developing new tools to serve science is an internationally recognized strength at several of the NERC marine Centres, and through a coordinated approach, as recommended by NERC's Marine Sector Review we deliberately increased resource for marine technology and underpinning engineering development in the Oceans 2025 proposal. This has been widely endorsed by the community. Focus will be put on the development of novel autonomous vehicles such as Autosub 6000, and intelligent landers, gliders and animal borne instruments, underpinned by advances in satellite telemetry. These platforms will allow the development and deployment of new miniaturised sensors and will make use of the latest navigation and remote handling technologies to enable operation in harsh environments.

32. Measurement at sea is fundamental to our science so we are pleased that in approving Oceans 2025 NERC has recognised the need for a fully funded cruise programme. This will enable NERC to ensure maximum benefit is derived from the major capital investments in new ships secured by NERC and OSI from Treasury. Moreover, the cruise programme is a major platform for bringing together interdisciplinary science teams and for providing strong cohesion within the national and international marine science community as a whole.

33. The new £36 million NERC research ship RSS James Cook, delivered in August 2006, represents a major and welcome commitment by the UK Government to ocean sciences. This world leading research vessel which can operate for the tropics to the edge of the ice sheets will enable the UK research community to deliver NERC's science priorities in the coming decades and fully utilise investments in oceanographic tools such as deep remotely operated vehicles. However her cruise programme is already fully loaded.

34. The second Research ship RSS Discovery, which has been the prime marine research ship is now some 40 years old and is becoming increasingly unreliable, leading to the cancellation of research cruises, some of which have been in the science planning for several years. This creates gaps and uncertainties in the UK science programmes and demotivates our leading researchers. It also impacts on our abilities internationally to honour commitments made through ship barter arrangements and cruises as part of international projects and programmes. The replacement project for RSS Discovery is approved by the Government but the replacement vessel will not come on stream under 2011 at the earliest, potentially leaving a major capability gap in the UK research fleet. A two ship fleet (excluding icebreakers) is the minimum to sustain operation and ensure the UK does not lose its capabilities to benefit from the investment in equipment and expert staff. The heavy demand for cruise time from funded marine science programmes already suggests that NERC may have to explore novel approaches to meet demand, such as adding capacity though charter arrangements as well as supporting initiatives to enable use of other ocean going vessels ("ships of opportunity").

THE STATE OF THE UK RESEARCH AND SKILLS BASE UNDERPINNING MARINE SCIENCE AND PROVISION AND SKILLS TO MAINTAIN AND IMPROVE THE UK'S POSITION IN MARINE SCIENCE

35. There are three prime areas of concern in relation to sustaining the UK research and skills base:

- The demography of the marine engineering community which risks losing key capabilities in the next few years, particularly in relation to experience of design and operation of moorings. Succession planning and new recruitment in these areas already poses a serious challenge, particularly as the marine labs are competing for expertise that is also attractive to the oil and gas sector, which is able to offer more rewarding remuneration packages.
- Although SAHFOS is a base for taxonomic knowledge on pelagic biodiversity, there is a general shortage of taxonomy skills, as has been well debated elsewhere. This impacts the marine community where new species are constantly being discovered. This deficit is recognised as an issue outside the immediate science community, for example BP is providing some fellowship funding to support a taxonomist at NOCS.
- A shortage, again widely debated, of skills and interest in physics, mathematics and engineering. Physical oceanography remains a core discipline but is hampered by availability of expertise. There is growing concern on where to find the next generation of physical oceanographers.

36. There are also concerns about the UK's ability to attract and retain key researchers, where we face increasing competition from in particular the US and Germany. Further details are given in our individual Centre responses.

Use of Marine Sites of Special Scientific Interest

37. The designation of sites or marine protected areas must be based on sound science. Only a small fraction of our oceans are well characterised. Research in respect of particular areas is not a part of the Oceans2025 programme therefore additional funding needs to be found. The designation and operation of such sites and the conditions for access must not actually inhibit the ability to undertake research. These issues are further explored in our individual submissions.

How Marine Science is Being Used to Advance Knowledge of the Impact of Climate Change on the Oceans

38. The Oceans2025 programme is intended as the major strategic components of NERC funding dedicated to addressing the impact of climate change on the oceans and more widely the role that oceans play in the global climate. Issues to be addressed include major changes to be seen in Arctic, the diminution of Arctic sea ice and expected freshening of the North Atlantic, Ocean acidification, work on regime shifts, ecosystem management and adaptive management strategies. The Oceans2025 proposal document provides full detail and at EU level the ESF's "*Navigating the Future III*" paper provides a good summary of the key issues.

Paper provided by the National Marine Coordination Office at NOCS, on behalf of the Directors of the NERC funded marine institutes.

January 2007

Annex 1

What is Oceans 2025?

1. Oceans 2025 is a coordinated programme of Strategic Research. The Oceans 2025 proposal was approved by NERC Council in December 2006 with a budget of £116 million over five years (not including capital funding).

2. Previously our seven institutions have each been funded separately by NERC for our own individual strategic programmes. In contrast to NERC's funding for curiosity-driven, blue skies research, its Strategic Research funding is for programmes of directed research addressing areas of present or anticipated national need, and with environmental issues where sustained national capability or major critical mass is required. Oceans 2025 provides a framework for NERC-funded strategic marine science which will not only maintain the leading role in Europe of the UK in this area, but also enable translation of science into the UK and European policy arena and provide many other opportunities to build on the existing strength of the Marine Centres in knowledge transfer and engagement between science and society.

3. Oceans 2025 addresses major science themes of:

— Climate, ocean circulation and sea level.

— Marine biogeochemical cycles.

— Shelf and coastal processes.

— Biodiversity and ecosystem functioning.

— Continental margins and the deep ocean.

— Sustainable marine resources.

— Technology development http://www.ocean2025.org/.

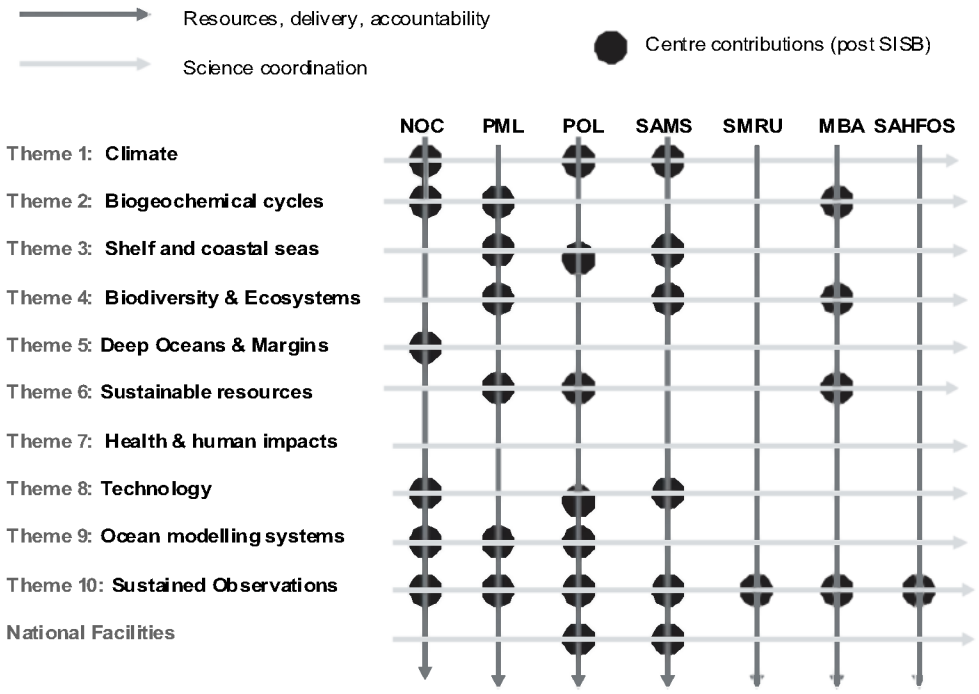
— Next generation ocean prediction.

— Integration of sustained observations in the marine environment.
and supports three national facilities:

— British Oceanographic Data Centre.

— Permanent Service for Mean Sea Level.

— Culture Collection for Algae and Protozoa.



4. Oceans 2025 will:
   - implement an exciting new approach to implementing strategic marine research for NERC;
   - provide NERC clear and coherent visibility of its major strategic investments in this crucial component of the earth system;
   - provide the basis for tackling the key earth system linkages and processes within its broader strategy and internationally;
   - enable NERC to demonstrate its "follow through"" on the major infrastructure and capability investments it has secured from Treasury over the past five years (eg ships, buildings, equipment and skilled people);
   - widen the participation in strategic UK marine science through the provision of SOFI and providing access to the HEI sector of national infrastructure and capability; and
   - contribute to many international research programmes (including those of DIVERSITAS, IGBP, SCOR and WCRP).
5. Funding recommendations at the "as bid" ("plus 10%") level and for major new areas will enable us to:
   - deliver the full Oceans 2025 cruise programme as bid, recognising that measurement at sea is fundamental to our science. The cruise programme is a major platform for bringing together interdisciplinary science teams and for providing strong cohesion within the marine science community as a whole—encompassing Research Centre, University and International colleagues including collaboration supported through SOFI (Themes 1, 2, 3, 5, 8 and 10);
   - develop the progressive clarity of the role of the "National Capability"" dimension of the NERC Marine Centres. In 2001 (at the last marine programme renewal) we clarified the role of "National Facilities" and Oceans 2025 now draws out very clearly the contribution to national capability made by our sustained observing programme and research infrastructure. The latter is integral to our science challenges, which fundamentally concern understanding decadal-scale variability in the earth system (Theme 10);
   - contribute to the "earth system science" theme of the emerging NERC Strategy through a major collaborative effort in ocean biogeochemistry (a critical regulator of earth system feedbacks and the source of significant quantitative uncertainty in the global carbon cycle) and which also includes tackling the crucial problem of ocean acidification (Theme 2);
   - advance significantly towards exploring the deep oceans and ocean margin frontiers. The recommended investments will provide us with the platform to capitalise on the UK's already world class status in this field, and to lever additional resources from major European and international collaborative programmes. These international linkages are crucial to developing our knowledge of this largely unknown, undoubtedly economically important, but also progressively "at risk"" part of the earth system (Theme 5);

— make a substantial contribution to UK Arctic marine research throughout the International Polar Year (2007–08), and to enhance long term observations of both physical and ecosystem parameters in the European Arctic shelf seas (Themes 1 and 3);

— increase our investments in technology development, and to enable us to operate in precisely the coordinated way recommended by the Marine Sector Review of 2005 (Theme 8);

— capitalise on the UK's world-leading position, working through the National Centre for Ocean Forecasting (NCOF), the Met Office and the Hadley Centre to develop and transfer into operational use enhanced current- and next-generation ocean prediction elements of coupled climate and other forecast systems. This now takes place within a much wider, coherent UK/EU ocean/climate modelling strategy in which NERC can now fully engage (Theme 9);

— by elucidating the role of biodiversity in ecosystem functioning, contribute to UK and European requirements to reverse the loss of biodiversity by 2010 thereby informing sustainable stewardship of healthy seas and coasts (Theme 4);

— work with key stakeholders (particularly Defra and SEERAD), to make an important start to developing and, more effectively transferring knowledge concerning sustainable use of marine bio-resources and ecosystem based approaches to marine management, one of the most pressing and challenging issues of the 21st century (Theme 6).This is despite the proposed reduction in funding for Theme 6;

— build important agility into Oceans 2025 and enable us to engage even more closely and strategically with University colleagues through the 7.5% contribution to the Strategic Ocean Funding Initiative;

— sustain key national facilities (British Oceanographic Data Centre, Permanent Service for Mean Sea Level, Culture Collection for Algae and Protozoa) each with a distinctive and highly prized role, both nationally and internationally. It will also support the statutory duty placed upon NERC under the Conservation of Seals Act 1970 (BODC, PSMSL, CCAP, SMRU); and

— lead best practice in data management and custodianship in all the Ocean 2025 themes and make such data available for the wider scientific and industrial community;

All of the above elements generate strong knowledge transfer opportunities and engagement with key stakeholders.

Annex 2

CURRENT ORGANISATIONAL STATUS OF THE MARINE CENTRES

The Marine Research and Collaborative Centres contributing to Oceans 2025

Institution	*Acronym*	*Type of Centre*	*Owning Body*	*Current Relationship with NERC since*
National Oceanography Centre, Southampton (formerly Southampton Oceanography Centre)	NOC (formerly SOC)	Collaborative Centre	Jointly owned between NERC and the University of Southampton	1994
Plymouth Marine Laboratory	PML	Collaborative Centre	PML (Company Limited by Guarantee with Charitable Status)	2002
Marine Biological Association of the UK, Plymouth	MBA	Grant in Aid funded Body	MBA (Company Limited by Guarantee with Charitable Status)	1965 (modified 1987 and 2001)
Proudman Oceanographic Laboratory, Liverpool	POL	Research Centre	NERC	1969
Scottish Association for Marine Sciences (Dunstaffnage, Scotland)	SAMS	Collaborative Centre	SAMS Group (Company Limited by Guarantee with Charitable Status)	1967 (updated 1994 and 2002)
Sea Mammal Research Unit, St Andrews (Scotland)	SMRU	Collaborative Centre	University of St Andrews	1996
Sir Alister Hardy Foundation for Ocean Science	SAHFOS	Grant in Aid funded body	SAHFOS (Company Limited by Guarantee with charitable status)	1990

Annex 3

RELATIONSHIPS BETWEEN THE NERC MARINE RESEARCH CENTRES AND WITH OTHERS IN THE UK RESEARCH BASE

Links between our Centres

1. There are numerous linkages (both formal and informal) between the NERC funded marine research centres.

Informal examples

- Their past institutional linkages are embedded in the "corporate memory" of each.
- Individual scientists within these centres are well networked and there are consequently numerous small-scale collaborations and contacts.
- Since 2000, there has been some flow of staff between these institutions (in just about every permutation) as individual career development opportunities have arisen

Formal examples

2. A vast number of major and longstanding scientific collaborations exist between the individual marine laboratories. These range from collaborations on specific research grants and observations through to joint participation in large international consortia. Other interactions include:

- NOCS, POL, PML, SAMS and SMRU are each corporate members of a joint NERC/Ministry of Defence forum CAROS (Cooperative Arrangements for Ocean Sciences) and meet formally twice a year with MoD colleagues to discuss shared issues.
- NOCS, POL, PML and SAMS are each members of POGO (Partnership for Observation of the Global Ocean) forming the UK Consortium to POGO which meets annually. SAHFOS is also about to join. POGO includes the heads of all other major marine laboratories world wide and representatives of major international marine research programmes. From the UK is also includes the British Antarctic Survey and the UK Met office.
- NOCS, POL, PML and SAMS have been each members, or affiliate members, of the Marine Information Alliance which meets quarterly each year and includes representatives of other public and private sector bodies with interests in access to marine information.
- Within the NERC context, the Directors participate in the annual NERC Directors meeting. The Directors of POL and NOCS meet monthly at NEB. The Director PML is a member of the NERC Science and Innovation Strategy Board and the Director SAMS is a former Member.

Links with other Centres, Universities and Institutions

3. Through our mutual parent NERC each of the marine centres maintains links to British Geological Survey and to British Antarctic Survey. These links include collaboration in joint projects at national and international level (particularly EU through the Framework programmes). Each of our centres will also participate in a number of projects under the International Polar Year banner, for instance SAMS is leading a major IPY cluster on Pan-Arctic Ecosystems with Canada and Norway.

4. Each of our centres undertakes collaborative research projects with a range of centres of academic excellence within the UK, Europe, and internationally through a wide range of funding mechanisms. This will be further facilitated under the Oceans 2025 initiative where we have allocated some 7.5% of the direct research funding to a new Strategic Ocean Funding Initiative SOFI will open up strategic funds for universities and other partners to bid for. Our Centres also host a number of national facilities and collections, for example the British Ocean Sediment Core Research Facility (BOSCORF) at NOCS and the UK Culture Collection for Algae and Protozoa at SAMS which are used by researchers worldwide.

5. The National Marine Equipment pool/Sea systems team based at NOCS provides at a national level the underpinning infrastructure and support for scientific cruises led by UK researchers based in institutes and Universities and there is continuous interaction in respect of use of the full range of NERC vessels and vessels access through international barter arrangements.

Engagement with Industry

6. The Oceans 2025 programme of strategic research represents only a part of each Marine Centres' programme of activities. Each of the Centres is obliged to seek external sources of funding to sustain its level of activity and most take the view that collaborative research with industry has to be closely related to their core strategic programmes. The sectors where collaboration mostly often occurs are oil and gas, defence

and insurance. At the regional level aquaculture, renewable energy and policy (national parks) are also important. The regional agenda involves close interaction with the Regional Development Agencies (especially in Plymouth) and Enterprise network (Oban).

7. Each of the marine institutes engages actively in knowledge transfer activities through a range of mechanisms. Several (PML, SAMS, SMRU) have their own commercial companies that make a more direct link to industry by providing services based on the knowledge, products and services developed within each institute.

Memorandum 32

Memorandum from Natural England

1. Introduction

1.1 Natural England is a new organisation that has been established under the Natural Environment and Rural Communities Act 2006. It is a non-departmental public body. It has been formed by bringing together English Nature and parts of the Rural Development Service and the Countryside Agency.

1.2 Natural England has been charged with the responsibility to ensure that England's unique natural environment including its flora and fauna, land and seascapes, geology and soils are protected and improved.

1.3 Natural England's purpose as outlined in the Act is "to ensure that the natural environment is conserved, enhanced, and managed for the benefit of present and future generations, thereby contributing to sustainable development".

2. Executive Summary

2.1 Natural England's response contains 12 key points on investigating the oceans:

- The importance Natural England attaches to having a flourishing, well organised, managed and quality UK marine science community.
- Much has been achieved in recent years to support the UK role in investigating the oceans and that this is welcome.
- The need for greater visibility on what is happening in UK marine science.
- The need to maintain funding for UK marine science and now increase this in order to provide the enhanced evidence base being required by Government to underpin the better regulation agenda.
- The need for further thought on thematic aspects of the organisation of UK marine science.
- The need for further consideration of the peer review process for funding UK marine science.
- The need to foster greater regular collaborative marine science efforts beyond the boundaries of Europe.
- The need to sustain the near-shore ship and boat capabilities to underpin UK marine science.
- The need to foster provision and skills in knowledge transfer and taxanomic experience to underpin UK marine science excellence.
- The need to take greater opportunities to use Marine Protected Areas to build Government, industry, research and environmental community partnerships to understand "shifting baselines" and to properly "benchmark" sustainable development.
- Celebrating the recent successes of how marine science has fed into our understanding of the impacts of climate change on the oceans.
- The need to ensure that national capabilities that inform industry investment in technologies, such as carbon capture and storage, are adequately resourced. This is so financial and marine environmental risks can be understood and adequately managed.

3. Introduction

3.1 Natural England attaches considerable importance to investigating the oceans and having a flourishing, well organised, managed, and quality marine science community in the UK to achieve this.

3.2 A strong and well-developed relationship is required between this community, and its activities to investigate the oceans, and agencies such as Natural England. This is because as an evidence-based organisation we are a principle customer for many aspects of marine science, evidence and knowledge. This evidence base is essential so we can provide advice to Government and others, and so we can foster and

champion improved understanding, protection and management of marine wildlife, habitats and resources. The better regulation agenda for Government is driving a requirement for more evidence to underpin our advice, and thus our requirement for such information is now increasing significantly,

3.3 Our information needs for investigating the oceans fall into four main areas:

— to know what is out there—the distribution of marine landscapes, habitats and species;

— to know the rules of ocean behaviour—understanding functions and processes and establishing boundaries on future conditions;

— to be aware of what is actually happening—both to inform policy but also improve predictive capabilities; and

— to find creative and adaptive solutions—using knowledge to promote human well-being, improved stewardship and ensuring the wildlife and other elements of the resource are sustained both now and for the benefit of future generations.

3.4 These needs match closely with similar values set out by the NERC-funded marine science institutions in Oceans 2025.

3.5 Natural England therefore welcomes the opportunity to provide comments on how we are investigating the oceans. Our response is set out by the categories established in the terms of reference for this enquiry.

4. Detailed Response to the Issues Raised

4.1 *Organisation and funding of UK marine science in the polar and non-polar regions*

4.1.1 Significant advances have been made in recent years on the organisation and funding of UK marine sciences. This includes developing cooperative approaches such as the Plymouth Marine Partnership, and also the development of stronger strategic alliances through initiatives such as Oceans 2025. There are five areas that we would identify as meriting further attention.

— Greater visibility is needed on what is happening in UK marine science—Oceans 2025 has been a significant step forward but important areas of UK marine science capabilities fall outside this programme. Visibility is a first step to improving engagement and maximizing the value of the work being undertaken through the end-user community. It is still challenging for stakeholders to understand how the various elements integrate together, who is doing what, and therefore how to take advantage of the relevance and value of particular aspects of their work.

— Maintaining and increasing funding for UK marine science to keep pace with the information requirements underpinning Government's better regulation agenda. We are concerned that economic pressures are in reality reducing funding through universities and the outputs that they can provide (eg closure of Port Erin Marine Laboratory). We are also concerned that, in real terms, funding for areas of marine science of importance to Natural England remains inadequate despite NERCs recent recognition of the importance of such issues. This is especially in areas studying long-term ecological issues and change. There are a variety of reasons for this, some of which relate to "down-sizing" pre-Oceans 2025, or because they are seen as marginal to NERC, or not "complex" or "exciting" enough. They are nevertheless some of the areas of highest policy and management relevance that need a sustained and adequate funding base, and that as a result Natural England and others struggle to help support through opportunistic contributions from small-scale resources. Set against this is the need a significant increase in funding for investigating our seas and oceans. This is to keep pace with the increasing demands being placed on Natural England and other agencies to produce more evidence to underpin our advice as part of Government's better regulation agenda.

— Further alignment of UK marine science. Oceans 2025 as been a significant step towards implementing a major UK strategic programme, whilst recognising the individual selling points of the institutes concerned. We are concerned that key research interests still appear isolated from these core efforts, eg research by Cefas v research by NERC institutions. The reasons behind this may be complex, but better overall integration should be encouraged to optimise value for money, accessibility and accountability.

— Further thought is needed on the organisation of UK marine science into thematic areas that best match and meet end-user needs—this is a challenging areas but one where we believe that more could be done to better interface UK marine science research with the end-user community. Multidisciplinary partnerships are evolving through European Union funding in particular and this is welcome, but major gaps still exist. A key example is understanding 'connectivity' in marine ecosystems. This involves disparate marine science interests (ranging from ecology of species, oceanographic processes, through to micro-satellite genetic analysis techniques) and yet understanding such issues is a clear pre-requisite for better managing and protecting our marine resources. Other gaps are in "bench-marking" sustainable development in our seas (see 4.5.2 below) or delivering an improved science-based understanding of how our oceans have changed in

recent decades (the concept of "shifting baselines"). Often it is the end-user customer that is piecing together such issues, rather than it being driven through a strong integrated science/end-user partnership approach.

— Peer review assessment procedures for funding UK marine science through NERC need further consideration—we are concerned that the current processes have apparent inconsistencies in operation, can require significant resources in a resource-scarce area to operate (from the applicants view-point), may favour mainstream disciplines, and still make it challenging to implement interdisciplinary studies that reach out into socio-economic areas and that are urgently needed to support achieving sustainable development. The perception that we are given is that in part this seems to be driven by a mismatch in peer review background (dominated by oceanography and earth science interests) set against the biological marine science focus of projects and programmes under consideration. An added perception is the fact that the corporate memory of previous grants panels provided an added value that is weaker or missing in modern peer review processes. The consequence may be to make it difficult to fund ongoing innovation or novel research in some areas of marine science.

4.2 *The role of the UK internationally, and international collaboration in marine science*

4.2.1 Considerable advances have been made in collaboration in recent decades, often spurred on by funding opportunities. We believe that such successes should be built upon, and that mechanisms should be explored to foster greater regular collaboration of UK marine sciences beyond European borders. Our marine science has an excellent international reputation and there has been significant and welcome expansion in regular collaboration within Europe. We feel that there are further gains to be made by encouraging similar regular levels of collaboration with the USA and other countries further a field. This has the potential to enhance the quality and depth of research, value for money, and the breadth of end-point application.

4.3 *Support for marine science, including provision and development of technology and engineering*

4.3.1 We welcome the ongoing replacement programme for the major UK capabilities in this area (James Cook and the in principle replacement of the Discovery) but we would also wish to highlight the contribution that smaller near-shore ships and boats make to our understanding of our seas and oceans. It would be unfortunate if such capabilities were to be diluted at a time when increasing human pressure on the near-shore zone makes our understanding such marine ecosystems all the more important.

4.3.2 It is our experience with the UK marine science community that maintaining such capabilities is a major challenge, and that any reduction has an immediate implication for near-shore information and datasets. Recognising this linkage is critical as we are becoming increasingly interested and dependent on such information in relation to understanding and tracking whole-scale changes to our marine ecosystems from climate and regime shifts.

4.4 *The state of the UK research and skills base underpinning marine science and provision and skills to maintain and improve the UK's position in marine science*

4.4.1 We believe there are two key areas that need greater attention in order to maintain and improve the UK's position in marine science.

— Provision and skills in knowledge transfer. Further actions are needed to deliver the level of knowledge transfer that we would wish. This is so we can make best use of the research and the evidence that is obtained. We welcome the greater visibility being given to this issue in recent years but we remain concerned that beyond recognised areas of dedicated effort the level of knowledge transfer is not high enough. Both easing access and shortening the lag-time between research findings and update by the end-user community can only but enhance the UK's position internationally in marine science. The use of Reference User Groups and the production of the MCCIP Marine Climate Change Annual Report Card (see 4.6 below) are excellent examples of how such knowledge transfer can be achieved for the benefit of all concerned. Clearly there are limits to where such approaches may be best applied, so further innovation enabling knowledge transfer is also needed.

— Provision and skills in taxanomic issues. The UK is reliant on an extremely small number of individuals with the experience to identify marine species, and the world-wide pool of experience is similarly restricted. Such skills are part of the mainstay of being able to understand our oceans and are often poorly supported. We remain concerned that the need to maintain UK capabilities in such core aspects are not lost in the desire to fund what may appear to be novel, new and more "exciting" aspects of investigating the oceans.

4.4.2 Alongside these issues we would also identify the importance we attach to fostering the skills needed to draw together research on the structure, functionality and processes of marine ecosystems, and to link them through to the benefits (goods and services) that we obtain from our oceans. Whilst research is being undertaken in these areas, as a community we still struggle to join such issues together in a compelling manner, despite its importance in driving management to secure the wellbeing of our oceans.

4.5 *The use of marine sites of special scientific interest*

4.5.1 We interpret this point more widely than SSSIs, to encompass all designation in our seas and oceans as expressed by the term Marine Protected Areas (MPAs). MPAs, particularly those that restrict or operate in the absence of human impacts, such as the Lundy no-take zone, provide ideal opportunities for scientific research. It is our view that major collaborative opportunities and partnerships based around Marine Protected Areas are not being exploited to the determent of our understanding of how to deliver sustainable development in the UK marine environment.

4.5.2 In reality the only way in which Government can currently estimate whether it is delivering sustainable development is, in part, by reference to past changes in our seas. These often remain more as personal view points rather than as a well documented evidence-based approach. Alongside this, studies of the impacts of our activities are often undertaken in areas already subject to other human impacts so gaining a clear idea of what may be natural changes from human induced ones is challenging. It is surprising that no control sites have been established (other than the 3.3 km2 Lundy no-take zone) where ecosystems are allowed to function in an unconstrained and un-impacted manner.

4.5.3 No take zones, and to a degree the restrictions in place around alternative energy sites (such as wind farms and the wave hub in south west England) provide idea opportunities to create partnerships between government, industry, the research community and environmental interests to discover how our marine ecosystems can function in the absence of major impacts. This holds the potential to show us the full range of benefits our seas and oceans may hold socially, environmentally and economically, and at the same time gain a better baseline for understanding sustainable development.

4.6 *How marine science is being used to advance knowledge of the impact of climate change on the oceans*

4.6.1 Within the last year considerable progress has been made in using marine science to advance our knowledge of the impacts of climate change on our oceans. One route has been through an emphasis on outreach in some key programmes, such as the RAPID work on ocean circulation and the Reference User Group (RUG) approach adopted by Plymouth Marine Laboratory of the Defta/DTI funded work on ocean acidification. The RUG approach enables a sustained dialogue to be undertaken throughout the life of the research between scientists and end users. Such approaches have helped raise the profile of results and discussions to new heights.

4.6.2 A significant step forward has also been the development of the Government-led Marine Climate Change Impacts Partnership. Natural England has been delighted to work closely with Government, the research community and end-users to create and implement the Annual report Card on marine climate change impacts. This has successfully created a new dynamic in regular reporting whereby all UK marine science in this area has been drawn together in a policy-friendly format to fast track UK knowledge on this topic through to those that need to know it. This has demonstrated in one process how to circumvent the lag time between science and policy, and how a framework can champion UK marine science excellence, where the sum is far more than the individual parts. We would commend this approach to the Committee as a mechanism that could be applied in other marine science areas and in other fields.

4.6.3 Set against these successes we do have some concerns about the level of funding being assigned to surface ocean acidification (SOA) research in particular. Whilst it is good that there is now widespread awareness of SOA as "the other CO_2 issue", adequate funding is not following at such a quick pace. The European Commission is recognising this issue but funds are small for the range of issues that needs to be considered. The UK national capability at Plymouth for understanding such issues and adding certainty to the emerging multi-billion pound industry around carbon capture and storage (CCS) struggles to sustain itself and secure long-term funding.

