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**Historical perspective and selective review of the literature  
on human impacts on the UK's marine environment**

Prepared by English Nature for the DETR Working Group  
On the Review of Marine Nature Conservation

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## Context

The Department of the Environment, Transport and the Regions (DETR) established a working group to review marine nature conservation. This forum was set up to help Government develop possible future mechanisms to protect, conserve and manage nationally important marine wildlife in the seas around England. The original remit of the Working Group focussed on territorial waters, but this position was revised in the summer of 2000 to cover the continental shelf and superjacent waters under UK jurisdiction (usually up to 200 nautical miles from the coast). The Working Group has a wide membership drawn from statutory and non-statutory organisations, industry and user groups with a particular interest in the marine environment.

This report is one of four submitted by English Nature to the Working Group in 2000. The four documents in the series, sequentially, are:

LAFFOLEY, D. d'A. & BINES, T. 2000. Protection and management of nationally important marine habitats and species. Prepared by English Nature based on the views of a sample for the members of the DETR Working Group on the Review of Marine Nature Conservation. Peterborough: *English Nature Research Reports*, No. 390. 20 pp.

LAFFOLEY, D. d'A. 2000. Historical perspective and selective review of the literature on human impacts on the UK's marine environment. Prepared by English Nature for the DETR Working Group on the Review of Marine Nature Conservation. Peterborough: *English Nature Research Reports*, No. 391. 20 pp.

LAFFOLEY, D. d'A., CONNOR, D.W., TASKER, M.L. & BINES, T. 2000. Nationally important seascapes, habitats and species. A recommended approach to their identification, conservation and protection. Prepared for the DETR Working Group on the Review of Marine Nature Conservation by English Nature and the Joint Nature Conservation Committee. Peterborough: *English Nature Research Reports*, No. 392. 17 pp.

LAFFOLEY, D. d'A., BAXTER, J., BINES, T., BRADLEY, M., CONNOR, D.W., HILL, M., TASKER, M. & VINCENT, M. 2000. An implementation framework for conservation, protection and management of nationally important marine wildlife in the UK. Prepared by the statutory nature conservation agencies, Environment Heritage Services (Northern Ireland) and JNCC for the DETR Working Group on the Review of Marine Nature Conservation. Peterborough: *English Nature Research Reports*, No. 394. 29 pp.

Copies of these reports can be obtained from the enquiry team at English Nature in Peterborough.



## **Context**

At the Working Group meeting held on 30 March 2000 it was agreed that English Nature would provide some further dialogue concerning impacts in the marine environment, selected references as well as further information supporting the text given in Laffoley & Bines (2000). Human impacts form just one of the drivers behind the implementation of any effective conservation policy and programme, helping to prioritise actions within a wider comprehensive and representative framework.

The production of this paper was seen as giving all members of the Working Group the same insight into the principles, history, some of the key literature and initiatives relevant to this area. This historical perspective and selective review is provided in fulfilment of this Working Group action.



## Contents

### Context

|   |    |
|---|----|
| <a href="#">1. <u>General introduction to principles and awareness</u></a> .....  | 9  |
| <a href="#">2. <u>Historical perspective and selective review of the literature and knowledge of impacts and associated initiatives</u></a> ..... | 10 |
| <a href="#">3. <u>Laffoley and Bines (2000): further information on impacts</u></a> .....   | 17 |
| <a href="#">4. <u>Acknowledgements</u></a> .....  | 20 |
| <a href="#">5. <u>References</u></a> .....  | 20 |

Table 1      Draft matrix being developed by the MarLLIN programme on probable and possible relationships between maritime activities and environmental factors.



## 1. General introduction to principles and awareness

- 1.1 Concerns over human impacts on the marine environment and biodiversity in general are not new. Despite the fact that knowledge of precise effects remains patchy, many of the problems seen today have been recognised for many years and resulted in calls for action, and the development of initiatives, at global, regional and national levels. Many of these include the marine environment as part of overall maintenance of biodiversity and incorporate the basic principles which the UK, together with other countries, should be addressing in relation to human impacts, the marine environment and conservation in general.
- 1.2 Primary amongst these are the United Nations Conference on the Human Environment (Stockholm 1972) and the adoption of the World Charter for Nature by the United Nations General Assembly in 1982 (Resolution 37/7) which mark, respectively, the beginning and end of the first decade of world awareness of threats to the natural environment and the importance of remedial action.
- 1.3 The Stockholm Declaration and the World Charter for Nature can be considered as soft law instruments of major importance for the development of international environmental law. Three of the general principles contained in the Charter are of particular relevance to conservation in the sea. These are:
- *The genetic viability of the earth shall not be compromised; the population levels of all life forms, wild and domesticated, must be at least sufficient for their survival, and to this end necessary habitats shall be safeguarded (Principle 2);*
  - *all areas of the earth, both land and seas, shall be subject to these principles of conservation; special protection shall be given to unique areas, to representative samples of all the different types of ecosystems and to the habitats of rare and endangered species (Principle 3); and*
  - *Ecosystems and organisms, as well as the land, marine and atmospheric resources that are utilised by man, shall be managed to achieve and maintain optimum sustainable productivity, but not in such a way as to endanger the integrity of those other ecosystems or species with which they co-exist (Principle 4).*
- 1.4 These general principles have provided both a basis and a framework for the development of conservation treaties. Four global sectoral conservation conventions covering, respectively wetlands of international importance (Ramsar Convention), sites of universal value (World Heritage Convention), trade in endangered species (CITES Convention on International trade in Endangered Species) and the conservation of migratory species (Bonn Convention) were concluded during this period. They were followed by a number of regional instruments.
- 1.5 It rapidly became clear, however, that such sectoral and regional approaches were not sufficient to cope with the depletion of biological diversity everywhere in the world.

There were many gaps. The need for a global convention covering all aspects of conservation and sustainable use of biological diversity became increasingly clear to conservationists in the early 1980s. The General Assembly of the IUCN in 1982 adopted a resolution calling for the conclusion of such a treaty. This was the first step in a lengthy process. Eleven years later the Convention on Biological Diversity was signed at the Earth Summit at Rio de Janeiro, on June 5, 1992 (Quarrie, 1992). Article 6A of this convention resulted in the production of the Biodiversity Action Plan in the UK (Anon, 1994).

1.6 Recommendations for a programme of actions to implement this Convention with respect to marine and coastal biodiversity were subsequently made by the Subsidiary Body on Scientific, Technical and Technical Advice (SBSTTA) around the five thematic areas of:

- *Integrated marine and coastal area management*
- *Marine and coastal protected areas*
- *Sustainable use of marine and coastal living resources*
- *Mariculture: and*
- *Alien species.*

These recommendations which signatories to the Convention on Biological Diversity are required to follow, became part of the Jakarta Mandate, established at the second Conference of the Parties meeting in Jakarta in 1995.

1.7 At a European level, the Convention on the Conservation of European Wildlife and Natural Habitats (Berne Convention), concluded at Berne on September 19, 1979 under the auspices of the Council of Europe, lists protected species, including some marine species, and requires its parties to prevent the disappearance of endangered natural habitats. The European Union accordingly adopted the Birds Directive in 1979 and the Habitats Directive in 1992, essentially to implement the Berne Convention. These are establishing Special Protection Areas and Special Areas of Conservation across Europe to tackle the continuing losses of European Biodiversity on land, at the coast and in the sea to human activities.

## **2. Historical perspective and selective review of the literature and knowledge of impacts and associated initiatives**

2.1 Some of the knowledge of impacts on the UK's marine environment considerably predate the major initiatives described above. Concerns, for example, about the adverse effects of fishing go back as far as the 14<sup>th</sup> century (Hore & Jex, 1880) whilst the Victorian passion for collecting may have depleted some seashore habitats (Gosse, 1906). By 1902 the International Council for the Exploration of the Sea (ICES) had been established which would, in time, play a fundamental role in our understanding of fisheries and their effects on the environment.

