ICES ADVICE 2005

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Volumes 1- 11

Report of the ICES Advisory Committee on Fishery Management, Advisory Committee on the Marine Environment and Advisory Committee on Ecosystems, 2005

Volume 1

International Council for the Exploration of the Sea

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Preface

This report contains the advice given by ICES to Clients regarding marine management issues in 2005. The report is produced by three advisory committees, all providing advice on behalf of the Council: the Advisory Committee on Fishery Management (ACFM) has the prime responsibility for providing advice on fisheries management, the Advisory Committee on Ecosystems (ACE) has the prime responsibility for providing advice on ecosystems, and the Advisory Committee on the Marine Environment (ACME) provides advice on human impacts on the marine environment, e.g. effects of contaminants. The integration of the advice produced by ACE, ACFM and ACME is a result of the introduction of the Ecosystem Approach.

The members of an advisory committee include one designated scientist from each of the ICES member countries and the committee has an independently elected chair. The chairs of the Consultative Committee and some of the scientific committees are *ex-officio* members. ACFM meets twice a year to review the status of fish stocks and to provide advice for fisheries in the coming year. ACE and ACME meet once every year. ICES has invited Client Commissions and some stakeholder groups to be present at advisory committee meetings in observer capacity.

The basis for the advice on fisheries is reports of fisheries assessment working groups. These assessment reports are peer reviewed by designated groups, each chaired by an ACFM member. The review groups are composed of scientists who are not members of the assessment working group under review and who normally do not originate from countries with a strong interest in the stocks concerned. A few review groups include invited reviewers not originating in research institutions normally involved in ICES stock assessments. The Assessment Working Group chairs assist the review groups. For other topics the advisory committee members provide the necessary review.

Beginning with this 2004 report ICES starts implementing an Ecosystem Approach as the basis for its advice. This will be done incrementally and the process will take several years.

Structure of the report

Volume 1 explains the conceptual and institutional framework for the assessments and advice. It contains a general introduction to the ICES advice.

Volume 2 includes general and non-regional advice.

Volumes 3 - 8 are regional reports. The structure has been further developed towards a regional based ecosystem approach. and each of these volumes deals with an ecosystem/region. In addition, there are separate chapters for widely migratory stocks, deep water stocks and for the North Atlantic salmon.

Each of these regional ecosystem-volumes includes an ecosystem overview, a description of the human impact on the ecosystem, answers to specific requests, a description of the fisheries in the region and the operational conclusions based on the stock assessments. Finally the report presents a series of stock summary sheets.

The fisheries advice includes some reflection on mixed fisheries issues in fisheries management. For those stocks for which mixed fisheries issues are known to be minor the advice is given on a stock basis. This applies mainly to pelagic stocks. For most demersal stocks or stocks where mixed fisheries are known to be important the advice is based on an identification of the critical stocks and the overall advice is based on the requirements for those stocks. As a consequence of the need to take a fisheries perspective the advice for all stocks is now given in the area overview section.

Advice is given for the following areas:

- The Barents Sea and the Norwegian Sea
- The Faroe Plateau Ecosystem
- Celtic Sea and West of Scotland
- North Sea
- Bay of Biscay and Iberian Seas
- The Baltic Sea

Widely migrating stocks (blue whiting, Norwegian spring-spawning herring, mackerel, horse mackerel, and hake) are dealt with separately. These stocks occur in several of the regionally defined ecosystems on their migrations, Volume 9.

The deep-water ecosystem(s) overlaps with some of the areas covered by divisions in other areas. However, the deep-water section (approximately beyond the 200-m depth contour) of these divisions shares properties which justifies their separate treatment, Volume 10.

Finally, the North Atlantic salmon is dealt with separately in Volume 11.

List of Special Requests

CUSTOMER	REQUEST – Non-recurrent	DATE	RESPONSE
IBSFC	Keep IBSFC updated on progress with revising estimates of smolt production potential in wild salmon rivers Information on the development of fishing practices for salmon in the gulf of Finland and assessment of the consequences of such development of catches of wild and reared salmon	04.10.04 04.10.04	10 June 2005 10 June 2005
NEAFC	to provide information on the spatial and temporal extent of all current deep-water fisheries in the NE Atlantic. to develop suitable criteria for differentiating fisheries into possible management types (e.g. directed deep-water fisheries, by-catch fisheries etc) and to apply these criteria to categorise individual fisheries.	17.05.05 Draft request	May 2006
OSPAR	Identification of suitable biological effects monitoring techniques for CEMP, and integration of biological effects measurements with chemical monitoring Guidelines on frequency and spatial coverage of monitoring for nutrients and eutrophication parameters Advice on threats to, or decline in the OSPAR area of, seamounts Scientific aspects of risk management of ballast water Review of the outcome of the ICES/OSPAR Workshop on the development of guidelines for integrated chemical and biological effects monitoring, and finalising the guidelines Assessment of the long term impact of oil spills on marine and coastal life Consideration of the current developments within OECD/EU regarding endocrine disruptors and whether this is adequate for the marine environment, and advice on any further work considered necessary to address issues specific to the marine environment	07.07.03 July 2004 – OSPAR to come back with more information in February 2006 July 2004 July 2004 July 2004 July 2004 July 2004	Partly June 2004. The remaining in 2005 - ACME ACME June 2006 ACE/ACFM October 2005 (after WGDEEP input) ACME June 2005 ACME June 2005 ACME June 2005 ACME June 2005
HELCOM	Include the Baltic Sea in a marine habitat classification and mapping To evaluate every second year the populations of seals and harbour porpoise in the Baltic marine area To review and revise the quality assurance section of the PLC Guidelines	June 2003 June 2004 June 2003	ACE June 2005 ACE June 2005 March 2005

List of Fast Track Requests

CUSTOMER	REQUEST – Fast track	DATE	RESPONSE
EC			
DG Fish	Compile status list of EU Fish stocks		February 2005
	Sole in IIIa – new information to be included in re-assessment of stock	21.01.05	10 June 2005
	Bycatch of common dolphin	25.01.05	ACE June 2005
	Advice on deep-sea stocks	23.03.05	October 2005
	Long term management of Baltic cod	14.03.05	10 June 2005
	Request on restocking of glass eel	15.03.05	10 June 2005
	DNA analysis of Baltic salmon	18.02.05	10 June 2005
DG Fish and Norway	Long-term management advice	21.01.05	10 June 2005
DG Env	Influence of sonar on marine mammals and fish	25.09.03	Marine mammals part February 2005 Fish part October 2005
NEAFC	Information on stock identity of *Sebastes mentella* and quantitative information to allow spatial and temporal limitations in catches	17.11.04	21 Oct 2005
	Advice regarding the proposal for the protection of vulnerable deep-water habitats	17.11.04	21 Oct 2005
	Stock assessment methods for Atlanto-Scandian herring and blue whiting stocks	17.11.04	21 Oct 2005
	NEA mackerel stock assessment methodology	17.11.04	21 Oct 2005
IBSFC	Advise, not later than 15.04.2005 on areas with the Gotland Deep and Gdansk Deep where the hydrological condition allow for a successful cod spawning in 2005	04.10.04	15.04.2005
OSPAR	The design of one-off surveys to provide new information for a number of OSPAR Chemicals for Priority Action	July 2004	1 April 2006
	Quality Assurance of Biological Measurements in the North East Atlantic	July 2004	Early March 2005
HELCOM	To coordinate quality assurance activities on biological and chemical measurements in the Baltic marine area and report routinely on planned and ongoing ICES inter-comparison exercises, and to provide a full report on the results	June 2003	March 2005
MEMBER STATES			
Norway	Catch of NEA cod and haddock for 2006	24.01.05	10 June 2005
	Management goals for seal stocks	16.06.05	Harp seal response: October 2005 Hooded seal response: June 2006
Spain	Advice on Anchovy stock in VIII	03.08.2005	21.10.2005

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1 ICES ADVICE

1.1 Introduction

ICES is requested to provide advice on a range of issues relating to marine policies and management. The clients for such requests are the governments of ICES' member countries, the European Commission and international intergovernmental organisations dealing with marine affairs such as the Helsinki Commission (HELCOM), the International Baltic Sea Fisheries Commission (IBSFC), the North Atlantic Salmon Commission (NASCO), the North East Atlantic Fisheries Commission (NEAFC) and the OSPAR Commission (OSPAR). ICES may also on its own initiative draw the attention of clients to marine matters which may require policy and management attention. The present report is the ICES advice produced in 2005.

ICES provides advice in relation to policies and objectives identified by governments and the international client commissions and the policies and guidelines of relevant international agreements and codes of practice. The latter include chapter 17 of Agenda 21 of the UN Conference on Environment and Development (UN 1992), the Convention on Biological Diversity (Convention on Biological Diversity 1992), the United Nations Fish Stocks agreement (UN 1995), the FAO Code of Conduct for Responsible Fisheries (FAO 1995) and the Declaration of the World Summit of Sustainable Development (UN 2002). The overarching guidelines from these policy documents include the precautionary approach to marine management, that marine management shall be based on an ecosystem approach by 2010 and that fish stocks shall be maintained or restored to levels that can produce the maximum sustainable yield by 2015. These policies form the normative basis for ICES advice.

1.2 New Report Format

The format is largely the same as for the ICES Advisory Report No. 2 (2004). However, now the report is split into volumes, each volume covering a region or ecosystem. Details of the report structure are discussed in ICES Advisory Report no 2 (2004), section 1.2.

1.3 The Scientific Basis for Advice

ICES advice is based on the work done by research organisations in ICES member countries which contribute to ICES work through data collection and analysis in the institutes and through participation in ICES expert groups. The outcomes of these analyses are translated into operational advice by ICES advisory committees which include scientists from all ICES member countries.

The normative basis for ICES advice includes the precautionary approach, that marine management shall be based on an ecosystem approach and that fish stocks shall be maintained or restored to levels that can produce the maximum sustainable yield as stipulated in international agreements and declarations. The translation of this basis into management advice is explained below.

1.3.1 The precautionary approach

ICES advice is based on the Precautionary Approach. The Precautionary Approach was summarised in the UN Stocks Agreement (1995) as follows: "States shall be more cautious when information is uncertain, unreliable or inadequate. The absence of adequate scientific information shall not be used as a reason for postponing or failing to take conservation and management measures." When advising on this basis, ICES applies a graduated approach dependent on the information available. If sufficient data and knowledge about the dynamics of the system in question is available to establish reference indicators and reference points and to measure the present state and predicted future outcomes of management action against such reference points, ICES advises on basis of precautionary approach reference points. Precautionary reference points are based on conservation limits with a buffer which relate to the uncertainty of the knowledge about the present and future state relative to the conservation limit. When reference points cannot be established or present knowledge does not enable an assessment of the state relative to reference points ICES may advise on basis of past pressure which was found to be sustainable. Using fisheries as an example this may be fishing effort or catches from a period where the stock was known to maintain productivity with that pressure. If there are indications that the present state is critical and there is insufficient information to demonstrate that the present pressure is compatible with a reversal of the situation ICES advises considerable reduction in pressure.

1.3.2 Ecosystem approach

Marine management should take an integrative view and include ecosystem considerations, i.e. use an "Ecosystem Approach". ICES is implementing an Ecosystem Approach in its advisory work. This is in response to several political declarations calling for such an approach, e.g. Reykjavik 2001, Bergen 2002, and the World Summit on Sustainable

Development, Johannesburg, 2002. Ecosystem considerations have been included in ICES advice in the past both as a response to requests for advice regarding ecosystems and more specifically in relation to fisheries. For example in response to requests from environmental and fisheries commissions the need to maintain a food base for predators has been the basis for advice regarding capelin and sandeel.

Numerous large national and international programmes exist to develop an ecosystem approach for the management of the marine environment and its resources. Some of these programmes are described by ICES (Report of the Advisory Committee on Ecosystems, 2002) according to region. There is a general consensus as to the intent of the expression "ecosystem approach". However, actual definitions of the expression vary and this must be considered when interpreting reports on the implementation of the "ecosystem approach".

Taking an ecosystem approach will contribute to achieving long-term sustainability for the use of marine resources, including the fisheries sector. Fishing fleet capacity exceeds in many regions the long-term sustainable fishing possibilities; there is mounting evidence that the fisheries sector and other human activities are having a serious impact on these ecosystems with many fish stocks being depleted. The most effective way to achieve ecosystem objectives regarding fisheries is to implement the measures advised for years based on single-stock fisheries considerations – namely to reduce the exploitation of fish stocks considerably. Measures with this effect will reduce the pressures on biota and habitats, and will contribute to restoring stocks to full reproductive capacity and thus provide the basis for higher long-term yields. A management approach including ecosystems considerations serves multiple objectives and should emphasize strong stakeholder participation and focus on human behaviour as the central management dimension.

At the 13th ICES Dialogue Meeting (26–27 April 2004) it was discussed how ICES plans to introduce an ecosystem approach. The implementation will include stakeholder interaction and will be incremental. ICES has opened its advisory committees to stakeholder observers who will get better insight into the advisory process. ICES accepts that our understanding of the functioning of the ecosystems is confined to certain ecosystem components and that this will remain so in the foreseeable future, although our understanding of the systems improves. Also, our understanding is not uniform among the ecosystems; there are ecosystems for which more data and better understanding of the critical processes exist compared to other systems. Therefore, implementation of the Ecosystem Approach and ICES ability to satisfy information requirements from clients varies among ecosystems.

Before an ecosystem approach can be implemented ecosystems must be defined. The identification of marine ecosystems for management advice must be based on their oceanographic and biological coherence, but must also be practical by corresponding as well as possible to existing area definitions as used in management. ICES has adopted a regional definition of ecosystems for its advice. This form of definition is not practical for all populations, e.g. widely migrating stocks of fish and sea mammals which occur in several of the regional ecosystems illustrating that the systems are open systems. Also, from a physical oceanography point of view regional ecosystems are open systems at least when considering longer time perspectives. However, for the time being a regional approach seems to be the better option.

Management advice under an Ecosystem Approach is a multi-step procedure which includes identification of ecosystems, identification of the relevant ecosystem components, and linking human activities to impact on the ecosystems. ICES implementation considers primary effects on a number of ecosystem components; it is hoped that these will be those components where impacts are most profound. This differs from having an overall ecosystem model with a single all-encompassing ecosystem health function, a proposition that ICES presently does not consider to be practical. ICES stresses that the implementation is an evolving process; therefore, it is only for the time being that the approach is confined to the evaluation of the primary effects.

In an advisory context ICES considers an ecosystem from two angles:

- A sector approach (e.g. industrial production discharging into the marine environment, fisheries);
- A quality status assessment of ecosystems.

Sector approach: As the first step the assessors list the human activities taking place in the sector and identify the ecosystems that are affected. The next step is then to detail these impacts through the mapping of each of these activities and their impact for as many ecosystem components as allowed by the available data and our understanding of the processes. Then compare the impact of this specific human activity with the impact of all human activities again component by component, i.e. is this specific impact significant among all human impacts. Finally, the impact of the sector under study is related to the acceptable overall impact for each component, e.g. based on sustainability considerations. Doing so requires a quality status assessment of the ecosystem component. Going through component by component allows the development of advice in an ecosystem context. Therefore, analysis of human impacts under this Approach only includes a subset of all the ecosystem components.

Assessment of the quality status of ecosystems: An overall quality status report starts from the components of the ecosystem and the first step is to assess the status of ecosystem components for which we have information. To provide management advice the next step is to identify the human activities that have major impact on each component and to evaluate if a reduction of human impact would be desirable. These impacts should be identified to sector to allow managers to take action. Assessing the status of the ecosystem is addressed within ICES/OSPAR under the heading of Ecosystem Quality Objectives.

1.3.3 Maintaining or restoring fish stocks to levels that can produce MSY

The World Summit on Sustainable Development (UN 2002) stipulated that fish stocks shall be maintained or restored to levels that can produce the maximum sustainable yield by 2015. ICES' clients are in the process of translating this requirement into operational management policies and ICES will modify its advice accordingly when policy decisions have been made. ICES contributes to this process by developing options for management strategies which aim at producing high long term yields while ensuring that there is little risk that the reproductive capacity of fish stocks will be impaired. Examples of such management plan options are presented in the present advisory report.

1.4 The Form of ICES Advice

According to international agreements, including the World Summit on Sustainable Development (UN 2002), the management of human impacts on marine ecosystems should be based on the precautionary approach. Management based on the precautionary approach seeks to be risk averse. Society may furthermore choose to pursue specific benefits from the marine ecosystem such as transport, sustainable harvest of living resources, recreational activities, and deposition of waste. Management for benefit achievement would be bounded by the requirement for risk aversion as stipulated by the precautionary approach.

ICES provides advice based on an ecosystem approach to management. In relation to a specific sector this advice will address specific issues arising from the practices within that sector. Beyond that, ICES also advices on the overall state of the ecosystem.

1.4.1 Fisheries advice

The fisheries advice is the result of a three-step process:

> Single-stock exploitation boundaries are identified first. These are the boundaries for the exploitation of the individual fish stock and are identified on the basis of its status, consistent with the Precautionary Approach and, if target reference points have been defined or management plans which are precautionary have been decided, in relation to targets or plans. The single-stock boundaries also include considerations of the ecosystem implications of the harvesting of that specific species in the ecosystem whenever such implications are known to exist. These single-stock exploitation limits are presented in the stock summaries in Section 1.4 within each volume (ecosystem), and collected in a table for each area in Section 1.3. The single-stock boundaries would apply directly as advice in the absence of mixed fisheries issues and ecosystem concerns beyond the impact of fishing on that stock.
>
> Then mixed fisheries issues are addressed. For stocks harvested in mixed fisheries the single-stock exploitation boundaries will apply to all stocks taken together simultaneously. It is thus necessary to identify the major constraints within which mixed fisheries should operate and through this analysis identify the additional constraints that further limit the fishing possibilities. Such major constraints may be stocks in the stock assemblage, which are outside precautionary limits and which therefore may become the limiting factor for all fisheries exploiting that stock. This implies that the stocks which are considered to be in the most critical state may determine the advice on those stocks which are taken together with critical stocks. The second step is therefore to identify which species within mixed fisheries have the most restrictive catch limits, because these constraints, when applied across all species in mixed fisheries, further limit the fishing possibilities. The single-stock exploitation limits are combined in relation to fisheries on an area basis in Section 1.3.
>
> The final consideration regards those ecosystem concerns which are not related to one specific stock, but rather to mixed fisheries or to groups of stocks. Such concerns may for instance include habitat and biota impacts of dragged gear, incidental by-catches of non-commercial species, and food chain effects when such impacts are known to occur. Ecosystem concerns may represent further boundaries to fisheries beyond those implied by single-stock concerns and mixed fisheries issues.

The overall advice for mixed fisheries is thus threefold: 1) limit the harvest of a critical stock as by-catch or targeted catch to the limit applying to that stock across all fisheries; 2) harvest within single-stock exploitation boundaries for all other stocks; and 3) in the event that further ecosystem impacts of fisheries beyond removal of the stocks included in the assessments have been identified such concerns may restrain specific fisheries further. The consequence may be that a fishery may fish less than the single-stock exploitation boundary for its target stocks if a critical stock is taken as a by-catch or other ecosystem concerns are to be addressed.

Single-stock upper boundaries on exploitation

ICES advice is based on the Precautionary Approach. Within these limits ICES does not prefer any particular option and the ICES advice is therefore formulated as an upper bound on, e.g., the total catch. Where management prefers a particular option, e.g. expressed through a management plan/recovery plan ICES will evaluate whether this plan is in accordance with the Precautionary Approach or not. If the plan is precautionary the ICES advice will be based on the management plan, i.e. the option preferred by management. Cases of non-precautionary management plans typically occur in situations where the stock is depleted and the plan is considered inadequate. However, when the stock is not in a precarious situation the management plan may produce precautionary options perfectly and ICES will advise on these options. Obviously, ICES will not advise on non-precautionary measures and when a management plan suggests non-precautionary management measures, e.g. for depleted stocks, ICES will evaluate the precautionary limits and base its advice on these limits independent of the management plan. Even in these situations ICES will, as a matter of routine, calculate the resulting management measure based on the management plan; such a calculation does not constitute advice unless this is explicitly stated.

The incremental introduction of the “Ecosystem Approach” supplements the “Precautionary Approach” implemented in the ICES advice on fisheries management since 1998. The single-stock upper exploitation boundaries that are fundamental building blocks of the ICES advice on fisheries management remain based on the Precautionary Approach biological reference points. These reference points are stated in terms of fishing mortality rates or biomass. They are predefined benchmarks (limit reference points) that should be avoided to ensure that stocks and their exploitation remain within safe biological limits and against which assessments should evaluate the status of the stock.

Risk aversion, based on the precautionary approach, defines the boundaries of management decisions for sustainable fisheries. Within these boundaries society may define objectives relating to benefits such as maximised long-term yield, economic benefits, or other ecosystem services. The achievement of such objectives may be evaluated against another set of reference points, *target reference points*, which may be measured in similar dimensions as limit reference points but which may also relate to money, food, employment, or other dimensions of societal objectives. Target reference points will always be bounded by limit reference points and their associated uncertainties.

Reference points for risk aversion

For risk aversion ICES advises within the following framework:

The single-stock exploitation upper boundaries are aimed at restricting the risk that the spawning biomass falls below a minimum limit. The minimum spawning stock biomass benchmark is described by the symbol $\mathbf{B_{lim}}$ (the biomass limit reference point). The value of $\mathbf{B_{lim}}$ is set on the basis of historical data, and chosen such that below it, there is a high risk that recruitment will ‘be impaired’ (seriously decline) and on average be significantly lower than at higher SSB. When information about the dependence of recruitment on SSB is absent or inconclusive, there will be a value of SSB, $\mathbf{B_{loss}}$, below which there is no historical record of recruitment. $\mathbf{B_{lim}}$ is then set close to this value to minimize the risk of the stock entering an area where stock dynamics are unknown.

Below $\mathbf{B_{lim}}$ there is a higher risk that the stock could “collapse”. The meaning of “collapse” is that the stock has reached a level where it suffers from severely reduced productivity. “Collapse” does not mean that a stock is at high risk of biological extinction. However, recovery to an improved status is likely to be slow, and will depend on effective conservation measures.

The fishing mortality rate should not be higher than an upper limit $\mathbf{F_{lim}}$ which is the fishing mortality that, if maintained, will drive the stock to the biomass limit.

Spawning biomass and fishing mortality can only be estimated with uncertainty. Therefore, operational reference points are required to take account of this. To keep the true risk low that spawning biomass falls below $\mathbf{B_{lim}}$, the estimated spawning biomass should in practice be kept above a higher level to allow for this uncertainty. Therefore, ICES applies a ‘buffer zone’ by setting a higher spawning biomass reference point $\mathbf{B_{pa}}$ (the biomass precautionary approach reference point). As long as the *estimate* of spawning biomass is at or above $\mathbf{B_{pa}}$, the *true* biomass should have a low probability of being below $\mathbf{B_{lim}}$. Therefore, ICES advises that when the spawning biomass is estimated to be below $\mathbf{B_{pa}}$, management action should be taken to increase the stock to above $\mathbf{B_{pa}}$. Because $\mathbf{B_{pa}}$ is a mechanism for managing the risk of the stock falling below $\mathbf{B_{lim}}$, the distance between these reference points is not fixed, but will vary with the uncertainty of the assessment and the amount of risk society is prepared to take. For example if the quality of catch data were to decline, or multi-year forecasts were required for catch advice, a higher $\mathbf{B_{pa}}$ would be needed for the same $\mathbf{B_{lim}}$. The same is true if society will only accept a very low risk that the true biomass is below $\mathbf{B_{lim}}$.

Similarly, to be certain that fishing mortality is below $\mathbf{F_{lim}}$, fishing mortality should in practice be kept below a lower level $\mathbf{F_{pa}}$ that allows for uncertainty as well. ICES advises that when fishing mortality is estimated to be above $\mathbf{F_{pa}}$, management action to reduce it to $\mathbf{F_{pa}}$ should be taken. Such advice is given even if the spawning biomass is above $\mathbf{B_{pa}}$ because fishing mortalities above $\mathbf{F_{pa}}$ are not sustainable.

ICES stresses that these precautionary reference points should not be treated as management targets, but as lower bounds on spawning biomass and upper bounds on fishing mortality. Good management should strive to keep SSB well above $\mathbf{B_{pa}}$ and fishing mortality well below $\mathbf{F_{pa}}$. If management keeps stocks very close to their precautionary reference points, then annual scientific advice will be altering conclusions on stock status and necessary management actions on the basis of assessment uncertainty as much as on the basis of true changes in stock status. Managing stocks to achieve targets well removed from the risk-based reference points would result in more stable scientific advice, as well as healthier stocks and more sustainable fisheries.

The spawning stock should always be kept above $\mathbf{B}_{pa}$. The fishing mortality should be kept below $\mathbf{F}_{pa}$ in order to achieve this. If a management plan exists which ensures that the SSB will be kept above $\mathbf{B}_{pa}$, $\mathbf{F}_{pa}$ may temporarily be above $\mathbf{F}_{pa}$ as long as there are mechanisms ensuring a downward adjustment before SSB approaches $\mathbf{B}_{pa}$.

ICES gives advice on many stocks for which there is no analytical assessment and accordingly no basis for setting reference points as described above. In these cases ICES also uses a precautionary approach, but alternative models are applied, with reference points referring to properties of the stock or fishery that can be estimated, for example catch per unit of effort instead of biomass.

Target reference points

The ICES advice is primarily risk-averse, i.e. it aims at reducing the risk of something undesirable happening to the stocks. Biological target reference points are also part of the Precautionary Approach, but setting targets for fisheries management involves socio-economic considerations. Therefore, ICES does not propose values for Target Reference Points, and until recently Management Agencies had not identified management targets based on socio-economic benefits. Hence Target Reference Points have not been used directly in the advice. This means that even if the ICES advice is followed and therefore the stock should be protected from impaired productivity, exploitation of most stocks is likely to be sub-optimal, i.e. the long-term yield is lower than it could be.

When societal objectives or targets have been identified ICES can provide advice relating to these targets. ICES may advise on the likeliness of achieving targets under different management regimes and may propose parameters and values for target points if a basis for such choices has been defined in fisheries policies.

Managers are invited to develop targets and associated management strategies. ICES will comment on these and consider if they are consistent with the precautionary approach. If they are, ICES will frame the advice to be consistent with the adopted management targets.

Language of fisheries advice

The framework used to phrase the advice in relation to the precautionary approach relies on the assessment of the status of the stock relative to precautionary reference points. When an assessment estimates that the spawning biomass is below $\mathbf{B_{pa}}$ ICES classifies the stock as being "outside safe biological limits", regardless of the fishing mortality rate.

When a stock is below $\mathbf{B_{pa}}$ ICES will provide advice to increase the spawning biomass above $\mathbf{B_{pa}}$, which may involve reducing fishing mortality to levels below $\mathbf{F_{pa}}$, possibly by a large amount. If $\mathbf{B_{pa}}$ cannot be achieved in the short term, ICES will recommend the development of a recovery plan specifying measures to increase SSB above $\mathbf{B_{pa}}$ in an appropriate time scale, depending on the biological characteristics of the stock and other relevant factors.

When an assessment shows that the stock is above $\mathbf{B_{pa}}$ but that the fishing mortality is above $\mathbf{F_{pa}}$, the stock is classified as "harvested outside safe biological limits". ICES will then recommend that the fishing mortality be reduced below $\mathbf{F_{pa}}$ in the short term.

However, referring to "safe biological limits" has in some cases mislead clients and other stakeholders to consider stocks described as being "outside safe biological limits" to be biologically threatened (i.e. close to extinction). The term "outside safe biological limits" is used in international agreements and has been used by ICES in the past to classify stocks for which the spawning biomass is below $\mathbf{B_{pa}}$. While ICES considers this language to be perfectly justified and in accordance with international practices the attention of ICES has also been drawn to instances of confusion in the public debate where "outside biological limits" has been equated to biological extinction. ICES has therefore from 2004 used a phrasing which more specifically refers to the concept on which this classification is based by referring to the reproduction capacity of the stock in relation to spawning stock biomass, and sustainable harvest in relation to fishing mortality. It should be emphasised that the expressions "outside safe biological limits" and "being at risk of reduced reproductive capacity" or "suffering reduced reproductive capacity" are considered entirely equivalent by ICES and that the change in language does not imply any change in judgement of the seriousness of the situation when a stock is outside safe biological limits and thereby outside precautionary limits.

The present ICES classification scheme is equivalent to the terminology used before:

- Biomass:
  - stock is "having full reproductive capacity" is equivalent to "inside safe biological limits";
  - stock is "being at risk of reduced reproductive capacity" or "suffering reduced reproductive capacity" is equivalent to "outside safe biological limits".
- Fishing mortality:
  - stock is "harvested sustainably" is equivalent to "harvested inside safe biological limits";
  - stock is "at risk of being harvested unsustainably" or "harvested unsustainably" is equivalent to "harvested outside safe biological limits".

The following terminology for the "State of the stock" is used in this report:

For the status relative to SSB: "Based on the most recent estimates of SSB, ICES classifies the stock as …"

If **SSB>B**$_{pa}$: "having full reproduction capacity."
If **B**$_{lim}$ <**SSB<B**$_{pa}$: "being at risk of reduced reproductive capacity."
If **SSB<B**$_{lim}$: "suffering reduced reproductive capacity." or "at a level where the stock dynamics is unknown and therefore risking reduced reproductive capacity" (in the case where **B**$_{lim}$ is the lowest observed).

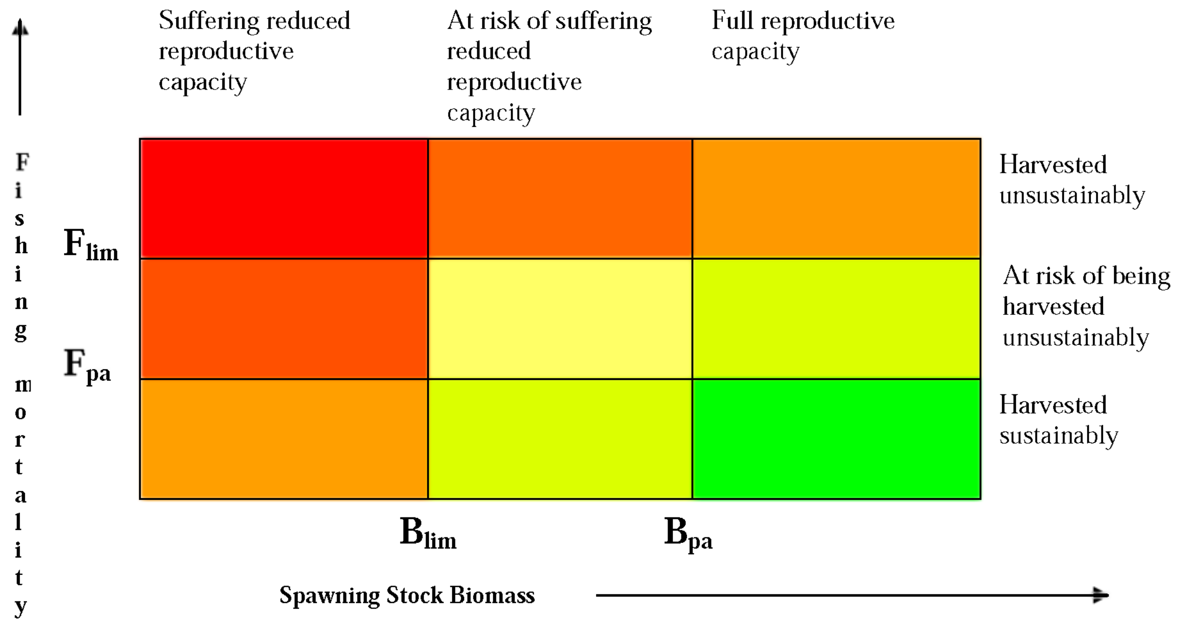
The two last categories were earlier referred to as "outside safe biological limits".

For the status relative to fishing mortality: "Based on the most recent estimates of fishing mortality ICES classifies the stock to be…"

If **F<F**$_{pa}$: "harvested sustainably."
If **F**$_{lim}$ **>F>F**$_{pa}$: "at risk of being harvested unsustainably."
If **F>F**$_{lim}$: "harvested unsustainably."

Also here the two last categories were earlier referred to as "outside safe biological limits".

1.5 Reference Points for the Status of Fish Stocks



The introduction of target reference points will necessitate an expansion of categories to include situations relative to targets. This remains to be developed in concert with the development of a framework for target reference points.

1.5.1 The identification of reference points for the status of fish stocks in the ICES area

Most ICES limit and precautionary reference points in current use were set in 1998 using the stock and fishery data then available, as a provisional step in the implementation of the precautionary approach. In some cases it has been necessary to change these reference point values as a result of changes in the data or the productivity of the stock, in order to improve consistency with the framework described above, and to take advantage of the new biological and fisheries information acquired on many stocks. In the meantime some reference points in the existing framework need to be revised because new biological data or major revisions in assessments make the existing values inconsistent with the current assessments.

A new framework which includes target reference points relating to yield is being developed and introduced in cooperation with clients. Target reference points have only been identified for a few of the stocks for which management plans have been defined. An example is Norwegian spring-spawning herring where the target fishing mortality used in the management plan has been identified to produce an outcome which relates to both high long-term yield and maintenance of the reproductive capacity. When such management plans are consistent with the precautionary approach ICES provides advice relative to target reference points. For other stocks ICES only provides risk averse advice. Some clients have through recent MoUs, which include requests for recurring advice expressed interest in advice on "the level of catch consistent with taking high long-term yields and achieving a low risk of depleting the productive potential of the stock". This implies that management plans which would lead to these outcomes would include parameters which could be seen as target reference points. If such management plans are of the same nature as those presently in force in the ICES area the fishing mortality used as target would be a target reference point. In the absence of such management plans ICES can identify candidates for target reference points expressed as fishing mortalities which in the longer term would be associated with high yields and a low risk of reduced reproductive potential.

1.6 Short-Term Implications: Catch Projections for the Current and Following Year

ICES provides advice which relates to long-term benefits such as maintenance or rebuilding of the full reproductive capacity of fish stocks and high long-term yield. Management systems and procedures can be identified which will achieve these benefits by using decision rules that do not require specific predictions about events in the coming year but rely rather on adaptation based on past outcomes.

However, all management procedures which are presently implemented in the ICES region rely on some prediction of the outcome of fisheries management in the management year. Under these conditions the Management Option table is a fundamental part of the ICES advice. These catch options rely on estimates of recent stock size and the fishing mortality and require an assumption about the total catch in the current or "assessment" year, because the fishery is rarely over when the assessment must be done.

Recent stock sizes and fishing mortalities are estimated on the basis of information on catches in commercial fisheries and catch rates in research surveys. The estimates may therefore be subject to serious error if there are significant amounts of unreported landings, or if information on discards at sea is not available. Catch information tends to become most unreliable in times when the management measures would be most restrictive if they were implemented. In recent years several stocks have been at a low level and catch information has deteriorated for many fisheries. The consequence is that the ability to provide quantitative advice such as catch forecasts with the required precision has deteriorated.

The proper fishing mortality value to assume for a particular stock in the current year is often unclear, especially when this implies a catch much larger than the total TAC for the given year. The value used as the catch in the current year can have a substantial influence on which catch options in the coming year that would be consistent with a Precautionary Approach.

The catch assumption is a projection of trends in the fisheries and the projection is based on case-specific conditions. In many cases, ICES considers two alternatives: 1) to assume that the catch will be equal to the TAC (a TAC constraint), or 2) to assume that the fishing mortality, F, will continue to be equal to that of the previous year (a $\mathbf{F}_{status\ quo}$ constraint). When possible, ICES evaluates the weight of the evidence for a TAC constraint vs. the $\mathbf{F}_{status\ quo}$ constraint and selects the more appropriate one. In some cases, however, neither might apply.

Calculation of the best estimate of the *status quo* fishing mortality by age varies between stocks depending on temporal trends in the fishing mortalities and in the exploitation pattern. Also the variance of the estimate in individual years needs to be considered. In several cases a mean over the last three years is used, sometimes scaled to the level of overall fishing mortality in the most recent year. In some cases the stock unit used by ICES does not match the TAC area used by the management agencies. In those cases it can be difficult to establish how the TAC will restrict the catch from the stock and often the $\mathbf{F}_{status\ quo}$ is used.

1.7 Management Advice for Mixed Fisheries

Once single-stock exploitation boundaries have been identified the next step in the formulation of management advice is to identify which single-stock boundaries are limiting in mixed fisheries as explained above.

ICES has worked on these issues together with scientific groups under EC STECF to develop the necessary framework and to build the required databases. Much of this work has concentrated on the North Sea demersal fisheries. Many fisheries harvest several quota species simultaneously and this poses at least two management problems. Even within a single fishery, managers must keep catches of all species within their TACs while trying not to forego catches of species whose TACs are taken up more slowly. When several fisheries all take a species in common, whether as a target species or as bycatch, managers must also allocate the safe harvest of the shared species among those fisheries in ways that allow the fisheries to take their allowable harvest of their various target species, without exceeding the total allowable catch of the shared species.

Experience from fisheries-based management in other parts of the world indicates that the provision of fishery-based advice is possible, but that it requires well-defined fisheries that are based on complete and reliable catch data. In the ICES case, model development has outpaced the compilation of appropriate data, both for defining fisheries and providing mixed fishery advice. Specifically, the lack of data on discards for most species is a principal concern. Although this is a weakness of many single-stock forecasts it becomes a fatal flaw in a mixed fisheries context. The absence of discard data will lead to inappropriate advice being given, thereby misinforming managers about the appropriate allocation of effort among fisheries consistent with desired levels of fishing mortality by species. For example, for a species under a recovery plan advice would be provided that would restrict fisheries reporting landings or bycatches of the species, but would ignore entirely fisheries that catch and discard that species, possibly at rates high enough to preclude recovery.

ICES is concerned that any approach to managing mixed fisheries that assumes a constant species composition over time implicitly discourages adaptive fishing behaviour. In many jurisdictions fishermen have demonstrated the ability to reduce bycatch of critical species, through season, area, or gear modifications, or through changes in their short-term fishing patterns. There is a danger that the allocation of fishing opportunities for different species based on past catch compositions will lock fisheries into their historical context, and provide no incentive for the industry to find ways to fish without catching species that are restrictive on fleet activities. Such adaptive changes in fishing behaviour are difficult to predict, but to the extent that they occur, they will limit the realism of mixed fishery forecasts.

ICES has previously advised that where industry-initiated programmes can be demonstrated (with independent and credible methods) to bring their catch rates of species under recovery plans down to near zero, then such programmes could be considered in the management of those fisheries. The pre-requisite for such programmes to be successful includes a high rate of independent observer coverage, or other fully transparent method for ensuring that catches are fully and credibly reported. This pre-requisite is not considered to be met in NE Atlantic fisheries.

In 2002 ICES established a preliminary database of North Sea demersal fleet-based landings data. This was used subsequently by STECF in the development of illustrative fishery-based management scenarios through mixed-species TAC evaluations and under various assumptions about the priority of access of various fleets to the allowable catch of shared species. The underlying model and its software implementation (MTAC) were further developed. The model has been further developed in 2003 and 2004 and can now be considered sufficiently mature to be used for mixed fisheries management scenario evaluations provided data on past catches (landings and discards) are available.

The main obstacle is hereafter that ICES does not have access to discard data for most fisheries. Given the lack of access to discard information for many species and fleets, the available catch data are not a valid basis for mixed fishery advice. Absence of discard information will result in misleading results with respect to which fisheries should be limited to keep total catches of all species (particularly those outside safe biological limits) within bounds that will allow eventual recovery of depleted stocks. Reliable mixed fishery forecasts suitable for use in management require estimates of total catch from all fisheries.

There is therefore not much point in proceeding with quantitative mixed fisheries scenario evaluations as long as these basic data are not available. The lack of such mixed fishery forecasts necessitates the development of complementary processes that do not require analytical short-term forecasts. As per 2004 ICES is therefore basing its advice on mixed fisheries on information available on the catch composition in these fisheries even though quantitative projections cannot be made. This means that the single-stock boundaries are supplemented with qualifiers about which targeted and mixed fisheries are known to harvest the critical species as target or incidental bycatch and to which extent different stocks should be seen as linked by being taken in the same fisheries.

1.7.1 The incorporation of ecosystem considerations

The final step in the formulation of advice is to address those ecosystem considerations which are associated with mixed fisheries or several stocks simultaneously. Ecosystem considerations regarding single-stock fisheries are addressed as a part of the single-stock exploitation boundaries.

Ecosystem considerations include the impact of fisheries on habitats and the impact on other biota beyond the fish populations which are already included in the advice, such as incidental bycatches on non-commercial fish species or sea mammals. The removal of fish from the ecosystem will also have more overall impacts on the structure and energy flow in the ecosystem.

The impact of fisheries on the ecosystem can at present rarely be quantified or predicted in quantitative terms. The incorporation of such considerations in the advice will therefore mainly be through qualifying statements regarding the quality and direction of expected impacts.

Present knowledge about ecosystem impacts is built on studies in specific ecosystems, but may not represent the overall ecosystem and can only be extended to other ecosystems in a general way. Many important ecosystem considerations regarding the impacts of fisheries will therefore be of a general, not area-specific nature. Such general considerations are therefore not dealt with in the area sections in Section 1.3, but in the general advice in Section 1.2. As more specific knowledge is produced the advice on ecosystem impacts will move from the general to the area-specific sections.

1.8 Quality of Fishery Statistics

The quality of the assessments is directly linked to the quality of the fisheries data, and ICES has expressed the greatest concern in past ACFM advice over the quality of catch and effort data from most of the important fisheries in the ICES area.

The assessments presented in this report are carried out using the best catch data available to ICES. These data are not necessarily identical with the official statistics but, where appropriate, include estimates of unreported landings as well as corrections for misallocation of catches by area and species. ICES seeks information on misreported or unreported landings through a range of sources, but there is no guarantee that all instances are discovered. Often the catch data used by ICES are collated on a stock rather than an area basis, and thus straightforward comparisons between these figures and the official statistics, which are provided on an area basis, are not appropriate. The catch data used in the assessments are given in the "summary table" found in Chapter 1.4 under each stock. In cases where there might be doubt, it has been indicated if discards, bycatches, and estimates of unreported landings are included in the assessments. Estimates of catches landed as bycatches, especially from the industrial fisheries, are included in the assessments wherever data allow it and are included in the catch options.

In some assessments, ICES tries to estimate the total catch taken, including slipped catches, discards, landings which are not officially reported, and the composition of the industrial bycatches. These amounts of different species, which have to be included in the estimates of what has been taken from a given stock in order for the assessments to be correct, thus appear in the tables and figures in this report. These discards, slipped fish, unreported landings, and industrial bycatches vary considerably between different stocks and fisheries, being negligible in some cases and constituting important parts of the total removal from other stocks. In recent years more information on discards has been collected through observer programmes. However, few of these data have been made available to ICES for assessment purposes.

In the past there have been problems associated with discrepancies between the official landing figures reported to ICES by member countries and the corresponding catch data used by ICES. ICES recognises the need for a clear identification of the categories of the catch data used for assessments and whenever possible specifies the composition of the catch data used to estimate fishing mortalities. ICES also attempts to identify factors contributing to the total fishing mortality in the various stocks, e.g.:

- recorded landings,
- discards at sea,
- slipping of unwanted catches,
- losses due to burst nets, etc.,
- unreported landings,
- catch reported as other species,
- catch reported as taken in other areas,
- catch taken as bycatch in other fisheries.

It is recognised that it may not always be possible to reveal the sources of the data. It is, however, indicated whether the data originate from sampling programmes, field observations, interviews, etc., in order to allow ICES and other interested parties to evaluate the quality of the data, and hence the basis for the assessment.

It should be noted that some industrial fisheries take protected species above the minimum landing size. When this catch is sorted and landed for human consumption, the landings are included in the estimates of human consumption landings, both in the catch input data and in the projected catch options. Estimates of industrial bycatches cover, in most cases, that part of the bycatch which is used for reduction purposes.

The overall responsibility for obtaining reliable, adequate, and timely fisheries statistics rests with the national offices for fisheries statistics and fisheries research institutes. The national fisheries research institutes control the design and execution of the abundance surveys. These agencies are also responsible for providing the catch data needed for assessments. They should ensure that catch statistics are collected on a gear basis and that the species composition of landings is determined in the case where landings are made unsorted by species.

Fisheries statistics and data sampling are collected in cooperation with the fishing industry. This means that the quality of a significant part of the data used in ICES fisheries advisory work relies on cooperation with the fishing industry and national authorities. The quality of these data depends on the degree to which the industry adheres to the regulations, e.g., the EU TAC and Quota regulation, and to which extent research institutes are allowed to observe fishing operations or to do market sampling.

It is becoming increasingly difficult to assure the quality of the data when the fishing industry is involved. There are numerous examples of such problems, e.g., access to discard data from the Dutch beam trawl fleet, and in previous years access to Danish discard data. There are reports of misreporting of landings from areas, e.g., for the fleet fishing herring in Division VIa and in Subarea IV, and there are non-reported landings in several fisheries, e.g., Scottish fishing around 2000 and recently in the Baltic cod fishery.