4.6.4 This is just one example but there does seem to be a miss-match between the central government imperative of reducing carbon dioxide emissions and the funding available to ensure that environmental issues surrounding approaches such as CCS are adequately research and understood. This would seem an urgent area to address if industry is to have certainty through UK marine science research to invest with confidence in these new technologies.

January 2007

Memorandum 33

Submission from EADS Astrium

I have pleasure in enclosing the EADS Astrium Ltd. written submission to your inquiry on investigating the Oceans and the important role they play in understanding climate change. Measurements of the oceans by satellites have long been a major contribution to scientific understanding, due to their ability to provide data over large areas of otherwise inaccessible locations.

We are convinced that a strong relationship between suppliers of Spaceborne sensors and the scientific communities ensures a virtuous circle of mutual benefit and growth through effective knowledge transfer. We have seen this in past years in the fields of Sea Surface Temperature and sea ice measurements—developing a UK lead through combining scientific and technological capabilities. Recently, this benefit has been recognised by the Natural Environment Research Council (NERC) and DTI in the establishment of their Centre for Earth Observation Instrumentation (CEOI)—bringing together scientists, technology researchers and industrial implementers. The CEOI offers opportunities to augment the UK international lead in climate change at policy, science and technology levels.

However, it is the evolution from scientific missions to the long-term provision of satellite systems where we are encountering difficulties. The "handing over" of responsibility from NERC to user departments within government is problematic. Currently, the UK positioning within the European Earth observation programme that will shape the future of ocean monitoring and climate change understanding is being severely compromised by a lack of coordination across Government departments.

It is within this context of opportunity and threat, set against the closing window of the Comprehensive Spending Review, that I welcome the opportunity presented by the Inquiry to highlight importance of space to the task of investigating the oceans and the related climate change issues. I would be delighted for the opportunity to give oral evidence before the Committee to elaborate on these issues.

1. Executive Summary

1. The UK has long been one of the leading European nations in developing spaceborne technologies to meet scientific needs. Indeed, the UK contribution to the ESA Earth Explorer programme is handled by NERC to ensure that the scientific goals are at the highest priority. This has proved to be a success in terms of mission selection. However, the lack of a supporting national programme has gradually allowed the science, technology and industrial communities to drift apart. This has been recognised by NERC and DTI through the recent establishment of the Centre for Earth Observation Instrumentation (CEOI) which will bring these communities together to ensure science-led technology developments.

2. There is, however, a more serious underlying concern about the UK approach to evolving scientific missions into long-term, sustainable monitoring systems. The change of leadership between Earth science missions (NERC) and operational missions (user departments) is proving difficult. The most recent example of this is the European flagship environmental monitoring programme, GMES (Global Monitoring for Environment and Security). Previously, ERS-1/2 and ENVISAT had strong UK scientific and industrial involvement, specifically in ocean and climate related areas. Their evolution to the next generation operational systems under GMES means that the job of coordinating the user-led response has passed to DEFRA. The minimal contribution to the first phase of the programme made by DEFRA at the ESA Ministerial Council in 2005, in the face of a significant over-subscription across the rest of Europe, demonstrates the problem.

3. Without long-term, consistent monitoring on a global scale the challenges to continued investigation and understanding of the oceans and of climate change will not be met. The UK policy to allow other nations to foot the bill of implementing the necessary monitoring systems needs to be reversed. In the middle of 2007, European countries will need to subscribe to the second phase of the programme, covering the period to 2013. Without proper investment, British industry will be effectively locked out from complementary EC funding of €1 billion. World leading capabilities built up over the last 25 years will move overseas with consequent impacts on jobs. The UK will also lose the chance to shape the programme to maximise its value to climate change policies.

2. Introduction

2.1 *Focus of EADS Astrium's submission*

4. EADS Astrium does not claim to be expert in oceanographic or climate change science. We rely on partnerships and relationships with organisations in NERC and other relevant institutions for such expertise. As a result, our submission is focused on the current situation in the UK for maintaining and growing the space-based capability to support the ocean science and user communities. Some background information is drawn from the recent "Case for Space" studies undertaken in light of the Comprehensive Spending Review. Currently, the situation is crystallised through the UK Government position in the future European Earth observation system, GMES.

2.2 *About EADS Astrium*

5. EADS Astrium is Britain and Europe's leading Space company providing a full range of space products from civil and military telecommunications to Earth observation, science, exploration and navigation programmes. In Britain, Astrium directly employs more than 2,500 people in its key sites in Portsmouth, Poynton and Stevenage, representing more than half of the total direct manufacturing workforce in UK Space, and the largest national workforce in Astrium's worldwide satellite operations. EADS Astrium has a strong history of working well within partnerships with other UK companies, notably SMEs.

3. Contribution of Space to Ocean and Climate Science?

6. Space contributes to both ocean and climate change understanding and monitoring by the provision of regular information on regional, national, European and global scales. The UK has taken a leading role in the developing space-based Earth observation systems within Europe over the past 25 years. The European Space Agency (ESA) environmental satellite series started with ERS-1, launched in 1991, and went onto ERS-2 in 1995 and ENVISAT in 2002. EADS Astrium in the UK delivered sensors for these missions enabling sea ice monitoring (Synthetic Aperture Radar, SAR) and Sea Surface Temperature (Advanced Along Track Scanning Radiometer, AATSR), in partnership with other UK companies, research organisations and academia. These sensors have played a major role in understanding and monitoring the oceans and related impacts on climate change.

3.1 *Case Study of UK Space Contribution to Ocean Science*

7. Sea Surface Temperature, (SST) is an important physical property that strongly influences the transfer of heat energy, momentum, water vapour and gases between the ocean and the atmosphere. The Earth's oceans act as an enormous reservoir of heat and the top two metres of ocean alone store the equivalent energy of all the energy contained in the atmosphere.

8. Measuring sea surface temperature from space on a long-term basis is the most reliable way to establish the rate of global warming.

9. As an example, ESA's Medspiration project is currently obtaining SST data for the Mediterranean where to obtain the same levels of data, the equivalent ground-based map would need almost 1.5 million thermometers placed into the water simultaneously. Combining data from multiple satellite systems permits the production of robust models forecasting sea surface temperature change.

3.2 *Space in Support of Climate Change Science*

10. For Climate Change adaptation to be effective, governments as well as the private sector need information about past and current climate conditions, their variability and extremes, as well as sound projections of future conditions, not only on a yearly basis but for many decades into the future. The global carbon cycle connects oceans with the other two major components of the earth system—atmosphere and land—each storing large pools of exchangeable carbon which for many centuries prior to the industrial revolution were more or less in equilibrium. Data from Earth observation satellites provide the only global, synoptic view of key measures of the carbon cycle and form an essential and central part of any integrated observation strategy. Satellite contributions to the understanding of the carbon cycle include:

- Global mapping of land cover use, land cover change, and vegetation cover characteristics that are important to full carbon accounting—using sensors such as AATSR, AVHRR, Landsat and MODIS.
- Seasonal growth characteristics generated on a global scale using sensors such as AVHRR, MODIS, MERIS, and SPOT VEGETATION.
- Fire detection and burn scar mapping, detected and mapped from space using thermal and optical sensors (radar sensors also show promise for burn mapping).
- Combinations of satellite measurements of parameters such as ocean chlorophyll, dissolved organic matter, and pigment composition.
- Physical measurements from satellite of ocean waves, winds, and temperature used to derive three main contributions for the study of ocean carbon:
  - quantifying upper ocean biomass and ocean primary productivity;
  - providing a synoptic link between the ocean ecosystem and physical processes; and
  - quantifying air-sea CO_2 flux.

11. As part of the measurements of the global carbon cycle, sea level rises and sea surface temperature rises are both good indicators of rates of global warming. Space based technology is being used to monitor these indicators and the associated changing global weather patterns, including establishing sea level rise data, ice sheet thickness data, precipitation measurements, and sea surface temperature (SST) data.

3.3 *New Sensors for Future Oceanographic Applications*

12. According to the recent evaluation by the GMES Marine Services Implementation group, two of the key challenges for future development are wide swath altimetry (for mesoscale ocean height measurements) and geostationary ocean colour. The first of these could be addressed by the current UK-led development of the PARIS sensor. The development is likely to stop, or be passed to other European countries, due to the lack of clear UK funding policy. This will mean that the oceanographic science community in the UK will miss out on the opportunity to establish a leading position in this exciting opportunity.

4. Delivery of Science, Public Benefits and Co-ordination

13. There are two phases in the lifecycle of a space-based measurement system. Firstly, the scientific experimental phase—establishing requirements and understanding of the associated Earth processes—and secondly, the operational phase, when the need for the continued monitoring of observables is established. It is in the evolution between these two phases that the failure occurs.

4.1 *Co-ordinating Science and Industrial Communities*

14. In delivering the first phase of the lifecycle, there has been a drifting apart of the scientific and industrial communities over the last 10 years, leading to a loss of effectiveness in developing new sensors able to meet the emerging science challenges.

15. A recent initiative by NERC and DTI to establish the Centre for Earth Observation Instrumentation (CEOI) aims to address the drifting apart of the science and industrial communities. The CEOI has a clear remit to collect the emerging science needs and translate those into relevant space technology and instruments. Through this, we expect to see an improvement in UK coordination which will only be turned into delivery of high quality science if the supporting UK Space policy is better coordinated than at present.

4.2. *Delivery of long-term public good*

16. In the second phase of the lifecycle, the UKs "centrifugal" space policy is based on laudable aims of engaging with user departments to ensure that, in the first instance, funding is directed at those space programmes with the greatest policy benefits, and secondly that these departments are then best placed to shape and benefit from them. However, the reality of space-based programmes is that they invariably benefit a number of departments. Other countries recognise this fact by investing in a funded central space agency with dedicated expertise in space applications, which can then make informed decisions for the whole of Government. The UK's British National Space Centre is more of a secretariat, comprising around 30 highly-skilled staff compared to, say 1,500 in its French equivalent, CNES. It therefore relies heavily on the engagement of user departments.

17. However, the history of decision-making under the UK's user-driven space strategy demonstrates clearly that user departments, when given the lead responsibility, find it difficult to consider broader benefits outside their own departmental remits. Space decision-making therefore works best in Britain when the benefits clearly fit within the remit and expertise of the lead agencies within Government. For example, in the field of Earth observation, NERC's commitment to scientific environmental research.

18. At the policy level, environmental monitoring is supported by strong words. Both the Prime Minister's Natural Hazards Working Group and the UKs 2005 G8 Summit both committed strong UK support to strengthening environmental monitoring to tackle climate change and natural disasters. Europe's flagship environmental monitoring programme, GMES, should therefore have topped the UK's space policy agenda, given the happy coincidence of policy support for tackling Climate Change; recognition of the role of environmental monitoring; and the UKs undisputed world leadership in environmental space science and technology. However, in December 2005, the UK opted to commit the minimal (1/4 GDP) funding allowed into GMES—the UK's investment of £4 million per annum compares with £20 million per annum from France and £24 million per annum from Germany.

19. The UK decision over GMES was caused by three main factors: firstly, the lead Department, Defra, did not significantly value those benefits from GMES outside its own departmental remit, specifically the socio-economic benefits. Secondly, Defra lacked the in-house expertise in Earth observation that would have allowed it to make an informed decision on behalf of the UK; and thirdly, there was an inadequate structure in place to coordinate decision-making across Government departments.

4.3 *Recommendations*

20. To maximise public benefits from space, and to improve policy coordination across Government, EADS Astrium Ltd. recommends:

— Continued successful lead in the UK of NERC for the Earth Explorer programme at ESA.

— Long-term commitment of NERC and DTI to the Centre for EO Instrumentation, ensuring that the virtuous circle between science, technology and instrumentation is effective in all spheres of Earth science—including the oceans.

— An urgent reassessment by Government of the UK's approach to GMES—including the roles and responsibilities of the lead department, DEFRA, in coordinating with the other stakeholders: NERC, DTI, MOD and possible DfID. EADS Astrium remains seriously concerned that, when the second phase of GMES requires funding later this year, the UK could remain under-prepared.

January 2007

Memorandum 34

Submission from WWF-UK

Executive Summary

1. With increasing pressures on our seas from the effects of climate change and the use of marine resources, it is essential that adequate marine science is available to inform the management of the UK marine environment and the decision making process in general.

2. Currently, there are crucial gaps in UK marine science which hinder policy formation—ranging from insufficient data on ocean acidification to the identification of marine sites for protection. In addition, the pace with which marine science is presented to inform policy is too slow when compared to the rate at which man-made change is impacting on the environment.

3. WWF is calling for:

— A more concerted and structured effort by the scientific community to produce speedier scientific conclusions that are suitable for decision making;

— Adequate and increased funding for research which maintains its independence from economic vested interests; and

— Greater and urgent research into marine changes such as ocean acidification, the potential for the oceans to exacerbate climate change and for more information to identify marine areas in need of protection.

Introduction

4. WWF is the world's largest and most experienced independent conservation organisation. We work in more than 90 countries to stop the degradation of the planet and to build a future in which humans can live in harmony with nature. WWF-UK is working to reduce our human ecological footprint so that we can start to live within the carrying capacity of one planet—we call this One Planet Living.

5. When it comes to policy in the marine environment, the ecosystem based approach is a tool to delivering "One Planet Living". The marine ecosystem based approach represents a more strategic way of managing our seas. It places the emphasis on a marine management regime that maintains the health of the marine ecosystem alongside appropriate human use of the marine environment for the benefit of current and future generations.

6. WWF specifically works on achieving the long-term sustainable recovery and management of fish stocks, the need for a new Marine Act to introduce a planning system to properly manage the UK marine environment and to protect marine wildlife and the need to reduce carbon emissions from land and marine activities to mitigate climate change.

7. Fundamental to our work, however, is credible and timely science with which to inform policy. WWF's submission, therefore, addresses the current gaps in and constraints on marine science in the UK.

Organisation and Funding of Marine Science

Summary

8. The production of scientific conclusions needs to keep up with the changes in the marine environment. Organisational change and greater inter-disciplinary cross-over is required to achieve this. In addition, policy makers must use the best available science to act when urgency is required.

9. An ecosystem based management system for our seas is essential for the sustainable use of marine resources and for the protection of marine wildlife. Managing one aspect and use of the marine environment in isolation can lead to unintended and counterproductive outcomes. Fundamental to avoiding this is the need for inter-disciplinary science to assess cumulative and synergistic (combined) impacts on the environment, leading to an assessment of the full impacts on an ecosystem with which to inform policy decisions. Many scientific institutions and studies, however, sit in silos. Even those institutions which cover a range of disciplines, keep them in separate sections, chapters or studies. The Strategic Environmental Assessment (SEAs) for oil and gas development in the UK, for example, needs to be improved to address the cumulative impacts on the environment. The challenge, therefore, is to encourage proper linkages across scientific research in order to take the wider picture and fullest assessment.

10. It is essential if science is to inform the policy making process that its findings are as up to date as possible. Modern society and technology run at a far faster pace than ever before, with a corresponding changing impact on the environment including our seas, and it is now necessary for reforms to the organisation of science to keep apace. The changes in the marine environment are happening faster than science can report them due to the procedures and standard practices set up over decades of methodical science, which relies upon lengthy processes to ensure its credibility. Climate change and its impact on the marine environment, for example, are progressing incredibly rapidly, and we do not understand the processes adequately to predict significant changes before they occur. In some cases, we are just reporting regime shifts (huge change in ecosystem dynamics) that occurred nearly 20 years ago. The risk is, with the current mechanisms in place, science will observe and record the degradation of the marine environment as decades pass.

11. In these circumstances where urgent mitigation and adaptation is required, a more rapid process for engaging with the available science is needed. An emerging and dynamic approach is to organise forums of scientific experts to resolve differences of opinion (through an assessment of uncertainty and probabilities) in order to produce a quicker scientific consensus. As such, real time data can be utilised also. This approach can also help with the beneficial fusion of science and policy. By including policy makers in these forums, decision makers can access and put key questions to the experts and view the state of the science. They can also advise on what further research is most relevant to developing the policy process and better understand how to set policy while some uncertainty remains.

12. Crucial to this approach, however, is that decision makers engage with this "early signs science" (best available science) and act on the basis of the precautionary principle. Further research should be undertaken but this should not be an excuse not to act. The use of fisheries science is a case in point. Scientific advice by the International Council for the Exploration of the Seas (ICES), for a zero catch for cod in the North Sea has been ignored by the EU Fisheries Council for the past five years. Indeed, for the past 15 years, political pressure has led to quotas being set an average of 30% above the recommendations made by ICES and fish stocks, notably cod, have to yet to recover. Regardless of how much science is undertaken, therefore, it will be next to useless if the best available advice is not followed by policy-makers.

13. WWF Recommends that:

- Greater interdisciplinary science is encouraged on the full array of inputs into the marine environment to inform better management.
- Scientific uncertainty, with regards to changes in the marine environment, is addressed more quickly through forums of experts so as better to inform the policy making process.

Funding

Summary

14. WWF believes that funding for marine science should not be reduced at a time when the marine environment is increasingly being affected by climate change and the pressure for resources. In addition it is vital that scientific research is able to maintain an independence from economic influences.

15. It is critical that the core of UK science is centrally funded by government and to an adequate level. WWF is deeply concerned about the impact that recent cuts in research budgets is having and the knock on effects of cuts elsewhere on the marine research agenda. In the 2006–07 financial year the originally agreed budgets for the Environment Agency, Natural England and the Marine Fisheries Agency were cut by £23.7 million (5%), £12.9 million (7%) and £1.7 million (7%) respectively. The Centre for Ecology and Hydrology also suffered losses. The lack of funding for marine research has meant that the Joint Nature Conservation Committee is unable to monitor the Darwin Mounds which has been proposed as a Special Area for Conservation (SAC). The JNCC have taken measures, through the CFP, to protect the rare and

important cold water corals on this site, but are unable to monitor and evaluate the success of their management regime or the conservation status of this site. In addition, the loss of funding for the long standing science facility in the Isle of Man at Port Erin is a significant blow.

16. Additionally, the move to introduce market forces into sections of institutions, such as the Met Office and the Centre for Environment, Fisheries and Aquaculture Science (CEFAS) has the potential to detrimentally affect research and science by affecting its focus and independence. The Royal Society, for example, in September 2006 expressed its deep concern over the impact that industry based research was having on the climate change debate, in particular ExxonMobil's influence on science. The standards of science in the UK, particularly on climate change issues, and in the marine environment, have been exemplary and of high repute in the international arena. Changes to the funding base of UK science could, therefore, put this reputation and the science itself at risk.

17. While the core of UK science should be funded by Government there is a role for additional funding—if properly managed. As much of the science needed today is to understand and predict the impacts of industry on the environment, and to develop technologies to avoid, reduce and remedy these impacts, it seems realistic that industrial funding for science is appropriate. Ocean acidification, noise and water pollution are all areas where further research on industrial impacts on the marine environment are required.

18. However, due to the reasons of scientific independence described above, it would be better if this additional funding was managed through a research levy on those industries that are having a particularly detrimental impact on the marine environment. The funds from the levy would be administered through an independent organisation which would then finance research into industry related impacts and solutions. This would be in addition to the independent research agendas that each industry might like to pursue. This is one way of adopting the polluter pays principle and of increasing funds.

19. WWF Recommends:

— Reversing cuts to the budget of UK marine science;

— Ensuring the independence of scientific research; and

— A levy on industry adversely impacting on the marine ecosystem to fund research into the solutions.

Science in the Polar and Non-polar Regions

Summary

20. Marine science around the poles must be extended in breadth and depth with the full range of plausible future scenarios investigated.

21. WWF is extremely concerned about the systems in the poles which will affect the rest of the world as climate change progresses. The extent of sea level rise which can be produced from the poles needs addressing and measurements and predictive techniques need to be further developed. Modelling needs to be updated with field observations and the full range of possible scenarios need to be explored and used when deciding the scale of mitigation needed.

22. The seas around the Arctic have already warmed by 4°C in some areas, and by 2080 the Arctic Climate Impact Assessment (2005) predicts that the central Arctic Ocean winter temperatures will have risen 8–9°C. The polar and marine sciences need to be developed so that politicians know what the polar areas will look like and what protection (from fishing/hunting, oil and gas exploitation and shipping) they will require as they respond to climate changes. Some changes will lead to further pressure on the region, if exploited. How potential additional oil and gas development and increased shipping in the polar regions (due to retreating ice) will affect the area directly, but also how they may further exacerbate climate change itself, must be researched.

23. WWF Recommends:

— That the full range of plausible future scenarios and uses for the poles should be investigated to determine what impact on the wider environment they may have.

Research into Marine and Climate Change (and Ocean Acidification)

Summary

24. While progress has been made on the impact of climate change on the marine environment, more is required. In addition, research is urgently required into the impact that changes in the marine environment could have on accelerating climate change—so called positive feedbacks mechanisms.

25. WWF helps fund the Marine Climate Change Impact Partnership, and also produced an Assessment of the Impacts of Climate Change on the NE Atlantic shelf seas in 2005 (Baker, 2005). Both of these studies, and others, helped start the process of understanding the impacts of climate change in the UK Seas. This work must be rapidly increased with a step change in the scientific understanding, particularly, in the

cumulative impacts of the predicted changes, and in the context of other human pressures, such as over fishing. The UK should also be studying the impacts of marine climate change in overseas territories, Commonwealth Seas and the wider marine environment.

26. Ocean acidification is an impact from CO_2 which is additional to climate change. The marine environment has absorbed roughly half the CO_2 produced by industrial processes to date. This has been to the detriment of the seas, as the CO_2 is forming carbonic acid and is making the seas more acidic. Within the next few decades, the seas are predicted to be more acidic than in the past 20 million years (see slide in annexe). More acidic seas are predicted to have impacts upon many marine organisms, eg some plankton and corals and other organisms which require a calcium shell to protect themselves. Cold water corals in UK waters are particularly vulnerable and predicted by the Royal Society to be likely to be lost due to acidification within decades (Royal Society, 2005). Research and monitoring science in the UK and internationally, therefore, is desperately needed into the impacts of this process on coral reefs, plankton and fish species. These species form the basis of ecosystems which are the main source of protein for a billion people (UN Atlas of the Oceans).

27. Of vital importance is better research into the impacts of the oceans on climate change. The ways the seas and climate interact are changing and several mechanisms exist which have the potential for the oceans to exacerbate climate change itself. One example is the huge reserves of methane hydrates in marine and coastal areas. Methane is a potent greenhouse gas, being 20 times more so than CO_2, and represents a huge potential feedback mechanism to climate change from our seas and coasts. Estimates vary, but there are thought to be total global methane hydrate reserves that correspond to 500–2,500 gigatonnes carbon (GtC) (Milkov 2004). By comparison, it is estimated that 5,000 GtC exist for all other fossil fuel reserves and only 230 GtC of other natural gas sources are estimated to exist (Milkov 2004, USGS 2000). The permafrost methane reservoir has been estimated at about 400 GtC in the Arctic (MacDonald, 1990), but no estimates have been made of possible Antarctic reservoirs.

28. To be stable, methane hydrates need high pressure or low temperatures. In the Arctic region, methane is being released as ecosystems warm and as sea levels rise. Huge lenses of methane hydrate ice crystals exist underneath the permafrost. Coastal areas are vulnerable to warmer waters rising and melting the methane ice crystals from below and it is thought that some reserves are already beginning to mobilise and release to atmosphere (pers comm., David Long, British Geological Survey, 2006). WWF has been unable to find adequate evidence of research into the level and nature of this feedback and any efforts to research into solutions. This is a vital area for research which the UK Government should develop rapidly, in partnership with other nations and industry as industry hold many of the tools and expertise for measuring and responding to methane hydrate release. The release must be measured and studied. Prevention should be studied, and where release is inevitable the best practicable environmental option should be employed to prevent methane causing rapid global warming, as it is thought to have done in the past.

29. Other major potential feedback mechanisms exist in the marine environment, including changes to cloud formation and changes to the transport of heat from the tropics to the poles. These need to be better understood and built into the modelling processes carried out to predict future scenarios for climate change. Many current climate models do not include some of the major feedback mechanisms and, consequently, may underestimate the climate change scenarios which are likely.

30. Finally, fish stocks throughout the world, are likely to be affected in differing ways by climate change impacts. Changes in the distribution of some species are already reported, with further changes anticipated. The productivity of some fish stocks is predicted to increase, and to decrease in others. The effects of environmental change brought about by climate change on stocks is amplified by the primary pressure of over-fishing. Over-fishing not only leads to declining stocks but removes the larger, older individuals that may be better able to buffer environmental variation. The combined impacts of over-fishing, climate change and acidification are considerable, and of major concern to the future of our fisheries and the people who rely upon this important food source. Therefore, fisheries management needs to account for these changes, and fishing levels potentially reduced or changed strategically in response to this added pressure on stocks to support future economic returns from the fishing industry. WWF advocates that greater research is carried out into the sustainable management of fish stocks in the changing climate where the UK and EU fish in the NE Atlantic, Arctic and through Access agreements.

31. WWF Recommends:

— Much greater research into the impact of climate change and greenhouse gas emissions on the marine environment, including ocean acidification.

— Urgent scientific study of potential marine changes that could accelerate climate change.

— Further research into sustainable fish management in light of climate change and the development of policies to respond to this.

Marine Sites of Special Scientific Interest and Marine Protected Areas (MPAS)

Summary

32. At present there are no marine sites of special scientific interest below the low water mark and no mechanism for establishing them. Protected marine sites have the potential to act as scientific baselines from which to measure changes in the wider marine environment. Scientific knowledge for establishing protected marine areas that are representative of the UK's marine biodiversity and habitats, however, is lacking for offshore sites.

33. The UK is a contracting party to the Oslo-Paris (OSPAR) Convention which requires signatories to designate an "ecologically coherent" network of nationally important marine protected areas by 2010. The UK Government is also committed to introducing a Marine Act, which would enable the designation of marine protected areas (MPAs).

34. The criteria to establish sites of special scientific interest provide a sound basis for selection of areas to protect terrestrial and inter-tidal biodiversity. At present there is no mechanism to designate marine sites of special scientific interest below the low water mark. WWF believes a mechanism to designate and manage nationally important marine sites of scientific interest are required under the Marine Act. This must also include a mechanism to designate areas which are highly protected and closed to human activities.

35. Highly protected marine reserves have been used in areas of the world as a scientific baseline on which to monitor and measure impacts of human activities and climate change. At present in the UK, all sites can be affected by human activities such as chemical, radioactive and noise pollution. A suite of highly protected areas are, therefore, urgently needed to inform science of changes in the marine environment, and to ensure greater resilience of the marine ecosystem to impacts such as water quality, fishing and habitat damage which are exacerbated by climate change.

36. With the approach of the Marine Bill and the prospect of marine protected areas, there is a clear need for better research into what areas should be protected, including how to achieve an ecologically coherent network of protected areas by 2010 as required by the OSPAR agreement. To inform this process WWF commissioned a report from the Marine Biological Association to best identify marine biodiversity hotspots, launched in January 2007. The report trialled the analysis of extensive benthic data sets using different "hotspot" measurements and gathering expert knowledge to identify potential areas of marine national importance. The unevenness in the data sets and unavailability of other data, due to commercial confidentiality, prevented an objective comparative analysis.

37. To address the gaps in our knowledge of what marine wildlife is where:

- Many more datasets need to be accessed, including data collected during a development consent process.
- A minimum standard applied to marine biological survey methods and results to enable comparison between marine sites.
- Government must invest in new surveys, where experts highlight our marine wildlife is at greatest risk.

38. In any sites of scientific interest or within the expected marine protected areas (MPAs), marine features are likely to need to move due to climate change—inshore as sea levels rise and north or to cooler water as temperatures rise. Some species may be lost altogether and features will move out of the protected areas. The protected sites will, therefore, require flexibility to be able to respond to changes in the marine environment. Further marine research will be needed to enable this flexibility (to inform where changes to boundaries should be made) and to inform the original designation of the network of MPAs. Finally, more research is needed to determine what is meant by an "ecological coherent" network of protected sites and what should be monitored in order to ensure a healthy, fully functioning ecosystem.

39. WWF recommends that:

- Further research is needed for the identification of marine sites for protection, as required by the OSPAR convention, particularly for offshore areas.

January 2007

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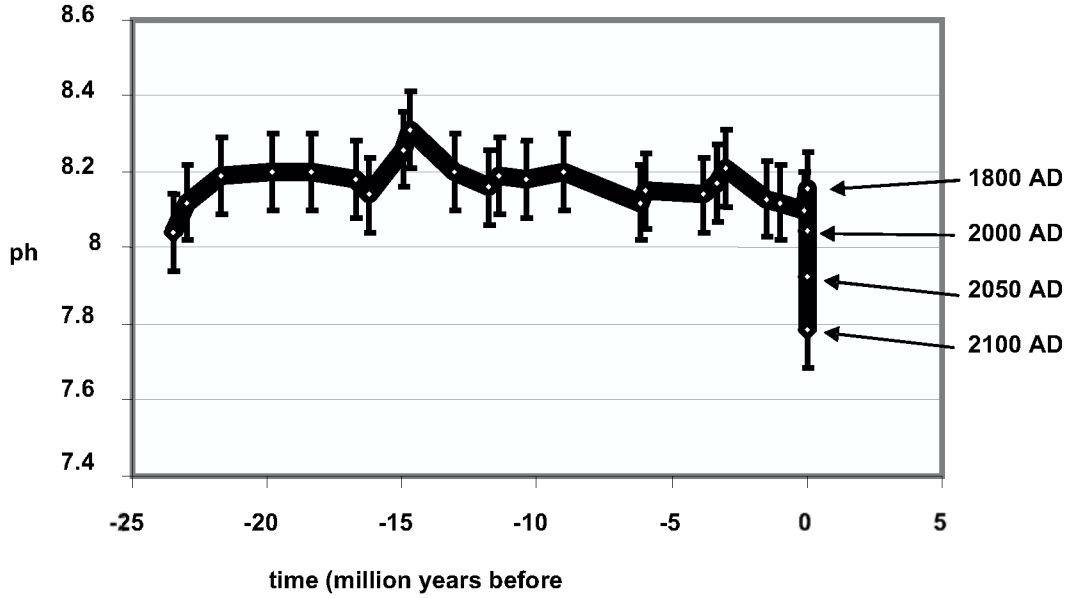
Annex

Ocean Acidification

A summary of the analysis of the impacts of climate change on the NE Atlantic seas, by WWF. Full report can be found at: http://www.wwf.org.uk/filelibrary/pdf/climatechangeandseas01.pdf

ANNEX

Oceanic pH is predicted to drop below any range known for 20 million years by 2050



Memorandum 35

Submission from the Environment Agency

Summary

We welcome the opportunity to present evidence to the House of Commons Science and Technology Committee. Our regulatory powers and interests are primarily in coastal waters. These areas are influenced by the "global ocean" and an understanding of the wider marine environment will directly benefit us in the discharge of our core activities. Our evidence highlights that:

- marine data needs to be managed through a comprehensive mechanism such as the UK Marine Monitoring and Assessment Strategy;
- an understanding of ocean processes helps our management of coastal regions; and
- deep sea micro-organisms have the potential to provide environmentally benign chemicals to replace and improve on synthetic organic compounds, many of which are environmentally harmful.

