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Report of the ICES Advisory Committee on Fishery Management, Advisory Committee on the Marine Environment and Advisory Committee on Ecosystems, 2006

Book 1

Introduction, Overviews and Special Requests

International Council for the Exploration of the Sea

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TABLE OF CONTENTS

ICES ADVICE 2006

BOOK 1

BOOK 2

BOOK 3

BOOK 4

Section	Page

BOOK 5

BOOK 6

BOOK 7

BOOK 8

BOOK 9

Section	Page

BOOK 10

Section	Page

Section	Page

Section	**Page**

Preface

This report contains the advice given by ICES to Clients regarding marine management issues in 2006. 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.

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, and includes general and non-regional advice.

Volumes 2 - 10 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 distributed and migratory 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:

- Iceland and East Greenland
- 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 Distributed and Migratory Stocks
- North Atlantic Salmon Stocks

List of special requests for 2006

CUSTOMER	REQUEST – Special	DATE	RESPONSE
EC			
DG Fish	Compile status list of EU Fish stocks	January 2006	Feb. 2006
	Use of pulse-trawl electrical gear to target plaice and sole in beam-trawl fisheries	24 November 2005	ACFM Late spring 2006
	In-year advice for Norway pout and sprat in the North Sea	9 March 2006	April 2006
	Propose key areas/species to be recorded on a dedicated internationally coordinated survey for deep sea stocks	16.11.05	ACFM June 2006
	Provide recommendations for better standardisation, coordination, efficiency and usefulness of IBTS surveys in the Atlantic area and coordinate sampling of 'other biological parameters' in the IBTS surveys	16.11.05	June 2006
	Long-term management of North Sea haddock	07.04.06	ACFM Oct 2006
	Catch options for North Sea herring	02.08.2006	1 September
	Coordination and views on anchovy surveys in the Bay of Biscay	23.08.2006	December 2006
	Management measures for Norway pout and Sandeel	25.08.06	ACFM Oct 2006 (remaining of Norway pout in spring 2007)
	Fleet based sampling - DCR	03.10.06	To be commented upon by selected group November 2006
NEAFC	Regarding redfish stocks in the Irminger Sea and adjacent areas: a. Continue to provide information of stock identity of *Sebastes mentella* b. provide quantitative information to allow spatial and temporal limitations in catches and other measures c. provide clear definitions of terms with respect to *Sebastes mentella*	November 2005	ACFM June 2006
	Regarding vulnerable deep-water habitats in the NEAFC Regulatory Area: a. on distribution of vulnerable habitats in the NEAFC Convention Area and fisheries activities in and in the vicinity of such habitats; b. assisting NEAFC in evaluating the closures of the Faraday, Hekate, Antialtair, Altair seamounts and the area on the Southern Reykjanes Ridge not later than November 2007	November 2005	ACFM 15 Oct 2006
	Regarding deep sea species: provide, preferably not later than May 2006, information on the spatial and temporal extent of all current deep-water fisheries in the NE Atlantic. ICES is	November 2005	ACFM May 2006

	also asked 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.		
	Regarding Rockall haddock: The NEAFC Commission requests ICES to provide information on the effect of the Rockall box in protecting juvenile haddock and possible revisions of the boundary of the box.	November 2005	ACFM 15 Oct 2006
	Regarding pelagic sharks: propose a sampling scheme and a list of information that should be obtained from the fisheries on pelagic sharks to allow ICES to improve the quality of assessment and advice	November 2005	ACFM 15 Oct 2006
OSPAR	Guidelines on frequency and spatial coverage of monitoring for nutrients and eutrophication parameters	July 2004 – OSPAR to come back with more information in February 2006	ACME June 2006
	Review of draft guidelines on frequency and spatial coverage of monitoring	July 2005	ACME mail 6-11 April
	EcoQO for changes in zoobenthos in relation to long-term eutrophication	July 2005	ACE June 2006
	Further development of the EcoQO on plastic particles in stomachs of seabirds	July 2005	ACE June 2006
	Quality assurance of biological measurements in the North East Atlantic	July 2005	ACME mail 10-20 March
	Use of food safety monitoring programmes for monitoring dioxins and furans in fish and shellfish	July 2005	ACME mail 6-11 April
	EcoQ element for fish communities	July 2005	ACE June 2006
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 2005	ACME and ACE June 2006
MEMBER STATES			
Norway	Management goals for seal stocks	16.06.05	Hooded seal response: ACFM late June 2006
	Evaluate harvest control rule for NEA haddock (left-over from response to special request in 2005)	24.01.05	ACFM June 2006
Norway on behalf of EC, Norway, Faroe Islands, Iceland	Evaluation of a multi-annual management arrangement of Blue Whiting stock in the North-East Atlantic	15.03.06	ACFM 15 Oct 2006

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1 Introduction, overview and special requests

1.1 About ICES

ICES was established in 1902 as an intergovernmental organisation. The ICES Convention outlines the fundamental purposes of ICES, which are:

> to promote and encourage research and investigations for the study of the sea particularly related to the living resources thereof;
>
> to draw up programmes required for this purpose and to organise, in agreement with the Contracting Parties, such research and investigations as may appear necessary;
>
> to publish or otherwise disseminate the results of research and investigations carried out under its auspices or to encourage the publication thereof.

Under the Convention, ICES is concerned with the Atlantic Ocean and adjacent seas, primarily the North Atlantic. For decades, ICES has led the way in the design and coordination of international marine research, and it has provided scientific advice. Its programmes have been carried out mainly at national expense. Throughout ICES' long history, its members have unselfishly supported the research programmes designed through ICES, because in reality, the members are ICES and the programmes of ICES are theirs. The past success of ICES has benefited very much from the ownership Member Countries feel for ICES and its programmes, which will also be critically important in the future. ICES has increasingly provided scientific advice based on its research programme. Today, ICES provides the scientific underpinning for most of the regulatory commissions concerned with fisheries and the environment in the Northeast Atlantic and the Baltic Sea.

ICES has grown from a small body of like-minded researchers to a complex organisation involving about 1600 scientists, with 20 Member Countries as well as several Observer Countries and non-governmental organisations. ICES fulfils its functions through an Annual Science Conference, about a dozen committees, close to 100 working and study groups, several symposia annually, and a wide range of publications. There is a Secretariat, which currently has about 35 full-time professional and support staff, located in Copenhagen.

It is the scientists who participate in ICES activities who generate ICES products. The main products are **scientific information** based on research conducted in the Member Countries and **scientific advice** containing information provided in a format that can be used by policy-makers. The responsibility for overseeing the production of scientific advice rests with the Management Committee for the Advisory Process. It assigns advisory tasks to the Advisory Committee on Fishery Management (ACFM), the Advisory Committee on the Marine Environment (ACME), or the Advisory Committee on Ecosystems (ACE). The membership of the advisory committees consists of one member per country.

ICES is requested to provide advice on a range of issues relating to marine policies and management. The clients for such requests are:

- governments of ICES' member countries,
- European Commission (EC)
- international intergovernmental organisations dealing with marine affairs
    - Helsinki Commission (HELCOM),
    - North Atlantic Salmon Commission (NASCO),
    - North East Atlantic Fisheries Commission (NEAFC)
    - 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 2006.

In the early days, the ICES' advice was directed primarily at the need for information regarding the status of commercial fish stocks. ICES expert groups were concerned largely with fisheries research and physical and chemical oceanography. However there has been a growing awareness of the impact that human activities, other than fishing, were having on the marine environment. ICES responded to the needs of international intergovernmental organisations for advice on how to measure these impacts and how to determine their significance. Many expert groups were formed to study the techniques for measuring chemical and biological variables in marine ecosystems and for determining the effects of human activities on marine biota. Starting in the 1990s, ICES has been asked to provide advice on how to integrate scientific knowledge of ecosystem components to provide the underpinning for an ecosystem approach to managing human activities in marine waters.

Over the past 5 years ICES has worked with its clients to find the most effective way of delivering integrated advice. The immediate delivery of advice is now through the ICES internet site and the annual summary of advice is provided in this document that includes all aspects of ICES' advice. This has meant challenging many expert working groups to undertake new research or to reconsider existing information in order to provide the scientific basis for this integrated advice. Also ICES has had to consider carefully the effectiveness of its organisation in meeting not only the types of requests for advice but also the timeliness in the delivery of that advice and the robustness of its peer review process. As a result of this review ICES expects to move towards a revised advisory process in 2008 that will provide all advice through one single advisory committee.

1.2 General guidelines for the ICES advice

ICES provides advice in relation to policies and objectives identified by governments and international client commissions. ICES provides that advice with reference to a number of international agreements and codes of practice that are used as overaching guidelines:

- "Precautionary principle": chapter 17 of Agenda 21 of the UN Conference on Environment and Development (UNCED 1992),
- "Precautionary approach": the United Nations Straddling Fish Stocks agreement (UN 1995) and the FAO Code of Conduct for Responsible Fisheries (FAO 1995)
- Convention on Biological Diversity (UN 1992),
- "Ecosystem approach" and "Maximum Sustainable Yield": the Johannesburg Declaration of the World Summit of Sustainable Development (UN 2002)

1.2.1 *Precautionary approach*

The Precautionary Approach was summarised in the UN Straddling Fish Stocks Agreement (UN 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."

In 1997, ICES has been asked by its clients to suggest an approach for implementing the precautionary approach into fisheries management in the North East Atlantic. The precautionary approaches suggested by ICES consists of a dual system of conservation limits (limit reference points) and a buffer to account for the uncertainty of the knowledge about the present and future states relative to the conservation limit (precautionary approach reference points). The reference points are expressed in terms of single-stock exploitation boundaries (limits on fishing mortality) and biomass boundaries (mimimum biomass requirements).

In practice the precautionary approach suggested by ICES (ICES 1997; ICES 1998; ICES 1999) is based on the following reference points:

	Spawning stock biomass (SSB)	Fishing mortality (F)
Limit reference point	B_{lim}: mimimum biomass. Below this value recruitment is expected to be 'impaired' or the stock dynamics are unknown.	F_{lim}: exploitation rate that is expected to be associated with stock 'collapse' if maintained over a longer time.
Precautionary reference point	B_{pa}: precautionary buffer to avoid that *true* SSB is at B_{lim} when the *perceived* SSB is at B_{pa}. The buffer is an expression of the uncertainty in the assessment process and the risk society is willing to take. B_{pa} is always higher than B_{lim}.	F_{pa}: precautionary buffer to avoid that *true* fishing mortality is at F_{lim} when the *perceived* fishing mortality is at F_{pa}. The buffer is an expression of the uncertainty in the assessment process and the risk society is willing to take. F_{pa} is always lower than F_{lim}.

Limit reference points

The minimum spawning stock reference point is described by the symbol B_{lim} (the biomass limit reference point). B_{lim} is set on the basis of historical data so that when a stock would be below B_{lim}, there is a high risk that recruitment will 'be impaired' (i.e. substantially lower than when the stock size is higher). Below 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 of the stock to an improved status is likely to be slow and will depend on effective conservation measures.

When information about the relationship between recruitment and SSB is absent or inconclusive, ICES has used the lowest observed biomass B_{loss} as a proxy for B_{lim}. This interpretation of B_{lim} is as a boundary under which the stock would enter an area where the stock dynamics are unknown..

The limit reference point for fishing mortality F_{lim} is the fishing mortality that is expected to drive the stock to the biomass limit when it is maintained over time.

Precautionary reference points

Spawning stock biomass and fishing mortality can only be estimated with uncertainty. Precautionary reference points B_{pa} and F_{pa} have been suggested by ICES to take account of this uncertainty. As long as the *estimate* of spawning biomass is at or above B_{pa}, the probability of actually being at or below B_{lim} should be small. Similarly for fishing mortality: when the *estimate* of fishing mortality is at or below F_{pa}, there should be a low probability of actually fishing at or above F_{lim}.

The precautionary reference points are a mechanism for managing the risk of the stock falling below B_{lim} or the fishing mortality exceeding F_{lim}. The distance between the precautionary reference points and limit reference points is not fixed and should reflect the uncertainty of the assessment process and the amount of risk society is prepared to take. If the quality of catch data were to decline, for example, a higher B_{pa} would be needed for the same B_{lim}. The same applies when society would want to accept a lower risk that the true biomass was below B_{lim}.

How have reference points been estimated?

Most reference points that are currently used were estimated in a process whose results were endorsed by the Advisory Committee on Fishery Management in 1998 (ICES 1999).

The estimation process consisted of the identification of limit reference points based on risk of reduced reproductive capacity and fishin mortality which is expected to drive stocks to reduced reproductive capacity. Precautionary reference points reflect the combined effects of the uncertainties in the assessments and the level of risk society is willing to take. In practice neither of these two effects could be directly quantified. Uncertainties in the assessments were approximated with rules-of-thumb estimates of coefficients of variation in the order of 20%. The level of risk that measures the distance between the limit and precautionary reference points was set at 5-10%. If, for example, the quality of catch data were to decline or multi-year forecasts were required for catch advice, a higher B_{pa} would be needed for the same B_{lim}. The same is true if society will only accept a very low risk that the true biomass is below B_{lim}.