Until now ICES has, as a matter of policy, attempted to correct for shortcomings in the data. For non-reported landings such corrections, by their very nature, are difficult to document and are obviously open to debate. Clearly, the ICES assessments in these situations are of poor quality and it is a policy matter when ICES should refrain from providing advice at all. Disregarding data from the fisheries would mean that ICES will be unable to provide reliable estimates of current stock sizes and forecasts that have been used to set TACs. Trends in stock size and the overall status of the stock can sometimes be evaluated from research vessel surveys, but such information alone cannot be used to give the short-term TAC advice usually required.

The fishing industry has on various occasions disagreed strongly with ICES' estimates and has in such situations blamed ICES for not performing well.

ICES cannot accept responsibility for quantifying non-reporting fisheries, or ensuring access to proper discard data, when there are reservations regarding the collection and use of such data from national authorities or industry. Simply, ICES has no monitoring apparatus at its disposal. Likewise ICES has no legal authority to demand access to existing data. The responsibility for discards and non-reporting and the uncertainty regarding the extent of these phenomena rests with the national authorities and the industry.

1.9 Information from the fishing industry

During the collection of data in harbours and through observer programmes onboard fishing vessels considerable interaction takes place with the fishing industry and crucial information is collected. There are also various formalised fora (meetings between scientists and industry representatives in most ICES countries, the North Sea Commission Fisheries Partnership and the Study Group on Fisheries Information) where information is exchanged. Extensive qualitative information is provided from the fishing industry and there are several efforts to extend the use of logbooks and qualitative information.

The fishing industry has through these channels provided information which has been included as part of the assessment process. Such information has contributed to the understanding of the fisheries, and is increasingly provided in a form which enables direct inclusion in quantitative assessments.

1.10 Environment Impact on Fish Stocks

The reproduction of fish stocks is variable and the reasons for this variation are incompletely known.

The environment is important in determining the survival of fish eggs and the survival and growth of fish larvae and juvenile fish. A multitude of environmental factors may be involved. For some fish stocks specific hydrographic conditions are known to be important and the composition and density of the plankton, which is the food source of fish larvae and juveniles, is known to be critical for growth and survival. The abundance of predators is also an important factor in juvenile survival. One of the best understood cases is the Baltic Sea where a linkage between the reproductive success of cod and hydrographic conditions has been demonstrated.

For a number of North Sea species (cod, whiting, plaice) recruitment in most recent years has been lower than in previous decades. Some stocks, notably North Sea plaice, have shown a reduction of growth. On the other hand, other species like sea bass and red mullet with more southern distributions have increased in abundance and/or growth rates, and have at times attracted a fishery. There are also indications of changes in distribution for some stocks. There is considerable speculation on the reasons for the observed changes. Changes in the environment may have played a role in the reduced productivity of several North Sea stocks. In the last 10 years mean temperatures in the sea have increased and changes in the sea currents have also been observed.

The state of the fish stocks themselves is an important factor in determining recruitment. For several stocks a relationship between recruitment and the size of the spawning stock is apparent for low spawning stock sizes. The composition of the spawning stock may also be important because studies with some species, particularly cod, have shown that young and small spawners produce a reduced quantity of eggs which are of a reduced quality. A spawning stock dominated by young spawners could therefore have less reproductive capacity than a spawning stock of comparable size with many older spawners. Spawning stock size should therefore be supplemented with information on its composition when the reproductive capacity is evaluated.

Fishing leads to a reduction in the spawning stock and to a higher proportion of young spawners in the spawning stock. The high fishing mortalities which have been prevalent for many fish stocks have resulted in reduced spawning stocks which are dominated by first-time spawners. High fishing mortalities have thus lead to low reproductive capacity independently of the environmental conditions. If climate change or other environmental changes have also played a role in the reduced productivity of fish stocks, it therefore becomes even more essential that exploitation rates on these stocks be reduced, to sustain the stocks under conditions of lower productivity.

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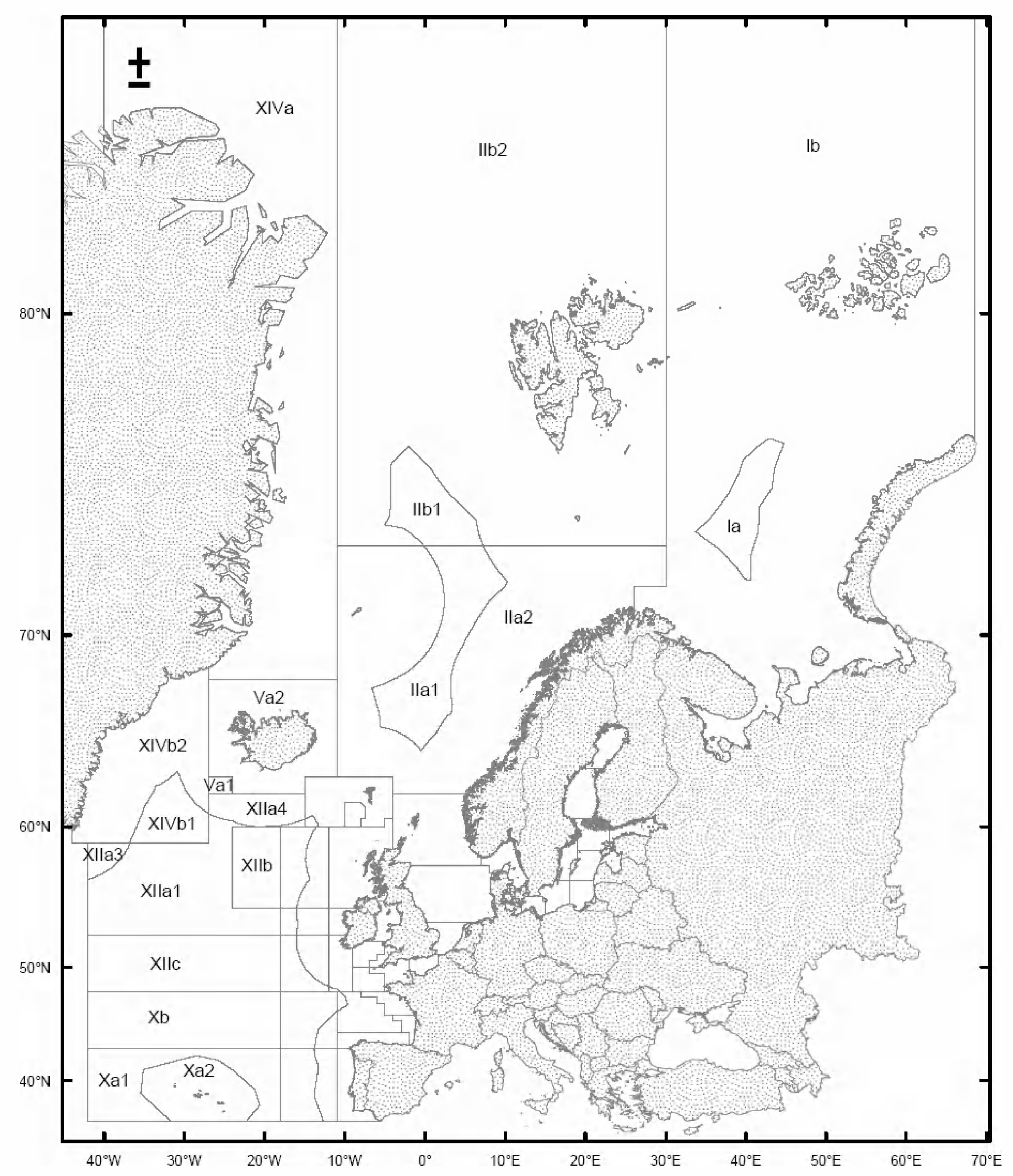

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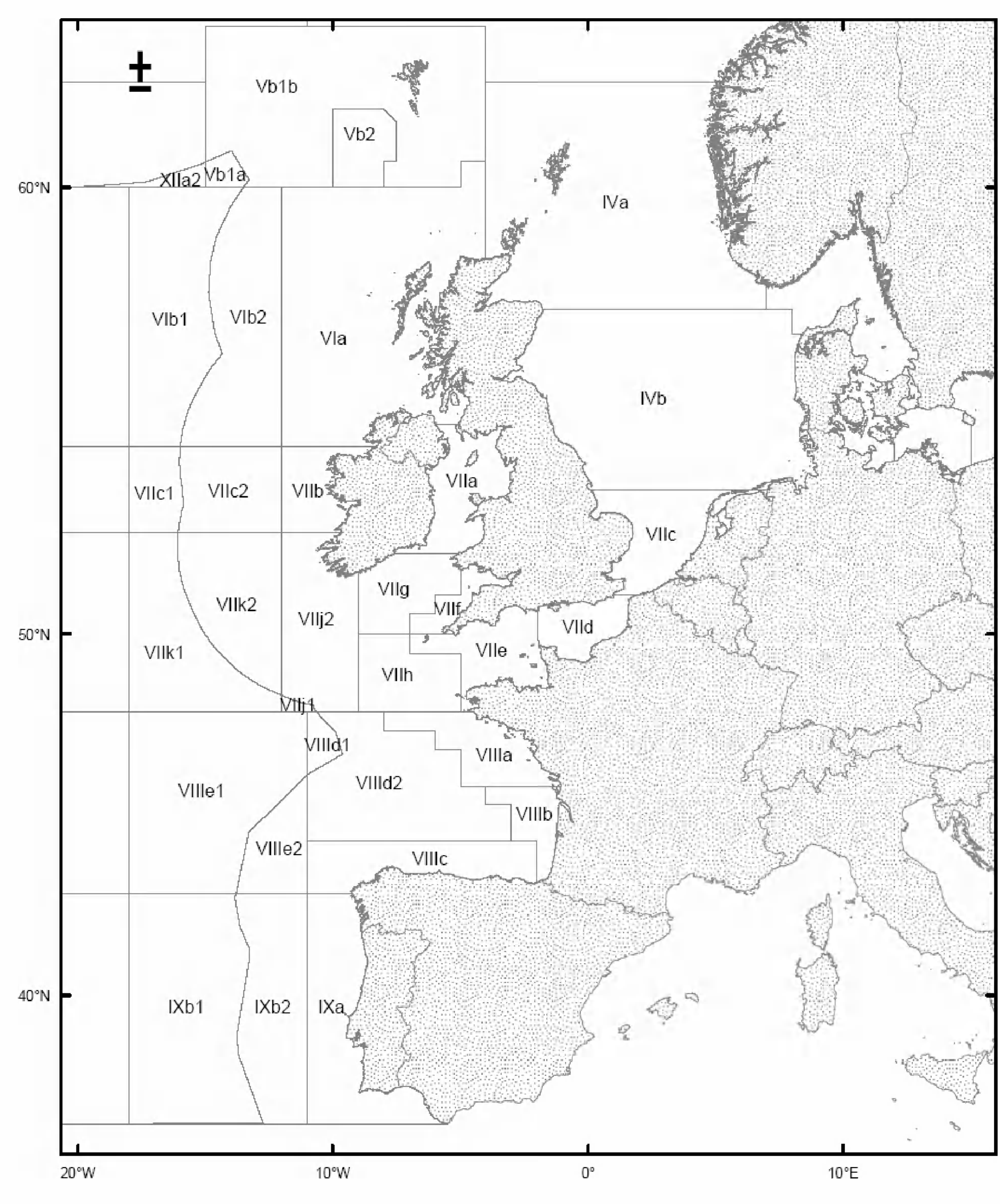

Continued. ICES Areas.

1.11 Future ICES advice in relation to the European Marine Strategy

The European Marine Strategy Consultation Paper proposes the management of all human activities in the sea based on three central features: an Ecosystem Approach, Integrated Management, and a Regional Focus for the coordination and delivery of management programmes. ICES notes that these central features correspond closely to the developments intended by the major clients of advice from ACFM as well as advice from ACE. As discussed in depth during the 13th ICES Dialogue Meeting in Dublin (ICES, 2004), fisheries management authorities are planning to adopt an Ecosystem Approach to Fisheries Management, and Regional Advisory Committees are being established as a key component of regionally-based management of fisheries. Hence the new science necessary to support the implementation of the European Marine Strategy will also be necessary to support the major current clients of ICES fishery advice in their traditional and future roles.

The incremental demands on a scientific advisory body to support Integrated Management and an Ecosystem Approach on a regional basis are much more numerous, onerous, and complex than scientific advice on single-sector, single-factor management. The 2005 WGECO report opens a discussion of these new demands in Chapter 3, and both experts and officers within ICES and major clients of ICES advice should engage in serious dialogue on these advisory issues. It also highlights activities by ICES officers, both in the Secretariat and in the organisation, which are needed to ensure that ICES remains the central source of scientific expertise and advice as the EU Marine Strategy continues to develop. ICES has a unique and central role to play in the implementation of the European Marine Strategy. Although ICES capacity and practices will both be challenged to support the Strategy, no other organisation or group of experts in Europe or internationally is nearly as ready to overcome these challenges as ICES is. ICES can maintain the scientific quality, impartiality, and breadth of expertise that must be contained in the scientific basis for implementation of the European Marine Strategy. In particular, ICES has an established track record for provision of scientific advice on ecosystem management issues. ICES is possibly the only science agency in Europe with the rigour and breadth to select the appropriate indicators and reference points which are the central tools for implementation of the Marine Strategy (Guidance Document, Sections 4 and 7) and to subsequently interpret and advise on management actions within the objectives-based framework. The short-term Action Plan in the WGECO 2005 report (ICES, 2005a – see Annex 1) should be a priority for ICES itself during the coming months.

In addition to the specific demands on the advisory system, the adoption of Regional Ecosystem Approaches to Integrated Management (hence REAIM) in the European marine areas means that ICES must develop some new areas of scientific excellence, and greatly strengthen some scientific areas where it may have been active in the past, but where much more rapid progress will be essential. The major new areas of urgent scientific activity for ICES include:

1) Coming to grips with providing a scientific basis for characterising a "healthy ecosystem" and "good ecological status" in objective and operational terms. Many major environmental policy documents, including the European Marine Strategy (paragraphs 5 and 67) feature those terms. ICES has correctly stressed that setting management *targets* is a societal responsibility, to the extent that targets reflect the desired state of an ecosystem property. However, just as medical science has to have operational ways to characterise "healthy" persons, ecological science has to have operational ways to conclude that an ecosystem is "healthy". Providing a scientifically sound basis for evaluating ecosystem health will require all the scientific disciplines of ICES working together. The questions to be addressed include:

   - How many and what dimensions or properties need to be considered in assessing ecosystem health, and do the number and types of dimensions depend on what uses are made of the ecosystem? What are sound indicators for those properties?
   - When considering multiple properties of an ecosystem, how are decisions made about healthy positions and conservation limits which are consistent and biologically sound?
   - What features of ecosystem structure and function should be preserved in order to conclude that good environmental quality has been maintained?

   ICES has experience in addressing questions of this nature, but generally in exploratory contexts. On the management side, many lessons have been learned from the experience of trying to make the Water Framework Directive operational. This experience and lessons need to be brought together, to facilitate answering the questions above. The answer will be central to the science advice for implementation of the Marine Strategy, and our rate of progress on the questions must accelerate and the breadth of consensus on the conclusions must widen. Also the review and therefore the strength of the science evidence for the conclusions, whatever they are, must be made stronger and more transparent and accessible, because the science and advice are likely to be subjected to, and must be able to withstand scrutiny by many managers, policy setters, and stakeholders.

2) Linking effectively to social scientists. REAIM requires integrating scientific advice across more than just multiple biological features of marine ecosystems. Advice supporting Integrated Management means evaluating the consequences of options in one economic sector (say energy), for the options available to other sectors (say, fishing). Some of the consequences will be on the marine ecosystems, and others on the social and economic benefits derived from the industrial sectors. ICES will be unable to provide useful advice on the ecological consequences of the options and tradeoffs if its ecosystem scientists are not working closely with experts who are evaluating which options and tradeoffs meet the various social and economic objectives of the various sectors. Moreover ICES is already acknowledging that fisheries advice, for example, must take much greater account of implementation uncertainty and human behaviour (credibility of science, likelihood of compliance, etc) to be effective (ICES, 2005b). When management decision-making has to be integrated across multiple sectors, the sector-specific implementation uncertainty is likely to be much higher. There were challenges to the credibility of science advice, and compliance with management regimes was sometimes low when the advice and management was developed with a narrow focus on the concerns of the specific sector being managed. The situation may well be even worse when decision-making is influenced by considerations and needs of other human users and components of the ecosystem of marginal interest to the sector. For that reason as well, ICES ecological scientists must work closely with social scientists.

   The IM component of REAIM has another implication for ICES science as well. Up to this point ICES has had great difficultly even obtaining reliable geo-referenced effort data on fisheries, and this has constrained ICES science efforts to understand and quantify the ecosystem effects of fishing. In a REAIM context ICES will need data on the intensity of all the human activities in the sea, on the finest geographic scales possible. These data will be needed in order to be able to understand and quantify the ecosystem effects of the various industrial sectors, and to apportion quantified changes in local and regional ecosystems among potential causal factors, including multiple industrial sectors, directional environmental change (regime shifts, climate change, etc.), and natural variance.

3) Developing knowledge and operational guidelines for extrapolating data, models, and conclusions across geographic areas, and up and down spatial scales from local to global. ICES scientists and science advisors have always had to make judgments about when data and models can be used for places and times other than those under which they were collected or tested. The regional focus of the European Marine Strategy accentuates the need for these judgments. Historically ICES has commonly used data sets on the spatial scale for which they were collected, whatever that scale happened to be. The regional implementation focus will put more pressure on ICES to extrapolate analyses and conclusions much more readily from the scales of the data sources to the regional scale, and from information-rich regions to information-poor ones. Furthermore, interpolation of data between discrete data points will become increasingly required. The commitment to an Ecosystem Approach will require more linkage of data and information about different ecosystem components – hydrography, biological and physical oceanography, benthos, fish communities, and human activities. The job of just assembling data sets for the REGNS integrated assessment is proving taxing for the ICES system. The implementation of the European Marine Strategy at the regional scale around Europe will replicate these demands many times over, and will frequently identify information gaps which might be reduced by importation of data or models from other areas. ICES needs a scientifically defensible understanding of when such importations should and should not be done.

   Also the European Marine Strategy acknowledges that many management plans will have to take account of species or processes on scales more local than regional, particularly—but not exclusively—the coastal zones, shelves, and deep-sea areas. The challenge to ICES is to develop and evaluate management strategies within an ecosystem approach that will be "parameterized" and applied at the regional scale, but which will also have to function at these more local scales when necessary. This is a complex, but not intractable science problem. Moreover, discrepancies among the scales of human impact, ecological processes, and management regimes will be the rule, and the nature of the discrepancies will be continually changing as the mix of human activities changes and ecological processes vary on many scales. ICES needs to develop approaches which are scientifically defensible, including operational guidelines on how such scaling up and down should be done.

4) Finally, ICES will have to develop, evaluate, acquire, and train its experts in analytical tools which are not currently widespread in the ICES science and advisory communities. In particular expertise for quantitative and qualitative risk assessment will have to be available in many Expert Groups, not just in a few groups with largely analytical foci. Likewise the expertise for developing and evaluating scenarios has to be broadly available in Expert Groups. This may include scenarios about future states of nature (invasive species, climate change, etc.), alternative options for levels and mixes of human activities in the seas, or both types of scenarios at once. There needs to be scientific consistency in the conceptual approaches underlying the risk assessments and scenario exploration across scientific disciplines, even if the operational features of the analyses maintain some characteristics of individual scientific disciplines. Finally, many of the Expert Groups in ICES will need the capacity to place their scenarios and risk assessments into the contexts of evaluating the robustness of

management strategies for IM, not just for management of a single activity. This will require greater capacity in spatially explicit modeling, and systems for exploring spatially-referenced data sets.

Not only must ICES develop new areas of scientific excellence, it must find its appropriate role in processes which are developing to implement REAIM. Important aspects of the new roles will emerge from the interactions between ICES and the many parts of the governance system working to implement REAIM. Some specific processes are expected to gain new prominence, however, such as Strategic Environmental Assessment (SEA). The SEA process has the ability to guide decisions based on available information and a considered view of the risks inherent in not having full information to hand. The roles of industrial sectors, managers, and scientists in preparation and review of SEAs is still evolving. ICES needs to engage in dialogue with the industries and management agencies undertaking SEAs to ensure that it has appropriate roles in both their preparation and their review. Moreover, one of the by-products of SEA is a clear identification of information and research needs, and thus SEA may also help in prioritising spending in these areas. As with any such assessment, there will be assumptions made over likelihood and scale of effects, and further survey, monitoring, or research to validate (or otherwise) these assumptions will help improve future assessments. These consequences of SEAs provide an additional incentive for ICES to become engaged with the industries and agencies conducting SEAs.

The four major scientific fields of activity listed above cut across the scientific disciplines of ICES. They can be considered to be almost new and as more ambitious ways to approach doing the Science of ICES. However, there are also some scientific questions which are either new, or which may have been interests of individual ICES experts or Expert Groups for some time, and which are now becoming of major scientific importance. These new or enhanced scientific priorities are not necessarily rooted in management agencies deciding to REAIM marine ecosystems, but nonetheless represent essential scientific knowledge to make such management systems successful. These key scientific questions include:

1) How is climate change affecting marine ecosystems, particularly—but not exclusively—exploited marine resources?
2) Do marine ecosystems in the Northeast Atlantic show "regime shifts", and if so, how are they characterized and what are the effective diagnostics indicating a regime shift?
3) What are the implications of both climate change / variability (1) and regime shifts (2) for sustainability of human activities in the sea, including fishing, and what management strategies are robust to each form of variation?
4) What ecosystem models (both trophodynamic and environment-organism) are actually scientifically sound bases for exploring the consequences of different levels of human activities in the sea, what are their limitations, and how should their results be used or not used?
5) What are the major invasive marine species in the ICES area, what have been their ecological and commercial consequences, how can the likelihood of additional invasive species becoming established be reduced, and what can be done to reduce detrimental effects of invasive species which are found in an area?
6) Considering the commitment of ICES member states to the Convention on Biological Diversity, how should biological diversity of the ICES waters be characterized, and what is the biodiversity status of those seas? What needs to be done to achieve the biological objectives specified in the Jakarta Mandate, in particular **"to achieve by 2010 a significant reduction of the current rate of biodiversity loss at the global, regional and national level"**?

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2 GENERAL ADVICE

2.1 Northeast Atlantic (General patterns)

Hydrography sets the context for the major ecosystems in the North East Atlantic. The upper water layers are characterized by two major current systems (Figure 2.1.1). Warm and saline waters that originate from the subtropical gyre are transported polewards by the North Atlantic Current and southwards by the Canary Current; these relatively warm waters dominate the eastern and southern parts of the area. In addition, the European Shelf Edge Current transports warm water northwards along the continental slope. This current is found throughout the year north of Porcupine Bank, but often disappears in summer along the shelf break in southern European Atlantic waters. In this area upwelling events can occur seasonally and these are considered important in the recruitment of some small pelagic species. Norwegian Sea deep water, which is generally very cold (around 0°C), travels through the Faroe Bank Channel where it drops into the Iceland Basin while mixing with the warmer Atlantic waters. Relatively cold and fresh Arctic waters, on the other hand, are transported southwards by the current systems in the west, e.g., by the East Greenland Current. These relatively cold waters dominate in the northwestern parts of the North East Atlantic. Detailed information on the hydrography of this area is available from the Annual ICES Ocean Climate Status Summary (Hughes and Lavin, 2004).

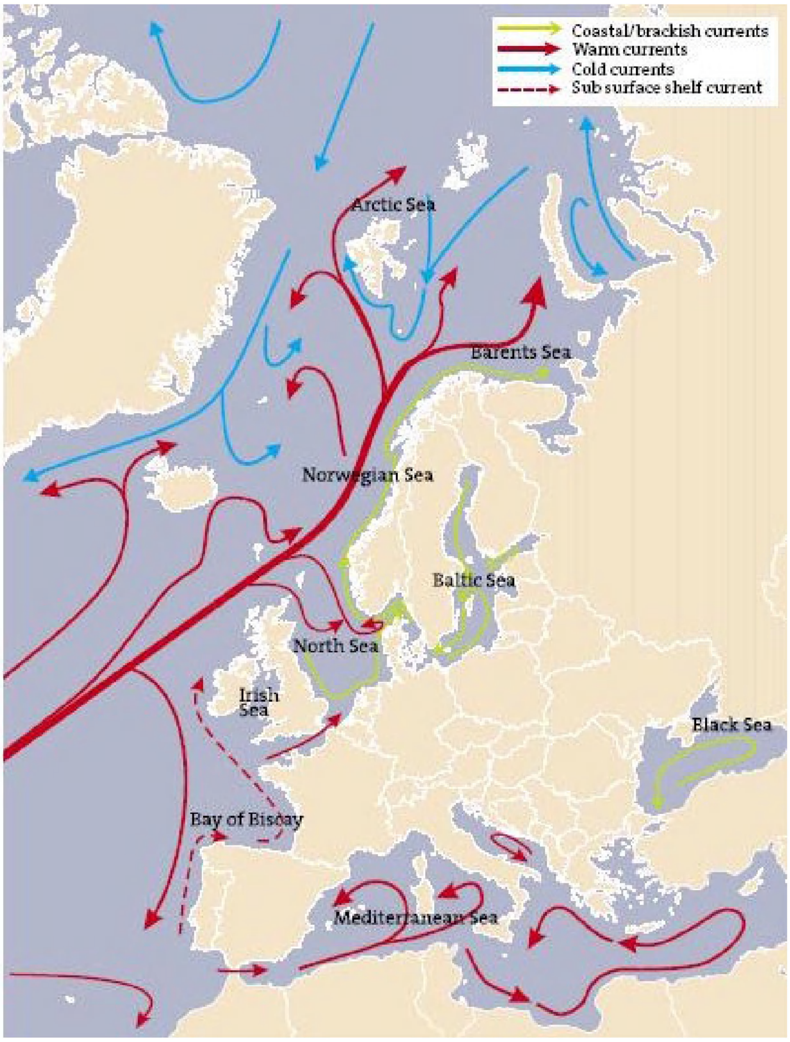

Figure 2.1.1 Water current systems in the Northeast Atlantic.

The topography is highly complex, but is best defined by a number of key features. These are the shelf areas, which are narrow with a steep drop off in the Iberian Peninsula, but broader to the north and often with reduced slopes into deep water, e.g. at Porcupine Bank, the Faroe-Shetland Channel, and Tampen Bank. The North Sea and the Baltic are distinct and environmentally separate parts of this shelf system. The North Sea links to the wider NE Atlantic via major inflows in the north and less importantly through the English Channel. In turn, the Baltic Sea ecosystem is dependent on a variable inflow of saline oxygenated water from the North Sea. To the west of the shelf break and north and west of Scotland across to Iceland there is a complex area of banks, ridges, and plateaus, e.g. Faroe, Rockall, and Iceland itself, representing a boundary between the Norwegian Sea basin to the north and the NE Atlantic basin to the south.

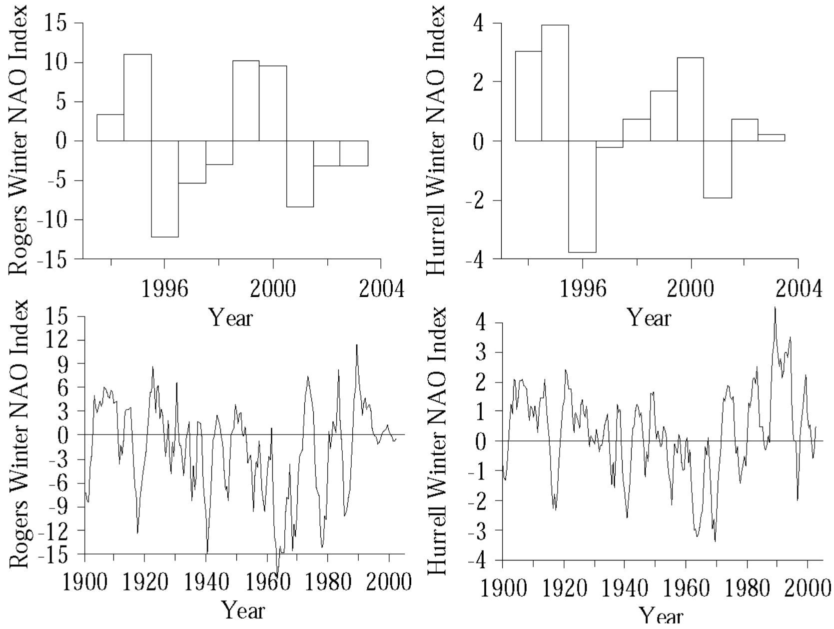

Figure 2.1.2 The winter NAO index for the last decade (top) and century (bottom). The Rogers Index (left) and the Hurrell Index (right).

The overall circulation pattern outlined above is modulated by short- and long-term climatic variability. The most studied of these is the North Atlantic Oscillation (NAO). When the NAO is in the positive index phase there is a strengthening of the Icelandic low and Azores high. This strengthening results in colder and drier conditions over the western North Atlantic and warmer and wetter conditions in the eastern North Atlantic. During a negative NAO index phase, a weakening of the Icelandic low and Azores high tends to reverse these effects. A high NAO index is believed to lead to a weakening of the warm North Atlantic Current and a stronger poleward current along the European shelf break, as well as stronger cold Labrador Sea water inflow. A low NAO index suggests a stronger North Atlantic current penetrating further into the Norwegian Sea and a weaker slope current.

In most areas of the North Atlantic during 2003, temperature and salinity in the upper layers remained higher than the long-term average, with new records set in several regions. In Biscay, sea surface temperature in summer 2003 was the warmest in the time-series (1993–2003). Values were 1ºC above the mean from June to October and the thermocline was shallow. In the Rockall Trough there were high surface temperatures and salinities, continuing a rise which began in 1995. Salinity values over the top 800 m were the highest on record, and corresponding temperatures were more than 0.5°C above the long-term average. Surface waters in the Faroe Shetland Channel continued the general warming trend observed over the last 20 years. Modified Atlantic Waters in the Faroe Shetland Channel were warmer and saltier in 2003 than at any period during the last 50 years. The sea surface temperature in 2003 was higher than normal over most of the Norwegian Sea. The distribution area of Atlantic water has decreased since the beginning of the 1980s, while the temperature has shown a steady increase. Since 1978 the temperature of Atlantic water has increased by about 0.6°C.

The area contains a number of widely distributed migratory stocks (mackerel, horse mackerel, blue whiting, Atlanto-Scandian herring, hake, and European eel). These mostly reside in the relatively warm waters in the eastern part of the North East Atlantic. The geographic distribution and properties of these water masses must therefore be important for the dynamics of these stocks. Probably the best-known factor impacting fish stocks is the abundance of zooplankton (particularly copepods). In broad terms the long-term Continuous Plankton Recorder database provides useful data. Long-term trends in the North East Atlantic show a general decline in zooplankton abundance and particularly of copepods (Heath *et al.*, 2000; Edwards *et al.*, 2004). An important consideration is that all life history stages of copepods are important for both adult and larval/juvenile fish. CPR records show that primary productivity in the North East Atlantic was consistent and restricted to the period April to November in the northern North East Atlantic. From the late 1990s, the period extended to March to November and intensified. Further south the productivity in the 1990s was greater than in previous decades, but diminished to some extent in the late 1990s. Seasonality was similar to the northern North East Atlantic (SAHFOS, 2003).

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2.2 Answers to Special Requests

2.2.1 EC DG Fish

2.2.1.1 Status of fish stocks managed by the Community in the Northeast Atlantic

The indicator chosen is the quantity of fish caught in 2003 that was taken from stocks grouped according to whether they were within or outside safe biological limits at the end of the year, i.e. 2004. In general terms, it is considered that a stock is within safe biological limits if its spawning stock biomass is above the value corresponding to a precautionary approach ($\mathbf{B}_{pa}$) advocated by ICES. Further details on the way ICES formulates advice in precautionary terms can be obtained from the ICES website http://www.ices.dk.

Basis for the calculation:

1) Source of data: 2004 ACFM report (spring and autumn).
2) Selection of stocks: all those for which ICES gives management advice and that are managed by the Community, autonomously or jointly with other partners. This excludes, for example, Arctic stocks managed by Norway or by Russia and Norway.
3) Catch data: taken as the total catch as estimated by ICES for assessment purposes. Sometimes this includes catch taken by third countries.
4) Criteria to judge stock status: If data exist, then a stock is considered within safe biological limits if its spawning stock biomass (SSB) estimated at the end of the year is higher than the SSB corresponding to the precautionary approach level, as recommended by ICES ($\mathbf{B}_{pa}$). Sometimes these estimates are missing, but ICES gives other types of indication:

    - Estimates of fishing mortality (F) in the terminal year and F levels corresponding to the precautionary approach or ($\mathbf{F}_{pa}$) or other desired levels of F serving as a guide for management. If F is higher than Fpa, then the stock is considered outside safe biological limits[1].
    - Estimates of catch per unit effort (U) and some desired level of U ($\mathbf{U}_{pa}$). For redfish this has been taken as half the maximum observed value. The reasoning goes on as for SSB[2]
    - If no warning signals are given by ICES in its advice, then it is assumed that the stock is within safe biological limits.
    - If ICES states, with no precise reference values, that the stock is outside safe biological limits, this is taken as a fact.

5) Type of fish: this is a classification intended to reflect both the biology of the species and the type of fishery realised. To some extent, this breakdown serves also purposes of economic analysis, since it brings together types of fish of comparable commercial value, although important differences still occur within each type. The possibility was examined to use prices per kg by species, but this part of the work is still going on. The difficulty is to obtain uniform price indices by stock.

    - Benthic: *Nephrops*, prawns, flatfish, anglerfish
    - Demersal: roundfish as cod, haddock, whiting, hake, etc.
    - Diadromous: salmon, sea trout (eel is classified in other category)
    - Pelagic: herring, anchovy, sardine, horse mackerel (North Sea and southern stocks), redfish
    - Industrial: sprat, sandeel, Norway pout
    - Widely distributed: blue whiting, western mackerel, western horse mackerel, eel, deepwater fish.

6) Region: The NEAFC regions, also defined in our technical measures legislation (Regulation 850/98). Essentially, Region 1 is ICES Subareas I, II, V, XII, and XIV, Region 2 is the Baltic, North Sea and western approaches (ICES Subareas III, IV, VI, and VII) and Region 3 is the Bay of Biscay and the Iberian peninsula (ICES Subareas VIII, IX, and X.

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[1] It should be noted that F values do not reflect the size of the stock in the precautionary context, but rather whether the stock is being exploited at precautionary levels. However, one may presume that in the long term, exploiting beyond precautionary levels will lead stocks outside biological limits.

[2] In this case, U does reflect the size of the stock and may be used as a proxy for SSB.

Results and discussion

The table below shows the values found for the whole set of stocks examined, broken down by region, type of fish and year. It should be noted that the precautionary reference points chosen ($\mathbf{B}_{pa}$ and $\mathbf{F}_{pa}$) are not management targets; they rather reflect a stock status that should trigger management action. In other words, maintaining a stock at $\mathbf{B}_{pa}$ values is not necessarily desirable or advisable.

Moreover, it should be noted that stock status as indicated by the relative values of SSB and $\mathbf{B}_{pa}$ cannot always be used to judge whether the stock is being exploited at a sustainable level. As an example, SSB2004 for blue whiting is above $\mathbf{B}_{pa}$, but the levels of exploitation in recent years are well above sustainable levels and will lead the stock to unsafe levels if no drastic management action is taken.

Table showing catch of stocks (managed by the Community) within and outside safe biological limits (SBL).

2004	2003 Catches	Within SBL		Outside SBL		TOTAL		
REGION	FISH TYPE	CATCH, ' 000 t	Dominant species	CATCH, ' 000 t	Dominant species	CATCH, ' 000 t	% within SBL(catch)	% outside SBL(catch)
1	Pelagic	922.44	Redfish Herring	0.00		922.44	100.00	0.00
2	Benthic	167.51	*Nephrops* Sole Flounder Pandalus	86.03	Plaice Anglerfish	253.54	66.07	33.93
2	Demersal	255.40	Haddock Saithe Whiting	210.59	Cod Whiting Hake	465.99	54.81	45.19
2	Diadromous	0.00		2.71	Salmon Sea trout	2.71	0.00	100.00
2	Industrial	492.52	Sprat	335.56	Sandeel Norway Pout	828.08	59.48	40.52
2	Pelagic	829.40	Herring (North Sea and Baltic) Horse mackerel	13.25	Herring VIa	842.65	98.43	1.57
2	All	1744.84		648.13		2392.96	72.92	27.08
3	Benthic	51.64	Megrim	11.79	Sole *Nephrops* Anglerfish	63.43	81.41	18.59
3	Demersal	0.00		47.40	Hake	47.40	0.00	100.00
3	Pelagic	122.67	Sardine Anchovy Horse mackerel	10.60	Anchovy Biscay	133.26	92.05	7.95
3	All	174.30		69.78		244.08	71.41	28.59
1,2 and 3	Pelagic	2553.35	Horse mackerel Blue whiting	617.33	Mackerel	3170.68	80.53	19.47
1,2 and 3	Demersal	0.00		145.84	Deep water fish	145.84	0.00	100.00
1,2 and 3	All	2553.35		763.17		3316.53	76.99	23.01
All	Benthic	219.15		97.81		316.96	69.14	30.86
	Demersal	255.40		403.83		659.23	38.74	61.26
	Diadromous	0.00		2.71		2.71	0.00	100.00
	Industrial	492.52		335.56		828.08	59.48	40.52
	Pelagic	4427.86		641.17		5069.03	87.35	12.65
All	All	5394.93		1481.08		6876.01	78.46	21.54

2.2.1.2 Interaction of common dolphins *Delphinus delphis* and fisheries in the Northeast Atlantic

Request

In a letter from the European Commission (DG for Fisheries and Maritime Affairs) ICES was requested to review all considerations concerning the interaction between common dolphin conservation and fisheries, in particular all available information on:

- the north-east Atlantic population(s) (or possibly sub-populations) including size, status and trends;
- the by-catch in fisheries (by fishing fleet, gear type, overall amount of by-catch, rate of by-catch and overall fishing effort);
- possible mitigation measures and advice, including level of priority.

The European Commission further requested that the above information could be disaggregated to area as appropriate, depending on the distribution of common dolphin population(s) and the dispersal of the fisheries.

Response

This response is based on a review carried out by the ICES Working Group on Marine Mammal Ecology in May 2005 (ICES 2005/ACE:05).

Advice

In order to understand the population level effects of by-catch, it is necessary to know the size and status of the common dolphin population and to estimate the contribution of by-catch mortality to total mortality. The following summary sections review these features and other relevant information as well as describing possible by-catch mitigation methods. A prioritised list of further information and mitigation measures is provided. Further information to support this Advice can be found in a section detailing background information.

The Northeast Atlantic population of the common dolphin

Population division

Studies of common dolphins in the Northeast Atlantic have shown that individuals from north Scotland to the Straits of Gibraltar (and maybe further), and at least as far west as 25°W are not genetically distinct and belong to a single population. However, the genetic markers investigated are not capable of identifying sub-populations with low rates of mixing. There is evidence of reproductive isolation of female common dolphins off Portugal compared with dolphins further north in their north-east Atlantic range, and of some mixing between the populations in the western Mediterranean and in the adjacent north-east Atlantic. In addition, cadmium levels may indicate a separation between animals feeding predominantly on the continental shelf and those feeding further offshore in deeper oceanic waters, indicating that a sub-population structure may exist among north-east Atlantic common dolphins. Without further research, it is not possible to conclude whether (or not) by-catch is causing differential impact on any possible sub-units.

Abundance and movements

Abundance estimates have been made for various sections within the distribution range. Although these surveys have not been simultaneous and partly overlap, the survey results suggest that around 500 000 common dolphins are present. There is no information on trends in total abundance. There is evidence of a northwards range extension as common dolphins have become more abundant off northern Scotland in recent years compared to two decades ago. There is evidence that common dolphins move into the western English Channel during winter, although the scale of this movement may vary between years. Observational evidence suggests that these animals are moving from offshore oceanic waters.

Life history

There is incomplete information on the life history of common dolphins and evidence of differences in distribution between various age/gender groups. There are some distinct differences in the distribution of the two genders and of age classes in the north-east Atlantic and some apparent differences in susceptibility to capture in fishing nets. This information may be important in deducing the overall effect of any extra anthropogenic mortality on the population. A number of life history traits of common dolphins in the north-east Atlantic may contribute to the vulnerability of the species to anthropogenic mortality in this area – these being a late maturity, a low pregnancy rate and an approximate lifetime reproductive output of four calves per female.

Strandings

National schemes to record strandings exist along the entire Atlantic seaboard, though some schemes are more comprehensive than others. Stranded animals often show evidence of having been caught in fishing gear. In general the annual number of common dolphin strandings per year has increased in all areas over the past decade, but the proportion of individuals showing evidence of by-catch injuries has not increased consistently. The increase in strandings could be due to a number of factors, including increase in population size and changes in the dolphin's distribution. The inconsistent changes in evidence of by-catch indicate that the increase in strandings is unlikely to be caused by an increase in fishing effort by gears liable to catch these dolphins.

In many areas there is a mid- to late winter peak in strandings. There is considerable inter-annual variation in numbers stranded, with peaks in the numbers stranded often occurring during periods when onshore winds are more prevalent. Whether this is due to interannual variation in distribution, higher mortality in these years, or just a higher proportion of dead animals arriving ashore is not known.

Diet

Many fish and cephalopod species have been recorded in the diet of common dolphins. When dolphins are feeding inshore, the diet is dominated by small pelagic fish species. Some of these species are fished commercially (e.g. sardines and blue whiting off the Iberian Peninsula). Deepwater species (e.g. lancet fish *Notoscopelus kroeyeri* and some squid) that are consumed in the offshore habitat are not commercially important. A greater understanding of the causes underlying prey distribution and its variability might aid in identifying areas where interactions between dolphins and fisheries occur.

Common dolphin by-catch in fisheries

Reports of by-catch of common dolphins in fisheries in the north-east Atlantic stretch back over several decades, but only since the 1990s have large numbers of dead dolphins that had evidently died in fishing gear arrived on beaches.

Two types of fishery are considered to pose a particular threat to common dolphins – pelagic trawls and bottom-set nets. Pelagic drift nets and the setting of purse seine nets on dolphins were formerly a threat, but both are now prohibited.

The pelagic trawl fisheries in the north-east Atlantic are complex and varied, with over twelve species targeted by vessels from six EU member states (with maybe further non-EU nations operating in international waters) using at least three major gear types. An even greater complexity applies to the bottom-set net fisheries. Some of these fisheries have relatively low or non-existent cetacean by-catches, others apparently have relatively high by-catches (e.g. the fishery for hake/pollock). For most fisheries, however, there is insufficient information to assess total cetacean by-catch at present. The difference in the age and gender composition of common dolphins caught in the UK bass pair-trawl fishery and those stranded, and the seasonal pattern and location in the fishing effort since 2001, suggests that this fishery is not responsible for most of the strandings with evidence of by-catch. Logically, this suggests that other fisheries operating in the same area are responsible.

As previously made clear by ICES and others, the only reliable way of assessing by-catches in fisheries is to gather data using fisher-independent observers (or observation methods). Various schemes to monitor by-catches (both as required under EU Regulation 812/2004 and otherwise) are under way, but it is not clear yet to ICES how comprehensive or representative these schemes will be.

EU Regulation 812/2004 requires monitoring on EU pelagic trawl vessels within EU waters, and for those areas of ICES Areas VII, VIII and IX in international waters within range of the common dolphin in the north-east Atlantic. As noted above, the range of the common dolphin extends west of these areas into at least parts of ICES Areas X and XII. It would be useful to know the scale of EU and non-EU pelagic trawl fishing in these areas to be able to determine the importance of monitoring by-catch in these areas.

EU Regulation 812/2004 requires monitoring of bottom-set gillnet fisheries in the majority of the range of common dolphins in EU continental shelf seas in the north-east Atlantic. The maximum depth recorded for common dolphin dives is 280 m, so the limitation to continental shelf seas will therefore probably cover most relevant fisheries. There may be some relevant fisheries in ICES Areas VIIb, c and k that require monitoring. Knowledge of the scale of any bottom-set gill net fisheries in these areas is needed to determine the priority for monitoring. The requirement for representative monitoring is not as rigorous for fisheries by vessels under 15 m in length as for vessels over this length; this may prove problematic in future attempts to estimate total fisheries by-catch.

In due course, it will be necessary to check whether observation efforts cover all fisheries in a representative and consistent manner. This will require analysis of the activities of the fisheries and observations in space and time, which will require access to international Vessel Monitoring System (VMS) data for all relevant fisheries, and compiled national data for smaller vessels not monitored with VMS.

There is considerable variability in estimated total by-catch in fisheries for which several years of data are available. This implies that there are dangers in taking (or not taking) measures based on only one or two years of by-catch data and that observation will need to continue in several fisheries where programmes appear to have finished.

Mitigation measures and further requirements

As noted above, the common dolphin population in the north-east Atlantic is estimated to be approximately 500 000 individuals. ICES has previously (in 2001) advised that a by-catch of greater than 1.7% of the harbour porpoise population per year would be unsustainable. Harbour porpoise and common dolphin have similar life histories, so until data are available for common dolphin, this figure is the best scientific information available for use with common dolphins as well. Using this value produced an estimate of unsustainable anthropogenic mortality of 8500 common dolphins per year. Data on the by-catch are not sufficient to indicate whether the annual by-catch mortality exceeds this figure. While this annual mortality has not been observed or suspected in a single fishery, it could occur across all fisheries combined.