A summary of our roles and responsibilities in the coastal and marine environment is included in an Annex.

Introduction

We are interested in this Inquiry as we rely on the national science-base to provide high quality, timely scientific evidence to support our regulatory role. One of our responsibilities is to regulate activities in controlled waters which include coastal waters out to three nautical miles (for control of land based discharges, and pollution incidents); establishing and enforcing environmental standards; compliance monitoring; reporting on the state of the environment and flood risk management. We have statutory responsibilities for the management of migratory fish to six nautical miles and, in 60% of estuaries across England and Wales, have powers to manage sea fisheries. We also have a duty to promote the conservation of wildlife and habitats dependent on the aquatic environment. We are the competent authority for several EC Directives, including Water Framework Directive (WFD), Bathing Waters Directive, Shellfish Waters Directive, Nitrates Directive and the Urban Waste Water Treatment Directive in England and Wales. We are also a competent authority for the Habitats Directive (full details in Annex 1). We rely on an understanding of ocean processes to predict and model the behaviour of coastal and transitional waters.

Our operational activities in coastal waters extend to the construction and maintenance of defences against flooding from the sea. This includes dredging bed material to "recharge" beaches in certain locations, mostly along the south coast of England. This work ensures that those beaches continue to provide defence against flooding. All of our work is subject to the appropriate levels of environmental impact assessment and the acquisition of the necessary permissions and licences.

We have a joint science research programme with Defra into flood and coastal erosion risk. We, and other maritime authorities, use the findings to enable us to work with natural processes as far as we practically can when exercising our permissive powers to protect people and property from flooding from the sea.

Response to the Inquiry

1. We are an evidence-based organisation and rely on sound science for our decision making.

In November 2005 we published a review on the State of the Marine Environment.[68] Of the key indicators mentioned in this review only one, pollution, had a positive outlook. The uncertainties introduced by climate change reinforce the need for a good understanding of marine processes.

2. We are an end-user of science that is carried out both internally and externally by the Research Councils and Academic Institutions. We value the breadth of UK marine science and the wealth of expertise this ensures.

3. Marine data in the UK is collected by a range of organisations and we make a significant contribution through the National Monitoring Programme (NMP) and through our monitoring for regulation and decision support for EC Directives. Despite the contribution of the British Oceanographic Data Centre (BODC), there is no common database for archiving and disseminating ocean and other marine data. Data collection is an expensive process and it is essential that its value is maximised by ensuring ready availability in a consistent format.

[68] *Cleaner Coasts, Healthier Seas, The State of our Marine Environment report, November 2005.*

We support the UK Marine Monitoring and Assessment Strategy as an essential step towards getting the best value from marine data and information, particularly when public money is used for its collection. If a new organisation is formed through the proposed Marine Bill, it could have a role in promoting the co-ordination of data from existing bodies undertaking marine research. They should not however take on responsibility for all data collection and archiving in the marine environment. For example, data collected for ensuring compliance with Directives should remain with the competent authority for that Directive.

4. The prestige associated with innovation should not obscure the continuing value of more traditional activities including the provision of mean sea level, tidal and storm surge data and predictions. We require this data to support our flood risk management activities, including flood forecasting and warning. This data provision requires long-term support to ensure that we can continue to reduce the risk to life and property.

5. We support the continuation and development of ocean and shelf-sea models which underpin the coastal models routinely used to manage coastal protection and flood risk activities.

6. The establishment of UK Coastal Observatories to monitor coastal processes is welcomed as an effective method of connecting the monitoring and research communities to the end user. The NERC Liverpool Bay Observatory is a good example where continuous measurement is coupled to on line modelling as a cost effective alternative to conventional monitoring, with improved understanding of the coastal sea. The establishment of a European network of observatories should be encouraged.

7. We control and regulate anthropogenic inputs to the sea. With global climate change a reality, anthropogenic stress has to be managed in the context of changing seawater quality. Modelling and measurement of the changes in temperature, pH and nutrients etc of ocean waters is required. There is a need for good long-term data collection to ensure that the effects of man made intervention can be separated from natural changes. We strongly support the continuation of those long term monitoring programmes which allow systemic changes to be detected. The Sir Alister Hardy Foundation for Ocean Science (SAHFOS) plankton trawls and the Marine Biological Association (MBA) MARCLIM programme are seen as particularly valuable.

Although we can demonstrate major improvements in the control of gross pollution, there is still a need for research to reduce the uncertainty surrounding the more subtle impacts of trace contaminants on ecosystem health.

8. Micro-organisms ultimately control all biological processes, including remediation mechanisms, in the oceans. We would support further investigation into their role and new initiatives for ensuring continuing microbiological biodiversity. Over a million types of microorganisms are found in the oceans; these produce a diverse range of natural chemicals including "bio-actives". These have the potential to replace synthetic chemicals used for drugs and a wide range of other purposes. Major improvements to the environment will be possible if replacements can be found for the persistent, toxic and polluting organic chemicals currently synthesised.

The natural microorganisms of the oceans also have potential to provide a means of natural remediation of contaminated land and waste. We would welcome further research in this area.

9. The Inquiry is to include a study on the "impact of climate change on the oceans". It might equally be valid to inquire on the "impact of the oceans on climate change", as the climate and ocean processes are inexorably interlinked.

We also draw the inquiry's attention to the Foresight "*Future Flooding*" report carried out in 2004 that looked at the impacts of climate change, including on coastal flooding. There is a wealth of information in this report and its use may reduce the amount of new work that is required for the Inquiry's proposed study. Details of the report can be found at:
http://www.foresight.gov.uk/Previous_Projects/Flood_and_Coastal_Defence/

3. Conclusions or Recommendations

By presenting the above evidence we wish to draw the Committee's attention to:

- The value we place in ocean research to underpin our duties in coastal regions.
- The role of the oceans in driving and moderating climate change.
- The benefits from a network of coastal observatories.
- The potential of oceanic micro-organisms as a source of environmentally friendly pharmaceuticals, and providing tools for remediation of contaminated material and land.
- The benefits to be realised from better co-ordination of data holdings.

January 2007

Annex

ENVIRONMENT AGENCY ROLES AND RESPONSIBILITIES IN THE COSTAL AND MARINE ENVIRONMENT

Regulator

- Competent Authority for the EC Water Framework Directive (including transitional and coastal waters);
- Effluent discharge permitting and compliance monitoring, under the Water Resources Act 1991, Environmental Protection Act 1990, and Pollution Prevention and Control Act 1999 (out to three nautical miles);
- Prosecution for pollution incidents in controlled waters under the Water Resources Act 1991 (out to three nautical miles);
- Consenting authority for dredging activities in coastal waters under regional Land Drainage Byelaws;
- Regulation of fishing for salmon, migratory trout and eels to three nautical miles under the Environment Act 1995;
- Sea Fisheries powers (out to six nautical miles) in a number of transitional waters (estuaries);
- Competent and Relevant Authority under the Conservation (Natural Habitats, etc) Regulations 1994;
- Competent Authority for the Bathing and Shellfish Waters Directives; and
- Competent Authority for the Dangerous Substances Directive.
- Flood Risk Management, Water Resources Act 1991;
- Regulation of coastal and some offshore installations for radioactivity (Radioactive Substances Act, 1993) and monitoring of sediments, seaweeds and air for radioactivity in the environment.

Monitoring and management

- Coastal and tidal flood risk management and shoreline monitoring;
- Flood forecasting and warning for sea and tidal flooding in England and Wales;
- Navigation—eg Rye Harbour (where we have a port authority role); Dee Conservancy;
- Monitoring, assessment and reporting for EC Directives and other international obligations (eg the National Marine Monitoring Programme), including research and Development of marine monitoring and assessment techniques; and
- Under the UK Biodiversity Action Plan, lead partner role for coastal saltmarsh and mudflats, (and contacts for many other BAP habitats and species); and
- Emergency Planning, eg Bristol Channel Counter Pollution Association Group;
- Under Defra's new strategy called "Making Space for Water" it is proposed to give the Environment Agency a strategic overview for all flood and erosion risk management on the coast of England. Under this proposal we will acquire the same powers as a Coastal Authority under the Coast Protection Act 1949.

Advisor

- Planning and development consultations; and
- Ports sector—advisory role on management.
- Joint Agency and Government Working Groups (eg National Marine Monitoring Programme (NMMP), Review of Marine Nature Conservation).

Promotional

- Recreational activities associated with coastal waters.

Memorandum 36

Submission from the British Embassy in Tokyo

REPORT ON JAPANESE OCEAN RESEARCH AND DEVELOPMENT

SUMMARY

With more than 1,000 islands comprising the archipelago, 34,390 kms of coastline, and the world's sixth largest economic exclusion zone, Japan is a major international player in ocean related research and development. Research strengths include marine biology, deep-sea exploration and mapping and advanced computer modeling of the effect of the ocean on climate change and *vice versa*. World leading research facilities, including the development of advanced submersibles, provides the underpinning infrastructure for much of the research being undertaken.

1. *Organisation, Structure and Funding*

Six Government Ministries are involved in Ocean related research and development. The most important ministry is the Education, Culture, Sports Science and Technology Ministry (MEXT) which has a coordination role across Government for ocean development and provides the secretariat for regular cross ministry meetings. MEXT is also responsible for the Japan's largest marine research institute, the Japan Agency for Marine Earth Science and Technology (JAMSTEC).

Since 1990 the overall budget for marine science and technology has gradually increased year on year. Total spend on marine science and technology across Government is around £500 million, with MEXT (mainly JAMSTEC) accounting for £200 million or 40% of the total (2006 figures).

In addition to MEXT, but of lesser importance for ocean research in terms of funding and staff, is the Ministry of Land Infrastructure and Transport (MLIT). MLIT is responsible for the Japan Meteorological Agency which carries out general oceanographic research and meteorology, and the Japan Coast Guard which is mainly responsible for hydrographical observations and navigational charts.

There are also important centres of expertise at Tokyo University's Ocean Research Institute, the Tokyo University for Marine Science and Technology, and regionally at Tohoku, Kyoto and Hokkaido universities.

2. *Ocean Policy and Research*

National strategic planning of science and technology is carried out by the Council for Science and Technology (CSTP), part of the Cabinet Office. CSTP is responsible for drawing up successive five year plans for S&T, agreed at Cabinet level. This current third basic five year plan, published in March 2006, sets a target of 1% of GDP for S&T spend over the next five year period.

Ocean research and development is a key policy area for the Japanese Government. It makes significant contributions to three of the eight priority areas in the 3rd basic plan, Environment, Infrastructure and Frontiers. For example, two of the four major themes in the Frontiers research priority area are focused on deep ocean drilling and offshore platform construction research.

Japan's long-term ocean policy for the 21st century was set out by the Council for Science and Technology Subdivision on Ocean Development within MEXT in August 2002. The policy stresses the sustainable use of the oceans for conservation, research and resources, together with three research goals:

- Applying new knowledge to ocean conservation and use of marine resources.
- Elucidating the mechanisms of global warming and climate change.
- Contributing to the expansion of the intellectual assets of mankind.

3. *Research Priorities*

Research priorities include exploration of the deep sea and sub seafloor, addressing global environmental problems such as global warming, prevention of natural disasters (for example high tides, tsunamis and sub floor landslides), conservation and exploitation of marine resources, developing fundamental technologies for supporting research and observation (for example, autonomous underwater vehicles), and maintaining the necessary organisation and infrastructure for research and development.

A key project, which is seen as critical to national security, is the "Earth Observation and Ocean Exploration System", a joint project between MEXT, JAXA (the national space exploration agency), JAMSTEC and the University of Tokyo. The project aims to fully integrate satellite earth observation and ocean exploration data to improve Japan's ability to understand, analyse and mitigate global environmental problems (for example, global warming) and large-scale natural disasters. Within this project. JAMSTEC leads on the development of advanced ocean exploration technology.

4. *JAMSTEC*

JAMSTEC is the largest marine-earth science research institute in Japan with over 1,100 staff, 30% of whom are contract researchers. JAMSTEC undertakes fundamental research and development on the oceans. It's main research centre (Institute for Earth Sciences) and administrative headquarters are based in Yokohama but it has regional offices and research institutes in northern Japan (Mutsu Institute for Oceanography), Shikoku (Kochi Institute for Core Sample research) and Okinawa (Global Oceanic Data Centre). It also has four offices in the US, including two research centres in Hawaii and Alaska which it operates jointly with the US National Science Foundation.

JAMSTEC is organized into seven research centres reflecting the key themes of research:

— global change (observation and modeling of climate, ocean circulation, atmosphere, hydrological cycle and their interactions);

— earth evolution (mantle-core, tectonic plate dynamics, paleoenvironment);

— extreme biosphere (marine biology and ecology, extremophiles);

— earth simulator centre (advanced computational and simulation using one of the world's fastest supercomputers);

— marine technology (ocean and sub sea research vessels); and

— deep sea drilling,

A selection of the most important research activities is given below. More detail can be found in a report of a recent JAMSTEC seminar, see Annex 1.

4.1 Marine Technology

JAMSTEC has developed some of the most advanced marine technology in the world. It operates eight research vessels, including the deep sea drilling ship "Chikyu", which was launched in 2005 with the capability of drilling in 2,500 metres of water. "Chikyu" will be used to attempt to drill down through the seabed to the earth's mantle.

JAMSTEC also holds world depth records for manned and remotely operated submersibles. The autonomous underwater vehicle (AUV) "Urashima" is the largest AUV of its kind in the world. It is capable of diving to a maximum depth of 3,500 metres and is powered by a closed system fuel cell, with an energy efficiency of 54% (the highest yet achieved in the world). Operations are mainly aimed at detailed seafloor mapping and sub sea floor profiling. The manned submersible "Shinkai" can operate at depths of 6,500 metres and the remotely operated submersible "Kaiko" has a maximum operational depth of 7,000 metres.

4.2 Climate Change

JAMSTEC hosts the Earth Simulator, a 40 Tflops supercomputer, ranked as the word's fastest supercomputer in 2004. The UK-Japan Climate Change Modelling Collaboration is based at the Earth Simulator in Yokohama, see below. Although not used exclusively for ocean research, the Earth Simulator has enabled Japanese scientists to better understand the significant role the ocean plays in global warming and other climate studies and to more accurately model future long term climate change scenarios. Output from the Erath Simulator is being used to inform the Intergovernmental Panel on Climate Change (IPCC) assessment reports.

4.3 Marine Resources

The advanced marine technology developed by JAMSTEC, see above, has led to significant research strengths in investigating the potential of the oceans for bio and mineral resources. JAMSTEC has built up a strong research capability in marine genetics, through the collection and analysis of new species of deep sea bacteria and extremophiles. JAMSTEC's deep sea drilling capability will also be used in the future to explore the feasibility of exploiting the considerable reserves of methane hydrate in the sea bed around Japan as a future energy source. It is estimated that there is sufficient methane hydrate reserves to meet domestic consumption of natural gas for 100 years.

5. *International Co-operation on Ocean Research and Development*

The US is the single most important partner in ocean research and development but JAMSTEC also has research collaboration agreements with Korea, Indonesia, Australia and India.

There is no formal agreement with the UK on ocean research, but collaboration does take place on an individual project basis, the best example of which is the UK-Japan Climate Change Modelling Collaboration (UJCC). This three year collaboration facilitated by the British Embassy in Tokyo, started in 2005 and brings together top UK climate modellers from the Met Office Hadley Centre, NERC's National

Centre for Atmospheric Science at Reading University and Japanese researchers based at the Earth Simulator. The collaboration has enabled UK climate models to be developed with higher resolution. The collaboration has significantly advanced scientific knowledge of the role of the oceans in climate change.

6. *Education and Training*

Recently the number of doctorate and post doc marine scientists in Japan has increased resulting in a steady stream of new talent. The Frontier Research Group at JAMSTEC which undertakes fundamental and blue sky research on the oceans recruits internationally for post docs in an open competition to attract the best researchers. In some groups the proportion of international researchers is higher than Japanese researchers.

February 2007

Annex 1

REPORT ON JAMSTEC SEMINAR 14 FEBRUARY 2007

JAMSTEC Seminar 2007
Wednesday 14 February 2007
Venue: Keidanren Hall
by Seiko Oya

I attended JAMSTEC's annual seminar titled "Science and Technology Opening the Way to Ocean-Planet Frontier" on 14 February.

Aim of the seminar was to "introduce JAMSTEC's activities, achievements and future plans to the general public" and introduce various efforts "to understand the entire global system as an Ocean-Planet from the viewpoint of the ocean". For speaker and summary of each talk, please see page 2.

MAIN POINTS

- A recent IPCC (International Panel on Climate Change) report suggests that temperatures would rise by between 1.8 and 4.0°C in the 21st century. As evidences of global warming have been so clearly observed in recent years, JAMSTEC recognizes the increasing importance of their roles in climate change research.
- IPCC's suggestions to reduce CO_2 include its ocean disposal and ocean sequestration to which JAMSTEC's ocean drilling/observation technologies could make a great contribution.
- Urashima, their main deep sea cruising autonomous underwater vehicle (AUV) is operated with fuel cells.
- For earthquake prediction, "ocean-floor network system" has been under development. This project will involve setting up seismic and water pressure meters at 20 points on bottom of the sea around Tonankai seismogenic zone off Kii Peninsula. The data will be taken 24 hours and transmitted to Meteorological Agency and relative universities and research institutes for analysis.
- Introduction of recently launched "CHIKYU" (the Earth), the world's best Drilling Vessel (D/V) was highlight of the seminar. Talk was given by Dr Taira, project leader and DirectorıGeneral of Center for Deep Earth Exploration. He first thanked various sponsoring/co-operative organizations such as MEXT, MHI, Mitsui Ship Building, Hachinohe Municipal Government (in Aomori Prefecture. It provided a testing site) and many other companies. CHIKYU features Riser Drilling Technology with Blow-Out Preventor (BOP). The riser is installed at so-called "Moon Pool" located in the middle of the ship. It will start Nankai Trough Drilling of Kii Peninsula as part of Integrated Ocean Drilling Program (IODP) starting this fall. Please see Page 4 for CHIKYU's mission.

SPEAKERS AND TITLES

The New Challenge of JAMSTEC

Dr Kiyoshi Suyehiro, Executive Director (R&D) of JAMSTEC.

Suyehiro is a seismologist and oversees Research and Development activities of JAMSTEC. He led the "Immediate Study of the Great Sumatran Earthquake and Tsunami Disasters" immediately after the event and identified the tsunami source in early 2005. He will present emerging challenges for JAMSTEC as the uncertainties of the Earth's future seem to increase.

"Connection"; From Scientific and Technological Points of View

Part 1: Science and Technology Connecting Sea Surface with Sea Floor.

— Observational research of ocean's absorption capacity of carbon dioxide.

Dr Makio Honda (Sub Leader of Mutsu Institute for Oceanography (MIO)).

He has been studying western North Atlantic Ocean using automatic observation system from the early 1990s. Clarify chemical component for a little bit of dead plankton or its excrement and a cup of seawater, and elucidate the ocean's control ability of atmospheric carbon dioxide concentration.

Part 2: Science and Technology Connecting Geosphere and Biosphere

— Challenge to exploration of biosphere under the seafloor.

Dr Fumio Inagaki (Sub Leader of Kochi Institute for Core Sample Research (KOCHI)).

Add a fresh dimension of "earth microbiology" to the drilling earth science which is centering on Integrated Ocean Drilling Program (IODP), elucidate whole picture of unknown biosphere under the deep seafloor. Attempt to clarify the material circulation that those life activities are involved in and metabolic function of unknown microbial species.

Part 3 : Science Technology Connecting Micro Structural Evolution in Rock with Massive Fault Motion

— Understanding the Scaling and Hierarchy of Fracture Phenomena and its Application.

Dr Hide Sakaguchi (Group Leader, Institute for Research on Earth Evolution (IFREE)).

From many observations and experimental data related to interior earth evolution we will perform more accurate prediction of plate motion behaviour, not based on speculative or conceptual models but based on physical models with the help of computer simulations of fracture and flow of geo-materials.

Development of Element Technology for Next Generation of Cruise Vehicle

Part 1 : Technology for Accurate, Long-hour Cruise

— Decentralized processing system by multiple micro CPU.

Dr Hiroshi Yoshida (Research Scientist of Marine Technology Center (MARITEC)).

Engaged in development of Autonomous Underwater Vehicle (AUV) Urashima, 10,000 metres class unmanned research vehicle, he is in favour of development of underwater robot, aiming to establish observation system utilization for such as seafloor study, marine research, (micro)organism study.

Part 2 : Technology for Long Distance Acoustic Communication

— Long distance horizontal acoustic communication by phase conjugate wave.

Dr Takuya Shimura (Research Scientist of Marine Technology Center (MARITEC)).

Among development of acoustic technology necessary for underwater communication and positioning, he is studying long distance acoustic communication, and aiming to contribute for development of real time communication with long-range cruise type unmanned research vehicle.

Establishment of Ocean-floor Network System to elucidate Mega-Thrust Earthquakes occurrence mechanism around the Nankai Trough

— Telescope project of Mega-thrust seismogenic zone.

Dr Yoshiyuki Kaneda, (Director of Department of Ocean-floor Network System Development for Earthquakes and Tsunamis (DONET), Marine Technology Center (MARITEC)).

As an executive director of seismological research project, he is developing advanced ocean-floor network system around the Tonankai seismogenic zone off Kii Peninsula, to promote seismological research and disaster prevention/mitigation.

Latest Status of the Deep-sea Drilling Vessel "Chikyu"

Dr Asahiko Taira, (Executive Director / Director-General of Center for Deep Earth Exploration (CDEX)).

He serves as Director-General of the operation department of the D/V "Chikyu", is challenging many tasks in order to respond to Japanese, American and European researchers' expectations for Nankai Trough Drilling off Kii Peninsula which is incorporated into Integrated Ocean Drilling Program (IODP) starting this fall.

Special Lecture: Expectations for Promotion of Marine Research and Industrial Development

Mr Naochika Namba, (The corporate advisor of Mitsubishi Heavy Industries, Ltd. (MHI)).

Mr Namba joined MHI in April 1962. After he holds the prominent positions such as the director of Kobe Shipyard & Machinery Works, Executive vice president and General Manager of Shipbuilding & Ocean Development Headquarters, now he is the corporate advisor of MHI. He was the president of the Japan Society of Naval Architects and Ocean Engineers from May 2003 to May 2005. He participated in Expert Panel on Basic Policy, Council for Science and Technology Policy, Cabinet Office to drawing up the third Science and Technology Basic Plan. And then he held the post of Technology commission member of Panel on Infrastructure Development/ Council of Transport Policy for Ministry of Land, Infrastructure and Transport Japan. In this lecture, he states his expectation for the ocean-related most-advanced technologies including the Key Technology of National Importance "Marine-Earth observation and explore system", and its expansion to the related industrial fields such as research/observation equipment and robots by operating such technologies.

D/V CHIKYU's Mission

Observation and direct sampling of the seismogenic zone

Investigating the earthquake mechanism requires surveys, direct observations, samples and monitoring under the earth at the plate boundary. D/V CHIKYU, because it can drill to the seismogenic zone, is the primary tool to obtain these crucial pieces of information.

Research into life in the earth's crust and in the sub-sea floor environment

Enormous amounts of microbes, more than those on the earth's surface, live in the crust, which is a completely different biosphere than the surface. Research into these microbes in extreme environments may resolve the origin and evolution of life on Earth.

Investigation of the internal structure of the earth

The main objective of D/V CHIKYU is to drill through the earth's crust and reach the mantle, where no one has ever explored before. We will open the door for direct understanding the relationship between global-scale environmental change and mantle processes.

Investigation of the record and causes of global environmental change

Sediment cores obtained by D/V CHIKYU are valuable records of global environmental change.

Detailed analysis of such records enables the understanding of global change mechanisms and prediction of future change.

Memorandum 37

Submission from the Association of Marine Scientific Industries (AMSI)

TECHNOLOGY TRANSFER IN MARINE SCIENCE AND TECHNOLOGY

Submission to the UK Parliament Select Committee on Science and Technology

1. Commercial Marine Science and Technology (MST) is predominantly a niche market for specialised products and services.

2. The majority of the private companies operating in the sector are SMEs (less than 250 workers) of which a large proportion are very small (less than 40 workers).

3. Much of the effort to exploit government funded technology has been inappropriate to the MST sector. Funds have been wasted setting up internal departments to patent, legally protect and market products which are not needed in most niche markets. These small markets are often non-competitive due to the investment required to place a product. One or two specialist companies can exist comfortably by establishing the products first in the market and then supporting them.

4. Although the market for individual products is small, the return, as a whole, can be significant for the small companies involved (in terms of % revenue), for the academic centres (in terms of return for investment) and for the UK (in terms of business growth).

5. The government should engage more with existing businesses in the private sector in order to make a true commercial success of technology transfer from MST. The practise of setting up "commercial" entities within government funded bodies (often directed by government employees) can be damaging to the private sector in terms of unfair competition and lack of personal accountability.

April 2007

Memorandum 38

Submission from the Institute of Marine Engineering Science and Technology (IMarEST)

Executive Summary

Following a description of IMarEST, the submission outlines the importance of the oceans as a resource and the significance of government in promoting coordination of marine research. In answer to the questions posed by the committee the response stresses that:

- There are gaps in our fundamental scientific knowledge of climate variability
- There is a need for coordination and funding of sustained marine measurements
- Priorities must be defined for marine measurements
- There is a need for investment in biological sciences and increased support for UK marine biotechnology
- It is imperative that the UK increases its support for the Global Ocean Observing System (GOOS)
- Marine Science education must be supported and developed in schools
- There is potential value in the designation of marine areas as Sites of Special Scientific Interest (SSSI's) or Marine Protected Areas (MPAs)

About IMarEST

The IMarEST is the international professional membership organisation and learned society for all marine professionals working in marine, coastal and offshore environments and supporting industries. The Institute, based in London, was originally formed in 1889 as the professional body for marine engineers and is today the overarching body bringing together professionals from across all the marine disciplines. The IMarEST currently has over 15,000 members with around half based in the United Kingdom. The IMarEST's role is to promote the scientific development and inter-disciplinary understanding for Marine Science, Engineering and Technology and to uphold and advance the knowledge of professionals across the international marine community.

The IMarEST Technical Affairs Committee was formed to establish clear technical views and policies on global marine matters and to bring these views to the attention of the members of the IMarEST, relevant government, industry, regulatory bodies, educational and professional bodies and the general public in appropriate cases. The Committee consists of experts in many areas such as Climatology, Oceanography and Marine Meteorology, Ports and Harbours, Naval Engineering and Living Resources.

The Importance of the Oceans and of Marine Science

1. The oceans are of vital importance to society;
   - As a fundamental driver of weather and climate
   - As a source of vast hydrocarbon energy resources (oil and gas)
   - As a future source of renewable energy (wind, wave and tide)
   - As a critical source of minerals, food and chemicals.
   - With a major role in transport, world trade, communications and recreation.

2. With increasing multiple uses of the oceans and a move towards planning systems similar to those seen on land it is imperative that a marine science evidence base is developed which can be utilised by the UK government to provide fact based decision making tools for policy makers.

3. Planned policy development ie The Marine Bill, The European Marine Strategy and the European Maritime Policy provides an opportunity for UK Government to act as a coordinated customer for the science it funds. The Marine Bill will no doubt place DEFRA at the forefront as a customer. However, it is essential that UK government as a whole is committed to understanding, commissioning and coordinating marine science for its policy and operational needs. For example, marine science can be used to make improvements to efficiency and safety of shipping through improved weather forecasting for ship routing (Department for Transport), and provide support for the offshore energy industry by, for example,

providing evidence of the benefits of disposing of obsolete rigs as a reefs (DTI). The Interagency Committee for Marine Science and Technology (IACMST) provides a vital role in bringing together the departments. It also essential that industry is also engaged with government and the scientific community.

4. Stronger linkages between the scientists, industry and policy makers in setting priorities and goals for marine science are critical to integrated ocean planning and management.

5. To sustain the vital resources provided by the oceans, stewardship of the marine environment must be promoted and reinforced at all levels of government. Government must promote the message that the health of the oceans rests with the entire community. To ensure this government must be committed to broadening its acceptance of the duty of care for marine heritage and to promoting marine science education for all.