Is is acknowledged that there is a need for input from fisheries managers and stakeholders on the level of risk they were willing to accept. For that reason, the limit reference points have been presented as considerations from ICES and the precautionary reference points as proposals.

How are reference points used in the advice

Precautionary and limit reference points are used in two ways in the fisheries advice: (1) to classify the state of the stocks (see text box)[1] and (2) to bound the advice for short term exploitation boundaries.

When the spawning biomass is estimated to be below B_{pa}, ICES advises that management action should be taken to increase the stock to above B_{pa}. Similarly, to be certain that fishing mortality is below F_{lim}, fishing mortality should in practice be kept below a lower level F_{pa}. When fishing mortality is estimated to be above F_{pa}, ICES advises management action to reduce it to F_{pa}. Such advice is given even if the spawning biomass is above B_{pa} because fishing mortalities above F_{pa} are considered unsustainable. If a management plan exists which ensures that the SSB will be kept above B_{pa}, F_{pa} may temporarily be above F_{pa} as long as there are mechanisms ensuring a downward adjustment before SSB approaches B_{pa}.

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 B_{pa} and fishing mortality well below F_{pa}. If stocks are managed 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.

State of the stock in relation to the precautionary approach

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 indicates 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.

Specific terminology concerning SSB:

If SSB is above $\mathbf{B}_{pa}$: "having full reproduction capacity."
If SSB is below $\mathbf{B}_{pa}$ but above $\mathbf{B}_{lim}$: "being at risk of reduced reproductive capacity."
If SSB is below $\mathbf{B}_{lim}$: "suffering reduced reproductive capacity." or "at a level where the stock dynamics is unknown and therefore risking reduced reproductive capacity".

Specific terminology with regards to fishing mortality:

If F is below $\mathbf{F}_{pa}$: "harvested sustainably."
If F is above $\mathbf{F}_{pa}$ but below $\mathbf{B}_{lim}$: "at risk of being harvested unsustainably."

What happens when if reference points cannot be estimated?

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] 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 Bpa. 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 following text-table maps the new ICES terminology into the old terminology:

	New terminology	Old terminology
Biomass	"having full reproductive capacity"	"inside safe biological limits"
	"being at risk of reduced reproductive capacity" or "suffering reduced reproductive capacity"	"outside safe biological limits"
Fishing mortality	"harvested sustainably"	"harvested inside safe biological limits"
	"at risk of being harvested unsustainably" or "harvested unsustainably"	"harvested outside safe biological limits"

1.2.2 *Maximum sustainable yield*

The World Summit on Sustainable Development (WSSD, 2002) has reinstated the concept of maximum sustainable yield (MSY) on the political agenda with regards to fisheries management. WSSD (2002, issue 30) states that:

> "30. To achieve sustainable fisheries, the following actions are required at all levels:(a) Maintain or restore stocks to levels that can produce the *maximum sustainable yield* with the aim of achieving these goals for depleted stocks on an urgent basis and where possible not later than 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 that aim to produce high long term yields while ensuring that there is little risk that the reproductive capacity of fish stocks will be impaired.

1.2.3 *Ecosystem approach*

The adoption of the Ecosystem Approach is intended to contribute to sustainable development. Sustainable development was originally defined in the Brundtland Report as development that

> "meets the needs of the present without compromising the ability of future generations to meet their own needs." (WCED, 1987)

The Ecosystem Approach has been variously defined, but principally puts emphasis on a management regime that maintains the health of the ecosystem alongside appropriate human use of the environment, for the benefit of current and future generations. For example, the 1992 UN Convention on Biological Diversity (CBD) defines the Ecosystem Approach as:

> "ecosystem and natural habitats management" to "meet human requirements to use natural resources, whilst maintaining the biological richness and ecological processes necessary to sustain the composition, structure and function of the habitats or ecosystems concerned."

The Reykjavik declaration forms the basis for using the Ecosystem Approach to the management of the marine environment:

> "in an effort to reinforce responsible and sustainable fisheries in the marine ecosystem, we will individually and collectively work on incorporating ecosystem considerations into that management to that aim." (FAO 2001)

and the World Summit on Sustainable Development:

> "(30.d) Encourage the application by 2010 of the ecosystem approach, noting the Reykjavik Declaration on Responsible Fisheries in the Marine Ecosystem 15 and decision V/6 of the Conference of Parties to the Convention on Biological Diversity"(UN 2002)

An ecosystem approach is expected to contribute to achieving long-term sustainability for the use of marine resources, including the fisheries sector. An ecosystem approach serves multiple objectives and should emphasise strong stakeholder participation and focus on human behaviour as the central management dimension.

There appears to be a general consensus as to the intent of the expression 'Ecosystem Approach'. However, the actual definitions of the expression vary and already in the Reykjavik declaration there was a plea to for best practices with regard to "introducing ecosystem considerations into fisheries management". Several large national and international research programmes attempt to develop an ecosystem approach (see ICES 2002)

How does the "Ecosystem Approach" affect ICES advice?

At the 13th Dialogue Meeting between ICES and the Clients (ICES 2004a), the ICES plans for the introduction an ecosystem approach into the advice were discussed. The implementation of the ecosystem approach into the advice 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. Work is ongoing to expand the number of ecosystem components that are included in the analyses. 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 and will develop through time as knowledge is gained.

The organisation of the advisory report in Ecoregions facilitates the ecosystem approach to fisheries management (see section 1.3.1).

Achieving "Ecosystem objectives"

The most effective short-term progress towards meeting ecosystem objectives is likely to be made by implementing the advice for single- and mixed stock fisheries. The advice is mainly to substantially reduce the exploitation of fish stocks. Fishing fleet capacity often exceeds the long-term sustainable use of the ecosystems. There is increasing evidence that fisheries and other human activities are having a serious impact on marine ecosystems. An overall reduction in the exploitation rates for target stocks will reduce the pressures on biota and habitats and will contribute to restoring stocks to full reproductive capacity. This provides the basis for higher long-term yields at lower fishing effort.

1.2.4 *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 and advice from ACE. Fisheries management authorities are planning to adopt an Ecosystem Approach to Fisheries Management and Regional Advisory Committees (RACs) have been 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. 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. 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.

1.3 Structure of the report

1.3.1 *A regional orientation*

The ICES advisory report is based on a regional orientation in so-called "Ecoregions" that allows the further development of an ecosystem approach in European waters. A review of existing biogeographical and management regions against a series of evaluation criteria has demonstrated that no existing regions could be adopted as ecoregions (ICES 2004b, p. 115-131). The proposed ecoregions (figure 1) are based on biogeographic and oceanographic features and existing political, social, economic and management divisions:

- Greenland and Iceland Seas (A)
- Barents Sea (B)
- Faroes (C)
- Norwegian Sea (D)
- Celtic Seas (E)
- North Sea (F)
- South European Atlantic Shelf (G)
- Mediterranean Ecoregions:
  - Western Mediterranean Sea (H)
  - Adriatic-Ionian Seas (I)
  - Aegean-Levantine Seas (J)
- Oceanic northeast Atlantic (K)
- Baltic Sea (*not numbered*)
- Black Sea (*not numbered*)

The allocation of the western Channel (ICES area VIIe) in either the Celtic Seas or the North Sea is still undecided. 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.

The ecoregions Norwegian Sea (D) and Barents Sea (B) are presented in one single volume (3).

The widely distributed and migratory species (ecoregion K) and the deepwater species for which stock identity have not been established, are addressed in volume 9.

The North Atlantic salmon stocks that are of interest to the North Atlantic Salmon Commission (NASCO) are treated in a volume 10.

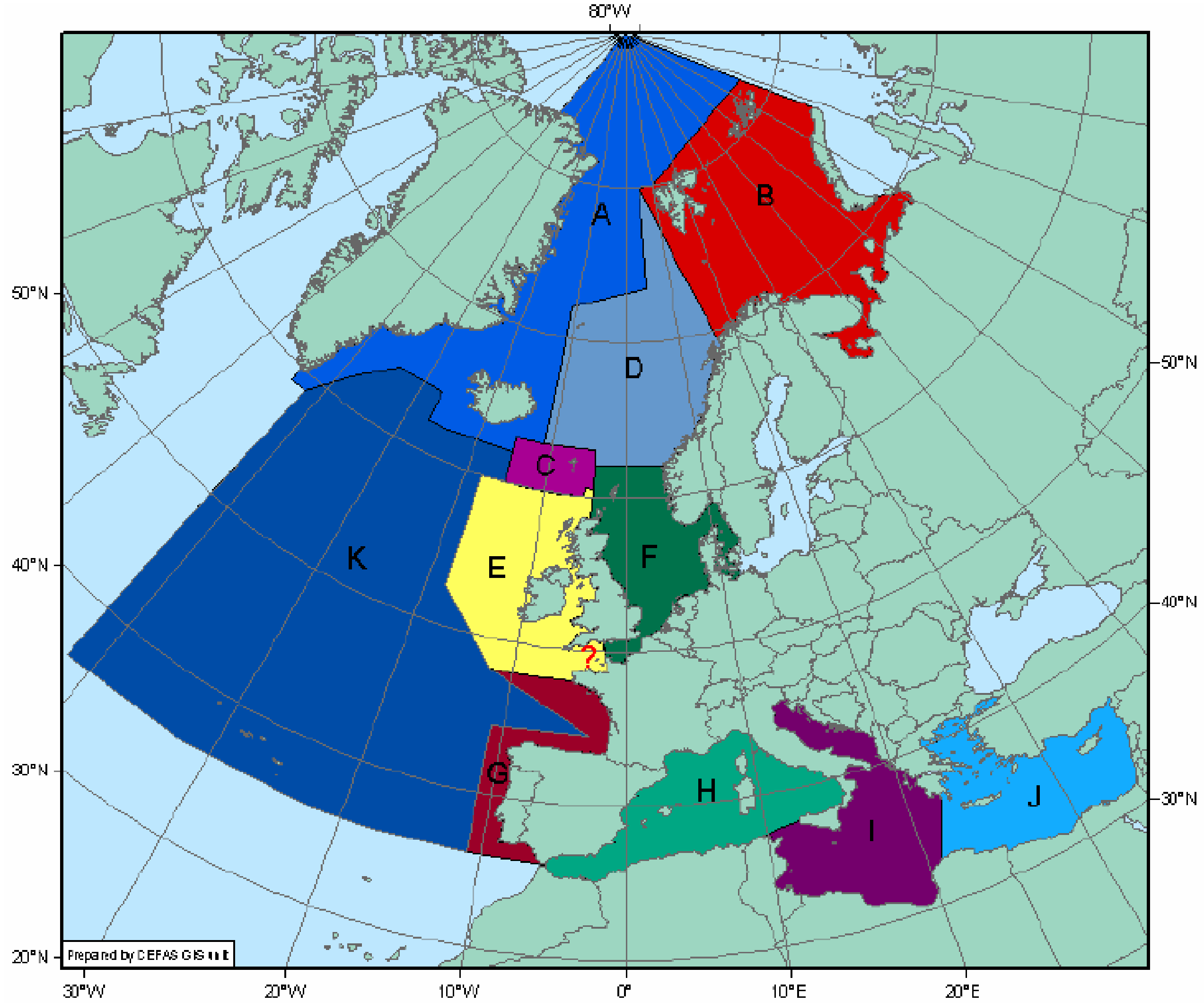

Figure 1. Proposed ecoregions for the implementation of the ecosystem approach in European waters. The ecoregions are Greenland and Iceland Seas (A), Barents Sea (B), Faroes (C), Norwegian Sea (D), Celtic Seas (E), North Sea (F), South European Atlantic Shelf (G), Western Mediterranean Sea (H), Adriatic-Ionian 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 ecoregion. Equidistant azimuthal projection.

1.3.2 *Ecosystem overviews*

Each of the regional ecosystem-volumes includes an ecosystem overview that provides a description of the ecosystem components and of the major ecological events and trends

1.3.3 *Human impacts on the ecosystem*

Description human impact on the ecosystem (if available)

- Fishery effects on benthos and fish communities
- Other extractive uses (e.g. description of gravel, oil etc extractions]
- Pollution (brief description of trends in pollution)

1.3.4 *Assessment and advice (e.g. mixed fisheries overviews)*

The sections on assessment and advice contains (if available)

- Assessments and advice regarding protection of biota and habitats
- Assessments and advice regarding fisheries. 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.
- Special requests that are applicable to the area or stocks within the area.

1.3.5 *Single stock summaries*

The single stock summaries contain information on the individual stocks and the basis for the advice. These sections present descriptions of stock trends, short term outlook and main factors to be considered in managing these stocks.