- 2.2 Concerns in the 20<sup>th</sup> century first focussed, ironically, on SCUBA diving, the very mechanism that was to give scientists new opportunities to study marine species. In the 1960s, fears were expressed that uncontrolled SCUBA diving was having a detrimental effect on some species, which were being over collected for food or as curios. The scale of such damage is now, however, seen to be very minor, especially in comparison with a wide range of other human activities.
- 2.3 By 1955 the first scientific assessment was taken on the likely effects of fishing on non-target species (Graham, 1955). The paper summarily dismissed the possibility that fishing could adversely effect seabed communities and probably precluded any further research in this area for a further 15 years.
- 2.4 Awareness of the issues grew, and various government groups convened. By 1965 a group of marine biologists and scientific divers wrote to the Natural Environment Research Council (NERC) recommending that certain areas below low water be set aside for photography, biological study and the effects of over exploitation. Public pressure and political interest increased, in part due to the wreck of the Torrey Canyon in 1967 and the subsequent oil pollution and related environmental damage which was caused (Smith, 1970).
- 2.5 In 1969 the first formal consideration of a marine conservation policy for Great Britain was made by NERC's nature conservation and marine science staff. The then Nature Conservancy prepared a paper entitled *Conservation policy in the shallow seas* which recommended that a scientific committee should be established to:
- *review the state of knowledge on intertidal Britain;*
  - *recommend measures for safeguarding, as nature reserves, areas of key importance as representative samples of major shore types or as research and educational sites; and,*
  - *consider whether conservation measures were desirable for areas below the low water mark.*
- 2.6 Progress on these proposals was, however, blocked by NERC's Oceanography and Fisheries Committee who advised that in the absence of strong evidence that a marine conservation problem existed due to controllable factors, proposals should not be pursued for the time being. Around the same time the first studies were published on the effects of bottom trawls on the seabed and its fauna (see de Groot, 1984, for review). These studies did not, however, progress much further beyond quantifying by-catch organisms in trawl catches and the depth fishing gears penetrated the seabed (Kaiser & de Groot, 2000).
- 2.7 In 1971 NERC, stimulated by Parliamentary Questions, established a Working Party on Marine Wildlife Conservation to make a preliminary assessment of evidence and advise whether there was a case for additional conservation measures in the marine environment. Despite preparing a report on *Marine wildlife conservation: an assessment of evidence of a threat to marine wildlife and the need for conservation measures* (NERC, 1973) little real progress emerged until the transfer of NERC's responsibilities for nature conservation to the Nature Conservancy Council in 1973.

2.8 This transfer in responsibility stimulated the formation of a further expert Working Party to review scientific information and general developments pertinent to the conservation of marine wildlife. As a result of ten meetings to consider written and oral reports, the Working Party published their report *Nature Conservation in the marine environment* (NCC & NERC, 1979). This report identified that impacts arising from marine activities were increasingly affecting marine habitats around the coast and that this made it essential to identify and safeguard outstanding sites before it was too late. In particular:

- *land reclamation;*
- *coastal structures;*
- *offshore structures;*
- *effluent discharges - domestic waste;*
- *effluent discharges - industrial wastes;*
- *shipping accidents;*
- *mineral extraction;*
- *fisheries and exploitation of other living resources;*
- *recreation;*
- *educational and scientific collecting;*
- *river management; and*
- *the introduction of alien species*

Many of these concerns which were to stimulate government action are as relevant now as they were then.

2.9 Partly in response to this evidence the Department of the Environment set up an inter-departmental working party on marine nature reserves in 1979, and by 1981 issued a consultation paper, *The establishment of marine nature reserves*. Opportunities were then taken to press for the insertion of relevant clauses in the Wildlife and Countryside Bill. This resulted in the inclusion of legislation to support statutory marine nature reserves in the Wildlife and Countryside Act, 1981.

2.10 By 1979 the first NCC 'Seabirds at Sea' surveys were underway to investigate the distribution and behaviour of seabirds in the North Sea (Blake et al., 1979). Such surveys were stimulated in part by the Torrey Canyon spill off Cornwall, the long known fact that scavenging seabirds were benefiting from wastes from fisheries (Fisher, 1950), and the rise of the oil industry in the North Sea. It rapidly became evident, however, that much more information would need to be gathered on the marine environment and human impacts upon it. This was recognised by the NCC in 1984, in their report *Nature Conservation in Great Britain* (NCC, 1984), which was a response indirectly to the World Conservation Strategy released the year before. The mid 1980's thus form the turning point for a major expansion in resource surveys and the synthesis of what was known about human impacts. It was also the era in which

NGO programmes really swung into action (see for example Bill Carter BBC Wildlife July 1998).

- 2.11 Major volunteer projects were initiated to collect basic habitat information. 1985 and 1986 respectively saw the implementation of Coastwatch (Bennett, Mitchell & Earll, 1987) for coastal and fringing habitats and Seasearch (Earll, 1992) for sublittoral habitats. By the mid 1980s the Seabirds at Sea surveys were expanded to provide more extensive coverage of the waters around the UK (see for example Webb et al., 1990) and their reviews of the distribution of seabirds were added to with reviews of the potential impact of oil pollution and the production of atlases of sensitivity to oil pollution (e.g. Tasker & Pienkowski, 1987). 1987 saw the NCC launch the Marine Nature Conservation review (Hiscock, 1996), which was to last for 11 years. In the same year a programme was established to record seabird numbers and breeding success throughout Britain and Ireland (Walsh, Avery & Heubeck, 1990). This work continues today. By the turn of the century these surveys culminated in the UK having a greater knowledge of its marine environment and its conservation values than most other countries in the world.
- 2.12 By the late 1980s the disappearance of once common biogenic reefs led to further concerns over the widespread alterations to the seabed and marine ecosystems being caused by fishing (Riesen & Reise, 1982). Large-scale changes were documented in the distribution and abundance of scavenging sea birds in the North Sea, possibly from the discarding activities associated with trawling (Hudson & Furness, 1988; Furness et al., 1988, 1992). This emerging awareness of the distribution of marine habitats and species (Gubbay, 1988) and possible human impacts in part stimulated the development of consultations with the NCC over the potential effects of various activities and operations.
- 2.13 This led to work being commissioned to develop a comprehensive overview of effects and resulted in the publication of the Marine Conservation Handbook (Eno, 1991) for use by NCC and after 1991 by country agency staff. This handbook, although focussed predominantly on inshore waters, documented the scientific evidence for effects arising from eight major categories of human activities on the marine environment:
- *Exploitation of living resources*
  - *Cultivation of living resources*
  - *Exploitation of non living resources*
  - *Use of coastal land and water space*
  - *Waste disposal*
  - *Natural processes*
  - *Coastal protection and sea defences*
  - *Education and scientific studies*