Regardless of the total by-catch mortality, measures to mitigate or prevent by-catch would be consistent with a precautionary approach. ICES identifies the following mitigation measures and further requirements. ICES notes that many of these measures and further requirements may improve understanding of the interaction of other cetacean species and fisheries.

Quantification of by-catch by the use of fisher-independent observers

This is an essential first step in identifying when, where, and on what scale by-catch is occurring. Without such information, it is not possible to target measures appropriately. As noted above, monitoring should be, now or in the near future, conducted on most relevant pelagic trawl and bottom-set gill nets in the range of the common dolphin in the north-east Atlantic. The type and amount of monitoring required varies by fishery. There is a risk that monitoring in fisheries by vessels of less than 15 m in length may not be adequate. ICES recommends that adequate monitoring of by-catch occurs in these fleets. In due course it will be necessary to check the representativeness of all by-catch observations in relevant fleets. ICES will be able to help in this check, but this will require access to international VMS data for all vessels operating in all relevant fisheries at all times, as well as national data on effort in vessels/fleets that are not subject to VMS regulations.

Mitigation in pelagic trawls

Two broad approaches to reduce by-catch in pelagic trawls are currently being tested, partly using EU funds. These are physical solutions (ropes, panels, grids) and acoustic deterrents. Different or combined systems may need to be used eventually, depending on the target fish species.

At this stage of testing, a grid system seems promising and appears to work in the bass fisheries. An acoustic deterrent system that aims to prevent entry of dolphins into a trawl has been designed and the system will now be tested at sea, eventually on a commercial trawler. Tests of further systems, both of potential physical and acoustic devices, are underway.

ICES encourages further testing of these mitigation devices and could review progress in 2006 with a view to advising on implementation in relevant fisheries.

Mitigation in bottom-set nets

In fixed-net fisheries, pingers can reduce the by-catch of harbour porpoises. However, for dolphins, acoustic deterrents give inconsistent results. During some tests, the deterrents appear to work, whereas in others they appear to fail. The reasons for this are not fully known but it is suspected that the effects will depend on:

- the cetacean species involved in the interaction with fisheries,
- the fish species (prey or not) present in the nets,
- the acoustics characteristics of signals used,
- the physical characteristics and quality of pingers, linked for some of the pingers to the operational conditions in the fishery (some pingers break, depending on the shooting and hauling speed, on the shape of vessels and on the hauling equipment).

Studies of the efficiency of pingers are (or will be) conducted at a national level under EU Regulation 812/2004. ICES notes that international coordination of such studies would benefit both scientific efforts in field experiments and avoid duplication. ICES would be pleased to contribute to such coordination. There have been concerns that the deterrent effect may exclude cetaceans from areas of important habitat. ICES advises that this is not proven on a biologically meaningful scale. ICES encourages further development of acoustic deterrent devices to reduce dolphin by-catch.

Education of fishers

The alerting of fishers to the existence of a by-catch problem often appears to modify their behaviour and lead to a reduction in by-catch. Given the need to gain the cooperation of fishers in any by-catch mitigation initiative, ICES recommends the introduction of schemes to inform and involve fishers in by-catch reduction issues.

Increase understanding in abundance of common dolphins and variation in their distribution

Knowledge of abundance of common dolphins in the north-east Atlantic is somewhat fragmentary, but is needed to place any anthropogenic mortality in a population perspective. The 2005 SCANS II survey of continental shelf waters of the north-east Atlantic will provide a new abundance estimate for these waters. However, it is obvious that large numbers of common dolphins occur also in deeper offshore waters. If by-catches are to be placed in a current population context, then it is important that an offshore abundance survey is also conducted in the next two or three years (to ensure temporal compatibility).

If there was greater understanding of why common dolphins were present in certain areas and an understanding of the differences in distribution between genders, then it might be possible to better target some of the mitigation techniques. Remote tracking devices may be particularly useful. These studies will need to continue in the longer term due, for instance, to the effects of climate change.

Population structure

The significance of a given number of dolphins killed as by-catch depends on the size of the dolphin population impacted. If there is sub-structure in the population in the wider north-east Atlantic, then different numbers killed as by-catch may have a greater impact on some subpopulations than others. Further studies to determine whether or not there might be population structure, the abundance of any subpopulations and improved knowledge of movements would help to interpret the regional significance of by-catch mortality.

Spatio-temporal measures

Measures to limit fisheries when dolphins are present (both spatially and temporally) may seem a logical and simple way to reduce by-catch in some fisheries. However, for such measures to work there needs to be a good understanding of the by-catch phenomena and of the factors inducing its variation (e.g. location and timing of fisheries). In the absence of such understanding, care should be taken when moving fishing effort from one area to another because the results may prove to be the opposite of that intended.

ICES considers that, with the present knowledge, there are no obvious areas or times in the north-east Atlantic where fishery closures should be proposed to mitigate common dolphin by-catch.

2.2.2 EC DG Environment

2.2.2.1 Scientific information concerning impact of sonar activities on cetacean populations and fish

The European Commission, DG Environment has requested ICES:

"to undertake a scientific review and evaluation of all relevant information concerning the impact of sonar on cetaceans and fish, to identify the gaps in current understanding and to make recommendations for future investigations/research. The Commission would also be interested in advice on possible mitigation measures to reduce or minimise the impact of sonar on cetaceans and fish."

ICES has commissioned an Ad hoc group to compile the relevant information in the 2004 report of the Ad hoc Group on the Impact of Sonar on Cetaceans and Fish (AGISC) (ICES CM 2005/ACE:06).

Scientific review and evaluation of relevant information concerning the impact of sonar on cetaceans

The full effects of sonar on cetaceans are not well known, mostly due to the difficulty of studying the interaction.

The review described a range of sonars that use a range of frequencies and intensities. There is no evidence of harm for sound sources other than high-intensity (>215dB) mid-frequency (1 – 10 kHz) sonar. The use of this sonar has led to the deaths of a number of cetaceans in some places. All incidents that have been investigated have occurred in the North Atlantic or Mediterranean and have related to the use of military sonar. Other stranding incidents have occurred in these and other seas, but their cause is not clear. From relatively limited knowledge, it appears that beaked whales are the most affected species, in particular Cuvier's beaked whale *Ziphius cavirostris*. It is not known whether this species is particularly sensitive or just the most often exposed to the sound. A characteristic of most of the known mortality incidents is that they have been on (or just off) shores near to the shelf break and deep water habitat favoured by these species. It is unclear therefore if further undetected mortality is occurring where the shelf break is further offshore. The precise mechanism causing the animals to beach themselves is unknown – many arrive ashore alive, but obviously distressed. The most consistent deduction from the evidence is that behavioural alteration is more important than the direct effect of the sound on hearing mechanisms. It is unknown how many animals that are affected further out to sea can survive and not strand. Little is known of the sub-lethal effects of sonar on beaked whales or on other cetacean species. The possibilities and consequences of these effects are summarised in Table 1.

Table 1. Summary of likely effects of sonar on beaked whales

Type of effect	Extent of effect	Severity of effect	Individuals affected	State of knowledge
Direct death and lethal injury	Very local	Severe	Few/none	Adequate for current purposes
Gas embolism	Medium scale	Severe	Small numbers?	Moderate
Sublethal injury	Medium scale	Unknown	Small numbers?	Poor
Behavioural (avoidance)	Widescale	Mild/long term	Large numbers	Poor

There have been globally about 40 scientifically-verifiable sonar-related deaths among cetaceans (mostly, if not all, beaked whales) over the last 9 years. A recent IWC report indicates that worldwide, fisheries kill several hundred thousand cetaceans as bycatch each year. We do not know of the scale of beaked whale bycatches but 35 fishery-related beaked whale mortalities were observed in the pelagic drift gillnet fishery off the east coast of the USA between 1989 and 1995 and between 1991 and 1995 the total average estimated annual fishery-related mortality of beaked whales in the U.S. EEZ was 9.7 (CV = 0.08). Even accepting that some beaked whales affected by sonar may die uncounted at sea, nevertheless it seems likely that the fishery-related mortality of beaked whales alone is several times higher than that caused by sonar.

Scientific review and evaluation of relevant information concerning the impact of sonar on fish

The full effects of sonar on fish are poorly known, mostly due to the lack of study. In the studies that have been conducted, effects of sonar have been noted at the individual level. However, these studies have focussed on a few species and it is not known whether their responses are representative of the wide diversity of other marine fish species. Based on the limited information currently available, wide-ranging species of fish of commercial importance are unlikely to be affected at the population level with current rates of usage (and areas of usage) of military sonar. Other sonars (and noise sources) are more widespread, but their effects are not known.

Gaps in current understanding and recommendations for future investigations or research on cetaceans

1. There is insufficient knowledge in European waters of the location and habitats of beaked whales. More reliable information on this topic would enable those wishing to use high intensity sound to avoid those areas. A survey of all shelf-break and adjacent deep-water waters of Europe is required, as is the collation of all current records. Habitat modelling may also improve predictability of beaked whale distribution and help identify critical habitat.
2. Techniques to detect beaked whales more reliably need to be developed with acoustic monitoring, and possibly high-resolution satellite monitoring being promising options for the future.
3. Increased research into the sound transmission properties in the waters near the shelf break may aid in choosing areas to avoid the use of high-intensity sonar.
4. Further research is needed on the apparently non-auditory responses of deep-diving marine mammals to low- and mid-frequency sonars. This could be aimed particularly at trying to understand the sphere of influence of sonar noise on cetaceans. Understanding the mechanisms behind the apparent formation of bubbles in body tissue might help in understanding the causes of death of beaked whales.

It is beyond the remit and the competence of ICES, as an organisation, to make any recommendations concerning the military use of sonar.

Thus, in order for DG Environment to reach a balanced judgement between the requirements for use of high intensity mid-frequency sonar and the need to protect beaked whales, DG Environment should consider commissioning a specialist review and evaluation of the military use of sonar in European waters.

Gaps in current understanding and recommendations for future investigations or research on fish

There are insufficient data on the effects of exposure to sound, let alone sonar, for the vast majority of fishes, and there is a great diversity of ear structures, hearing capabilities, and/or acoustic behaviours among fish. The literature on the detection of, and response to, sound are limited and the data on vulnerability to injury are almost totally non-existent, only relevant to particular species, and because of the great diversity of fishes are not easily extrapolated. The major differences in anatomy between fish may affect the degree of injury to fish from high intensity sounds or sonar.

1. As well as a need for information on the hearing thresholds for a range of fish species, information is also required on temporary and permanent hearing loss associated with exposure to sounds. The use of sounds during spawning by some fish, and their potential vulnerability to masking by anthropogenic sound sources, requires investigation.
2. The effects of sound may not only be species specific, but depend on the mass of the fish (especially where any injuries are being considered) and life history phase (eggs and larvae may be more or less vulnerable to exposure than adult fish.)
3. No studies have investigated effects of cumulative exposure of fish to any type of sound. Moreover, no studies have carefully examined effects on fishes that are distant from the source, or have considered whether there are subtle and long-term effects on behaviour or physiology that could have an impact upon survival of fish populations.
4. It is important to note that some fish are sensitive to the particle motion component of sound rather than the sound pressure. Even in fish that are sensitive to sound pressure the particle motion may be important for discriminating sounds from different directions. In determining the sensitivity of fish to sounds and the impact of sounds upon fish it is important to express the sound levels in terms of particle velocity or intensity as well as sound pressure. Different signal parameters (e.g. bandwidth, duration, temporal variation) are also important. Producing a controllable particle motion signal in a small tank is extremely difficult and care must be taken to choose a suitable acoustic environment.

Possible mitigation measures to reduce or minimise the impact of sonar on cetaceans

As described above, the only major effect noted on cetaceans from sonar comes from high intensity mid frequency military sources. This section therefore focuses on this usage, though the principles may be extended more widely.
In order for mitigation to be considered, it is necessary to know

1. the species that might be present,
2. their sensitivity to the noise and hence the area that might be affected;
3. the population density, such that the number of individuals that might be in this affected area can be calculated, and

4. the significance of the effect, or the risk of that effect, on those individuals or their stock.

If the environmental consequences are deemed too great, then use must be made of suitable mitigation measures to reduce the impact to an acceptable level. Note that decisions on whether or not an environmental consequence is too great are societal choices rather than a scientific fact. Examples where the effects of noise might not be acceptable include:

1. where species are displaced away from a significant proportion of their feeding grounds;
2. where the species are endangered species, and management is required to apply particularly risk-averse measures;
3. where the noise is in confined waters, on a migratory route, and is of sufficient duration that a significant proportion of a migratory period would be blocked;
4. where the noise has an economic impact, as for instance if whales were displaced from a whale watching area.

In many cases the noise may cause an effect which is of no environmental significance. For instance, a behavioural effect in which cetaceans are simply displaced from the area of the sonar operation to another area of similar habitat for a limited period may well be unimportant.

It is difficult to comment on the practicality of mitigation possibilities without considering military requirements for high intensity low- and mid-frequency sonar, upon which ICES is not qualified to comment. From first principles though, there are three obvious mitigation possibilities, a) limit overall use, b) limit area of use and c) limit season of use. It is assumed that it would not be possible to reduce the source level, as it seems unlikely that this would not be as high as it is unless such power was needed for operational reasons.

Limits on overall use would reduce risk to cetaceans, while limiting the area of use away from those known or thought to be important to beaked whales may be the most efficient way of reducing risk. The difficulty with this is that our knowledge of beaked whale biology and habitat needs is still fairly rudimentary and this species is comparatively difficult to detect in the wild. Acoustic detection may present a way forward, but even here, there is little knowledge of the acoustic behaviour of beaked whales. The calls of Cuvier's beaked whales have been recorded four times. While the three recordings in the presence of Cuvier's beaked whale suggested that they may produce both whistles and pulsed sounds, one identified the vocalizing whale using an acoustic recording tag, and these data only recorded clicks with peak frequencies in the 40-50 kHz range, and little energy in the frequencies humans can hear. Whether these could be specifically separated from the other cetacean species is not known. Cuvier's beaked whales may not click at depths less than 450 m, and they may therefore be more difficult to record at the surface than at depth. One recent solution for this problem would be to use autonomous submersible vehicles to 'sweep' an area, listening for beaked whales, for a period prior to the use of high intensity sonar. Plainly there is an area for great research and development here.

The aim of mitigation is to control and minimise environmental impact, and comprises control of noise at source, mitigation by use of engineering and other methods, and monitoring.

Control at source

Of key importance is the use of the minimum source power to achieve an adequate resolution or range. Mitigation can take the form of reducing the total amount of sound produced, possibly by reducing power, duration and/or by reducing the number of times a system is transmits sound. Where the species of concern has a well-defined hearing sensitivity, it may be possible to operate at frequencies where the animal's hearing is relatively insensitive. We do not know the characteristic(s) of the mid frequency sonar that causes problems for beaked whales – determination of the characteristic(s) and of its precise effect on beaked whales might help in enabling a sonar to be designed that does not affect beaked whales.

Mitigation of death and injury caused by the direct effects of sound

The range at which death or injury due to the direct effect of sound levels (as opposed to behavioural alteration that may lead to death) can occur is limited. Hence the likelihood of a marine mammal straying into the area prior to the commencement of a sonar transmission is relatively low unless there is a large degree of overlap between important or critical beaked whale habitat and areas of sonar usage. Since the range of the effect is small, there are several mitigation measures that might be effective in preventing injury through the direct effects of sound. A first mitigation measure might therefore be to avoid areas of known beaked whale abundance. Second, it might be possible to regulate the use of sound if marine mammals are detected close to the source. Such detection could occur in two main ways:

Marine Mammal Observers (MMOs) MMOs are trained observers who aim to visually detect and identify marine mammals, at distances of up to 500 m during daylight hours. Their use is mandatory during UK and some other nation's offshore seismic surveys. It may be possible to watch for whales prior to commencing sonar operation and not start transmitting sound if whales are seen or to cease operations if whales enter the area during transmission. However, beaked whales in particular are very difficult to detect and spend a long time under water; in addition the approach does not work in poor visibility or at night. The efficiency of this mitigation measure is low under many conditions likely to be encountered in naval sonar operation.

Passive Acoustic Monitoring (PAM) or Active Acoustic Monitoring (AAM) Both passive and active acoustic monitoring may be used to detect marine mammals. Passive acoustic monitoring is the term used for listening passively to sources of sound, while active acoustic monitoring is the term used for producing sounds and listening for echoes from nearby objects. Active acoustic monitoring is thus a form of sonar and offers several potential advantages compared to passive. Unlike passive acoustic monitoring, which can only detect animals when they vocalize, active acoustic monitoring can detect non-vocalizing animals such as marine mammals or fish. Active acoustic monitoring can estimate the range of targets more easily than can passive monitoring. In spite of these advantages, active acoustic monitoring is relatively undeveloped compared to passive acoustic monitoring for detecting marine mammals. Both systems might be installed on remotely operated or autonomous vehicles to provide a sweep of a wider area or a longer time period than would be possible from one ship at one time.

Passive or active acoustic monitoring offers one way that a wider area might be surveyed for beaked whales. If the lethal effects observed in beaked whales are due to behavioural alteration caused by sound and not to the direct effects of the sound, then such wider area surveys are needed if sonar deployment is to be avoided near beaked whales. This though would be challenging to accomplish, as little is known of beaked whale vocalisations and suitable technology has yet to be developed.

Other control methods

Two other measures can be taken that would reduce the risk of exposure of marine mammals to loud sound (though as noted earlier, not necessarily risk to behavioural change):

Scheduling Sonar transmissions may be timed for periods when the species are not in the area, for instance by avoiding migratory periods or periods where local breeding or calf-rearing grounds are used. However, as noted in earlier sections, this information is largely absent for beaked whales, so it is difficult to apply this measure without further research on the use that beaked whales make of certain areas of the sea.

Warning signals. It has been suggested that warning signals for marine mammals could be developed – these are sounds that would make marine mammals move away from dangers such as explosions, fast ships, or intense sound sources such as sonars. There has been little development and testing of warning signals, but it is known that even though right whales do not respond to vessel noise, they do show strong responses to signals designed to alert them. In the absence of information on what sounds cause avoidance reactions, regulators have required some intense sound sources (seismic sources) to be increased in level slowly. In principle, such a 'soft start' might offer animals a chance to move out of the danger zone, but this seemingly reasonable technique is unproven. Soft start should be viewed as a type of warning signal, one selected because the sound source is already there, not because it is necessarily effective. In most cases, it is more likely that warning signals specially designed to elicit the appropriate avoidance safely would be more successful than soft start. Since it is not known what levels of sonar sounds are safe for beaked whales, warning signals other than sonar sounds would likely pose less risk as well. Nothing is known about behaviours at lower sonar power levels, or in response to sounds other than mid-frequency sonar. In other situations (e.g. salmon farms), noise is used to deter marine mammals and it might be that suitable noises exist that could achieve this for beaked whales. There may be value in studying sounds that might elicit avoidance responses in beaked whales that do not pose the risks of sonars.

Monitoring

It is plain that much still needs to be learned about the interaction of marine mammals and sonar. Knowledge can be gained and potential mitigation measures identified through good observation and monitoring. Monitoring can include:

Noise monitoring Anthropogenic noise levels may usefully be recorded in order to be matched against any behavioural reactions by cetaceans. Such recordings also enable the sonar to be ranked against other local sources of noise.

Marine mammal observation The monitoring of local cetaceans would help confirm whether there is any obvious effect of the noise. Monitoring the distribution of individuals around the noise source can be by tagging, by using passive acoustic monitoring to detect vocalisation, or by using active acoustic monitoring.

The latter monitoring strategies may serve two purposes, either of demonstrating that there is an effect, or, if an effect is observed, of identifying the level at which it occurs. While it may be argued that the monitoring itself has an effect on the species, this effect may be outweighed by the process providing information which may be used in the longer term to conserve stocks of the species. It should be noted that no monitoring program can demonstrate that there is no effect, for the range of potential effects is large, and many effects would be too subtle for a generic monitoring program to detect. A more scientific approach would test for specific hypotheses about effects, with experiments designed with strong statistical power.

Possible mitigation measures to reduce or minimise the impact of sonar on fish

Given that there is little evidence of effects of sonar on fish, it is difficult to propose mitigation measures to reduce effects. If there is concern that sonar may be having effects, then the obvious measure would be to disassociate any sonar use from areas known to contain concentrations of fish believed to be at risk.

2.2.2.2 Information and advice about appropriate eco-regions for the implementation of an ecosystem approach in European waters

Summary

This report provides information and advice on eco-regions for the implementation of an ecosystem approach in European waters. A review of existing biogeographical and management regions against a series of evaluation criteria demonstrated that no existing regions could be adopted as eco-regions. Thus eco-regions are proposed based on biogeographic and oceanographic features, taking account of existing political, social, economic and management divisions.

Eleven eco-regions are proposed (Figure 1):

- Greenland and Iceland Seas (A)
- Barents Sea (B)
- Faroes (C)
- Norwegian Sea (D)
- Celtic Seas (E)
- North Sea (F)
- South European Atlantic Shelf (G)
- Western Mediterranean Sea (H)
- Adriatic-Ionian Seas (I)
- Aegean-Levantine Seas (J)
- Oceanic northeast Atlantic (K)

Although the group were not asked to provide specific advice for the Baltic Sea and Black Sea, it was noted that the Baltic Sea should be treated as one eco-region and the Black Sea as one eco-region, if these eco-regions are to be consistent with others. This would result in a total of 13 eco-regions.

The group did not decide whether the western Channel (ICES area VIIe) should be placed within the Celtic Seas or North Sea. Biogeographic considerations favour inclusion of the western Channel in the Celtic Seas, while management and policy considerations favour inclusion of the western Channel in the North Sea. Further consultation would be needed to resolve the status of the western Channel.

It was considered desirable to include (1) areas under the jurisdiction of Spain around the Canary Islands and (2) the area under the jurisdiction of Portugal around Madeira (which overlaps slightly with the OSPAR maritime area) in an eco-region. It is proposed that these waters should be included in the same eco-region as the Azores (Oceanic northeast Atlantic).

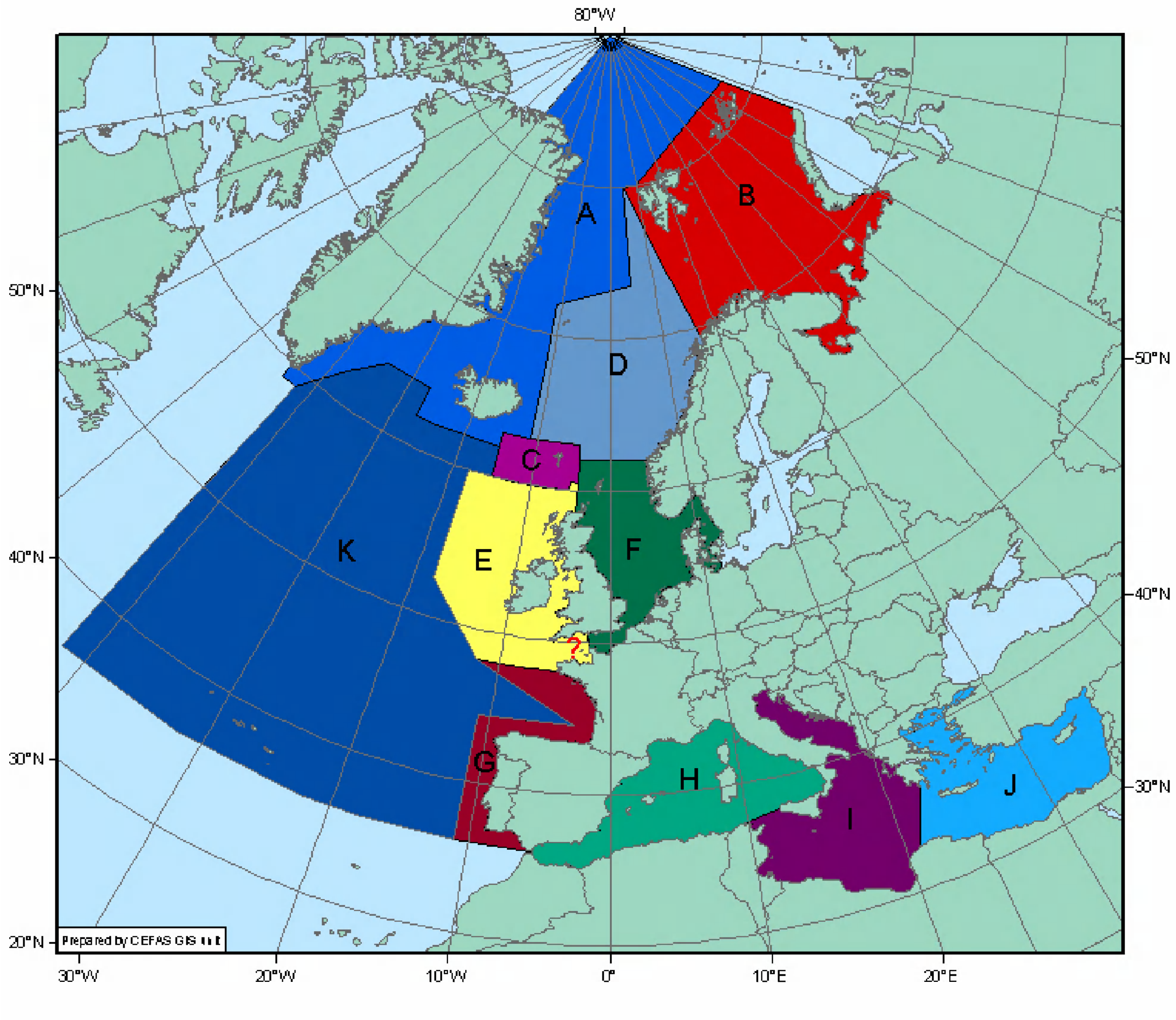

Figure 1 Proposed eco-regions for the implementation of the ecosystem approach in European waters. The eco-regions are Greenland and Iceland Seas (A), Barents Sea (B), Faroes (C), Norwegian Sea (D), Celtic Seas (E), North Sea (F), South European Atlantic Shelf (G), Western Mediterranean Sea (H), Adriatic-Ionian Seas (I), Aegean-Levantine Seas (J) and Oceanic northeast Atlantic (K). Equidistant azimuthal projection. The question mark denotes the western Channel (ICES Area VIIe), which could be placed in either the Celtic Sea or North Sea eco-region.

Request

Within the framework of the existing Memorandum of Understanding between the European Commission and ICES, ICES was asked to provide information and advice about appropriate eco-regions for the implementation of an ecosystem approach in European waters, preferably in advance of the Rotterdam Stakeholder Conference 10-12 November 2004 but not later then by the end of 2004. The European Commission submitted the following request.

'Request of scientific information and advice about appropriate eco-regions for the implementation of an ecosystem approach in European waters'

'The Marine strategy will be implemented at many levels, ranging from local to pan-European. This leads to the need to identify individual regional areas for which ecological objectives are to be defined. Ecosystem boundaries are typically based on biological and physical processes. The boundaries of these eco-regions should therefore be based on biogeographic and oceanographic features, taking account of existing political, social, economic and management divisions. By doing so, eco-regions should be characterised by greater similarity in biogeographic and oceanographic characteristics among sites within the same eco-regions. It is envisaged that the eco-regions could be subdivided in sub-regions as appropriate.

Appropriate biogeographic characteristics may be the composition of faunal communities and patterns of primary production. Appropriate oceanographic characteristics may be depths, basin morphology, tidal and ocean currents, temperature or degree of seasonal stratification. Identification of eco-regions should also take account of the links between the marine and terrestrial environment, including patterns of land use and distribution and density of human populations.

Boundaries between eco-regions should be defined unambiguously to guide research, objective-setting, assessment, monitoring and enforcement and should take account of the jurisdiction of existing management authorities and areas for sectoral activities, and utilise existing boundaries where they meet the wider criteria for boundary selection.

There are several existing divisions of the marine areas into regions such as those to be found in the CFP, Marine Conventions, Large Marine Ecosystem, Biogeographical regions used by EEA, WFD etc.

In the light of the above, we would like to request ICES, within the framework of the existing Memorandum of Understanding between the Commission and ICES, to undertake a scientific review and evaluation of all relevant information concerning the above mentioned classification in regions. The work should focus on the how the above criterions have been applied and which classification offers the best starting point for the identification of eco-regions. In the event that the analysis suggest that a new system are needed ICES is requested to provide recommendation on such or alternatively on how this could be achieved.'

ICES convened a meeting of experts to provide a response to this request at ICES HQ Copenhagen 19-21 October 2004. Participants are listed in Annex 1.

Geographical scope of study

The documents on the development of the European Marine Strategy draw a distinction between the European seas and the rest of the world's seas, but they have not specified precisely what parts of the sea would be covered as the "European seas".

In responding to the EC request, it was assumed that the areas to be covered are the maritime areas of the Barcelona, Bucharest, Helsinki and OSPAR Conventions - that is, the Atlantic Ocean west of a line from the south of Greenland, north of a line drawn west from the straits of Gibraltar, and east as far as longitude 51° East, to include the Baltic Sea, the Black Sea and the Mediterranean Sea (Annex 2).

In addition to these maritime areas, it was considered desirable to include areas under the jurisdiction of Spain around the Canary Islands and the area under the jurisdiction of Portugal around Madeira (which overlaps slightly with the OSPAR maritime area). The waters surrounding these islands share the same characteristics as the nearest parts of the OSPAR maritime area and form part of the economic and social systems of Europe

The whole of the island of Greenland has the status of an Overseas Country and Territory under the EC Treaty. However, the waters on its western coast cannot be managed sensibly without taking account of the concerns of Canada. This takes them into a framework different from that for European waters. The waters west of Greenland were therefore not considered further in this study.

No consideration was given to the waters adjoining non-European constituent parts of EU Member States. The management issues for which eco-regions are being identified would require such waters to be considered in the context of their local global region and not in the context of European waters. On the same basis, no consideration was given to Arctic marine eco-regions east of the Barents Sea (that is, east of 51° East), even though they may adjoin European parts of the Russian Federation.

In the landward direction, the response is based upon the recognition that the OSPAR Convention includes not only the territorial seas and exclusive economic zones (or equivalent jurisdictions) of the Contracting Parties and the relevant parts of the high seas, but also the internal waters of Contracting Parties as far as the freshwater limit. The situation is less clear in relation to the other regional seas conventions, but it seems sensible that, for the EU and EEA Member States, the definitions of the eco-regions should fit together with the areas delimited for the purposes of the EC Water Framework Directive[1]. The response to the request therefore assumes that the landward boundaries of the proposed eco-regions will be those defined as the landward boundaries of coastal waters and intermediate waters under the EC Water Framework Directive

While the response to the EC request necessarily considers boundaries between various areas, nothing in the response is intended to express any view on the correct boundaries of States, their territorial seas, their exclusive economic zones (or similar jurisdictions) or their continental shelves. Any references to such boundaries are solely for the purpose of putting into context the discussion on eco-regions.

The names suggested for the proposed eco-regions (or used to describe other areas) are used solely to simplify discussion by providing a short, descriptive title each of the proposed eco-regions. The names are not intended to have any implications for the naming or status of the eco-regions or of any other areas.

Claims of Maritime Jurisdictional Zones by Member States of EU and Other States in the North-East Atlantic are summarised in Annex 3.

Evaluation of existing biogeographical and management regions

Consistent with the terms of the request, eco-regions were defined as the areas for which ecological objectives would be set when implementing an ecosystem approach in European waters. The request required that the boundaries of eco-regions should be based on biogeographic and oceanographic features, taking account of existing political, social, economic and management divisions. Thus eco-regions should be characterised by greater similarity in biogeographic and oceanographic characteristics within than among regions. Moreover, the European Commission requested that the boundaries between eco-regions should be defined unambiguously to guide research, objective setting, assessment, monitoring and enforcement.

The evaluation of existing biogeographical and management regions followed a four step process. First, existing biogeographical and management regions that might be used as eco-regions were catalogued. Second, a series of criteria that could be used to assess potential eco-regions (based on oceanographic, biogeographic, ecological, management and policy perspectives) were identified (Table 1). Third, the qualities of existing biogeographical and management regions were evaluated using the criteria. Fourth, changes to existing biogeographical and management regions that would improve their match to the evaluation criteria for eco-regions were identified. Since no existing biogeographical and management regions proved to be suitable for adoption as eco-regions, step four was used to determine the boundaries of the new eco-regions described in Section 5.

In practice, it was impossible to define a specific scoring system that could be used to balance the often conflicting requirements of the assessment criteria and the relative weighting given to assessment criteria would show regional variation. For example, a proposed eco-region that met the biogeographic, oceanographic and ecological criteria may not have been an optimal eco-region from a management perspective. Accordingly, the expert judgement of the ICES eco-regions group (Annex 1) was used to determine the preferred boundaries for new eco-regions, taking into account the relative strengths and weaknesses of the new eco-region in relation to the criteria in Table 1.

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1 Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy Official Journal L 327 , 22/12/2000 P. 0001 - 0073

Table 1 Criteria for evaluating existing or proposed eco-regions and the expected qualities of eco-regions that would be appropriate for the implementation of an ecosystem approach in European waters

Category/ Criterion	**Expectation in appropriate eco-region**
1. Oceanography/ Biogeography/ Ecology	
a. Do the boundaries of existing or proposed eco-regions appropriately demarcate areas with identifiable oceanographic characteristics?	Clear oceanographic justification for demarcation
b. Do the boundaries of existing or proposed eco-regions appropriately demarcate the distribution of a range of species or communities that inhabit many different depths?	Boundary should demarcate distribution of both pelagic and benthic species and communities
c. Will oceanographically/ biogeographically defined boundaries of the existing or proposed eco-regions continue to apply over the time-scales used for management (decades or more)?	They would apply for decades or more
d. Would there be significant spatial variation in the response of existing or proposed eco-regions' physical characteristics, species and communities to climate variability and climate change?	Spatial variation should be low so that the rate of management adaptation to climate change can be similar throughout the eco-region
e. Is the level of exchange of materials between existing or proposed eco-regions as low as can reasonably be expected?	Low exchange, eco-region should be a relatively self sustaining system
f. Is the oceanographic and biological variability among sites within the existing or proposed eco-region smaller than variability among eco-regions?	Variability within eco-regions should be smaller than variability among regions
g. If there are sub-regions within the eco-region (oceanographically/ biogeographically identifiable regions that do not meet the criteria for eco-regions), do they nest within eco-regions without gaps or inefficiencies?	Eco-region should divide clearly and completely into a small number (typically ≤ 3) of sub-regions
2. Human impacts and their management	
a. Would management action in one existing or proposed eco-region negatively affect management in another eco-region?	Responses to management action on one eco-region should have a minimal or positive impacts on management actions in other eco-regions
b. Are the existing or proposed eco-regions compatible with the distributions and management of commercially exploited fish populations?	Fish populations should ideally be distributed and managed within the same eco-region
c. Are the boundaries of existing or proposed eco-regions consistent with those of existing or proposed management regions (e.g. WFD, GFCM, MAP, RACs, ICES, OSPAR)?	Consistency should be high
d. Are the boundaries of existing or proposed management and/ or eco-regions consistent with terrestrial management regions?	Boundaries should be consistent to support integration of marine and terrestrial assessment and management
e. Can research, assessment and monitoring of terrestrial and marine impacts be effectively linked at the scale of the existing or proposed eco-region?	It should be possible to link research, assessment and monitoring of terrestrial and marine impacts to effectively support integrated management
f. Are the existing or proposed eco-region boundaries compatible with patterns of land use type and change and the distribution of human populations?	There should be compatibilities between eco-region boundaries and land use type and change and the distribution of human populations since these are key drivers of impacts on the marine environment
g. If there are sub-regions within the eco-region (management regions that do not meet the criteria for eco-regions), to they nest within eco-regions without gaps or inefficiencies?	Eco-region should divide clearly and completely into a small number (typically ≤ 3) of sub-regions
h. Do contiguous shelf areas and the slope to a depth of at least 1000m fall into the same eco-region?	The shelf and slope to a depth of at least 1000m should fall within the same eco-region as human activities such as fishing have increasingly spread from shelf to slope regions.

3. Management/ Policy	
a. Do the existing or proposed eco-regions apply to the fullest possible extent to the marine environment including the coastal areas, internal waters, the territorial sea, the exclusive fishery zones and other sea areas under the sovereignty and jurisdiction of the Member States of the European Union and neighbouring countries?	Eco-regions should apply to the fullest possible extent to the marine environment
b. Are the boundaries of the existing or proposed eco-region compatible with the provisions of UNCLOS and other relevant international conventions?	Eco-region boundaries should be compatible with the provisions of UNCLOS and other relevant international conventions
c. In relation to the jurisdiction areas of regional conventions, are there any gaps within the existing or proposed eco-region?	There should be no gaps in jurisdiction
d. If a number of conventions apply in different parts of the existing or proposed eco-regions, then will the management response to any human impact be inconsistent in different parts of the eco-region?	Management responses should be consistent throughout the eco-region
e. Do the boundaries of existing or proposed eco-regions create any known impediments to effective management? (in relation to the management of, for example, aggregate extraction and mining, aquaculture, dredging, engineering and construction, fisheries, land-based impacts, military activities, oil and gas, reclamation, recreation, renewable energy, shipping)	Boundaries should not create impediments to effective management
f. Do the existing or proposed eco-regions facilitate partnerships with neighbouring countries in the Atlantic, Baltic, Mediterranean Sea and Black Sea?	The eco-regions should facilitate partnerships
g. Can the existing or proposed eco-regions be subdivided into political or management regions with as few gaps and inefficiencies as possible?	Eco-region should divide clearly and completely into political and management regions

The proposed eco-regions met more of the criteria in Table 1 than any of the existing schemes we reviewed, partly because they took account of biogeographic/ oceanographic/ ecological and human impact/ management issues that had often been treated more or less independently.

There is no universally agreed method for biogeographical classification, but rather, as stated by Dinter (2001), there are as many methods as there are biogeographers. This reflects the fact that nature is continuous and that each part of nature has some uniqueness while it shares some features with other areas. There are no sharp and absolute boundaries but rather more or less clearly expressed transisition zones. Biogeographical classification, in common with other classifications such as partitioning into Large Marine Ecosystems, builds therefore to a high degree of judgements by experts who have a thorough knowledge of the areas to be classified. The experts are helped by there being discontinuities associated with transition zones. These discontinuities may reflect topographical features such as capes, peninsulas, ridges, slopes, and shelf edges that influence the ocean currents and water mass distributions. The discontinuities influence bottom and water characteristics and distribution patterns of flora and fauna. These patterns form the basis for the biogeographical classification.

The evaluation of existing and proposed eco-regions demonstrated that there is often not a sufficient understanding of biogeographical, oceanographical and ecosystem processes to allow the assessment of issues such as the extent to which eco-regions could be regarded as self-sustaining units. Moreover, it was clear that appropriate boundaries would often be mobile. In setting boundaries for the purposes of responding to this request, we attempted to select boundaries with the highest possible temporal and spatial stability, but acknowledged that the boundaries could never be truly fixed in space and time given climate variation and change.

The following biogeographical/ oceanographic or management regions that might serve as eco-regions were considered.

OSPAR regions
ICES areas
Large marine ecosystems (LME)
Longhurst provinces
Dinter biogeographical regions
Regional Advisory Council areas

OSPAR regions

Since 1992 the OSPAR Convention has recognised that there may be the need to divide the OSPAR maritime area into sub-regions. The existing divisions were established for the purposes of the Quality Status Report 2000. Three factors were particularly significant in establishing the boundaries:

(a) the Greater North Sea region (Region II) reflected the area defined for the purposes of the International Conferences on the Protection of the North Sea, so that the regional report would be directly comparable with the North Sea Quality Status Report produced in 1993;

(b) the other boundaries were intended to delimit regions that had significantly different ecological circumstances;

(c) in drawing them, however, account was also taken of the extent to which coastal States facing the Wider Atlantic (Region V) had information on that region, and Region IV (Bay of Biscay/Golfe de Gascogne and Iberian Waters) therefore included some of the deeper waters similar to the rest of Region V

ICES areas

The system of ICES areas has evolved incrementally since the early 1900s. ICES areas have been based on the requirements for the collection of fisheries statistical data and management, and have some links to regions defined by biogeography/ oceanography and ecology, because the location and timing of fisheries was closely linked to biogeographic and oceanographic factors.

With the publication of its first fisheries statistics publication (Bulletin Statistique 1904) ICES developed a system of Subareas and Divisions for use in the collection and presentation of fisheries statistics. This system evolved and around 1960 the fisheries statistics system was reviewed by the Continuing Working Party on Fishery Statistics in the North Atlantic Area (CWP). In 1984 ICES compiled a document that brought together the extensive description contained in the appendix to Volume 58 of Bulletin Statistique (published January 1976), the description of Divisions XIVa and b contained in the appendix to Volume 60 of Bulletin Statistique (published April 1978), and the description of the sub divisions of Divisions IIIb d (the waters around Denmark and the Baltic) adopted by the International Baltic Sea Fishery Commission, and the description of all the divisions in Sub areas VII - IX which had not previously been given. The latter Divisions were described because ICES Council Resolution1986/4:9 requested member countries to begin reporting fishery statistics by divisions for Sub areas VII and VIII in 1987. In 2004 a further refinement to the ICES areas is being introduced to accommodate the statistics needs for deep water fishing, and the NEAFC requirements for reporting by EEZs.

Large marine ecosystems

Large Marine Ecosystems (LME) were originally proposed by Ken Sherman of the US NOAA. A Large Marine Ecosystem is defined as a relatively large ocean area, typically 200 000 km^2 or larger, with characteristic bottom topography, hydrography and productivity, and with trophically coupled populations. This definition also provides the criteria for the identification of LMEs. Most LMEs are located on the continental shelves. Here the bottom topography has a strong influence on currents and water mass distribution. The physical conditions again determine the characteristics of plankton production.

The last criterion for LMEs, having trophically coupled populations, distinguishes LMEs from other classification systems such as biogeographical partitioning. Commercial fish populations are usually important ecological components as prey and predators for other marine biota. Because of their large size, such fish populations require a large living space as they need to feed on the production of prey organisms over a large area. The populations at the same time need to achieve geographical life cycle closure, where spawning areas, larval drift routes, juvenile nursery areas, feeding areas and spawning migrations form a spatial life cycle context in relation to ocean currents and circulation patterns. The distributions of commercial fish populations are therefore an important element to consider when delineating LMEs. Since their distributions reflect circulation and water mass distributions, this criterion is related to the other criteria of characteristic bottom topography, hydrography and productivity

The current classification (http:/www.edc.uri.edu/lme) lists 11 LMEs in the Northeastern and northern North Atlantic. These are:

(a) The Barents Sea LME
(b) The Norwegian Sea LME
(c) The Iceland Shelf LME
(d) The East Greenland Shelf LME

(e) The Faroe Plateau LME
(f) The North Sea LME
(g) The Baltic Sea LME
(h) The Celtic-Biscay Shelf LME
(i) The Iberian Coastal LME
(j) The Mediterranean LME
(k) The Black Sea LME

Longhurst provinces

The Longhurst provinces (Longhurst, 1998) provide a scheme for partitioning the water column of the world's oceans into biogeographical units. This scheme includes four primary compartments (*biomes*) that are further subdivided into secondary compartments (*provinces*). In the North Atlantic, Longhurst subdivided the Polar biome into three and the Westerlies biome into four provinces.

(a) Boreal Polar Province (BPLR)
(b) Atlantic Arctic Province (ARCT)
(c) Atlantic Subarctic Province (SARC)
(d) North Atlantic Drift Province (NADR)
(e) North Atlantic Subtropical Gyral Province (East and West) (NAST)
(f) Gulf Stream Province (GFST)
(g) Mediterranean Sea, Black Sea Province (MEDI)

Longhurst (1998) also divided the coastal shelves of the northeast Atlantic into two provinces

(h) Northeast Atlantic Shelves Province (NECS)
(i) Eastern (Canary) Coastal Province (CNRY)

The Northeast Atlantic Shelves Province (NECS) is large and diverse, and Longhurst (1998) therefore recognised that a subdivision of the province could be useful for some purposes. He suggested the following subdivisions:

(i) the North Sea, from the Straits of Dover to the Shetlands;
(ii) the Channel from Dover west to Ushant;
(iii) the southern outer shelf from northern Spain to Ushant, including the Aquitaine and Armorican shelves off western France;
(iv) the northern outer shelf, including the Celtic Sea and the Irish, Malin, and Hebrides shelves off Britain;
(v) the Irish Sea;
(vi) the central Baltic (Gottland) Sea
(vii) the Gulfs of Bothnia and Finland.

Dinter Biogeographical regions

The Dinter biogeographical classifications were based on a German Federal Agency for Nature Conservation study to identify biogeographical units (provinces) in the NE Atlantic and Arctic Oceans (Dinter, 2001). This was based on a review of previous oceanographic and biogeographic classifications. The analysis considered (1) pelagic, (2) benthic and neritic of the shelf and upper continental shelf (<1000m depth) (3) benthic and neritic of the shelf and upper continental shelf (<1000m depth) and ice-cover biomes and (4) deep-sea distribution patterns (benthic and pelagic >1000m depth). Dinter (2001) defined a *province* as a geographical unit with either a higher rate of or peculiar endemism, or more often an oceanographic constellation that supports a characteristic biotic association. The *Sub-province* was not specifically defined by Dinter (2001) but is a further subdivision of a province based on examination of species distribution patterns within the province.