1.4 Basis for the advice

1.4.1 *Data used and data quality*

Catch and effort data

The quality of the fish stock assessments is closely linked to the quality of the fisheries data, and ICES has expressed the greatest concern over the quality of catch and effort data for some of the important fisheries in the ICES area.

The stock assessments presented in this report are carried out using the best possible estimates of the total catch. These estimates are not necessarily identical with the official landings statistics because they may include estimates of unreported landings and corrections for misallocation of catches by area and species. 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. ICES attempts to identify factors contributing to the total removals from the various stocks through:

- 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 (e.g. industrial) fisheries.

The discards, slipped fish, unreported landings and industrial bycatches may vary considerably between different stocks and fisheries. It may not always be possible to reveal the sources of the estimated removals because of restrictions on how the data has been made available to ICES (e.g. confidentiality clauses). As a minimum, ICES describes the origin of the data (sampling programmes, field observations, interviews, etc.) so that interested parties can evaluate the quality of the information. Estimates of by-catches from the industrial fisheries are included in the assessments wherever the data is available. In recent years more information on discards has been collected through observer programmes and this information is increasingly made available to ICES for assessment purposes. The catch data used in the stock assessments are presented in the "summary table" in each of the stock summaries (sections x.4 in each Ecoregion).

The catch data used by ICES are collated on a stock basis and not on an area basis so that direct comparisons between these figures and the official statistics are not always appropriate.

ICES attempts to correct the shortcomings in the catch data. For non-reported landings such corrections, by their very nature, are difficult to document and are obviously open to debate. The stock assessments that are based on these data are of poor quality but they are still expected to be the best possible assessment of the state of the stocks. The fishing industry has on various occasions strongly disagreed with ICES' estimates and has blamed ICES for not performing well. ICES does not accept the responsibility for quantifying non-reporting fisheries or ensuring access to proper discard 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.

When catch data could not be estimated, the trends in the stocks have sometimes been evaluated using research vessel data. This will only allow relative trends to be estimated and cannot be translated into a numerical advice on removals or effort. .

Research vessel data

Research vessel surveys are an essential fishery-independent source of information for scientists and a vital cross-check to the figures gathered from the international landings and from sampling onboard fishing boats. On research vessel surveys, scientists sample demersal fish such as cod, haddock, hake and plaice or pelagic fish such as mackerel and herring.

To sample fish on or near the seabed scientists use bottom trawls in the same way that fishers do. But whereas fishers target hotspot areas and continually try to upgrade their fishing gear to maximise their catch, fisheries scientists don't want to maximise their catch but instead collect a representative sample. They also have to compare their results with previous years to follow trends, so it is vital that they use the same standard fishing gear each year rather than continually improving it.

Research vessel surveys are carried out by national research institutes. ICES has an important role in internationally coordinating and analysing the surveys.

Information from the fishing industry

There is an increasing interaction between scientists and fishers during the collection of data in harbours and through observer programmes onboard fishing vessels. There have been a number of joint research projects between the fishing industry and scientists that have aimed to collect additional information on e.g. catch rates or catch compositions. In recent years, fishers in the North Sea have also been filling in questionnaires recording their perception of the state of key fish stock. This information is considered during the process of deriving ICES advice.
Commercial Catch per Unit Effort (CPUE) series have been used in several stocks assessment as an indicator of stock abundance. In most cases the catch is then disaggregated by age through a market sampling process. A major difficulty in the use of CPUE series in stock assessment is the standardisation of fishing effort. The increasing efficiency of fishing vessels (e.g. through technical developments, GPS devices, new gear materials etc.) needs to taken into account in an estimate of effective fishing effort. This is not always possible due to lack of the relevant data for standardisation.
The collaborations between the fishing industry and scientists has 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.

1.4.2 *Assessing the status of fish stocks*

Stock sizes and fishing mortalities are estimated in a stock assessment model. Most stock assessment models use catch at age information from the commercial fisheries and use additional information to "calibrate" the assessment. The additional information is mostly research survey indicators or catch rates in the commercial fishery (CPUE information). The estimated catches can be subject to serious bias if there are significant amounts of unreported landings or when information on discards at sea is not available. Catch information tends to become most unreliable when management measures are 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 reliable, quantitative catch forecasts has decreased.

Most management strategies in the ICES area rely on some forecast of the outcome of fisheries management in the management year. Under these conditions the Management Option table is an important part of the ICES advice. The catch options rely on estimates of recent stock size and fishing mortality and requires an assumption about the total catch in the current or "assessment" year, because the fishery is rarely over when the assessment is carried out. 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 will continue to be equal to that of the previous year(s) (a $\mathbf{F}_{status\ quo}$ constraint). ICES attempts to evaluates the weight of the evidence for a TAC constraint vs. a $\mathbf{F}_{status\ quo}$ constraint and selects the more appropriate assumption.

1.4.3 *Evaluations of management plans*

When fisheries management plans have been agreed or proposed, ICES will evaluate the consistency of the management plan with international agreements and commitments. The main comparison will be in relation to the consistency with the precautionary approach.

The methods for evaluating management plans differ by area, species and type of plan, but the general characteristics are that both fish populations and the management measures are simulated in a computer simulation process. The results of the simulations are scored in relation to the probability with which the stocks would be expected to be below Blim in near to medium term future.

If the evaluation of a management plans indicates that a stock has a low probability (e.g. less that 5%) of being below Blim in the medium term, ICES considers the plan in accordance with the precautionary approach even when the stock is below the precautionary biomass level (Bpa) or above the precautionary fishing mortality (Fpa).

1.4.4 *Three layers in providing fisheries advice ("form of the advice")*

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

- Single-stock exploitation boundaries are identified first,
- Consideration of mixed fisheries aspects,
- Consideration of ecosystem aspects.

1.4.4.1 *Single stock exploitation boundaries*

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 the status of stock in relation to the Precautionary Approach reference points, the (agreed) target reference points and/or and the agreed management plan. 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 boundaries are presented in the stock summaries (sections x.4 in each Ecoregion) and summarized in a table for each Ecoregion in Section x.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.

The ICES advice will always be consistent with the Precautionary Approach. Within these constraints ICES does recommend any particular option and the ICES advice is therefore formulated as an upper bound on catch or exploitation. Where management bodies have agreed to a management plan or recovery plan, ICES will evaluate whether this plan is in accordance with the precautionary approach. If the plan is precautionary, the ICES advice will be based on the management plan. There are cases of non-precautionary management plans typically because the plan is inadequate in situations when the stock is depleted. However, when the stock is not in a precarious situation these management plan may still produce precautionary options and ICES will advise on these options. Obviously, ICES will not advise measures which are not consistent with the precautionary approach. In those cases, ICES will not be based on the management plan but on the strict interpretation of the precautionary approach. In these situations, ICES will calculate the management measures consistent with the management plan but states explicitly that these calculations do not consistute advice unless this is explicitly stated.

1.4.4.2 *Mixed fisheries advice*

For stocks harvested in mixed fisheries, the single-stock exploitation boundaries will apply to all stocks taken together simultaneously. The major constraints within which mixed fisheries should operate may be those stocks in the fish assemblage which are outside precautionary boundaries and which should therefore become the limiting factor for all fisheries exploiting those stocks. 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. ICES identifies which species within mixed fisheries have the most management advice and how these should limit the fishing possibilities on the mixed fish assemblage (section x.3 for each Ecoregion).

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 initially concentrated on the North Sea demersal fisheries but has been extended to other areas. Many fisheries harvest several quota species simultaneously and this poses at least two management problems:

- maintain catches of all species within their TACs while trying not to forego catches of species whose TACs are taken up more slowly.
- allocate the safe harvest of the shared species among 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 area, model development has outpaced the compilation of appropriate data, both for defining fisheries and for providing mixed fishery advice. Specifically, the lack of complete catch data (including discards) and the problem of sampling all fisheries are major concerns.

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 and they will limit the realism of mixed fishery forecasts.

ICES is currently investigating a new approach to assessing the consistency of the advice for different stocks in mixed fisheris. The new approach uses both catch compositions and effort by fishery. Results of this new approach will be presented and disseminated at a study group on Mixed Fisheries Management (SGMIXMAN) in January 2007.

In the absence of an analytical approach to mixed fisheries scenario evaluations, ICES is basing its advice on mixed fisheries on information available on the catch composition in these fisheries and the knowledge about the main interactions between fisheries and species. 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.

1.4.4.3 *Ecosystem aspects*

Some ecosystem concerns 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 or food chain effects of fishing. Ecosystem concerns may represent further boundaries to fisheries beyond those implied by single-stock concerns and mixed fisheries issues and are presented (if available) in section x.3 for each Ecoregion.

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.

1.4.5 *Quality of the advice*

ICES is dedicated to being transparent on the quality of the advice. Since 2004 a number of stakeholder organization are invited as observers to the advisory committee meetings. The quality of the advice can further be assessed through two sources of information in the stock summaries:

- the Advice table contains information on the basis for the advice in the subsequent years
- for stocks where analytical assessments could be carried out, a comparison (graph) is presented between the most recent assessment and the previous assessments

1.5 Answers to non-Ecoregion Specific Special Requests

1.5.1 EC DG Fish

1.5.1.1 Status of fish stocks managed by the Community in the North-East Atlantic

The indicator chosen is the quantity of fish caught in 2004 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. 2005. 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: 2005 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 $\mathbf{F}_{pa}$, then the stock is considered outside safe biological limits[2].
   - 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[3]
   - 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.

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

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[2] 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.

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

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, SSB2005 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).

2005	2004 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	917.93	Redfish Herring	0.00		917.93	100.00	0.00
2	Benthic	173.10	Nephrops Sole Flounder Pandalus	81.06	Plaice Anglerfish	254.16	68.11	31.89
2	Demersal	228.67	Haddock Saithe Whiting	177.87	Cod Whiting Hake	406.53	56.25	43.75
2	Diadromous	0.00		3.17	Salmon Sea trout	3.17	0.00	100.00
2	Industrial	593.07	Sprat	372.86	Sandeel Norway Pout	965.93	61.40	38.60
2	Pelagic	898.39	Herring (North Sea and Baltic) Horse mackerel	12.29	Herring VIa	910.68	98.65	1.35
2	All	1893.22		647.25		2540.47	74.52	25.48
3	Benthic	54.85	Megrim	11.94	Sole Nephrops Anglerfish	66.79	82.13	17.87
3	Demersal	0.00		52.83	Hake	52.83	0.00	100.00
3	Pelagic	121.22	Sardine Anchovy Horse mackerel	16.36	Anchovy Biscay	137.59	88.11	11.89
3	All	176.08		81.13		257.21	68.46	31.54
1,2 and 3	Pelagic	2572.39	Horse mackerel Blue whiting	611.46	Mackerel	3183.85	80.79	19.21
1,2 and 3	Demersal	0.00		145.84	Deep water fish	145.84	0.00	100.00
1,2 and 3	All	2572.39		757.30		3329.69	77.26	22.74
All	Benthic	227.95		93.00		320.95	71.02	28.98
	Demersal	228.67		376.54		605.21	37.78	62.22
	Diadromous	0.00		3.17		3.17	0.00	100.00
	Industrial	593.07		372.86		965.93	61.40	38.60
	Pelagic	4509.92		640.11		5150.04	87.57	12.43
All	All	5559.61		1485.69		7045.30	78.91	21.09

1.5.1.2 Answer to Special request on pulse trawl electrical fishing gear

The European Commission has requested ICES to evaluate the possible effect of the use of pulse-trawl electrical fishing gear to target plaice and sole in beam-trawl fisheries:

a) What change in fishing mortality could be expected following the adoption of such gear in the commercial fishery, assuming unchanged effort measured in KW-days at sea?
b) What effect would such a widespread introduction have in terms of (i) the mixture of species caught; (ii) the size of fish caught?
c) What, if any, effects would such introduction have on non-target species in the marine ecosystems where this gear was deployed?

This response deals with questions b) and c). Due to resource constraints ICES has not been able to finish the response to question a). This will be delivered in the middle of June 2006.

Background

The tickler chain beam trawl makes substantial impact to the sea bottom. Tickler chains are iron chains in front of the ground rope attached to the ground rope or the shoes of the beam trawl. They stimulate the fish to leave the bottom and by that increase their catchability. As a side effect, the top layer of the bottom will be disturbed and mortality on various bottom organisms increase. Also considerable bycatches of bottom organisms can be made. These are usually discarded with a poor chance of survival. The pulse trawl may be an alternative which could reduce the impact on the sea bottom. Electrical systems have been used as a survey tool in freshwater environments for many decades and in some non-commercial marine fisheries since the 1960's. Until recently, use in commercial fisheries has been held back by technical problems.