Q1. *Organisation and funding of UK marine science in the polar and non-polar regions*

CLIMATE CHANGE

6. The executive summary of the POST report 128, July 1999 highlighted the main objectives of a national strategy for Marine Science and Technology up until around 2020. These were: environmental protection, exploitation of ocean resources, national defence, prediction of climate change and its effects, marine technology and statutory and regulatory obligations. It may be prudent to assume that these objectives have not changed over the last 7 years but there is now more scientific evidence available to us in order to be able to prioritise these goals logically.

7. Described as "mankind's greatest threat" and "the ultimate weapon of mass destruction" there is global acceptance we must act now to mitigate and adapt to climate change. However, it should not be forgotten that significant gaps still exist in our fundamental scientific knowledge. How the oceans influence natural climate variability and long term anthropogenic change and how these changes impact on the oceans are still not well understood. The formation of the Marine Climate Change Impacts Partnership (MCCIP) was a positive step towards coordinating UK Marine Climate Change research and activity and should be supported.

8. The 1st annual MCCIP report card highlighted the significant gaps in our scientific knowledge, including the impact of changes in, and on, ocean salinity, potential changes to storminess and waves, the effect of climate change on large scale oceanic processes, the impact on fish and marine mammals and changes to seabed ecology. Knowledge of the impact of climate change on commercial activities is also limited, which means we don't know what the implications of climate change are for shipping, ports, offshore structure design criteria and effects on aquaculture.

CO-ORDINATION OF MARINE MEASUREMENTS

9. Measurements of the open ocean are essential for a thorough understanding of weather and climate. It is somewhat counterintuitive that ocean observations are therefore vital for land activities such as agriculture, forestry, water supplies, energy supplies, construction and transportation. It is more widely appreciated that ocean temperature, currents and salinity have profound effects on marine ecosystems. The effectiveness of marine climate services is dependent on the quality of the network that delivers the basic observational data, alongside the forecasting and prediction models and a delivery system which allows effective use by end users and policy makers.

10. These basic requirements underlie the case for a Global Ocean Observing System (GOOS) that will be the marine component of the proposed Global Earth Observing System of Systems (GEOSS), the call for which is supported by the G8. As has been made plain in 2005/6 by IACMST, the requisite network of ocean observations in and adjacent to UK waters and in areas of interest to the UK is not yet in place, depriving the UK information end user community of value, and causing the UK to lag behind other nations in its commitments to both the GOOS and the GEOSS.

11. UK marine science needs to be organised in a more coherent fashion, through a plan agreed by all departments and agencies, to ensure (i) that value is added by each observation made, (ii) that duplication of effort is avoided, and (iii) that gaps in geographic coverage or in technology are filled. To meet the fundamental needs of a diverse information user community the UK needs to improve the flow of information from both the open ocean and the coastal ocean.

12. It is essential that the UK commits to long term funding of ocean and coastal observations. Continued development also is required in advanced numerical models of the ocean, the ocean-ice-atmosphere system, and the ocean ecosystem. The UK government needs to recognise that processes in the Arctic and Antarctic Oceans drive the climate system and as such, should invest more in studying the nature and variability of these processes. It is imperative that measurement and monitoring funded by the UK as contributions to the International Polar Year are sustainable and not simply seen as short term research projects.

THE UK CONTRIBUTION TO MARINE MEASUREMENT—SPECIFIC EXAMPLES

13. The UK should commit to (in order of importance)

Open Ocean

- Deployment of 45+ Argo profiling floats per year to contribute to the global network of subsurface ocean data for ocean and climate models
- Maintenance of the Atlantic Meridional Transect (A programme which undertakes biological, chemical and physical oceanographic research during the annual return passage of the RRS James Clark Ross between the UK and the Falkland Islands or the RRS Discovery between the UK and Cape Town)
- Maintenance of the national tide gauge network
- Support for the expansion of the continuous plankton recorder programme
- Collection of Carbon Dioxide data from ships drifting buoys and transects
- Collation of a Met Office buoy with and Porcupine Abyssal Plain subsurface mooring
- Deployment of additional drifting buoys outside the North Atlantic, and sea ice buoys, especially in both polar regions
- Digitising the historical collections of ocean data in the National Archive (Kew)

Coastal Ocean

- Repeated hydrographic survey lines across the UK margin to establish regional properties and change
- Creation of a coastal HF radar network to obtain wave and current data
- Increasing the geographical and vertical coverage of measurements of plankton, nutrients, dissolved oxygen and organic matter, and total suspended matter
- Investment in advanced numerical models used to determine the best locations for observations to be made and to establish where there is redundancy, duplication and where more measurements are needed
- Deployment of sampling equipment on many ferry lines

14. Nationally consistent monitoring and data gathering must be coordinated at a central government level with an appropriate level of funding. To gain full benefit the quality controlled data gathered by the UK must be made readily available within the framework of the EU Inspire Directive and UK commitments to other international data exchange initiatives.

THE NEED FOR INVESTMENT IN BIOLOGICAL SCIENCES

15. Whereas funding of oceanography is significant for climate change impact studies, the biological sciences should not be forgotten. It is fair to say that there is shrinking budget for fisheries research, and for marine biodiversity studies. While the UK Marine Bill will no doubt feature heavily the policy goals of obtaining "healthy, biologically diverse seas" there is little idea of what constitutes "healthy" and "diverse". This difficulty will be compounded by directives from Europe requiring the UK to achieve good ecological status, something which, again, is difficult to define.

COORDINATION OF UK RESEARCH

16. Oceans 2025 is an excellent initiative that, with £120 million in funding over five years, should greatly improve the coordination of marine scientific research within the UK. However, there are concerns about over-reliance on "government labs" (ie NERC labs and fisheries labs) to deliver all the marine science required. The government-funded labs have to deliver specific research for government, eg data for Europe on fish stocks, and water quality, but are increasingly having to find "consultancy" type work to make ends meet. This tends to reduce their opportunities for novel, questions-driven marine research of the kind that is commonly found in university departments. Any decline in fundamental research, whether in government or university labs, will be detrimental, in the long term, to the standing of the UK in the global marine science arena.

17. Finally, it is the view of the marine scientific industry, that there is strong evidence that much of the £100 million spent by government to create spin-off companies has been ineffective. Many of the marine technology transfer offices set up by academic organizations are excessively bureaucratic and barely cover their own costs. The current scheme which encourages and funds academics to exploit their research and technology is often ineffective and can even be damaging to existing businesses where unfair competition

may be the result. Nevertheless it is recognized that good ideas for exploitable technologies do arise in academic and government labs; ideally these labs should be encouraged to work in partnership with industry to "design for manufacture", so as to make their inventions saleable.

18. As an enthusiastic supporter of commercial exploitation the government should engage more with the private sector in order to make a true commercial success of technology transfer.

2. *The role of the UK internationally, and international collaboration in marine science*

19. The UK makes a contribution to the management of, and observations for, Global Ocean Observing System that underpins weather and climate forecasting worldwide. At present the GOOS is only around 50% developed. Therefore, the UK's investment in observations should be doubled to meet the increasing requirement for detailed and accurate information in support of global sustainable development, as called for by the World Summit on Sustainable Development, 2002. Observations are needed in particular in remote locations, especially in polar seas that are difficult to access. The UK must continue shared funding of the European Space Agency's (ESA) programme of measurements of the open ocean and increase funds to ESA for new sensors (eg salinity).

20. The UK should take a stronger lead in supporting international operational observations of the oceans. Especially important in the context of climate forecasting is maintenance of the network of satellite altimeters which make crucial observations of ocean circulation. At present there is a critical gap between existing missions (which are near to the end of their design lives) and replacement missions (which are not scheduled for launch until 2013).

21. The UK also plays a key role in influencing the directions taken by UNESCO's Intergovernmental Oceanographic Commission, the main international body for marine science and lead agency for the GOOS.

22. The UK marine science community should play a stronger role in the work of the International Maritime Organisation (IMO) which is the only UN agency based in the UK. The community should provide more effective support to the UK delegation from the Department for Transport and the UK's interests represented by a number of Non Governmental Organisations including the Institute of Marine Engineering, Science and Technology. The IMO strives to achieve both improved maritime safety and environmental protection which must be backed by sound science and requires a much more joined up approach between government departments. Of particular relevance are the issues of invasive species, ship emissions and ship recycling.

23. The UK must take a lead in developing "green" ship technologies. It must develop a stronger capability for recycling and environmentally friendly decommissioning and recycling of ships. The development of decision support systems for the management of ballast water and associated treatment techniques to minimise the transfer of alien species must be encouraged. However, of utmost importance is the engagement of the Marine Science community in areas broader than their specific area of research.

3. *Support for marine science, including provision and development of technology and engineering*

24. The ocean is like outer space—an environment that is difficult and costly to reach and hostile to work in. It has the added disadvantage that it is largely non-transparent beyond depths of around 100 meters. As a consequence we know far less about the bottom of the sea than we do about the surface of Mars, which has been photographed in detail. We also know very little about life in the sea beyond the sunlit zone, yet it seems highly likely, given that there are many more phyla in the ocean than on land, that the prospects of finding medically useful chemical compounds there is more or less unlimited. The sea is a biotechnological frontier waiting to be exploited. Discovery and exploitation demand novel technologies. As in outer space, scientists are limited in what they can do without technological assistance. Ocean science is blind without ocean technology.

25. Of significance perhaps is the omission of pharmaceutical, biotechnology and genetic resources from the POST report of 1999. This demonstrates how rapidly this area is developing. UK government must realise the potential of marine biotechnology industries and provide a similar level of backing to that typical of terrestrial biotechnology industries. There is potential for marine biotechnological products to be used as anti-cancer agents, for bulk chemicals such as adhesives, for feed additives for aquaculture, and for remediation of environmental damage. The completion of the NERC funded Marine and Freshwater Microbial Biodiversity (M&FMB) programme (2000–05) leaves a potential gap in linkages between industry participants and research providers. A five year funding timescale for such projects is unsuitable due to the lack of understanding of new products (by both governments and potential users) and the long lead times for screening, testing and development. It is estimated that the UK currently supports 93 % of the publicly funded bioscience companies in Europe of which most are predominantly terrestrial based. This is an industry which should received continued support to expand into marine research.

4. *The state of the UK research and skills base underpinning marine science and provision and skills to maintain and improve the UK's position in marine science*

26. There exists a general difficulty in persuading students to follow a career in science and technology and in particular the marine sciences. The UK is still affected by the so called "Cousteau Effect" (or what might nowadays be termed the "Attenborough Effect"") with large number of people wishing to study Marine Biology as opposed to the physical sciences. However, universities are constantly struggling to bring in students with the right level of numerical skills now needed for the biological sciences (such is the integration of ecosystem modelling). Although the UK government is committed to promoting science and engineering in schools (following the Roberts report, 2002), how marine science fits into the picture is unclear. Marine science is typically integrated into the geography syllabus, or even, citizenship, as opposed to being incorporated into the traditional sciences. This is something that government should seek to review.

27. Alongside a review into the correct place for marine science education, more attention is needed to increase teacher confidence in teaching "unusual subjects"". This could be done through an emphasis on training in marine subjects and the development of appropriate teaching materials with practical applications. The UK government must also seek to support careers initiatives in Marine Science, Engineering and Technology. It is vital that school aged children are aware of the heritage aspects of the marine environment in order to understand their duty of care towards its protection.

28. At a higher education level training provision is currently lagging behind employer need. IMarEST is discussing with IACMST how to identify these and similar future needs, and what strategies should be implemented to meet them; we suggest more effort should be focused on this issue.

29. Streamlining and reorganisation in recent decades have pared the UK's oceanographic research base to the bone. What he have left is a hard core that could form the nucleus of a programme expanded to provide added value for the wide UK users of ocean information (which includes the land sectors mentioned above). A better developed UK marine science base could support an expanded UK marine information sector that could form the basis for an expanded UK marine services sector. Given the inevitable decline in North Sea service requirements over time, as oil wells dry up, developing a more outwardly directed UK marine services sector at this time would seem wise, along with an expanded skills and research base to serve its needs. As an island nation, it would be surprising and unfortunate if the UK did not exploit its maritime knowledge to the full in this way.

5. *Use of marine sites of special scientific interest*

30. It is first imperative to decide whether a site is being designated as a site of special scientific interest or a marine protected area as each will be subject to different legislation (ie Wildlife and Countryside Act versus a Marine Bill). There is also confusion with sites being defined as particularly sensitive seas areas by the IMO.

31. SSSI's are a very poor tool for the delivery of conservation in marine areas (including the intertidal area) and the proposed Marine Bill provides the opportunity to develop a more appropriate and effective regime for the UK marine area.

32. In an integrated management regime a site, whether an SSS or an MPA, should have a regime that delivers multiple benefits to society. So, for example, if a site is designated due to the presence of an historic wreck, but is also then a fish nursery, then the management plan should take this into consideration, which may actually reduce the need to designate an additional area for the protection of the fish habitat ie explicit consideration of multiple management objectives should lead to fewer protected areas and a lower total area under "high protection" than if each objective were pursued in isolation.

33. It is vital that economic and social factors should be taken into account and they should be a fundamental inclusion. Underlying principles must be properly implemented. There should not be a presumed preference for conservation; all considerations should include economic and social requirements in equal measures. This is required to meet the government's objectives of sustainable development.

DISCLAIMER

The information provided represents the views of the IMarEST Technical Affairs Committee and not necessarily the views of the IMarEST membership as a whole.

The IMarEST Marine Voices campaign provides the platform of opportunity for professionals to discuss and exchange ideas and practices, and promotes the scientific development of marine engineering, science and technology

May 2007

Memorandum 39

Supplementary submission from IMarEST

Additional Comments

From an international perspective it is our opinion that there is a relatively healthy on-going dialogue between the international offshore oil & gas industry and those in the UK involved in marine science and technology. This includes Institutes and government organisations, as well as commercial contractors.

In the absence of another forum (eg UKOOA), this dialogue is coordinated by the Metocean Committee of the International Oil & Gas Producers (OGP). This committee meets twice per year once in the USA and once in Europe. When the committee meets in the UK, Institute and contractor representatives from the UK and internationally are regularly invited to give presentations, and to discuss how the committee members can work together on common goals where this would be appropriate. Also these organisations are invited to participate in OGP initiated workshops, seminars etc. This has led to various projects with OGP members, either involving individual OGP members or together in Joint Industry Projects (JIPs). The focus is on international co-operation, making the best use of organisations (both Institutes and contractors) from different countries with the best tools and expertise for the task in hand. These JIPs are funded from various sources including the O&G industry and the EC.

The dialogue can always be improved. Understanding of the O&G industry needs for marine science and technology is sometimes mixed in the UK. Compared to other countries the interaction is less close. Perhaps some changes in attitude are necessary with more open interaction and cooperation, and more adaptation to the business needs. Examples from the metocean perspective include more user involvement in the specification of satellite monitoring programmes and more involvement in the assessment of the potential impact of Climate Change. Both of these topics are on the radar screen of the OGP metocean committee.

Marine science that is undertaken by private sector is primarily in support of the offshore oil and gas sector and renewable energy. Offshore work relating to other marine interests generally resides with academia and government agencies, and this position is unlikely to change whilst the bulk of funding for this type of work comes from government departments such as DEFRA. Much of the work could be undertaken by the private sector, which could possibly provide a more cost effective solution whilst maintaining or improving the scientific standards. Similarly academia could also provide greater input into the work commissioned by the Government departments. It is suggested that the effort required to secure government work is not commensurate with the potential reward due to the advantages, in terms of data access, proximity to clients, etc. that are maintained by bodies such as CEFAS.

Some areas of hope are provided, for example the provision of real time metocean data by the oil industry to forecasters offers an excellent demonstration of how integrated data solutions may work to benefit all sectors through improved forecasts.

A more balanced scenario exists nearshore, mainly due to the greater number of users of the marine environment in this geography. A mixture of public, private and academic bodies undertakes science in this sector. Due to the accessibility of this geography data collection is cheaper and generally more science is undertaken. The quality of science varies, with certain sectors undertaking the minimum to achieve legislation or due diligence to secure commercial funding, whereas others recognise the benefit of greater scientific knowledge and the positive impact it can make on their business activity. It is suggested that former is due to lack of knowledge and that education of such sectors would grow with the implementation of the Marine Bill and the requirement to provide evidence based on sound marine science. Greater data availability permitting multiple uses of the same data set would also decrease the cost to these sectors, which may then fund science on existing data sets.

The number of high quality courses available to physical oceanographers is severely limited. Additionally the role of applied oceanography in under-graduate courses is generally ignored. The private sector provides significant export value in the Marine Science sector. To maintain the health of this capability UK industry must maintain its cutting edge science as routine tasks can be undertaken cheaper by many overseas countries. The present R&D tax breaks may help to do this, but also greater technology transfer from Government funded research, eg through NERC, is also required.

Some coordination of Marine Science is poor. A simple example is the Environment Agencies tide gauge network. The Agency has approximately 300 tide gauges around the UK coast, often with different departments funding and maintaining gauges at similar locations. When considered with Harbour and Port authority tide gauges a comprehensive network could be implemented at probably lower cost with greater accuracy, dissemination and benefit to the general public and industry.

The Marine Bill white paper demonstrates the effectiveness of the overall coordination of activities relating to Marine Science. Within the paper the Marine Data Information Partnership (MDIP) appears to be considered as a permanent body that is appropriately funded, that could undertake some of the data storage and dissemination that will be required by the Marine Bill. In reality MDIP is a 2-year project coordinated by IACMST, with a single permanent member of staff. It is grossly underfunded and relies on the goodwill of industry, government agencies and academia.

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May 2007

Memorandum 40

Submission from the Office of Science and Innovation

This memorandum outlines OSI's interests in relation to marine science and technology. Funding is provided for marine science via the Research Councils, in the same manner as for other research areas. There has been some specific OSI involvement over the last 15 years. There was a Marine Panel in the first Foresight round; more recently, marine science made an important contribution to the Foresight project on Flooding and Coastal Defence; and, until 2003, the Office of Science and Technology (OST) chaired the Inter-Agency Committee on Marine Science and Technology (IACMST). These issues are addressed in response to the specific questions raised by the Select Committee (below).

1. The role and responsibilities of the OSI in relation to the marine sciences and technology sector

Marine science and technology responsibilities are distributed widely across Government departments, agencies and Non-Departmental Public Bodies (NDPBs). In the past, this meant that there was no single, obvious policy lead on marine science issues. The Inter-Agency Committee on Marine Science and Technology (IACMST) was therefore set up to maintain an overview of national and international activities in marine science and technology activities and encourage the optimum use of major UK facilities for this area of science. Because of the then lack of a clear lead department, OST originally chaired this committee. In 2003, the decision was taken to transfer the committee to the Department for Environment, Food and Rural Affairs (Defra), whose formation in 2001 had created a focus for marine policy and science in Whitehall.

OSI maintains a broad interest in science within and across Government as an input to evidence-based policy making. OSI has continued its formal membership of IACMST but has not played an active role in it.

The seven Research Councils are the main public investors of research in the UK universities and RC institutes. They are funded by the Science Budget through the Department of Trade and Industry (DTI)/ OSI. There is a good and long-standing principle that Government does not prescribe to individual Research Councils the details of how they should allocate resources between competing priorities. It is the responsibility of each of the Councils to decide what science it should fund and where, in order to deliver its Charter objectives and its mission. At a strategic level, OSI agrees the Delivery Plans prepared by each Council setting out their priorities and deliverables for the Spending Review period. OSI is not resourced to retain expertise in each research sector or discipline. This is the responsibility of the relevant Research Council(s).

Three Councils (NERC, EPSRC and BBSRC) fund research relating to marine science, details of which were provided in their individual memoranda to the Committee. NERC's Delivery Plan for the period 2005-08 included the renewal of funding for marine research which resulted in the Oceans 2025 Programme.

2. Support available from the OSI either exclusive to or of particular relevance to marine science and technology

In addition to the individual funding allocations made to each of the Research Councils following Spending Review 2004, during which some Councils made commitments in areas relevant to marine science, the DTI/OSI Large Facilities Capital Fund (LFCF) provided £25 million of funding to NERC to assist with the purchase of the RRS James Cook. This new oceanographic research ship was delivered to NERC in August 2006. The provision of LFCF funding followed prioritisation by RCUK of the projects listed in their Large Facilities 'Roadmap'. The remainder of the project cost was met by NERC.

LFCF funding of £38.5 million has also been earmarked for a replacement for the RRS Discovery, which is expected to be ready for service in around 2011/12.

3. COVERAGE OF MARINE SCIENCE AND TECHNOLOGY WITHIN THE FORESIGHT PROGRAMME, INCLUDING THE REASONS FOR DISBANDING THE MARINE PANEL AND HOW MARINE ISSUES HAVE BEEN COVERED WITHIN FORESIGHT SINCE THAT TIME

Foresight was established in 1994 in response the Government's 1993 Science and Technology White Paper "Realising Our Potential". At that time the Foresight Programme was formed of sixteen sector-based Panels, one of which was the Marine Panel. The Marine Panel published its findings in 1997, together with a report by a working group on Marine Fisheries and Aquaculture.

The next Foresight round started in 1999 and had only eleven sector-based panels, none of which specifically addressed marine issues. However, the Marine Panel had found its work sufficiently successful and thought-provoking that it decided to continue its work in a private capacity. In support of this Foresight provided the Panel with funding of £20k a year for two years.

In 2000 Lord Sainsbury (the then science and innovation Minister) announced a review of the Foresight Programme aimed at building on the successes of the first two rounds, and ensuring that the programme was fully able to exploit the challenges of the future. The key findings of the review were that the programme needed to refocus on science and technology; be more flexible to take account of emerging developments; and to focus resources more clearly on where they would best add value. As a result, the programme moved away from a structure of standing panels, covering broad sectors, to one that would allow new issues to be targeted and picked up quickly. The new rolling programme of projects was established in April 2002.

Foresight's move to project-based activities meant that it was unable to continue funding the Marine Panel, as the Panel's work no longer aligned with Foresight policy and its new objectives.

That said, the marine environment is fundamental to the issue of coastal flooding, and formed an integral part of a Foresight project on Flooding and Coastal Defence. The project delivered a qualitative and quantitative assessment of the drivers of coastal flood risk over the next 30 to 80 years in four socioeconomic- and CO_2 emission-based scenarios. This included an analysis of coastal processes and the impacts of climate change on, for example, the frequency and intensity of marine storms and their associated surges and wave action and sea-level rise. The project also assessed the efficacy and sustainability of a number of responses, such as managed realignment of coastal defences and structurally engineered solutions. It reported its findings in April 2004.

4. ANY OTHER RECENT WORK OR RESEARCH UNDERTAKEN BY OSI INTO ISSUES RELATED TO MARINE SCIENCE AND TECHNOLOGY

OSI has not itself undertaken any recent work or research into issues related to marine science and technology. Rather, its role is to provide funding via the Research Councils, who support research relating to marine science.

5. THE RELATIONSHIP BETWEEN OSI AND THE IACMST, AND BETWEEN OSI AND THE RESEARCH COUNCILS INVOLVED IN MARINE RESEARCH, WITH PARTICULAR REFERENCE TO NERC AND EPSRC

The relationship between OSI and IACMST

Since 2003, Defra has had lead responsibility for IACMST. The Committee is currently chaired by Defra's Chief Scientific Adviser, Professor Sir Howard Dalton, but in an independent capacity. OSI, which formerly had the lead, has retained formal membership of the IACMST.

The change in leadership came about following the creation of Defra, which provided a focus for marine policy and science in Whitehall that had not existed previously. Specifically, marine science supports Defra's work on conservation, environmental protection, fisheries and costal management objectives. (Other departments which sit on IACMST, such as the Ministry of Defence and the Department for Transport, have an interest in marine science, but to a lesser extent than Defra.)

The British National Space Centre (BNSC) attends IACMST by invitation when space-related issues are on the agenda. For example, last year, BNSC provided an overview and update to IACMST on the space component of the Global Monitoring for Environment & Security (GMES) initiative.

The relationship between OSI and the Research Councils involved in marine research

Each Research Council is a Non-Departmental Public Body (NDPB) responsible to the Secretary of State (DTI) and receives most of its funds by grant-in-aid approved by Parliament as proposed by the OSI. The Secretary of State is accountable to Parliament for the activities of each Council and determines the broad policy framework within which they operate and the amount of Parliamentary grant-in-aid. The Director General Science & Innovation is responsible for supporting the Secretary of State in securing the successful and high-quality operations of each Council in pursuit of its Charter objects, and for advising the Secretary of State and the DTI Accounting Officer in pursuance of their responsibilities in respect of the Councils. Detailed reporting, operations and accountability requirements for each Council areset out in a 'Management Statement and Financial Memorandum' (which is agreed between OSI and the respective

Council). This provides the principal vehicle for setting out the accountability requirements, and is supplemented by detailed guidance on objective setting, planning and reporting, which is issued annually by OSI to the Councils.

EPSRC and NERC collaborate closely on multidisciplinary research in marine science where it crosses the remit of both Research Councils, and there is aConcordat in place on responsive mode fundingto support research that crosses remits.

6. OSI'S VIEWS ON THE EFFECTIVENESS OF THE CO-ORDINATING MECHANISMS FOR MARINE SCIENCE BETWEEN GOVERNMENT DEPARTMENTS AND ON ITS OWN RELATIONSHIPS WITH OTHER GOVERNMENT AGENCIES WORKING IN THIS AREA

IACMST maintains an overview of national and international activities in marine science and technology and provides a mechanism for liaison between its members. If IACMST members had doubts about the effectiveness of the body we would expect them, or the IACMST Chair, to draw these to OSI's attention. This has not so far occurred.

7. OSI'S ASSESSMENT OF THE HEALTH OF THE SECTOR AND OF TRENDS IN FUNDING MARINE SCIENCE AND TECHNOLOGY, BOTH FROM PUBLIC AND PRIVATE SOURCES, OVER THE LAST TEN YEARS

OSI does not perform detailed analyses by sector. OSI monitors the levels of R&D more generally performed and funded by the business, government, higher education and private non-profit sectors, and departmental spends on R&D and science, engineering and technology. Funding for the marine sector will contribute to these totals.

June 2007

Memorandum 41

Supplementary evidence from the Natural Environment Research Council (NERC) following the evidence session on 1 May 2007

This memorandum covers three of the points raised in the Committee's letter of 11 May 2007. A fourth point (point 2 in the letter, regarding consultation on the Oceans 2025 proposals) was covered in our communication of 15 May 2007.

The three points are:

1. further details of the discussion between NERC and the Royal Navy regarding bartering or other arrangements to use their platforms (Question 37 refers)—see pages 2-3.

2. NERC's policies and arrangements regarding co-operative international ship bartering arrangements (Question 77 refers)—see pages 4-6.

3. details of NERC's case for capital funding for the new vessel to replace RRS Discovery, including details for the case made by NERC regarding the effective use of existing fleet facilities (Questions 86-87 refer)—see pages 7-13.

1. FURTHER DETAILS OF THE DISCUSSION BETWEEN NERC AND THE ROYAL NAVY REGARDING BARTERING OR OTHER ARRANGEMENTS TO USE THEIR PLATFORMS (QUESTION 37 REFERS)

1. NERC holds discussions with the Ministry of Defence (MOD)/Royal Navy (RN) through various fora, and some of its Research and Collaborative Centres (in particular the British Antarctic Survey (BAS), the British Geological Survey (BGS), the National Oceanography Centre (NOCS) and the Scottish Association for Marine Science (SAMS)) interact directly. The main fora are CAROS (the Co-operative Arrangement for Research on Ocean Science), the Inter-Agency Committee on Marine Science and Technology (IACMST), and the Marine Data and Information Partnership (MDIP). The RN appears keen to provide a service to the marine science community when possible but the RN is not as large as the US Navy and the availability of vessels for research is inevitably limited.

2. Examples of the contribution made by RN vessels were given by Professor Ed Hill in the oral evidence session on 16 May (Question 235 refers), and details of some collaborative work are provided below. Professor Hill mentioned the involvement of the RN in deploying ARGO floats, thus contributing to maintaining the global array of such floats, from which the data are freely available. Other data obtained by the RN, eg meteorological data, and ocean temperature data from expendable bathythermographs (XBTs) are also made available.

3. BAS has a close working relationship with *HMS* Endurance. There is no official agreement between the RN and BAS, but support to BAS science is given as one of the three tasks in the mission statement of *HMS Endurance*. In Antarctica a third of *HMS Endurance's* time is in support of BAS science, including the Antarctic Funding Initiative. This role is crucial to BAS science, particularly the helicopter capability. BAS works extremely closely with the RN to make this support effective and the commitment that the RN has to BAS is fully supported by the First Sea Lord. BAS has found the RN to be very receptive to requests for supporting other BAS science, especially access to their submarine capability. This tends to be on an ad-hoc basis.

4. BGS has been co-operating with the RN for over 25 years in using RN sidescan sonar and bathymetric data collected in UK waters and interpreting this RN data for incorporation in BGS offshore maps and digital map products. BGS also acts as a depository for RN sidescan records and sea-bed samples collected in UK waters.

5. After the Indian Ocean Tsunami of 26 December 2004, the RN approached Government to offer the services of the *HMS Scott*, a MoD hydrographic survey vessel with a specific purpose to acquire high-resolution multibeam bathymetry. This was the first time that the *HMS Scott* had had civilians onboard as it is specifically used for the acquisition of highly confidential data. *HMS Scott* was in the Indian Ocean at the time of the devastating tsunami and, like the *HMS Chatham*, was offered for use in humanitarian aid. In collaboration, BGS, NOCS and the UKHO met with the MoD and discussed a possible survey plan to acquire seabed data over the earthquake rupture zone. As a result we have a unique high-resolution bathymetric dataset that allows insight into the processes taking place during Great Earthquakes. The experience on both sides (RN and scientists) was very positive.[69,70]

6. BGS gained the impression that future joint exercises would be possible if the ship was available and if the imperative was significant. One area that may be raised in future discussion with the RN is access to the data *HMS Scott* acquires in her service role. She works in both the Indian and Atlantic oceans and the data sets, although confidential in the first instance, might be made available downstream for scientific research. In addition the ship's complement during the Indian Ocean survey were very appreciative of having scientists aboard who could actually interpret the data they acquired; this again may provide a basis for future collaboration.