Regional Advisory Councils

For the purposes of the EC Common Fisheries Policy, regional advisory councils are being established. The regions for the purposes of these councils have been defined in two separate ways: geographically and functionally. There are two functional "regions" (pelagic stocks and high seas/long-distance fleet) and five geographical regions:

a. the Baltic Sea,
b. the Mediterranean Sea,
c. the North Sea,
d. north-western waters,
e. south-western waters.

These geographical regions have been defined in terms of the ICES areas and CECAF divisions, except for the Mediterranean, which includes all maritime waters of the Mediterranean Sea east of longitude 5°36′ west[2]. The geographical areas, however, have been chosen in part on the basis of the locations of the fishing fleets which are interested in them. As a result, they do not always reflect biogeographical considerations. For example, the whole of the English Channel (ICES areas VIId and VIIe) is allocated to the North-Western Waters Regional Advisory Council, while the Kattegat (ICES area IIIb) is allocated wholly to the Baltic Sea Regional Advisory Council.

Proposed new eco-regions

Following the evaluation process and the redefinition of boundaries, 11 eco-regions are proposed (Figure 2). These eco-regions are:

Greenland and Iceland Seas (A)
Barents Sea (B)
Faroes (C)
Norwegian Sea (D)
Celtic Seas (E)
North Sea (F)
South European Atlantic Shelf (G)
Western Mediterranean Sea (H)
Adriatic-Ionian Seas (I)
Aegean-Levantine Seas (J)
Oceanic northeast Atlantic (K)

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2 Council Decision 2004/585/EC of 19 July 2004 establishing Regional Advisory Councils under the Common Fisheries Policy, Annex 1.

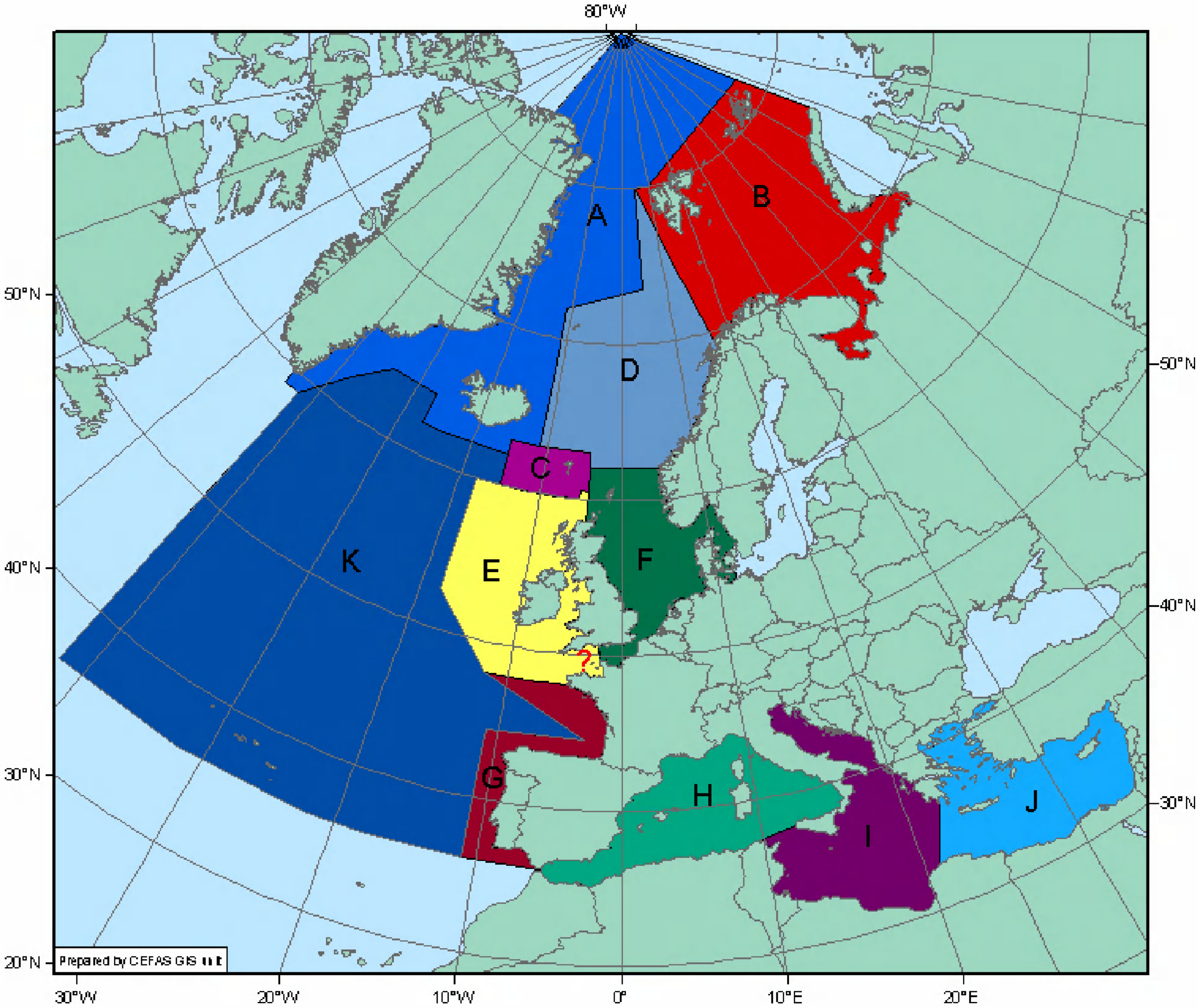

Figure 2 Proposed eco-regions for the implementation of the ecosystem approach in European waters. The eco-regions are Greenland and Iceland Seas (A), Barents Sea (B), Faroes (C), Norwegian Sea (D), Celtic Seas (E), North Sea (F), South European Atlantic Shelf (G), Western Mediterranean Sea (H), Adriatic-Ionian Seas (I), Aegean-Levantine Seas (J) and Oceanic northeast Atlantic (K). The question mark denotes the western Channel (ICES Area VIIe), which could be placed in either the Celtic Sea or North Sea eco-region. Equidistant azimuthal projection.

Although the group was not directly asked to consider the Baltic Sea and Black Sea, the approach adopted to distinguishing what constitutes an eco-region suggests that it would be consistent with the identifications proposed elsewhere to treat the Baltic Sea and Black Sea as a single eco-regions. This would result in a total of 13 eco-regions.

In the Black Sea, there are clearly significant differences between the shallow northern shelf (including the Sea of Azov) and the deep basin and southern rim. These two areas form parts of a whole from a systems perspective, both in terms of ecology and pressures. In line with the proposals for other European seas, a single Black Sea eco-region is therefore suggested, subject to comments from experts on the region, with the two parts being treated as sub-regions.

The names suggested for the eco-regions are used solely to simplify discussion by providing a short, descriptive title for each of the proposed eco-regions. The names are not intended to have any implications for the naming or status of the eco-regions or of any other areas.

The Arctic was divided into a number of eco-regions as this is consistent with the biogeographic/ oceanographic weighting given to other eco-regions. However, given the low population density and relatively limited level of human impacts in the Arctic, the eco-regions may need to be federated and treated as a single unit for management purposes.

It was considered desirable to deal with areas (1) under the jurisdiction of Spain around the Canary Islands and (2) the area under the jurisdiction of Portugal around Madeira (which overlaps slightly with the OSPAR maritime area) in this request. The waters surrounding these islands share the same characteristics as the nearest parts of the OSPAR maritime area and form part of the economic and social systems of Europe. It is therefore proposed that these waters are included in the same eco-region as the waters around, for example, the Azores.

Boundaries that have been defined for the purpose of responding to this request are fuzzy and the optimal boundary locations will change with climate variation and climate change. It is proposed that boundaries should be re-evaluated at 20 year intervals. It was also noted that according to the Coast Guidelines under the CIS for the WFD, that the recommended interval for examining eco-region borders is every 6 years to account for climate change.

The relationships between the boundaries of the proposed eco-regions and the boundaries of ICES areas and the OSPAR regions are shown in Figures 3 and 4 respectively. The relationships between proposed eco-regions and depth are shown in Figures 5 and 6.

In general, eco-region boundaries were set to follow the boundaries of the ICES areas, unless there were strong reasons for making a division within a given ICES area. This is because fisheries management will be a very important component of the European Marine Strategy and will have a significant effect on the ecological and operational objectives that are set for individual eco-regions. Since fisheries are largely managed on the basis of data collected by ICES areas, and since it is important to use historic data collected for ICES areas to support fisheries and environmental management, objective setting and management will be more effective if the eco-regions are aligned with ICES areas.

The large scales of the maps presented in this report do not allow us to represent small scale boundary information, but this is available from ICES as shape files. These files were used to produce the maps presented in this report. The boundaries that cross lines of both latitude and longitude may need to be defined in N-S and E-W 'steps' for the purposes of the practical implementation and reporting of boundaries and ICES did not attempt to do this.

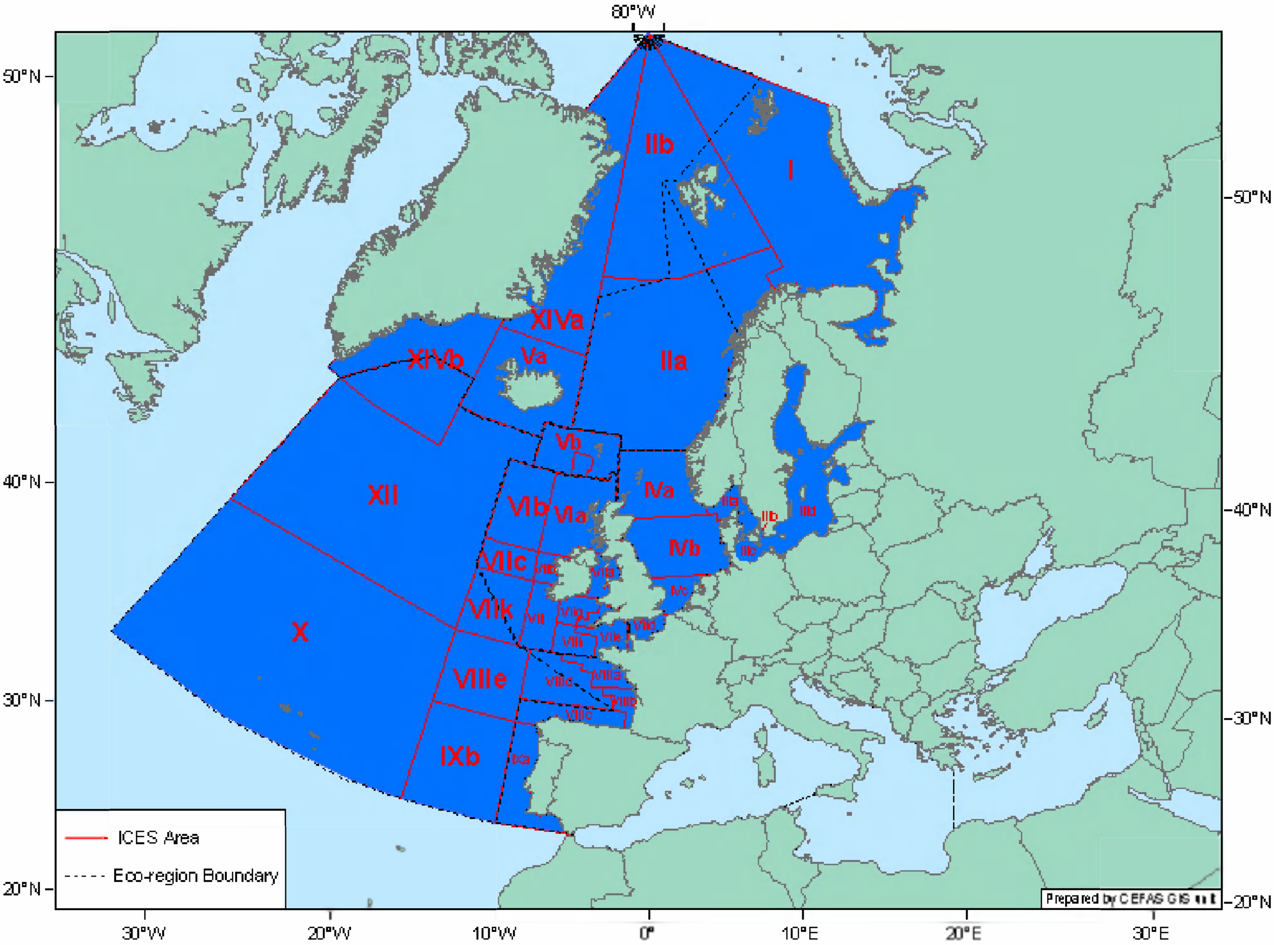

Figure 3 The boundaries of the proposed eco-regions Greenland and Iceland Seas (A), Barents Sea (B), Faroes (C), Norwegian Sea (D), Celtic Seas (E), North Sea (F), South European Atlantic Shelf (G), Western Mediterranean Sea (H), Adriatic-Ionian Seas (I), Aegean-Levantine Seas (J) and Oceanic northeast Atlantic (K)and the existing ICES areas. Equidistant azimuthal projection.

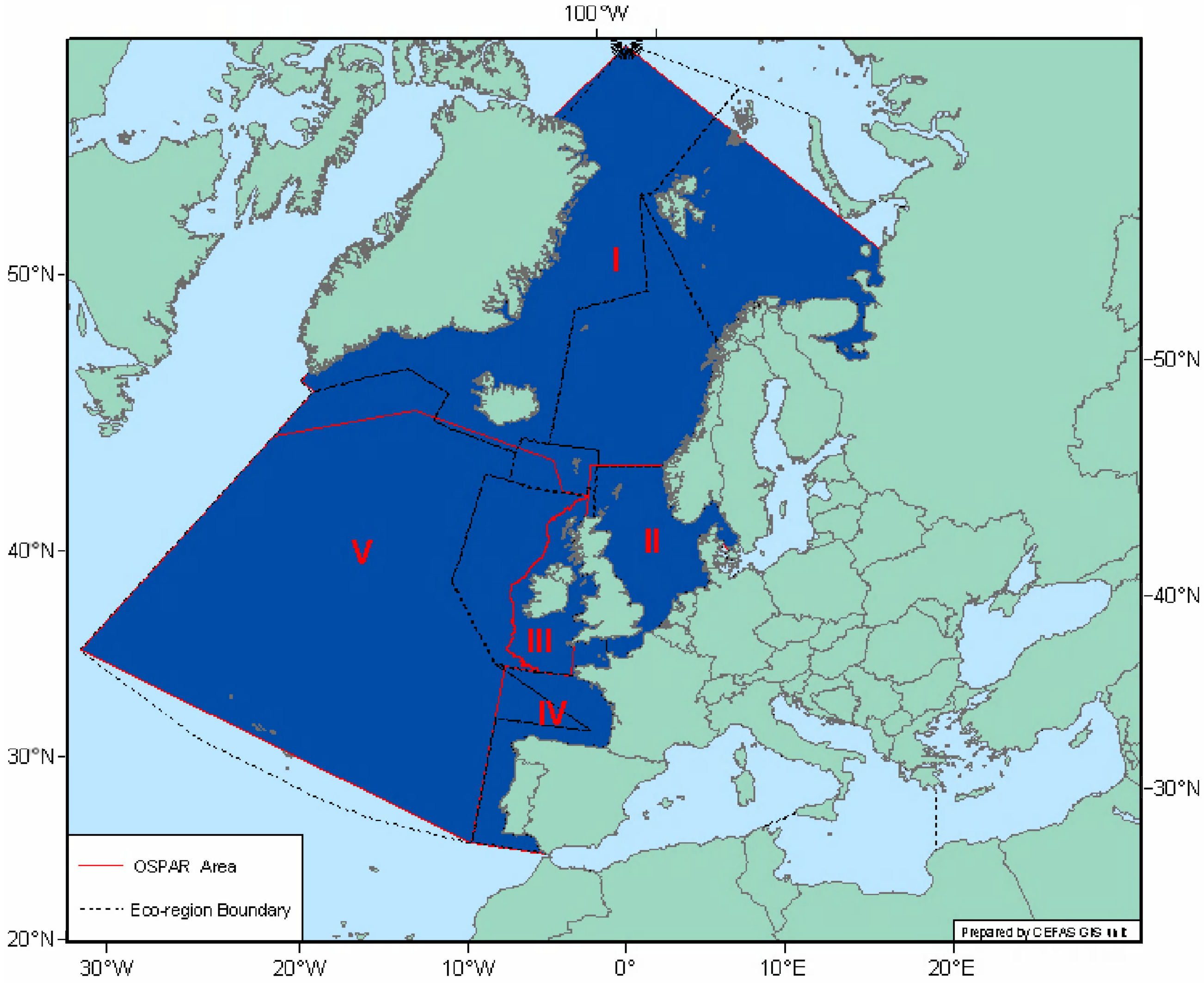

Figure 4 The boundaries of the proposed eco-regions Greenland and Iceland Seas (A), Barents Sea (B), Faroes (C), Norwegian Sea (D), Celtic Seas (E), North Sea (F), South European Atlantic Shelf (G), Western Mediterranean Sea (H), Adriatic-Ionian Seas (I), Aegean-Levantine Seas (J) and Oceanic northeast Atlantic (K) and the existing OSPAR areas. Equidistant azimuthal projection.

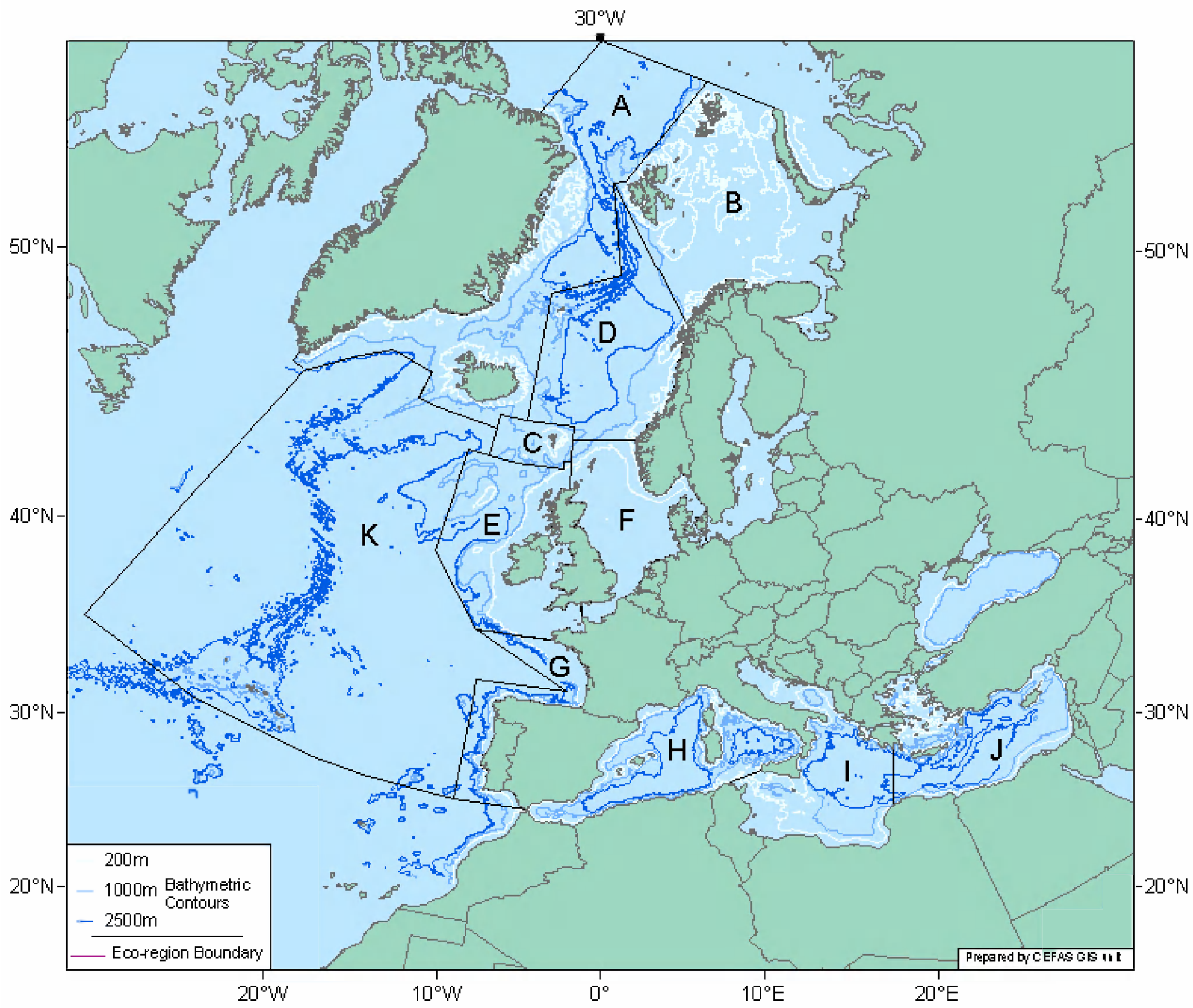

Figure 5 The boundaries of the proposed eco-regions Greenland and Iceland Seas (A), Barents Sea (B), Faroes (C), Norwegian Sea (D), Celtic Seas (E), North Sea (F), South European Atlantic Shelf (G), Western Mediterranean Sea (H), Adriatic-Ionian Seas (I), Aegean-Levantine Seas (J) and Oceanic northeast Atlantic (K) and the locations of 200m, 1000m and 2500m bathymetric contours.

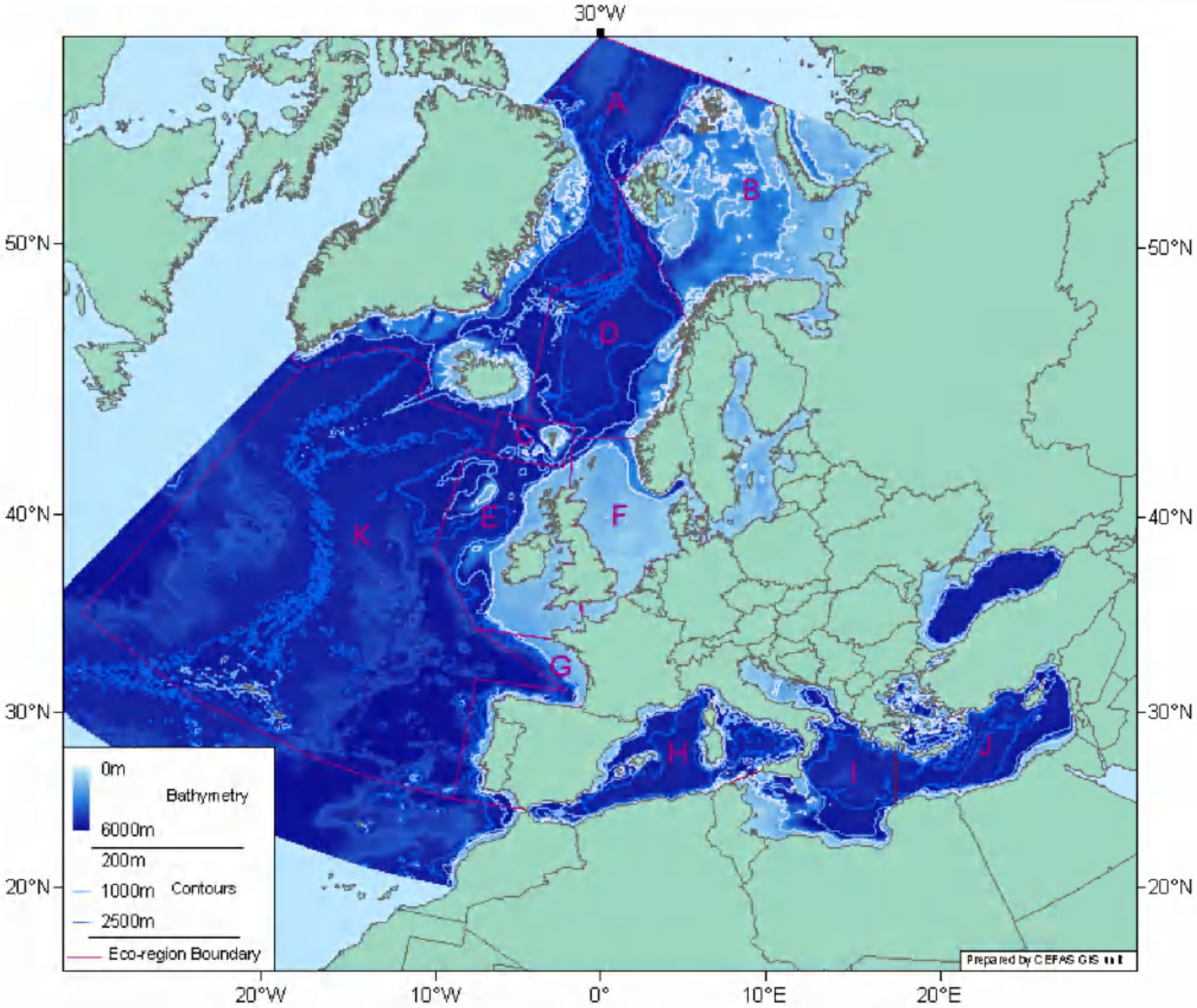

Figure 6 The boundaries of the proposed eco-regions Greenland and Iceland Seas (A), Barents Sea (B), Faroes (C), Norwegian Sea (D), Celtic Seas (E), North Sea (F), South European Atlantic Shelf (G), Western Mediterranean Sea (H), Adriatic-Ionian Seas (I), Aegean-Levantine Seas (J) and Oceanic northeast Atlantic (K) and the locations of 200m, 1000m and 2500m bathymetric contours and additional bathymetric information

Comments on the designation of eco-regions and further division into subregions

The following subsections contain justifications for the locations of eco-region boundaries and suggest some sub-regional boundaries. They are intended to demonstrate why boundaries were selected when such boundaries appear inconsistent with the some of the evaluation criteria in Table 1, and to highlight how biogeographic/ oceanographic/ ecological, management/ human impacts and management/ policy constraints were balanced. The texts are not intended to be comprehensive justifications for, or descriptions of, the process of eco-region selection, nor do they consider all possible sub-regions.

The group did not decide whether the western Channel (ICES area VIIe) should be placed within the Celtic Seas or North Sea. Biogeographic considerations favour inclusion of the western Channel in the Celtic Seas, while management and policy considerations favour inclusion of the western Channel in the North Sea. Further consultation would be needed to resolve the status of the western Channel.

Greenland and Iceland Seas

There is evidence for a north-south biogeographical split around Iceland, but the management imperative of treating Iceland as a single unit was too great to allow a split on a biogeographical basis. It was also noted that a number of stocks, such as capelin, migrate between the northern and southern areas.

The Greenland and Iceland Seas eco-region_comprises the shelves around Iceland, the Iceland Sea, the East Greenland shelf, and the western and larger part of the Greenland Sea.

The southwestern border of the Greenland and Iceland Seas eco-region has been drawn to include the shelves and slopes along southeastern Greenland and southwestern Iceland but to exclude the deep northern part of the Irminger Sea (border runs from 59°N 42°W to 62°N 38°W to 64°N 34°W to 64°N 27°W). The southern border includes the shelf and slope south of Iceland bordering the deep Iceland Basin to the east of the Reykjanes Ridge. The southern shelf of Iceland and the waters north of Iceland are ecologically closely connected. The Iceland capelin and cod stocks have spawning areas along the south and southwest coasts of Iceland. The larvae drift with the currents (Coastal and Irminger Currents) to nursery areas west and north of Iceland. The capelin have a seasonal feeding migration north in the Iceland Sea where they exploit the plankton production. They return to spawn by migrating with the southwards flowing East Iceland Current along the eastern side of Iceland.

In the east, the Greenland and Iceland Seas eco-region borders the Norwegian Sea eco-region. The part of the area that lies to the north of the Iceland Sea includes the northeast Greenland shelf and the western part of the Greenland Sea. This is an ice-covered and mainly high-Arctic area, but Atlantic water that recirculates in the Greenland Sea may give somewhat warmer conditions in the deeper part of the shelf and along the upper slope. There are few fisheries in this part of the eco-region. Arctic zooplankton which are produced in this area are partly advected with the currents (Jan Mayen and East Iceland Currents) into the Iceland and Norwegian Seas where they contribute to the rich feeding conditions for the large stocks of pelagic fish.

Barents Sea

The Barents Sea eco-region is similar to the Barents Sea Large Marine Ecosystem with the western border following the shelf edge to the deeper Norwegian Sea.

The shelf along the west coast of Svalbard is considered part of the Barents Sea eco-region. The surface waters of the northwestern Barents Sea flows southwesterwards along the eastern slope of the shallow Svalbard Bank as the cold Arctic Bear Island Current, turns around the Bear Island, and continues north as a cold coastal current along the western Spitsbergen shelf. The deeper shelf areas are also a nursery area for juvenile cod and haddock of the Barents Sea stocks. Ecologically therefore, the shelf is connected to the Barents Sea system. From a practical management point of view, it is advantageous to have the east and west coasts of Spitsbergen within the same ecosystem management unit.

Faroes

The Faroes eco-region corresponds to the Faroe Plateau Large Marine Ecosystem but an adjustment of the boundary has been suggested. The shelf around the Faroe Isles and the shallow Faroe Bank to the southwest form a distinct ecological unit with characteristic circulation pattern, plankton production and composition, and self-contained fish populations of cod, haddock and other species. The slopes around the shelf and bank areas are included in the eco-region. For practical purposes, the borders should correspond to those of ICES area Vb.

Norwegian Sea

The Norwegian Sea eco-region broadly corresponds to the Norwegian Sea LME but with a change in the northern border. The mid-Atlantic ridge continues north from Iceland through the Iceland Sea, then turns north-eastward from Jan Mayen as Mohn Ridge, before it turns north again through the Greenland Sea. The Lofoten Basin in the northern Norwegian Sea continues as a northwards extension to the east of the mid-Atlantic Ridge along Spitsbergen. The border of the Norwegian Sea eco-region is suggested to follow Mohn Ridge northeast from Jan Mayen and then north along 5°E to 80°N. Thus the deep extension from the Lofoten Basin in the eastern Greenland Sea is included in the Norwegian Sea eco-region. Part of the Norwegian Atlantic Current continues north along the Spitsbergen slope and into the Arctic Ocean through the Fram Strait. The northwards extension of the eco-region can be justified ecologically. The Atlantic water is ice-free and phytoplankton production is driven by seasonal warming. Zooplankton production is similar to that of the northern Norwegian Sea and there is an advection of zooplankton with the northwards current. Also the fish community along the slope of Spitsbergen resembles that further south, and commercially important species such as Greenland halibut have a continuous distribution north in this area.

Celtic Seas

ICES Area VIIe (western Channel) would be included in the Celtic Seas on biogeographic grounds. However, for management purposes there were good reasons to include it with the North Sea, since activities such as shipping and pollution control need to be managed for the Channel as a whole. The group propose that the decision whether to include the western Channel in the Celtic Seas or North Sea requires further consideration.

In including the entire western Channel in either the Celtic Seas or North Sea, the group ignored an apparently clear biogeographical division at approximately 50° N that was identified by Dinter (2001) and split the western Channel and parts of the Celtic Sea into northern and southern regions. Based on the evidence that Dinter (2001) reviewed and knowledge of water masses, fish and benthic invertebrate distributions in this area, this split was not considered justifiable.

The main differences between the Celtic Seas sub-region identified for the purposes of the OSPAR Joint Assessment and Monitoring Programme and the proposed Celtic Seas eco-region are that (a) the eco-region is defined by reference to ICES sea areas, rather than by reference to a natural feature, such as an isobath and (b) the eco-region extends substantially further west than the OSPAR sub-region.

The justification for the greater westwards extension lies in the changes in perception of the slopes of the continental shelf since the OSPAR sub-regions were defined in the mid-1990s. At that time, the emphasis was on defining an area for which consistent data was available, and there was little data for the areas west of the 200-metre isobath. The sub-region was therefore confined to the area shallower than this isobath. Since the mid-1990s, much more has become known about the slopes of the continental shelf. It is now clear that this is a very important area for the well-being of the continental shelf, and that it contains important features, such a cold-water coral reefs, which are exposed to significant threats. It is therefore important that it should be managed consistently with the shallower shelf waters. This will be facilitated by including both the shelf and its slopes in the same eco-region. The proposed eco-regions are therefore designed, particularly in the Celtic Seas eco-region, to contain the whole of the slope down to 1 000 metres- the greatest depth to which cold-water coral are usually distributed.

North Sea

In the Kattegat, both ecological and management arguments can be found for the inclusion of the Kattegat in either the North Sea or the Baltic eco-region. On balance, however, it is recommended that the Kattegat should be included in the North Sea eco-region. The ecological and management arguments depend on the balance between considerations relating to the upper waters (which are heavily influenced by the Baltic) and the deeper waters (which are equally influenced by the Atlantic/North Sea). At present the Kattegat forms part of the maritime areas of both the Helsinki and OSPAR Conventions. There could be a case, in spite of the wish to have unambiguous eco-regions, for preserving this situation. However, inclusion of the Kattegat in the North Sea eco-region is recommended for the reasons given below.

Kattegat is a fairly shallow area with a two-layered and strongly stratified water mass structure. The brackish water flowing out from the Baltic forms the upper layer, while North Sea water flowing south forms the lower layer. The mean salinity of the brackish water as it flows through the Danish Belts into Kattegat is about 10‰, while the mean salinity as it exits Kattegat in north is about 25‰. This shows that roughly two portions of North Sea water from the deeper layer mixes with one portion of the brackish Baltic water as it flows northwards through Kattegat. In terms of circulation and hydrography, therefore, the North Sea water has a dominant influence in Kattegat. This is reflected also in the biological conditions and the biota shows in general stronger similarity to that in the North Sea than to the Baltic Sea. In terms of eutrophication assessment, the Kattegat is very much linked to the circulation in the eastern part of the

North Sea. Nutrient enriched water from the coastal areas of the southeastern North Sea is likely to affect the water quality (e.g. oxygen conditions) in Kattegat due to the circulation described above.

In terms of fish stocks, Kattegat form part of the distribution area for several stocks in Skagerrak and also for some stocks in the wider North Sea. Kattegat is, therefore, often included with Skagerrak in assessments of stocks by ICES. This is the case for plaice, sole, whiting, sandeel, and sprat. Kattegat is also part of the distribution area for some stocks in the Baltic. Thus, autumn spawning herring from the western Baltic may migrate out to feed in Kattegat and even in Skagerrak.

The boundary of OSPAR Area II (Greater North Sea) was formerly at 5° W, but the group could not see an oceanographic, biogeographical, ecological or management justification for this and propose that the boundary is moved to 4°W where it is consistent with the western boundary of ICES Area IVa.

The benthic fauna of the deep Norwegian trench would be more closely related to that of the Norwegian Sea. On balance, however, the surface waters above the trench are affected by the outflow from the Baltic and so this area is better treated as part of the North Sea.

South European Atlantic Shelf

In setting the boundary of the South European Atlantic Shelf at 48°N, the group ignored an apparently clear biogeographical division at approximately 50° N that was identified by Dinter (2001) and used by him to split the western Channel and parts of the Celtic Sea into northern and southern regions. Based on the evidence that Dinter (2001) reviewed and knowledge of water masses, fish and benthic invertebrate distributions in this area, this split was not considered justifiable. Moreover, the Dinter (2001) Lusitanean province was differentiated into a Northern and Southern warm subprovince with a cool subprovince in between. This discrimination was not considered sufficiently profound to justify the division of the South European Atlantic Shelf into more than one eco-region.

Consistent with the requirement to include the shelf and slope to 1000m depth in the same eco-region, the western boundary of the South European Shelf Seas in the vicinity of the ICES areas VIIIa and VIIIb was redefined as a line from 48°N, 12°W to 44°30'N 3°W rather than following the ICES boundary. It was recognised that this change from the boundary of the existing ICES areas would mean that historical data collected in these areas might not easily be compiled and analysed at the scale of the new eco-region, but the management imperative of keeping the slope and shelf in the same eco-region was considered to override this concern.

If subdivisions of the South European Atlantic Shelf are required, it is recommended that the divisions are based (1) on the main river catchments affecting this eco-region and (2) on topographical and oceanographic features of the shelf.

Western Mediterranean Sea, Adriatic-Ionian Seas and Aegean-Levantine Seas

For the Mediterranean, the group concluded that the levels of differentiation between eco-regions used in the Atlantic, when applied to the Mediterranean evidence, supported a division into three eco-regions. However, it is suggested that each of the three eco-regions in the Mediterranean could be subdivided into two sub-regions (Figure 7). These would be

Western Mediterranean Sea
- Sub- region 1A : *Ligurian-Catalan-Algerian Seas*
- Sub- region 1B : *Tyrrhenian Sea*

Adriatic-Ionian Seas
- Sub- region 2A : *Adriatic Sea*
- Sub- region 2B : *Ionian Sea.*

Aegean-Levantine Seas
- Sub- region 3A : *Aegean Sea*
- Sub- region 3B : *Levantine Sea*

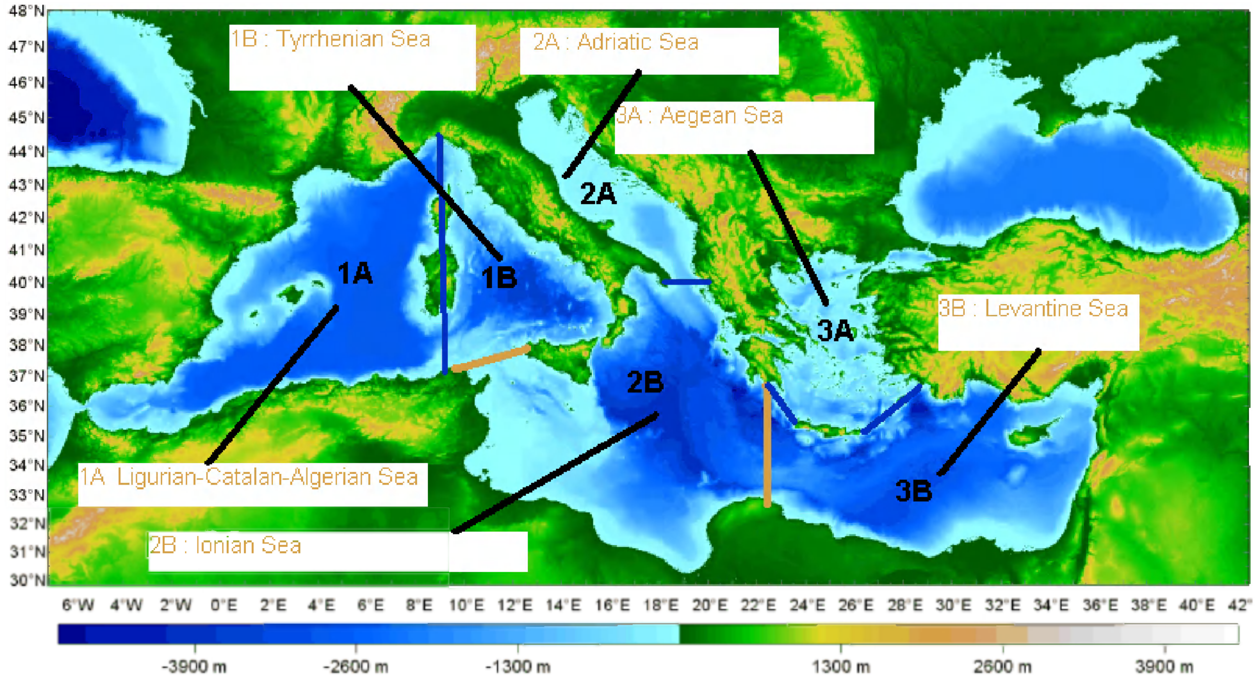

Figure 7 The three eco-Regions for the Mediterranean Sea (bordered by red lines) and the proposed divisions and names of sub-regions (bordered by blue lines).

Oceanic northeast Atlantic

The Oceanic northeast Atlantic is treated as a single eco-region because the latitude of any division E-W in the Oceanic north-east Atlantic is particularly difficult to define when there is a near continuum in water temperature. An E-W line at around 43° N might be considered as sub-regional division, but would not be not sufficiently well defined to be adopted as an eco-region boundary. The location of the E-W line could be guided by the division between the Longhurst (1998) NADR and NAST provinces, which lies at 43° N.

References

Dinter, WP (2001) Biogeography of the OSPAR Maritime Area. Federal Agency for Nature Conservation, Bonn.
Longhurst, A. (1998) Ecological geography of the sea. Academic Press, San Diego. 398 pp

APPENDICES

Annex 1. Participants at the ICES meeting (ICES HQ Copenhagen 19-21 October 2004) to provide a response to the EC request for information and advice about appropriate eco-regions for the implementation of an ecosystem approach in European waters

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Annex 2. Definitions of areas from Regional sea-conventions

BARCELONA CONVENTION

Article 1 - Geographical Coverage

1. For the purposes of this Convention, the Mediterranean Sea Area shall mean the maritime waters of the Mediterranean Sea proper, including its gulfs and seas, bounded to the west by the meridian passing through Cape Spartel lighthouse, at the entrance of the Straits of Gibraltar, and to the east by the southern limits of the Straits of the Dardanelles between Mehmetcik and Kumkale lighthouses.
2. The application of the Convention may be extended to coastal areas as defined by each Contracting Party within its own territory.
3. Any Protocol to this Convention may extend the geographical coverage to which that particular Protocol applies.

BUCHAREST CONVENTION

Article I - Area of application

1. This Convention shall apply to the Black Sea proper with the southern limit constituted for the purposes of this Convention by the line joining Capes Kelagra and Dalyan.
2. For the purposes of this Convention the reference to the Black Sea shall include the territorial sea and exclusive economic zone of each Contracting Party in the Black Sea. However, any Protocol to this Convention may provide otherwise for the purposes of that Protocol.

HELSINKI CONVENTION

Article 1 - Convention Area

This Convention shall apply to the Baltic Sea Area. For the purposes of this Convention the "Baltic Sea Area" shall be the Baltic Sea and the entrance to the Baltic Sea bounded by the parallel of the Skaw in the Skagerrak at 57 44.43'N. It includes the internal waters, i.e., for the purpose of this Convention waters on the landward side of the base lines from which the breadth of the territorial sea is measured up to the landward limit according to the designation by the Contracting Parties.

A Contracting Party shall, at the time of the deposit of the instrument of ratification, approval or accession inform the Depositary of the designation of its internal waters for the purposes of this Convention.

OSPAR CONVENTION

Article 1 – Definitions

For the purposes of the Convention:

(a) "Maritime area" means the internal waters and the territorial seas of the Contracting Parties, the sea beyond and adjacent to the territorial sea under the jurisdiction of the coastal state to the extent recognised by international law, and the high seas, including the bed of all those waters and its sub-soil, situated within the following limits:

- (i) those parts of the Atlantic and Arctic Oceans and their dependent seas which lie north of 36° north latitude and between 42° west longitude and 51° east longitude, but excluding:
  - (1) the Baltic Sea and the Belts lying to the south and east of lines drawn from Hasenore Head to Gniben Point, from Korshage to Spodsbjerg and from Gilbjerg Head to Kullen,
  - (2) the Mediterranean Sea and its dependent seas as far as the point of intersection of the parallel of 36° north latitude and the meridian of 5° 36' west longitude;
- (ii) that part of the Atlantic Ocean north of 59° north latitude and between 44° west longitude and 42° west longitude.

Annex 3. Claims of Maritime Jurisdictional Zones by Member States of EU and Other States in the North-East Atlantic (Breadth in Nautical Miles)

	TS	CZ	EEZ	FZ
Belgium*	12	24	DBC	+[3]
Cyprus*	12	24	200	
Denmark	12		200	200[4]
Estonia	12[5]		DBC	
Finland*	12	14		DBC
France*	12	24	200[6]	
Germany*	12		DBC	
Greece*	6[7]			
Iceland*	12		200	
Ireland*	12			200
Italy*	12			
Latvia	12		DLM	
Lithuania*	12		DLM	
Malta*	12	24		25
The Netherlands*	12		DBC	
Norway*	12	24	200	200[8]
Poland*	12		DLM	
Portugal*	12	24	200	
Spain*	12	24	200[9]	+[10]
Slovenia*				
Sweden*	12		+[11]	
United Kingdom*	12[12]		200[13]	200 or 12[14]

TS: territorial sea CZ: contiguous zone EEZ: exclusive economic zone FZ: fisheries zone
*: party to the UN Convention on the Law of the Sea DBC: defined by coordinates
DLM: defined by the delimitation line or an equidistance line in the absence of a maritime delimitation line

*Land-locked States (Austria, Czech Republic, Hungary, Luxemburg, Slovakia) in the EU are excluded from the list. Iceland and Norway are not member States of the EU.

**Demnark, Iceland, Ireland Norway and the United Kingdom have extended continental shelf claims beyond 200 nautical miles in accordance with Article 76 of the United Nations Law of the Sea Convention.