Under EC regulation 850/98 (article 31.1) it is illegal to use such an electrical gear. The rationale for this was the potential increase in CPUE with the electrified beam trawl at a time when policy was aimed at reducing fleet capacity. However, the environmental concerns relating to physical impact on the sea floor caused by beam trawling and the increased fuel prices, have caused a renewed interest in this technology.

ICES comments

b) What effect would such a widespread introduction have in terms of (i) the mixture of species caught; (ii) the size of fish caught?

There were two main sources of data. (1) Comparative fishing trials were conducted on FRV "Tridens" with a conventional and a pulse beam trawl fished simultaneously at the relatively low speed of 5.5 knots. (2) The second source of data was from a year-long feasibility study onboard a commercial beam trawler fitted with a complete system of cable winches and two pulse beam trawls. In this case catch data were compared with similar commercial vessels fishing with two conventional beam trawls. These vessels fished at their normal operating speed (i.e. 6-7 knots) in the same weeks and at comparable locations.

The catch data from the research vessel trials showed a reduction in catch rates (in kg/hr) of undersized sole and an increase in catch rates of sole above the minimum landings size compared to the traditional beam trawl. There was a decrease of plaice catch rates over all length classes. The effects on other commercial species were variable.

Data on the comparison of catch rates of the pulse trawl system with conventional beam trawls on commercial vessels was only available shortly before the provision of this reply and could not be fully reviewed due to lack of time. However, the preliminary analysis by The Netherlands Institute of Fisheries Research revealed that the catch rates of commercial species were lower than those observed during the research vessel trials. In comparison to the reference vessels, the pulse trawl caught 22% less sole and 35% less plaice (in kg/hr) above the minimum landing size. The reasons for this reduction are subject to ongoing investigations.

The pulse trawl system is designed as an alternative to tickler chain beam trawls while beam trawls fitted with chain mat that traditionally operate on 'rough' ground are not expected to change to pulse trawling. The overall effect on catch rates will therefore be metier dependant.

c) What, if any, effects would such introduction have on non-target species in the marine ecosystems where this gear was deployed

The pulse trawl system that was tested in both trials showed:

- reduced catches of benthic invertebrates (~51%),
- reduced trawl path mortality on shallow burrowing in-fauna like sea potato (from 49 to 5%), artemis shell (from 38 to 6%) and sea mouse and increased trawl path mortality for helmet crabs
- reduction in the capture of undersized sole (~22%)
- considerable reductions in fuel consumption (~40%),
- decrease in swept area (~22%) due to the lower towing speeds

Compared to the traditional beam trawling with heavy tickler chains, the operation of the pulse trawl is likely to have less impact on the sea bottom and its fauna. However, it is not clear whether the gear could damage fish and whether survival rates of discarded animals would be reduced... For a full evaluation of the ecosystem effects of the gear, ICES considers that it is important to evaluate the effects that the gear could have on fish and on the survival rates of discarded animals.

Research in the freshwater environment has demonstrated that electrical fishing can damage fish. It can lead to mortality from stress, haemorrhaging, respiratory failure and spinal damage. Often mortality does not occur until some days after exposure to the electric field. The extent of the mortality depends on many factors in the technical specification of the pulse and the exposure, so there is no clear link between mortality and the electrical gear..

Some observations were made of cod with broken spines in the catches of the pulse trawl and there may be increased mortality on target and non-target species that contact the gear but are not retained.

The electric signals created by the pulse trawl could possibly affect electro-sensitive fish such as sharks and rays. However, the relation between behavioural change as a result of electric fields in general and from the pulse trawl in particular is not known and has not been studied. Aquarium tests should be carried out to assess the effect of the pulse system on elasmobranches.

ICES Conclusion

The available information shows that the pulse trawl gear could cause a reduction in catch rate (kg/hr) of undersized sole, compared to standard beam trawls. Catch rates of sole above the minimum landings size from research vessel trials were higher but the commercial feasibility study suggested lower catch rates. Plaice catch rates decreased for all size classes. No firm conclusions could be drawn for dab, turbot, cod and whiting but there was a tendency for lower catch rates.

The gear seems to reduce catches of benthic invertebrates and lower trawl path mortality of some in-fauna species.

Because of the lighter gear and the lower towing speed, there is a considerable reduction in fuel consumption and the swept area per hour is lower.

There are indications that the gear could inflict increased mortality on target and non-target species that contact the gear but are not retained.

The pulse trawl gear has some preferable properties compared to the standard beam trawl with tickler chains but the potential for inflicting an increased unaccounted mortality on target and non-target species requires additional experiments before final conclusions can be drawn on the likely overall ecosystem effects of this gear.

Other comments

Because the pulse system needs to be towed at a slower speed, there will be a reduction in effective effort (swept area) by approximately 22%. This change in efficiency does not affect nominal effort measured in kW days fishing with the existing fleet.

There appear to be some decrease in catch rates of both plaice and sole. These reductions could be partially compensated by the addition of one or a few tickler chain, but this would negate any reductions in benthos mortality, see answer to point c).

ICES recommendation on additional data needs

Further tank experiments are needed to determine whether injury is being caused to fish escaping from the pulse trawl gear. The experiments need to be conducted on a range of target and non-target fish species that are typically encountered by the beam trawl gear and with different length classes. In these trials it should be ensured that the exposure matches the situation *in situ* during a passage of the pulse beam trawl. Fish should be subjected to both external and internal examination after exposure.

If the pulse trawl were to be introduced into the commercial fishery, there would be a need to closely monitor the fishery with a focus on the technological development and bycatch properties.

Source of information

Report of the Ad-hoc Group on Pulse trawl evaluation. ICES April 2006
Report of the Working Group on Fish Technology and Fish Behaviour. ICES April 2006
Reports of the EU funded IMPACT study which provides data on mortality caused by beam trawls, see review by ICES (ACME report 2001, CRR 248).

Second Reply: Answer to Special request on pulse trawl electrical fishing gear

The European Commission (EC) has requested ICES to evaluate the possible effect of the use of pulse-trawl electrical fishing gear to target plaice and sole in beam-trawl fisheries:

a) *What change in fishing mortality could be expected following the adoption of such gear in the commercial fishery, assuming unchanged effort measured in KW-days at sea?*
b) *What effect would such a widespread introduction have in terms of (i) the mixture of species caught; (ii) the size of fish caught?*
c) *What, if any, effects would such introduction have on non-target species in the marine ecosystems where this gear was deployed?*

This second response to the EC's request deals with the outstanding question a). ICES' earlier response dealt with questions b) and c) and that advice was released in May 2006 where further background details to the request can be found.

Background

Council Regulation (EC) No 850/98 (article 31, paragraph 1) states that '... *The catching of marine organisms using methods incorporating ... electric current shall be prohibited*'. Nonetheless, electrical systems have been used as a survey tool in freshwater environments for many decades and in some non-commercial marine fisheries since the 1960's. The environmental concerns relating to the physical impact on the sea floor caused by beam trawling and the recent economic reality of increased fuel prices, have led to renewed interest in this technology for use in commercial fisheries.

ICES Advice

a) What change in fishing mortality could be expected following the adoption of such gear in the commercial fishery, assuming unchanged effort measured in KW-days at sea?

ICES is unable to accurately predict the change in fishing mortality from the introduction of the pulse trawl in the North Sea flatfish fishery. The two sets of data that are available to assess the effects of the pulse trawl give contradictory information for sole. The potential uptake of the pulse trawl by the commercial fleets in the North Sea if the current legal status of the system was changed is unknown. There is also a lack of information on the proportion of vessels currently using tickler chain beam trawls which would be the candidates to change to pulse trawl.

Based on the comparative trials with the pulse trawl onboard a commercial vessel, ICES has been able to approximate the potential losses and gains in fishing mortality, yield and spawning stock biomass (SSB) for plaice and sole assuming 100% uptake The results are summarized in the text table below. The commercial trials indicate lower fishing mortalities for both plaice and sole with yields in 2010 which would be slightly below current yields and SSB which would be expected to be substantially higher than at present.

Species	Plaice	Sole
F2-6	-27%	-22%
Initial Yield	-14%	-19%
Yield by 2010	-3%	-5%
SSB by 2010	+34%	+21%
Cumulative Yield	-9%	-10%

ICES comments

There were two main sources of sea trial data:

1) Comparative fishing trials were conducted on the research vessel FRV *Tridens* with a conventional and a pulse beam trawl fished simultaneously at the relatively low speed of 5.5 knots, which provides the optimum catching efficiency.

2) A year-long feasibility study onboard a commercial beam trawler (MFV) fitted with a complete system of cable winches and two pulse beam trawls. In this case, catch data were compared with similar commercial vessels fishing with two conventional beam trawls. These vessels fished at their normal commercial operating speed (~6-7 knots) in the same weeks and at comparable fishing locations.

Data from the two sources produced different results for each species – plaice and sole. The RV trials showed a 16% reduction in plaice catches across all length classes; whilst the MFV trials showed no significant reduction in catches of plaice below the minimum landing size (MLS) but a 35% reduction in catches above the MLS. By contrast, the RV data collected using the electrical pulse trawl showed that for sole the probability of capture increased with length and that higher catch rates were obtained for fish larger than ~25cm in length. Conversely, the MFV trials failed to show any significant length dependency for sole with a ~25% reduction in catches across all length classes.

To determine the possible stock effects, it is necessary to estimate the level of commercial uptake if the current legal status of the system was changed. It should be noted that the pulse trawl system can only be used as an alternative to tickler chain beam trawls and not for the chain mat type because the gear cannot operate on rough fishing grounds. To accurately predict the stock effects it is necessary to obtain information on the partial fishing mortalities or the relative effort associated with the two gear types. However, current data collection programmes do not distinguish between the two gear types. Gear technologists (pers. comm.) note that there are national differences between the beam trawl fleets of the Netherlands, Belgium and the UK in terms of relative usage of the two gears. In the Netherlands, approximately 95% of the vessels use tickler chain beam trawls, whereas the converse is true in Belgium and the UK (non-flag vessels). The recent commercial evaluation trials indicated that the electrical pulse system did not provide an economically viable alternative due to the losses of target species associated with the electrical pulse system (van Marlen et al., 2006).

After the five weeks of comparative trials on the commercial vessel there were technical modifications to the pulse systems and cable winches, with the objective to improve the catching performance of the gear, which was reported by the crew as being lower than in initial weeks of fishing with the gear. Apparently the system has not fully outgrown the experimental development phase at the time of trials. This makes final conclusions about the relative efficiency of the fishing gear premature and more comparative data would need to be collected to get a better estimate of the relative efficiency during commercial fishing operations.

Given the differences in results highlighted above, together with the unknown level of potential uptake by the commercial fleet and the relative importance of each gear type, a number of options have been simulated in order to give an indication of the likely range of effects that the introduction of the electric technology might have on the North Sea stocks of plaice and sole.

Plaice

Research vessel trial data: A 16% reduction in fishing mortality would be expected. In the case of full commercial uptake, the yield from the fishery would fall by 13% initially but would reach current levels by 2010, with an overall cumulative gain of 3%. SSB should be above $\mathbf{B}_{\text{lim}}$ within 2 years and have increased by 27% by 2010 (Figure 1[upper panels]).

Commercial vessel trial data: The data from the commercial trial have only been analysed in terms of catches above and below MLS. For the purposes of stock modelling, this has been represented as a step function at MLS and that fish below MLS are either 1- or 2-group where fish above MLS are 3-group and over. The trials show no difference in plaice catches below MLS and a reduction of 35% in catches of plaice above. The modelling suggests that the yield from the fishery will diminish by approximately 14% in the first year but lead to a cumulative loss (2005 – 2010) of 10%; by 2010 yield will be 3% lower with full commercial uptake. SSB will increase by 34% approaching $\mathbf{B}_{\text{pa}}$ (Figure 1 [lower panels])

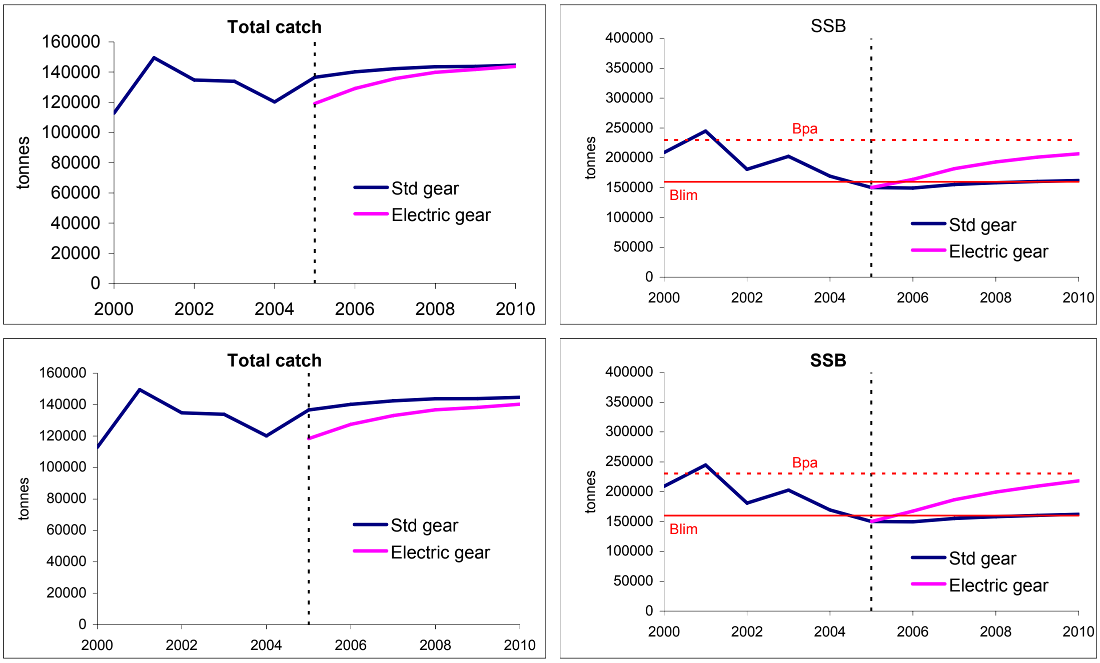

Figure 1. Scenario results for North Sea plaice. Top panels: based on research vessel data, bottom panels: using commercial trial data. Left panels: total catches, right panels: SSB. The blue line indicates the no-change scenario and the pink line the full implementation of the new trawl.