7. SAMS interacts with the RN partly through the presence on SAMS' Council of Commodore Charles Stevenson CBE, the Naval Regional Officer for Scotland and Northern Ireland, and until recently the Director of the RN Directorate of Naval Surveying, Oceanography and Meteorology (DNSOM). SAMS' own Director, Professor Graham Shimmield, is currently chair of CAROS.

8. Since 1971 the RN has made submarine platforms available to support environmental science by the academic community in the UK, notably the ice-thickness studies by Professor Peter Wadhams (University of Cambridge) in the Arctic. The RN remains ready to assist with this research when possible, ie on an "opportunity" basis. In addition to offering platforms for research, the RN is keen to help the scientific community promote itself through the media. For example, during the latest Ice Exercise (ICEX 2007), the RN welcomed a camera team to *HMS Tireless* for the filming of a documentary about ice-thinning.

3. NERC'S POLICIES AND ARRANGEMENTS REGARDING CO-OPERATIVE INTERNATIONAL SHIP BARTERING ARRANGEMENTS (QUESTION 77 REFERS)

Introduction

1. NERC has marine facilities-exchange arrangements with organisations in the USA, Germany, France, the Netherlands, Norway and Spain. In addition, it is anticipated that a bilateral barter exchange arrangement between the UK and Ireland will be in place later this year.

2. From each barter partner's perspective, the exchange arrangements have two significant advantages. Firstly, it allows scientists access to a wider range of facilities and equipment than would otherwise be possible. This includes 44 research ships and other facilities such as remotely operated vehicles (ROV), towed arrays and shipboard surveying systems. Such facilities are required to carry out "cutting edge" research, but are frequently so expensive that it makes little sense for all countries to purchase their own facilities.

3. Secondly, it reduces wasted time, and therefore wasted cost, spent on long passage legs between areas of scientific interest, and allows scientists access to a wider range of geographical areas in a given year. In these ways the exchange arrangements promote more efficient and cost-effective use of each country's national resources.

4. To facilitate these arrangements, barter partners have now synchronised their annual cruise planning cycles and meetings are held in the spring and autumn of each year to allow for partners to consider programming and bartering possibilities.

[69] http://nctr.pmel.noaa.gov/indo20041226/hms—scott.htm, www.bgs.ac.uk/esissues/sumatraupdate.html
[70] www.noc.soton.ac.uk/nocs/news.php?action=display—news&idx223

5. Although the underlying principal is that no money changes hands, the arrangement does not provide "free" ship time. For every cruise on a foreign ship, the beneficiary country must mount a full cruise on one of its own ships in return, and to an equivalent value. The operating costs still fall to the ship owners, and each country has an appropriate scheme of banking to support the process. An equivalence points system has been agreed for the value of each of the ships, to ensure like-for-like value and barter points are allocated per ship day used.

NERC-NSF bilateral arrangements

6. NERC has had a bilateral barter arrangement with the National Science Foundation (NSF) in the USA since the mid-1980s. NERC has in recent years had regular exchanges with the NSF and this has allowed UK scientists to take advantage of the positioning of US ships in the Pacific and the Gulf of Mexico; to use the state-of-the-art US geophysics ship and its facilities; and to take part in joint cruises (see paragraph 10ii for more information).

NERC's trilateral arrangement

7. NERC has had a trilateral barter arrangement with organisations in Germany and France since the mid-1990s. These arrangements were then extended to include organisations from the Netherlands (in 2002) and Norway and Spain (in 2006). All trilateral arrangement organisations are now members of the Ocean Facilities Exchange Group (OFEG), which was formed in 2002 to facilitate the exchange of European ocean-going facilities.

8. NERC has played a lead role in developing OFEG through its Chairmanship/Secretarial roles. Recent OFEG highlights include:

- a step change in barter activity as trust has built up amongst the members of OFEG—with activity increasing from less than ca.50-days a year before 2003 to exchanges of up to 250-days a year;
- exchanges of marine equipment and technicians;
- the development of an OFEG deep-platforms facility (eg ROVs, deep-ocean towed platforms) and an OFEG marine geophysics facility—which will provide for better collaboration, and possibly integration, of these expensive facilities;
- workshop meetings that are planned for OFEG technicians to facilitate the improvement of information exchange, collaboration, and training activities.

NERC's barter activity

9. Over the past five-years there has been a step change in NERC's barter exchange activity and this has been made possible by the high levels of trust that NERC has built up with its barter partners. Before 2003, NERC was typically involved in 1-2 exchanges per year (typically amounting to less than 30-days exchanged per year) but from 2003 NERC has had between 12 and 15 exchanges per year with between 160 and 220 days exchanged.

10. NERC has in recent years proactively used barter arrangements to maximise the science that it can deliver with its marine facilities by, for example, minimising the number of science days that are lost in the cruise programme to extended passage legs between science areas. In addition, the barter arrangements have allowed NERC to realise a number of other significant benefits, which include:

i) Opportunistic interventions

The barter arrangements allow NERC to take advantage of the geographic position of barter partner ships to, for example, recover data from drifting moorings and then re-deploy the mooring quickly to maintain long-term time series. Such opportunistic interventions have proved invaluable to ensure that monitoring systems, such as the UK-US funded RAPID mooring array—that monitors the thermohaline circulation across the North Atlantic at 26°N—continues to collect a largely complete time-series. In 2004, for example, opportunistic interventions allowed for the timely recovery of drifting RAPID moorings on both the eastern and western boundaries of the North Atlantic using US and German barter ships, respectively. Such timely interventions would not have been possible using NERC ships.

ii) Joint cruises

In recent years NERC's barter partners have been willing to consider programming options that deliver a number of national science programmes on joint cruises. One recent example of this used a NERC ship to deliver a joint UK-Dutch-German cruise to recover and turn around the long-term moorings in the high latitude North Atlantic. Programming this cruise in this way ensured that all three nations did not need to send their own ships into this geographically remote region at the same time and it allowed for there to be interaction/collaboration between the members of the science and technical support teams.

iii) Large-scale exchanges

The increased collaboration that NERC has had with its partners has enabled it to programme the largest ever exchange by any nation—and it is anticipated that similar large exchanges will now be possible in the future. As part of this exchange, UK scientists will gain access to 130 days on the German research ship *Sonne* in 2008 and 2009 to do a geophysics experiment off Sumatra to improve our understanding of the earthquake that caused the tsunami in December 2004. Without the confidence that partners now have in the barter arrangements, it might not have been possible to deliver this science programme, as it is in such a geographically remote region that the use of a NERC ship would have introduced large passage legs into the NERC cruise programme at a time when there is high science demand for the available ship-time.

4. Details of NERC's case for capital funding for the new vessel to replace RRS Discovery, including details for the case made by NERC regarding the effective use of existing fleet facilities (Questions 86-87 refer)

Annex A formed the basis of discussions held between the Research Councils and with OSI regarding obtaining funding for a replacement for the RRS Discovery from the Large Facilities Capital Fund.

Annex A

Large Facilities Roadmap: Oceanographic Research Ship

1. *Executive summary*

1.1 The oceans play a pivotal role in the functioning of the Earth system, for example the possible rapid collapse of the Atlantic Ocean's thermohaline circulation would lead to severe and rapid climate change in north west Europe. Seagoing science is an essential element of Earth-system science. To maintain the UK's strong international leadership in producing high quality research in this area, NERC must retain the capability to field internationally competitive scientific programmes at sea using state-of-the-art research ships. NERC has two dedicated research ships for multidisciplinary ocean science cruises—the Discovery and the Charles Darwin (to be replaced by the James Cook in 2006)—and continued investment in these facilities is required to ensure that the UK remains in the first division of seagoing science nations.

1.2 The Discovery will be at the end of its scientifically useful life by 2011, by which time the ship will have been in service for 49-years. The replacement of Discovery with a ship that is capable of supporting large multidisciplinary science cruises is required to avoid driving detrimental large-scale changes to UK marine science research, to deliver NERC's strategy of Earth-system science, and to ensure that the UK's ocean sciences overall ranking as second to the USA in research excellence is maintained. It will ensure that the UK continues to provide strong international leadership and partnership within International programmes, and that the UK can continue to be involved in large-scale international collaborations. Failure to invest in the timely replacement of Discovery would risk the delivery of NERC strategic priorities and the UK's strong international reputation with it collaborative science and barter partners—as the ship may have to be withdrawn from service at short notice in the event of a major systems failure.

1.3 The UK is heavily involved with the bartering of marine facilities with its partners in the United States, Germany, France, the Netherlands and Norway—with *ca.*200 barter days a year exchanged by NERC. These arrangements ensure that research ships are used far more efficiently and cost-effectively, and they allow the UK scientific communities access to a wider range of marine facilities (including 32-research ships) and geographical areas than would have otherwise been possible. Continued access for the UK research community to barter facilities is contingent on the UK having state-of-the-art facilities to barter with, and so the replacement of Discovery will ensure that the UK's barter arrangements remain strong and that the UK science community can continue to conduct research on a worldwide basis.

1.4 The total cost of the replacement of Discovery with the required specification will be £55 million, and NERC has earmarked 30 per cent of the required funding (ie £16.5 million) for this project. The indicative funding profile for the build of a ship to be delivered in 2011 is outlined below:

FY 06/07	*07/08*	*08/09*	*09/10*	*10/11*	*11/12*
100k	1000k	14000k	18000	18000k	3900k

2. Importance of the science knowledge delivered

2.1 NERC has two dedicated ocean-going research ships, the Discovery and the Charles Darwin—both of which are approaching the end of their scientifically useful lives. The Darwin will be replaced by the James Cook in 2006, and the Discovery will reach the end of her useful life by 2011. The timely replacement of Discovery with a new state-of-the art ship will ensure that the UK can continue to mount the large

multidisciplinary science programmes that are required to improve our understanding of the inter-relationships between biological, chemical, physical and geological processes, in the marine and atmospheric realms, many of which are on a scale that will continue to require strong international collaboration. Such programmes are required to meet key outcomes in the sustainable Earth system theme that are highlighted in the Government's 10-year Science & Innovation Investment Framework. These include: a considerable reduction in the uncertainties in predicting climate change and sea level rise, both globally and regionally; a significant reduction in the current uncertainties about the possible rapid collapse of the Atlantic Ocean's thermohaline circulation; and understanding of the implications of global environmental change for the sustainability of marine ecosystem goods and services.

2.2 The science knowledge provided by research ships is critical to delivering against a number of NERC's strategy and delivery plan science priorities. NERC's two dedicated research ships have been essential research facilities for improving our understanding and prediction of the Earth's environment and they will continue to underpin the UK's approach to Earth system science. This is driven by NERC's science strategy, "Science for a Sustainable Future" (SSF), in which seagoing research makes a major contribution to two of NERC's three strategic science priority areas (ie 'climate change' and "Earth's life-support systems") and to fourteen of SSF's thirty-two strategy questions. In addition, seagoing science will make a major contribution to realising the 3 to 10–year objectives of the NERC Delivery Plan, such as through: the directed investments in Integrated Ocean Drilling (for site survey investigations), the UK Surface Ocean Lower Atmosphere Study, and Rapid Climate Change; planned future investments in Deep Oceans and Sustainable Management of Marine Bioresources; and the renewal of seagoing programmes at four of NERC's Research and Collaborative Centres. This research is important for the UK as it will improve our understanding of the Earth's life-support system—and its sustainability and ability to adapt to climate change—and our prediction of the various drivers of climate change, and consequent impacts, so that the UK can minimise and mitigate effects that will cause serious harm to the environment, the economy and society.

2.3 Further measures of the importance of the science knowledge are the quality, multidisciplinarity and international collaboration that are delivered. The UK has world-class strengths in the ocean sciences—with the UK's ocean science ranking as second to the USA in research excellence—and the maintenance of the health of this science base is heavily dependent on the UK having world-class marine facilities and maintaining its access to some of the best international facilities via barter partnerships (see section 7. for more information). Access to ship-time (on NERC and barter ships) is only provided for science programmes that have been graded as being of international quality at peer review and these programmes are increasingly multidisciplinary in nature with strong collaborations with a number of partners from UK and international institutions. NERC typically programmes *ca.*550 science days at sea a year, which is effectively all of the available ship-time. Approximately two-thirds of this science is funded by NERC with directed strategic funding (that contributes to NERC's science priorities), with the remainder coming from NERC's responsive "blue-skies" funding and other sources, including the MOD, DEFRA, the European Union and the USA's National Science Foundation. NERC believes that the timely replacement of Discovery is required to avoid driving detrimental large-scale changes to UK marine science research, to meet its strategy of delivering Earth-system science, and to ensure that international barter partnerships remain strong.

3. Contribution to international positioning of UK science and science strategy

3.1 Oceanography and earth science are two of the seven strongest areas of UK research in the environmental sciences. Bibliometrics analysis (using the ISI's Science Citation Indices) shows that in the environmental disciplines that the ocean sciences make a major contribution, the UK is second only to the USA, and closing the gap[71]. If the UK is to maintain this leadership edge and to retain its world-class centres of research excellence, which is Government's ambition outlined in the 10-year framework, then it will require on-going investment in state-of-the art marine facilities and continued access to the best international ships available through NERC's barter arrangements (see section 7. for more information). Such access is contingent on the UK continuing to have state-of-the-art ships to barter with.

3.2 The strength of the UK in the ocean sciences has ensured that it provides international leadership, influence and partnership within International programmes—notably those of the World Climate Research Programme (WCRP) and the International Geosphere Biosphere Programme (IGBP)—and has allowed NERC to fund and manage three International Project Offices (IPOs): WCRP's Climate Variability (CLIVAR) project; IGBP's Global Ocean Ecosystem Dynamics (GLOBEC), and Surface-Ocean Lower-Atmosphere Study (SOLAS). Through hosting these IPOs the UK is able to help set the scientific agenda of these international projects to maximise their value for the UK.

3.3 On-going international partnership in multidisciplinary research programmes is critical if the UK is to conduct world-class research in collaboration with world-class scientists. Over the last 5–years, 50 per cent of NERC's research cruises have involved collaboration with international scientists and students—who have come from 49 institutions and 17 countries—and this level of collaboration will only be

[71] 3 Source: UK environmental science review report for the Environment Research Funders' Forum

maintained if the UK's research ships remain state-of-the-art. One recent example of international collaboration has allowed for the deployment of a £10 million US-UK instrumental array stretching across the Atlantic Ocean to continuously study the dynamics, strength and structure of the large-scale circulation that moderate European climate. Maintenance and data-recovery require access to large research ships throughout the year. Recent work on this circulation indicates that the circulation may have reduced by 30 per cent over the past decade[72]—a change that could have significant climatic implications; the array will enable the true variability to be established, and the risk of associated rapid climate change in Europe to be quantified. Such large-scale international collaboration is realistically only possible if the UK continues to have access to two state-of-the-art research ships.

3.4 The UK science community is currently able to conduct research on a worldwide basis. Through close co-operation with NERC's barter partners, ocean-going research ships are positioned strategically around the world. In recent years this has allowed the international community to gain access to ship-time in, for example, the Indian Ocean on NERC ships and the Pacific Ocean on US and French ships. The non-replacement of Discovery would stop NERC supporting science on a worldwide basis—as NERC ship-time would mainly be restricted to the North Atlantic—and that would severely restrict the UK's contribution to international science programmes and to the "virtual" fleet of international barter ships.

4. Timeliness: urgency or potential lost opportunity if delayed'from proposed start date

4.1 Research ships are typically designed for a life of 25 to 30 years after which they are at the end of their scientifically useful lives. The Discovery has been in service for 43 years, which makes it the oldest ship in the world's oceanographic research fleet. A major refit to Discovery in 1992, which cost half the replacement cost of a new ship, was commissioned to ensure that the ship continued to have state-of-the art facilities for another 15 years (ie until 2007). NERC has continued to invest in the enhancement of Discovery's facilities to extend its life by a further 4-years, including the fitting in 2003 of a *ca.*£2 million scientific winch system. By 2011, the Discovery will have reached the end of its scientifically useful life; and it is expected that the programming of the ship will become increasingly difficult in the years leading up to 2011 as the ship becomes less capable of supporting the requirements of future multidisciplinary science programmes.

4.2 Failure to invest now in the replacement of Discovery will severely reduce the UK's ability to deliver world-class multidisciplinary ocean sciences, and it will reduce the scientific impact of UK science and its contribution to major international programmes. This would lead to some world-class scientists and engineers in UK universities and research institutes relocating to other countries.

4.3 To prolong the ship's life beyond 2011, by which time it will be 50-years old, is unrealistic on science grounds and the ship's major systems will increasingly be at risk of failure. This is because some of the Discovery's systems, such as its propulsion motors, are original and the "new" electronic systems that were fitted during its major refit in 1992 are now obsolete and cannot be easily repaired. A major failure would render the ship unfit for service and there is doubt about the cost-effectiveness of major refit works given the ship's age and its scientific capability. A major failure would seriously disrupt the cruise programme and delivery of NERC strategic objectives. Given that the UK cruise programme includes a significant number of international collaborative and barter cruises, which cannot easily be changed in the event of a ship being withdrawn from service (because international cruise planning typically takes some 12-18 months), there is a significant risk to the UK's international reputation in using the Discovery so near to the end of its operational life. A modest failure on the Charles Darwin, which comes out of service in 2006, highlighted this risk as the disruption that was caused to the UK's cruise programme jeopardised the support of the recovery and re-deployment of four sets of long-term moorings for four German and Dutch research programmes.

5. Breadth of science base that will benefit

5.1 The UK currently has world-class strengths in marine physics, chemistry and biology; marine geology and geophysics; marine engineering and technology; environmental computational modelling; atmospheric physics and chemistry; and earth observation—all of which need the data and samples that are collected using NERC's research ships.

5.2 The UK currently has eighteen seagoing research groups in RAE graded 5 and 5* university departments and four world-class marine research institutes (NB. this was recently established by peer review). In addition, the data and samples collected during cruises are used by many other groups in the UK in universities and stakeholder institutions, such as the Met Office, Hadley Centre and Natural History Museum, and by groups in many international institutions.

[72] Nature (in press)

5.3 Most cruise data and samples are readily available to the UK and international scientific community via, for example, NERC's British Oceanographic Data Centre website, which can provide access to biological, chemical, physical and geophysical oceanographic data with some 10,000 different variables. In addition, cruise data are available to Government Departments, agencies, and users via the UK Marine Environmental Data Network partnership.

6. Opportunity for knowledge or technology transfer and innovation, and wider benefit

6.1 Access to research ships provides the UK ocean sciences and engineering community with significant opportunities for technology transfer. The development of innovative new oceanographic instruments and sensors for use on research cruises will continue to be required if we are to improve our understanding of the Earth system. These instruments have wider applications. For example, an electromagnetic instrument originally developed for the study of volcanic activity in mid ocean ridges is now used by the oil industry for the detection of new sources of offshore hydrocarbons. This development has led to the recent floating of a University of Southampton technology spin-out company, Offshore Hydrocarbon Mapping Limited, for a value of just under £50 million. Similarly, the development of an Autonomous Underwater Vehicle (AUV) as a ship-launched platform for oceanographic sensors has led to a licensing agreement to give Halliburton Subsea exclusive use of the AUV for applications in the oil, gas and subsea cable markets.

6.2 The UK's world-class ocean sciences research also provides for knowledge transfer activities, such as, those of the recently launched National Centre for Ocean Forecasting (NCOF)—which is a collaboration between the Met Office and a number of NERC's Research and Collaborative Centres. NCOF will co-ordinate the UK's ocean forecasting activities and provide as much information on the short-range (5–10 day) conditions in the oceans as is currently available about the weather. Development such as this will ultimately benefit society and the economy by providing support to, for example, oil slick responses, search and rescue, defence, the management of water quality, ecosystems and fisheries, wind farms, oil exploration, safety of shipping and improved weather forecasts.

6.3 The 10-year framework emphasises the need to deliver evidenced-based policies and this is central to many of the UK's seagoing science programmes. For example, the Sustainable Management of Marine Bioresources programme will, following wide consultation with UK stakeholders, meet key elements of the underpinning knowledge that Government will need to formulate policy in this area. And on-going investments in the seagoing research that are required to reduce uncertainties in climate prediction will continue to contribute to the development of international policy via the work of, for example, the Intergovernmental Panel on Climate Change.

7. Scope for partnership with other funders

7.1 The UK exchanges more time on marine facilities through international barter arrangements, and with more partners, than any other country. These arrangements promote a more efficient and cost effective use of each country's marine facilities by allowing the scientific communities access to a wider range of technical facilities and geographical areas in a given year than would have otherwise been possible. In recent years these arrangements have allowed the UK to programme science on state-of-the-art facilities, such as a US geophysics ship, and to maximise the science that is programmed through, for example, the use of the most appropriate ships given the size and geographic location of science programmes. They are also increasingly being used for opportunistic barter cruises (that take advantage of the geographic location of barter ships) to recover UK moorings that have broken free and are drifting in the North Atlantic—which saves expensive capital equipment and data. Continued access for the UK research community to barter facilities is however contingent on there being on-going modernisation of the UK research fleet and an enhancement of its facilities, and so the timely replacement of the Discovery will ensure that the UK's barter partnerships remain strong.

7.2 The UK has arrangements with France, Germany, the Netherlands, Norway and the USA. These partnerships have strengthened significantly over the last 4-years with NERC exchanging *ca.*200-days a year, which represents over a third of the available ship-time within NERC's annual cruise programme. The leverage gained by the UK each year is considerable—not least because the number of science days "lost" to passage and down-time (when no UK science programmes are bidding for the available time) are significantly reduced by having effective international ship programming. In 2005, for example, NERC's ships operated at full capacity throughout the year (ie *ca.*550 sea days) in the Southern Indian Ocean, South Atlantic and North Atlantic, and only 15 sea days were 'lost' to passage (ie *ca.*2.5 per cent of available ship-time).

7.3 NERC has proactively examined co-ownership options with its barter partners to see if it is possible for the UK to have shares in two or more ships, which collectively would provide the UK with the same number of sea days as Discovery. At this time there are no opportunities to co-own any large ocean-going research ships and this is principally because no partners have any immediate requirement and/or funding in place for new ships. The strong international partnership relations within the Ocean Facilities Exchange Group (in which NERC is a member) will ensure that all new ship plans are made available to partners for comment so that, wherever possible, all new ships are compatible with the requirements of each nation. This

is now leading to the establishment of a virtual fleet of research ships that can easily be used by all partners. The proposed replacement of Discovery is supported by NERC's barter partners and any new ship would be built to complement the capabilities within the barter fleet and so, for example, it would not duplicate highly specialised capabilities, such as an ice-strengthened hull or 3-D seismics, that can be delivered using barter ships.

8. SCOPE FOR TRAINING AND PRODUCTION OF TRAINED PEOPLE

8.1 There are approximately 50 PhD students currently conducting research that has involved active participation in research cruises and in a typical year up to 350 scientists, engineers and students would gain research training and experience whilst using NERC's research ships.

8.2 As seagoing science has become more multidisciplinary it has allowed for NERC's research cruises to provide for more cross-disciplinary training for scientists and engineers, which is a key area for further improvement in the Government's 10-year framework. One current example of a multidisciplinary research programme is the £2.4 million consortium on the Atlantic Meredional Transect (AMT), which has just been independently reviewed for NERC. This Review found that AMT, which had 6 cruises over 3-years, had contributed to 11 UK and 16 internationally funded research programmes and 21 UK registered and 7 international PhD and MRes studentships, and was judged by the Review team to be "an outstanding means of training" UK ocean scientists

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Memorandum 42

Supplementary evidence from the Natural Environment Research Council (NERC) following the evidence session on 1 May 2007

Response from Dr Philip Newton to 11 May request for note on:

— the details and timescales regarding the consultation process for the Oceans 2025 proposal (Questions 45 to 50 refer)

In my response to Q42 of the Committee, I stated that: ". . . the Oceans 2025 Directors, when they were developing the proposal, had an open consultation to try to answer our question of what needed to be in it, and that [it] involved the universities, as well as the various agencies and departments [that] could play a part in trying to shape what was in it".

I can confirm that the above statement is correct.

The actual consultation process used by the Oceans 2025 Directors was as follows:

(i) A 25-page overview of the draft Oceans 2025 proposal was posted on public-access areas of the websites of the seven Oceans 2025 institutes on 30 November 2005 (a few days later for some institutes)—shortly after its approval for such a purpose by NERC's Science & Innovation Strategy Board—with an open invitation to comment.

(ii) The consultation was open until 30 January 2006 (a period of two months). The overview draft remained on the public website until final proposal submission (end March 2006), whereupon it was replaced by a revised and finalised version of the overview.

(iii) The consultation was flagged as a website 'news' item.

(iv) In addition, the overview document (and in some cases parts of the draft proposal) was used as a basis for a targetted consultation of key stakeholders, including relevant Government Departments and agencies.

(v) Parts of the university sector were also involved in some elements of the targetted consultation, such as in a 2-day workshop to develop the ocean modelling component of the proposal.

It should be emphasised that the open component of this consultation was on the Oceans 2025 "overview" document, not the more detailed draft proposal which was in iteration until its submission as a final version for peer-review to NERC in March 2007. This distinction reveals that my answer to Q46 is technically incorrect, in that I said that "the proposal was subject to an open consultation.". By "proposal" I was in fact referring to the Oceans 2025 overview document (I have always been fully aware that the proposal was not openly consulted on). I apologise for the confusion caused here by my imprecise choice of language. The quote from Professor Henderson in Q46 refers to "the Oceans 2025 document", which seems ambiguous as to whether it refers to the overview document or the draft proposal.

Additional remarks:

An open consultation of this nature has not previously been normal practice in developing science proposals to NERC, and it is not normal practice for the actual proposals to be public documents. Indeed, if this were the case then the ensuing process of national and international peer-review of the proposal, and consequent analysis of the reviews by a panel of national and international experts, would arguably be compromised.

NERC encouraged the Oceans 2025 Directors to undertake the open consultation on the overview document, to support development of the proposal, but did not issue any formal direction on following guidelines for Government-style consultations. In this case, the time constraints of the process would not have allowed a full 3-month consultation period. Moreover, it should be noted that this is a science proposal, not a strategy document, and it is highly unusual to conduct any sort of open consultation on science proposals.

The final Oceans 2025 science proposal, minus the elements that were not funded by NERC, will be made publicly available on the Oceans 2025 website during the week commencing 14 May 2007.

May 2007

Memorandum 43

Submission from Professor Paul Hardaker, Chief Executive, Royal Meteorological Society, the UK's Professional and Learned Society for Meteorology

SUPERCOMPUTING RESOURCES FOR UK METEOROLOGY

I noted from a recent evidence session carried out under the "Investigating the Oceans" enquiry that you expressed an interest in the supercomputing capacity available to the Met Office for modelling and forecasting.

Through the efforts of both the Natural Environment Research Council and the Met Office, the UK has a world leading reputation in the field of atmospheric modelling and climate prediction. I believe that this leading position is important because of the role of the meteorological community in both the UK's civil contingencies and in driving forward global and national climate change policy. Our science and innovation in these areas leads the current levels of technology investment and our global lead in climate in particular is being threatened as other countries significantly increase their supercomputing resources.

At present the current shortfall of our supercomputing resources is limiting the UK's ability to deliver the benefits from the investment in the underpinning science. This is particularly relevant to the climate modelling work that is focusing on both mitigation and adaptation issues, both of which require a far greater ability to unravel these complex policy issues at regional scale.

This was highlighted recently in an independent review of the Met Office's Hadley Centre, which concluded that although "it is beyond dispute that Hadley occupies a position at the pinnacle of world climate science, and in translating that science into valuable policy advice" it also stated that "world leading climate research is not sustainable over any reasonable period of time without continued access to supercomputers amongst the world's fastest". The full report is available at "http://www.defra.gov.uk/environment/climatechange/research/index.htm".

My belief is that investment can come in terms of both increased financial support and in the greater integration of existing facilities and the programmes of work that surround these. The latter, of course, is more practically challenging but offers significant benefits if it can be effectively achieved.

July 2007

Memorandum 44

Submission from the Marine Climate Change Impacts Partnership

STATEMENT ON MCCIP FOR "INVESTIGATING THE OCEANS"

The following statement provides an introduction to the Marine Climate Change Impacts Partnership (MCCIP) and outlines how the partnership is being used to advance knowledge of the impacts of climate change on the oceans.

What is MCCIP?

MCCIP is a partnership between scientists and sponsors from government, its agencies and NGOs. Our principal aim is to provide a co-ordinating framework for the UK, so as to be able to transfer high quality evidence on marine climate change impacts, and related advice, to policy advisors and decision-makers.

The initial objectives of MCCIP are to:

- Develop and maintain a co-ordinating framework for marine partners in the UK.
- Build the knowledge base and consolidate evidence of marine climate change impacts.
- Create effective mechanisms for the efficient transfer of marine climate change knowledge from the scientific community to policy advisers and decision makers.
- Facilitate the uptake of tools and strategies to assist stakeholders in developing and assessing adaptation strategies.

Why was it Formed?

The Marine Climate Change Impacts Partnership (MCCIP) was announced and launched in March 2005 as one of the actions from the UK government and devolved administration report *Charting Progress: An Integrated Assessment of the State of the UK Seas,* which identified climate change and unsustainable fishing as the two main threats facing the UK's marine environment.

How is it Structured?

The institutional structures for MCCIP include a fluid Steering Group of key stakeholders (chaired by the United Kingdom Department for Environment, Food and Rural Affairs) and an Expert Advisory Panel that provides scientific quality assurance across the programme.