[3] Coterminous with the exclusive economic zone

[4] For Greenland and Foroe Islands

[5] In some parts of the Gulf of Finland, defined by coordinates

[6] Applies to the North Sea, the English Channel and the Atlantic Ocean from the Franco-Belgian border to the Franco-Spanish border, Saint Piere and Miquelon, French Guiana, Réunion, New Caledonia, French Polynesia, Franch Southern and Antarctic Lands, Wallis and Futuna, Tromelin, Glorioso, Juan de Nova, Europa and Bassad da India Islands, Clipperton Island, Mayotte, Guadaloupe and Martinique.

[7] Ten-mile limit applies for the purpose of regulating civil aviation.

[8] Jan Mayen and Svalbard

[9] In the Atlantic Ocean

[10] In the Mediterranean Sea

[11] To be determined by agreement or up to equidistance line

[12] Also three nautical miles. (Three nautical miles in Anguilla, Guernsey, British Indian Ocean Territory, British Virgin Islands, Gibraltar, Monserrat and Pitcairn; 12 nautical miles in United Kingdom, Jersey,Bermuda, Cayman Islands, Falkland Islands, Isle of Man, St. Helena and Dependencies, South Georgia, South Sandwich Islands, and Turks and Caicos Islands.)
[13] Bermuda, Pitcairn, South Georgia and South Sandwich Islands.
[14] 12 nautical miles in Guernsey; 200 nautical miles in United Kingdom, Anguilla, British Indian Ocean Territory, British Virgin Islands, Cayman Islands, Falkland Islands, Monserrat, St. Helena and Dependencies, and Turks and Caicos Islands.

2.2.3 Helsinki Commission (HELCOM)

The advice provided in response to special requests from the Helsinki Commission (HELCOM) can be found in Volume 8 of the ICES Advice 2005 report.

2.2.4 International Baltic Sea Fishery Commission (IBSFC)

The advice provided in response to special requests from the International Baltic Sea Fishery Commission (IBSFC) can be found in Volume 8 of the ICES Advice 2005 report.

2.2.5 North Atlantic Salmon Conservation Organization (NASCO)

The advice provided in response to special requests from the North Atlantic Salmon Conservation Organization (NASCO) can be found in Volume 11 of the ICES Advice 2005 report.

2.2.6 North East Atlantic Fisheries Commission (NEAFC)

The advice provided in response to special requests from the North East Atlantic Fisheries Commission (NEAFC) can be found in Volumes 2, 9 and 10 of the ICES Advice 2005 report.

2.2.7 Oslo and Paris Commission (OSPAR)

2.2.7.1 Design of one-off surveys to provide new information for a number of OSPAR chemicals for priority action

Request

OSPAR has requested ICES to provide advice on the design of one-off surveys to provide new information for a number of OSPAR Chemicals for Priority Action. Specifically ICES is requested to provide advice on appropriate strategies for undertaking the one-off surveys specified below to provide new information about the following Chemicals identified by OSPAR for Priority Action:

> to provide new information about the following chemicals identified by OSPAR for Priority Action: 2,4,6 tri-*tert* butylphenol (exploratory one-off survey to establish whether the substance is actually found in sediments in the OSPAR area), endosulphan, (exploratory one-off survey and a hot-spots survey to establish whether the substance is actually found, and to define "hot-spots" of the substance, in sediments of the OSPAR area), and short chained chlorinated paraffins (baseline survey to establish baseline in sediments in the OSPAR area against which to measure progress on the substance towards the goals of the OSPAR Hazardous Substances Strategy) according to specific OSPAR requests; taking into account sources and modes of dispersion/transport, the specific questions to be addressed for each substance (or groups of substances) under consideration are:
>
> i. indicate where there is any new information available on presence in the marine environment that has not already been taken into account in the relevant OSPAR background document as updated by the OSPAR lead country,
> ii. indicate whether the matrix (sediment, biota, water) proposed to be sampled is appropriate or whether an additional or more appropriate matrix should be included in the survey,
> iii. identify whether analytical techniques are available for the relevant matrices,
> iv. identify achievable detection limits, and reference materials, and
> v. determine how many stations/samples from each part of the OSPAR Convention area are necessary to address the objectives of the one-off surveys proposed, taking into account that more than one one-off survey may be required [OSPAR 2005/1]

Sources of the information presented

The 2005 reports of the Marine Chemistry Working Group, the Working Group on Statistical Aspects of Environmental Monitoring, and the Working Group on Marine Sediments in Relation to Pollution. In particular, see Annexes 7 and 8 from MCWG, and Annex 7 from WGMS.

Summary

The one-off surveys can be conducted however there are significant limitations to the proposed surveys for all three compounds or groups of compounds. These limitations are specific to the individual compounds and are detailed below.

There is virtually no information about the presence of 2,4,6 –tri-*tert*-butylphenol in the marine environment. It appears to have a limited anthropogenic source function. Preliminary data from a recent survey of sediments in the UK will provide useful information for developing the details of the proposed one-off survey. The preferred sample matrix is sediment however no suitable reference materials are available.

Endosulphan is known to be widely spread in the marine environment although the input function is not well known. A one-off survey is certainly feasible with sediment as the preferred sample matrix. Endosulphan has also been found at detectable concentrations in marine waters and biota. Chemical analyses should include both the α and β homologues and the sulphate degradation product.

The short-chain chlorinated paraffins probably represent the greatest challenge since they have a wide variety of sources and being a complex mixture they are difficult to quantify ambiguously. A one-off survey is feasible using sediments as the preferred sample matrix. However there are no suitable calibration or reference materials available.

Recommendations and Advice

There are some general considerations which are important with respect to this advice. In particular it is important to understand the meaning of "actually found." The ability to find a particular contaminant is related to whether or not it is actually present in the matrix in the area selected and the ability of the analytical methods to detect the presence of that compound. Simply stated if the compound is detected then we know that it is present. However, if we fail to detect the compound this does not prove that it is not present; we may not have looked in the right place or in the right matrix or our analytical methods may not be sufficiently sensitive.

The implications of detecting the compound of interest also need to be considered. In the present instance the compounds of interest are all man-made therefore their presence in the environment other than where they were intentionally placed can be considered undesirable. However in order to assess the risk associated with the presence information is also needed about the direct impact of these compounds on the organisms thus exposed and subsequently on indirect impacts through ingestion, predator-prey relationships, etc. It is in this context that the following advice is provided.

2,4,6-tri-tert-butylphenol

Currently, no data are available for this compound in any marine environmental matrix. As the lead country, the UK has commissioned a small-scale survey in sediments from a number of major industrialised UK estuaries. This survey is in progress and should be completed during March 2005. A one-off survey is feasible in the OSPAR area, and ICES advises that the analyses be undertaken within a single laboratory. Limits of detection can be supplied from the UK survey, along with the data. OSPAR should examine the results from the UK survey and take account of these when deciding whether or not to proceed with a wider survey. No reference materials are available which are certified for this compound. On the basis of available information sediment seems an appropriate matrix, although no studies have been undertaken to date. Detection limits are critical to the usefulness of the proposed survey so special attention needs to be given to selecting the analytical laboratory for this work.

Endosulphan

There are new data available for the presence of endosulphan in water and sediments from the North and Baltic seas. These data are from studies conducted within a research program and the German monitoring program. The limit of determination of endosulphan in water samples was 20 pg/l and in 20 g. sediment samples it was 0.03 µg/kg. Sediment is an appropriate matrix for endosulphan surveys. However detectable levels in sea water were clearly shown as well. There is a geographical variation in the European use of endosulphan, with most being used in the south (Spain, Greece, Italy, and France). As with 2,4,6 –tri-*tert*-butylphenol, detection limits for endosulphan are critical to the usefulness of the proposed survey so special attention needs to be given to selecting the analytical laboratory for this work. Analysis should include both the α and β homologues as well as the degradation product endosulphan sulphate.

Short-chain chlorinated paraffins (SCCP)

SCCPs are on the OSPAR list of chemicals for priority action and are listed as priority hazardous substances under the Water Framework Directive Annex X (EU Dec. 2001/2455/EC). While there are other uses, its primary use has been in metalworking fluids. The production level has been relatively high (4000 tonnes in 1998). The complexity of the substance makes analysis very challenging. Lack of a harmonised approach to calibration and quantification as well as lack of calibration and reference materials is currently a major contributing factor to apparent poor laboratory performance and comparability.

Although there is still limited information on levels of SCCPs in the marine environment, it is evident that they are very widespread, including in remote arctic areas. Water is not considered an appropriate matrix for monitoring in the marine environment. SCCPs concentrations have been determined in sediment, SPM, fish and shellfish, seabirds and marine mammals and recent data are presented in the review note. The one-survey can make use of the SCCP data collected as part of the DIFFCHEM study. Also, where possible, sampling stations should be selected so as to overlap with the DIFFCHEM stations. Due to the analytical problems mentioned above comparing the data may be difficult but it will still provide useful information. It also may be possible to re-analyse some of the DIFFCHEM samples.

Sampling Strategy

Sediments are recommended as the preferred sample matrix for the proposed surveys. To further optimize the value of the study, areas that accumulate fine grain sediments are also preferred. These areas can be identified through the use of side-scan sonar or, in the absence of that data, information on bathymetry and circulation patterns can be useful in identifying potential sampling areas. It is also important to include some samples from areas where the compounds of interest are not expected to be found. Where core samples are collected this baseline data can also be determined by subsampling sediments that predate the production of the compounds of interest.

The one-off surveys should include samples from at least 25 locations representing the whole convention area (e.g. DIFFCHEM locations plus the Spanish part of the Bay of Biscay and the Spanish/Portuguese Atlantic Ocean).

Contracting Parties are encouraged to suggest which estuaries should be included in the one-off surveys including locations for the collection of baseline samples. Contracting parties can also assist with the identification of depositional areas.

The One-off surveys proposed here are mainly exploratory, and whilst they might give indications of potential hot-spots, they should not be formally regarded as a hot-spot survey. ICES recommends that local authorities or Contracting Parties should identify potential hot spots for sampling for endosulphan. Sampling should then follow recognized procedures for evaluating hot spots (*Nicholson &Barry, 1996 and 2005*).

Due to the difficulties associated with the SCCP analyses it is recommended that larger than normal samples be collected and archived so as to facilitate future analyses for SCCP as analytical techniques evolve. This will also provide a capacity for analyses for other emerging chemicals.

Additional recommendations

It is important that the interpretation of the data from these surveys undergo a peer review process. It is also important that the data from the surveys be archived and managed so that it is readily accessible in the future.

Scientific Background

2,4,6 – tri-tert-butylphenol

Currently, no data are available for this compound in any environmental matrix. As the lead country, the UK has commissioned a small-scale survey in sediments from a number of major industrialised UK estuaries, which is underway and should be completed during March 2005. Although the OSPAR background document indicates that the chemical is used in the manufacture of plastics and rubber, industry sources in the UK indicate that it is not used in making rubber, and the only registered manufacturer in the UK makes additives for petroleum products. A one-off survey is feasible in the OSPAR area, and ICES advises that the analyses be undertaken within a single laboratory. Limits of detection will be supplied from the UK survey, along with the data. OSPAR should examine the results from the UK survey and take account of these when deciding whether or not to proceed with a wider survey. No reference materials are available which are certified for this compound. On the basis of available information sediment seems an appropriate matrix, although no studies have been undertaken to date.

Endosulphan

There is a geographical variation in the European use of endosulphan, with most being used in the south (Spain, Greece, Italy, and France). New information is available on the presence of endosulphan in the marine environment. The new data are for water and sediments from the North and Baltic seas from studies conducted within a research program and as part of the German monitoring program. Solid phase and microwave extractions were made for water and sediment samples respectively and after clean up and fractionation, the extracts were analysed for endosulphan by gas chromatography mass spectrometry in electron capture negative ionisation mode (GC-MS-ECNI).

The limit of determination of endosulphan in water samples was 20 pg/l. The concentrations of endosulphan were below the limit of detection at many stations in the North and Baltic seas. The concentrations ranged between < 20 and 43 pg/l and between < 20 and 37 pg/l for endosulfan I and II respectively in the North Sea. For this area the highest concentrations were determined at some off-shore stations indicating an atmospheric transport route. Slightly higher concentrations in the Baltic Sea ranged between <20 and 62 and between < 20 and 49 pg/l for endosulphan I and II respectively. The levels in the North and Baltic Seas were compared to the literature data (e.g. Bering Sea between 1 and 5 pg/l, Canadian Arctic lake 40 pg/l, and rainwater in Belgium 1 to 224 ng/l).

The limit of determination of endosulphan in 20g sediment samples from these studies was 0.03 µg/kg. Most of the samples analysed were below this concentration, and only in a few samples from the Baltic Sea were levels of up to 0.067 µg/kg observed.

Sediment is an appropriate matrix for endosulphan surveys. However detectable levels in sea water were clearly shown as well. It may also be possible to use passive samplers (such as plastic membranes) for sampling. In addition, endosulphan has a high bioconcentration potential and biota such as mussels might also be a good alternative means of sampling for endosulphan monitoring.

A sediment reference material with certified values for endosulphan has been produced by the IAEA.

Short-chain chlorinated paraffins (SCCP)

SCCPs are on the OSPAR list of chemicals for priority action and are listed as priority hazardous substances under the Water Framework Directive Annex X (EU Dec. 2001/2455/EC). While there are other uses, its primary use has been in metalworking fluids. The production level has been relatively high (4000 tonnes in 1998).

The complexity of the substance (with over 7000 theoretical positional isomers) makes analysis very challenging. Various techniques have been applied, primarily employing Gas Chromatography-Mass Spectrometry (GC-MS) techniques. Variations of GC-MS with negative chemical ionisation (NCI-MS) have been used although there are various drawbacks, such as ion source temperature dependence of mass spectra and response differences, up to a factor of 10, depending on the degree of chlorination. Use of high-resolution MS gives advantages in terms of sensitivity and selectivity. While no separation is achieved, use of short GC columns can also offer increased sensitivity. It was noted that GC-EI-MS/MS offers potential for cost-effective analysis, although issues in relation to interference from aromatic compounds need to be resolved. Lack of a harmonised approach to calibration and quantification as well as lack of calibration and reference materials is currently a major contributing factor to poor laboratory performance and comparability.

Although there is still limited information on levels of SCCPs in the marine environment, it is evident that they are very widespread, including in remote arctic areas. Water is not considered an appropriate matrix for monitoring in the marine environment. SCCPs concentrations have been determined in sediment, SPM, fish and shellfish, seabirds and marine mammals and recent data are presented in the review note. For instance, SCCPs in Drammensfjord, Norway, ranged from 94 –1300 µg/kg dw. Concentrations recently reported for SCCPs in sediments from the North Sea/German Bight and the Baltic Sea were similar when expressed on an organic carbon basis, (3.7-9.1 and 2.1-8.4 mg/kg OC respectively). In marine organisms, the highest levels (up to 1.4 mg/kg wet weight) were recorded for Beluga from the St. Lawrence river.

In discussion, it was highlighted that, as it is known that these substances are widespread in the Marine environment, the one-off survey is required to establish baseline levels in the OSPAR area against which future progress can be assessed. Several recommendations were made specific to the baseline survey for SCCPs:

- Given the difficulty of analysis and problems of between-laboratory comparability, one expert laboratory should carry out all the analysis;
- GC-NCI-HRMS currently offers the best available technique and should be used for analysis;
- Sediment is an appropriate matrix for such a one-off survey;
- Although there are no sediment CRMs available for SCCPs, within-laboratory reproducibility should be established by analysing laboratory quality control sediment materials;
- There is an urgent need for calibration standards and appropriate reference materials.

Survey strategy

Matrix

Contaminants are best measured in the matrix where they have the highest concentration. Based on the K_{OW}s in Table 1, it is expected that 2,4,6 –tri-*tert*-butylphenol, endosulphan and SCCP will accumulate in sediment organic matter. Only endosulphane has a K_{OW} that would allow it also to be measured in water. However, as this compound is sensitive to degradation, sediment is a more appropriate matrix. As also noted earlier, concentrations in sediment are higher than in the water phase. For 2,4,6 –tri-*tert*-butylphenol, the K_{OW} is the only basis for selecting sediment as a matrix. As these compounds primarily bind to the fine particles, sediment should be sieved to remove sand from it.

Biota could also be considered a suitable matrix. However, if compounds are metabolised by biota, this matrix may be less representative of their presence in the environment. Passive sampling could also be a good alternative, but these sampling methods still require some development before they can be widely used in a quality assured way. However, passive sampling is the preferred technique to find hotspots. ICES recommends using sieved sediment samples for the one-off surveys, perhaps supported by biota samples.

Sampling strategy

The DIFFCHEM survey is a good starting point for designing the One-Off surveys. The survey design for DIFFCHEM was to collect 3 samples in each estuary, separated from each other in a square of 100 × 100m. Each sample was composed of 3 subsamples in a smaller (<20m) area. This design matches well with the exploratory nature of the request for 2,4,6 –tri-*tert*-butylphenol and endosuphan. It is assumed that for this request "hotspot" is used in the context of determining which estuaries, in the OSPAR area, have the highest contamination level. Within an estuary, it may be assumed that the most likely place for hotspots is more upstream. Therefore it is suggested that the DIFFCHEM approach be extended by including two extra stations, each a square of 100 × 100m, one more upstream and one more downstream in the estuary. A steep gradient will indicate a potential upstream source or hotspot. The one-off surveys can also be regarded as pilot studies which would inform a more rigorously designed survey for hotspots.

The selection of the stations within an estuary will in principle be directed by the salinity. The general approach should be: (1) a sample at the river mouth at about 25‰, (2) in the 10-15‰ range and (3) in the upstream area near the freshwater line (0-5‰). It is clear that the local situation or knowledge may raise needs to deviate from this. A further requirement is that samples are taken at a place where the fine sediment is deposited, as the contaminants will not bind to coarse sediment or rocks.

The PAH data available from DIFFCHEM were used to establish the likely precision and power of the proposed one-off surveys. This approach assumes that the variability in the PAH data (the combined analytical and spatial variability) will be similar to the variability of the substances under investigation. The results probably represent the best precision that can be achieved, since in DIFFCHEM the samples were sieved and normalised, and analysed in one laboratory within a very short time period by the same chemist. Analysis in a central laboratory might be useful in the current exercise as well, particularly if analytical expertise is not widespread, and/or inter-laboratory QA may be difficult to establish.

Sampling areas

The selected estuaries should be the mouth of industrialised rivers and preferably be identified as transitional waters for WFD purposes. It is expected that input data from those rivers may be available subsequently through the WFD monitoring of the substances in question. For a baseline survey in the OSPAR area not only the depositional areas in the estuaries should be sampled but also depositional areas in the open sea.

The selected sampling depth may vary per estuaries. For pragmatic reasons, DIFFCHEM had selected to sample the upper 5 cm of the sediment. It is suggested that the depth representing the last 5 years of deposition would be ideal. In depositional areas this is typically 1 cm but in some estuaries this could be much more. In areas that dynamic, the upper layer is often perturbed over greater depths. In those cases, 5 cm will be the maximum sampling depth.

The following survey strategy is proposed:

- For the exploratory surveys of 2,4,6-tri-*tert*-butylphenol and endosulphan, to sample one station (3 samples) at river near the freshwater line (0-5‰)
- For the baseline of SCCP, to sample 3 stations (each 3 samples) in the estuaries. In addition 4 depositional areas in different regions of the Convention area, sampled at 3 stations (each 3 samples) representing the depositional area in the best possible way..
- If the exploratory survey confirms the presence of 2,4,6-tri-*tert*-Butylphenol or endosulphan in more than half of the cases, they can be considered diffusively spread and it is recommended to sample also the stations in the depositional areas.
- A limited search for hotspots of endosulphan could follow the same sampling scheme as used for SCCP.

Sampling locations

DIFFCHEM used samples from 23 estuaries from B, D, F, IRL, N, NL, S and UK. It is recommended that samples be collected from at least 25 estuaries, basically the 22 from DIFFCHEM and additional estuaries with industrial impact in Spain and Portugal, covering the Bay of Biscay, Cantabric Sea and the Atlantic Ocean e.g.

- Ria de Pasajes, Ria de Bilbao or Ria de Aviles for the Bay of Biscay/Cantabric Sea; and
- Ria de la Coruna, Ria de Vigo, Ria de Aveiro, Estuario do Rio Tefo, Estuario do Rio Sado for the Atlantic Ocean.

Additionally Iceland and the Arctic part of the OSPAR area should be considered for the baseline one-off survey on SCCP.

Selection of the estuaries to include can be made based on expectations of sources, such as the use of endosulphan in agriculture (Endosulphane is mainly used in southern Europe today) and for SCCPs, the presence of metal working industries. Sources are not well known for 2,4,6-tri-*tert*-Butylphenol). Local information may well be held by Contracting Parties and the final choice of estuaries to investigate should take account of this information. For the sampling in depositional areas, the prevailing current can be a basis for choosing the position of the 3 stations where samples are taken so that the best coverage of the area is obtained. In other words, the 3 stations in a depositional area should more emphasise the variability in the area rather than the similarity.

Table 1 Summary of sampling strategy

Substance	2,4,6-tri-*tert*-Butylphenol Endosulphane(2 homologues)	Endosulphane (2 homologues)	Short chained Chlorinated parafins (sCCP)
Objective of the one-off survey	Exploratory	Hot-spots	Base-line
Estuary	1 station 3# samples per station	3 stations 3# samples per station	3 stations 3# samples per station
Depositional area			3 stations 3# samples per station

each sample is composed of about 3 sub samples

Sampling method

Sampling methodology is based on the guidelines for sampling in DIFFCHEM. As stated in the survey design samples should preferably represent no more than the last 5 years of sedimentation. This may then determine the sampling depth. In areas where information on sedimentation rate is lacking or that are regularly mixed to a large depth, the top 5 cm is taken. In general, samples can be taken by a Box-corer-sampler according to the "Guidelines for the use of sediments in marine monitoring in the context of the Oslo and Paris Commissions Programmes" (A13/91-E). Samples on a tidal flat can be taken manually at low tide.

Some Contracting Parties may have more sophisticated equipment than a box corer to sample sediments and may be able to locate areas of fine-grained sediments using sonar equipment. Such techniques have been developed to identify laminated sediments that are useful to detect time trends. Pipe cores can be used to collect a very distinct layer of the sediment. The use of grab-samplers is not recommended but they can be used provided it known that the sediment is reworked continuously and no significant stratification exist.

At each station, 3 samples are taken at least 50 metres from each other in a 100 × 100m square. Such a single sample consists of at least 3 subsamples collected in about a 10 × 10m square. If using a pipe core about 3 kg of sample is required larger samples need to be taken. The intention is that the small scale variability is covered as much as possible by the sub samples. The strategy is to take fine-grained sediments as much as possible and a position should be selected within the above mentioned limits where the proportion of fine material is the highest.

The samples should immediately, preferably in the field, be screened over a 2 mm sieve to remove debris and biotic material. Some water can be used to assist this process. As long as the amount of water is limited to about 1 l water for 1 l sediment, there is no need to separate it from the sediment. Water and sediment are collected in the sample container and the water can be used for sieving (see below).

Sample handling and analysis

Storage

Samples can be stored in a 10 L polypropylene container and topped to 70% of the volume with water. The samples are frozen immediately after sampling and delivered in frozen condition to laboratory to do the sieving. The seawater that was added is used for the sieving to avoid any chemical transformations during the sieving process caused by salinity change. The polypropylene containers are not optimal but necessary to guarantee safe transport. Theoretically, some contaminants may be adsorbed to the wall of the container. This process is however slow and is still slower in frozen samples, emphasizing the need for immediate freezing.

Sample handling in the laboratory

For sieving, the wet sieving (<63µm) procedure as used in DIFFCHEM must be applied. By weighing both the dried fractions obtained from sieving the amount of fines should be determined. After sieving, the samples are freeze-dried. Precautions should be taken to avoid cross contamination and Quality Control procedures should be applied to monitor for it. After freeze-drying, the samples need to be homogenised using a ball mill. The samples should then be stored at -20°C. Subsamples are used for analyses of the requested parameters and co-factors.

Sample analysis

One laboratory should be selected for each substance, according to well or best established analytical expertise for the substance(s) in question, including formal accreditation and participation in inter-comparison exercises. Considering that "new" compounds are involved, it cannot be expected that laboratories will be accredited for the compounds in question. The laboratory should however in some way have demonstrated that they are competent and can provide evidence of the quality of their analyses.

For endosulphan the analytses should include both homologues, endosulphan-α and endosulphan-β as well as the degradation product endosulphanesulfate. TOC must be measured in the sieved sediment as well as in the original sample material. Additional supporting information is smell, any apparent layers in the sediment, biota present in the sediment, and any other properties recommended in the OSPAR guideline.

The demand on detection limits for the different substances to be fulfilled by the laboratories is indicated in Table 3. When quality criteria are only available for water, detection limits in water are used to estimate detection levels required for sediment.

Table 2 Suggested quality parameters for analytical methods

Substance	Detection Limit Sediment	Detection Limit water	Uncertainty (RSD, 10x DL)
2,4,6-tri-*tert*-Butylphenol	0,02 µg/kg[3)]	<1 ng/l[3)]	<10%
Endosulphane	0,02 µg/kg	0,5 ng/l[1)]	<10%
SCCP	3 µg/kg [4)]	10 ng/l[2)]	<10%

1) 10% of German water quality criterion
2) 10% of EQS proposed in WGMS05-10-08SCCP
3) Expected concentrations could be lower as this is a low volume substance, no data on concentrations available
4) DL known to be achievable

These constraints are based on the expected concentration levels (or 10% of the EQS or other quality parameter), but could be difficult to attain with current analytical techniques.

References

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Nicholson M. Barry J (accepted 2005) Target detection from a classical and a Bayesian perspective. *Journal of Applied Statistics*, to be published.
ICES. 2005. Report of the ICES Marine Chemistry Working Group. ICES CM 2005/E: 03.
ICES. 2005. Report of the ICES Working Group on Marine Sediments in Relation to Pollution. ICES CM 2005/E: 01.
ICES. 2005. Report of the ICES Working Group on Statistical Aspects of Environmental Monitoring. ICES CM 2005/E: 02.

2.2.7.2 Quality assurance of biological measurements in the Northeast Atlantic

Request

ICES operates a joint ICES/OSPAR Steering Group on Quality Assurance of Biological Measurements in the North East Atlantic (SGQAE) in order to coordinate the development of QA procedures and the implementation of QA activities required for the implementation of the JAMP.

Recommendations and advice

ICES recommends to OSPAR that:

- OSPAR Member Countries should be urged to participate in BEQUALM, since the present lack of international participation in BEQUALM indicates that the scheme does not fulfill its role in international QA.
- As the current JAMP guidelines for benthos, phytoplankton, and chlorophyll do not meet current QA standards, OSPAR should consider a prompt review of these guidelines to ensure that they meet current international standards.
- OSPAR should ask their contracting parties to provide specific information on the use of guidelines and standards by the laboratories contributing data to national monitoring schemes. SGQAE offered a questionnaire to help collect relevant information. SGQAE would review the results at its 2006 meeting.
- OSPAR should circulate the SGQAE guidance on quality considerations relating to the testing and use of EcoQO and other biological indicators (Annex 10, SGQAE 2004) to the groups developing EcoQOs, requesting feedback on its content and applicability for SGQAE to consider in 2006.
- Specific information on the proposed QA measures to be adopted for EcoQOs should be gathered from the relevant drafting groups, and this information provided to SGQAE for review in 2006.
- OSPAR should consider the aligning of the measures proposed for EcoQOs with the emerging assessments under the Water Framework Directive.

Summary

More detailed information about the treatment of various requests from OSPAR can be found in the 2005 report of the ICES/OSPAR Steering Group on Quality Assurance of Biological Measurements in the Northeast Atlantic. The OSPAR-proposed terms of reference are treated in the following sections of this report: a) section 13; b) section 14; c) section 15; d) section 9; e) section 16.

Source of information

The 2005 report of the ICES/OSPAR Steering Group on Quality Assurance of Biological Measurements in the Northeast Atlantic (ICES CM 2005/ACME:03).

2.2.7.3 Scientific aspects of risk management of ballast water

Request from OSPAR

This work was initiated by ICES in response to the OSPAR request on Risk Management of Ballast Water (OSPAR 2005/5), which asks to consider the scientific aspects of risk management of ballast water by:

i. comparing and evaluating existing risk assessment and management approaches applicable to ballast water and their interlinkages, as exemplified by GloBallast risk assessments, the Australian DSS, the EMBLA system being developed by Det Norske Veritas (Norway) and the Slovenian risk assessment approach,

ii. considering how to develop:

1. *criteria for the ranking of risks, i.e. to enable the determination of the likelihood of organisms transferred from one marine area surviving if transferred to another marine area (e.g. from tropical waters to the North Sea), or the likelihood of organisms surviving in ballast water / ballast tanks (for the duration of a voyage or between exchanges of ballast water/ cleaning of ballast tank sediment). Ultimately this should provide criteria for identifying "high risk" ballast water;*
2. *techniques for the rapid detection of non-indigenous species and for the possible containment/eradication of organisms transferred through ballast water and by other vectors. In this respect consideration should be given to sampling techniques and strategies.*

Recommendations and advice

ICES recommends that OSPAR considers the development and use of environmental matching and species-specific risk assessment approaches for the determination of low-risk exemptions under Regulation A-4 of the recently adopted IMO Ballast Water Management Convention (see Summary).

Based on discussions around these risk assessment approaches, ICES was not able to provide clear recommendations on criteria for identifying "high risk" ballast water. However, ICES recommends that, if risk-based exemptions are granted by OSPAR and other Member Countries under Regulation A-4, their application should be limited to transits between ports located within areas that are characterized by a high degree of similarity in aquatic animal and plant species. However, the determination of an acceptable system documenting biological separation between coastal regions for the purpose of ballast water risk-based exemptions requires further scientific discussion within ICES and Member Countries.

Summary

ICES made significant progress in addressing scientific aspects of ballast water risk management through completion of a comparison and evaluation analysis of various risk assessment methods that are being developed or used around the world. According to this analysis, several types of risk assessment have been conducted on ballast water with varying scales of assessment and objectives. As a result, discussions within ICES focused mostly on the recently implemented IMO Ballast Water Management Convention, under which some provisions require a risk-based ballast water management approach. In particular, Regulation A-4 of this Convention allows Parties to exempt vessels from compliance to ballast water management procedures prior to discharge if an acceptably low risk can be discerned. ICES considers that the risk assessment to support an exemption must be able to determine the likelihood of an unmanaged ballast water discharge causing at least one new species to be introduced into the receiving port. Two types of risk assessment are likely to achieve the stated goal:

- Environmental matching risk assessments which compare environmental conditions in the donor and receiving port to determine if they are sufficiently different that any species found in the source port are unlikely to survive in the receiving port; and
- Species-specific risk assessments which consider information about individual species and the environmental conditions in the receiving port.

In addition, under the IMO Ballast Water Management Convention, an exemption can be granted for up to five years for a ship that operates within a specified transit between two or more ports. While it was noted that states should inform neighbouring states when an exemption is granted, ICES concluded that the only biologically defensible means to support an exemption over such a time period would be to limit its application to transits between ports located within a single bio-province (eco-zone). ICES also concluded that there is a need to review risk-based exemptions on a regular

basis because of the current rate of invasions in many regions of the world (e.g. a newly introduced species was recorded every seven months in the North Sea and adjacent water bodies since the 1950s).

Some progress was made by ICES on the development of criteria for the determination and/or ranking of risks, mainly with respect to the two risk assessment approaches mentioned above. Some limitations or caveats were provided with regards to the use of environmental matching and species-specific risk assessment methods in support of Regulation A-4 of the IMO Ballast Water Management Convention. More specifically, it was concluded that Regulation A-4 exemptions should only be based on environmental matching risk assessments between freshwater (< 0.5 psu) and fully marine environments (> 30 psu), and on species-specific risk assessments for voyages within the same biological province. Under these limitations, environmental matching risk assessments should include spatio-temporal comparisons of salinity, as well as an assessment of native, cryptogenic or non-indigenous species that can tolerate wide ranges of salinity (euryhaline, diadromous species). As for species-specific assessments within a biological province, they should target non-indigenous and cryptogenic species in all port for which the exemption is sought as well as native species only present in the source ports, including those that may have socio-economic impacts. Based on these conclusions, a system that documents biological separation between coastal regions is needed to support ballast water risk assessment and related management. ICES recognizes the fact that several classification systems exist and no single system is sufficient for all species in all habitats (benthic, pelagic or neritic).

The issue of rapid detection of non-indigenous species was not addressed by ICES. However, ICES recognises that early detection of non-indigenous species and pursuant actions requires information about species distribution in coastal and port waters of ICES Member Countries. ICES agrees that a sampling or monitoring strategy is needed in this regard and proposes to review existing or developing sampling and monitoring strategies for non-indigenous species in order to recommend possible actions.

Scientific background

Scientific discussions around risk assessment approaches and methodologies focused on the views and philosophies relating to the benefits of applying risk assessment and risk management principles to ballast water management versus taking a "blanket", all-encompassing approach. In general, two different assessment philosophies have been developed: risk assessment versus hazard assessment. A hazard assessment will allow management (or control) based on a ranking exercise, but not on a vessel by vessel basis. A risk assessment allows a single vessel or ballast tank to be evaluated and subject to management (or control). Table 2.2.7.3.1 summarises ten risk assessment initiatives that were considered by ICES and for which the information was available. It should be noted that this table only covers the management of vessels (including ports and shipping routes). Other risk assessment methods are being used in Member Countries and around the world to identify ballast exchange areas, target species, etc.

Source of information

Report of the Working Group on Ballast and Other Ship Vectors (WGBOSV) (ICES CM 2005/ACME:04) and ACME deliberations.

Table 2.2.7.3.1 Comparison of selected risk assessment initiatives relevant to vessel management (References at end of table). DSS = Decision Support System.

Risk assessment initiative	Management unit	Assessment unit	Assessment based on	Approach	Environmental variables	Endpoint	Temporal resolution	Purpose	Date
Germany (Gollasch, 1996)	Target species (varies)	Region	Environmental matching between localities	Qualitative	2	Hazard assessment	Annual	Risk identification for species invasions in German coastal waters	1992–1996
AQIS 1994	Target species (2)	Target species (2)	Species based tolerance, volume of ballast discharged and bloom dynamics	Quantitative	1	Estimate economic impact of toxic dinoflagellates on aquaculture, tourism, etc.	Annual	Estimate cost of toxic dinoflagellate introductions in Australian waters	1994
Australian DSS (Hayes and Hewitt, 1998, 2000)	Routes	Target species (8+)	Models four steps in the bio-invasion process: donor port infection, vessel infection, journey survival, and survival in the recipient port	Quantitative	1	Target species life cycle completion in recipient port	Month	Identify low risk routes, vessels and tanks	1997– ongoing
NORDIC countries (Gollasch and Leppäkoski, 1999)	Target species (varies)	Port	Environmental match between donor and source localities	Qualitative	5	Hazard assessment	Annual	Risk identification for species invasions in NORDIC countries	1998–1999
EMBLA	Target species	Target species (various)	Models four steps in the bio-invasion process: donor port infection, vessel infection, journey survival, and survival in the recipient port	Quantitative	2	Target species life cycle completion in recipient port	Month	Identify low risk routes, vessels and tanks	1998– ongoing

Risk assessment initiative	Management unit	Assessment unit	Assessment based on	Approach	Environmental variables	Endpoint	Temporal resolution	Purpose	Date
GloBallast	Routes	Port	Environmental matching between localities, weighted by target species presence in the donor location and inoculation factors	Semi-quantitative	37	Identify and rank high and low risk ports	Annual	Enhance awareness and recommend ballast water management strategies	2000–2004
Slovenia	Vessels	Vessel + Target species	Four step assessment of the bio-invasion process: donor port infection, journey survival, survival in recipient port, and potential to cause harm in recipient port	Quantitative ~ qualitative	2	Identify and rank high and low risk ports as well as high risk target species	Annual	Vessel-to-vessel assessment from low to high risk ballast water before discharge for ballast water management purpose (DSS)	2001– ongoing
Canada 1 (MacIsaac *et al.*, 2002)	Vessels	Target taxa	Species-based tolerance, and taxa concentrations in no ballast on board vessels (NOBOB)	Quantitative	2+	Journey survival of target species		Estimate risk associated with NOBOB vessels entering the Great Lakes	2002
Finland (Bitis)	Port	Port	Environmental match between donor and source localities	Qualitative	2	Hazard assessment	Seasonal	Create baseline knowledge on the risks associated with NIS and shipping	2003–2005
EMBLA (Croatia)	Routes	Routes	Locality-based region and species tolerances	Qualitative	1	Hazard assessment	Seasonal	Recommend ballast water management plan for Croatia	2004–2005

References

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Gollasch, S 1996. Untersuchungen des Arteintrages durch den internationalen Schiffsverkehr unter besonderer Berücksichtigung nichtheimischer Arten. Diss., Univ. Hamburg; Verlag Dr. Kovac, Hamburg, 314 pp.

Gollasch, S & Leppäkoski E 1999. Initial risk assessment of alien species in Nordic coastal waters. 1-124. In: Gollasch, S. & E. Leppäkoski (eds.) Initial risk assessment of alien species in Nordic coastal waters. Nord 1999: 8. Nordic Council of Ministers, Copenhagen. 244 pp.

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MacIsaac HJ, Robbins TC & Lewis MA 2002. Modelling ship's ballast water as invasion threats to the Great Lakes. Canadian Journal of Fisheries and Aquatic Sciences, 59: 1245-1256.

2.2.7.4 Review of the outcome of the ICES/OSPAR Workshop on the development of guidelines for integrated chemical and biological effects monitoring

Request

Item 6 of the 2005 Work Programme from the OSPAR Commissions to:

- Review the outcome of the ICES/OSPAR Workshop on the development of guidelines for integrated chemical and biological effects monitoring, and finalise the guidelines;
- Follow up on the outcome of the ICES/OSPAR workshop to resolve any outstanding issues and finalise a set of draft guidelines for presentation to the relevant OSPAR Committee for adoption.

Recommendations and advice

ICES supports a second ICES/OSPAR Workshop on Integrated Monitoring of Contaminants and their Effects in Coastal and Open-Sea Areas (WKIMON), scheduled for January 2006 at ICES HQ, Copenhagen, Denmark, aiming at the further development of guidelines for integrated monitoring. The detailed comments and recommendations provided by WKIMON and ICES Expert Groups should be taken into account in the planning of the workshop and when finalising the programme for the workshop, this being scheduled for completion by 30 September 2005[1].

It is further recommended that, as a first step, the draft guidelines should focus on those techniques that are included in the OSPAR Coordinated Environmental Monitoring Programme (CEMP).

ICES emphasises that the development of strategies and guidelines for integrated monitoring is considered to be a complex task and should be seen as a dynamic process requiring considerable further work.

Summary

The ICES/OSPAR Workshop on Integrated Monitoring of Contaminants and their Effects in Coastal and Open Sea Areas (WKIMON) took place 10-13 January 2005 at ICES HQs, Copenhagen, Denmark. The workshop was co-chaired by K. Hylland (Norway) (Chair of the ICES Working Group on Biological Effects of Contaminants, WGBEC) and R. Law (UK) (Chair of the ICES Marine Chemistry Working Group, MCWG) and was attended by 22 participants representing various ICES Expert Groups, OSPAR and the ICES Secretariat.

The WKIMON Terms of Reference were as follows:

develop guidelines for integrated biological effects and chemical monitoring, including:

i) specific guidelines for the integration of chemical and biological effects techniques with special emphasis on those parameters that have become mandatory in the OSPAR Coordinated Environmental Monitoring Programme;
ii) guidelines towards integrated chemical and biological effects monitoring for the entire range of issues in the OSPAR Joint Assessment and Monitoring Programme.

Based on the review of the outcome of the ICES/OSPAR Workshop on Contaminants and their Effects in Coastal and Open Sea Areas (WKIMON) as well as on comments to the report provided by relevant ICES Expert Groups (see below) the following was concluded:

- ICES strongly supports the concept of the integration of monitoring efforts on contaminants and their effects. The development and implementation of appropriate guidelines is considered to be a complex task to be seen as a dynamic process, requiring further collaborative work by ICES and OSPAR Expert Groups.
- The WKIMON Workshop is considered successful in that it brought together specialists from various ICES and OSPAR Expert Groups and disciplines, discussing the issue of integrated monitoring and formulating the general approach and the basic requirements for integrated monitoring as part of the OSPAR CEMP/JAMP. Furthermore, the development of guidelines was started.
- The draft guidelines developed so far by WKIMON have to be further elaborated since, for certain elements, they are considered insufficient. Therefore, ICES supports the plan to hold a second workshop in

1 Preliminary Terms of Reference were drafted at the OSPAR Working Group on Concentrations Trends and Effects of Substances in the Marine Environment (SIME). These were reviewed and amended by the OSPAR Environmental Assessment and Monitoring Committee (ASMO) at its meeting in April 2005. The terms of reference are presented at Annex 10 to the ASMO Summary Record and are available at www.ospar.org.

January 2006 and welcomes the Terms of Reference as detailed in Annex 10 of the Summary Record of ASMO 2005.

- It was noted that the SIME Vice-Chairman (assessment) will convene an intersessional drafting group to merge the current JAMP Guidelines for monitoring contaminants in biota and sediment and JAMP Guidelines covering the use of biological effects techniques. It was further noted that on this basis of this work, the drafting group, together with the SIME Chairman and Vice-Chairman (monitoring) will draw up a detailed programme for WKIMON 2006
- ICES Expert Groups provided detailed comments on the WKIMON Report and suggestions for amendments of the draft guidelines, and WKIMON itself generated a number of general and specific recommendations and identified actions to be taken. These should be considered at the 2006 WKIMON Workshop.
- In the first run, the further development of the draft guidelines should be focused on those techniques that are included in the OSPAR Coordinated Environmental Monitoring Programme (CEMP) to be monitored on a mandatory and voluntary basis.
- For this purpose, the existing JAMP Guidelines/Technical Annexes for the CEMP chemical monitoring and general as well as contaminant-specific biological effects monitoring need to reviewed and harmonised as appropriate in the light of the requirements of integrated monitoring. At its 2005 meeting, the ICES WGPDMO has already reviewed the disease-related JAMP guidelines for general and PAH-specific monitoring and has suggested some amendments (see Technical Annex).
- For some of the CEMP techniques there is still a lack of quality assurance or assessment criteria and there is a need to develop assessment criteria specifically tailored to the requirements of integrated monitoring. In this context, it was emphasised that attempts should be made to define background reference levels for biological effects covered by the CEMP.

Scientific background

Detailed information can be found in the reports mentioned under Sources of information.

Sources of information

Report of the ICES/OSPAR Workshop on Contaminants and their Effects in Coastal and Open Sea Areas (WKIMON). ICES CM 2005/ACME:01.

Report of the Working Group on Biological Effects of Contaminants (WGBEC). ICES CM 2005/E:08.

Report of the Marine Chemistry Working Group (MCWG). ICES CM 2005/E:03.

Report of the Working Group on Marine Sediments in Relation to Contaminants (WGMS). ICES CM 2005/E:01.

Report of the Working Group on Pathology and Diseases of Marine Organisms (WGPDMO). ICES CM 2005/F:02, Section 13 and Annex 9.

2.2.7.5 Assessment of the long term impact of oil spills on marine and coastal life

Request

OSPAR has made a direct request to ICES for advice on assessment of the long term impact of oil spills on marine and coastal life. Specific advice is sought on the following:

- The distinction between the effects of the oil and what is caused by natural changes;
- The impacts of oil on different types of habitats (i.e. the nature of the coastline) and ecosystems (variability in rates of recovery);
- The impacts of different types of oil, both toxic impacts (toxic effects and accumulation) and non-toxic impacts (physical properties creating nuisance and hazardous conditions – physical contamination and smothering);
- The impacts of remedial activities such as the use of heavy equipment and high pressure hosing to clean oil spills;
- Whether the current framework of environmental risk assessment and toxicology is sufficient to take account of the long term effects of oil pollution.

OSPAR would like to have the material for presentation to the North Sea Intermediate Ministerial Meeting to be held in April 2006.

Recommendations and advice

Although many lessons have been learnt from previous oil spills it is apparent that the number of variables, including the characteristics of the oil, the environment into which the oil enters, the time of year and prevailing weather conditions, means that each event is, to an extent, unique. However, there are some common issues which arise repeatedly such as being able to identify the background concentration and composition of PAHs in local sediments and biota.

- ICES recommends that OSPAR puts in place the criteria that will allow the full range of oil-associated PAHs to become mandatory determinands within the CEMP.
- ICES recommends that OSPAR develops proactive monitoring schemes in areas vulnerable to oil spills so as to provide relevant background information. This should include mapping of sensitive areas.
- ICES recommends that OSPAR liases with groups developing the monitoring programmes for the EU Water Framework Directive on the issue of long-term assessment of impacted water bodies.
- ICES recommends that OSPAR collects data on human impacts and also long-term impacts of acute effects so as to inform oil spill response methodology.
- ICES recommends to OSPAR and Member Countries that basic research be undertaken into the association between the biochemical observations made during an oil spill event and subsequent observations on pathology, reproduction and survival in marine organisms made in the long term.
- ICES recommends to Member Countries to test whether current clean-up and oil-spill remediation is sufficient to match the ecological requirements for a long-term restoration process with regard to oil pollution.