- 2.14 Such a focus is endorsed by more recent global investigations into threats to marine biodiversity (e.g. Norse, 1993). A more popularised and expanded version of the Handbook has recently been published by the Marine Conservation Society (1999). Work continues to develop a similar view of impacts in offshore and deeper continental shelf waters. Work was also undertaken around this time to develop an atlas of coastal conservation sites sensitive to oil pollution (NCC, 1991).
- 2.15 The initiation of the Marine Conservation Handbook was rapidly followed by the Estuaries Review (Davidson et al., 1991). This review synthesised what was known about the UK's estuaries and brought the threats facing them into focus. It documented 21 main categories of human use and over 230 separate activities that occurred within estuaries, assessing the impact of the more major ones on the biodiversity of the UK's estuaries. This research determined that loss and damage to estuarine SSSIs was running at about twice the then national average. It resulted a few years later in the development of government- and conservation agency-sponsored programmes to put in place multi-sectoral voluntary estuary and firth management plans.
- 2.16 More regional multi-partner exercises were also implemented to draw together what was known at a detailed level for major section of the coast and areas of sea. At an international level, concern for the state of the North sea led to a series of Ministerial North Sea conferences. These conferences stimulated the UK to produce an atlas of the North Sea coastal margin (see for example Doody, Johnston & Smith, 1993) and at the international level, the production of the Quality Status Reports for the North Sea (see for example North Sea Task Force, 1993). Information on the coastal margin was published in a much more detailed fashion in the Coastal Directories (see for example Barne 1995, 1996 & 1998) and the publications of the Irish Sea Study Group report (Irish Sea Study Group, 1990). All these initiatives have stimulated greater awareness, action, responsibility and integration for coastal and marine matters and how man interacts with the environment. Programmes continue today to build on such early work.
- 2.17 By the early 1990s, the heightened awareness worldwide of the potential impact of fishing on marine ecosystems caused ICES (the main scientific advisors on fisheries to the European Commission) to found the Study Group on Ecosystem Effects of Fishing Activities, including in its membership for the first time in ICES someone working full time on nature conservation issues. Work on the effects of fishing has expanded worldwide considerably since then to encompass effects on benthic biota, non-target fish species, marine reptiles, marine mammals and seabirds, and has led to a number of recent review publications (e.g. Jennings & Kaiser, 1998).
- 2.18 Within the UK, it became evident that sectoral responsibilities needed to embrace environmental concerns and a range of legislation was introduced, such as the Water Resources Act 1991, the Water Industry Act 1991, the Transport and Works Act 1992 and the Sea Fisheries (Wildlife Conservation) Act 1992), which place a varying degree of environmental responsibility on the relevant bodies to take account of nature conservation when carrying out their functions. Sea Fisheries Committees would, for example, soon move from having no documented environmental responsibilities, to having a duty to take account of the effects of fishing on the marine environment, to one where an environmental advisor would sit as a member on each Committee.

- 2.19 By the mid 1990s the conservation agencies views on the impacts on marine conservation interests underwent a notable evolution. In 1994, at about the same time the Habitats Directive was being introduced in Europe, the conservation agencies through Countryside Council for Wales, commissioned the University of Liverpool (Holt et al., 1995) to consider the differing sensitivities of marine habitats and species and their recoverability to human impacts. This work was extended to cover fishing impacts a year later (McDonald et al., 1996). These contract were notable in that they changed the emphasis from one of examining the range of impacts of a given activity, to one of viewing the situation from the aspect of the ecology of individual habitats and species. This turning point would in due course provide the basis from which to develop advice on operations to underpin the implementation of SACs in the marine environment (European marine sites), under the Habitats Directive, and would act as the platform from which major initiatives such as the Marine Biological Association of the UK-based Marine Life Information Network (MarLIN, 1999) would in part arise.
- 2.20 At the end of the 1990s further significant developments had occurred in relation to the understanding of impacts on marine conservation interests. The introduction of the Habitats Directive stimulated the nature conservation agencies to seek and be given financial support from the European Commission's LIFE fund to establish the UK Marine SAC LIFE project (English Nature, 1997). This project *inter alia* involved significant synthesis of recent scientific research and knowledge (both published and unpublished, from the UK and abroad) on habitats and impacts. The reports it produced are a useful source of references for such information.
- 2.21 The LIFE project synthesised knowledge on the conservation requirements of particular key habitats and species and in so doing linked in with the publication of the Marine Habitat Reviews (Jones, Hiscock & Connor, 2000) being prepared to support the OSPAR process concerning managing the marine biodiversity of the north-east Atlantic. Each review includes sections which examines what is known about the sensitivity of the habitat or species to human activities and to natural events. The key habitats and species on which it focussed are:
- *Zostera* (Davison & Hughes, 1998)
  - *Intertidal sandbanks and mudflats & subtidal mobile sandbanks* (Elliot et al., 1998)
  - *Sea pens and burrowing megafauna* (Hughes, 1998)
  - *Brittlestar beds* (Hughes, 1998)
  - *Maerl* (Birkett, Maggs & Dring, 1998)
  - *Intertidal reef biotopes* (Hill, Burrows & Hawkins, 1998)
  - *Infralittoral reef biotopes with kelp species* (Birkett et al., 1998)
  - *Circalittoral faunal tuft biotopes* (Hartnoll, 1998)
  - *Biogenic reef biotopes* (Holt et al., 1998)

- 2.22 In addition the UK Marine SAC LIFE project also produced a series of best practice reports. These document the impact of various operations on features of international conservation importance and how such effects can be ameliorated or avoided. The reviews focussed on:
- *Guidelines for recreational user interactions (UK CEED, 1999)*
  - *Good practice guidelines for port and harbour related operations (ABP Research, 1999)*
  - *The effects of fishing (Gubbay & Knapman, 1999)*
  - *Guidelines for managing the collection of bait and other shoreline animals within UK European marine sites (Fowler, 1999).*
  - *Guidelines for managing and investigating water quality in lagoons (Johnson, 1999)*
  - *Guidelines for managing and monitoring aggregate extraction (Posford Duvivier, 2000)*
  - *Guidelines for managing water quality impacts (Cole et al., 1999).*
- 2.23 In the same period more evidence became available on the wider insidious effects that might be arising from the discharge of endocrine disrupters into the marine environment (Matthiessen et al., 1998). The serious and widespread effects of TBT contamination has already been widely acknowledged, although only partially tackled through national measures (Bryan & Gibbs, 1991). Up to now water quality issues had, on the whole, focussed on direct and obvious effects arising from sewage and nutrient contamination and the discharge of heavy metals and toxic waste. Some areas of the coast had been declared Eutrophic Sensitive Areas due to the effects of discharges, such as Chichester and Langstone Harbours on the south coast.
- 2.24 The implementation of the UK Biodiversity Action Plan reflects and acknowledges this growth in information and understanding. A key route for implementing the UK plan is through Habitats and Species Action plans. Publication of the volume on maritime species and habitats (English Nature, 1999) illustrates not just the wide multi-sectoral understanding of impacts on marine biodiversity but also proposes practical measures to recover some populations and habitats that have been particularly badly affected.
- 2.25 In recognition of the impacts that a range of marine activities have on the marine environment, the 1997 EC Directive on the environmental assessment of major projects (97/11/EC) introduced the need for full EIA statements to be provided prior to consent for projects likely to have a significant effect on the environment. As part of the process of implementation, the UK introduced new regulations to require EIA for sectors including oil and gas developments (including pipelines), marine fish farming, marine aggregate extraction and harbour works. Around this time recognition was also given to the impact that shipping can have on maritime conservation interests. As a consequence of the enquiry following the loss of the Braer oil tanker on Shetland in January 1993, the concept of Marine Environmental High Risk Areas (MEHRAs) was developed, which is now in the process of being implemented.