The Steering Group is the funding provider and manages the direction of MCCIP, overseeing primary partnership outputs. The current Steering Group comprises the following organisations; Countryside Council for Wales, Defra; Department of Environment—Northern Ireland; Department for Trade and Industry; Environment Agency; Marine Environmental Change Network, Natural England; Royal Society for the Protection of Birds; SAHFOS, Scottish Environmental Protection Agency; Scottish Executive; Scottish Natural Heritage, States of Guernsey; States of Jersey; UK Climate Impacts Partnership (UKCIP), Welsh Assembly Government and the World Wide Fund for Nature. Defra is the biggest funding partner, with many of the other partners also providing income or help in-kind. However, it is important to note that group membership is not solely limited to funders and we anticipate future growth.

The MCCIP secretariat services and reports to the Steering Group, acting as the UK focus for marine climate change impacts information. The secretariat co-ordinates and leads on the delivery of MCCIP products.

An independent Expert Advisory Panel (EAP), comprised of international leaders in Marine and Climate Science, both guide and peer review scientific products from MCCIP.

Progress Made and Future Directions

During the start-up phase of MCCIP, the partnership has concentrated on building the scientific evidence base, principally through the provision of the marine climate change impacts annual report card.

The first annual report card (ARC), delivered ahead of schedule in November 2006, provides an at-a-glance summary of current scientific understanding of UK marine climate change impacts (www.mccip.org.uk/arc). The ARC is based on reviews submitted by leading UK climate and marine scientists on a broad array of subjects, encompassing all aspects of the marine environment. The ARC addresses what we know is already happening, what could happen in the future and rates the scientists' confidence in our current level of understanding. It strongly suggests that climate change has important consequences for the health and biological diversity, cleanliness and safety and the commercial productivity of our seas.

The partnership is now exploring the development of new products that are distinguishable from the annual report card and we are looking to significantly develop the MCCIP website, with a view to its future development as a "one-stop shop" site for UK marine climate change impacts evidence. In the first instance, this will focus on providing more up to date information on UK marine climate change impacts and supporting better links to relevant organisations and data sources.

MCCIP is currently providing guidance to the UK Climate Impacts Programme for the production of its next climate information package, UKCIP08. The inclusion of a marine climate change scenarios report for the first time in the next UKCIP climate information package (due October 2008) should significantly enhance our understanding of future change in marine and coastal environments, at both national and regional scales. The MCCIP will have a key role to play in disseminating the outputs of these scenarios and

is in consultation with the Met Office Hadley Centre to determine how best to use anticipated outputs to meet policy and stakeholder requirements. In particular we are providing advice on the type and frequency of data to be stored and the regional areas that should be included in these outputs.

Having successfully engaged the scientific community into the MCCIP process, with leading UK marine climate change researchers providing broad-based impacts evidence for MCCIP outputs, significant challenges lie ahead in ensuring that these messages are incorporated into planning and climate adaptation strategies. The ability to build effective mechanisms for knowledge transfer is critical to the success of this initiative. Indeed, the reasoning behind and institutional design of MCCIP is dictated by the need for effective mechanisms for knowledge transfer from the scientific community to end-users.

The MCCIP will use conferences, workshops and meetings to promote our activities and as the partnership develops MCCIP will hold its own stakeholder workshops. The MCCIP will continue to develop its website and will deliver regular updates on marine climate change issues through the MCCIP newsletter.

As the partnership continues to mature, it is planned that it will help to; identify gaps in knowledge and recommend priority areas for future research; assemble community views and partner requirements for climate change tools and information (eg marine scenarios of climate change) and advise on the development of an integrated marine climate impacts monitoring programme.

MCCIP is currently at an early stage. It will continue to develop over the forthcoming years and it is anticipated that its products will increasingly demonstrate the value of a co-ordinated approach to addressing marine climate change. This requirement for MCCIP to successfully evolve is critical given the prominent role that our seas play in both shaping and regulating our climate. What seems clear from the first MCCIP annual report card is that the marine environment *is* being affected by climate change and society needs to be able to adapt to the wide-ranging impacts such changes are likely to have.

The progress that MCCIP has made during its first two years has been impressive and provides a clear and effective way to address the needs of policy makers and advisors. The focus now is on expanding the scope and flexibility to enable MCCIP to get to grips with the ever-growing range and complexity of climate change information and process it effectively and in an appropriate (short) timescale.

Current Lifetime and Funding

The current MCCIP programme runs from December 2005 until 2010 (with a formal review scheduled for year 3). In order to assure financial security over this five-year period, a detailed partnership agreement has been negotiated and put in place between the MCCIP funding bodies. Approximately 75% funding for MCCIP's core products through to 2010 is already in place. These monies are supplied via the main MCCIP budget provided by the Steering Group's funding bodies and agreed with individual funding partners accordingly. Forecast costs for MCCIP are approximately £100,000 per annum.

July 2007

Memorandum 45

Supplementary memorandum from the Biotechnology and Biological Sciences Research Council (BBSRC)

BBSRC Annual Expenditure on Marine Science and Technology-related Research

Overall, BBSRC's total spend on marine science research for the period 2002–03 to 2006–07 can be seen in Table 1, below.

Note that these figures include all relevant research, including research grants, Institute Core Strategic Grant (CSG) projects and studentships. For 2006–07, figures shown are forecast spend as 2006–07 annual spend for Institute CSG projects is not yet available.

This paper should be read in conjunction with the BBSRC's response to the Investigating the Oceans Inquiry (Memorandum 26, for information). As discussed in the initial response, marine science research is at the periphery of BBSRC's remit and therefore the Council supports little research that is directly relevant to this area. The data provided below includes research on: aquaculture involving animals that naturally have all or part of their life cycle in a marine environment, (eg cod and salmon); MSc degrees in aquaculture; research involving cephalopods, cyanobacteria and crustacea. It does not include freshwater organisms; model species such as zebrafish; studies into run-off, catchment or environmental pollution (unless a marine environment is specifically targeted).

TOTAL MARINE SCIENCE SPEND FOR THE PERIOD 2002–03—2006–07

Table 1	*Estimated Spend (£K)*				*Forecast spend*
	2002–03	2003–04	2004–05	2005–06	2006–07 (£K)
Total	2,342	2,887	2,839	3,585	3,111

MARINE SCIENCE SPEND BY RESEARCH COMMITTEE

Table 2	*Estimated Spend (£K)*				*Forecast spend*
Committee area	*2002–03*	*2003–04*	*2004–05*	*2005–06*	*2006–07 (£K)*
Agri-Food	401	376	545	848	702
Animal Sciences	821	877	652	917	1,197
Biochemistry and Cell Biology	275	362	366	377	207
Biomolecular Sciences	43	81	74	67	50
Engineering and Biological Systems	7	14	22	24	17
Genes and Developmental Biology	667	1,008	1,056	1,144	775
Plant and Microbial Sciences	130	168	126	210	162
Total	**2,342**	**2,887**	**2,839**	**3,585**	**3,111**

Details of the Research Committee remits can be found at: http://www.bbsrc.ac.uk/science/areas/Welcome.html

MARINE SCIENCE SPEND BY CROSS-COMMITTEE PRIORITY AREA

Name of cross-Committee priority area	*Awarding Committee*	*Estimated Spend (£K)*				*Forecast spend*
		2002–03	*2003–04*	*2004–05*	*2005–06*	*2006–07 (£K)*
Bioscience Engineering	PMS	0	0	0	0	2,409
Theoretical Biology	GDB	0	0	0	71,428	77,922
Total		**0**	**0**	**0**	**71,428**	**80,331**

RESEARCH CO-FUNDED WITH ANOTHER RESEARCH COUNCIL

BBSRC did not co-fund any marine science research jointly with other Research Councils in the period 2002–03-2006–07.

July 2007

Memorandum 46

Submission from the Ministry of Defence

MOD ENGAGEMENT WITH UK MARINE SCIENCE ACTIVITIES

1. A statement on the NERC/MoD Joint Grant scheme for marine science research and any other MoD-sponsored schemes to fund research outside the MoD.

The Ministry of Defence/Royal Navy collaborates extensively with NERC and its research centres (in particular the British Antarctic Survey, the British Geological Survey, the National Oceanography Centre, the Scottish Association for Marine Science, Plymouth Marine Laboratory and Proudman Oceanographic Laboratory. The main forums are the Co-operative Arrangement for Research on Ocean Science, the Inter-Agency Committee on Marine Science and Technology, and the Marine Data and Information Partnership. The Royal Navy is keen to provide a service to the marine science community whenever possible.

2. A statement on the formal and informal arrangements between the OSI, the Research Councils and the MoD regarding access to naval vessels for scientific research purposes within the polar and non-polar oceans.

The MOD provides access to Royal Navy vessels for research purposes on a case by case basis whenever possible and practicable within the limitations of the operational employment of the ships concerned. Examples of the contribution made by Royal Navy vessels were given by Professor Ed Hill in the oral evidence session on 16 May (Question 235 refers), and details of some collaborative work are provided

below. Defence Intelligence—Intelligence Collection Strategy and Plans is in the process of arranging for CAROS members to meet with the Hydrographer of the Navy to discuss future collaborative work involving Royal Navy Survey vessels. Data routinely obtained by the Royal Navy, e.g. meteorological data, and ocean temperature and salinity data from expendable bathythermographs are also made available through the Met Office and Hydrographic Office.

HMS ENDURANCE has a close working relationship with the British Antarctic Survey. Whilst there is no official agreement between the Royal Navy and the British Antarctic Survey, support to British Antarctic Survey science is given as one of the three tasks in the mission statement of HMS ENDURANCE. Whilst in Antarctica, approximately one third of HMS ENDURANCE's time is spent in support of British Antarctic Survey science, including the Antarctic Funding Initiative. This role is crucial to British Antarctic Survey science, particularly the helicopter capability.

The British Geological Survey has been co-operating with the Royal Navy for over 25 years in using Royal Navy side scan sonar and bathymetric data collected in UK waters and interpreting this data for incorporation in British Geological Survey offshore maps and digital map products. The British Geological Survey also acts as a depository for Royal Navy side scan records and sea-bed samples collected in UK waters.

After the Indian Ocean Tsunami of 26 December 2004, the Royal Navy approached Government to offer the services of HMS SCOTT, a MOD hydrographic survey vessel with a specific purpose to acquire high-resolution multi-beam bathymetry. HMS SCOTT was in the Indian Ocean at the time of the devastating tsunami and, along with HMS CHATHAM, was offered for use in humanitarian aid. In collaboration, the British Geological Survey, the National Oceanography Centre and the UK Hydrographic Office met with the MOD and developed a survey plan to acquire seabed data over the earthquake rupture zone. The result was a unique high-resolution bathymetric dataset that allows insight into the processes taking place during great earthquakes. The experience on both sides (Royal Naval and scientific) was very positive.

Since 1971 the Royal Navy has made submarine platforms available to support environmental science by the academic community in the UK, notably the ice-thickness studies by Professor Peter Wadhams (University of Cambridge) in the Arctic. The Royal Navy remains ready to assist with this research when possible, ie on an opportunity basis. In addition to offering platforms for research, the Navy is keen to help the scientific community promote itself through the media. For example, during the latest Ice Exercise (ICEX 2007), the Royal Navy welcomed a camera team to HMS TIRELESS for the filming of a documentary about ice-thinning.

3. A statement on the MoD's participation in the Inter-Agency Committee on Marine Engineering, Science and Technology, including attendance and the substance of discussions held over the last five years.

Defence Intelligence—Intelligence Collection Strategy and Plans (DI ICSP) attends Inter-Agency Committee on Marine Science and Technology meetings, including sub-groups (Marine Environmental Data Action Group, Global Ocean Observing System Action Group and Marine Data Information Partnership on behalf of MOD. The substance of discussions has covered the whole of Inter-Agency Committee on Marine Science and Technology spectrum of activities. However, the MOD has been most heavily involved in discussions surrounding the continued support to ARGO floating buoys, the Marine Bill and Marine Data Information Partnership. Participation in Marine Data Information Partnership extends to active involvement in Working Groups and co-ordination of UK Hydrographic Office and Met Office input the initiative. DI ICSP recently developed a pilot project with the UK Hydrographic Office and Wessex Archaeology as a Use Case for Marine Data Information Partnership to demonstrate the benefits of collaborative data sharing.

4. Other ways in which the MOD research effort in the area of marine science and technology is co-ordinated with that of other Government departments and non-Government stakeholders.

There is good co-ordination between MOD and other Government Departments. A prime example of this would be HMS SCOTT's move from Military Data Gathering to Marine Scientific Research (a civilian role rather than military) to provide MoD assistance to OGDs by the provision of a large quantity of survey data following the Indonesian Tsunami in 2004 and early 2005. This is not an isolated case and a close eye is kept to see where OGDs may benefit from integration with military data gathering efforts. Defence Intelligence—Intelligence Collection Strategy and Plans is responsible for Defence Geospatial Intelligence policy and the research efforts of the UK Hydrographic Office and UK Met Office in support of marine sciences. Work carried out by the Met Office as part of the Defence Oceanographic Programme and by the UK Hydrographic Office, as part of the Defence Hydrographic Programme is co-ordinated internally between the two MOD Trading Funds and with the Research and Development work conducted by the Research Acquisition Organisation to ensure a coherent approach which delivers an improvement in the ocean modelling capability provided to the Royal Navy.

5. A statement on the Department's policy regarding access to MoD data by the scientific community for research purposes.

Meteorological data gathered by Royal Navy vessels is routinely made available to the Word Meteorological Organisation (WMO) through the Met Office. Oceanographic and Hydrographic data is held at the UK Hydrographic Office and is released on a case by case basis subject to classification and security implications. MOD supports the improved data sharing aspirations of Marine Data Information Partnership and the EU INSPIRE initiative and has been actively involved in providing input to both.

July 2007

Memorandum 47

Submission from BP

Introduction

1. BP is organized into three different business segments ie Exploration and production; Refining and marketing; and Gas, power and renewables. Within the Exploration and production or "Upstream" segment, activities include oil and natural gas exploration and production, together with the management of crude oil and natural gas pipelines, processing and export terminals.

2. BP currently has exploration and production interests in twenty five countries. Our main areas of activity include the USA, UK, Russia, Norway, Canada, South America, Africa, the Middle East and Asia. These interests are managed in a series of strategic performance units together with central functional support in specific areas of engineering, technology and science from the exploration and production technology group (EPTG). This has its main centres in the US (Houston) and UK (Sunbury-on Thames).

3. BP's activities in the marine environment, particularly in terms of marine science and technology, are largely confined to the Exploration and production segment. There are some minor activities in the other two segments but these are not discussed further below.

BP's Investment in Marine Science and Technology

4. EPTG leads BP's Upstream Research and Development (R&D) programme, within which specific areas of engineering and technology are pursued. The 2007 total investment in the EPTG program amounts to around £220m. A major focus for the R&D programme is the development of technologies and expertise in deepwater. This includes the ability to explore and produce oil and gas deposits in water depths of up to 3,000 metres.

5. Within this R&D programme, specific interests in marine science and technology include the development of autonomous underwater vehicles (AUVs). Work is ongoing to enable AUVs to monitor subsea pipelines with inbuilt intelligent tracking devices. Also included in the technology development programme is research into the deepwater installation of subsea hardware. Since 2001, BP has led a Joint Industry Project (JIP) on this technology, where the water depths ($>2{,}000$ metres) necessitate the use of fibre rope deployment systems rather than the traditional steel wire-based systems. This project ("DISH") has 28 companies including nine oil and gas operators, six major contractors and thirteen specialist supply companies.

6. BP's central Group Technology function supports strategic research relationships with a range of universities and academies around the globe, including Cambridge University and Imperial College in the UK. In the US, there is a collaborative agreement on ocean sciences and earth climate with the Scripps Institution for Oceanography at the University of California, San Diego. Work there includes development of autonomous underwater "gliders" to monitor the sea temperature, salinity and ocean currents. It is planned to use such devices to monitor the "Loop Current" and its associated eddies in the Gulf of Mexico. These can cause significant operational difficulties for exploration drilling activities and during the installation of offshore facilities. In addition, work is planned to investigate the use of high frequency radar devices to monitor the surface current field from fixed offshore installations. Two such devices, mounted some kilometers apart on adjacent installations, can provide a detailed spatial picture of the surface current speed and direction across a wide area. The primary focus is monitoring the Loop current.

7. From the environmental perspective BP is involved in several initiatives and projects related to marine science. Most of these projects aim at gaining a better understanding of the marine environment as well as environmental monitoring. These projects are developed in close collaboration with the scientific community who maintain their independent scientific view. The key areas where BP is involved include seabed and deep water monitoring, seabed surveys and sound and marine mammals.

Some examples include:

Serpent

8. This is a joint industry effort of on-going monitoring of the seabed West of Shetland (WoS) using remote operated vehicles (ROVs). It has international scientific acclaim with its own website and has published its own scientific papers. BP is a founding partner along with Subsea 7 and Transocean. The project has featured in a number of media publications and broadcasts including the BBC's Blue Planet series. There has been a big drive to develop and promote educational links to schools both in the UK, USA and elsewhere in the world.

9. Additionally BP is working with the Natural History Museum on a project in the WoS to study the fate of cetacean carcasses in the deep-sea which have been shown to support novel and new species and allows scientific information to be gathered on how animal communities develop on them.

Seabed Surveys

a 10. Elsewhere in the North Sea BP is revisiting the original environmental baseline surveys and drill cutting piles as part of our response to the EU Liability Directive and to understand long term impacts on the marine environment. With SERPENT we have PhD students based at the National oceanography Centre, Southampton (NOC,S) researching the colonisation of platforms in term of marine life. Other projects include mussel sampling on our southern North Sea gas installations and working jointly with geophysical contractor Gardline Environmental looking at herring spawning grounds around our Amethyst installations. Both these activities are ongoing research.

Deepwater Monitoring

11. "DELOS" (Deep ocean Environmental Long term Observatory System) is deep water technology being developed with BP funding in conjunction with OceanLab Aberdeen in partnership with National Oceanographic Centre, Southampton (NOC,S), Aberdeen University, Glasgow University and Texas A and M University. The deep sea environment is still poorly understood with surveys regularly discovering new habitats and communities of animals previously unknown to science. Two sea floor monitoring platforms will be deployed, one within 50 metres of a sea floor well, and a second 5 miles from any sea floor infrastructure. These platforms will be situated off Angola for 25 years and serviced every six months by ROV. The long term monitoring by the DELOS platforms will allow BP, amongst other benefits, to determine long term natural environmental conditions at deepwater sites, compare any changes observed at near field monitoring sites, increase the understanding of mechanisms linking climate change to deep water ecology and improve understanding of the reef effect from large fixed structures in deep water environment

AFEN (Atlantic Frontier Environmental Network)

12. This presents data and their interpretation from extensive seafloor environmental surveys carried out in 1996 and 1998 on the UK Atlantic margin to the north and west of Scotland. An area of more than 30,000 km^2 of the seafloor was studied, first by using sidescan sonar to provide acoustic imagery of the different environments within the area, then by sampling for biological, chemical and geological analysis, and by photographic and video surveys. The purpose of the work was to provide a regional assessment of this part of the Atlantic margin, and also to provide a baseline against which future changes might be gauged

Post-Doctoral Fellowships

13. In the recent past BP (2001) sponsored two, three-year postdoctoral posts in the fields of deep-sea invertebrate taxonomy and biodiversity hosted by the Texas A & M University (USA) and the NOC,S (UK). These two posts were part of a concerted effort by BP to take a leading role in improving our understanding of deep-sea ecosystems. The primary aims of the roles were twofold; firstly to develop and maintain a database of ecological data from BP deep water surveys, and secondly to identify critical needs for improved taxonomy from this database and thus publish taxonomic, biodiversity and other ecological papers on this work.

Marine mammals JIP

14. This is a joint effort organised under the auspices of the International Association of Oil and Gas Producers (OGP) in collaboration with the scientific community. It focuses on understanding the possible impacts of sound on marine mammals as well as on mitigation solutions.

Deepwater Engineering

15. We also conduct a wide range of research into the engineering of subsea and floating systems required for deepwater production facilities. While much of this is very specific to the energy industries we have developed much expertise in areas of interest to the wider marine community eg vessel motions , mooring and station keeping systems , current induced vortex induced vibrations for long tendons and risers, corrosion in the deep ocean environment . We could present a more comprehensive summary of this work if this was of interest to the Select Committee.

BP'S POLICIES REGARDING ACCESS TO DATA ON THE MARINE ENVIRONMENT FOR THE PURPOSES OF SCIENTIFIC RESEARCH

16. There is no overarching policy within BP regarding the access of our data on the marine environment for the purposes of scientific research. However, in general terms BP's marine meteorological and oceanographic ("metocean") data is available to the scientific community. This includes data on such parameters as waves, currents, sea temperatures and salinity, and associated marine meteorological information such as winds, air temperatures, atmospheric pressure etc..

17. However, one difficulty the scientific community faces is knowing exactly which data sets BP has available. This fact is generally true for the offshore industry on a global basis. To address this issue, several companies, including BP, have joined an initiative organised by OGP. The project is called "SIMORC" (System of Industry Metocean Data for the Offshore and Research Communities). Its funding comes from the EU under a Framework VI programme. The SIMORC system consists of an index metadatabase and a database of actual data sets that together are accessible through the Internet. The index metadatabase is public domain, while access to data is regulated by a dedicated SIMORC Data Protocol. This contains rules for access and use of data sets by scientific users, by oil & gas companies, and by third parties. All metocean data sets in the SIMORC system database undergo quality control and conversion to unified formats, resulting in consistent and high quality, harmonized data sets. BP will make available freely its data sets within SIMORC to registered scientific users.

18. Another example of BP sharing metocean data is collaboration with the groups monitoring the fluxes in the Faroe—Shetland Channel. These include the Fisheries Research Services in Aberdeen and the Faroese Fisheries Laboratory in Torshavn, Faroe Islands. Estimation of fluxes has been made for several years and includes measuring the currents and monitoring the temperature and salinity along transects between Scotland and the Faroes on a regular basis. BP have made available to these institutions our long term measurements of currents at our West of Shetland sites, around the Foinaven and Schiehallion production systems, in order to assist with their calculations.

19. In the Gulf of Mexico, BP performs detailed monitoring of the ocean current conditions using acoustic Doppler current profilers (ADCP's). In conjunction with other operators, and in collaboration with the US Minerals Management Service, these ADCP data are made available publicly, in real time, at the US National Data Buoy Centre web site.

21. In the area of marine meteorology in the North Sea and West of Shetland, BP is collaborating with Shell to extend an existing real-time network of weather monitoring systems (the "Metnet" system). BP's stations are being added in order to extend the spatial coverage. The data include meteorological and wave parameters and are used by the companies to plan operations such as helicopter flights and supply boat schedules. The data are also provided to meteorological agencies to assist in their provision of weather forecasts. The wave data is freely provided to DEFRA and is included on their public internet system ("WaveNet"). Also in conjunction with Shell, we are assisting the Offshore Safety Division of the HSE in establishing wave and water level criteria for the UK sector.

22. Very recently, we have started discussions with the Proudman Oceanographic Laboratory to make available water level data from offshore platforms, measured using the radar sensors deployed to monitor waves and water levels. This data could assist a planned research project at POL to examine the spatial variability of storm surge conditions in the North Sea.

23. BP has also provided funding for certain scientific advances in the marine sciences. A good example is our sponsorship of the publication of the atlas series linked to the World Ocean Circulation Experiment ("WOCE"). The WOCE project office was based at the then Southampton Oceanography Centre (now NOC,S). In the period 2001 to 2003, BP provided a total of U$300k to assist the publication of the 4 volume atlas series.

July 2007

Memorandum 48

Submission from Shell Plc

INVESTIGATING THE OCEANS

I am writing in response to your recent request for information about Shell's activities and investments in technologies within the marine environment.

Shell shares the UK Government's vision of "clean, healthy, safe, productive and biologically diverse oceans and seas", outlined in the recent Marine Bill White Paper. A healthy marine environment based on these principles matters to us for a number of core reasons. We have several businesses operating in the UK marine environment:

- Our *Exploration and Production (EP)* business is engaged in the upstream activities of acquiring, exploring, developing and producing oil and gas. Today we have ventures in more than 36 countries, with a significant presence in the North Sea, where we operate some 35 offshore production and sub-sea installations.
- *Shell WindEnergy (SWE)* focuses on the development and operation of utility-scale wind farms that add significant power, flexibility and capacity to the grid. It is developing three major offshore wind farm projects in Europe—Egmond Aan Zee in The Netherlands and two in the UK: London Array in the outer Thames Estuary and Cirrus Shell Flat Array in the Irish Sea.
- *Shell International Trading and Shipping Company (STASCO)* has more than 100 years of shipping experience transporting crude oil, refined products, liquefied natural gas and liquefied petroleum gas by sea and is responsible for managing and/or manning Shell's large portfolio of liquefied natural gas carriers and tankers.

Shell has been at the forefront of innovation for over 100 years. The launch of the Murex, the world's first seagoing tanker, revolutionized oil product transport in 1892 and helped to establish Shell as the major force in the industry.

Today, investing in technology continues to be central to our business strategy. For example, Shell has implemented technologies in the North and Norwegian Seas that were unheard of a few years ago.

Listed below are details of some of the most significant technologies being applied across Europe:

(i) *Maximising Recovery*

Tubular technology is used in the North Sea where there are many advantages. It can be applied both to upgrade the performance of existing wells and to promote the development of new wells. It reduces costs and, in some cases, increases productivity by up to 70%. Depressurisation—for example, the Brent redevelopment project was the largest offshore field depressurisation ever taken, helping to prolong the life of the Brent Field.

Horizontal drilling helps to reduce costs and improve recovery. The technology was swiftly implemented and has been a huge success in the North Sea.

Monotower platforms—the Monotowers Cutter and K17 deliver gas from separate sectors of the Southern North Sea. Both are ultra-minimal Monotowers, a new low cost low maintenance design, powered exclusively by renewable energy sources and with reduced CO2 emissions. We believe this innovation was a world first. There are plans to install four new platforms during 2007.

(ii) *Bringing Gas to Market*

Ormen Lange—a massive subsea development in deep, harsh, northern seas, more than 600 hundred miles from its customers. Its successful development will require the application of a wide range of advanced technology. The wells that Shell is now drilling are the largest deepwater gas wells ever installed.

Goldeneye platform—developed to be unmanned, it serves as a safe and cost effective platform in challenging marine conditions.

(iii) *Safety and planning*

METNET 3G Real-Time Network—this system provides continuous measurement of wind, wave and meteorological data at 25 offshore installations. This is the leading (and largest) oil and gas industry metocean network in the UK and is used for safety and planning of a wide range of Shell operations.

(The data also has many uses in the external organisations including improving weather forecast accuracy, coastal flood defences, flight planning/routing etc. http://www.metnet3g.com/).

In-house Load Statistics Module (LSM)—a system developed by Shell to derive the joint probability of extreme events. It enables quantification of winds and currents associated with a 100 year wave and factors the combination of wave, tide and surge to derive the 10,000 year extreme water level used in setting deck elevations.

(iv) *Addressing the CO_2 challenge*

Carbon capture and storage—carbon dioxide has long been injected into the ground to assist in enhancing oil recovery from existing reservoirs. Now Shell is working to develop cost-effective technologies to capture man-made carbon emissions, (for example from power plants and refineries) and store them safely underground.

I hope this provides you with a useful overview of our marine activities and some of the key technologies we have been helping to develop.

July 2007

Memorandum 49

Supplementary evidence from Inter-Agency Committee on Marine Science and Technology (IACMST)

INVESTIGATING THE OCEANS

As per your request, please find the following documents:

(i) a spreadsheet showing the attendance at each Plenary meeting since January 2002 by member organisations (Annex 1);

(ii) a similar spreadsheet but for the subgroups of IACMST, where the membership is by different organisations (Annex 2); and

(iii) a list of the topics covered at meetings of IACMST Plenary during the same period, as extracted from the agendas. (Annex 3).

You also asked for the "latest available statistics on marine science and technology investment, and the value to the UK economy of the sector as a whole and its constituent parts".

To my knowledge the most recent synthesis available is that commissioned and published by IACMST (Pugh and Skinner, 2002). I have recently learnt that a more comprehensive study has been commissioned through The Crown Estate. You should be able to obtain information on the scope and schedule for this study from Professor Mike Cowling of The Crown Estate.

Regarding the request for "a statement on the relationship between IACMST with (a) Defra and (b) OSI" I also thought it might be helpful to include the following extract from the approved minutes of the 34th IACMST meeting in June 2003:

> "The Chairman, Howard Dalton (Chief Scientist DEFRA), welcomed new members and visitors. He explained that this was his first meeting as Chair of IACMST: he aimed to be impartial in the role, and emphasised that he will be chairing a cross-Government committee, not one singularly attached to DEFRA."

The same minutes state "It was confirmed that DEFRA will support IACMST activities with the expected allocation for 2003–04 to be transferred from OST (£48k)." Defra and OSI (OST as it was then) are members of IACMST in their own right, the Defra representative throughout the period having been Dr John Lock. The funding held by OST for IACMST purposes was transferred across to Defra and John Lock has been responsible for its oversight.

Regarding "the formal reporting structures and arrangements for IACMST activities between IACMST and the Government" I took up position as Secretary of IACMST at the same time as Howard Dalton became Chairman. My understanding at the time (and since) is that IACMST continued formally to report to OST and I have been able to find no record of any change to this.