Summary

Large oil spills, as exemplified by the *Exxon Valdez*, *Braer*, *Sea Empress*, *Erika*, *Prestige* and *Tricolor/Vicky*, attract considerable media attention and are invariably described as environmental disasters. The response of the competent authorities is to initiate a monitoring programme which focuses on the polycyclic aromatic hydrocarbons present in crude oils and their refined products. The objective of the response is to prevent contaminated food products reaching the market place and to assess the environmental impact of the spill. In the short term, when PAH concentrations are generally high and readily measured in water, biota and sediments, a considerable amount of data is generated. Furthermore, at this stage in a monitoring programme, biological signals are often definitive. However, as the oil weathers and the lighter PAHs evaporate, as concentrations decrease and as exposed populations are replaced by e.g. recolonisation, so signals become less clear, concentrations approach 'background', natural variability in biological effects and seasonality in contaminant concentrations become significant and there is a distinct lack of clarity in assigning observed data to a specific incident. What this means is that assessing the long-term impacts of an oil spill is very difficult. However,

- Improved spatial and temporal measurement of relevant PAHs (2- to 6-ring, parent and branched) should provide reference data which can be used to develop Background Concentrations (BCs) and Background Assessment Concentrations (BACs) which can then be used to assess the status of the impacted area.
- Many of the biological effects measurements are indicative of recent exposure and their relationship to the development of pathological lesions or even population effects is poorly understood.

- 'Oil' is not a simple material and can vary with respect to both its physical and chemical characteristics further complicating the assessment of the long-term impacts of an oil spill event.
- The prevailing weather and location of an oil spill can have a significant bearing on what happens to the oil and so its impact.
- There is no clear correlation between tonnages and impacts. In addition, impacts will vary with time of year, weather, breeding season (specifically related to birds) etc.

Thus a multi-factorial approach is required to properly describe an event.

Scientific background

The distinction between the effects of the oil and what is caused by natural changes

When oil is released into the marine environment there follows a range of impacts, some visible, (e.g. the oiling of seabirds), some only identifiable through detailed scientific experimentation. Often the initial investigations are for the purpose of introducing a fisheries exclusion order so as to prevent contaminated food products reaching the market place as against making an environmental assessment of the impact of the spill. At this stage the concentrations of the polycyclic aromatic hydrocarbons (PAHs) in the biota can be high and there is a clear indication, through the PAH composition, that the impact on the biota is a result of exposure to oil. This effect on fish and shellfish can be assessed using sensory assessment or else by gas chromatography-mass spectroscopy, collecting detailed information on 2- to 6-ring parent and branched PAHs. When the PAH concentrations are high, when a taint is detected by the sensory panel, when relevant PAH metabolites are detected in fish bile and when geochemical biomarkers produce a clear petrogenic signal, the problems of ascribing the observations to the incident are limited. However, even in large incidents such as the *Braer* oil spill, taint in wild fish, and indeed in farmed fish impacted by the event, is of limited duration. As time passes, PAH concentrations in biota decrease as do the biochemical responses typically measured following an oil spill event. Several approaches have been adopted to investigate longer term impacts on biota:

1. continuous monitoring of *in-situ* biota,
2. the introduction of shellfish from a recognised reference location to the impacted area.

Regardless of which approach is used, the biota will be subject to seasonal variations as well as chronic exposure typical of the specific geographical location. There may also be minor acute incidents or else re-exposure from 'reservoirs' following e.g. a severe weather event which may be evident as a spike in PAH concentration. In this context there is clearly a need to analyse the 2- to 6-ring parent and branched PAH and to report both concentration and composition. Currently, the full range of PAHs is not mandatory within the OSPAR CEMP and as such this data is not contained within the ICES website. There is also a need to establish:

- background concentrations (BCs) and background assessment concentrations (BACs) for relevant PAHs; and
- background levels of the various effects measurements resulting from exposure to PAHs.

This is needed so as to ensure that the relevant information is available to enable the competent authorities to make the appropriate decisions following a marine incident such as an oil spill. A repeated comment from ICES Expert Groups is that there is a lack of background data making it difficult to properly assess when an environment has returned to its pre-spill condition.

Understanding the broader environmental and ecological significance of an oil spill requires an investigation of sediments and a broader range of biota. As far as sediments are concerned, areas of sedimentary deposition can be both coastal and offshore with oil being carried some distance from, what is in effect, a point source discharge. BCs and BACs have been described for selected PAHs in sediment[1]. Although the list includes those PAHs which are of concern due to their known toxicity, it does not include those PAHs which are dominant in crude oils (i.e. 2- and 3-ring branched compounds). In the short term, the contamination will be within the surface sediments. However, over time this will change due to bioturbation, sedimentation etc, the rate of change varying depending on local circumstances. As such, sampling the surface may not provide a true indication of the state of the seabed in the longer term and so taking both core and surface samples should be encouraged.

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[1] PAHs are determined in biota (fish and shellfish (mussels)) and sediments as part of the OSPAR Coordinated Environmental Monitoring Programme (CEMP). For the purpose of OSPAR, the PAHs measured are: anthracene; benz[*a*]anthracene; benzo[*ghi*]perylene; benzo[*a*]pyrene; chrysene; fluoranthene; indeno[123-*cd*]pyrene; pyrene; phenanthrene.

Many of the biological effects measurements made following an oil spill, e.g. EROD, bile metabolites, DNA adducts, are indicative of recent exposure. Interpretation of e.g. EROD can be further complicated by sex, season and the fact that the response is not specific to PAHs. Thus interpretation of such measurements should be done in association with other parameters.

An issue which has to be addressed is the provision of a definition for long-term. For biota, several studies have indicated that a period of two – three years is appropriate for recovery. Certainly monitoring of EROD levels at the two main areas of oil deposition (Burra Haaf and south east Fair isle) from the *Braer* indicated that by 1996, and on subsequent occasions, the levels had fallen to those found at sites not impacted by the oil spill. Both the fish and shellfish monitoring programme and a range of biological effects studies showed that the demonstrable effects of the *Sea Empress* spill were over within two years. Indeed within little more than a year, the contribution of 2- and 3-ring PAH to the contamination of shellfish tissues had returned to the presumed background concentrations prior to the spill and had been replaced by a seasonal cycle of 4- to 6-ring PAH. A 100% mortality was observed for the sea urchin (*Paracentrotus lividus*) consequent on the oil from the *Erika*. Comparable densities to the reference state were observed in the impacted inter-tidal pools after three years.

The relatively short timescales detailed above are to be contrasted with sedimentary deposits which can have a much longer life, especially in low temperature, low energy environments or where the impacted sediments are buried. A sediment survey in the Burra Haaf in 2003, 10 years after the *Braer* oil spill, has shown there to have been movement of the Gullfaks oil downcore. Re-exposure from such 'reservoirs' is always a possibility. However, differentiating between resuspension and a minor event is not easy. Furthermore, as contaminant concentrations reach pre-spill concentrations there is the issue of separating any effects from the spill versus on-going, chronic concentrations. There are areas where there is good pre-spill environmental reference samples, but these are rare.

The bulk of the discussion has focussed on the organic component of an oil and, in reality, a sub-set of the organic component; the PAHs. Crude oil is a mixture of many organic compounds, some of which are heterocyclic. In addition, there are inorganic components. Vanadium and nickel in scallop shells and soft tissue were studied as part of the scientific investigations following the *Erika* oil spill with a peak in V concentrations observed 5 months after the accident. A similar time delay for maximum V concentrations was observed in mussel soft tissue examined as part of the monitoring programme following the *Prestige* incident.

Thus, from a scientific perspective, there are many issues which have to be considered, but the overarching issues is being able to differentiate, in the long-term, between the impacts of the oil spill and chronic or localised small events

The impacts of oil on different types of habitats (i.e. the nature of the coastline) and ecosystems (variability in rates of recovery)

The Working Group on Seabird Ecology (WGSE) produced a useful overview of the impacts of recent major oil spills on seabirds. Seabirds are highly vulnerable to oil pollution and hundreds of thousands of seabirds die annually as a result of oil pollution in the North Atlantic alone (Camphuysen 1989; Wiese 2002; Wiese and Ryan 2003). However, oil-induced mortality is surprisingly difficult to assess and few studies have succeeded in identifying changes in population parameters, such as trends in population size, caused by the effect of a given spill.

Seven oil spills in Western Europe have been analysed, some of which caused substantial wildlife casualties, others of which did little (recorded) damage to seabirds. Among these were tanker incidents (*Amoco Cadiz, Braer, Sea Empress, Prestige, Erika*), an incident with a car carrier (*Tricolor*), and a deliberate discharge (*Stylis*). The spills were evaluated in terms of amount of oil spilled, distance to the coast, seabirds present during the event, timing in the annual cycle of the (main) victims, number of casualties counted and number of casualties estimated to have died.

There was no positive correlation between the number of casualties counted and the amount of oil spilled. Some spills occurred in areas that were known to be very vulnerable to oil pollution from seabird at sea censuses in the area (e.g., *Tricolor* spill; Carter *et al.*, 1993), others took place in areas of unknown sensitivity (no recent at-sea surveys available), but numerous casualties were recovered, possibly partly because the oil travelled a long way before it reached the coast, sweeping vast sea areas clear of birds (e.g., *Erika* and *Prestige* spills).

The spills were different in their impact on resident seabirds (local breeding populations) and wintering birds (breeding elsewhere). The *Amoco Cadiz* spill, for example, affected wintering seabirds such as common guillemots, razorbills and divers Gaviidae, but also substantial numbers of European shags that were locally breeding. Atlantic puffins, the main casualties, originated from breeding colonies in the UK as well as from the local population (Jones *et al.*, 1978; Monnat 1978). The *Braer* incident on the south tip of Shetland in 1993 mainly affected resident birds, notably black guillemots and European shags (Heubeck *et al.*, 1995). The *Erika* off Brittany killed a very large number of guillemots, and while there is a local breeding population, at least according to numerous ringing recoveries a large proportion (if not the majority) of these birds were wintering visitors nesting further to the north, such as within the UK and on Helgoland

(Germany). Common scoters killed in the *Sea Empress* incident probably mainly originated from the distant Scandinavian breeding population. The *Tricolor* spill killed virtually exclusively wintering birds, notably common guillemots and razorbills (Stienen *et al.*, 2004; Grantham 2005; Camphuysen and Leopold 2005), whereas the *Prestige* kill involved a mixture of local residents and wintering individuals (García *et al.*, 2003).

The evaluation of recent oil spills resulted in some important conclusions. Of seven oil spills examined, the amount of oil spilled ranged from 170 tonnes (*Stylis*) to 223,000 tonnes (*Amoco Cadiz*). The number of casualties recorded, varied from 1800 (*Braer*) to 45,000 (*Stylis*). Most spills took place in winter or in the pre-breeding season, and most events affected winter visitors breeding elsewhere.

There was no positive correlation between the amount of oil spilled and the number of casualties recorded. Some of the smaller spills caused major mortality. There is a large difference in the sensitivity of different sea areas with regard to surface pollutants, and these differences were in part responsible for the observed variability in the impact on seabirds.

In the case of acute oil contamination, particularly following a large spill, there are clear ecological effects on the benthos (Dauvin, 1982, 2000; Elmgren *et al.*, 1983; Jewett *et al.*, 1999; Peterson, 2001; Peterson *et al.*, 2003; Sanders *et al.*, 1990). In a situation with chronic exposure to oil, however, in combination with other discharges and emissions (e.g., around harbours), it is much more difficult to distinguish the cause of changes in benthic communities and to separate oil impacts from natural variability.

The impacts of oil will vary dependent on the nature of the coastline and local environment (e.g., *Prestige* vs. *Exxon Valdez* oil spill: Sánchez *et al.*, 2003, 2004; Jewett *et al.*, 1999). Effects on soft bottom communities might be different from effects on hard bottom communities, and quite big geographical and temporal variability in the benthic communities exists due to climatic variations.

In different marine regions climatic and hydrographical regimes will vary and this in turn will affect the nature of impact and the recovery process from oil spills. For example, in more exposed areas with dynamic regimes, oil will be dispersed more quickly and over a greater area. ICES suggests that there is a need to evaluate variation of impacts by marine region and that a review is prepared comparing the results of the monitoring studies from a variety of regions of varying climatic influence.

The impacts of different types of oil, both toxic impacts (toxic effects and accumulation) and non-toxic impacts (physical properties creating nuisance and hazardous conditions – physical contamination and smothering);

Many factors affect the impacts of the different types of oil. This is in part a consequence of the fact that spilt oils vary widely in their physical and chemical properties, and in their toxicity. In addition, higher air and water temperatures and higher wind speeds increase evaporation while lighter oils evaporate easier and faster than the heavy oils. The greatest toxic damage has been produced by lighter oils in more enclosed areas. There is some information within the 2005 report of the Benthos Ecology Working Group (BEWG) specifically comparing the effects of the *Aegean Sea* and the *Prestige* oil spills. These studies showed very clearly that impacts vary significantly with the type of oil. The *Aegean Sea* was carrying Brent oil which has a high toxicity and solubility. This caused mortality and spread very quickly around the immediate area. However, the oil from the *Prestige* was much less soluble than the Brent oil carried by the *Aegean Sea*, was very dense and had a high tar content. The impacts were limited to direct contact of the oil with organisms in the surrounding environment.

The impacts of remedial activities such as the use of heavy equipment and high pressure hosing to clean oil spills

The impacts of remedial activities can be quite significant. During the response to the *Prestige* spill, the supralitoral and adlitoral areas suffered severe impact derived from the cleaning procedures, over and above the impact of the fuel. The lack of initial guidance in how to proceed and of pre-designed protocols contributed to the impact, specifically in the LICs (Places of Community Importance) of the Nature Net and some other protected areas. The use of heavy equipment on beaches, paths and through the dune system, storing fuel in dunes, indiscriminate opening of paths, sieving of the beach sand and hydrocleaning all contributed to the impact. Annual communities of the beaches first flora belt, such as *Honkenyo-Euphorbietum* and *Cakiletea*, were completely destroyed or fragmentised on some beaches, generally due to the cleaning procedures.

Two of these interventions were especially damaging. Sieving of the beach sand severely affected the intertidal infaunic communities as it removed animals with the fuel, some of which were feeding on the dead algae and animals. In addition, the mechanical effect of sieving helped to break the fuel into small particles, which were not easily seen However, people walking on the beach for leisure purposes or else while collecting samples picked up contamination on their feet.

The hydrocleaning used following the *Prestige* oil spill used hot, fresh water while the sorbent propylene layers were not always, or were improperly, used. As a consequence of this, the fuel removed from the rocks by the cleaning process sometimes went back into the seawater. The use of hydrocleaning in rocky substrates removes not only the fuel, but plants and Cirripides exoskeletons such as *Chthamalus* spp. Consequent on this was that settlement was slowed down.

Bioremediation following the *Prestige* was used in only a few specific areas where mechanical cleaning could not be done. The results were worse than expected, increasing the speed of degradation by only about 20% at best. The capacity of retention of nutrients and microbiota, as well as the aging of the fuel, seemed to be some of the key factors affecting the success of this treatment.

Is the current framework of environmental risk assessment and toxicology sufficient to take account of the long-term effects of oil pollution?

At present the requirements for monitoring of coastal waters under the EU Water Framework Directive are still being developed. However, WFD monitoring is, by its nature, long-term. If over a period of time the status of a water body changed as a result of a degradation in ecological quality, then it is likely that investigative monitoring would be initiated. This may make the reasons for the change in status more explicit and enable an association to be made with an historical event such as an oil spill.

There is a lack of clarity regarding the specific nature of the 'current framework', a point emphasized by some of the Working Groups that reviewed this topic. However, after each major oil spill, there often follows a set of recommendations and these can include guidance on long-term monitoring. Recommendations produced following the *Prestige* oil spill include a suggestion of any study lasting not less than 3 – 6 years as this time frame is required to take account of long-term fluctuations of benthic systems.

Seasonal variation and differentiating between the effects of chronic contamination and the effects of the oil spill, especially in the longer term when contaminant concentrations from the spill diminish, are common themes. There is a need to review all the available information, to compare similar spills (quantities and nature of oil) in a number of different habitats and to better describe background concentrations.

Source of information

The 2005 reports of the ICES Working Group on the Biological Effects of Contaminants (WGBEC), the ICES Marine Chemistry Working Group (MCWG), the ICES Working Group on Integrated Coastal Zone Management (WGICZM), the ICES Benthos Ecology Working Group (BEWG), the ICES Working Group on Seabird Ecology (WGSE), a paper prepared by Law *et al.*[2] for presentation at the ICES 2005 Annual Science Conference and ACME deliberations.

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2.2.7.6 Endocrine disruptors in the marine environment

Request

Consideration of the current developments within OECD/EU regarding endocrine disruptors and whether this is adequate for the marine environment, and advice on any further work considered necessary to address issues specific to the marine environment.

Recommendations and advice

ICES recommends to OSPAR that:

- Every effort should be made to include marine species in the OECD test programme, focusing on species found in the ICES and OSPAR regions; test development with 3-spined stickleback or other marine species should be encouraged.
- Test protocols take years to develop. Therefore, OSPAR should consider accepting the use of test protocols even before they have gone through the lengthy and final stages of validation at OECD.
- Test methods should be developed to include dietary exposure. Development of test methods should also consider different compartments including sediment, e.g., include a benthic sediment-associated species. Thyroid hormone-related end points and biomarkers in fish test protocols should be included when available.
- The estrogenic effects observed in male cod throughout the North Sea is of particular concern and should be investigated by more extensive surveys and studies to determine if cod are picking up estrogenic disrupters via the benthic food chain.
- Generally, field surveys and monitoring activities directed to endocrine disrupting compounds should also include areas away from hotspots to ensure that unexpected occurrences are not missed. Given their particular sensitivity to endocrine disrupting compounds, greater attention should be given to fish early life stages at breeding and nursery grounds.

Summary

The issue of endocrine disruptors is of high relevance to OSPAR.

OSPAR is awaiting the OECD test guidelines for endocrine disrupting chemicals to be finalized by the EU in 2005. Subsequently, the application of test methods will enable OSPAR to identify a list of candidate causative chemicals. Once this list is available it should be used as the basis for exposure assessments in the marine environment (sources and volumes; via discharges from land, atmospheric inputs, shipping, and the offshore oil and gas industry) in order to direct future studies which will directly address concerns for effects in the marine environment. ICES is of the opinion that it is perhaps overly optimistic to anticipate that test systems would be available in 2005. Therefore, OSPAR should consider accepting the use of test protocols even before they have gone through the lengthy and final stages of validation at OECD.

ICES noted the OSPAR HSC progress report (OSPAR HSC 05/3/3-E), which gives an overview of the state of work on endocrine disrupters within the EC and the OECD until early 2005. However, ICES felt that the report inadequately described current developments for the marine environment, in particular with respect to ecotoxicological test methods and national activities. Additional information and knowledge gaps on these points are provided below under Scientific background. ICES felt that test methods should be developed to include dietary exposure. Development of test methods should also consider different compartments including sediment, e.g. include a benthic sediment-associated species. Possibilities to include more relevant marine species such as sheephead minnow (*Cyprinodon variegates)* or stickleback should be seriously considered.

ICES noted that the OSPAR Working Group on Concentrations Trends and Effect of Substances in the Marine Environment (SIME) reviewed, at its meeting in 2005, a report from the UK on possible routes towards the assessment of endocrine disruption (ED) in the marine environment. This included an overview of recent UK Government-funded marine ED research and made several recommendations to OSPAR. As a result of this report, the WG decided to include vitellogenin on the list of techniques for biological effects monitoring for which a background document should be developed as part of the review of the CEMP, and it invited the UK to further elaborate, for the next SIME meeting, how the techniques described in their report could be applied in the context of OSPAR wide monitoring. SIME further asked OSPAR Contracting Parties already monitoring VTG to inform the next SIME meeting of their experience with the technique (SIME Summary Record).

Several EU-funded projects (e.g. FIRE, EDEN, COMPRENDO) are currently addressing the effects of single and mixtures of endocrine-disrupting chemicals, and include studies of marine food chains including fish. These studies will

provide new information for marine risk assessment. In addition, many other studies are currently in progress and are being reported in the scientific literature relevant to OSPAR.

ICES noted that there are a growing number of examples of direct estrogenic effects in fish from the marine environment. This is of particular concern, as also illustrated by the recent finding of estrogenic effects observed in male cod from the North Sea, and these findings warrant further studies. It also emphasises the importance for surveys and monitoring activities to include areas away from hotspots to ensure that unexpected occurrences are not missed. Given their particular sensitivity to endocrine disrupting compounds, greater attention should be given to fish early life stages at breeding and nursery grounds.

Scientific background

The following provides current developments on endocrine disrupting compounds for the marine environment, in particular in respect to the effects on marine fish, ecotoxicological test methods and national activities. It should be considered additional to the OSPAR HSC progress report (OSPAR HSC 05/3/3-E), which gives an overview of the state of work on endocrine disrupters within the EC and the OECD until early 2005.

Ecotoxicological test methods

This section reviews recent studies on marine fish and invertebrates in respect to the effects of endocrine disrupting compounds (EDCs) and sums up available and potentially useful methods for testing the effects of endocrine disrupting compounds in the marine environment.

Fish

There are large numbers of examples of xenoestrogenic endocrine disruption in freshwater fish and until very recently, only a few in estuarine or marine environments (Oberdörster and Cheek, 2000). However, the number of examples in the marine environment is now large and growing. Male flounder (*Platichthys flesus*) caught in industrialised estuaries of the UK and the Netherlands have been found to have elevated (in some cases grossly elevated) concentrations of vitellogenin (VTG) in their plasma (Lye *et al.*, 1997; Lye *et al.*, 1998; Matthiessen *et al.*, 1998; Allen *et al.*, 1999a; Allen *et al.*, 1999b; Vethaak *et al.*, 2002; Kirby *et al.*, 2004; Kleinkauf *et al.*, 2004). Some male flounder with elevated VTG concentrations have also been caught in the open sea (Allen *et al.*, 1999a), but these were hypothesised to be fish that had recently emigrated from a contaminated estuary.

In estuarine and coastal areas of Japan, many male marbled sole (*Pleuronectes yokohamae*) (Hashimoto et al., 2000), common goby (*Acanthogobius flavimanus*) (Ohkubo *et al.*, 2003) and grey mullet (*Mugil cephalus*) (Hara *et al.*, 2001) have also been found with unexpectedly high concentrations of VTG in their plasma. Moving away from the coast and into the open sea, the presence of VTG and zona radiata protein (Zrp) in blood plasma (and/or immunohistochemical evidence of enhanced liver production of VTG and Zrp) has been confirmed in swordfish (*Xiphias gladius*) caught in the Mediterranean (Fossi *et al.*, 2001; Fossi et *al.*, 2002; Fossi *et al.*, 2004; Desantis *et al.*, 2005) and off the coast of South Africa (Desantis *et al.*, 2005), but not fish in the Pacific Ocean (Desantis *et al.*, 2005). Similarly, many male tuna (*Thunnus thynnus*) caught in the Mediterranean have VTG in their plasma (Fossi *et al.*, 2002), while tuna (*Thunnus obesus*) caught in the Pacific Ocean (Hashimoto *et al.*, 2003) do not.

In addition to direct evidence of estrogenic effects provided by the presence of VTG and Zrp in plasma, there is also indirect (circumstantial) evidence provided by the presence of intersex gonads (Lye *et al.*, 1997; Allen *et al.*, 1999a; Cho *et al.*, 2003; De Metrio *et al.*, 2003) and feminised secondary sexual characteristics (Kirby *et al.*, 2003) in males of some of these marine species.

Unpublished work on the Atlantic cod (*Gadus morhua*) now indicates the presence of oestrogenic endocrine disruption in the Northeast Atlantic. An ELISA for cod vitellogenin (VTG) was set up and applied to plasma samples collected from male and female cod caught in four distinct areas of the Northeast Atlantic, three areas off the Norwegian coast, and one fish farm site. The aim of the study was to clarify whether there were any signs of estrogenic endocrine disruption in a fish species that is found in both coastal and offshore areas. VTG induction was found in male cod caught in the North Sea, the Shetland Basin area, off the coast of Iceland, in Oslofjord, and on the fish farm. There was very strong relationship between concentrations of VTG and fish size. There was no evidence that the presence of VTG in the plasma of males is a natural part of their life cycle (i.e., endogenous oestradiol did not appear to be involved; nor were the males intersex). The size of fish at which these elevated VTG concentrations appear (ca. 5 kg) is about the size where cod change from feeding primarily on pelagic organisms to feeding primarily on benthic organisms – suggesting (though by no means proving) that the large cod might be picking up estrogenic endocrine disrupters via the benthic food chain. This needs to be examined.

None of the three major OECD model species (the medaka, the fathead minnow, and the zebrafish) are suitable for testing the effect of endocrine disrupting compounds in marine situations. Within Europe, the only two species that potentially fulfill the two key roles of a model species (small size and short life cycle) in estuarine/marine conditions are the three-spined stickleback (*Gasteroseus aculeatus*) and the sand goby (*Potamoschistus*). There are many reasons to choose the stickleback. It is already 'entered on the books' of the OECD as a test organism for endocrine disrupting compounds. There is a huge amount of background information on its biology. Its full genome will have been sequenced by the middle of 2005. Work is presently underway in the UK to develop a stickleback DNA microarray with thousands of interesting genes for environmental monitoring. The stickleback has a unique biomarker for androgens, the production of the glue protein spiggin by male and female sticklebacks in response to model and environmental androgens (and anti-androgens). The highly ritualised reproductive behaviour of the species has also established it as a frequent subject of behavioural research (winning Tinbergen the Nobel Prize in Physiology and Medicine in 1973). They can very easily be bred and reared in the laboratory, making them suitable for the development of a full life cycle test. Although all work on the stickleback at the moment is presently directed at the development of methods for assessing endocrine disruption in freshwater environments, these methods can just as easily be applied to marine environments. The stickleback is one of the few fish species that can live and breed in both freshwater and full seawater. Their present breeding habitats include ponds, rivers, lakes, drainage canals, freshwater and saltwater marshes, tidal creeks, and sublittoral zones. They are found across most of the northern hemisphere.

There is increasing evidence that thyroid signalling pathways are subject to chemical interference in estuarine and marine animals. However, at this stage thyroid hormone-related end-points and biomarkers are not included in current tests. ICES advises to consider the inclusion of such end points and biomarkers in fish test protocols when available.

Invertebrates

Despite the fact that endocrine disruption in invertebrates has been investigated on a smaller scale than in vertebrates, invertebrates provide some of the best documented examples of deleterious effects in wildlife populations following an exposure to EDCs (Oetken *et al.*, 2004). Tributyltin (TBT)-induced imposex and intersex in gastropod molluscs provide some of the strongest evidence for the occurrence of ED in the field (Gibbs *et al.*, 1988). Intersex has frequently been observed in many groups of crustaceans in the field including amphipods (see Kelly *et al.*, 2004). However, contradicting results concerning the interplay between intersex and reproduction success have been presented. By analysing histological aberrations in gonads a closer relationship between EDCs and ED was shown. Fewer yolk bodies and lipid globules in amphipod oocytes near sewage treatment work releasing EDC, histological aberrations of the reproductive tract, i.e., indications of hermaphroditism, disturbed maturation of germ cells, and disturbed spermatogenes demonstrated the interplay between histopathology and EDCs (Gross *et al.*, 2001; Vandenbergh *et al.*, 2003). Exposure to the fungicide fenarimol lowering the endogenous ecdysone levels in *Daphnia magna*, resulting in embryo abnormalities (Mu and Leblanc, 2002), illustrates the relationship between antiecdysteroidal activity, and reproduction effects.

Despite the huge diversity of invertebrates (95% of known species) and the wide distribution patterns of many species little effort has been put on research to increase knowledge of the endocrine system of different invertebrate phyla. Most used methods are adopted from vertebrates despite a limited knowledge about their physiological function in invertebrates. Consequently the knowledge of the basic endocrinology of invertebrates is limited and major unresolved issues remain. Insects are the group most frequently researched and the close phylogenetic relationship between insects and crustaceans implies that crustaceans are particularly sensitive to insecticides. Methoprene is a juvenile hormone analog (JHA) used in aquatic areas to control several types of insects and also affects reproduction of crustaceans (Celestial and McKenny, 1994; McKenney and Celestial, 1996; Chu *et al.*, 1997). PAHs and PCBs interact with ecdysone-dependent gene expression in crustaceans (Oberdörster *et al.*, 1999). Ecdysteroid levels in *Daphnia magna* rise after exposure to cadmium (Bodar *et al.*, 1990), and effects have been demonstrated on molting and reproduction of the grass shrimp *Palaemonetes pugio* after long-term exposure to pyrene (Oberdöster *et al.*, 2000). The synthetic estrogen 17α-ethinylestradiol disturbed the germ cell maturation in the male amphipod *Hyalella azteca* (Vandenberg *et al.*, 2003). Exposure of *D. magna* to the synthetic estrogen Diethylstilbestrol resulted in reduced molt frequency and fecundity, the steroid hormone metabolic capacity was also affected (Baldwin *et al.*, 1995). Diethyl phtalate, PCB29, and Aroclor 1242 reduced molting frequency in *D. magna* (Zou and Fingerman, 1997). Positive xenoandrogenic effects of androstenedione on male secondary sex characteristics in *D. magna* have been observed (Olmstead and LeBlanc, 2000).

A number of vertebrate type sex steroids such as progesterone, 17ß-estradiol and testosterone have been found in crustaceans (for an extended list, see Subramoniam, 2000). The metabolic pathways for testosterone is localized (Verslycke *et al.*, 2002) and has been shown to be sensitive to pollution (Baldwin *et al.*, 1998; Oberdörster *et al.*, 1998a; Oberdörster *et al.*, 1998b), but the function of vertebrate sex steroids in crustaceans remain to be clearly demonstrated. Due to the lack of basic knowledge of the physiological importance of vertebrate sex steroids in crustaceans these results give rise to even more questions on the effects of EDCs on crustacean reproduction. If arthropods besides their specific hormone system have physiologically active vertebrate sex steroids, it will result in a higher vulnerability to EDCs due to the increase in target substances for EDCs.

Until now there are no optimal standardized bioassays for detecting effects of EDC in invertebrates. In a workshop on Endocrine Disruption in Invertebrates: Endocrinology, Testing and Assessment (EDIETA) in the Netherlands 1998 (DeFur *et al.*, 1999) the 40 members underlined the urgent need to adapt current monitoring programmes and develop biomarkers for detecting reproduction disorders and endocrine disrupters for invertebrates. Since the outcome of the EDIETA workshop has been almost totally ignored in the design of monitoring programmes and test development this issue was further underlined in the European ED workshop organised by the European Commission Environment DG in Sweden 2001 and a greater understanding of the endocrinology of the test species used was underpinned. The EDIETA workshop identified insects and crustaceans as potential organisms for evaluating chemically induced endocrine disruption by virtue of the wealth of information available on their endocrinology compared with other invertebrates, and measurements of ecdysteroids have been suggested as a possible biomarker for ED in crustaceans. However, the endocrine system of different invertebrate phyla differs tremendously and the opinion of ICES is that it is not possible or desirable to extrapolate effects on crustaceans and insects to other phyla. Thus we need to increase the knowledge of the endocrine systems in important invertebrate groups to be able to perform laboratory studies as well as field studies. Most studies of endocrine disruption in invertebrates are carried out in bioassays and methods are not validated in the field. ICES stresses the importance of using methods and variables that are applicable also *in situ* and in addition to try to link the effects on sub-cellular and molecular levels to individuals and population level. For example, the hormone analyses should be complemented with analyses on the individual level e.g., fecundity, sexual maturation histology of gonads, etc.

Tests are available for only a few species. Guidelines are in progress for copepods and mysids. However, mysids are omnivores with a pelagic life style and the selected copepods are substrate grazers. Copepods and mysids might preferably be used for testing sewage water from sewage-treatment plants. Recent results presented by Alexander Scott (elevated concentration of VTG in male cod) underlined the significance of sediment as a sink for EDC, which means that bioaccumulation via the water phase could be disregarded. Deposit-feeding invertebrates should therefore be included in an invertebrate test system for ED. Sediment-dwelling amphipods that carry their brood are suitable species, due to the possibility of linking effects on a molecular level to the next generation. Also the mysids carry their brood and show a direct development. However, mysids do not offer the same possibility to link the effects to the next generation since effects on embryos will be confounded as the mysids drop the dead embryos before hatching. Another important issue is to discriminate between effects of EDCs and other causes of reproductive and developmental impairment. Many studies have falsely concluded that chemicals have endocrine disrupting modes of action when a much simpler explanation was not previously ruled out (e.g., egg mortality, feeding inhibition) (Barata *et al.*, 2004). Therefore there is an urgent need for integration of toxic effects on energy intake to toxicity assessments.

Relevant tests under development in OECD include a fish screening assay, a fish sexual development test, an amphibian development test (thyroid effects), and tests with copepods. At the moment, both fish assays only include freshwater fish (zebrafish, medaka, and fathead minnow), although there has been a proposal for stickleback (for the screening assay).

Reference was made to notes from the last VMG-eco meeting (December 2004), at which a validation exercise for the fish screening assay was reported and a draft guideline for the fish sexual development test was presented. The fish screening assay uses adult fish, which are exposed for 21 days; main endpoints are vitellogenin, histology, and secondary sexual characteristics (medaka and fathead minnow), but there was discussion at VMG-eco on whether to include fecundity in addition. With the current design of the test, most countries thought that this would not give any additional information, but USA will investigate further. The fish sexual development test exposes fish from embryo until sex can be determined (60–90 days for the three species). Endpoints in this test are vitellogenin and sex ratio. With a guideline in place, this test can progress to validation. It is envisaged that even for the fish screening test an OECD protocol will at the earliest be available in 2006. The fish sexual development test will presumably have an even longer time perspective before there will be an agreed OECD protocol.

Useful invertebrate tests for research and development

The following summarizes a number of potentially useful tests or research developments for detecting ED in marine invertebrates in the laboratory or field.

<u>Imposex induction in gastropods; Lab and field</u>

The use of prosobranch gastropods as bioindicators for endocrine disruptions is well documented, especially in relation to the development of imposex and intersex as a specific response of exposure to organotins TBT (tributyltin) and/or triphenyltin.

Imposex, i.e., morphological alternations by the development of masculine sex characters imposed on females, in prosobranch gastropods has been described in more than 180 marine species world-wide (Oehlmann *et al.*, 2004). Several laboratory and field studies have demonstrated clear dose-response relationships. Studies have also shown that the phenomenon is related to increased levels of the androgens like testosterone in the females. However, different hypotheses for mechanisms for TBT causing the endocrine disruptions have been suggested, including aromatase inhibition of phase II conjugation and excretion of steroid metabolites or by inhibiting penis formation inhibition factors in the cerebrale ganglia (Oehlmann *et al.*, 2004). In the laboratory, imposex can be induced after 1–3 months exposure to TBT in seawater as well as in sediment, but juvenile specimens are generally more sensitive than adults.

Recent laboratory studies have also shown that prosobranch gastropods are used as sensitive bioindicators of estrogenic effects. Concentrations as low as 1 µg/l of octylphenol and bisphenol A can induce morphological alterations of females and increased production of spawning masses and eggs, but also has effects on sperm production in male gastropods (Oehlmann *et al.*, 2000). Similar responses have been found by exposure to EE2 (Schulte-Oehlmann *et al.*, 2004)

<u>Copepod life cycle tests (OECD standard); Lab</u>

Duration of bioassay: a few weeks to a month. Variables to be measured: fecundity, time to first brood release, egg developmental time, growth (RNA/DNA), moult time and success, ecdysteroid concentrations (enzyme immuno assay EA), vitellin.

<u>Mysid life cycle tests; Lab and field</u>

Duration of bioassay: a few weeks to some months. Variables to be measured: sexual maturity, sex ratio and intersexuality, fecundity, time to first brood release, embryo developmental time, growth (RNA/DNA, CEA), moult time and success, ecdysteroid metabolism, oestrogen/androgen metabolism, cytochrome P 450, histopathology.

<u>Amphipod sediment test; Lab and field</u>

Duration of bioassay: 1–3 months depending on species (time of life cycle, temperature). Variables to be measured: Sexual maturity (oocyte development and secondary sexual characteristics, precopulation stage, sex ratio and intersexuality, fertilisation rate, fecundity, embryo development time and frequency of embryo malformations, growth (RNA/DNA), moult time and success, ecdysteroid concentrations (RIA), HSP (involved in the ecdysteroid synthesis).

<u>Sea urchin test</u>

An example of another ready-to-use water invertebrate reproduction test is the fertilisation test using sea urchins. This test has been validated and is frequently used for regulatory purposes. Sea urchins occupy a unique position in animal evolution because they are the only invertebrate, non-chordate deuterostome (link to vertebrates and humans). Recently published findings of exposure experiments with developing sea urchin larvae indicate a great potential of these organisms as models for testing endocrine disruption, suggesting more than one mode of action in the developmental sea urchin embryo (Roepkea *et al.*, 2005). The development of a sea urchin genome is currently being researched.

Progress of work on endocrine disrupters

Specific work programmes on endocrine disrupters from Norway, United Kingdom, and The Netherlands are presented below.

<u>Norway</u>

In addition to one-off surveys in the past along the Norwegian coast, there is annual monitoring of oestrogenicity around oil rigs in the Norwegian sector of the North Sea. This monitoring has been performed with cod caged at various distances from selected oil rigs. In addition to this annual activity, vitellogenin has been measured in gadoids sampled during the regional monitoring programme (performed once every third year).

<u>The United Kingdom</u>

An extensive programme on the presence and effects of endocrine disrupting chemicals in the marine environment (EDMAR) was conducted between 1996 to 1998 (Allen *et al.*, 1999a). This has been followed up with a programme on endocrine disruption in invertebrates and the terrestrial environment which includes an investigation into nuclear hormone receptors in the common mussel (*Mytilus edulis*). More recently, CEFAS have observed VTG induction in male cod caught offshore in the North Sea and the Shetland Basin. This is currently being investigated (see above under fish) to clarify if this is a natural phenomena or the result of exposure of cod to endocrine disrupting chemicals. In 2004, the UK conducted a nationwide imposex survey in-line with the current OSPAR guidelines using *Nucella lapillus*, *Littorina littorea* on the coastline and *Buccinum undatum* and *Neptunea* sp. offshore. This was a follow-up to previous surveys conducted in 1992/3 and 1997/8 and provides a baseline for further surveys following the ban on the use of TBT-based antifouling coatings on large ships. The data will be reported to ICES for the OSPAR MON assessment in 2005.

The Netherlands

The results of the LOES project on estrogenically active substances and their effects in fish have recently been published in Vethaak *et al.* (2005). Follow-up surveys have focussed on smaller regional freshwaters.

A three-year field study was conducted by RWS-RIKZ to determine the relationship between TBT and the prevalence of intersex (ISI) in periwinkles (*Littorina littorea*) in Dutch coastal waters. The results of this intersex field study show that raised ISI levels rarely occur outside harbour areas. In open waters (TBT; 6.2–73.2 µg Sn/kg suspended matter), ISI levels never exceed 0.05. The absence of periwinkles on the coast of South Holland may be related to high levels of TBT in the relevant area, as is suggested by the high ISI values in parts of the harbours where periwinkles were present. TBT levels in Dutch coastal waters are extremely high, as is witnessed by the major disparity between TBT levels in the various compartments of the environment and the available quality criteria.

A SETAC-sponsored book on integrated approaches for the effect assessment and monitoring of estrogenic compounds in the aquatic environment will be published later this year. The book describes the findings and experiences gained in the Dutch LOES study and similar studies from Germany, the UK, Canada, and the EU project COMPREHEND. The book will provide practical frameworks and methods for field monitoring, statistical analysis of integrated data, and effect assessment for fish in freshwater and marine environments.

France

A field study has been conducted since 1998 on flounder (*Platichthys flesus*) by the University of Le Havre. Among the 700 sampled fish 4% of the males showed intersex in the Seine Bay. Elevated plasma vitellogenin content was also recorded even in fish caught at sea. No such results were obtained at other sites in the Manche or the Atlantic Ocean.

During the EU project BEEP, red mullet (*Mullus barbatus*) were collected from different sampling sites in France and Italy (NW Mediterranean) before and after the reproductive period, with the aim of assessing potential alterations of the endocrine system linked to pollutant exposure. During the spring sampling (before reproduction), delayed gamete maturation, intersexuality, and high prevalence of fibrosis and melanomacrophage centres were observed in individuals from Cortiou (urban/industrial site) together with low ovarian P450 aromatase activity.

To understand the environmental fate of estrogenic chemicals, bioavailable steroid receptor agonists were detected using the YES receptor assay (yeast estrogen screen) in wastewater effluents, sediments and mussel or fish tissues from the Manche oriental regions.

The University of Le Havre has also participated in the BEQUALM project on vitellogenin assessment.

Source of information

Report of the Working Group on Biological Effects of Contaminants (WGBEC) 2005, draft.
Report of the Marine Chemistry Working Group (MCWG), ICES CM 2005/E:03.

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2.2.7.7. Review of the report of the OSPAR/MON assessment in relation to contaminants in sediments (and biota) and update the view of evaluation of the use of background concentrations (BCs) and background assessment concentrations (BACs)

Request

This work is a follow-up response of ICES to the joint OSPAR/ICES work on the development of Background Concentrations (BCs) and Background Assessment Concentrations (BACs) and to the advice provided by ICES in the 2004 Report of the ICES Advisory Committee on the Marine Environment. This advice forms part of the ICES on-going activities to assist in the next JAMP assessment of temporal trends and levels of contaminants in sediments and biota.

Recommendations and Advice

ICES recommends that OSPAR calculates the BACs from variance estimates derived from the full CEMP data set, held at ICES, which is considered as the best current estimates for BACs for contaminants in sediment and biota.

ICES recommends that OSPAR MON pay more attention to spatial distributions of contaminant data in further assessment work and that, where possible, data from stations that have been sampled only occasionally should be included and also that a more detailed interpretation of the data should be provided.

ICES recommends that OSPAR considers the grouping of PAHs in future assessments in light of the fact that existing Environmental Assessment Criteria (EACs) for PAHs are based on grouped congeners and that MON has resolved some of the statistical difficulties in estimating the errors in grouped parameters.

ICES recommends that OSPAR should not group data from different stations, as there is evidence that some significant events known to be present in the data from individual stations might be lost ("smoothed out") in the grouping process. Therefore, ICES recommends that stations are assessed individually.

ICES recommends that OSPAR reviews the EACs for contaminants in sediments as a matter of some urgency, as it is important that the EACs are confirmed or revised, and that guidance is developed on the interpretation of the relationships between field data and EACs.

ICES recommends that OSPAR changes the BC for nickel to approximate the median value of the data sets reported in 2004 by the Working Group on Marine Sediments in Relation to Pollution (WGMS), i.e., to 30 mg kg^{-1} normalised to 5% aluminium or 50 mg kg^{-1} when normalised to lithium, and that the BAC be consequently adjusted to 36 mg kg^{-1}, in the case of aluminium-normalised measured data.

ICES recommends that OSPAR clarifies the method for the normalisation of organic compounds in biota. The generally accepted method is to normalise with total extractable fat. OSPAR initially used wet weight but, since the 2004 MON assessment, uses dry weight to calculate BCs and BACs for organic compounds in biota.

ICES advises that OSPAR explores the use of passive sampling techniques to investigate possible correlations between extractable concentrations of organic contaminants and the degree to which the total concentrations of these contaminants exceed BCs.

Summary

The majority of this review relates to assessments of contaminants in sediments.

ICES recognises that the OSPAR-MON assessment report is an extensive product and welcomes the considerable progress that has been made since the previous assessment. ICES strongly supports and encourages this work and will assist MON to further exploit the potential of the CEMP data set during 2005. To this end ICES supports the use of BCs and EACs in future assessments and will continue to review the values used.

More attention should be given to spatial distributions in further assessment work. It was also proposed to review the EACs and the guidance on the interpretation of the relationships between field data and EACs.

Sediments

ICES recommends to OSPAR that for sediment data, grouping of stations should not be carried out and that each station should be assessed individually. Any grouping of stations should be carried out with care, as some significant events kown to be present in the data from individual stations can be lost ("smoothed out") in the grouping process.

ICES remarked that their reservation on the BC of nickel in sediment appeared to be justified. The majority of the fitted nickel values were below the BC, strongly suggesting that the BC concentration is too high. ICES proposes a revised value of 30 mg kg^{-1},normalised to 5% aluminium, or 50 mg kg^{-1}, when normalised to lithium and that the BAC be consequently adjusted to 36 mg kg^{-1}, in the case of aluminium-normalised measured data.

The BCs for the anthropogenic organic contaminants CB153 and for ΣCB7 in sediment are, by definition, zero, and therefore any revision of these assessment criteria were considered not necessary.

BCs, defined for PAHs in sediment, appeared to be appropriate, and it was concluded that no changes were currently needed.

It is also clear that the BACs, calculated from variance estimates derived from the full CEMP dataset, held at ICES, should be considered as the best current estimates for BACs of contaminants in sediment.

Grouping of PAHs in future assessments should be explored in light of the fact that MON has resolved some of the statistical difficulties of estimating the errors in grouped parameters and that existing EACs for PAHs are based on grouped congeners.