- 2.26 The closing years of the twentieth century show further progression in the development of approaches to managing marine biodiversity in light on human activities, operations and impacts. The implementation of European marine sites has perhaps been the most recent key driver in influencing the understanding of impacts and the ecology of habitats and species. This mirrors similar initiatives in other countries and has led the need to develop further thinking and information on the sensitivity of marine habitats and species to human impacts. For example, a single matrix (see Table 1), being developed for the implementation of MarLIN, starts to capture the scale of possible and potential interactions between human activities and environmental effects (factors), whilst world wide web-based systems being developed by MarLIN and the National Biodiversity Network will make such scientific knowledge and evaluation available to all those who seek it.
- 2.27 Thus over the last fifty years a very considerable amount of research has been undertaken and weight of evidence gathered to demonstrate the impacts that human activities and operations may have, have had, and continue to have, on marine ecosystems around the England and the rest of the UK. This is part of a broader emerging international picture where it is now widely acknowledged in scientific circles that no oceans or seas in the world now remain unaffected by human use. The DETR Working Group is just one of a several convened by the UK Government over the years to keep pace with this developing information base and to answer the case for comprehensive conservation systems to be introduced in the face of continuing losses and changes in structure of marine biodiversity.

### **3. Laffoley and Bines (2000): further information on impacts**

- 3.1 In addition to a general perspective on impacts on the marine environment, the Working Group on March 2000 also asked that further information be provided expanding the text on human impacts in the marine environment mentioned in Laffoley and Bines (2000). Specific interest revolved around section 5.2 of that report and particularly the four bullet points it contained.
- 3.2 Bullet point 1:
- the overall ecological structure and functioning of the marine environment more generally around the UK has now been significantly altered, in terms of long-term species composition by the effects of fisheries operations. Put simply, some species components of the ecosystem no longer occur in our waters or are now at radically different abundances. Short to long term effects, resulting from the associated bycatch, are a serious concern;*
- 3.3 This first bullet point was based on initiatives and published literature concerning the effects of fisheries operations. For example, in Bergen in 1977 the inter- Ministerial meeting between fisheries and environment ministers recognised that fishing can have a significant effect on the marine environment, needed more integration and concluded, inter alia, that the effects of fishing needed to be addressed (IMM, 1997). The recent EU communication on fishing and nature conservation (*Fisheries management and nature conservation in the marine environment*, COM (1999) 363) recognised issues that needed to be addressed such as bycatch, seabed impacts and indirect effects.

3.4 Studies by ICES (1992) have identified some of the ecosystem effects arising from fishing activity. This has been augmented by more recent detailed studies supported by the European Commission to identify the effects on the benthos of particular types of fishing (eg Lindeboom & de Groot, 1998). This and other information has recently been synthesised in Gubbay and Knapman (1999) and extensively in Kaiser and de Groot (2000). In relation to changes in species composition and bycatch, specific examples, in addition to those given earlier in section 3, are:

- *The bycatch of Atlantic salmon smelt*
- *The bycatch of harbour porpoise in the Celtic Seas running in excess of the 'safe' 2% limit (ICES, 1996; ASCOBANS, 1997)*
- *The research undertaken on changes in the population and species composition of skates and rays which has occurred over the last few decades (ICES, 1995; Walker, 1996).*

3.5 Bullet point 2:

*'the overall quality and health of the seas around the UK has been measurably, and, in some locations, significantly altered by human activities, particularly in enclosed waters or other locations that act as sinks for contaminants. More obvious effects are from land run off or discharges, and dumping at sea, causing elevated nutrient levels and sometimes eutrophication, but these are complemented by growing evidence of more insidious effects on species and the food chain from endocrine disrupters, amongst others;'*

3.6 The overall impact of human activities on water quality has been summarised for the UK Marine SAC LIFE project by Cole et al (1999) and water quality issues in coastal waters more recently by the Environment Agency (Environment Agency, 1999). The issues have been recognised at European and UK levels through the Urban Waste Water Treatment Directive and the definition of Eutropic Sensitive Areas. However, since these do not have nature conservation-based objectives, their implementation in the UK will not address comprehensively problems of eutrophication for marine wildlife in sites.

3.7 The current situation is that point sources are declining although they still pose risks to biodiversity locally. This will be addressed for *Natura 2000* sites through the Environment Agency review of consents under the Habitats Regulations. Issues relating to water quality arising from diffuse sources remain a problem. Risks to biodiversity in estuaries (through eutrophication) have been reviewed for English Nature and the Environment Agency in a jointly funded report (Scott et al., 1999). Contamination by persistent organic pollutants remains a serious source of concern because of the widespread extent of contamination, and as understanding grows of sub-lethal effects and of effects of interactions between substances. These have been identified as a priority under OSPAR. Persistent organic pollutants including polychlorinated biphenyls, (PCBs), dioxins and organochlorine pesticides are being measured at high levels in species from seals and whales to fish, turtles and shellfish

3.8 Interest in the effects of endocrine disrupters is shown at Department level through EDMAR (Endocrine Disrupters in the Marine Environment), a partnership investigative project being funded by DETR and others (DETR, 1998). Evidence

already exists for the potential disruption that could be caused based in the UK experience of TBT and effects on invertebrates including commercially farmed species of molluscs (Bryan & Gibbs, 1991; Spence et al., 1990). Perhaps missing from bullet point 2 are the problems arising from the introduction of non-native species in ballast water and from other sources. Current initiatives by the International Maritime Organisation and the UK's Marine Coastguard Agency are aimed at tackling such problems.

### 3.9 Bullet point 3:

*'at least an area of the UK sector of the North Sea seabed, perhaps equivalent to the size of Cambridgeshire, has been measurably contaminated by exploitation for oil and gas. Areas of seabed have slumped by up to 20 metres as reserves have been extracted from below, whilst more widespread disruption to cetaceans now seems to be occurring due to exploration activities.'*

3.10 This information was drawn from Hailey (1995). The reference to the contamination is an estimate from the work of Davies et al (1988) based on the areas of seabed beneath platforms smothered and contaminated by oil-based muds and diesel oil based muds, before the industry moved over to more environmentally friendly drilling processes post 1997. Evidence for drill cutting piles affecting benthic communities 1 - 2 km distant is given in Breuer et al., (2000).

3.11 The text on seabed slumping is drawn from the same report and should have been expressed as 'anticipated' to have slumped by up to 20 metres. The fields in question are concerned with gas extraction. This localised problem associated with the very unusual geological formation was recognised in 1985 by Phillips Petroleum Company as a serious sea floor subsidence problem associated with the Ekofisk Reservoir in the North Sea. By 1995 the total subsidence was in the order of 3 - 6 m, was at that time anticipated to be as much as 20 m, and resulted in the platform being raised by 6 m.

3.12 The reference to disruption of cetaceans due to exploration activities was based on the scientific debate and carefully worded to suggest, but not completely accept, that some link exists. Whilst evidence is now available to show that cetaceans respond to the exploration activities and might avoid such areas (see for example Gordon & Moscrop 1996; Dolman & Simmonds, 1998; Simmonds & Dolman, 1999; Stone, 2000) it is still to be definitively concluded as to the consequences or otherwise of such responses, localised or widespread, on cetacean populations or individual animals.

### 3.13 Bullet point 4:

*'other direct impaction of marine habitats and species continues from a variety of sources, some localised, some widespread. Some habitats and species are more tolerant to this than others, illustrated by meta data studies on the effects of fishing gear on seabed ecology. Systems to assess and where necessary ameliorate the effects of human activities go some way to avoiding damaging impacts, but it is what is happening that we don't know about that must give greatest cause for concern.'*

3.14 The evidence for localised and widespread impacts can be obtained from an overview of the many references contained in this report. The Estuaries Review (Davidson *et al*, 1991) illustrates this point well but many other examples could be cited. The fisheries reference is drawn directly from the as yet unpublished findings of Kaiser and Hall, presented at the EU/MAFF funded workshop on biological, conservation and socioeconomic effects of fishing, held at Beaumaris, Wales in the winter of 1998. The

last point reflects the fact that we have been surprised on several occasions by novel and unanticipated impacts of human activities on marine life in the past; there is no reason to suspect that new and unwanted effects of human activities will not be discovered in the future.