June 2007

Annex 1

UNDERWATER SOUND FORUM

19/06/2002	*26/11/2002*	*08/07/2003*	*01/03/2006*	*20/06/2006*	*29/11/2006*	*22/05/2007*	*Membership*		
Yes		Yes	Yes	Yes	Yes		BODC	–	Yes
X		Yes			Yes		BP Exploration	Yes	X
Yes		Yes	Yes	X	X		Defra	Yes	Yes
		X			X		DfID	X	X
Yes		Yes	Yes	Yes	Yes		DSTL	X	X
Yes		Yes	X	Yes	X		Dti	Yes	Yes
Yes		Yes	Yes	Yes	Yes		EA	Yes	Yes
					Yes		FCO	Yes	Yes
					Yes		IAGC	Yes	X
Yes		Yes	Yes	Yes	Yes		IAOGP	X	X
			Yes	Yes	Yes		IMarEST	X	Yes
			Yes	Yes	Yes		Marine Connection	Yes	Yes
Yes		Yes	Yes	Yes	Yes		Met Office	X	X
							MoD	Yes	Yes
							Mod–Royal Navy		
							NOC	Yes	X
							OPG	Yes	Yes
X		Yes					QinetiQ	Yes	Yes
Yes		Yes					R&V Hazelwood	Yes	Yes
Yes		Yes					SEERAD	X	X
X		Yes					University of East Anglia	Yes	Yes
Yes		X					University of St Andrews	Yes	Yes
							Worley, Parsons, Komex	Yes	X

13/01/2005	*24/05/2005*	*13/09/2005*	*30/01/2006*	*18/05/2006*	*19/09/2006*	*25/01/2007*	*24/05/2005*	*Membership as at June 2007*
				Yes	Yes	Yes	X	Cefas
Yes	X	X	Yes	Yes	Yes	X	X	Defra
Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	DfID
	X	X	X	X	X	X	X	DfT
Yes	X	X	X	X	X	X	Yes	DTI
Yes	X	X	Yes	Yes	Yes	Yes	X	EA
Yes	Yes	Yes	Yes	Yes	X	Yes	X	EPSRC
X	X	X	X					FRS
X	X	X	X	X	Yes	Yes	Yes	FCO
Yes	Yes	09/05 became corresponding member						IMarEST
				X	Yes	Yes	Yes	Met Office
						Yes	Yes	MoD
Yes	X	Yes	Yes	Yes	Yes	Yes	Yes	NERC
X	Yes	Yes	Yes	Yes	Yes	Yes	X	Northern Ireland Office
Yes	Yes	Yes	Yes	Yes	X	Yes	X	OSI
X	X	X	X	X	X	X	X	UKHO
Yes	Yes	X	Yes	X	Yes	Yes	Yes	Welsh Assembly Government
					Yes	X	X	
					X	X	Yes	**Independent Members**
X	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Professor Peter Liss
Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Mr Ian Townend
Yes	Yes	Resigned 08/05						Professor Graham Shimmield
				Yes	Yes	X	Yes	

Consultants
Dr Peter Collar
Dr Leonard Skinner

Secretariat
Trevor Guymer
Anne Brazier

Annex 3

IACMST PLENARY COMMITTEE MEETING DISCUSSION ITEMS 2002 TO DATE

10/01/02	NERC Laboratory Programme Presentation GOOSAG Report 2001 and plans for 2002 MEDAG Report 2001 and plans for 2002 Govternment Web for Science and Technology IACMST Website IACMST Programme 2002 DTI "Beyond Climate Change" meeting IACMST survey of marine-related activities in UK universities The Global Climate Observation System
16/05/02	University marine research interests FCO meeting on Law of the Sea Government Marine Stewardship Report and follow up NERC Marine Projects Presentation OST Review of Renewable Energy Research Developments in Marine Foresight Panel Future UK involvement in ARGO and JASON-2 Ocean Observatories and Associated Technologies IACMST Open Forum
12/09/02	Future UK involvement in ARGO and JASON-2 IACMST Open Forum OST Flooding and Coastal Defence Foresight Project Defra Coastal Zone Mapping meeting Possibility of working with OST on marketing MST
09/01/03	Future Chairmanship of IACMST CREST Marine Science Meeting and UK Representation UK Integrated Marine Mapping—data strategies GOOSAG Report 2002 and 2003 proposals MEDAG Report 2002 and 2003 proposalsJASON-2
11/06/03	JASON-2 UK support IACMST Plenary member presentations Climate Change Presentation—RAPID Programme, NERC Climate Change Presentation—Met Office UK Integrated Marine Mapping workshop Autonomy (A commercial software system offering "super-Google" capabilities Marine CREST Working Group
18/09/03	Marine CREST Working Group ERANET and ECORD JASON-2 UK support RAPID Marine Data and Information—where to now? UK Ocean Modelling Strategy and European/Global Modelling Centres Items from Action Group Chairs European Science Foundation Marine Board
15/01/04	European Science Foundation Marine Board CREST Marine Working Group RAPID Fisheries-related Research GOOSAG Report 2003 and proposals for 2004 MEDAG Report 2003 and proposals for 2004 ERANET meeting, Madrid
06/05/04	Gregynog Workshop ERANET Government Report "Net Benefits" plus presentation Global Marine Assessment Marine data and Information—where to now? Action Group Chairs items—UK monitoring strategy ARGO and Met Office marine observation moorings Cross-departmental spending review submission on a UK marine observing programme Oceanology International Underwater noise and impact on marine mammals

16/09/04	Fisheries-related Research Underwater noise and marine mammals UK modeling strategy initiative Eftec Economics Report Spending review—Outline Bid IACMST Retreat EARNET and MariFISH IACMST way ahead
13/01/05	Marine Bioresources MarinERA and ERANET IACMST Retreat Underwater Noise and Marine Life Working Group NGO representation on IACMST Marine Bill/State of the Seas Report/ EU Marine Strategy GOOSAG annual report and Forward Look NCOF Argo FloatsLong-term data sets MEDAG annual report and Forward Look INSPIRE Profile-raising of IACMST Spending Review Bid update Task Force on Asian Tsunami
24/05/05	Marine Bioresources "Net Benefits" MEDAG Review Indian Ocean Tsunami ERANets and MarinERA INSPIRE Marine Climate Change Impacts Partnership Underwater Noise Working Group OSPAR Spending Review and UK Marine Monitoring Programme IACMST Retreat Horizon Scanning Marine Bill and EU Marine Strategy NCOF and UK GOOS Strategy "State of the Seas"
13/09/05	INSPIRE Spending Review UK Argo Programme funding Sustained observations with CSA Marine Bioresources Underwater sound and marine life IACMST Retreat Horizon Scanning Marine Bill and Marine Monitoring Strategy Indicators MDIP Structure MEDAG Review ABPMer Marine Spatial Planning Pilot Hazards and Predictability
30/01/06	Marine Bioresources Horizon Scanning Underwater sound and marine life MEDAG review MDIP review MEDAG annual report and future plans GOOSAG annual report and future plans
18/05/06	Horizon Scanning MEDAG review and issues Underwater sound and marine life MDIP status and future plans IACMST response to Marine Bill consultation Relationship between MMO and IACMST Marine Bioresources Oceans 2025

	GOOSAG issues and UKMMAS
19/09/06	Marine Bill consultation document Underwater Sound and launch of Forum Horizon Scanning and Alternative Futures for Marine Ecosystems Global Monitoring for Environment and Security and possible IACMST role Marine Core Service GOOSAG issues including UK Argo funding Future of GOOSAG, MAPC, and MAPC re UKMMAS MEDAG/MDIP Issues
25/01/07	Underwater Sound Forum membership Horizon Scanning Clarification of status of UKMMAS IACMST Retreat Global Monitoring for Environment and Security Marine aspects of translating science into policy Oceans 2025 programme—outcome of proposal IACMST submission to Commons Science and Technology Committee Inquiry GOOSAG Annual report and plans for 2007 in light of UKMMAS Secondment from GOOSAG to assist UKMMAS MEDAG annual Report and plans for 2007 INSPIRE directive Change in IACMST meeting to one annual full Plenary and more sub-group meetings.
24/05/07	Select Committee Inquiry into Marine Science Marine Bill White Paper EU Maritime Policy Green Paper Underwater Sound Forum IACMST Retreat 2007 GOOSAG progress with transfer to UKMMAS Status report on UK Argo MEDAG/MDIP issues

Selected acronyms

ARGO	System of profiling floats
ERANET	European Research Area Network
GOOSAG	Global Ocean Observing System Action Group (the UK' s committee for GOOS)
JASON-2	Satellite altimeter mission
MarinERA	Marine European Research Area (a specific ERANET)
MEDAG	Marine Environmental Data Action Group
NCOF	National Centre for Ocean Forecasting

Memorandum 50

Supplementary evidence from the Met Office following oral evidence session on 16 May 2007

During oral evidence on 16 May, Dr Mike Bell offered to provide a written response on the sort of marine science research that MoD is looking for from the Met Office.

MOD funded marine research is carried out in three programmes at the Met Office: the Defence Climate Research Programme (DCRP), which forms part of a much larger Integrated Climate Research Programme that incorporates the Defra Climate Prediction Programme; the Defence Environmental Research and Technology Programme (DERTP); and the Defence Oceanographic Programme (DOP).

The Climate Research Programme includes research and development of ocean models as components of Earth system models for use in seasonal and decadal predictions and to provide advice on the likelihood, magnitude and patterns of climate change. This includes patterns of sea level rise and effects of climate change on shelf seas.

The DERTP includes a range of research and development activities in the marine area that have potential or specific application to military operations. These activities both underpin the basic science (e.g. water clarity) and engage with stakeholders to demonstrate the application of ocean models to military decision making, for example through the development of improved water column visibility products for underwater operations.

The DOP supports research and development of the Met Office's ocean forecasting systems that are used to provide operational weather forecasts for the Navy through the Fleet Weather and Oceanographic Centre (FWOC) at Northwood. In the past this research and development was focussed on the conditions which

affect sound propagation, particularly the depth of the layer of nearly uniform temperature near the ocean surface and the forecasting of temperature fronts and eddies. More recently the focus has been on near-shore waters including near-shore waves and water clarity.

In the case of DCRP and DERTP, MOD's requirements are formulated by the Research Acquisition Organisation (RAO). These requirements originate from a range of MOD stakeholders, including various Equipment Capability Customer areas, frontline Commands and, for the DCRP, policy areas.

Funding for the requirements formulated by the RAO is currently channelled through seven Science and Technology Outputs (these are the "pillars" Dr Bell referred to in his oral evidence). Each Output is owned by a high level customer in MOD such as the S&T Director for *advice availability* and the Deputy Chief of the Defence Staff (Equipment Capability) for *advice to capability management*. Funding for Met Office ocean R&D is currently channelled through the DERTP and DCRP from three of these seven Outputs. However, during the current financial year the seven Outputs are being re-organised into three channels: enabling research capability, capability planning and management, technology development. Nevertheless, the basic model of funding being channelled to the above Met Office programmes from higher level themes remains unchanged.

In the case of the DOP, MOD's requirements are formulated by DI ICSP (Defence Intelligence, Intelligence Collection Strategy and Plans) under the Chief of Defence Intelligence. This is informed by regular stakeholder gatherings such as the Forecast Ocean Model Working Group whose membership includes FWOC, Fleet Warfare, Dstl, the Maritime Warfare Centre and ICSP. The Forecast Ocean Model Working Group also oversees the ocean elements of the DERTP ensuring coherence between the programmes.

All three programmes, the DCRP, the DERTP and the DOP are encapsulated within Customer Supplier Agreements, which define the services required by the customer (expressed in output terms) including quality measures where applicable.

June 2007

Memorandum 51

Supplementary evidence from the Natural Environment Research Council (NERC) following oral evidence session on 23 July 2007

NOTE REGARDING THE UTILISATION OF NERC'S REMOTELY OPERATED VEHICLE (ROV)

This note follows up references made to the ROV at the oral evidence session on 23 July 2007.

I understand that the Committee heard from scientists during its visit to Portugal that the ROV is not fully utilised, and that full utilisation is not possible because of a shortage of technical staff. I would like to clarify these statements.

The ROV has a dedicated team of technicians in the National Marine Facilities Division (NMFD), based at the National Oceanography Centre, Southampton, who can support the deployment of the ROV for approximately 100 days per year. Currently this level of support meets the strategic and responsive-mode science demands of NERC. Should NERC science require greater access to the ROV in the future then the technical support arrangements for the ROV would need to be reconsidered.

The ROV is only required to support a relatively small proportion of NERC sea-going science and the main platform for ROV deployments is the *RRS James Cook*, which is also required to deliver other marine science activities. Consequently, the full utilisation of the ROV has to be balanced against the other needs of the NERC cruise programme.

Partnership arrangements with other countries for the shared resourcing and use of expensive marine equipment, such as the ROV and marine seismics, would seem sensible in the future to ensure that such equipment is fully utilised. NERC expects such arrangements to emerge as relationships with its barter partners develop.

July 2007

Memorandum 52

Supplementary memorandum from the Department for Innovation, Universities and Skills (DIUS)

1. Is UK Marine Science Underfunded? How Optimistic can we be About Oceans 2025 Receiving Guaranteed Funding Under the Comprehensive Spending Review settlement?

NERC is satisfied that marine science receives an appropriate proportion of the funding provided to NERC to administer for environmental science. There are always more excellent research applications made to NERC (and other Research Councils) than can be funded—this applies equally in marine science—and thus NERC turns down proposals for projects rated alpha 4 in many areas of science.

The Oceans 2025 programme is one of a number of NERC's activities addressing marine science. NERC Council's decision was that Oceans 2025 funding at the desired level is guaranteed only until March 2009, and that the future funding level would be set after the outcome of CSR2007 for NERC is known. NERC would expect to fund Oceans 2025 beyond 2009, but the level of funding will be dependent on the settlement, which has not yet been announced. It is the responsibility of the individual Research Council (in this case NERC) to allocate appropriate funding to its research programmes.

2. How is DIUS Working with the European Commission on Coverage of Marine Science Within the Maritime Strategy Green Paper and the Seventh Framework Programme?

Defra provided input into the UK's response to the maritime strategy green paper, on which the Department for Transport lead. We see the resulting maritime policy as an opportunity to promote more joined up approaches across the Community's institutions, including in relation to marine science and research, where, for example, existing structures can be used to promote better co-operation.

Marine science is a cross cutting issue in the Seventh Framework Programme with marine resources covered in Theme 2 (Food, Agriculture and Fisheries and Biotechnology) of the Co-operation Specific Programme and pressures on the marine system and the management of marine environments covered in Theme 6 (Environment, including climate change). The UK works with the Commission through the programme committees for these themes and is represented by Defra, FSA and BBSRC in Theme 2 and Defra and NERC in Theme 6.

3. What Steps are you Taking to Encourage Knowledge Transfer and Investment in Marine Technology?

DIUS encourages knowledge transfer through the Higher Education Innovation Fund. This provides funding that allows every (English) University to increase its capacity for knowledge transfer. Particular areas are not specified; rather the HEIF operates at a strategic level, allowing universities flexibility to increase knowledge transfer according to their strengths.

The Public Sector Research Exploitation fund provides support for the commercialisation of research carried out in public sector bodies including Research Council Institutes, Government Laboratories, NHS hospitals and major museums and art galleries. Funding is awarded on the basis of a competition which is open to all Public Sector Research Establishments. In the last round of the competition (worth a total of £25 million) organisations which received funding included the Sea Mammal Research Unit and a consortium of institutes lead by the Plymouth Marine Laboratory.

The Technology Strategy Board is funding a range of research looking at future commercial potential some of which as has a marine context. In particular, investigating marine micro organisms as a source of novel enzymes for biocatalysis and supporting research into wave and tidal energy. The aim of these projects is to support collaboration between business and academia to create future products and services.

NERC, along with other Research Councils, is placing increasing emphasis on ensuring that the research it funds benefits society and the economy. It has a knowledge transfer (KT) strategy and its activities cover liaison with industry and policy makers, training to encourage scientists to engage in knowledge exchange, and support for the commercialisation of intellectual property arising from NERC-funded research.

Research proposals submitted to NERC are judged on scientific excellence, but even responsive-mode applicants will in future need to include a KT plan, showing how they would engage with potential users of the research outputs. All NERC directed research programmes include and implement a KT plan, and their programme management committees often include users. NERC's knowledge-transfer funding schemes are available to the marine-science community. NERC invests in developing marine technology where needed for its research, such as AutoSub. NERC's Research and Collaborative Centres, including the Marine Centres, have active KT programmes, and many have staff specifically allocated to KT activities. In preparing the Oceans 2025 proposal, consultation with stakeholders helped to identify opportunities for knowledge transfer, both policy- and technology-related, and Oceans 2025 is currently developing an overarching KT strategy.

The EPSRC Marine energy SUPERGEN project has nine industrial partners. Industrial involvement is encouraged in EPSRC responsive mode grants but is not a requirement. 26 of the 53 marine technology research projects it supports have industrial collaboration and include 68 separate companies plus other, not for profit, organizations.

4. What Representations have you Received on the Adequacy of the UK's Research Fleet? Should the Government Invest in more UK Vessels or Should the UK Pool Resources with Other European Countries?

I have not received any representations on the adequacy of the UK's research fleet.

The UK is already pooling resources with other European countries through a highly efficient bartering scheme for ocean-going vessels that has been actively grown in recent years. NERC now has seven barter partners: Germany, France, Norway, the Netherlands, Spain, Ireland and the USA. The UK could not participate in the scheme if it did not have its own ships. NERC currently barters about 200d per annum on average. Further information on NERC's bartering arrangements was provided in its memorandum to the Committee.

NERC/BGS leads the European contribution to the Integrated Ocean Drilling Programme by managing scientific operations. The Japanese and the Americans each have their own research vessels for the programme, but the Europeans use the expertise of NERC/BGS to charter "mission specific platforms" from industry, international research organisations, etc, so that research is not restricted to specific vessels, as exemplified by an expedition of ice breakers chartered to mount a drilling expedition close to the North Pole—adapting an ice breaker to a drilling facility.

5. What Involvement did the Former OSI/DTI have with the Non-Government Sector Initiative to Continue the Work of the Marine Foresight Panel After Funding was Withdrawn Two Years into the Second Foresight Round?

Following the review of the Foresight programme in 2001, the sector-based panels were all disbanded. The programme moved away from this structure, and now operates a highly successful project structure, based around major areas of public policy, such as flooding, infectious diseases, and obesity. The Panel's work at this stage was in a private capacity and did not align with revised Foresight policy and objectives. Foresight had some discussions with the Marine Panel after its funding was terminated, on whether a new Foresight project in their area would be possible. However, their proposals did not receive support from stakeholders within Government—an essential feature in project selection—and therefore the Marine Panel's proposals could not be taken forward.

6. Whose Responsibility is it to Monitor and Address Skills Shortages in Marine Science?

The prime responsibility must rest with employers who are able to make representations through the Sector Skills Councils. Depending on whether the skill shortage is assessed as having a demand side or a supply side cause, action can be taken to try to address it at an appropriate level.

The Science and Innovation Investment Framework 2004–14 set out a long-term strategy to secure and sustain a supply of scientists, technologists, engineers and mathematicians to support the science base. The March 2006 Next Steps document sets out further commitments. Progress against these commitments is reported in the latest Science and Innovation Investment Framework Annual Report.[73] DIUS is working closely with DCSF, who lead on the school science commitments in Next Steps, in ensuring these are delivered. Improving the pipeline flow of scientists and attractiveness of science as a career should be a combined effort by Government, Higher Educational Institutions, National Academies, Business, and other leading stakeholders.

Research Councils monitor the research capacity and leadership of the science and engineering areas within their respective remits. (Research Councils are not responsible for undergraduate training.)

NERC's new strategy recognises that the skills base (in general) is an area requiring action. It has identified mathematical modelling, physical oceanography, deep-sea biology and taxonomy as areas of marine science subject to gaps in the skills base. NERC funds research studentships in all areas of marine science—over a thousand studentship grants have been awarded in the past six years. NERC's Research and Collaborative Centres, including the Marine Centres, have close relationships with universities, some having collaborative status or being at least co-located—helping to encourage postgraduate students to work in the marine sciences. The Strategic Oceans Funding Initiative part of Oceans 2025 includes studentship funding to help develop the next generation of marine scientists.

EPSRC monitors research capacity in engineering generally, of which marine engineering is a subset. EPSRC monitors the health of the engineering discipline and engages in dialogue with employers about their requirements for engineers trained to a postgraduate level.

[73] http://www.berr.gov.uk/science/science-funding/framework/page9306.html

7. What Research has been Conducted into Wider Public Awareness of the Importance of Healthy Seas and Sustainable Ecosystems?

The Plymouth Marine Laboratory (PML) led an EC Framework Programme 6 project "COST-IMPACT" which aimed, *inter alia*, to estimate the economic cost/benefit of fishing relative to the "value", economic and otherwise, of the environment. One of the activities involved extensive social-science analysis of stakeholders' views of the value of the environment, etc.

The level of public sponsorship for NGOs in the marine area shows concern for charismatic species, such as the albatross, whales and dolphins, and suggests that there is considerable awareness of the importance of the health of the marine environment/ecosystem.

NERC's Research and Collaborative Centres support a range of awareness-raising activities.

List of occasions within the past five years on which the IACMST has reported on its activities to the GCSA/OSI, including annual reporting arrangements and special reports.

In April 2003, Defra took over responsibility for IACMST. The conditions for the new arrangement included that IACMST have "*Access to the CSA, CSAC, and OST where necessary*", and that "*OST to remain a member of IACMST*".[74]

Since the transfer, IACMST has not formally reported to the Government's Chief Scientific Adviser (GCSA), Chief Scientific Advisers Committee (CSAC), or the Government Office for Science (GO-Science) and/or Science and Innovation Group (which together previously formed OSI).

GO-Science has retained membership of IACMST, and receives circulated papers.

July 2007

Memorandum 53

Supplementary evidence from the Department for Environment, Food and Rural Affairs

1. *Please provide a copy of the chart of monitoring arrangements collated by Defra and promised by the Minister (Q480 refers).*

A key requirement of the UK Marine Monitoring and Assessment Strategy (UKMMAS) is to understand what, where, why, and when monitoring is taking place, and who is carrying it out. The attached table (Attachment 1) (not printed) contains this marine monitoring metadata (data on data) which will assist in ensuring monitoring programmes are co-ordinated, efficient and fit for purpose. This information will be updated on an annual basis by the key agencies involved in monitoring the marine environment and will be made available through a new database called the UKDMOS (UK Directory of Marine Observing Systems).

2. *Please provide a copy of the league table referred to by the Minister in relation to the comparison of funding in the UK and elsewhere in Europe (Q502 refers).*

The table below gives the spend on "marine fisheries science" by all partners in the MariFish project. It is not easy to compare between partners since some countries include fisheries stock monitoring and assessment whilst other do not. Defra's annual spend is €5 million R&D and €14 million non-R&D.

Country	*Total annual value of marine fisheries science*
Ireland	€13 million
Poland	€2.3 million
Netherlands	€6–10 million
Portugal	n/a
Spain	€21.5 million
Sweden	€2.5–3 million
Cyprus	n/a
Belgium	€3 million
UK (Defra)	€19 million
Norway	€25 million
Germany	€13 million

[74] Inter-Agency Committee on Marine Science and Technology: Thirty-third Plenary Meeting held on Thursday 9 January 2003 from 11.30 am in the Council Room, Church House, Westminster, London.

Country	*Total annual value of marine fisheries science*
Greece	€8.5 million
Denmark	€18 million
Iceland	€24 million

3. *Please provide a copy of the chart of Defra spending areas and shortfalls within marine science (Q505 refers).*

The attached figure (Attachment 2) (Annex 1) and supporting table (Attachment 3) (Annex 2) provides:

— an estimated current annual UK spend on monitoring and surveillance in the marine environment (c > £37 million); and

— an estimated future annual UK spend on monitoring and surveillance to meet new and emerging commitments in the marine environment (c > £60 million).

These figures are conservative estimates based on returns made to the UKMMAS Secretariat by those key agencies responsible for marine monitoring in the UK.

4. *How will the Defra fisheries laboratories work with the NERC institutes under Oceans 2025? Is there a need to review how the two sides could work together better to the good of UK marine science?*

Defra welcomes the development of Oceans 2025. Following from the Net Benefits report, and the government response ([1],[2]), Defra jointly with other government departments commissioned a review of the Science for Sustainable Marine Bioresources and its delivery across the UK science community. Within Oceans 2025, one of the 10 Themes is Sustainable Marine Resources. The government marine laboratories were engaged in scoping meetings for the contents of this Theme along with detailed discussions of the final plans. In parallel, Defra, NERC and the devolved administrations have contributed to a Sustainable Marine Bioresources Programme with cash or work in kind. The call for projects had to incorporate direct linkages with the government marine laboratories. The proposals are being evaluated at this time. In addition there are many individual contacts between NERC and government scientists in their day to day activities.

In the oral evidence (Q230–Q234) the NERC Directors commented on the lack of vessel access for shelf seas science. Subsequently Cefas wrote to NERC offering to discuss whether Cefas vessel time, on its 72 metre Cefas Endeavour, could be made available to NERC.

References

[1] Net Benefits. A sustainable and profitable future for UK fishing. Prime Minister's Strategy Unit, March 2004.

[2] Securing the Benefits. The joint UK response to the Prime Minister's Strategy Unit Net Benefits report on the future of the fishing industry in the UK, Defra, 2005

5. *What is Defra's policy on the release of data from publicly-funded operations (Q 531 refers)?*

Defra strives to make all data generated from publicly funded operations freely available as soon as is reasonably possible. Current research contracts outline that contractors must endeavour to make information and results from any project generally available, provided it is accompanied by an acknowledgment of the financial support received. However, this does not apply for any information covered by the Data Protection Act 1998 or considered "commercial in confidence". Contractors are permitted to "add value" to this data in order to generate "value added products" which may then be subject to licence restrictions and appropriate charges.

Defra Marine Environment Division is in the process of drafting a Marine Data Policy and appropriate new wording for insertion into research contracts to facilitate the collation, release, re-use, and storage of marine data. This is in-line with the work currently underway within the Marine Data and Information Partnership (MDIP—http://www.oceannet.org/mdip/) to create a framework for marine data stewardship.

6. *Please provide a note on the work undertaken to date on designating MPAs (Q537 refers)?*

Natura 2000 sites

The Habitats Directive requires the creation of a network of protected areas known as Natura 2000. This network consists of Special Areas of Conservation (SACs) to protect habitats and species listed under the Habitats Directive and Special Protection Areas (SPAs) to protect wild birds as set out under the Wild Birds Directive.

A range of legislative measures are in place to provide protection to important marine species and habitats. We currently have 182 marine protected areas with marine features in UK inshore waters (up to 12 nautical miles), which include:

- 81 Special Protections Areas with marine habitats for birds;
- 98 Special Areas of Conservation with marine habitats or species; and
- three statutory marine nature reserves.

In total the area coverage of these sites exceeds 1.8 million hectares, or 2.2% of UK waters.

Work is underway to identify further sites in UK waters (English territorial waters and UK offshore waters). To date 20 areas for marine habitats have been surveyed and there are plans for additional survey of a further 16 areas. Approximately seven areas for marine birds have also been surveyed, with plans for 30 more. A selection of these areas surveyed are likely to be recommended as marine protected areas under the Habitats and Birds Directives, but the number and area of these sites is not yet known.

The Joint Nature Conservation Committee is responsible for the identification of SACs and SPAs beyond 12 nautical miles from the coast. It is due to consult on the first tranche of draft offshore marine SACs later this year.

Under OSPAR there is an international commitment to establish an ecologically coherent network of well managed Marine Protected Areas by 2010. By then we will have largely completed our network of European Natura 2000 sites by building on those already present in inshore waters. We will then add to this network by including Marine Conservation Zones (MCZs) proposed as part of the Marine Bill. We are continuing to discuss the timetable for completing this network of Marine Protected Areas with conservation agencies, Natural England hope to have identified the network in English territorial waters by 2012.

There is as much data available in relation to the range, extent, and distribution of broadscale marine features termed marine landscapes (http://www.jncc.gov.uk/page-2117). There is a balance to strike between using coarse level data to inform the selection of MCZs and commissioning further scientific research to more narrowly identify the features or species in need of conservation. Nature conservation bodies will consider how best to address this balance when selecting MCZs in order to make sure that we achieve our network within timescale.

Marine Conservation Zones

MCZs will allow us to protect a wide range of species and habitats that are important in UK waters. Among other purposes they will enable the designation of rare and threatened species and habitats as well as areas that best represent the range of biodiversity in our waters. Nature conservation agencies have funding to carry out further scientific surveys to identify areas that could be suitable for selection as MCZs. Whilst we do not have a comprehensive understanding of all marine ecosystems, we are aware of key species, habitats and ecosystems that will require protection under the MCZ mechanism.

MCZs will be designated using a flexible approach that enables protection of ecosystems and biodiversity without causing inappropriate economic or social impacts wherever possible. We propose to take account of both the current situation in the area and the future situation anticipated as the result of factors such as planned economic development or climate change.

7. *What monitoring has taken place to check whether the recommendations of the Foresight Marine Panel have been implemented (Q538 refers)?*

Defra has recently reviewed its priorities for Marine Fisheries Research, and as a result has restructured their R&D programme. The Defra R&D programme is broken into the following three topics: Impacts of Fishing on the Marine Ecosystem, Effects of the Environment on Fish Stocks, and Fisheries Management. The New programme incorporates all of the recommendations of the Foresight Marine Panel on Marine Fisheries. In addition, direct fisheries management measures are making an impact on the monitoring and control of fishing activity, and Bio-economic modelling has been enhanced through Defra and SFIA modelling.