Biota

ICES took note that OSPAR MON recalculated BCs and BACs for organic compounds in biota on the basis of the dry weight, instead of the initial normalisation on wet weight (Tables 2 and 3). Unless specific reasons can be specified for the use of either wet weight or dry weight, ICES questions why the normalisation which is normally used for monitored organic data, e.g. total extractable fat, hasn't be adopted for the calculation of these parameters.

Scientific background

In 2004, ICES recommended the use of BCs and BACs for metals and some organic contaminants in sediment and biota in forthcoming OSPAR assessments of temporal trends and levels of contaminants in sediments and biota (ICES, 2004).

In addition ICES advised that the BCs and BACs should be reviewed following their use in the CEMP assessment and also on an annual basis.

Review of the 2004 OSPAR/MON assessment report

It should be noted that a final version of the report was not available at the time the relevant ICES Working Groups met. The review was subsequently based on a draft version of the report. During 2005, more progress was made by ICES in reviewing the BC and BAC for sediments than for biota.

Significant technical developments and improvements have been made by OSPAR/MON and ICES in data handling and data presentation. In particular, important developments have been made in the handling of errors in normalised concentrations, and in the utilisation of weighted smoothers in analysing temporal trends. It is also noted that trends in sediments and biota can differ at the same site and that many chemicals sharing similar sources, such as combustion-derived PAHs, can show different behaviours.

ICES considers that the interpretation of the data was still incomplete. Although it had been possible to compare the monitoring data with input data from the OSPAR Comprehensive Study on Riverine Inputs and Direct Discharges (RID) in a qualitative way, no quantification had been attempted.

ICES wishes to point out that in appendix 2 of the draft MON report on derivation of pivot values, it appeared that errors or mishandling of data on contaminants in sieved sediment from Germany have been incorporated. This may have been caused by the inclusion of data from the Baltic Sea as well as data from the North Sea.

It was noted that some maps showing the geographical patterns of the fitted values for the final years of time-series had been prepared but were not discussed in the report. Data from stations that were sampled only occasionally were omitted.

ICES recommends that further data analysis be carried out to compare the direction and magnitude of temporal trends with the relationship of the fitted value for the final year with the BC. In theory, one might expect larger rates of decrease at those locations where concentrations are well above the BC, compared to areas where concentrations were close to background.

ICES noted that trend analyses had been carried out for PAHs as individual compounds. However, EACs have been proposed for grouped PAHs, based on ranges of numbers of rings. ICES recommends that the grouping of PAHs in future assessments be explored in light of the fact that the MON has resolved some of the statistical difficulties in estimating the errors in grouped parameters.

MON expressed concerns over the interpretation of data in relation to the proposed EACs; however, ICES considers that the degree to which normalised concentrations exceeded BCs might provide some measure of relative environmental risk. Recent developments in passive sampling technology are intended to address the availability of lipophilic organic contaminants directly. These techniques might be useful to investigate possible correlations between the concentrations of organic contaminants, extractable from sediment by passive samplers, and the degree to which the total concentrations of these contaminants exceed BCs.

Use of EACs

ICES notes that OSPAR/MON2004 had expressed considerable uncertainty as to the interpretation of the relationships between the observed concentrations and the proposed EACs. Specifically, the EACs for metals in sediment were often substantially lower than the BC/BACs. This might be caused by the use of two different methods to derive the two sets of assessment criteria and that no consistent relationship should be expected between them, e.g., there are estimations made of critical parameters such as bioaccumulation factors, toxicity and safety factors in deriving EACs. Nonetheless, it seems illogical that BCs exceed EACs.

It was concluded that there was scope for review of the proposed EAC values or for a reassessment of the interpretation of field sample data that exceed the EAC.

ICES endorses the view expressed by OSPAR/MON, and notes that for some contaminants all the observed concentrations in sediment exceeded the EAC. ICES recommends that the proposed review be undertaken as a matter of some urgency, as it is important that the EACs are confirmed or reviewed, and that guidance is developed on the interpretation of the relationships between field data and EACs.

Review of BC values for metals and organic contaminants in sediment

It should be noted that the methods for estimating BC for metals and organic contaminants were slightly different. Briefly, the BCs for metals approximated values in the upper part of the ranges of normalised concentrations whereas the BC for organics were derived as the median values of the median normalised concentrations found in sediments that were reported to ICES as being from areas representing background conditions. As a consequence of the approach used to derive BCs from the field data, in both cases, a proportion of the sediments in areas representing background conditions would be expected to contain concentrations of contaminants close to or below the BCs.

Objective criteria are not available for assessment of the appropriateness of BCs in sediment. Conceptually, one might expect that in the OSPAR Convention area, which has received inputs of contaminants for many years, only a small proportion of the area would display background conditions in sediment contamination i.e., at or below the BCs. The complete absence of concentrations below the BC might suggest that the BC is too low, whereas in situations where a large proportion of concentrations fall below the BC it might suggest that the BC is too high.

In order to investigate this hypothesis, the fitted values for the final years of the time trends assessed by OSPAR/MON2004 were compared to the BCs developed by WGMS in 2004, the existing draft BACs, and the BACs derived from the complete CEMP data set held at ICES. The output Figures from this exercise are contained in Annex 5 of the WGMS report.

Metals

This comparison showed that only a small proportion of the arsenic, cadmium, chromium, copper, mercury, lead, and zinc data lay below the BC concentration. In no case did a large proportion of the data lie below the BC.

It is noted that some laboratories might have difficulty detecting concentrations below the BC values, and that there appeared to be occasional outlying data (e.g., one very low fitted value for chromium).

For nickel in sediment, the majority of the fitted values were below the BC, strongly suggesting that the BC concentration is too high. Discharges containing large quantities of nickel are rare in the OSPAR area and so marine sediments would not be expected to commonly show significant anthropogenic enhancements of nickel concentration. The core data from Region II and the Baltic area suggest that a lower value than the proposed 45 mg kg^{-1}, normalised to 5% aluminium could be applied for this region. The 2004 WGMS approach on BCs for nickel may have been too conservative.

ICES recommends that the BC for nickel be changed to approximate the median value of the data sets analysed at WGMS 2004, i.e., 30 mg kg^{-1}, normalised to 5% aluminium. Based on an analysis of the whole CEMP data set, this results in a BAC of 36 mg kg^{-1} normalised to 5% aluminium.

Organic contaminants

The BCs for the anthropogenic organic contaminants CB153 and for ΣCB7 in sediment are, by definition, zero, and therefore any revision of these assessment criteria were considered not to be necessary.

In 2004, ICES expressed difficulties in determining BCs for PAHs (ICES Advice, 2004). This year, the BCs for PAHs were recalculated again from the whole CEMP dataset held in the ICES database. As for the metals in sediments, the comparison of the BC for PAHs in sediments showed very few data points below the BC and ICES considers the BC for PAHs to be appropriate and do not require to be changed.

Update of BAC values

Background Assessment Concentrations (BACs) used for making precautionary tests of whether measured concentrations are *near background or close to zero*, were developed jointly by WGMS and WGSAEM at their 2004 meetings. BACs are derived from the residual variability measures in determining BC values. At the ICES working group meetings in 2004, BACs were constructed from BCs using the residual variability found in UK monitoring data only. The reason for this is that these data were the only data conveniently available at that time.

Later in 2004 MON2004 had ready access to the ICES database and it was possible to recalculate the BACs based on the variability of the entire CEMP dataset. The statistical methods used to calculate the BACs from these two sets of data differed in some respects which may be reflected in the differences in the values obtained for some BACs. Notwithstanding this, it was considered possible to compare the BAC derived from the UK data only and the BAC derived from the entire CEMP dataset. From this MON2004 concluded that:

- The two sets of BACs for metals in sediment are broadly similar.
- The two sets of BACs for CBs in sediment are also broadly similar.
- The BACs for PAHs in sediment based on the CEMP data are always less than those based on the UK data.

ICES considers that BACs should be derived from residual variance estimates for the full CEMP data set, rather than just from UK data. Therefore, ICES recommends that BACs calculated from the revised variance estimates should be considered to be the best current estimates for BAC for contaminants in sediment (noting the recommended revised BC and BAC for nickel in sediment). Furthermore, ICES recommends the continued use of the statistical method used to derive these estimates.

Grouping of stations

It is recognised that trends observed at some stations may be strongly influenced by local management practices (such as waste management). Therefore, during the process leading up to MON2004, Contracting Parties were invited to group monitoring stations where they felt that data could be combined. Only Germany did this exercise for some areas in the German Bight, and around the island of Borkum. MON2004 combined data from these areas and developed and analysed the resulting time series. WGMS was informed that this had not been entirely successful, as some significant events known to be present in the data from individual stations had been lost ("smoothed out") in the grouping process. It was not clear whether this loss arose from the grouping process, or from the statistical analysis of time trends (or a combination of both). On the basis of this limited evidence, WGMS suggested that grouping of stations should be carried out with care and by experts prior to any further assessments. The default position should remain that stations are assessed individually.

Tables 2.2.7.7.1, 2.2.7.7.2, and 2.2.7.7.3 summarise the BACs originally calculated on the basis of variability within UK National Marine Monitoring Programme temporal monitoring data (BAC_{UK}) and the BACs calculated by MON on the basis of the variability within the current CEMP dataset (BAC_{CEMP}).

Table 2.2.7.7.1 Metals in sediments – Bold text indicates metals that are OSPAR Chemicals for Priority Action.

Metal	Sediment (mg kg^{-1} normalised to 5% Al)		
	BC	*BAC$_{UK}$*	*BAC$_{CEMP}$*
Arsenic	15	22	25
Cadmium	**0.2**	**0.31**	**0.31**
Chromium	60	76	81
Copper	20	31	27
Mercury	**0.05**	**0.08**	**0.07**
Nickel[1]	30		36
Lead	**25**	**34**	**38**
Zinc	90	116	122

[1]Following the MON 2004 assessment, the BC was altered and the BAC recalculated.

Table 2.2.7.7.2 PAHs in sediments and mussels.

PAH	Sediment (µg kg^{-1} normalised to 2.5% organic carbon)			Mussel (µg kg^{-1} wet weight)		Mussel[1] (µg kg^{-1} dry weight)	
	BC	*BAC$_{UK}$*	*BAC$_{CEMP}$*	*BC*	*BAC$_{UK}$*	*BC*	*BAC$_{CEMP}$*
Naphthalene	5	11	8	0.2	1.1	1	81.2
Phenanthrene	17	41	32	0.9	4.9	4.5	12.6
Anthracene	3	8	5	0.2	0.4	1	2.7
Fluoranthene	20	44	39	1.4	2.5	7	11.2
Pyrene	13	28	24	1.1	1.8	5.5	10.1
Benz[*a*]anthracene	9	22	16	0.3	1.1	1.5	3.6
Chrysene	11	29	20	1.3	3.4	6.5	21.8
Benoz[*a*]pyrene	15	56	30	0.2	0.7	1	2.1
Benzo[*ghi*]perylene	45	140	80	0.5	2.7	2.5	7.2
Indeno[123-*cd*]pyrene	50	128	103	0.4	1.6	2	5.5

[1]The BCs were converted to a dry weight basis and the BACs are reported accordingly.

Table 2.2.7.7.3 CBs in sediments, mussels and fish liver.

CB	Sediment (µg kg^{-1} normalised to 2.5% organic carbon)[1]			Mussel (µg kg^{-1})[2]			Fish liver (µg kg^{-1} wet weight)		
	BC	*BAC$_{UK}$*	*BAC$_{CEMP}$*	*BC*	*BAC$_{UK}$* (wet weight)	*BAC$_{CEMP}$* (dry weight)	*BC*	*BAC$_{UK}$*	*BAC$_{CEMP}$*
CB28	0	0.4	[3]	0	0.3		0	0.6	
CB52	0	0.4		0	0.4		0	0.2	
CB101	0	0.8		0	0.6		0	1.9	
CB118	0	0.7		0	0.3		0	1.3	
CB138	0	0.8		0	0.4		0	0.2	
CB153	0	0.5	0.2	0	0.4	1.1	0	0.2	
CB180	0	0.2		0	0.2		0	0.5	
Sum$_7$CB	0	1.3	1.5	0	0.7	4.6	0	1.2	

[1]The BACs are based on nominal low, but measurable concentrations of CBs of 0.1 µg kg^{-1} normalised to 2.5% organic carbon for the individual CB and 0.4 µg kg^{-1} normalised to 2.5% organic carbon for the Sum$_7$CB.
[2]The BACs are based on nominal low, but measurable concentrations of CBs of 0.1 µg kg^{-1} wet weight for the individual CB and 0.4 µg kg^{-1} wet weight for the Sum$_7$CB.
[3]Shaded boxes, data not recalculated.

Sources of information

The 2004 report on the ICES Advice. *ICES Advice* Volume 1.
The 2004 Draft Assessment Report of OSPAR/MON.
Report of the ICES Working Group on Marine Sediments in Relation to Pollution (WGMS). ICES CM 2005/E:01.
Report of the ICES Working Group on Statistical Aspects of Environmental Monitoring (WGSEAM). ICES CM 2005/E:02.
Report of the ICES Marine Chemistry Working Group (MCWG). ICES CM 2005/E:03.
Report of OSPAR's Assessment and Monitoring Committee (ASMO).

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ICES. 2004. Report of the ICES Advisory Committee on the Marine Environment. *ICES Advice* Volume 1. Number 1, 283 pp.

ICES. 2005. Report of Joint Meeting of WGMS and WGSAEM. *In* Report of the Working Group on Marine Sediments in Relation to Pollution. ICES CM/2005/E:01, pp. 3–8.

ICES. 2005. Report of the Working Group on Statistical Aspects of Environmental Monitoring. ICES CM/2005/E :02.

ICES. 2005. Report of the Marine Chemistry Working Group. ICES CM/2005/E :03, pp. 26–27.

OSPAR. 2004. OSPAR MON Assessment Report.

2.3 Fish Disease and Related Issues

2.3.1 Review of 'health indices' used for the interpretation of data obtained from biological effects monitoring activities and assessment of their applicability in relation to fish disease monitoring

Request

This is part of continuing ICES work to consider information on new developments with regard to the development of tools for biological effects monitoring and ecosystem health assessment.

Recommendations and advice

ICES recommends that further studies be conducted on the development of indices to be used as tools for ecosystem health assessment. One such index reflecting the health status of biota and the potential impact of environmental stressors could be a 'fish disease index'. This would be constructed based on data submitted to the ICES Databank derived from monitoring programmes of Member Countries on diseases in wild fish populations. If successful, this approach may be applied to other biota, such as shellfish species.

Summary

The purpose of a 'health index' in the present context is to summarise information on the health status of marine organisms to be used as a tool for the assessment of the status of the marine environment, e.g. related to the effects of contaminants and other anthropogenic impacts and natural stress factors. The development of health indices is of particular relevance with regard to the discussion on the development of objectives and indicators/elements of ecological quality (EcoQ).

The goal of the present section is to review health indices that have been developed and to assess their applicability for data derived from monitoring programmes carried out by Member Countries on infectious and non-infectious diseases in wild fish populations.

While the original information on health status is expressed by several (many) quantities, an index is expected to represent the most relevant information by one (or at least few) number(s) or category(ies). Such an index should facilitate the interpretation of measurements as well as communication about health status based on a broad range of information. Monitoring results could be presented in a concise way via such an index. An index could also be the target quantity on the basis of which spatial comparisons and trend assessments could be performed.

An index should meet the following criteria:

- The issue for which the index is supposed to be used must clearly be defined to allow a sensible index construction.
- The components of the index must exhibit a monotone (only up or only down, not variable) relationship between exposure and response.
- The relationship between exposure and response must be biologically plausible (to prevent coincidental correlations from contributing to the index).
- The set of components contributing to the index should provide a proper summary of the measurements, which the index is to represent.
- The index definition should be so detailed that subjective decisions about its calculation are avoided.

There is a wealth of possibilities to calculate a summarising index and this is reflected in the various indices developed so far which are reviewed in the scientific background. In summary, none of the indices reviewed described parameters related to infectious and non-infectious diseases appropriately. As in other cases, if an index for fish disease and/or parasite prevalence is to be constructed, then it must be specific for this particular problem. The construction, however, faces the problem that no *a priori* choice for a weighting or a construction principle exists. Therefore, to derive an index that quantifies the proportion of diseased fish, a stepwise procedure seems appropriate, starting with a simple index defined as the mean of the relevant disease prevalences, checking the amount of information that is lost in this way and then to revise the initial definition, as necessary.

A health index based on fish disease prevalence/severity data shall include the following:

- The prevalences that enter the index should be standardised for confounding factors such as age/size and possibly others.
- The decision on which factors should be considered for standardisation should be checked beforehand by appropriate statistical tests.
- The index might be improved by including severity data in addition to prevalence. However, the ICES database presently does not provide severity data, but could be made to do so in future. Those data are presently available only in national databases.
- The resulting index should better be termed a 'fish disease index', as effectively the disease (not the health) status is summarised.

In order to assess the feasibility of constructing a fish disease index, a pilot study is considered appropriate. The study can utilise disease data held in the ICES Databank (only prevalence data plus accompanying information) and/or data from national sources that include information on disease severity. As a model, data derived from monitoring programmes on diseases of the common dab (*Limanda limanda*) in the North Sea can be used.

Scientific background

A summary of health indices in use is provided in Annex 8 of the 2005 WGPDMO Report.

Source of the information presented

Annex 8 of the 2005 report of the ICES Working Group on Pathology and Diseases of Marine Organisms (WGPDMO) and ACME deliberations.

2.3.2 Effects of contaminants on the immune system in fish and shellfish

Request

This is part of continuing ICES work to consider new information on effects of contaminants on the health status of marine organisms and the development of tools for biological effects monitoring and assessment.

Recommendations and advice

ICES recommends that Member Countries conduct studies on effects of contaminants on the immune system of fish and shellfish in order to assess their usefulness for regular monitoring and assessment purposes, e.g. as part of an integrated chemical and biological effects monitoring programme. Studies should e.g. focus on:

- Natural background levels of immuno-parameters;
- Relationship between immuno-stimulation and immuno-suppression;
- The role of natural and anthropogenic environmental factors;
- Effects of contaminants on different components of the innate and acquired immune system;
- The role of host-specific factors (age, gender, condition, spawning stress etc.);
- Relationship between immuno-modulation (as an early warning indicator) and the development of infectious and non-infectious diseases;
- Intercalibration and standardisation of promising techniques employed by different laboratories in Member Countries.

While this advice is based on studies in fish and shellfish, it should be assessed if the information provided can also be applied to other marine organism such as marine mammals and sea birds.

Summary

There is a growing body of published information derived from experimental and field studies on effects of contaminants on the immune system of fish and shellfish. The results suggest that changes in the functioning of the immune system (immuno-modulation) associated with contaminant exposure may be causally involved in the development of infectious and non-infectious diseases and may, thus, result in variation of the disease prevalence. Therefore, this issue is of relevance for monitoring programmes on temporal and spatial aspects of diseases and parasites in wild fish population carried out by Member Countries and, furthermore, for the developments of tools to be used in environmental monitoring and assessment programmes.

The main focus of studies carried out so far on the relationship between contaminants and the immune system of fish and shellfish was placed on changes of the innate immune system due to its important role as the first line of defence against pathogens and its evolutionary conservation. The aim of this exercise was to review available information and to assess the usefulness of immunological studies for monitoring and assessment purposes.

In summary, the following conclusions can be drawn from the review:

- Almost all known environmental contaminants seem to have either stimulating or suppressing effects on innate immunity of fish and all components of the innate immunity might be affected; external factors, humoral internal factors, and cellular internal factors.
- Results obtained were dependent on toxicant doses, exposure time, toxicity of mixtures, methods used, cell type used, origin of the cells, species, and other confounding factors such as gender, temperature, and salinity changes.
- Acute responses to sublethal contaminant concentrations often initiate general stress effects reflected by enhanced immune activity, whereas chronic responses might be coupled with cytotoxic effects reflected by immunosuppression.
- Several studies indicated a potential interaction between reproduction, biotransformation, and immune response in fish.
- Techniques for measuring effects of contaminants on the innate immune systems of fish and shellfish have been developed and are considered promising early-warning tools in ecotoxicology. However, the relationship between immunomodulation and increased susceptibility to infectious and non-infectious diseases was only rarely demonstrated.
- There is evidence that the immune system of fish and shellfish reacts to various environmental factors, including natural and anthropogenic ones, and immune responses (either stimulation or suppression) have, therefore, to be considered as an unspecific indicator of environmental stress.

- In the context of infectious diseases, more information is required on effects of contaminants on the acquired immune system.
- More research and validation is needed before studies on effects of contaminants on the immune system of fish and shellfish can be recommended for regular monitoring and assessment activities. These should encompass studies on natural background/reference levels, the identification of environmental and host-specific factors with prime impact on the immune system and the relationship between immune responses and the onset of clinical diseases.

Scientific background

A review of information on effects of contaminants on the innate immune system of fish and shellfish is provided in Annex 9 of the 2005 WGPDMO Report below.

Source of the information presented

Annex 9 of the 2005 report of the ICES Working Group on Pathology and Diseases of Marine Organisms (WGPDMO) and ACME deliberations.

2.3.3 Distribution, causes and significance of the Summer Mortality syndrome in the Pacific oyster (*Crassostrea gigas*) and in other bivalve species

Request

This is part of continuing ICES work to consider information on new developments with regard to diseases of farmed fish and shellfish and to provide advice on control and prevention.

Recommendations and advice

ICES recommends to Member Countries that coordinated studies continue to be carried out in areas affected by the Summer Mortality syndrome in Pacific oyster (*Crassostrea gigas*). These should focus on intrinsic and extrinsic factors (and their interactions) associated with the syndrome in order to better define their causative roles in the phenomenon. The studies should be extended to other bivalve species since there is evidence that they might be affected as well and the studies should take into account possible ecological implications.

Summary

Several bivalve species (e.g. oysters, blue mussels, scallops) are affected by Summer Mortality in different countries. However, most research programmes are focused on the Pacific oyster (*Crassostrea gigas*) because of its worldwide commercial importance. The first description of the Summer Mortality syndrome concerned the Pacific oyster in Japan in the 1940s. The syndrome was, and continues to be, associated with high mortality of Pacific oysters and other bivalves around the world (Japan, USA, Canada, China and France). The causes remain unclear, but a multifactorial aetiology is suspected. The collective evidence suggests that Summer Mortality involves a suite of intrinsic and extrinsic factors. The most important extrinsic factor seems to be elevated temperature coming at a time when the intrinsic factors, gametogenesis and spawning, place the animal in a relatively unstable physiological condition. Any other external factor that exacerbates this instability, including e.g. high food availability, physical stressors or pathogens, may push the animals over a threshold from which they cannot recover.

In France, a multidisciplinary MOREST Programme on Pacific oyster Summer Mortality is being carried out, involving a research network on the topics of genetics, physiology, immunology, pathology, ecotoxicology and ecology. To date the following resultshave been obtained:

- A temperature of 19 °C or more is the primary necessary condition, but alone is not sufficient to produce mortalities.
- A genetic component evidenced by divergent selection in two generations was confirmed. Resistant oysters produce fewer gametes and spawn more completely than susceptible ones regardless of food supply.
- High nutrient levels favour reproduction over other metabolic needs and may lead to energetic imbalance.
- Triploids, which have greatly reduced gametogenesis, suffered the lowest mortalities and also demonstrated higher potential defence capacities than diploids.
- A stressor, such as a simple transfer of oysters, was necessary to induce mortality even when temperature and reproduction were favourable. Proximity to the sediment consistently exacerbated the mortalities.
- Herpesvirus (OsHV-1) was mostly detected in juvenile mortality events and when the temperature was high. Different species and strains of Vibrios (including *V. splendidus* and *V. estuarianus*) were also isolated from moribund oysters.

It was pointed out that there is an apparent invasion of the Pacific oyster, most likely introduced by oyster farming/culturing in some coastal areas of the North Sea. Because of the potential ecological implications of the disease, information is required on the occurrence of the Summer Mortality syndrome in these areas.

Scientific background

Detailed information on the Summer Mortality syndrome is provided in Annex 6 of the 2005 WGPDMO Report.

Source of the information presented

The 2005 report of the ICES Working Group on Pathology and Diseases of Marine Organisms (WGPDMO) and ACME deliberations.

2.3.4 New disease trends in wild and cultured fish, molluscs and crustaceans

Request

This is part of continuing ICES work to consider information on new developments with regard to fish and shellfish diseases that is disseminated to ICES Member Countries and relevant organisations in order to inform them of present and potential future problems.

Recommendations and advice

ICES recommends that Member Countries and relevant organisations take note of the information on new disease trends in wild and cultured fish, molluscs and crustaceans. This information is of use in the context of the assessment of ecosystem health and ecological quality, as well as in relation to mariculture.

ICES furthermore recommends that Member Countries ensure that adequate funding is made available for fish disease monitoring programmes to sustain fish health surveillance of wild stocks. This information is of vital importance to integrated assessments of the health of marine ecosystems, such as the ICES Integrated Assessment of the North Sea Ecosystem, the Baltic Sea Regional Project (BSRP), the OSPAR CEMP, and the revised HELCOM Monitoring Programme.

ICES further recommends that Member Countries continue their efforts to intercalibrate methodologies applied in fish disease surveys, in particular participate in the Biological Effects Quality Assurance in Monitoring Programmes (BEQUALM). In addition, for the Baltic Sea, intercalibration can be achieved through the fish disease monitoring component of the Baltic Sea Regional Project (BSRP).

Based on the review of new developments regarding diseases of wild and farmed fish and shellfish, ICES recommends that Member Countries conduct further studies on the following specific issues of concern:

- Causes and effects of heart and skeletal muscle inflammation (HSMI) farmed Atlantic salmon (*Salmo salar*) in ICES Member Countries;
- The role of epitheliocystis and Atlantic salmon paramyxovirus (ASPV) in proliferative gill inflammation of farmed Atlantic salmon;
- The significance of the newly described bacilliform virus in brown shrimp (*Crangon crangon*) from the North Sea as a population modulator in this important European fishery;
- Identification of *Bonamia* species infecting Asian oysters (*Crassostrea ariakensis*) and crested (horse) oysters (*Ostrea equestris*) in the USA;
- Gill anomalies in mussel (*Mytilus edulis*) in the Gulf of Gdansk, Baltic Sea, including histopathological studies;
- Causes of the Summer Mortality Syndrome in Pacific oysters (*Crassostrea gigas*).

Summary

This section provides the most recent information on outbreaks and new disease trends in wild and farmed fish and shellfish (molluscs and crustaceans) submitted by Member Countries.

Information is provided on viral and bacterial diseases as well as on diseases caused by fungi, parasites and other diseases. New findings considered of particular importance are:

WILD FISH

Infectious pancreatic necrosis virus was isolated 20 times from wild-caught dab (*Limanda limanda*) (16 isolations), grey gurnard (*Eutrigla gurnardus*), plaice (*Pleuronectes platessa*), long rough dab (*Hippoglossoides platessoides*) and flounder (*Platichthys flesus*) around the Shetland Islands, UK.

A new rhabdovirus was isolated from starry flounder (*Platichthys stellatus*) in Puget Sound, Washington, USA.

Viral hemorrhagic septicaemia virus, preliminarily identified as genotype two, was isolated from herring (*Clupea harengus*) in Finland.

Isolates of *Mycobacterium* from striped bass (*Morone saxatilis*) in Chesapeake Bay, USA, are primarily *M. shottsii* and co-occur with five other *Mycobacterium* spp.

An intracellular bacterial pathogen of the gill epithelium was associated with mass mortalities of Atlantic croaker (*Micropogonias undulatus*) along the eastern US coast.

Gyrodactylus salaris was detected on Arctic charr (*Salvelinus alpinus*) in tributaries of the River Numedalslågen, Norway. The parasite belongs to a genotype previously found on farmed Arctic charr.

Lepeophtheirus salmonis was found on approximately 63% of juvenile pink (*Oncorhynchus gorbuscha*) and chum salmon (*O. keta*) in British Columbia, Canada. Prevalence and intensity of infections on these hosts were much higher than in 2003.

Prevalences of hyperpigmentation in dab continued to be high in most North Sea areas.

The intersex condition has been detected for the first time in dab from the North Sea.

FARMED FISH

Heart and skeletal muscle inflammation (HSMI) is an emerging problem for Norwegian Atlantic salmon (*Salmo salar*) aquaculture and was recently recorded in farmed Atlantic salmon in Scotland.

Proliferative gill inflammation remains a problem for farmed Norwegian Atlantic salmon.

There is an increase in the number of cases of *Parvicapsula pseudobranchicola* in farmed Atlantic salmon in Norway.

A new wild type strain of Infectious Salmon Anaemia Virus (ISAV) was identified in farmed Atlantic salmon in Maine, USA.

A field trial vaccine for *Philasterides dicentrarchi* in turbot (*Scophthalmus maximus*) will be conducted in Spain.

Wild and Farmed Shellfish

A newly reported bacilliform virus was found in 100% of brown shrimp (*Crangon crangon*) in the Wash fishery, North Sea, UK.

The α-proteobacterium, *Roseovarius crassostrea*, was found for the first time before and during the development of Juvenile Oyster Disease (JOD) in eastern oyster (*Crassostrea virginica)* in Maine and Massachusetts, USA. Previously, it had been found only in sick oysters. This new finding supports the contention that the bacterium is the proximate cause of JOD.

Bonamia ostreae was reported, at high prevalence (60%), for the first time in flat oysters (*Ostrea edulis*) in British Columbia, Canada. Associated mortality was documented in the laboratory, but was confounded with algal bloom-caused losses in the field.

The SSU rDNA of a newly discovered *Bonamia* sp., enzootic to North Carolina, USA, and infecting an introduced oyster (*Crassostrea ariakensis*), is similar in sequence to the southern hemisphere *Bonamia exitiosa* and *B. roughleyi*. The parasite was detected also in a native oyster *Ostrea equestris*. Also in *O. equestris* (but not *C. ariakensis)*, a second new *Bonamia* sp. was detected that is more similar in SSU rDNA sequence to the northern *B. ostreae* than to the southern hemisphere forms.

A previously undescribed intranuclear microsporean, the first for an invertebrate, was found in edible crabs (*Cancer pagurus*) in UK. Another microsporean infection was discovered in Chinese mitten crabs (*Eriocheir sinensis*) in UK.

A newly described disseminated neoplasia affecting >90% of stout razor clam (*Tagelus plebeius*) in the Chesapeake Bay, USA, was found in 2002 and 2004. The incidence of neoplasia in clams (*Macoma balthica*) has become more widespread and is now found throughout the whole area of the Gulf of Gdansk, Baltic Sea.

A previously undescribed gill anomaly was found in up to 23% of blue mussels (*Mytilus edulis*) in the Gulf of Gdansk, Baltic Sea.

Shell disease of American lobsters (*Homarus americanus*) was found for the first time north of Cape Cod, Massachusetts, USA.

The effect of local climate on shellfish diseases was illustrated by a significant decline in *Haplosporidium nelsoni* and *Perkinsus marinus* infections in eastern oysters (*Crassostrea virginica*), and in *Hematodinium perezi* infections in blue crabs (*Callinectes sapidus*) in the USA, all associated with the end of an unusually warm, dry period. High mortalities of surf clams (*Spisula solidissima*) off the US mid-Atlantic coast, of blue mussels (*Mytil*

Scientific background

The distribution and prevalence of the diseases in wild and farmed fish and shellfish is monitored closely by ICES Member Countries with special attention to those listed below.

WILD FISH

Viruses

Infectious pancreatic necrosis virus – A total of 11,110 fish comprising 18 marine species were sampled for IPNV in Scotland. IPNV was isolated from dab (*Limanda limanda*) (16 isolations), grey gurnard (*Eutrigla gurnardus*), plaice (*Pleuronectes platessa*), long rough dab (*Hippoglossoides platessoides*) and flounder (*Platichthys flesus*) (one isolation each). In total, 20 IPNV isolations were made. The majority (19) were made from wild marine fish caught around the Shetland Islands; the remaining isolation was from dab caught east of the Fair Isle.

Lymphocystis – In UK waters slight changes in the prevalence of lymphocystis in dab (*Limanda limanda*) occurred in local areas in 2004. Liverpool Bay and Off Humber showed decreases and Cardigan Bay and in Scotland had slight increases. A marked decrease in prevalence (7.1% to 1.5%) was observed at West Dogger. German studies showed seasonal fluctuations in the prevalence of lymphocystis in North Sea dab; however, the overall trend appeared to be decreasing. In 2004 the lowest prevalence ever observed in the German Bight (1.8%) was recorded. Prevalences in flounder (*Platichthys flesus*) from the western Baltic Sea ranged from 14.3% to 38.5%. Summary data from Poland for 1998 to 2004 show herring (*Clupea harengus*) and flounder had mean prevalences of 0.13% and 0.41%, respectively. Decreasing trends in 2004 were observed in flounder and herring from this area. In the northeastern Baltic, lymphocystis in flounder ranged from 0.22% to 4.5%.

Rhabdovirus - A rhabdovirus was isolated from one asymptomatic starry flounder (*Platichthys stellatus*) collected during a survey of marine fishes from the Puget Sound, Washington, USA. PAGE of the structural proteins and PCR assays using primers specific for other known fish rhabdoviruses, including IHNV, VHSV, SVC and Hirame rhabdovirus, indicated this is a previously undescribed virus, tentatively termed starry flounder rhabdovirus (SFRV). Sequence analysis of 2,678 nucleotides of the amino portion of the viral polymerase gene indicated that SFRV is genetically distinct from other members of the family *Rhabdoviridae* for which sequence data are available.

Viral hemorrhagic septicaemia virus – The North American strain of VHSV was isolated from one brown trout (*Salmo trutta*) in Nova Scotia and one striped bass (*Morone saxatilis*) in New Brunswick, Canada, and one herring in Maine, USA. VHSV, preliminarily designated as genotype 2, was isolated from 25% of herring (*Clupea harengus*) samples taken from the Archipelago Sea, Finland.

Bacteria

Acute/healing skin ulcerations – Continued geographic variations were reported in dab (*Limanda limanda*) in the North and Baltic Seas. In the Irish Sea, prevalence for 2004 off Morecambe Bay was 8.7% compared to 10.1% and 11.9% for 2003 and 2002 respectively. Several sites showed clear increases in prevalence: Burbo Bight, Carmarthen Bay, Inner Cardigan Bay, Liverpool Bay and St Bees of 13.5%, 4.6%, 4.8%, 5% and 4.1%, respectively, since 2003. England and Wales reported a clear decrease in prevalence at all Dogger Bank sites since 2003. In contrast, the German report described slight elevations from the German Bight, Dogger Bank and Firth of Forth compared to 2003. Prevalence in flounder (*Platichthys flesus*) from the Baltic Sea ranged from undetectable to 11.9%, with the highest level off the Lithuanian coast. Similarly, the prevalence in Baltic Sea cod (*Gadus morhua*) ranged from 0.6% to 9.4% at individual sites and was low compared to previous years. The exception was in ICES Subdivision 24, where prevalence increased from 4% (2003) to 8% (2004). Spatial variation was not as pronounced as in previous years. The mean prevalence for all species was lower in ICES Subdivisions 25 and 26. The number of flounder with skin ulceration varied irregularly over five years in the Barents Sea.

Mycobacterium – Isolates from striped bass (*Morone saxatilis*) collected in the Chesapeake Bay, USA, over several years have been characterised. More than 76% of the 196 fish sampled were infected, and in 38% of the samples, mycobacterial densities were greater than 10^4 cfu per gram tissue. *Mycobacterium shottsii* was present in 57% of samples. Co-infections of *M. shottsii* and other mycobacteria were found in 25% of samples. *M. shottsii* clearly dominated among co-isolates of *M. interjectum*, *M. marinum*, *M. scrofulaceum*, *M. szulgai* and *M. triplex*.

Unknown bacteria – Mass mortalities were reported in adult Atlantic croaker (*Micropogonias undulatus*) between July and September extending from New Jersey to Florida, USA. The only sign of disease was haemorrhage from the gills.

Histopathology confirmed the haemorrhage and degeneration of respiratory tissues associated with an uncharacterised bacterial infection. A universal molecular probe identified the organism as an intracellular bacterial pathogen infecting the respiratory epithelial cells. Water samples screened for toxic algae were negative.

Parasites

Ichthyophonus hoferi –The parasite is still endemic at low prevalence in herring (*Clupea harengus*) populations in the North Sea and the Baltic Sea.

***Parvicapsula* sp.** – Spores resembling a *Parvicapsula* sp. were identified in Gram-stained kidney imprints from four of 60 juvenile pink (*Oncorhynchus gorbuscha*) and one of 60 juvenile chum (*O. keta*) salmon. The spores were similar to those observed in 3 of 15 adult pink salmon collected from the Quinsam River, British Columbia, Canada, in 2003. DNA from pink salmon and chum salmon parasites was not amplified by PCR using primers for *P. minibicornis*.

Gyrodactylus salaris – Remains a major threat against Atlantic salmon (*Salmo salar*) in Norway. In 2004 *G. salaris* was detected on Arctic charr (*Salvelinus alpinus*) in the tributaries of the river Numedalslågen. This parasite belongs to a genotype previously only found on farmed Arctic charr.

Stephanostomum baccatum – Prevalence of metacercariae in North Sea dab (*Limanda limanda*) ranged from 1.3% at the Indefatigable Bank to 61.3% at West Dogger. This parasite shows a pronounced spatial pattern, with high prevalences in the northern North Sea (e.g. the Firth of Forth area). In the Firth of Forth area, the prevalence increased again after the drop observed in 2003.

Cryptocotyle lingua – Prevalence of metacercariae in Baltic cod (*Gadus morhua*) was similar to that of previous years. This parasite has a distinct spatial distribution pattern, with highest prevalences in the western Baltic Sea.

Prosorynchoides gracilescens – A total of 950 fish (cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*) and whiting (*Merlangius merlangus*)) were sampled during a parasite survey from the west and east coast of Scotland as well as the Shetland Islands during 2003–2004. Metacercariae occurred at prevalences of 60% (west coast), 42% (east coast) and 67% (Shetland Islands).

***Anisakis simplex* (larvae)** – In Scotland the prevalence ranged from 3.6% to 27.3% in cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*) and whiting (*Merlangius merlangus)*. In Barents Sea cod, prevalence over the past decade appears steady but the abundance index (intensity) has decreased. Decreasing trends were observed in the prevalence and intensity of infection in Baltic herring (*Clupea harengus*) from Subdivisions 24–26 (Polish EEZ). A similar decreasing trend during 1999–2004 was observed in herring in the Russian EEZ (2004 prevalence was 1.3% in Subdivision 26). In Barents Sea redfish (*Sebastes mentella*) the prevalence remained the same but the abundance index was lower (2.6 vs. 5.7 in 2003). Pink salmon (*Oncorhynchus gorbuscha*) and chum salmon (*O. keta)* in the Far Eastern Region of Russia continued to have a high prevalence of infection. 75% to 96% of post-spawned pink salmon were infected in the muscle with an abundance index of 3–8. These values for chum salmon were 94% to 100% and 32–45, respectively.

Pseudoterranova decipiens (larvae) – An increase in liver infections in Barents Sea cod (*Gadus morhua*) has recently been recorded. Investigations conducted in 2004 show that the prevalence was 20% and the abundance index was 0.4.
***Corynosoma strumosum* (larvae)** – Prevalence was 4.5% in Baltic cod (*Gadus morhua*) and 6.1% in Baltic flounder (*Platichthys flesus*) (Russian EEZ, ICES Subdivision 26).

Lepeophtheirus salmonis – Fisheries and Oceans Canada continued monitoring juvenile pink (*Oncorhynchus gorbuscha*) and chum salmon (*O. keta)* fry in the Broughton Archipelago and surrounding waters in British Columbia. The overall prevalence was approximately 62% on pink salmon and 64% on chum salmon. Mean intensities were approximately 4.1 and 11.1 lice per fish, respectively. Infestations are a problem in Atlantic salmon (*Salmo salar*) and sea trout (*Salmo trutta*) in Norway, although infestations in salmon seem to be less severe than in previous years.

Lepeophtheirus pectoralis – Prevalence in dab (*Limanda limanda*) ranged from 1.2% at the Amble off the coast of northeast England to 62.7% from Liverpool Bay, Irish Sea. The prevalence at the Dogger Bank continued to increase to 30.2%.

Sphyrion lumpi – In 2004 the prevalence showed a continued increasing trend in deep-water redfish (*Sebastes mentella*) from the Barents Sea to 38%.

Clavella adunca – The prevalence in North Sea cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*) and whiting (*Merlangius merlangus*) from Scottish waters ranged from 9.2% to 12.6%.

Other diseases

Epidermal hyperplasia/papilloma – Variable prevalence between the areas visited previously with few sites showing general trends. In dab (*Limanda limanda*) from Morecambe Bay (Irish Sea) an increased prevalence was apparent between 2002 (0.9%) and 2004 (3.0%). Prevalence at the Indefatigable Bank (North Sea) shows a slight increase between 2002 (1.3%) and 2004 (2.9%). Off Flamborough and Off Tees (North Sea) both show a downward trend in prevalence since 2002 of 3.2% to 0.8% and 2.3% and 0.4%, respectively. The prevalence in summer samples remained steady at West Dogger (North Sea) at around 2.5% since 2002. Prevalence increased to 6.2% in Nov/Dec.

Liver nodules/tumours – In dab (*Limanda limanda*), differential prevalence of liver nodules > 2 mm, being low in the northern North Sea and high in the central and southern North Sea, consistently observed until the mid 1990s, has almost disappeared. The prevalence may have approached constant background levels in some areas. Similarly, the prevalence in former hot-spot areas (German Bight, Dogger Bank) remained at a low level. In contrast, an increase in prevalence of 7.4% to 9.6% was seen at St Bees (Irish Sea). Furthermore, liver nodules were observed for the first time at South East Isle of Man (Irish Sea) (5.8%), since sampling began there in 2001. None were observed at Burbo Bight (inner Liverpool Bay, Irish Sea) during 2004. The highest prevalence was recorded in fish captured from Inner Cardigan Bay at 16.7%.

Tumours were detected in 0.02% of fish in the Barents Sea. Among tumours detected during 1999–2004 epithelial cancer (cod (*Gadus morhua*), long rough dab (*Hippoglossoides platessoides*)), reticulum cell sarcoma, fibrosarcoma, chondrosarcoma (haddock (*Melanogrammus aeglefinus*), wolffish (*Anarhichas* spp.)), papilloma (wolffish), fibroma (long rough dab), rhabdomyoma (wolffish) and poorly-differentiated liver cancer (haddock) were diagnosed.

Hyperpigmentation – Prevalences in North Sea dab (*Limanda limanda*) continued to be high in most North Sea areas, e.g. in the German Bight and at the Dogger Bank (27.4% and 53.1%, respectively). The England/Wales report showed somewhat lower values but concluded that the disease still appears to be most prevalent in the North Sea. An increase in prevalence of 5.8% in 2003 was observed at the Indefatigable Bank. Although the prevalence of hyperpigmentation still remains relatively low at sites in the Irish Sea, 2004 saw an increase of 11.1% to 15.0% at Inner Cardigan Bay, similar to those levels observed in 2002. In dab from the western Baltic Sea, the prevalence was below 0.1%.

Intersex – The condition has been detected for the first time in an offshore flatfish species. Two dab (*Limanda limanda*) from a total of 14 male fish from a station at the North Dogger Bank (North Sea) were found to exhibit the condition in 2004. Both cases exhibited only previtellogenic oocytes amongst the testicular tissue. In one fish where both lobes of the gonad were sectioned, only one was affected. In the second fish only one lobe was sampled. The significance of this condition in dab is currently unknown.

Skeletal deformities – The prevalence of skeletal deformities in Baltic cod (*Gadus morhua*) in 2004 varied between 0.3% and 3.8% and was lower than in previous years. Skeletal deformations were recorded in sprat (*Sprattus sprattus*) caught in ICES Subdivision 25 and 26 (0.1% and 0.02%, respectively). Percentage of sprat with deformations in Subdivision 25 was higher than in 2003. The deformations were found in 0.1% of flounder (*Platichthys flesus*) from the Baltic Sea (ICES Subdivisions 24 and 26).

FARMED FISH

Viruses

Viral Haemorrhagic Septicaemia Virus (VHSV) – A North American strain of VHSV was isolated from farmed Atlantic salmon (*Salmo salar*) showing visceral haemorrhage in British Columbia, Canada, during March 2004. This was associated with a low-level mortality from 150 g smolts that had entered seawater four months previously. Laboratory studies with previous isolates have shown this strain to be pathogenic.

Salmon pancreas disease virus (SPDV) – SPDV is widespread in Ireland in farmed Atlantic salmon (*Salmo salar*) and now affects the majority of marine farms. Mortality ranged from 5% to 30%. In Norway, an increase in losses associated with cases of clinical SPD (Salmon Pancreas Disease) has been noted together with the first diagnosis of this disease in Nordland and Rogaland.

Infectious pancreatic necrosis virus (IPNV) – IPNV was isolated in Ireland from two different Atlantic salmon (*Salmo salar*) farms in 2004. One isolate from one of these farms was the Ab serotype. In Scotland 44% of sites were positive for IPNV. Overall there is no major trend but the data indicates the widespread nature of the virus. IPNV has recently been deregulated and designated area orders revoked.