## 4. Acknowledgements

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- 4.2 Whilst this has been a highly selective review in order to keep the paper to a manageable length, the interpretation and perspective given, and any inaccuracies, errors or omissions in the text, remain the sole responsibility of the author.

## 5. References

ABP RESEARCH. 1999. *Good practice guidelines for ports and harbours operating within or near UK European marine sites*. English Nature (UK Marine SACs Project). 218 pages ISBN 1 857 16 478 4

ANON, 1994. *Biodiversity. The UK action plan*. London, HMSO, for the Department of the Environment. (Cm. 2428).

ASCOBANS, 1997. A review of harbour porpoise bycatch in the ASCOBANS area. Paper adopted at the second meeting of parties to ASCOBANS.

BARNE, J.H., ROBSON, C.F., KAZNOWSKA, S.S. & DOODY, J.P., eds. 1995. *Coasts and seas of the United Kingdom. Region 12 Wales: Margam to Little Orme*. Peterborough: Joint Nature Conservation Committee.

BARNE, J.H., ROBSON, C.F., KAZNOWSKA, S.S., DOODY, J.P. & DAVIDSON, N.C., eds. 1996. *Coasts and seas of the United Kingdom. Region 3 North east Scotland: Cape Wrath to St Cyrus to Little Orme*. Peterborough: Joint Nature Conservation Committee.

BARNE, J.H., ROBSON, C.F., KAZNOWSKA, S.S., DOODY, J.P., DAVIDSON, N.C. & BUCK, A.L., eds. 1996. *Coasts and seas of the United Kingdom. Region 7 South east England: Lowestoft to Dungeness*. Peterborough: Joint Nature Conservation Committee.

BENNETT, T.L., MITCHELL, R. & EARLL, R.C. 1987. Development of a map based recording unit for the Coastwatch project. *Marine Recording*, **2**, 28 - 32.

BIRKETT, D.A., MAGGS, C.A., & DRING, M.J. 1998. *Maerl (volume V) An overview of dynamics and sensitivity characteristics for conservation management of marine SACs*. Scottish Association for Marine Science (UK Marine SACs Project).

BIRKETT, D.A., MAGGS, C.A., DRING, M.J., BOADEN, P.J.S. & SEED, R. 1998. *Infralittoral reef biotopes with kelp species (volume VII) An overview of dynamics and sensitivity characteristics for conservation management of marine SACs*. Scottish Association for Marine Science (UK Marine SACs Project).

BLAKE, B.F., JONES, P.H., DIXON, T.J. & TASKER, M.L. 1980. *Investigation of the distribution of seabirds at sea*. First report November 1979 - March 1980. Nature Conservancy Council commissioned research report.

BREUER, E., HOWE, J.A., SHIMMIELD, G.B., CUMMINGS, D & CARROLL, J. 2000. *Contaminant leaching from drill cutting piles of the norther and central North Sea - literature review*. UKOOA Research Report - Drill Cuttings Initiative.

BRYAN, C.W. & GIBBS, P.E. 1991. Impact of low concentrations of tributyletin (TBT) on marine organisms. A review. *In*: NEWMAN & MCINTOSH, eds. *Metal exotoxicology: concepts and application*. CRC, USA.

COLE, S., CODLING, I.D., PARR, W. & ZABEL, T. WRc. 1999. *Guidelines for managing water quality impacts within UK European marine sites*. English Nature (UK Marine SACs Project). 443 pages ISBN 1 857 16 483 0

DAVIDSON, N.C., LAFFOLEY, D.D'A., DOODY, J.P., WAY, L.S., GORDON, J., KEY, R., PIENKOWSKI, M.W., MITCHELL, R. & DUFF, K.L., 1991. *Nature Conservation and estuaries in Great Britain*. Peterborough: Nature Conservancy Council.

DAVIES, J.M., BEDBOROUGH, D.R., BLACKMAN, R.A.A., ADDY, J.M., APPLEBEE, J.F., GROGAN, W.C., PARKER, J.G. & WHITEHEAD, A. 1988. The environmental effects of oil-based mud drilling in the North Sea. *Proceedings of the 1988 International Conference on Drilling Wastes, Calgary, Alberta, Canada 5-8 April 1988*. Elsevier Science Publishers. Pp 59-89.

DAVISON, D.M., HUGHES, D.J. 1998. *Zostera biotopes (volume I). An overview of dynamics and sensitivity characteristics for conservation management of marine SACs*. Scottish Association for Marine Science (UK Marine SACs Project).

DE GROOT, S.J. 1984. The impact of bottom trawling on the benthic fauna of the North Sea. *Ocean Management*, **10**, 21-36.

DETR, 1998. *EDMAR. A programme of research. Endocrine disruption in the marine environment*. DETR leaflet.

- DOLMAN, S. & SIMMONDS, M.P. 1998. The threat posed by noise to cetaceans: preliminary considerations with particular reference to anti-predator devices. Unpublished report to the International Whaling Commission scientific committee, SC/50/E8.
- DOODY, J.P., JOHNSTON, C. & SMITH, B. 1993. *The Directory of the North Sea coastal margin*. Peterborough: Joint Nature Conservation Committee.
- EARLL, R.C. 1992. *The Seasearch habitat Guide*. An identification guide to the main habitats found in the shallow seas around the British Isles. Marine Conservation Society
- ELLIOT, M., NEDWELL, S., JONES, V., READ, S.J., CUTTS, N.D. & HEMINGWAT, K.L. 1998. *Intertidal sand and mudflats & subtidal mobile sandbanks (volume II) An overview of dynamics and sensitivity characteristics for conservation management of marine SACs*. Scottish Association for Marine Science (UK Marine SACs Project).
- ENGLISH NATURE. 1997. *The UK Marine SACs Project - a project to establish management schemes on selected UK marine Special Areas of Conservation*. Peterborough: English Nature.
- ENGLISH NATURE. 1999. *UK Biodiversity Group. Tranche 2 Action Plans. Volume V - maritime species and habitats*. Peterborough: English Nature.
- ENO, C. 1991. *Marine Conservation Handbook*. Peterborough: English Nature.
- ENVIRONMENT AGENCY. 1999. *The State of the Environment in England and Wales: Coasts*. London: The Stationary Office. 210pp.
- FISHER. 1950. *The Fulmar*. London: Collins.
- FOWLER, S.L. 1999. *Guidelines for managing the collection of bait and other shoreline animals within UK European marine sites*. English Nature (UK Marine SACs Project). 129 pages ISBN 1 857 16 479 2
- FURNESS, R.W., ENSOR, K. & HUDSON, A. 1992. The use of fishery waste by gull populations around the British Isles. *Ardea*, **80**, 105-13.
- FURNESS, R.W., HUDSON, A.V. & ENSOR, K. 1988. Interactions between scavenging seabirds and commercial fisheries around the British Isles. *In: BURGER, J. ed. Seabirds and other Marine Vertebrates: Competition, Predation and other Interactions*, pp. 240-68. New York: Columbia University Press.
- GORDON, J & MOSCROP, A. 1996. Underwater noise pollution and its significance for Wales and Dolphins, *In: SIMMONDS, M.P. & HUTCHINSON, J.D., eds. 1996. The Conservation of Whales and Dolphins*. John Wiley & Sons.
- GOSSE, E. 1906. *Father and son*. London: Heinemann.
- GRAHAM, M. 1955. Effects of trawling on animals of the seabed. *Deep Sea Research*, **3** (Sppl.), 1-16.

GUBBAY, S. 1988. *A coastal directory for marine nature conservation*. Ross-on-Wye: Marine Conservation Society. 319pp.