8. *How is Defra working with the European Commission on the coverage of marine science within the maritime strategy green paper and the Seventh Framework Programme? Why is the Department of Transport the lead Government department on the green paper?*

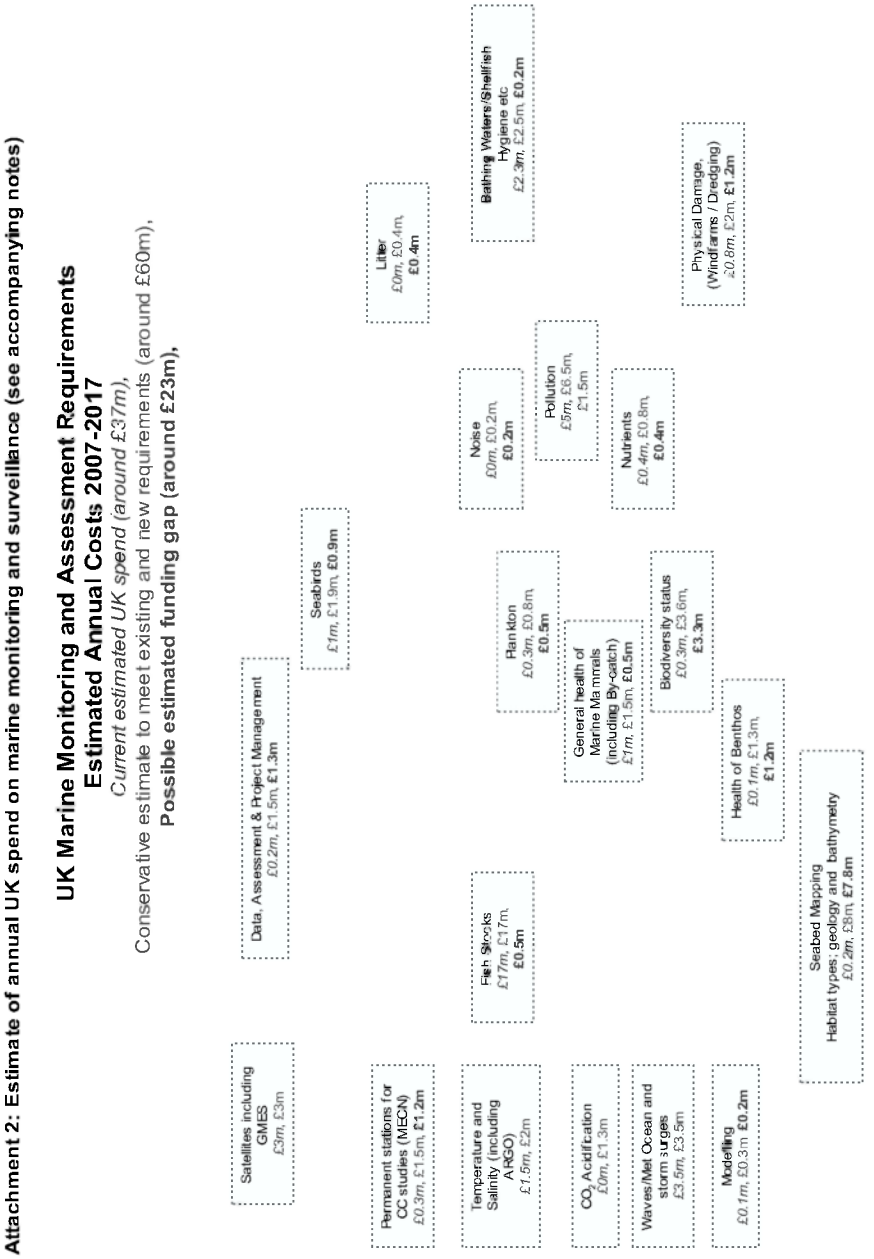
Marine science is a cross cutting issue in the Seventh Framework Programme with marine resources covered in Theme 2 (Food, Agriculture and Fisheries and Biotechnology) of the Co-operation Specific Programme and pressures on the marine system and the management of marine environments covered in Theme 6 (Environment, including climate change). The UK works with the Commission through the programme committees for these themes and is represented by Defra, FSA and BBSRC in Theme 2 and Defra and NERC in Theme 6.

The aim of the EU Maritime Green Paper is to launch a debate about a future Maritime Policy for the EU that treats the oceans and seas in a holistic way. It will try to determine how links between maritime transport, industry, coastal regions, offshore energy, fisheries and the marine environment are to be brought together. The Green Paper is a consultation, and the substantive work with the Commission by Defra on maritime science is through the Seventh Framework programme. The Department of Transport's lead reflects their lead role on maritime transport, the key component of the Green Paper.

September 2007

Annex 1

Attachment 2: Estimate of annual UK spend on marine monitoring and surveillance (see accompanying notes)



PUTTING THE ANNUAL MONITORING COSTS IN ATTACHMENT 2 INTO PERSPECTIVE

Estimated baseline costs to meet current legislative and obligatory commitments (in italic font).

Through the UK Marine Monitoring and Assessment Strategy (UKMMAS) the costs associated with marine monitoring in the UK and borne by various Government Departments, Agencies and the Devolved Administrations have been estimated at around £37 million per annum.

Estimated cost of new monitoring requirements likely to be required in the coming years (in bold font).

There are a number of emerging drivers which require or recommend additional marine monitoring.

National: Firstly, the UK report *Charting Progress* on the status of the UK Marine Environment drew attention to the fact that in general, it was difficult to say definitively whether the status of UK marine waters were good or not because many key indicators of status were not being measured, and recommendations were made to rectify this situation. It is also desirable to harmonise data collection and storage and make the information easily accessible to stakeholders and the public.

European and International: The recently adopted Water Framework Directive and the Draft European Marine Strategy Directive (EMSD) require monitoring programmes to show whether UK waters will achieve good environmental status. The bathing Waters Directive is being revised to include new parameters, and the OSPAR Convention is developing new indicators to show whether the seas are achieving good ecological status and are biodiverse.

New concerns such the effects of climate change, ocean acidification, noise and mapping the sea bed: The major impacts of these drivers are poorly understood and require a mix of physical, chemical and biological monitoring.

Uncertainty in the additional costs for new marine monitoring.

The UKMMAS Partners have been trying to build up a picture of the likely costs of the monitoring to meet the drivers and concerns listed above. However, until a consensus arises at European level and it becomes clearer exactly what is considered to be an appropriate suite of indicators to show whether the seas are achieving good environmental status, the costs will not be clear. We have therefore given a very conservative estimate of £23 million per annum assuming that a very comprehensive suite of monitoring programmes will be required starting in 2007 and the recommendations of *Charting Progress* are fully implemented. However, there are already indications from a number of EC Member States that less ambitious programmes may be needed to demonstrate good environmental status, and that additional comprehensive monitoring programmes under the EMSD will not be required for several years. This could mean that a figure of £10 million per annum might suffice to provide an adequate assessment of status.

How do the costs of Marine Monitoring compare with Terrestrial Monitoring?

Current monitoring spend in the terrestrial environment is >£80 million per annum. The marine environment is far less understood and is more costly to monitor due to technological requirements and the need for seagoing vessels.

Annex 2

Attachment 3

ESTIMATED COSTS TO THE UK OF MARINE MONITORING

Estimated UK Marine Monitoring and Assessment Requirements—Annual Costs 2007–17—Sources of Information

MARG have identified and costed most of the marine monitoring which is undertaken by the UK.

There is no central source of this information and many lines are still estimates.

Note that these figures are spread over the UK departments and agencies and that the commitments to both programme and administrative resources should be maintained in the short to medium term if the UKMMAS strategy is to be a success.

The cost is estimated as £37 million but is likely to be higher once aerial surveys and the true costs of field work and management are included.

There are many new demands and ongoing commitments which should have regular sampling programmes. These include the biological aspects of OSPAR, the need to map our sea floor, etc. MAPC discussed the various demands on current spending in May 2006, MARG has worked with the IACMST and others to rationalise the estimates. The total new resources need to fully comply with marine monitoring requirements is an increase of £22 million (£59.6–£37 million).

These monies could be distributed. The breakdown includes, approximately: £8 million Mapping and understanding the seafloor; £2 million Data co-ordination, stewardship and integrated assessments; and £12 million Provision for smaller increases in numerous other areas.

The immediate focus will be on identifying efficiency savings. The examples we can use include the cost saved by combining the requirements of the Water Directive Monitoring with existing activities—estimated £6 million saving per year.

Resolving the issues of data management is essential for the success of the UKMMAS. This will be a vital contribution towards the overall marine data stewardship initiatives on MDIP and MEDAG.

Table 1

Monitoring and Assessment Component (see Figure 1)	*Spend (£m/Year) Current (2006)*	*Required*	*Figures calculated from:*
Litter	0.00	0.40	Proposal to Government from Marine Conservation Society (2005).
Bathing Waters/Shellfish Hygiene	2.30	2.50	England and Wales shellfish and bathing waters—£1.7 million guess for shellfish hygiene.
Noise	0.00	0.20	IACMST Report: Underwater Sound and *Marine Life* (2005).
Pollution	5.00	6.50	NMMP costs (UK wide) plus RID includes WFD requirements (EA bid to Defra).
Nutrients	0.40	0.80	Defra research report (2005) includes some needs for plankton assessments.
Physical Damage (Windfarms/Dredging)	0.80	2.00	Estimate of increase in activity—wind farms—could be cost-recovered from industry—Hydro morphology measurements for WFD may increase these costs.
Seabirds	1.00	1.90	pers comm JNCC (2006).
Plankton	0.30	0.80	CPR—SAHFOS running costs and current contribution—increase for gaps in our seas.
General Health of Marine Mammals (including By-catch)	1.00	1.50	Estimates SMRU (2006).
Biodiversity Status	0.30	3.60	JNCC bid to Defra WHB 2006.
Health of Benthos	0.10	1.30	Estimate.
Permanent Stations/lines for Climate Change Studies	0.30	1.50	MECN costs—co-ordination and data collection ME sustains obs of Oceans 2025 plus coastal observatories—(POL Liverpool and Scottish observatory £1 million not currently funded as monitoring). Ships of Opportunity (Ferry Box).
Temperature and Salinity (including ARGO)	1.50	2.00	IACMST bid Guymer 2005 (3d structure hydro graphic sections and ARGO)—(structure of ocean Argo 850k)—(Hydro graphic sections—much is rand used for some may be offset by NERC oceans 2025 proposal).
CO_2 budget and acidification	0.00	1.30	Defra research proposal plus IACMST.
Waves/Met Ocean and storm surges	3.50	3.50	Met Office figures (not argo) plus POL GLOSS contribution and PSMSL (£0.5k)—2d aspects drifting buoys and sea level.
Modelling	0.10	0.30	NCOF current and estimate needed to redesign and manage monitoring—IACMST report.
Satellite including GMES	3.00	3.00	EU-UK contribution—not all for marine. Does not include AATSR—(GMES-UK ESA Space contribution 7.23 million/three years plus 0.5/year for satellites outside GMES eg JASON AATSR).
Seabed Mapping (Habitat Types, Geology and Bathymetry)	0.20	8.00	UKHO/BGS/CEFAS business case (2006) could be spent over different profile. This exercise will cost approx £100 million to map the entire sea floor. NB: This cost could be spent over any number of years and sea floor areas prioritised to where there is active management needed.
Productive seas evidence needs	?	?	Socio-economics.
Commercial Fisheries	17.00	17.00	EU Data Regulations—Defra and SERRAD spend.
Data, Assessment and Project Management and co-ordination	0.20	1.50	MDIP (gateway), Charting Progress 2.
Estimated Total	37.00	59.60	

Figures correct at September 2006. NB: Ariel Surveillance is not included and Oceans 2025 is not reflected.

Memorandum 54

Supplementary submission from the Natural Environment Research Council (NERC)

MARINE SCIENCE EXPENDITURE

	£m 1999–00	£m 2000–01	£m 2001–02	£m 2002–03	£m 2003–04	£m 2004–05	£m 2005–06	£m 2006–07	£m Total
1. Ship Operations expenditure:*									
UK Ocean Research Services (UKORS)				2.198	2.753	1.753	1.830		**8.534**
Research Ship Unit (RSU)		4.600					7.425		**12.025**
Research Vessels Service (RVS)	7.000								**7.000**
Research Ship Services			7.000	6.898	7.890	7.181			**28.969**
Sea Systems—NMFD							0.894	12.226	**13.120**
Sub-total	**7.000**	**4.600**	**7.000**	**9.096**	**10.643**	**8.934**	**10.149**	**12.226**	**69.648**
2. Marine Centres expenditure:*									
Centre for Coastal and Marine Sciences (CCMS) (excl SAMS and MBA)	9.200	9.300							**18.500**
Proudman Oceanographic Laboratory (POL) (incl PSMSL and BODC)			2.900	5.602	8.170	4.352	4.811	4.940	**30.775**
National Oceanography Centre Southampton (NOCS)/ Southampton Oceanography Centre (SOC) (excl marine facilities of NMFD, UKORS, RSU, RVS)	6.200	7.100	6.200	6.624	8.635	7.039	8.398	7.020	**57.216**
Plymouth Marine Laboratory (PML)			4.900	5.980	4.311	4.262	4.487	4.565	**28.505**
Sea Mammal Research Unit (SMRU)	0.500	0.500	0.600	0.628	0.640	0.630	0.640	0.940	**5.078**
Sir Alister Hardy Foundation for Ocean Science (SAHFOS)	0.200	0.200	0.200	0.155	0.155	0.375	0.000	0.196	**1.481**
Scottish Association for Marine Sciences (SAMS) (incl CCAP)	0.300	0.300	2.400	2.237	2.311	2.323	2.534	2.642	**15.047**
Marine Biological Association (MBA) (including National marine biological library and Grants to the MBA)	0.400	0.400	1.000	1.040	1.175	1.184	1.179	1.194	**7.572**
Sub-total	**16.800**	**17.800**	**18.200**	**22.266**	**25.397**	**20.165**	**22.049**	**21.497**	**164.174**
3. Directed Programmes:**									
Autosub Science Missions	0.900	0.300							**1.200**
Autosub Under Ice			1.100	1.284	1.154	0.784	0.549	0.449	**5.320**
Developmental Ecology of Marine Animals (DEMA)	0.900	0.500	0.200	0.023					**1.623**
Ocean Drilling Programme (ODP)	0.500	0.500	0.500	0.404	0.591	0.189	0.090	0.042	**2.816**
Ocean Drilling Programme subscription	1.800	1.900	2.100	2.014					**7.814**
Integrated Ocean Drilling Programme (IODP) (including subscription)					1.796	2.458	2.606	2.506	**9.366**
Marine Productivity	0.100	0.900	1.300	1.696	1.025	0.616	0.083	-0.040	**5.680**
Ocean Margins LINK		0.200	0.200	0.918	1.068	0.840	0.595	0.478	**4.299**
Rapid Climate Change (RAPID)			0.100	0.180	3.950	3.609	4.325	3.197	**15.361**
LINK Aquaculture	0.300	0.400	0.300	0.165	0.083				**1.248**
LINK SEASENSE	0.200	0.200	0.200		0.048				**0.648**

	£m 1999–00	£m 2000–01	£m 2001–02	£m 2002–03	£m 2003–04	£m 2004–05	£m 2005–06	£m 2006–07	£m Total
Plankton Reactivity in the Marine Environment (PRIME)	0.100								**0.100**
The Deep Ocean Benthic Boundary Layer (BENBO)	0.500	0.200							**0.700**
Marine Biofouling	0.100								**0.100**
Sub-total	**5.400**	**5.100**	**6.000**	**6.684**	**9.715**	**8.496**	**8.248**	**6.632**	**56.275**
4. Blues Skies (responsive mode funding)* **			**4.736**	**5.205**	**4.785**	**5.889**	**6.408**	**7.022**	**34.045**
Total Marine Science Expenditure** **	**29.200**	**27.500**	**35.936**	**43.251**	**50.540**	**43.484**	**46.854**	**47.377**	**324.142**
5. Other Directed Programmes:									
Arctic Ice Environmental Variability (ARCICE)	1.200	0.900	0.400	0.214	0.041				**2.755**
Coupled Ocean-Atmosphere Processes and European Climate (COAPEC)		0.700	0.600	1.376	1.175	0.780	0.407	0.073	**5.111**
Environmental Genomics			0.400	2.777	4.901	4.292	2.338		**14.708**
Marine (and Freshwater) Microbial Biodiversity (MMB & M&FMB)		0.700	1.500	1.427	1.497	1.199	0.265		**6.588**
Post-Genomics and Proteomics					0.057	0.674	2.230	3.890	**6.851**
Quantifying and Understanding the Earth System (QUEST)					0.029	0.606	1.072	3.086	**4.793**
UK Surface-Ocean/Lower Atmosphere Study (UK SOLAS)					0.025	0.125	1.257	2.822	**4.229**
Sub-total	**1.200**	**2.300**	**2.900**	**5.794**	**7.725**	**7.676**	**7.569**	**9.871**	**45.035**

Notes:

* Sections 1 and 2 include science, infrastructure and capital expenditure.

** The following Directed Programmes include further Marine Science expenditure; figures are total programme spend.

*** Blues skies figures are not included for 1999–00 and 2000–01 because the NERC database does not extend back to those years.

**** Total marine science expenditure does not include "Other Directed Programmes" or, in 1999–00 and 2000–01, blues skies funding, nor marine science spend in the core programmes of BAS, BGS or CEH.

Abbreviations not explained elsewhere

NMFD: National Marine Facilities Division.

PSMSL: Permanent Service for Mean Sea Level.

BODC: British Oceanographic Data Centre.

CCAP: Culture Collection of Algae and Protozoa.

Memorandum 55

Supplementary submission from the Natural Environment Research Council (NERC)

Table 1 shows funding data for all of NERC's highly graded (ie α4/α5) standard grant research proposals and for marine science (MS) standard grant research proposals. In 2006–07, NERC's expenditure on responsive grants was £32 million of which 74% was on standard grants.[75]

The data exclude the Antarctic Funding Initiative (AFI) and consortium grants.

[75] NERC expenditure also included 5% on small grants and 3% on new investigator grants—for which NERC seeks to fund, where possible, all α4/α5 graded research proposals.

Table 1

FUNDING DATA FOR ALPHA4/ALPHA 5 RESEARCH GRANT PROPOSALS

Year	*Total number of funded* α4/α5 graded research proposals	Total number of funded α4/α5 graded MS research proposals	Total number of unfunded α4 graded research proposals	Percentage of unfunded α4 graded research proposals	Total number of unfunded α4 graded MS research proposals	Percentage of unfunded α4 graded MS research proposals
2001	105	18	70	40	16	47
2002	53	9	24	31	9	50
2003	122	25	44	27	9	26
2004	112	10	63	36	13	57
2005	103	19	76	42	18	49
2006	102	19	25	20	7	27

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Memorandum 56

Supplementary submission from the Natural Environment Research Council (NERC)

Comments from the Natural Environment Research Council (NERC) regarding the UK Marine Monitoring and Assessment Strategy (UKMMAS).

OVERVIEW

NERC regards the UKMMAS as a worthwhile initiative, which has made a good start in bringing together the organisations in the marine community to co-ordinate UK marine-monitoring work. This will be important for the gathering of data for national and international marine assessments, and should facilitate knowledge transfer. However, the focus is currently on compliance monitoring, and there is a need for more consideration of how better to include generic marine research and meet longer-term and global-scale monitoring requirements. Almost inevitably, more resources are required than have so far been committed.

DETAIL

Many NERC research and collaborative centres were represented at a recent workshop to discuss UKMMAS, and the participants were generally positive about the value of the discussions. The following summarises points made about UKMMAS progress to date.

The remit of the UKMMAS is seen by most of the NERC participants as covering compliance monitoring (ie monitoring driven by legislation, eg the Water Framework Directive) and long-term science-driven monitoring (designated "Sustained Observations" in the Oceans 2025 programme) which can include contextual monitoring, ie obtaining wide-scale information, for example from indicator species, to reveal the status of marine ecosystems.

This view is consistent with the UKMMAS definition of monitoring as "the taking, on a reasonably regular basis, of any form of observations relative to the status of the marine environment, regardless of the frequency of, or purpose for which, the observations are made". However, there seems to be an alternative perception that the UKMMAS was set up primarily to establish a coordinated approach across the agencies with responsibility for reporting on legislative drivers. Indeed, the composition of the working groups, and the activities of the UKMMAS, are currently slanted towards compliance, in particular towards compliance with current (rather than proposed) legislation. This suggests that there may be some ambiguity.

What should be clear is that there is value in ensuring that compliance monitoring and science-driven monitoring—and research—are well linked, and that the agencies could make more use of the range of monitoring carried out by academia and other institutions. Compliance monitoring, if done well, can inform and be part of science-driven long-term observations, and the latter can similarly inform and provide context for compliance monitoring. Ideally, good compliance monitoring should be nested within sustained

science-driven monitoring and both should feed into and be informed by process-driven research. Context is important so that change can be interpreted and the causes, eg whether anthropogenic or natural, distinguished between.

UKMMAS needs to recognise the value of existing datasets, in particular the importance of investing resources in making them more easily accessible and analysing them. [This is obviously one aim of the Marine Data Information Partnership (MDIP).] The burden cannot fall only on those who generate the data.

Another concern is the need to consider wider oceanic influences, ie to monitor in non-UK waters, including the North Atlantic, because of their potentially overriding influence, eg on nutrient levels in UK coastal waters. Monitoring should also tie in as far as possible with other European schemes.

NERC is ready to work with Defra to improve the UKMMAS delivery plan, which needs to take the above points into account. It is recognised that UKMMAS needs a near doubling of resources to carry out even relatively basic marine monitoring and data management to meet current legislative requirements, and more to have a big impact on the accessibility and usability of data, to be able to monitor in new strategic locations (including open oceans) and to monitor climate-change indicators.

There may be a need for more questioning about the monitoring programmes being supported, and their ability to deliver the necessary answers; data collection must be tailored to the issues being addressed, and spatial and temporal integration would facilitate the linking of pattern with process.

From a geological perspective, marine monitoring is mainly of value in assessing mobile sediments, coastal change and geohazards. The British Geological Survey has been promoting the idea of a UK National Seabed Mapping Programme; a proposal was submitted to Defra in 2006 to carry out systematic high-resolution surveys. The programme would provide a framework for informing marine management decisions, and context within which to implement UKMMAS. (It would improve on 1980s maps currently used for marine spatial planning.) A proposal being developed by a UKMMAS working group is looking at how seabed survey activities and the data acquired can be better co-ordinated and collated, but in the long term, high-resolution mapping is needed to support both marine management and marine research in general.

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Memorandum 57

Supplementary submission from the Natural Environment Research Council (NERC)

MARINE SCIENCE EXPENDITURE BY THE BRITISH ANTARCTIC SURVEY (BAS), BRITISH GEOLOGICAL SURVEY (BGS) AND CENTRE FOR ECOLOGY AND HYDROLOGY (CEH)

Submission to the House of Commons Science & Technology Committee in connection with its inquiry "Investigating the Oceans".

BAS

Year	*Marine science programme expenditure, including capital (£k)*		
	Staff,and other resource	*Proportionate ship/aircraft running/maintenance costs including staff, repairs and fuel*	*Total*
1997–98	1,388	1,147	2,535
1998–99	1,429	1,180	2,609
1999–2000	1,466	1,210	2,677
2000–01	1,496	1,766	3,262
2001–02	1,518	1,827	3,345
2002–03	1,555	1,914	3,469
2003–04	1,604	2,023	3,627
2004–05	1,649	2,173	3,822
2005–06	1,695	2,322	4,017
2006–07	2,346	2,461	4,806

Notes:

These are the best estimates in the time available. No overheads have been applied.

Most staff and other resource spend has been estimated for 2004–2005 and earlier using HM Treasury GDP deflator.

Fuel spend has been estimated for 1997–98 and 1998–99 using HM Treasury GDP deflator.

Support to marine science represents 75 days ship time (per annum?).

BAS notes that it supported about the same level of science and infrastructure activity each year over the decade, but that fuel costs rose very significantly over the period.

The marine science programmes supported were: Sustainability, Climate Change and Sea Level.

BGS

Year	*Expenditure on marine-related activities (£k)*					
	A: Responsive Mode Grants (Commercial)	*B: Directed Programme Grants (internal awards)*	*C: Centre Programmes (Science Budget)*	*D: Capital*	*E: Infrastructure (Marine Operations)*	*Total spend*
1997–98	1,533	85	626	0	0	2,263
1998–99	1,681	87	666	0	0	2,434
1999–2000	2,368	42	1,123	0	0	3,532
2000–01	1,809	78	758	64	0	2,709
2001–02	1,873	119	845	0	0	2,837
2002–03	1,605	20	976	0	0	2,602
2003–04	1,133	37	1,071	25	125	2,392
2004–05	1,195	60	942	94	84	2,376
2005–06	6,241	196	1,451	15	255	8,158
2006–07	2,724	170	1,254	1,527	250	5,925

Notes:

Figures include costs on all projects and cost centres within the following BGS Programmes, for the years indicated.

Year from	*Year to*	
2005–06	2006–07	Marine Coastal and Hydrocarbons Programme
2000–01	2004–05	Continental Shelf and Margins Survey and Resources
2000–01	2004–05	Coastal Geoscience and Global Change
1999–2000	1999–2000	Petroleum and Marine Geology
1999–2000	1999–2000	Coastal and Engineering Geology
1997–98	1998–99	Offshore Surveys
1997–98	1998–99	Coastal Surveys
2003–04	2006–07	Marine operations

For most years the programmes include some coastal as well as pure marine research, plus subsurface basin research—primarily related to hydrocarbons work.

Column A includes all BGS marine-related commercial contracts. Around £1 million of this per annum is hydrocarbons-related subsurface work. The large figures in this column (2005–06 and 2006–07) relate to contracts in BGS's role as European Science Operator for the International Ocean Drilling Programme.

In years 2003–04 and 2004–05 it is not possible to differentiate co-funded projects into responsive and Science Budget SB modes. For these years, all co-funded projects have been placed in the Centre Programmes (SB) category.

Column B (Directed Programme Grants) is the additional awards from NERC (on top of core funding); these sums will have been included also in the Directed-Programme figures provided previously.

Column C is Science Budget (without overheads).

Column D is capital. It is the actual purchase price of marine-related assets, in the year the asset was placed in service. It only includes assets that are currently still on the BGS Asset Register. The large figure in 2006–07 includes a grant from NERC to build a new seabed rock drill, which was completed in 2006–07—this may have been included in the infrastructure figures provided previously.

CEH

CEH has carried out programmes of seabird research, but precise funding figures are not easily available.

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Memorandum 58

Submission from the Economic and Social Research Council (ESRC)

ESRC Activities on Marine Related Research

Interdisciplinary collaborative research

NERC/ESRC Interdisciplinary Research Studentships—The ESRC and NERC fund jointly a small number of interdisciplinary research studentships each year on environmental issues which are of interest to both Councils. For this year's competition applications relevant to the Living with Environmental Change Programme were encouraged. (This scheme is administered by NERC).

NERC/ESRC Transdisciplinary Research Seminar Competition—Each year ESRC and NERC invite applications for a Transdisciplinary Research Seminar Competition. This year's competition focused on sustaining future ecosystem services as an initial contribution to the new Living with Environmental Change Partnership Programme. Under this year's competition the two councils have agreed to fund the following in marine related research:

RES-496-26-0036
Prof E Matlby (Liverpool University) *et al*
New approaches to managing ecosystem services in the marine environment
£23,642
1 September 2007–31 August 2009.

RES-496-26-0040
Dr P White (York University)
Coastal Wetland Ecosystem Services
£22,885
1 November 2007–31 October 2009.

Centre for Social and Economic Research on the Global Environment (CSERGE)—The Centre for Social and Economic Research on the Global Environment (CSERGE) at the University of East Anglia is an ESRC Research Centre in the field of environmental and sustainable development. One of the Centres key areas of research is the economics of environmental problems relating to water and watery environments, which includes wetland ecosystems, rivers, lakes and sea bed environments.

The Tyndall Centre for Climate Change Research—The Tyndall Centre, established in 2001 by ESRC, NERC and EPSRC is a national UK centre for inter-disciplinary research on climate change. It is dedicated to the identification, promotion and facilitation of sustainable responses to the challenge of climate change. One of the Centre's seven research programmes is "Coasts", which includes marine related research.

UK Energy Research Centre—The UK Energy Research Centre (UKERC) was established in 2004 as part of the Research Councils Energy Programme and is funded by ESRC, NERC and EPSRC. One of the research topics under UKERC's "Future Sources of Energy" research theme is "Marine Renewables", investigating wave and tidal stream energy.

Responsive mode funding (in the last five years)

ESRC has funded the following marine related research under its responsive mode:

Public engagement grant as part of the RCUK National Science Week Awards: Dr D Schroeder, Marine Biological Association, *Marine Viruses . . . Friends or Foe?* £2,000, 1 March 2007–31 March 2007.

Small Grant: Dr J A Galloway, University of London, *London and the Tidal Thames 1250–1550: Marine Flooding, Embankment and Economic Change*, £99,909, 1 March 2008–28 February 2010.

Postdoctoral Fellowship: (Dr Lynda Rodwell, University of York, £26,334, 1 December 2001–31 November 2002).

Standard Grant: Dr James G Carrier, Oxford Brookes University, *Conflict in Environmental Conservation: A Jamaican Study*, £173,732, 1 January 2004–30 June 2005.

Sustainable Technologies Programme: Dr M Winskel, University of Edinburgh, *Building Renewable Energy Innovation Systems*, £147,024, 1 February 2004–31 March 2006.

Research Fellowship: Dr J Pugh, University of Westminster, *Developing Institutional Capital in the Neo-Liberal Era: Caribbean Environmental Planning*, £66,332, 1 February 2003–31 December 2004.

Standard Grant: Professor M Bloor, Cardiff University, *Problems of Global Governance of Seafarers' Health and Safety*, £66,394, 1 December 2002–31 March 2004.

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