For a range of commercial uptake scenarios, the cumulative effect on plaice catches, discards and SSB are given in table 1 based on the commercial vessel trials. In those scenarios the implementation of the pulse trawl is expected to increase landings and SSB in the longer term.

Table 1. Predictive effects on plaice based on a range of uptake scenarios and based on the commercial vessel trial data.

Uptake	F2-6	Cum disc	Cum landing	SSB 2010	Catch 2010	Discards 2010	Landings 2010
1	0.42	347420	294060	217873	140272	59279	55453
0.8	0.45	353196	302840	203817	141716	60312	55814
0.6	0.48	358723	309917	191411	142801	61298	55863
0.4	0.51	364014	315575	180432	143603	62240	55677
0.2	0.54	369079	320053	170689	144187	63140	55315
0	0.58	373930	323548	162019	144601	64001	54826

Sole

Research vessel trial data: The effect on catches was weakly length dependent. The model suggests no initial or cumulative (2005-2010) loss in yield and a slight increase by 2010 (1%) and a slight reduction in SSB (2%), but remains above $\mathbf{B}_{pa}$ (Figure 2[upper panels]).

Commercial vessel trial data: The model predicts a significant initial loss in catches (19%) and an 11% reduction in cumulative yield (2005-2010). With full commercial uptake, yield could still be 5% lower in 2010 but could result in a 21% increase in SSB (Figure 2[lower panels])

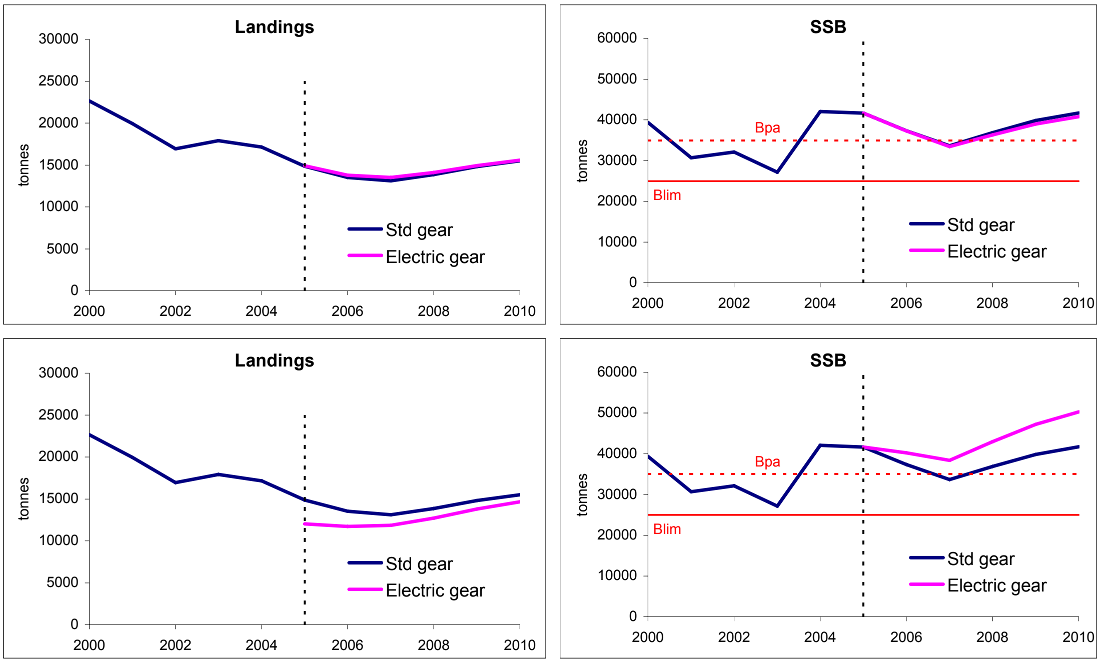

Figure 2. Scenario results for North Sea sole. Top panels: based on research vessel data, bottom panels: using commercial trial data. Left panels: total catches, right panels: SSB. The blue line indicates the no-change scenario and the pink line the full implementation of the new trawl.

For a range of commercial uptake scenarios, the cumulative effect on sole catches, discards and SSB are given in table 2 based on the commercial vessel trials. In the scenarios the implementation of the pulse trawl is expected to result in slightly lower landings and a higher SSB in the longer term.

Table 2. Predictive effects on sole based on a range of uptake scenarios and based on the commercial vessel trial data.

Uptake	F2-6	Cum disc	Cum landing	SSB 2010	Catch 2010	Discards 2010	Landings 2010
1	0.27	0	76746	50278	14659	0	14659
0.8	0.29	0	78785	48349	14878	0	14878
0.6	0.30	0	80689	46531	15069	0	15069
0.4	0.32	0	82470	44816	15236	0	15236
0.2	0.34	0	84135	43197	15382	0	15382
0	0.35	0	85694	41669	15509	0	15509

Discussion

As one might expect, the analyses demonstrate that different results are obtained in model output depending on which data source is used (Table 3). For plaice almost all the differences are small. For sole, however, the differences are more apparent, particularly for initial losses in yield and SSB predictions. The differences in the results between the research vessel trials and the commercial trials are a major source of uncertainty in the analysis but might be attributable to the difference in towing speeds used.

The analyses were based on strong assumptions about future recruitment, mean weight-at-age and fishing effort. Recent recruitment for sole has been very low but the scenarios have assumed that future recruitment is back on the average level. The analyses that were conducted only explored deterministic projections.

Table 3. Comparison of predictive effects of plaice and sole based on research vessel (RV) and commercial (MFV) catchability inputs assuming 100% uptake.

Species	**Plaice**		**Sole**	
Source	RV	MFV	RV	MFV
Fishing mortality	-16%	-27%	+3%	-22%
Initial Yield	-13%	-14%	0%	-19%
Yield by 2010	0%	-3%	-1%	-5%
SSB by 2010	+27%	+34%	-2%	+21%
Cumulative Yield	+2%	-9%	+1%	-10%

Source of information

Report of the Ad-hoc Group on Pulse trawl evaluation. ICES April 2006

Report of the Working Group on Fish Technology and Fish Behaviour. ICES April 2006

Reports of the EU funded IMPACT study which provides data on mortality caused by beam trawls, see review by ICES (ACME report 2001, CRR 248).

ICES (2006). Report of the working group on the assessment of demersal stocks in the North Sea and Skagerrak. Copenhagen, 6-15 September 2005. ICES C.M. 2006 / ACFM: 09.

Marlen, B. van, Grift, R., Keeken, O. van, Ybema, M.S., and Hal, R. van (2006). Performance of pulse trawling compared to conventional beam trawling. IMARES (RIVO) Report C014/06, March 2006.

1.5.2 Helsink Commission (HELCOM)

The advice provided in response to special requests from the Helsinki Commission (HELCOM) can be found in Book 8 of the ICES Advice 2006 Report.

1.5.3 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 Book 10 of the ICES Advice 2006 Report.

1.5.4 NEAFC

The advice provided in response to special requests from the North East Atlantic Fisheries Commission (NEAFC) can be found in Books 2, 5, and 9 of the ICES Advice 2006 Report.

1.5.5 OSPAR

1.5.5.1 OSPAR request regarding additional CBs and PAHs

Request

OSPAR has requested advice on additions to the list of CB congeners and PAH to be included in their collaborative monitoring programmes.

Recommendations and advice

ICES recommends that additional mono-*ortho* CB congeners (CB105, CB156 and CB157 as a minimum) be included within the OSPAR marine monitoring programmes, and that a suite of alkylated PAHs (those deriving from naphthalene, dibenzothiophene and phenanthrene/anthracene; with alkylation degrees of C_1 to C_3) likewise be included.

Summary

Additional dioxin-like CB congeners with mono-*ortho* substitution are recommended for inclusion in the OSPAR monitoring programmes, but the non-*ortho* congeners are not recommended at this time as different methodologies need to be used for their determination. For the PAHs, only parent PAHs are currently determined. Recognising, however, that oil sources including spills will contain a greater proportion of alkylated PAHs than parent compounds, a number of these are recommended for inclusion.

Scientific background

Following the proposal by WKIMON and in view of recent proposals at OSPAR SIME, ACME considered which PAH isomers and CB congeners should additionally be monitored in order to facilitate integrated chemical and biological effects monitoring. Clearly, the main criteria for this are presence in the marine environment and toxicological relevance, i.e. being acutely toxic to organisms or posing a serious risk through chronic exposure.

PAHs

The PAH compounds currently proposed for inclusion are present in the marine environment and are toxicologically relevant, with humans and other higher organisms being most at risk. Analysis using GC-MS is, furthermore, relatively straightforward.

The proposed PAHs do not comprise all toxicologically relevant PAHs. A list was compiled which includes some additional toxic PAH which are not currently monitored (Table 1):

Table 1: List of toxic PAHs
Cyclopenta[*cd*]pyrene
methylchrysenes
Methyl-substituted benzo[*a*]pyrenes
PAH with six rings (formula $C_{24}H_{14}$) m/z 302 *
dibenzo[*a,l*]pyrene
naphtho[2,1-*a*]pyrene**
naphtho[1,2-*b*]fluoranthene
dibenzo[*b,k*]fluoranthene
dibenzo[*a,i*]pyrene**
dibenzo[*a,e*]pyrene**
naphtho[2,3-*a*]pyrene
naphtho[2,3-*e*]pyrene
naphtho[2,3-*k*]fluoranthene
naphtho[2,3-*b*]fluoranthene
dibenzo[*e,l*]pyrene
naphtho[1,2-*k*]fluoranthene

* Human mutagens (Durant *et al*. 1998, EST, 32), ** Highest toxicity i.e. mutagenic potency

Also, nitro-PAHs and certain heterocyclic PAHs, e.g. dibenzothiophenes, are important mutagens and taint-inducing compounds, respectively. The dibenzothiophenes are commonly found in petrogenic sources, which is another advantage of measuring additional PAHs. Determining alkylated 2- and 3-ring PAHs (naphthalenes and phenanthrenes) allows us to distinguish between pollution caused as a result of combustion related processes and of petrogenic origin.

ACME further considered the PAHs listed in Table A1.1. (reproduced below) of the JAMP Guidelines for Monitoring Contaminants in Biota as candidates for inclusion in the monitoring programmes.

Table A1.1. Compounds of interest for environmental monitoring for which the JAMP guidelines apply

Compound	MW	Compound	MW
Naphthalene	128	C_2-Phenanthrenes/Anthracenes	206
C_1-Naphthalenes	142	C_3-Phenanthrenes/Anthracenes	220
C_2-Naphthalenes	156	Fluoranthene	202
C_3-Naphthalenes	170	Pyrene	202
C_4-Naphthalenes	184	C_1-Fluoranthenes/Pyrenes	216
Acenaphthylene	152	C_2-Fluoranthenes/Pyrenes	230
Acenaphthene	154	Benz[*a*]anthracene	228
Biphenyl	154	Chrysene	228
Fluorene	166	2,3-Benzanthracene	228
C_1-Fluorenes	180	Benzo[*a*]fluoranthene	252
C_2-Fluorenes	194	Benzo[*b*]fluoranthene	252
C_3-Fluorenes	208	Benzo[*j*]fluoranthene	252
Dibenzothiophene	184	Benzo[*k*]fluoranthene	252
C_1-Dibenzothiophenes	198	Benzo[*e*]pyrene	252
C_2-Dibenzothiophenes	212	Benzo[*a*]pyrene	252
C_3-Dibenzothiophenes	226	Perylene	252
Phenanthrene	178	Indeno[1,2,3-*cd*]pyrene	276
Anthracene	178	Benzo[*ghi*]perylene	276
C_1-Phenanthrenes/Anthracenes	192	Dibenz[*a,h*]anthracene	278

ACME proposes that alkyl (C_1-C_3) naphthalenes, alkyl (C_1-C_3) dibenzothiophenes, alkyl (C_1-C_3) phenanthrenes and anthracenes should be added to the list of PAHs determined in annual monitoring programmes.