GUBBAY, S. & KNAPMAN, K. 1999. *A review of the effects of fishing within UK European marine sites*. English Nature (UK Marine SACs Project). 120 pp.

HAILEY, N. 1995. Likely impacts of oil and gas activities on the marine environment and integration of environmental considerations in licensing policy. Peterborough: *English Nature Research Reports*, No. 145.

HARTNOLL, R.G. 1998. *Circalittoral faunal turfs (volume VIII) An overview of dynamics and sensitivity characteristics for conservation management of marine SACs*. Scottish Association for Marine Science (UK Marine SACs Project).

HILL, S., BURROWS, M.T., HAWKINS, S.J. 1998. *Intertidal reef biotopes (volume VI) An overview of dynamics and sensitivity characteristics for conservation management of marine SACs*. Scottish Association for Marine Science (UK Marine SACs Project).

HISCOCK, K., ed. 1996. *Marine Nature Conservation Review, rationale and methods*. Peterborough: Joint Nature Conservation Committee. (Coasts and seas of the United Kingdom, MNCR series.).

HOLT, T.J., JONES, D.R., HAWKINS, S.J. & HARTNOLL, R.G. 1995. *The sensitivity of marine communities to man-induced change - a scoping report*. Countryside Council for Wales, Contract Science Report 65.

HOLT, T.J., REES, E.I., HAWKINS, S.J. & SEED, R. 1998. *Biogenic reefs (volume IX). An overview of dynamics and sensitivity characteristics for conservation management of marine SACs*. Scottish Association for Marine Science (UK Marine SACs Project).

HORE, J.P. & JEX, E. 1880. *The deterioration of oysters and trawl fisheries of England; its causes and remedy*. London: Elliot Stock.

HUDSON, A.V. & FURNESS, R.W. 1988. Utilization of discarded fish by scavenging seabirds behind whitefish trawlers in Shetland. *Journal of Zoology*, London. **215**, 151-66.

HUGHES, D.J. 1998 *Sea pens and burrowing megafauna (volume III). An overview of dynamics and sensitivity characteristics for conservation management of marine SACs*. Scottish Association for Marine Science (UK Marine SACs Project).

HUGHES, D.J. 1998. *Subtidal brittlestar beds (volume IV). An overview of dynamics and sensitivity characteristics for conservation management of marine SACs*. Scottish Association for Marine Science (UK Marine SACs Project).

ICES. 1992. *Report of the Study Group on Ecosystem Effects of Fishing Activities*. International Council for the Exploration of the Sea. CM 1992/G11.

ICES, 1995. *Report of the Study Group on Elasmobranch Fishes*. ICES CM 1995/G:3.

ICES, 1996. *Report of the study group on seals and small cetaceans in European Seas*. ICES Cm/96/N:1

IMM (INTERMEDIATE MINISTERIAL MEETING). 1997. *Statement of conclusions of the Intermediate Ministerial Meeting on the North Sea, Bergen, 1997*.

IRISH SEA STUDY GROUP. 1990. *The Irish sea: an environmental review*. IV Parts. Liverpool: Liverpool University Press.

JENNINGS, S. & KAISER, M.J. 1998. The effects of fishing on marine ecosystems. *Advances in Marine Biology*, **34**, 201-352.

JOHNSON, C.M. 1999. *Guidelines for investigating and managing water quality (nutrients) in saline lagoons within UK European marine sites*. English Nature (UK Marine SACs Project). 85 pages (in prep) ISBN 1 857 16 480 6

JONES, L.A., HISCOCK, K. & CONNOR, D.W. 2000. *Marine Habitat Reviews. A contribution to OSPAR and MarLIN*. Peterborough: Joint Nature Conservation Committee.

KAISER, M.J. & DE GROOT, 2000. *The effects of fishing on non-target species and habitats. Biological, conservation and socio-economic issues*. London: Blackwell Science. 399pp.

LAFFOLEY, D.d'A. & BINES, T.J. 2000. *Protection and management of nationally important marine habitats and species*. Prepared by English Nature based on views of a sample of the members of the DETR Working Group on the Review of Marine Nature Conservation. Peterborough: English Nature. 20pp.

LINDEBOOM, H.J. & DE GROOT, S.J., eds. 1998. *The effects of different types of fisheries on the North Sea and Irish Sea benthic ecosystems*. IMPACT - II. Netherlands Institute for Sea Research.

MACDONALD, D.S., LITTLE, M., ENO, N.C. & HISCOCK, K. 1996. Disturbance of benthic species by fishing activities: a sensitivity index. *Aquatic Conservation*, **6**, 257 - 268.

MARINE CONSERVATION SOCIETY. 1999. *Marine Conservation: the UK action guide*. Ross-on-Wye: Marine Conservation Society.

MarLIN, 1999. The Marine Life Information Network for Britain and Ireland. [Web site] Plymouth: Marine Biological Association of the United Kingdom. [cited 23 May 2000].

MATTHIESSEN, P., ALLEN, Y.T., ALLDRIN, C.R., FEIST, S.W., KIRBY, M.F., LAW, R.J., SCOTT, A.P., THAIN, J.E. & THOMAS, K.V. 1998. *Oestrogenic endocrine disruption in flounder (Platichthys flesus L.) from United Kingdom estuaries and marine waters*. Science series Technical report 107. Lowestoft: CEFAS.

NATURAL ENVIRONMENT RESEARCH COUNCIL. 1973. *Marine wildlife conservation. An assessment of evidence of threat to marine wildlife and the need for conservation measures*. London: Natural Environment Research Council. (Publication Series 'B', No.5.)

- NATURE CONSERVANCY COUNCIL, 1984. Nature conservation in Great Britain. Shrewsbury: Nature Conservancy Council.
- NATURE CONSERVANCY COUNCIL, 1991. Atlas of coastal sites sensitive to oil pollution. Peterborough: Nature Conservancy Council.
- NATURE CONSERVANCY COUNCIL & NATURAL ENVIRONMENT RESEARCH COUNCIL, 1979. *Nature Conservation in the marine environment*. Report of the NCC/NERC joint working party on marine wildlife conservation. London: Nature Conservancy Council.
- NORSE, E. 1993. *Global Marine Biodiversity Strategy - A strategy for building conservation into decision-making*. Washington: Island Press. 383 pp.
- NORTH SEAS TASK FORCE. 1993. North Sea Quality Status Report 1993. Oslo and Paris Commission, London. Fredensborg, Denmark: Olsen and Olsen. 132pp.
- POSFORD DUVIVER. 2000. *Guidelines for managing and monitoring aggregate extraction within UK European marine sites*. Countryside Council for Wales (UK Marine SACs Project). 140 pages (in prep) ISBN 1 857 16 481 4
- QUARRIE, J., ed. 1992. Earth Summit'92. The United Nations Conference on Environment and Development. Rio de Janeiro 1992. London: The Regency Press Corporation. 240pp.
- RIESEN, W. & REISE, K. 1982. Macrobenthos of the subtidal Wadden Sea: revisited after 55 years. *Helgolander Meeresuntersuchungen*, **35**, 409-23.
- SCOTT, C.R., HEMMINGWAY, K.L., ELLIOT, M., DE HONGE, V.N., PETTWICK, J.S., MALIDIN, S. & WILKINSON, M. 1999. Impact of nutrients in estuaries - Phase 2. Report to the Environment Agency and English Nature under European LIFE-Nature Programme.
- SIMMONDS, M.P. & DOLMAN, S. 1999. A note on the vulnerability of cetaceans to acoustic disturbance. Unpublished report to the International Whaling Commission scientific committee, IWC51/E15.
- SMITH, J.E. ed. 1970. Torrey Canyon pollution and marine life. Cambridge: Cambridge University Press.
- SPENCE, S.K., BRYAN, G.W., GIBBS, P.E., MASTERS, D., MORGAN, L. & HAWKINS, S.C. 1990. Effects of TBT contamination on *Nucella* populations. *Functional Ecology*, **4**, 425-439.
- STONE, C.J. 2000. *Cetacean observations during seismic surveys in 1998*. JNCC report No 301. Peterborough: Joint Nature Conservation Committee.
- TASKER, M.L. & PIENKOWSKI, M.W. 1987. *Vulnerable concentrations of birds in the North Sea*. Peterborough: Nature Conservancy Council.
- UK CEED. 1999. *Guidelines for managing recreational interactions within UK European marine sites*. Countryside Council for Wales (UK Marine SACs Project). 151 pp(in prep) ISBN 1 857 16 477 6

WALKER, P. 1996. *Sensitive skates or resilient rays? Spatial and temporal shifts in ray species composition in the central and northwestern North Sea*. CM 1996/Mini:4. ICES Annual Science Conference: Reykjavik, Iceland.