Infectious Salmon Anaemia Virus (ISAV) – In Norway there has been an increase in reported cases of ISAV in Atlantic salmon (*Salmo salar*). An investigation into high mortality among farmed salmon post smolts in Scotland resulted in declaration of suspicion of ISAV at one farm following positive results from IFAT and RT-PCR. Significant gill pathology and ***Ichthyobodo* spp.** were recorded on these salmon in low to high numbers. The site was fallowed and the fish ensiled.

ISAV was confirmed at six Atlantic salmon farm sites in Cobscook Bay, Maine, USA. This virus was detected in June and continued through the year. Nearly all infected cages were voluntarily harvested before cell culture confirmation. During routine surveillance of all salmon culture sites in Maine, a second strain of ISAV was detected at a site south west of Cobscook Bay. This was the first detection of ISAV in Maine other than Cobscook Bay. ISAV was detected by RT-PCR in several pens, and appeared to spread to all cages at the net-pen site before dissipating over a period of 6 months. The new wild type strain (strain-2) did not cause disease in the cultured salmon and did not grow on normal cell lines. There was no spread to four other farms in the area. Segment 6 gene sequencing of PCR products indicates this strain is more closely related to the possible non-pathogenic or wild types from Scotland, Nova Scotia and Norway than to the New Brunswick strain that has caused mortality in Cobscook Bay. Preliminary results of sequencing of archived samples from the Cobscook Bay outbreaks shows that the strain-2 occurred with the pathogenic strain of ISAV in five out of the seven sites tested. In at least two cages, strain-2 infection was followed by a strain-1 disease outbreak; suggesting strain-2 may not be fully protective. Observational data demonstrated there were more ISAV-PCR positive sea lice (*Caligus elongatus*) than positive fish among the moribund fish examined.

Heart and skeletal muscle inflammation (HSMI) – In farmed Atlantic salmon (*Salmo salar*) in Norway, HSMI was first described in 1999 and a significant increase was reported for 2004. The outbreaks are generally severe with losses up to 25%. HSMI is an infectious disease of possible viral origin. A condition resembling HSMI has been reported in Scottish salmon with a cumulative mortality of 9%. Moribund fish showed swollen abdomen, dermal oedema, ascites and pericardial fluid with a thin gelatinous membrane over the liver. The heart appears soft and flabby. Histopathological changes in myocardial spongy layers were characterised by widespread vacuolation, degeneration and subsequent cavitation of cardiac myocytes, with loss of striation.

Bacteria

***Aeromonas salmonicida* –** An outbreak of furunculosis occurred at a federal US Atlantic salmon (*Salmo salar*) hatchery with significant mortality. Historically, incoming broodstock at this hatchery experienced 50% pre-spawn mortality due to terramycin-resistant *A. salmonicida*. The problem had been managed by inoculating incoming broodstock with oxolinic acid and a water-based vaccine. This recent outbreak occurred in post-spawned broodstock approximately two weeks post treatment.

Atypical *A. salmonicida* has been a problem in halibut (*Hippoglossus hippoglossus*) in Norway. In Ireland, furunculosis (typical and atypical strains) re-emerged on some freshwater rainbow trout (*Oncorhynchus mykiss*) sites to cause significant mortality.

***Aeromonas hydrophila, A. salmonicida*, myxobacteria and *Pseudomonas* spp. –** were detected in Atlantic salmon (*Salmo salar*) in Latvia, as well as several outbreaks of myxobacteriosis in some salmon hatcheries. *Pseudomonas spp.* constituted 23–35% of the isolates from hatchery juvenile Atlantic salmon in the Far East of Russia.

***Edwardsiella tarda* –** The number of isolations of *Edwardsiella tarda* has increased from farmed turbot (*Scophthalmus maximus*) in Spain.

***Tenacibaculum (Flexibacter)* sp.** is frequently isolated from halibut (*Hippoglossus hippoglossus*) fry in Norway.

***Moritella viscosa* –** Outbreaks of *Moritella viscosa* are causing significant losses, mainly due to decreased quality, both in salmon (*Salmo salar*) and rainbow trout (*Oncorhynchus mykiss*). The losses are especially high in northern Norway, probably due to low temperature and a slow healing process. In Ireland, outbreaks are associated with mortality in S0 Atlantic salmon smolts.

***Renibacterium salmoninarum* –** *R. salmoninarum* in Denmark was found in two new marine rainbow trout (*Oncorhynchus mykiss*) farms. The number of outbreaks of BKD in rainbow trout in Finland showed a slight decrease in 2004.

***Piscirickettsia salmonis* –** *P. salmonis* outbreaks with associated high mortality occurred at three marine sites rearing Atlantic salmon (*Salmo salar*) in Ireland during the late summer. In Scotland there is a slight upward trend in reported cases.

Vibriosis – *Vibrio* (*Listonella anguillarum*) is the main disease problem in cod fry (*Gadus morhua*) in Norway.

Parasites

Paramoeba sp. – Amoebic gill disease affected Atlantic salmon (*Salmo salar*) at four sites in Ireland. Two sites had losses of 10–20% in some pens.

Philasterides dicentrarchi – An increasing trend in turbot (*Scophthalmus maximus*) culture in Spain is reported. A vaccine against *Philasterides* should be shortly available for field trials.

Ichthyophonus hoferi – A farmed Atlantic salmon (*Salmo salar*) in Scotland was reported with a proliferative granulomatous response with numerous encysted spores of *I. hoferi* at different developmental stages.

Tetracapsuloides bryosalmonae – Proliferative kidney disease was observed on some Atlantic salmon (*Salmo salar*) farms in Ireland.

Parvicapsula pseudobranchicola – In 2002 the first clinical disease outbreaks caused by *Parvicapsula* were diagnosed in five Atlantic salmon (*Salmo salar*) farms in northern Norway. In 2004 the parasite was detected in several farms in northern Norway as well as in Trøndelag and Møre and Romsdal. The significance of the disease is uncertain.

Enteromyxum scophthalmi shows an increasing trend in turbot culture in Spain.

Eubothrium crassum – A possible increasing problem with *Eubothrium crassum* is reported from some regions in Norway rearing Atlantic salmon (*Salmo salar*). The effect of treatment (praziquantel) has in some cases been unsatisfactory and improper treatment procedures or emerging resistance has been proposed as possible causes.

Other diseases

Proliferative gill inflammation – Proliferative gill inflammation has been detected in Norwegian Atlantic salmon (*Salmo salar*) for at least 15 years, and generally occurs during the first months following seawater transfer. Losses vary between 15–60% and growth is often seriously retarded. This condition has been associated with **epitheliocystis** and a newly described, **Atlantic salmon paramyxovirus (ASPV)**. In 2004 this has been a serious disease problem especially in the southern part of Norway (Rogaland).

Congenital deformities – A high prevalence of congenital deformities were present in some batches of imported Atlantic salmon (*Salmo salar*) fry in Ireland.

WILD AND FARMED MOLLUSCS AND CRUSTACEANS

Viruses

Herpesvirus in bivalves – No change reported in France and no new information from the US (but see report section 8 on Summer Mortality of Pacific oysters)

Viral Gametocytic Hypertrophy in Pacific oysters (*Crassostrea gigas*) – Continued rare presence in France.

Bacilliform virus in brown shrimp– Infections were detected for the first time in brown shrimp (*Crangon crangon)* from the North Sea collected from the offshore Wash fishery (UK). The virus, apparently the same as the *C. crangon* bacilliform virus (CcBV) previously described from *C. crangon* in estuarine environments, was present in 100% of shrimp sampled. Light to heavy infections affected the hepatopancreas.

White Spot Syndrome Virus in shrimp – WSSV was found in 20% of a sample of 100 shrimp (*Litopenaeus setiferus*) in Mississippi Sound, Gulf of Mexico, USA. The same virus was detected a few years ago in wild penaeid shrimp in the Gulf, but at a prevalence of <1%. Preliminary analysis indicates that this may represent a localised outbreak of an introduction or the eruption of an indigenous form of WSSV or related virus. The first outbreak of disease due to WSSV in the Pacific region of the USA occurred in a commercial shrimp farm on the island of Kauai, Hawaii. Quarantine restrictions were placed on the affected facility, prohibiting the movement of shrimp. Prior to this outbreak, WSSV in the USA was reported only in commercial facilities in Texas and South Carolina in 1995 and from wild shrimp and crabs off shore in the Gulf of Mexico and near shore in Texas, Mississippi, Georgia and South Carolina.

Taura Syndrome Virus in shrimp – An outbreak of TSV occurred at four pond-culture facilities in Texas, USA, that were growing Pacific white shrimp (*Litopenaeus vannamei*). Sixteen of 38 ponds tested positive for the virus and experienced 80–90% mortality. Based on sequencing of the VP1 region, the isolated virus is 97% similar to isolates from the Americas, 96% similar to a Belize isolate and 98% similar to an Asian isolate in the OIE Reference Laboratory collection. Quarantines were placed on the facilities to prohibit water discharge and to restrict shrimp movement to processing facilities only.

Bacteria

***Rickettsia* in shore crabs** – A putative rickettsia-like organism (RLO) was found for the first time in shore crabs (*Carcinus maenas*) from Southampton Water, English Channel, UK. Two individuals, collected in July and October 2004 exhibited white opaque haemolymph upon dissection. Histopathology and transmission electron microscopy revealed a heavy RLO infection associated with connective tissues. Spongy connective cells, reserve inclusion cells, fixed phagocytes and haemocytes appeared the target for infection.

Nocardiosis of Pacific oyster – No new trends reported for *Crassostrea gigas* in Canada and USA.

Juvenile Oyster Disease of eastern oysters – No change in distribution reported. Sampling of eastern oyster (*Crassostrea virginica)* cohorts deployed experimentally in Maine and Massachusetts, USA, and followed during the summer of 2004 documented, for the first time, the presence and predominance of the □-proteobacterium, *Roseovarius crassostrea*, before and during the development of JOD in oysters. Previously, it had been found only in sick oysters. The disease has not been experimentally reproduced, but the new finding, along with earlier documentation that *R. crassostrea* is found in all JOD outbreaks over a wide geographical range, supports the contention that this newly described bacterium is the proximate cause of JOD, although other factors may be necessary to trigger disease outbreaks.

Fungi

Yeast in edible crabs – Continued low prevalence of yeast was found in edible crabs (*Cancer pagurus*) in UK waters. The yeast is possibly a co-infecting organism in immunosuppressed crabs infected with *Hematodinium sp.*

Parasites

Picoeucaryot alga in blue mussels – Infections by a previously undescribed green alga were found in 3-year-old or older blue mussels (*Mytilus edulis*) in southern Norway. Infections were primarily on the edge and in the connective tissues of the mantle, and resulted in severe shell deformation.

***Hematodinium* (Pink Crab Disease) in edible crabs (*Cancer pagurus*)** – continues to be present in UK waters at prevalences of 3% to 33%, depending on month of collection.

***Hematodinium* in blue crabs** – The end of a 4-year drought in the southeastern USA significantly reduced the prevalence (to 5%) of *Hematodinium perezi* in blue crabs (*Callinectes sapidus*). This parasite was associated with marked declines in fishery landings during the drought. To the north, it remains more abundant in the Atlantic coastal bays of Maryland, USA, where prevalences vary by month: 52% in September and October; 14% in November and 30% in December.

***Perkinsus marinus* in eastern oysters** – Another relatively cold wet winter/spring in 2003/04 led to the second year of marked decrease in the prevalence and intensity of *P. marinus* in Chesapeake and Delaware Bays, USA, oysters (*Crassostrea virginica*). Although the majority of sampled locations continue to be infected, prevalences fell to levels not seen since the early 1990s in Chesapeake Bay. In 2002 in the lower bay 26 of 29 stations had at least 80% prevalence in the fall survey; in 2004 this ratio was only 6 of 29. In the upper bay the prevalence of infected oysters fell from 94% to 52% between 2002 and 2004. In Delaware Bay the decrease was from 81% to 43% during the same period. No change was reported in New England, South Carolina, or around the Gulf of Mexico.

***P. andrewsi/chesapeaki* in clams** – During 2004 infections remained ubiquitous and prevalent among commercial soft shell clams (*Mya arenaria*) (45%) and stout razor clams (*Tagelus plebeius*) (72%) throughout the upper Chesapeake Bay, USA. A single sample of 18 *T. plebeius* examined for the first time in lower Delaware Bay, USA, had a prevalence of 84%, all very light infections. This pathogen, along with haemic neoplasia, is thought to be responsible for a serious decline in soft clam harvests in Chesapeake Bay.

***Perkinsus olseni* in Manila clams** – Infections continue to be prevalent in Manila clams (*Ruditapes philippinarum*) along the French coast (547 positive clams among 759 analysed).

Quahog Parasite X (QPX) in hard clams – An outbreak of QPX in farms on the north side of Cape Cod, Massachusetts, USA, in 2004 resulted in the loss of several million clams (*Mercenaria mercenaria*), which were destroyed in an attempt to halt the spread of the parasite. The outbreak occurred in seed clams that had been transplanted earlier from an enzootic site. The prevalence at the time of transplantation was 1%, but it quickly increased, with concomitant mortalities, over the next several months. To date, there is no evidence that the parasite was transmitted to resident clams in the area. By using molecular methodologies, it has been possible to detect QPX-like particles in water samples and to further associate the parasite with marine aggregates, especially the seaweed portion of those aggregates. No change was reported in the remainder of the known range in Canada and the USA.

***Bonamia ostreae* in flat oysters** – Infections were reported for the first time in British Columbia, Canada in November 2004. A prevalence of about 60% was detected in 3-year old flat oysters (*Ostrea edulis*) sampled from one location. Re-examination of archived samples indicated that *B. ostreae* was present in flat oysters from the same location in 2003. Mortalities of 3–4 year old oysters over the past two years at the affected site were associated with severe algal blooms; thus, the exact correlation between these mortalities and *B. ostreae* infection is not clear. However, flat oysters from the infected stock held in the laboratory at ambient temperatures (9–10 °C) experienced continuous mortality associated with very heavy *B. ostreae* infections that reached about 40% over two months. Flat oysters account for less than 1% of the total British Columbia oyster production.

No change was found in France, Ireland, Spain and the UK. Samples of adult oysters in Scotland and the Limfjorden area of Denmark tested negative for *B. ostreae* in 2004 and the latter received approved status as being free from Bonamiosis by the EU in December.

***Bonamia* sp. in Asian oysters**– In 2003, a new species of *Bonamia* was discovered killing an exotic oyster species (*Crassostrea ariakensis*) experimentally deployed in South Carolina, USA. This oyster is being considered for introduction into Chesapeake Bay to replace the native eastern oyster (*C. virginica*), which has been devastated by diseases. The pathogen is considered to be a previously unrecognized enzootic parasite infecting a susceptible introduced host. Subsequent analyses demonstrated that the pathogen is similar in SSU rDNA sequence to the southern hemisphere *Bonamia exitiosa* and *B. roughleyi*. The parasite persisted throughout 2004, and was detected also in the native crested (horse) oyster *Ostrea equestris*. Also in *O. equestris*, another new *Bonamia* sp. was detected that is more similar in SSU rDNA sequence to the northern *B. ostreae* than to the southern hemisphere forms. Neither North Carolina *Bonamia* sp. was observed in *O. equestris* at (PCR) prevalence greater than 6%. The second *Bonamia* sp. (sequenced from *O. equestris*) was never found in *C. ariakensis* by species-specific PCR. The geographical distribution of the North Carolina *Bonamia* spp. is unknown, although neither has been detected in *C. ariakensis* being tested in Chesapeake Bay.

***Mikrocytos mackini* in Pacific oysters** – In mid-February 2004, a mikrocytosis outbreak in Pacific oysters (*Crassostrea gigas*) within the known distribution of *M. mackini* in British Columbia, Canada, suspended harvesting of infected *C. gigas* because of the high prevalence of visible lesions. Unlike previous cases involving oysters harvested from the beach, this disease outbreak occurred among oysters in a suspension culture system. However, the affected stock had been maintained in culture for one year longer than the usual harvest regimen because of harvest closures due to toxic phytoplankton concerns. In April 2004, an estimated mortality of 7% was directly attributable to mikrocytosis. Three percent of juvenile oysters hung adjacent to the infected stocks on 8 April 2004 had light infections when sampled in June 2004.

***Haplosporidium nelsoni* (MSX) in eastern oysters** – To date, confirmed infections remain restricted to the Bras d'Or Lakes area of Cape Breton where the pathogen was first found in Canada in 2002. Surveillance of the buffer region around Cape Breton and oysters in the southern Gulf of St. Lawrence is ongoing. Continued above-average rainfall and consequently reduced salinities in 2003/04 depressed *H. nelsoni* prevalences and intensities for the second year in a row in Chesapeake Bay, USA. In the upper bay, mean prevalence fell from 28% to 0.3% between 2002 and 2004. In the lower estuary *H. nelsoni* was found at 28 of 29 sampling stations in 2002; in 2004 it was detected at just 5 of 29 stations. No change was recorded in Delaware Bay, where infection prevalence continues to be very low, apparently due to resistance in the native population, or in the southeastern USA, where prevalence has always been relatively low. No data were reported from New England.

***Haplosporidium costale* (SSO) in eastern oysters** – Infections, detected by PCR alone, with no confirmatory detection by histology and no associated mortality, were found in Atlantic Canadian oysters (*Crassostrea virginica*). No infections were detected in USA oysters examined by histology.

***Marteilia refringens* in Pacific oysters** – No change in France. Samples of adult Pacific oysters (*C. gigas*) in Scotland and the Limfjorden area, Denmark, tested negative for *M. refringens* in 2004 and the latter received approved status as being free from Marteiliosis by the EU in December.

***Marteilia maurini* in blue mussels** – Infections were found in three of 50 blue mussels (*Mytilus edulis*) examined from Southampton Water, UK, in June 2003. A further sample of 150 mussels was examined in June 2004. Eight of these were infected. It was confirmed by 18s DNA sequence analysis using the OIE approved method that the species was *Marteilia maurini*. Nearby native flat oysters (*Ostrea edulis*) were negative for *Marteilia*. Further sampling of mussels from this site revealed one infected individual during October 2004 (n = 50) and another in November 2004 (n = 50).

Paramarteilia-like organism in edible crabs – One individual per sample of 30 edible crabs (*Cancer pagurus*) from UK waters was infected each month in January, February and April, 2004. The organism was found throughout the hepatopancreas and was also shown to be infecting the ovary and oocytes.

Microsporeans in crabs – An intranuclear microsporean infection was present in one individual per sample of 30 edible crabs (*Cancer pagurus*) collected each month from March through May, 2004, in the UK. The microsporean was distributed throughout the hepatopancreas tubules, infecting the nuclei of the endothelial cells. This is the first finding of an intranuclear microsporean infection of an invertebrate. Current work is attempting to classify this organism using ultrastructural and molecular tools. Another microsporean infection, with prevalence of over 60% in some months, was discovered in Chinese mitten crabs (*Eriocheir sinensis*) from the River Thames in London.

***Prosorhynchus squamatus* in blue mussels** – Moderate infections were detected in 3% of wild mussels (*Mytilus edulis*) in Nova Scotia, Canada, collected from two sites: Aspy Bay, a new site for detection in October 2003 and Lennox Passage in June 2004. A three-year directed sampling program for this parasite has not detected it in the other Maritime Provinces nor has it revealed a significant impact to mussel resources either wild or cultured.

Other diseases

Neoplasia – No new trends were reported in Canada or in cockles (*Cardium edule*) in Spain. Disseminated neoplasia (DN) remains present (13% in a sample of 30) in soft shell clams (*Mya arenaria*) from upper Chesapeake Bay, USA. A similar, but also distinctive, haemolymph proliferative disorder was detected in stout razor clam (*Tagelus plebeius*) collected during both 2002 and 2004. This appears to be a previously undescribed disseminated haemocytological neoplasia of unknown aetiology, epidemiology, and pathology. To date, two 2002 samples and one 2004 *T. plebeius* sample have shown >90% prevalences of this neoplasm.

In 2004 neoplasia was for the first time observed in clams (*Macoma balthica*) from four new sampling stations in the Gulf of Gdansk, Baltic Sea, where the disease had not been noted before. Three of those at depth 40 m and one at depth 60 m had an average prevalence of 11%. Prevalence among all stations varied from 2.5% to 25%. When compared to a previous study it appears that the incidence of neoplasia has become more widespread and is now found throughout the whole area of the Gulf of Gdansk.

By using the nucleus-to-cytoplasm ratio of haemocytes it was confirmed that histopathological lesions detected in soft shell clams (*Mya arenaria*) from the German Wadden Sea area, and originally considered to be haemic neoplasia, were of an inflammatory nature.

Gill disease in blue mussels – A newly described gill anomaly was identified in blue mussels (*Mytilus edulis trossulus*) from the Gulf of Gdansk, Baltic Sea, sampled from the 45 m depth station in 2003 and 2004, with prevalence of 11% and 23%, respectively. Gills of affected mussels, viewed macroscopically, appeared highly eroded. Gill filaments were totally destroyed in advanced cases.

Mortalities of adult flat oysters (*Ostrea edulis*) – No new trends were reported in Canada.

Cockle mortality – Unusually heavy mortality, of up to 70%, occurred in some cockle (*Cerastoderma edule*) beds in November in Milford Haven, South Wales, UK. Most individuals were parasitised by a combination of digeneans in the muscle or gut lumen or by gregarines. These were in low numbers in all cases and were thus not considered significant. In addition, there was some necrosis and infiltration present in the digestive gland but this was again felt to be within normal limits. Overall, there were no consistent features that would indicate a cause for the observed mortality and an environmental cause is suspected.

Mussel mortality – High mortality of blue mussels (*Mytilus edulis*) was reported in the UK in June, and along the northern Mediterranean coast of Spain between June and November. The mortality in Spain was attributed to unusually high water temperatures. These mussels had up to 80% prevalence of *Mytilicola* sp. and *Marteilia* sp. with associated alteration of internal organs.

Shell disease of crustaceans – American lobster (*Homarus americanus*) mortality/shell disease, which is associated with various bacterial and fungal species, continues to be a problem primarily from eastern Long Island Sound, New York to Buzzards Bay, Massachusetts, south of Cape Cod, USA. The appearance of shell disease off Salem and Cape Ann, Massachusetts, north of Cape Cod, is the first since extensive sampling began in 2000. In Maine and New Hampshire the prevalences are generally less than 0.1%, although in some areas of Maine the prevalence is as high as 5%.

Shell disease associated with carapace infestations of *Pseudomonas* spp. is common in crustaceans in Sakhalin Island, Russia. Prevalence ranges from 1% to nearly 60%, depending on host species. Chitinolytic fungus disease, caused by

Trichomaris invadens, is observed in 1% to 8.5% of snow crabs (*Chionoecetes opilio*). Hyphae penetrate the exoskeleton and invade the epidermis and other tissues and organs. Moderate infection prevents moulting, and invasion of the eyes probably causes blindness and a potential lethal outcome.

Summer Mortality of Pacific oysters – Oyster herpes virus was detected in juvenile oysters (*Crassostrea gigas*) in Tomales Bay, California, USA, an area that has experienced repeated episodes of Summer Mortality for the past decade. A causal relationship, however, has not been demonstrated and previous studies have associated a variety of physiological and environmental factors in the mortalities. Summer mortality studies continued in France in the MOREST Programme (see Report Section xx).

Mortality of Surf Clams – A widespread mortality of surf clams (*Spisula solidissima*), as documented by a marked (~50%) drop in abundance of live clams, occurred between 1999 and 2002 off the mid-Atlantic coast of the USA. A histological survey in 2003 found no evidence of a pathogen, but did document a loss of condition, gonadal "abnormality", and digestive gland atrophy that increased in a southerly direction and has been called a "malnourishment syndrome". It is hypothesized that regional increases in temperature due to global warming have resulted in a mismatching of food supply and feeding rate, leading to the slow starvation of the clams at the southern edge of their range. At the same time, there is evidence that clam densities are increasing at the offshore and the northern edge of the range, suggesting that the mortality is part of a range shift to regions of cooler water temperature in this species.

Black Spot Disease in brown shrimp (*Crangon crangon*) – No new trends have been reported in the German Wadden Sea.

Miscellaneous

Due to the heavy mortalities of eastern oysters (*Crassostrea virginica*) experienced in Chesapeake Bay, USA, from 1998 to 2002 caused by *Perkinsus marinus* and *Haplosporidium nelsoni*, the harvest of native oysters is now less than 2% of what it was in the 1970s. The state of Maryland, which borders the upper estuary, has proposed releasing diploid Asian oysters (*C. ariakensis*) in 2005 with the hope that this species, which is resistant to mortalities caused by these two pathogens, will restore oyster populations in the bay. The proposal has met with resistance from some adjacent states (Delaware and New Jersey), and with most of the scientific and environmental community. It is presently unclear whether Maryland will carry through with the project, at least this summer. In Virginia, which borders the lower bay, growers have been experimenting with cage-culture of triploid Asian oysters and also triploid, selectively bred native eastern oysters, both of which have performed well in commercial-scale tests.

The project on effects of antifouling compounds (Irgarol, Diuron, and Copper) on wild mussels (*Mytilus edulis)*, Pacific oysters (*Crassostrea gigas*) and periwinkles (*Littorina littorea*) from a harbour area (Norderney) and a reference area at the German North Sea coast was finalised. Whilst the specimens from the reference area were affected only by lesions induced by parasites (trematode larvae and *Mytilicola intestinalis*), those from the harbour area displayed necrotic and inflammatory changes of the gonads and the hepatopancreas (*C. gigas*, *L. littorea*) as well as of the gills (*L. littorea*). A link with the antifouling compounds is not clear, however. In the harbour area, lesions known to be caused by tributyltin were also recorded (shell deformities in *C. gigas*, intersex and atrophy of gonads in *L. littorea*).

Source of the information

The 2005 report of the ICES Working Group on Pathology and Diseases of Marine Organisms (WGPDMO) and ACME deliberations.

2.4 Monitoring Issues

2.4.1 Integrated Monitoring for Phytoplankton and Harmful Algal Blooms

Request

This is part of continuing ICES work to evaluate the occurrence of harmful algal blooms and to monitor phytoplankton dynamics.

Recommendations and advice

ICES recommends that Member Countries establish pro-active and *ad-hoc* harmful algal bloom (HAB) monitoring schemes that record in particular hydrographic parameters (mixed layer depth, circulation patterns, frontal dynamics, temperature, etc.) and nutrient concentrations in combination with the occurrence of HABs. This information should support the growing interest in the 3D modelling of individual harmful species.

ICES recommends that Member Countries work toward the integration and cooperation on all phytoplankton and zooplankton data collected and generated with remote sensing, continuous plankton recorders and other such unattended devices like ferryboxes to ensure that maximum use is made, *inter alia* for modeling.

ICES recommends promoting initiatives to develop and establish an operational Pan-European hydrological model to provide high resolution (in time and space) predictions of freshwater and nutrient inputs to the ICES areas.

Summary

ICES is concerned that it may be difficult to detect and assess the impacts of climate change on phytoplankton dynamics because of the lack of long-term data series. ICES urges Member Countries to continuing existing monitoring programmes recognizing their international importance. Model-generated data cannot replace real long-term data for assessing temporal changes.

With the increasing focus on the functioning of marine ecosystems future work on phytoplankton should concentrate on functionality in relation to:

- the living resources and the marine foodweb,
- climate change and biogeochemical cycling; and
- nuisance species with negative economic impacts.

This will require increased integration and cooperation between all groups dealing with phyto- and zoo-plankton issues as well as the physical and biological sciences. This integration should ensure that maximum use is made of all data collected and generated such as remote sensing, continuous plankton recorders and other such unattended devices (see www.ferrybox.org) and the development of phytoplankton production models. The integration of physical and biological modeling, coupled with good ground truth data could provide useful tools in understanding how the marine ecosystems function. The techniques of remote sensing and numerical modelling of phytoplankton and primary production are quite useful for providing information and resolving issues where full quantitative information are not completely necessary. Some of the present day uncertainties in modelling primary production are caused by the lack of information on sources of freshwater and nutrients.

ICES noted that there is a problem in several Member Countries in providing contributions to the Annual Phytoplankton Summary.

ICES also recognizes that monitoring of harmful algal blooms (HAB) should be done jointly with the collection of other environmental information, in particular hydrography (mixed layer depth, circulation patterns, frontal dynamics, temperature, etc.) and nutrients. Knowledge of the spatial and temporal variations in environment variables prior to HABs may be important for revealing the causes for initiation and development of such blooms.

ICES recognizes the growing interest in 3D modelling of individual harmful species.

Action levels for phytoplankton numbers and related shellfish toxicity are country- and location- specific and in some countries not reliable. Simultaneous and regular monitoring of phytoplankton numbers and toxicity is needed.

Both toxic (*Nodularia spumigena)* and non-toxic Baltic Sea cyanobacteria *(Aphanizomenon* sp. and *Anabaena sp.*) decrease growth in cryptophytes and diatoms.

Source of information

The 2005 reports of the ICES Working Group on Harmful Algal Bloom Dynamics (WGHABD) and the ICES Working Group on Phytoplankton Ecology (WGPE) and ACME deliberations.

2.4.2 Passive sampling techniques for contaminants

Request

This work was initiated by ICES as a means of contributing to developing new tools for integrated monitoring and assessment in support of requests from OSPAR, HELCOM and the EU.

Recommendations

ICES recommends Member Countries continue work on passive sampling techniques as a monitoring tool and to report on this item in future meetings.

ICES noted that passive sampling techniques are rapidly developing and show great potential for (integrated) monitoring and assessment. ICES therefore recommends to OSPAR that the draft guidelines for integrated monitoring should be formulated in such a way that these techniques can be included, where appropriate, as they become more established.

Summary

It has been known for many years that total concentrations of metals or organic contaminants in water and sediment are unlikely to reflect the bioavailable portion. Many attempts have been made to address this question, but with only limited success. ICES is currently investigating the use of passive samplers, in particular silicone rubber sheets, as a new methodology that directly addresses the availability (e.g. the chemical potential) of organic contaminants from sediments and water. The availability of organic contaminants from sediment can be expressed as an equivalent concentration in the water phase. It is also possible to determine the total mobilisable (available) concentrations in sediments. To date this approach has been successfully applied in several monitoring exercises. In addition to sediment and water, a similar approach might be possible for mussel or fish homogenates. This could ultimately result in one assessment criterion applicable to all compartments, namely the free dissolved concentration in the aqueous phase. This approach could be applied in (integrated) monitoring as a prognostic tool for assessing the impact of organic contaminants on ecosystem health. ICES notes that the passive sampler approach offers great potential to address the problem of availability directly and would be complementary to the more contaminant-specific biological effects measurements that would reflect the biologically available contaminants in the environment.

Scientific background

Principle of passive sampling

A passive sampler can be seen as the glass level indicator often fitted to a large coffee container. The level in the glass reflects how full the coffee container is and at the same time the "pressure" which will drive the coffee out of the container if the tap is opened. The aqueous environment can be seen as a compilation of different compartments connected with each other through the water phase. In equilibrium, all compartments will be filled to the same degree. Using the fugacity or partition theory it can be derived that in equilibrium the ratio of the concentration of a compound in a matrix (activity) to its uptake capacity is equal for all of the compartments. The uptake capacity is equivalent to solubility for water and for a sediment it is the sorption capacity. The ratio between concentration and uptake capacity will also be reflected by any reference phase connected to these compartments and used as a passive sampler. When seeking a compartment in which a compound can be accurately measured and the uptake capacity of which is well defined, it is apparent that this is only the case for the reference phase. So, the reference phase can act as a gauge to measure the "pressure", i.e., pollution level in a compartment. One condition is, of course, that the reference phase is in equilibrium with the compartment in question. Principally, a reference phase can be used in any watery matrix to measure the pollution level, provided that equilibrium can be attained. The results from, for example, two sediments with different compositions, or a soil and a sediment sample, can be compared directly. Ideally, everybody using passive samplers should use the same reference phase and appropriate assessment criteria should be developed, so as to avoid problems with units when comparing data. There is however a need to recalculate to an already existing phase with a known fugacity capacity, since different materials are already in use as the reference phase (at least six have been observed in literature already) and others may be developed in the future. The suggested approach is to determine the water-reference phase partition coefficient of the compound of interest and recalculate to the free dissolved concentration in the water phase. Reference phases can be used in both water and sediments to give an estimate of the level of exposure.

Detailed information on passive samplers and on-going and planned activities by ICES Member Countries is provided in the reports listed in Source of information section.

Source of information

The 2005 reports of the ICES Working Group on Marine Sediment in Relation to Pollution (WGMS), ICES Marine Chemistry Working Group (MCWG) and the OSPAR/ICES Workshop on Integrated Monitoring of Contaminants and their Effects in Coastal and Open Sea Areas (WKIMON).

2.5 Extraction of marine sediments

Request

This is the annual update of data on sand and gravel extraction activities in the OSPAR region.

Recommendations and advice

ICES recommends that all Member Countries report data to ICES annually on marine aggregate extraction activities.

ICES recommends that Member Countries submit null reports when no sediment is extracted.

Summary

An increasing number of ICES Member Countries undertake marine sand and gravel extraction activities, and others are looking at the potential for future exploitation. Each year, relevant developments on these issues are reviewed and summarized by ICES. ICES also reviewed and reported on programmes of national resource mapping, changes to legislative and administrative frameworks, approaches to Environmental Impact Assessment, and research of Member Countries in the field of marine sediment extraction.

In addition, ICES has collated available information for OSPAR countries on the annual amounts of sand and gravel extraction and the area dredged in comparison to the area licensed. ICES welcomed the continued interest by the OSPAR Biodiversity Committee (BDC) and the Working Group on the Environmental Impact of Human Activities (EIHA) in the work of WGEXT and ICES.

Scientific background

As in previous years, about half the ICES Member Countries were able to supply figures for marine aggregate extraction. The majority of the extraction takes place from the North Sea area, with lesser amounts from the Baltic Sea area, the English Channel, the Irish Sea, and the North Atlantic. More than 95% of the material extracted has been sand and gravel, with limited amounts of maerl taken by France and Ireland and shell by the Netherlands.

The main use for marine aggregates continues to be for construction, beach recharge/coast defense and land reclamation. The Netherlands is the predominant user of sand for beach recharge/coast defense, the UK uses sand and gravel for construction. The use in other countries such as Denmark and Belgium is more variable and significant amounts can be required for specific projects.

Exports of marine aggregates have not changed significantly in quantity or destination. The UK remains the largest exporter at 3.8 million m^3 to Netherlands, Belgium, and France, followed by the Netherlands and Denmark.

A summary of data on marine sediment extraction is provided in Table 2.5.1; this covers the OSPAR region and seeks to fulfill the requirements of OSPAR for this type of data.

Table 2.5.1 Summary Table of National Aggregate Extraction Activities as reported by Member Countries, primarily covering the year 2004.

Country	Aggregate extracted (m^3)	Non-aggregate extracted (m^3)	Aggregate exported (m^3)	Beach replenishment (m^3)	New Maps available in 2004	New legislation	New Policy	EIA initiated	EIA ongoing	EIA finished	EIA published
Belgium	1,551,000	0	0	1,600,000[1]	No	Yes	Yes	Yes	Yes	No	No
Canada	N/d[2]	N/d	N/d	N/d	N/d	N/d	N/d	N/d	N/d	N/d	N/d
Denmark[3]	2,280,000	N/d[3]	N/d	N/d	No	No	No	Yes	Yes	Yes	Yes
Denmark[4]	4,180,000	7,070	89,000	2,600,000	No	No	No	Yes	Yes	Yes	Yes
Estonia	1,400,000	0	0	90,000	N/d	N/d	N/d	No	No	No	No
Finland	1,600,000	0	0	0	Yes	No	No	Yes	Yes	No	No
France[5]	3,448,000	358,000	0	N/d	No	No	No	Yes	Yes	Yes	No
Germany	N/d	N/d	N/d	N/d	No	Yes	Yes	N/d	N/d	N/d	N/d
Greenland and Faroes	N/d	N/d	N/d	N/d	N/d	N/d	N/d	N/d	N/d	N/d	N/d
Iceland	N/d	N/d	N/d	N/d	N/d	N/d	N/d	N/d	N/d	N/d	N/d
Ireland	0	7,690	0	0	Yes	No	No	Yes	No	No	No
Latvia	N/d	N/d	N/d	N/d	N/d	N/d	N/d	N/d	N/d	N/d	N/d
Lithuania	N/d	N/d	N/d	N/d	No	N/d	N/d	N/d	N/d	N/d	N/d
Netherlands	23,590,000*	185,600**	2,397,000***	10,625,000	Yes	No	Yes	Yes	No	No	No
Norway	Up to 150,000****	N/d	N/d	N/d	No	N/d	N/d	N/d	N/d	No	No
Poland	846,000	N/d	0	790,400	N/d	N/d	N/d	N/d	N/d	No	No
Portugal	N/d	N/d	N/d	N/d	N/d	N/d	N/d	N/d	N/d	N/d	N/d
Spain	845,000*****	0	0	845,000	No	No	No	No	No	No	No
Sweden	0	0	0	0	Yes	No	No	No	Yes	No	No
United Kingdom	12,981,000	0	3,730,000	949,400	No	No	Yes[6]	Yes	Yes	Yes	Yes
United States	N/d	N/d	N/d	N/d	N/d	N/d	N/d	N/d	N/d	N/d	N/d

[1] Belgian data for beach replenishment is unreported and cannot be combined with total aggregate extraction figure.
[2] N/d – no data.
[3] Denmark - the Baltic.
[4] Denmark – North Sea OSPAR Area.
[5] French data is estimated based on total authorised extraction.
[6] Interim Welsh National Assembly Marine Aggregate Dredging Policy, 2004.

*Total sand extraction.
** Total shell extraction.
***Exported amounts from the Netherlands are approximate.
****Norwegian figures are approximate. Norway extracts carbonate sands.
*****Spanish data does not include data from the community of Huelva and the province of Gran Canaria in the Canaries.

ICES has attempted to provide information for OSPAR countries on the annual amounts of sand and gravel extracted but have still found difficulty in obtaining information from countries not represented on WGEXT. In an attempt to resolve this, the OSPAR Secretariat provided the WGEXT Chair with a list of national contact points for collecting national extraction data. Those on the contact list will be approached for input to the 2006 WGEXT report.

Table 2.5.1 summarizes the information available. As noted last year, a number of countries did not provide data.

Table 2.5.2 Specific matters highlighted in response to OSPAR request for WGEXT to supply national data.

OSPAR COUNTRIES FOR WHICH DATA HAS NEVER BEEN RECEIVED (As of 2005)

- PORTUGAL
- ICELAND
- **GREENLAND AND FAROES (DENMARK)**

OSPAR COUNTRIES REPORTING TO WGEXT BUT NOT ANNUALLY IN RECENT YEARS

- FINLAND (report received for 2005)
- GERMANY

DATA ADJUSTMENTS FOR SPECIFIC COUNTRIES NECESSARY TO DISTINGUISH DATA FOR THE OSPAR REGION

- SPAIN – Atlantic coast activities only (excludes Mediterranean)
- FRANCE – Atlantic coast and English Channel activities only (excludes Mediterranean)
- GERMANY – North Sea activities only (excludes Baltic)
- FINLAND – Excludes Baltic activities
- SWEDEN – Delineate activities in the Baltic area which fall within the boundaries of the OSPAR 1992
- DENMARK – As for Sweden

In response to the OSPAR request to provide data on the area dredged in comparison to the area licensed, the following table summarises information, where available, for countries represented on WGEXT.

Table 2.5.3 Licensed area and actual areas over which extraction occurs.

COUNTRY	LICENSED AREA KM^2*		AREA IN WHICH EXTRACTION ACTIVITIES OCCUR KM^2	
	2003	**2004**	**2003**	**2004**
Belgium (Zone 1) (2002)	291.5	N/a	131	N/a
Belgium (Zone 2) (2002)	227.5	N/a	151	N/a
Belgium Total (2002)	519** (15% of Belgian Sea Area)	N/a	N/a	N/a
Denmark (estimate for recent years)	800	800	30	30
Germany (OSPAR)	979	N/a	N/a	N/a
Germany (Non OSPAR)	473	N/a	N/a	N/a
Netherlands	478	484	38	41
UK	1,245	N/a	144****	N/a

*Potential area from which material could be taken during the lifetime of that licence / dredging permit. **Total surface area available for extraction activities is less than this figure once seabed structures (e.g. pipelines, cables, and fisheries areas) are accounted for. ***Includes 26.59 sand & gravel extraction area and 8.84 non-aggregate extraction area.****90% of material extracted in UK is taken from 46 km^2.

It was again noted that this type of information has to be taken from an analysis of electronic monitoring data and this is not a straightforward task. Furthermore not every Member Country employs electronic monitoring or black box systems. Data collated in the above table highlight the trend anticipated in last years report based on the UK and Danish data, namely that the actual area dredged is considerably smaller than the total area licensed.

It should be recognised that variability exists between the area actually dredged in each licence within each country as well as between different countries.

Assessment of environmental effects

An increasing number of activities are aimed at assessing the effects of marine aggregate extraction as part of the application process for obtaining dredging permits or as research programmes.

- Belgium reported that an Environmental Impact Report (EIR) has been initiated by the Federation of Sand and Gravel Extractors on behalf of several licensees.
- Denmark provided information on a number of environmental impact assessments and research programmes ongoing in 2004.
- Ireland reported a collaborative research project involving a number of Irish and Welsh organisations, funded through the European InterReg IIIa programme entitled IMAGIN. The project aims to facilitate the evolution of a strategic framework, within which development and exploitation of marine aggregate resources from the Irish Sea may be sustainably managed with minimum risk of impact on marine and coastal environments, ecosystems and other marine users.
- France reported on a number of research projects currently underway. A research programme has been initiated that aims to better understand the impact of sandpits on seabed morphology in shallow water areas. France also reported a study which monitors the effects of marine sediment extraction on biological resources off Dieppe. This study is expected to continue throughout 2005. The French Ministry of Industry has also commissioned a study to identify potential aggregate extraction sites in terms of resource availability and possible constraints.
- Finland reported for the first time in many years, specifically detailing research investigating the effects of turbidity arising from sand extraction.
- Many of the studies ongoing in The Netherlands, which were mentioned in last year's ACME report, are in their final stages and are expected to report later in 2005.
- In the UK, over 30 research projects have recently been commissioned supported by funding from the UK Department of Environment, Food and Rural Affairs (Defra) managed Aggregate Levy Sustainability Fund (ALSF). Research is focused on a number of different areas including environment protection, marine heritage and nature conservation. Non-ALSF funded research into the effects of marine sediment extraction also continues.

There are also a number of ongoing international research programmes such as SANDPIT and EUMARSAND. The overall objective of the SANDPIT project is to develop reliable prediction techniques and guidelines to better understand, simulate, and predict the morphological behaviour of large-scale sand mining pits/areas and the associated sand transport processes at the middle and lower (offshore) shore face, and also in the surrounding coastal zone. This project is in its final stages and a book detailing the findings of the research is due to be published in 2005. The EUMARSAND project addresses the need for integrated and coherent approaches (at a European level) for resource prospecting and for the assessment of the environmental impacts of marine aggregates (sand and gravel) extraction. A special edition of a peer-reviewed journal which will detail the findings from this research project is planned for 2006. The French partners involved in the CHARM (a European InterReg IIIa project) presented the results of the first phase of this programme which evaluated the distribution of fish resources in the eastern English Channel.

Source of information

Report of the ICES Working Group on the Effects of Extraction of Marine Sediments on the Marine Ecosystem (WGEXT), 2005. ICES CM 2005/E:06.

2.6 Potential impacts of escaped non-salmonid candidates for aquaculture on localized native stocks

Request

This is part of continuing ICES work to assess the potential impact of cultured marine fish species (non-salmonid) escaping from aquaculture sites and their effects on local wild marine fish (native) stocks with the view of developing risk assessment and management strategies.

Recommendations and Advice

ICES recommends that:

- Member Countries continue to conduct research on the interaction between wild and cultured non-salmonid marine fish. Research is also required to develop cost-effective genetic tools to discriminate cultured and wild stocks from the same habitat.
- Member Countries document and report all marine fish aquaculture escape events and submit reports annually to ICES (via the WGEIM).
- Member Countries use reproductively sterile fish in commercial mariculture operations wherever feasible.

Summary

Work continues on five documents dealing with the potential impacts of escaped marine non-salmonid finfish species. The 2005 WGEIM report contains a draft of the next report in the series, this one dealing with turbot (*Psetta maxima*) culture.

A standard risk analysis is being used to access the impacts which parallels the approach being taken by the World Organization for Animal Health (OIE) to the risk analysis for diseases of aquatic organisms. As discussed last year, this approach will allow Member Countries to tailor the application of the advice to their specific environmental conditions and cultured species under consideration.

Hazards associated with the culture of new exotic species and their associated disease interactions are not discussed. Local regulatory authorities are responsible for evaluating the different species being considered for aquaculture using the ICES Code of Practice on the Introductions and Transfers of Marine Organisms and the OIE Protocols.

Scientific Background

The draft of "state of knowledge" of the potential impacts of escaped aquaculture turbot (*Psetta maxima*) is available from the 2005 report of WGEIM. Comments on this draft text are being solicited by WGEIM and can be directed by that group through the ICES secretariat.

Source of information

The 2005 report of the ICES Working Group on Environmental Interactions of Mariculture (WGEIM) and ACME deliberations.