ACME also recommends that MCWG and WGBEC review the analytical methodology and toxicity information relating to these compounds at their 2007 meetings.

CBs

Concerning the need to add additional CB congeners to the list of the ICES7 (CB28, CB52, CB101, CB118, CB138, CB153 & CB180), this is mainly related to the determination of the non-*ortho* and mono-*ortho* congeners, as they exhibit the highest dioxin-like toxicity and contribute most to the TEQ (toxic equivalency) by which it is expressed. Mono-*ortho* CBs can be determined relatively easily within the routine schemes of PCB analysis and it is suggested that, as a minimum, a selection of these congeners (e.g., CB105, CB156, CB157) be added to the current suite of CBs. Other mono-*ortho* congeners may not be present in environmental samples (CB114, CB123, CB167 & CB189). However, determining the concentrations of the non-*ortho* CB congeners (CB77, 126 and 169), which exhibit the highest dioxin-like toxicity, is less straightforward and requires specialised fractionation procedures. Moreover, concentrations of these congeners in environmental samples tend to be very low, which generally requires very low detection limits and the use of GC-HRMS instruments or GC with low resolution MS/MS for analysis. However, the TEFs (toxic equivalent factors) for these congeners are relatively high, and so they may contribute significantly to the TEQ values. In considering this question, it is also important to realise that, in fish, most of the “dioxin” toxicity (expressed as TEQs) is often due to planar CBs and not the dioxins and furans themselves (up to 75%). However, in different locations and/or species, any of the dioxins and furans, non- or mono-*ortho* CB congeners could dominate the TEQ. Two recent studies in fish in Canada and Ireland have shown that dioxin toxicity could be mostly related to the non-*ortho* CB congeners. Clearly, both mono-*ortho* and non-*ortho* CBs should be monitored but, given the difficulties with the latter, another possibility is suggested. Is it possible to calculate the ratios of mono-*ortho* and non-*ortho* CBs to the concentrations of the, routinely monitored, ICES7 CBs, and to use that to estimate the overall risk for the environment? Clearly, these ratios may be site specific and may not be applicable across the whole OSPAR area. Nevertheless, using region specific ratios was considered to be a reasonable approach, although analysis remains the preferred option. There are indications that these ratios are constant and can be calculated but this hasn’t been sufficiently well evaluated to date. ACME recommends that MCWG explore this possibility at its 2007 meeting.

Source of the information

The 2006 report of the ICES Marine Chemistry Working Group (MCWG) and ACME deliberations.

1.5.5.2 EcoQO for changes in zoobenthos in relation to long-term eutrophication

Request

OSPAR requested of ICES:

To develop a list of area-specific (groups of) benthic indicator species in relation to the development of the Ecological Quality Objective for changes in zoobenthos in relation to long-term eutrophication.

Sources of information

BEWG Report 2006; numerous references.

Advice

Due to regional differences in benthic communities and the state of eutrophication, it is not possible to develop a list of common indicator species. Furthermore, it is impractical for ICES to create numerous comprehensive lists of indicator species for marine regions within the OSPAR area. Therefore we provide guidance in the form of specific recommendations and by way of regionally specific examples for a process that would allow species lists to be developed for any marine region within the OSPAR area. Regional experts are presumably best suited to perform these analyses. We recommend that an approach, which focuses on shifts in zoobenthic community structure, should be adopted. We further recommend a number of aspects of community structure that might be used to develop an EcoQO for changes in zoobenthos in relation to long-term eutrophication.

- Changes in diversity of taxa specifically identified as being sensitive to variable levels of organic enrichment and related oxygen depletion, e.g. crustacean (incl. hyperbenthic forms), echinoderms, bivalves.
- Changes in ratios of species number to total abundance or biomass.
- Changes in community structure reflected by changes in feeding strategies, e.g. from suspension to deposit feeders.
- Changes in size structure of specific populations.
- Changes in recruitment success of specific taxa, e.g. increase of opportunistic species.

These elements would be region specific. Selecting appropriate parameters for each region will require specific investigations such as those summarised in Table 1.5.5.2.1

The following additional work is recommended:

1. To assess the quantitative impacts of eutrophication on zoobenthos in regions of interest to OSPAR while covering a range of physiographic features.
2. To partition the causes of variation (natural and anthropogenic) in measured zoobenthos parameters (at individual, population, and community level). Efforts should be made to specifically link the impact of anthropogenic activities to zoobenthos-related parameters.
3. To develop a weight-of-evidence approach in an effort to determine the significance of the eutrophication event. This would be necessary when it was not possible to clearly distinguish between eutrophication and other causes of variation. The effects of eutrophication on zoobenthos community structure should be assessed in conjunction with other measured variables (e.g. nutrients, chl-a) and known anthropogenic pressures (e.g. sewage outfall, dredging) on the system. This process could be facilitated by good communication between groups working on eutrophication, pelagic recycling, and benthic indicators.
4. To assess a range of remote sensing technologies (e.g. video and sediment profiling), that may be used as cost-effective tools to monitor the effect of eutrophication on zoobenthos.
5. To further review the changes in chemical composition of zoobenthic organisms in response to varying oxic conditions, e.g. manganese in tissues of crustaceans.

Background

OSPAR requires that a list of (groups of) zoobenthic species indicating long-term eutrophication is generated. Several proposals and models already exist which address indirect effects, mainly organic enrichment and oxygen deficiency due to eutrophication on zoobenthos. An example is the Pearson and Rosenberg (1978) model. The conceptual model states that benthic communities change through successive stages depending on the amount of organic matter reaching the sediments. Initially, the species present react with an increase in growth rate, resulting in higher biomass and abundance. If the organic loading increases, the "normal" resident species are replaced by opportunistic species (mainly polychaetes) which increase the benthic biomass. A further increase leads to the disappearance of benthic animal species and ultimately to azoic sediments.

In 2004, ICES provided advice to OSPAR relating to the utility of developing an ecological quality element on density of opportunistic benthic species as an indicator of general ecosystem health. The advice was that OSPAR should consider dropping this EcoQ element on the basis that opportunistic species are ubiquitous; changes in their abundance are not closely linked to specific human impacts, and thus they may fail to correctly trigger management actions. However, given the importance of opportunistic species to the Pearson and Rosenberg (1978) model, the utility of using information on opportunistic species in the context of eutrophication is justified. Information on opportunistic species would be an important component in an overall evaluation of the impact of eutrophication on marine systems.

Nutrient, chlorophyll a, and phytoplankton concentrations vary both inter- and intra-annually and the observed levels of these parameters are strongly affected by the timing of the assessment. While changes in phytobenthos may be a good early indicator of local changes due to eutrophication, zoobenthos are more stable in time and can provide an integrated picture of changes in the eutrophication situation over a wider area and a larger time frame. Also, benthic species are usually not very mobile and therefore provide an indication of the local effects of eutrophication. For these reasons, it is useful to monitor zoobenthos, and if possible, develop a list of zoobenthic indicator species for eutrophication.

Effects of eutrophication on zoobenthos can vary in severity, and can be direct or indirect. They can range from subtle effects on the biomass of filter-feeding zoobenthos due to slightly increased plankton availability, to a complete die-off of most benthic invertebrates due to significant (and usually seasonal) oxygen depletion of the lower water masses. Eutrophication can locally increase the organic content of the sediment, and can cause benthic habitat changes due to a decrease in the light penetration. The effects of eutrophication on zoobenthos can be a change in species occurrence, species abundance, including higher number of non-indigenous species (Cloern, 2001), species diversity, trophic structure, overall biomass, and chemical composition of some species (e.g. crustacea).

In addition to these eutrophication effects on zoobenthos, one should consider other anthropogenic or natural pressures that can have similar, antagonistic, or additive effects.

Table 1.5.5.2.1 describes a number of examples, when the effects of eutrophication were documented in relation to different marine physiographic features, and considered the impact on benthic invertebrate organisms. This review concluded that the hydrodynamics of the areas selected greatly influence the level and type of impact of eutrophication on zoobenthos. The table emphasises the variation in impacts among regions and hence the requirement to develop region-specific metrics of impact.

Table 1.5.5.2.1 Examples of effects of eutrophication on zoobenthos found within different marine physiographic features.

Marine physiographic features	Specific region	Description of eutrophication state	Effects on zoobenthos	Reference
OSPAR AREAS				
Open waters	German Bight, North Sea	Nutrient increase.	Correlations found between nutrient concentrations and the benthic community development in the inner German Bight. In combination with unfavourable hydrographic conditions, eutrophication also favours the occurrence of benthic hypoxia, leading to a reduction or elimination of macrobenthos.	Schroeder, 2003
Open waters	German Bight, North Sea	Increased production of phytoplankton due to increase in nutrients.	Deep-burrowing and long-lived species derive less benefit from changing conditions than animals which 1. live near the sediment surface; 2. have an adaptive feeding behaviour; and 3. grow and reproduce quickly. Observed changes are reflected in the dominance structure of the benthic fauna.	Rachor, 1990
Open waters	Northern North Sea	Increase in pelagic productivity.	Broad-scale temporal and spatial variability in benthic communities is driven by climatic forces influencing the overlying water masses; there may have been some increase in pelagic productivity and/or in benthic pelagic coupling.	Pearson and Mannvik, 1998
Coastal waters	Western Dutch Wadden Sea (Balgzand)	Low oxygen concentration in summer, small and rare anoxic areas due to strong tidal mixing.	Total numbers of individuals of certain species increased, biomass and production; proportion of polychaetes increased at the expense of molluscs and crustaceans; decrease of overall mean weight per individual of macrozoobenthos; decline in carnivores and increase in deposit feeders; little change in suspension feeders; small-scale occurrence of mass mortality caused by low oxygen concentrations.	Beukema, 1991
Marine physiographic features	**Specific region**	**Description of eutrophication state**	**Effects on zoobenthos**	**Reference**
Coastal waters	Western Dutch Wadden Sea (Balgzand)	Low oxygen concentrations in summer, small and rare anoxic areas due to strong tidal mixing.	Benthic consumer populations benefited from eutrophication-induced enhancement of their food supply by enlargement of their stocks only where they were not too stressed by unfavorable abiotic conditions.	Beukema and Cadee, 1997
Coastal waters	Wadden Sea	Nitrogen load.	Possible shift in species composition, with disappearance of some molluscs and increased abundance of small polychaetes such as *Heteromastus filiformis*, *Scoloplos armiger*, and *Nereis diversicolor*; possible shift in growth rate and productivity. Caution: interactions are complex, effects were observed only at a regional scale, and effects will possibly only be detectable on a long-term scale.	van Beusekom *et al.*, 2001

Table 1.5.5.2.1 Examples of effects of eutrophication on zoobenthos found within different marine physiographic features.

Coastal waters	Kattegat, Baltic Sea	Low oxygen values in autumn.	Below halocline: widespread kill of zoobenthos.	Karlson *et al*., 2002
Coastal waters	Kattegat, Baltic Sea	Increase in biomass.	Deeper water: increase in the suspension feeder *Amphiura filiformis* (Echinodermata) and some polychaetes, decrease in the abundance of some crustaceans. Shallow water: biomass of bivalves increased, local reductions in zoobenthos due to hypoxia.	Ærtebjerg *et al*., 1989
Coastal waters	Shallow soft bottoms, Swedish west coast	Increased abundance of filamentous algae.	Due to the formation of algal mats, biomass of benthic macrofauna was 40–50% lower and a shift in species composition was observed.	Troell *et al*., 2005
Estuary	Estuaries and coastal lagoons (The Netherlands)	Nutrient input through rivers.	Lagoon modification confuses the effects of nutrient loadings; relation between nutrient loadings and a change in production is questionable in the very turbid waters.	Nienhuis, 1992
Marine physio-graphic features	**Specific region**	**Description of eutrophication state**	**Effects on zoobenthos**	**Reference**
Lagoons	Portugal	Increase in opportunistic macroalgae species; decrease in seagrass beds.	Decrease in macro-zoobenthos was reflected in reduced harvest of mussels.	Newton *et al*., 2003
Fjords, no sill	Norwegian and Faeroe Islands coasts	Increased load of organic matter.	Normally no large-scale effects are observed; locally the response would follow the Rosenberg-Pearson model.	BEWG, 2006
Fjords, shallow sill (20–40 m)	Norwegian coast	Increased load of organic matter leading to hypoxia.	Initial increased diversity and biomass of bottom-fauna; below an oxygen concentration of 3.5 ml/l decrease in hyperbenthos is stronger than for infauna; below 2 ml/l only few species left.	BEWG, 2006
Fjords, deep sill (50–300 m)	Norwegian coast	Hypoxia (rarely).	Initial increased diversity and biomass of bottom-fauna; below an oxygen concentration of 3.5 ml/l decrease in hyperbenthos is stronger than for infauna; below 2 ml/l only few species left.	BEWG, 2006
NON-OSPAR AREAS				
Coastal waters	Gulf of Finland, deeper stratified areas	Hypoxia.	Complete disappearance of macrozoobenthos at many localities.	Haahti and Kangas, 2004; 2006

Table 1.5.5.2.1 Examples of effects of eutrophication on zoobenthos found within different marine physiographic features.