WALSH, P.M., AVERY, M. & HEUBECK, M. 1990. *Seabird numbers and breeding success in 1989*. Nature Conservancy Council, CSD Report, No.1071

WEBB, A., HARRISON, N.M., LEAPER, G.M., STEEL, R.D., TASKER, M.L. & PIENKOWSKI, M.W. 1990. *Seabird distribution west of Britain. Final report of Phase 3 of the Nature Conservancy Council Seabirds at Sea Project November 1986 - March 1990*. Peterborough: Nature Conservancy Council. 282pp.

**Table 1.** Draft matrix being developed by the MarLIN programme on probable and possible relationships between maritime activities and environmental factors.

| ACTIVITIES  | FACTORS                         |                       |             |                      |                            |                        |                      |                          |       |                 |                                  |                           |                           |                                  |                            |                     |                        |             |              |  |  |                                      |                                       |  |  |
|---|---------------------------------|-----------------------|-------------|----------------------|----------------------------|------------------------|----------------------|--------------------------|-------|-----------------|----------------------------------|---------------------------|---------------------------|----------------------------------|----------------------------|---------------------|------------------------|-------------|--------------|--|--|--------------------------------------|---------------------------------------|--|--|
|   | Changes in Physical Environment |                       |             |                      |                            |                        |                      |                          |       |                 | Changes in Chemical Environment  |                           |                           | Changes in Biological Conditions |                            |                     |                        |             |              |  |  |                                      |                                       |  |  |
|   | Substratum loss                 | Smoothering siltation | Desiccation | Changes in emergence | Changes in water flow rate | Changes in temperature | Changes in turbidity | Changes in wave exposure | Noise | Visual presence | Synthetic compound contamination | Heavy metal contamination | Hydrocarbon contamination | Radionuclide contamination       | Changes in nutrient levels | Changes in salinity | Changes in oxygenation | Abandonment | Displacement | Introduction of microbial pathogens/ parasites | Introduction of non-native species and translocation | Selective extraction of this species | Selective extraction of other species |  |  |
| Aquaculture: algae                                  |                                 |                       |             |                      |                            |                        |                      |                          |       |                 |                                  |                           |                           |                                  |                            |                     |                        |             |              |  |  |                                      |                                       |  |  |
| Aquaculture: fin-fish                               |                                 |                       |             |                      |                            |                        |                      |                          |       |                 |                                  |                           |                           |                                  |                            |                     |                        |             |              |  |  |                                      |                                       |  |  |
| Aquaculture: shellfish                              |                                 |                       |             |                      |                            |                        |                      |                          |       |                 |                                  |                           |                           |                                  |                            |                     |                        |             |              |  |  |                                      |                                       |  |  |
| Climate: sea level change                           |                                 |                       |             |                      |                            |                        |                      |                          |       |                 |                                  |                           |                           |                                  |                            |                     |                        |             |              |  |  |                                      |                                       |  |  |
| Climate: current change                             |                                 |                       |             |                      |                            |                        |                      |                          |       |                 |                                  |                           |                           |                                  |                            |                     |                        |             |              |  |  |                                      |                                       |  |  |
| Climate: weather pattern change                     |                                 |                       |             |                      |                            |                        |                      |                          |       |                 |                                  |                           |                           |                                  |                            |                     |                        |             |              |  |  |                                      |                                       |  |  |
| Climate: temperature change                         |                                 |                       |             |                      |                            |                        |                      |                          |       |                 |                                  |                           |                           |                                  |                            |                     |                        |             |              |  |  |                                      |                                       |  |  |
| Coastal defence: barrage                            |                                 |                       |             |                      |                            |                        |                      |                          |       |                 |                                  |                           |                           |                                  |                            |                     |                        |             |              |  |  |                                      |                                       |  |  |
| Coastal defence: dredging                           |                                 |                       |             |                      |                            |                        |                      |                          |       |                 |                                  |                           |                           |                                  |                            |                     |                        |             |              |  |  |                                      |                                       |  |  |
| Coastal defence: groynes                            |                                 |                       |             |                      |                            |                        |                      |                          |       |                 |                                  |                           |                           |                                  |                            |                     |                        |             |              |  |  |                                      |                                       |  |  |
| Coastal defence: sea walls                          |                                 |                       |             |                      |                            |                        |                      |                          |       |                 |                                  |                           |                           |                                  |                            |                     |                        |             |              |  |  |                                      |                                       |  |  |
| Collecting: algae/kelp harvesting                   |                                 |                       |             |                      |                            |                        |                      |                          |       |                 |                                  |                           |                           |                                  |                            |                     |                        |             |              |  |  |                                      |                                       |  |  |
| Collecting: bait digging                            |                                 |                       |             |                      |                            |                        |                      |                          |       |                 |                                  |                           |                           |                                  |                            |                     |                        |             |              |  |  |                                      |                                       |  |  |
| Collecting: shellfish                               |                                 |                       |             |                      |                            |                        |                      |                          |       |                 |                                  |                           |                           |                                  |                            |                     |                        |             |              |  |  |                                      |                                       |  |  |
| Collecting: peelers (boulder turning)               |                                 |                       |             |                      |                            |                        |                      |                          |       |                 |                                  |                           |                           |                                  |                            |                     |                        |             |              |  |  |                                      |                                       |  |  |
| Collecting: curios                                  |                                 |                       |             |                      |                            |                        |                      |                          |       |                 |                                  |                           |                           |                                  |                            |                     |                        |             |              |  |  |                                      |                                       |  |  |
| Collecting: eggs                                    |                                 |                       |             |                      |                            |                        |                      |                          |       |                 |                                  |                           |                           |                                  |                            |                     |                        |             |              |  |  |                                      |                                       |  |  |
| Collecting: higher plants                           |                                 |                       |             |                      |                            |                        |                      |                          |       |                 |                                  |                           |                           |                                  |                            |                     |                        |             |              |  |  |                                      |                                       |  |  |
| Development (coastal/land): dock/port facilities    |                                 |                       |             |                      |                            |                        |                      |                          |       |                 |                                  |                           |                           |                                  |                            |                     |                        |             |              |  |  |                                      |                                       |  |  |
| Development (coastal/land): land claim              |                                 |                       |             |                      |                            |                        |                      |                          |       |                 |                                  |                           |                           |                                  |                            |                     |                        |             |              |  |  |                                      |                                       |  |  |
| Development (coastal/land): urban                   |                                 |                       |             |                      |                            |                        |                      |                          |       |                 |                                  |                           |                           |                                  |                            |                     |                        |             |              |  |  |                                      |                                       |  |  |
| Development (marine/offshore): artificial reefs     |                                 |                       |             |                      |                            |                        |                      |                          |       |                 |                                  |                           |                           |                                  |                            |                     |                        |             |              |  |  |                                      |                                       |  |  |
| Development (marine/offshore): communication cables |                                 |                       |             |                      |                            |                        |                      |                          |       |                 |                                  |                           |                           |                                  |                            |                     |                        |             |              |  |  |                                      |                                       |  |  |
| Dredging (navigational/maintenance)                 |                                 |                       |             |                      |                            |                        |                      |                          |       |                 |                                  |                           |                           |                                  |                            |                     |                        |             |              |  |  |                                      |                                       |  |  |
| Energy generation (wind/tide/wave)                  |                                 |                       |             |                      |                            |                        |                      |                          |       |                 |                                  |                           |                           |                                  |                            |                     |                        |             |              |  |  |                                      |                                       |  |  |
| Energy generation (power stations)                  |                                 |                       |             |                      |                            |                        |                      |                          |       |                 |                                  |                           |                           |                                  |                            |                     |                        |             |              |  |  |                                      |                                       |  |  |