Marine physio-graphic features	**Specific region**	**Description of eutrophication state**	**Effects on zoobenthos**	**Reference**
Coastal waters	Gulf of Finland, 20-m depth, Baltic Sea	Increased production of phytoplankton; high input of organic matter.	Decrease in crustacean *Monoporeia affinis*; increase in filter and deposit-feeder bivalve *Macoma baltica*.	Haahti and Kangas, 2004
Coastal waters	Western Baltic Sea	Increase in (opportunistic) macro-algae cover responding to a limited increase in nutrients.	Increase in numbers of grazers in response to an increased algal cover; increased numbers of predators on grazers.	Worm *et al*., 2000
Deep waters	Baltic Sea	Long intervals of stagnation leading to hypoxia.	Catastrophic widespread destruction of deepwater benthos associated with extreme hypoxia and anoxia.	Fonselius & Valderrama, 2003; Laine *et al*., 1997; in: Tett, 2004; Karlson *et al*. 2002
Estuary	North Carolina, USA	Model generated of large-scale hypoxic events on estuary with microbial loops dominating.	Reduced ability of system to transfer energy to higher trophic levels due to extinction of dominant grazers (oysters) and apex predators (fishes).	Baird *et al.,* 2004
Estuary	Massachusetts, USA	Experimental situation where plots in intertidal salt marshes were fertilized continuously for 15 years, and macro-invertebrate response was compared with control locations.	Higher secondary production in enriched creeks compared to control. Oligochaete: polychaete ratio higher in enriched waters.	Sarda *et al*., 1996
Marine physio-graphic features	**Specific region**	**Description of eutrophication state**	**Effects on zoobenthos**	**Reference**
Estuary	North Carolina, USA	Comparison of micro-algal response between systems with high and low levels of nutrient loading, respectively.	Decreases in abundance, but increases in biomass were observed for macrofauna. Predators mediated the response of some macrofauna. Background nutrient levels were important in determining the response.	Posey *et al*., 2006
Estuary	Neva River estuary (Gulf of Finland, Baltic Sea)	Increased production of phytoplankton; high input of organic matter.	Increase in non-indigenous filter-feeders, *Dreissena polymorpha* (Bivalvia) and *Balanus improvisus* (Cirripedia).	Lyakhnovich *et al*., 1994

Table 1.5.5.2.1 Examples of effects of eutrophication on zoobenthos found within different marine physiographic features.

Estuary	Massachusetts, USA	Increased macrophyte production in response to different nutrient loading.	Grazer abundance and their control on macro-algae was high at low nutrient levels.	Hauxwell *et al*., 1998
Lagoons	Mediterranean lagoon, (Etang du Prévost)	Highly eutrophic lagoon with dystrophic crisis during the summer.	Marked decrease in both biomass and abundance of macrozoobenthos; shift of macrobenthic dominance from suspension feeding bivalves to subsurface deposit feeding annelids.	Bachelet *et al*., 2000
Lagoons and enclosed bays	Curonia and Vistula Lagoons, Russia; enclosed areas of Neva Bay (SE Baltic Sea)	Increased production of phytoplankton; high input of organic matter.	Decrease in biomass of macrozoobenthos; decrease in diversity in the communities; increase in Oligochaeta and Chironomidae.	BEWG, 2006
Marine physio-graphic features	**Specific region**	**Description of eutrophication state**	**Effects on zoobenthos**	**Reference**
Lagoons and enclosed bays	Vistula lagoon, Russia (Baltic Sea)	Increased production of phytoplankton; high input of organic matter.	Establishment of non-indigenous polychaete *Marenzelleria neglecta*.	Schiedek, 1997
Open waters	Eastern Gotland Basin, Baltic Sea	Suboxic conditions.	Mobile polychaetes (e.g. *Bylgides* [Harmothoe] *sarsi*) replace sedentary bivalves (mainly *Macoma baltica*).	HELCOM EUTRO, 2005
GENERAL AREA				
Open waters	Generic open waters	Nutrient enrichment.	No changes of benthic community structure resulting from increased food supply; intense local pulse disturbances resulting from sinking Red Tides; chronic changes in community structure as deepwater oxygen content falls and/or the anoxic region of the sediment extends towards the surface; catastrophic widespread destruction of deepwater benthos associated with extreme hypoxia and anoxia.	Tett, 2004

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1.5.5.3 Further development of the EcoQ on plastic particles in stomachs of seabirds

Request

OSPAR has asked ICES:

"To provide advice on whether the EcoQO on plastic particles in stomachs of seabirds would be more appropriately expressed in terms of mass of plastics rather than the number of pieces. The recommendation from the Save the North Sea (SNS) project is that the target should be revised from 2% to *<10% of fulmars having more that 0.1 g (equivalent of 10 pieces) plastic in their stomachs*. Their results also suggest that within the North Sea sampling in 4 to 5 regions with each having over 50 samples would be appropriate."

Sources of information

Report of ICES Working Group on Seabird Ecology, 2006; Van Franeker, 2004; Van Franeker *et al*., 2005, 2006; Guse *et al*., 2005.

Advice

ICES recommends that the formulation of the proposed EcoQO should be changed to: "There should be fewer than 10% of northern fulmars (*Fulmarus glacialis*) having more than 0.1 g plastic particles in the stomach in samples of 40 or more beach-washed fulmars found in winter (November to April) from each of 4 to 5 areas of the North Sea over a period of at least five years."

This formulation has four main changes from the current wording of the proposed EcoQO: i) a change from 2% to <10% in the limit of numbers; ii) numbers of particles to mass of particles; iii) reduction from 15 to 4–5 sampling areas, and iv) reduction in number of samples per area. The background to these changes is examined in separate sections below.

Background

Currently, the EcoQO is formulated as follows:

"There should be less than 2% of northern fulmars (*Fulmarus glacialis*) having ten or more plastic particles in the stomach in samples of 50–100 beach-washed fulmars found in winter (November to April) from each of fifteen areas of the North Sea over a period of at least five years."

The EU Interreg IIIB project 'Save the North Sea' (Van Franeker *et al*., 2005) recommends that the formulation of the EcoQO should be revised to:

"There should be less than 10% of northern fulmars (*Fulmarus glacialis*) having more than 0.1 g plastic particles in the stomach in samples of 50–100 beach-washed fulmars found in winter (November to April) from each of 4 to 5 areas of the North Sea over a period of at least five years."

Background to changes

Change in % of samples (from 2% to <10%) not meeting the EcoQO

Current levels of plastics in stomachs indicate that between 44% (Shetland) and 60% (Netherlands) of northern fulmars have plastics in their stomachs exceeding both the 0.1 g and the ten item levels. In contrast, only 26% northern fulmars foraging in the cleaner waters of the Faroe Islands exceed these levels. The reduction of levels of plastic content to 2% of stomachs exceeding the 0.1 g or ten item limit may not be achievable in the medium term and will certainly require action over a much larger (maybe even global) geographic scale than the North Sea alone. The 'Save the North Sea' project suggests that 10% would be a more realistic—ambitious but achievable—level to set as a target. The 2% target could remain as a long-term aspirational goal. As far as can be learned, though, there is no biologically meaningful level to set this percentage at, so ICES notes that this is primarily a political choice rather than one with a scientific justification.

Change of numbers of particles to mass of particles

The use of the unit, 'mass of plastic' instead of the 'number of plastic pieces' in the stomachs of fulmars was recommended by 'Save the North Sea'. ICES concurs with these recommendations. The reason for adopting 'mass' rather than 'number' of plastic pieces is because 'mass' is the more representative unit in terms of the amount of plastic in the sea. In regional or time-series analyses, 'mass of plastics' is a more consistent measure than 'number of plastic pieces' because the latter may vary strongly with changes in plastic characteristics. For example, whereas time-series analysis of the 'numbers' of plastic pieces in fulmar stomachs since the late 1990s does not show a significant decrease, the 'mass' of plastic does. This may reflect a change in type and character of commonly used plastics, but other factors may be involved such as usage of waste grinders. Another consideration is the fact that paraffin-like plastic substances tend to fragment during handling and analysis; the use of 'mass' as the unit of measurement negates that effect.

Reduction from 15 to 4–5 sampling areas

The choice of 15 sampling areas in the original advice to OSPAR was based on the link to the EcoQO on oiled guillemots. These 15 sampling areas were in turn based on an analysis of trends in oiled birds and practical arrangements in place within and between countries surrounding the North Sea. It was felt originally that corpse collection and analysis arrangements would be easily augmented to allow the collection of northern fulmar stomachs. The 'Save the North Sea' project examined only four areas of the North Sea and only achieved a sufficient sample size in three of them. The proposal to reduce the number of areas therefore seems sensible. It is also worth noting that the variation in extent of contamination with plastic particles is not as great as the variation in proportions oiled – this being likely because oiling (and subsequent arrival on beaches) occurs over a relatively small geographic scale compared with the likely long-term, wide geographic scale of accumulation of plastic particles in northern fulmar stomachs. Therefore, given the smaller variation over a geographic scale, fewer locations will be needed to be representative of the North Sea. The 'Save the North Sea' project did not specify the 4–5 areas, but did collect samples in the Skagerrak, SE North Sea, eastern English coasts, and Orkney/Shetland (Figure 1.5.5.3.1).

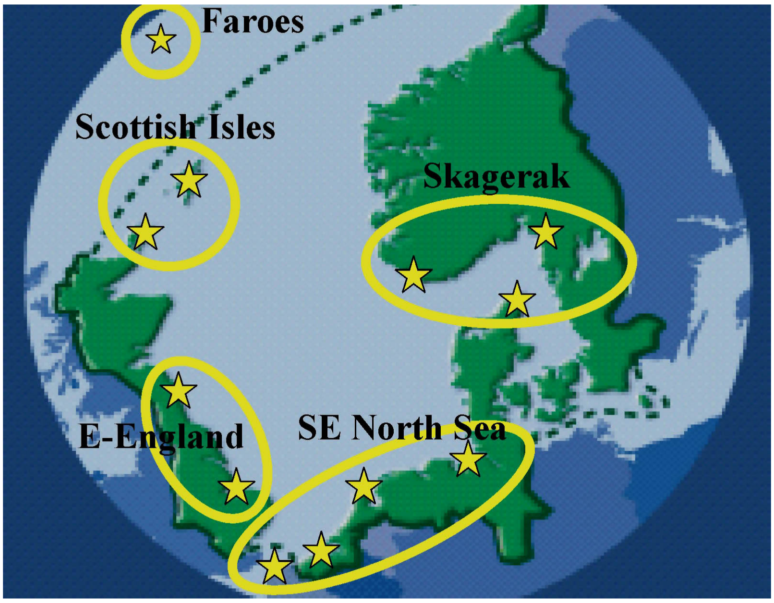

Figure 1.5.5.3.1 Sampling sites (stars) and areas used by the 'Save the North Sea' project (Van Franeker *et al.* (2005). The areas reflect sets of sample sites where northern fulmars show similar levels of contamination of stomachs.

ICES therefore supports the reduction of number of sampling areas. It would be logical to continue to use those areas sampled by the 'Save the North Sea' project, with the addition of an eastern Scotland or western Jutland sampling area. This reduction in sampling areas would be unlikely to increase the risk of missing any local pollution effects due to the widespread nature of plastic contamination and foraging areas of northern fulmars. It should be noted in this context that northern fulmars are comparatively rare in the Channel and therefore this area of the North Sea will not be sampled.

Change in number of samples per area

Analysis of variability in data and power analysis by Van Franeker and Meijboom (2006) revealed that reliable figures for plastics in stomachs are obtained at a sample size of about 40 birds per year for any one area and that reliable conclusions on change and stability in ingested litter quantities can be made after periods of 4–8 years.

Implications of changes on monitoring requirements

Standardised monitoring for this EcoQO has not yet been implemented throughout the North Sea (the Netherlands has implemented monitoring). However, a North Sea wide monitoring network has effectively been established by the 'Save the North Sea' project. The revised formulation reduces the overall monitoring requirement and thus reduces the need for funding and resources. ICES notes that Van Franeker (2004) provides a suitable set of standards for collection, dissection, and analysis of stomach samples.