| Removal of substratum                               |                                 |                       |             |                      |                            |                        |                      |                          |       |                 |                                  |                           |                           |                                  |                            |                     |                        |             |              |  |  |                                      |                                       |  |  |
| Extraction: maerl                                   |                                 |                       |             |                      |                            |                        |                      |                          |       |                 |                                  |                           |                           |                                  |                            |                     |                        |             |              |  |  |                                      |                                       |  |  |
| Extraction: oil/gas                                 |                                 |                       |             |                      |                            |                        |                      |                          |       |                 |                                  |                           |                           |                                  |                            |                     |                        |             |              |  |  |                                      |                                       |  |  |
| Extraction: sand/gravel                             |                                 |                       |             |                      |                            |                        |                      |                          |       |                 |                                  |                           |                           |                                  |                            |                     |                        |             |              |  |  |                                      |                                       |  |  |
| Extraction: rock/minerals (coastal quarrying)       |                                 |                       |             |                      |                            |                        |                      |                          |       |                 |                                  |                           |                           |                                  |                            |                     |                        |             |              |  |  |                                      |                                       |  |  |
| Fishing: angling                                    |                                 |                       |             |                      |                            |                        |                      |                          |       |                 |                                  |                           |                           |                                  |                            |                     |                        |             |              |  |  |                                      |                                       |  |  |
| Fishing: netting                                    |                                 |                       |             |                      |                            |                        |                      |                          |       |                 |                                  |                           |                           |                                  |                            |                     |                        |             |              |  |  |                                      |                                       |  |  |
| Fishing: potting/creeling                           |                                 |                       |             |                      |                            |                        |                      |                          |       |                 |                                  |                           |                           |                                  |                            |                     |                        |             |              |  |  |                                      |                                       |  |  |
| Fishing: suction dredging                           |                                 |                       |             |                      |                            |                        |                      |                          |       |                 |                                  |                           |                           |                                  |                            |                     |                        |             |              |  |  |                                      |                                       |  |  |
| Fishing: trawling                                   |                                 |                       |             |                      |                            |                        |                      |                          |       |                 |                                  |                           |                           |                                  |                            |                     |                        |             |              |  |  |                                      |                                       |  |  |
| Fishing: spear fishing                              |                                 |                       |             |                      |                            |                        |                      |                          |       |                 |                                  |                           |                           |                                  |                            |                     |                        |             |              |  |  |                                      |                                       |  |  |
| Predator control                                    |                                 |                       |             |                      |                            |                        |                      |                          |       |                 |                                  |                           |                           |                                  |                            |                     |                        |             |              |  |  |                                      |                                       |  |  |
| Recreation: dive site                               |                                 |                       |             |                      |                            |                        |                      |                          |       |                 |                                  |                           |                           |                                  |                            |                     |                        |             |              |  |  |                                      |                                       |  |  |
| Recreation: marina                                  |                                 |                       |             |                      |                            |                        |                      |                          |       |                 |                                  |                           |                           |                                  |                            |                     |                        |             |              |  |  |                                      |                                       |  |  |
| Recreation: popular beach                           |                                 |                       |             |                      |                            |                        |                      |                          |       |                 |                                  |                           |                           |                                  |                            |                     |                        |             |              |  |  |                                      |                                       |  |  |
| Recreation: resort                                  |                                 |                       |             |                      |                            |                        |                      |                          |       |                 |                                  |                           |                           |                                  |                            |                     |                        |             |              |  |  |                                      |                                       |  |  |
| Recreation: water sports                            |                                 |                       |             |                      |                            |                        |                      |                          |       |                 |                                  |                           |                           |                                  |                            |                     |                        |             |              |  |  |                                      |                                       |  |  |
| Uses: education/interpretation                      |                                 |                       |             |                      |                            |                        |                      |                          |       |                 |                                  |                           |                           |                                  |                            |                     |                        |             |              |  |  |                                      |                                       |  |  |
| Uses: military                                      |                                 |                       |             |                      |                            |                        |                      |                          |       |                 |                                  |                           |                           |                                  |                            |                     |                        |             |              |  |  |                                      |                                       |  |  |
| Uses: archaeology                                   |                                 |                       |             |                      |                            |                        |                      |                          |       |                 |                                  |                           |                           |                                  |                            |                     |                        |             |              |  |  |                                      |                                       |  |  |
| Uses: boats/ships                                   |                                 |                       |             |                      |                            |                        |                      |                          |       |                 |                                  |                           |                           |                                  |                            |                     |                        |             |              |  |  |                                      |                                       |  |  |
| Uses: mooring/beaching/launching                    |                                 |                       |             |                      |                            |                        |                      |                          |       |                 |                                  |                           |                           |                                  |                            |                     |                        |             |              |  |  |                                      |                                       |  |  |
| Uses: research                                      |                                 |                       |             |                      |                            |                        |                      |                          |       |                 |                                  |                           |                           |                                  |                            |                     |                        |             |              |  |  |                                      |                                       |  |  |
| Uses: coastal forestry                              |                                 |                       |             |                      |                            |                        |                      |                          |       |                 |                                  |                           |                           |                                  |                            |                     |                        |             |              |  |  |                                      |                                       |  |  |
| Uses: coastal farming                               |                                 |                       |             |                      |                            |                        |                      |                          |       |                 |                                  |                           |                           |                                  |                            |                     |                        |             |              |  |  |                                      |                                       |  |  |
| Uses: animal sanctuaries                            |                                 |                       |             |                      |                            |                        |                      |                          |       |                 |                                  |                           |                           |                                  |                            |                     |                        |             |              |  |  |                                      |                                       |  |  |
| Waste: spoil dumping                                |                                 |                       |             |                      |                            |                        |                      |                          |       |                 |                                  |                           |                           |                                  |                            |                     |                        |             |              |  |  |                                      |                                       |  |  |
| Waste: industrial effluent discharge                |                                 |                       |             |                      |                            |                        |                      |                          |       |                 |                                  |                           |                           |                                  |                            |                     |                        |             |              |  |  |                                      |                                       |  |  |
| Waste: litter and debris                            |                                 |                       |             |                      |                            |                        |                      |                          |       |                 |                                  |                           |                           |                                  |                            |                     |                        |             |              |  |  |                                      |                                       |  |  |
| Waste: sewage discharge                             |                                 |                       |             |                      |                            |                        |                      |                          |       |                 |                                  |                           |                           |                                  |                            |                     |                        |             |              |  |  |                                      |                                       |  |  |
| Water supply  |                                 |                       |             |                      |                            |                        |                      |                          |       |                 |                                  |                           |                           |                                  |                            |                     |                        |             |              |  |  |                                      |                                       |  |  |

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