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1.5.5.4 Quality assurance of biological measurements in the Northeast Atlantic

Request

ICES operates a joint ICES/OSPAR/HELCOM Steering Group on Quality Assurance of Biological Measurements (STGQAB) in order to coordinate the development of QA procedures and among those the implementation of QA activities required for the implementation of the JAMP.

Recommendation and advice

The detailed recommendations and advice can be found in the 2006 report of the ICES/OSPAR/HELCOM Steering Group on Quality Assurance of Biological Measurements (STGQAB). This recommendation and advice has been presented for the OSPAR ASMO meeting in April 2006.

1.5.5.5 Use of food safety monitoring programmes for monitoring dioxins and furans in fish and shellfish

Request

OSPAR has requested ICES to provide advice on whether the existing systems for monitoring dioxins in fish and shellfish for the purposes of safeguarding human health could be used to monitor trends in concentrations, and/or spatial extent, of dioxins in the marine environment. The specific questions to be addressed are:

i) What food safety monitoring of dioxins and furans in fish and shellfish is being carried out in the OSPAR area;
ii) To what extent it is possible to trace fish and shellfish samples to the locations in which they were caught;
iii) To what extent do the data obtained support the determination of trends in concentrations and/or spatial extent of dioxins in the marine environment?

Sources of the information presented

The 2006 report of the Marine Chemistry Working Group (MCWG).

Advice

ICES reviewed and discussed the extensive amount of data from surveys on dioxin and dioxin like PCB in fish, shellfish and fish products for the purposes of safeguarding human health available from UK, Sweden, Norway, Ireland and France. The existing reports showed a large diversity of products analyzed. The timing of the surveys and the choice of products, species, tissues and sources are *ad-hoc* rather than regular and logically reflect the local/regional food market for each survey. In many reports no individual measurements but only ranges of concentration or TEQ values are given. Sometimes, data produced are not published in a national report but only reported to the EU and stored on their database (e.g. in the case of Norway). In only some cases is it possible to trace back the fish/product samples to their exact origin at sea, and the samples are often collected from the consumer market (fishmongers and/or supermarkets). The surveys for food safety are directed by the need to assess the intake of dioxins, furans and dioxin–like CBs by human consumers. There is, therefore, no need to control many factors (selection of species, number and size of individuals) and record information (exact origin, age, length, condition etc) that are considered crucial to monitoring programmes conducted for spatial and temporal trends. In addition, only edible tissues are analysed rather than those in which concentrations are likely to be highest (e.g. liver). The lack of information and control in these food-monitoring programmes and their *ad-hoc* nature make the data unsuitable for defining temporal and spatial trends. In cases where the location and conditions of sampling are well documented, retrospective analyses of archived material from monitoring programmes can very well be used for temporal trend analysis (e.g. French study of PCDD/Fs in mussels, Annex 1). Several food and safety surveys do not provide the detailed knowledge required to answer the OSPAR request.

Recommendation

ICES recommends that dioxin data gathered for food safety purposes are not suitable for the investigation of environmental levels and trends due to the way in which the surveys are conducted.

1.5.5.6 Development of EcoQO on changes in the proportion of large fish and evaluation of size-based indicators

Request

This advice is based on the OSPAR request for further development of the EcoQO on changes in the proportions of large fish and hence the average weight and average maximum length of the fish community.

Sources of information

The Working Group on Fish Ecology (WGFE) (ICES, 2003b; 2004b; 2005b; 2006b);
The Working Group on Ecosystem Effects of Fishing Activities (WGECO) (ICES, 2001; 2002; 2003a; 2004a; 2005a; 2006a).

Summary

All of the work done on size-based indicators shows that they are affected directly and indirectly by fishing. However, making the EcoQO operational as a management tool in the North Sea, with performance indicators, metrics, and associated reference points is not straightforward, and has contributed to the lack of adoption of this EcoQO by OSPAR. ICES proposes a way forward, building on suggestions made for the use of size-based indicators in an ecosystem approach to fisheries management, including using suites of indicators and identifying reference directions. It is suggested that the goal for the North Sea fish community is to "halt as rapidly as possible, and begin to reverse by 2010, both the decline in the mean weight and the decline in proportion of large fish". To make this operational, ICES recommends that the mean size of fish in survey catches, and the proportion of fish greater than 30 cm in survey catches act as the indicators of progress towards this objective. To reverse the decline in large fish, it is necessary to reduce mortality on the fish community, and allow fish that are capable of reaching large size to live longer. The reduction in mortality on the community should result in an increase in the mean size in the survey samples of the fish community. Existing ICES advice to reduce mortality on many target species of fisheries, including reduced discarding, will contribute to this objective. Additional management measures may be necessary and will speed achievement of this objective. Any further application of this method must be specific to the relevant area for which it is developed and the survey methodology employed. Moreover, although analyses have demonstrated that fishing has a strong effect on the size structure of the fish community, changes in the proportion of large fish and mean weight of fish could also be affected by large anomalies in recruitment, distribution and migration patterns for a number of species, or for a species numerically dominant in the community. For this reason, as is the case for any indicator, the effects of fishing on the value of the indicator typically need to be assessed and interpreted in the context of other information about the fish community, and trends are most informative when they are assessed over several years.

Recommendations and advice

The EcoQ element on changes in the proportions of large fish and hence the average weight and average maximum length of the fish community is clearly linked to fishing. In the context of the North Sea this change would be monitored using catches taken in relevant demersal trawl surveys. It is a useful state indicator and a good measure of this component of ecosystem health. Although these metrics clearly serve as useful indicators of the effect of fishing on the whole fish community, ICES has advised that they are also indicative of wider changes in the ecology of the fish community and biodiversity. Reduction in the mean size of fish in the community has implications for trophic structure (fewer large fish, more small fish), for reproductive potential of the larger predators in the community, and the overall role of fish in ecosystem functionality.

The EcoQ element describes two interrelated aspects of fish communities:

- size-structure: proportion of large fish and average weight
- species composition: average maximum length of the fish community

The measure of average maximum length of the fish community is related to the frequency distribution of species with specific life-history characteristics. Both indicators can be considered complimentary when using them to assess the effects of fishing on the fish community.

ICES concludes that the EcoQO can be further progressed as part of an objectives-based management framework, in the North Sea, and so has defined an overarching objective, consistent with high level international agreements (e.g. World Summit on Sustainable Development) to achieve 'by 2010 a significant reduction in the current rate of biodiversity loss'.

ICES therefore suggests the goal for the fish community to be:

Halt as rapidly as possible, and begin to reverse by 2010, both the decline in the mean weight and the decline in proportion of large fish.

The setting of reference levels, both in the sense of OSPAR "reference level" (the level of the EcoQ where the anthropogenic influence on the ecological system is minimal), and in the way that ICES uses reference points in scientific advice, are challenging because of constraints of data availability. Although long-term international monitoring programmes exist in the North Sea (e.g. SAGFS, IBTS), changes over time in the gears used, sampling practices such as haul duration, and indeed the size and power of vessels employed, mean that the survey data are not completely consistent over the periods involved. The data from these monitoring programs will have to be made as comparable as possible before any reference points for use in advice can be estimated for the entire North Sea fish community. Furthermore, even the longest time-series of data available started long after the time at which fishing may have affected the fish community. This poses particular problems for the estimation of "reference levels" as defined by OSPAR.

Regarding the two metrics, mean weight of fish in survey samples is readily defined. The proportion of large fish in the community needs "large fish" to be defined. In all uses of the term "large fish" in this advice, ICES is referring to fish which have already achieved a large size, not those which are capable of achieving a large size. In a recent analysis of long-term data for the demersal fish community of the northwestern North Sea, Greenstreet and Rogers (2006) defined large fish as those above 95% of the cumulative frequency distribution of all fish lengths sampled over the entire 1925 to 1996 period. Only 5% of all the individuals caught exceeded 30 cm. They therefore defined large fish as fish of greater than 30 cm in length. At their 2006 meeting WGFE evaluated definitions of large fish according to selection criteria as described by Rice and Rochet (2005) (ICES, 2006b). For proportion of large fish three definitions of large fish were used: percentiles; arbitrary cut-offs (e.g. 20, 30, 40 cm); and biologically relevant cut-offs (e.g. length-at-maturity). The proportion of large fish, either measured as a percentile or using an arbitrary cut-off, was the only indicator that scored high for all selection criteria.

In the short term therefore, operational targets for both metrics could be:

1. Based on survey catches: Halt the decline in the proportion of fish greater than 30 cm in length as rapidly as possible.
2. Based on survey estimates: Halt the decline in the mean weight of fish as rapidly as possible.

Meeting the target in the short term should cease the decline in the proportion of large fish as described above by lowering fishing mortality on all species (taking into account discarding, etc). Existing ICES advice to reduce mortality on many target species of fisheries will contribute to this objective, but additional management measures may be necessary and will speed achievement of this objective. Both these measures will lead in time to an increase in the maximum length of each species in the fish community, and no additional metrics have been formulated to define this element.

OSPAR is clear that in its objectives-based management approach, management targets are not intended to be the pristine "reference level". Such objectives would exclude sustainable human activities. Instead, management targets should be guided by societal choices regarding the costs and benefits of moving towards such reference levels, and reflect the overall commitment in WSSD and the CBD to conservation and sustainable use of ecosystems. In the medium-term, operational reference points will need to be established to restore the proportion of large fish and the mean weight of fish, and management plans implemented with appropriate control measures to facilitate their achievement. This will involve the selection of a time period in the recent past, and using reasonable assumptions about stock productivities from recent assessments, estimate how many years it would take for stocks to rebuild. One suggested method for identifying such medium term operational reference points is based on selecting a time period when fishing mortalities on exploited stocks were considered at the time to be sustainable. The early 1980s was regarded by ICES as a period when ICES advice on the management of the exploited species was generally for the maintenance of "*status quo*" exploitation rates. The data in Greenstreet and Rogers (2006) suggests that, by the early 1980s, both size-based metrics had clearly departed from the "non-fished" OSPAR reference level. Nevertheless, the proportion of fish over 30 cm was 1.4 times higher, and the mean weight of fish 1.3 times higher, than current values.
Other areas and/or communities might require other dates with which to define reference directions. All reference dates may then be further revised in the light of socio-economic considerations and the outcome of ecosystem modelling studies to assess whether, for example, sustainable mortalities and the proportion of large fish might change over time.

The reduction in mortality on the community should result in an immediate increase in the mean size. It will, however, result in a short-term decline in the proportion of large fish, because small fish comprise such a great proportion of the fish community at present, and it will take a few years for the additional ones surviving to grow to become "large". However, in the medium term, as more fish grow above the 30 cm size, the desired reversal in the decline in the proportion of large fish will occur.

In the long term it will be necessary to continue to improve the scientific basis of our estimates of reference points for the proportion of large fish and mean weight indicators. Because of the limitations on historic data, empirical analysis of them will have to be augmented by ecological modelling studies to provide insight into fishing mortality rates for the fish community at which there are no serious biodiversity concerns, the proportion of large fish that is associated with such mortality rates, and how both the sustainable mortalities and proportion of large fish might change over time. In addition, it will be necessary to discuss with policy customers those states of the fish community and corresponding target levels for proportion of large fish that are acceptable to society as targets. Modelling approaches will be required to determine how long it should take to move the indicators to the target levels. The modelling will inform the setting of a realistic time-frame for both the achievement of targets and our ability to measure progress towards them.

Scientific background

The Working Group on Fish Ecology (WGFE) and the Working Group on Ecosystem Effects of Fishing Activities (WGECO) have been studying the Ecological Quality Element (EcoQ) on fish length for several years (ICES 2003b; 2004b; 2005b,c; 2006b; 2001; 2002; 2003a; 2004a; 2005a; 2006a). At their most recent meeting WGFE (ICES, 2006b) attempted to synthesise the available knowledge by identifying and evaluating a range of ecological issues which could potentially be informed or monitored by a large fish index (which might include the proportion of large fishes).

The following ecological issues could be informed by a large fish metric: large fish as large predators (size, trophic structure and predatory function); assemblage reproductive capacity; conservation of threatened and declining species; wider biodiversity; and charismatic species. WGFE realised that the latter three issues were unlikely to be well represented by an indicator of size and that others may also be required. The assemblage reproductive capacity is a promising approach which deserves more work done on it. This has recently been explored whereby numbers (or weights) of fish > ½ max. length have been taken as an indicator of reproductive capacity (Niels Daan, pers. comm.). Future work could explore ways of incorporating such biologically relevant metrics.

Different measures of large fish were examined, including percentiles, arbitrary cut-offs (e.g. 20, 30, 40 cm), and biologically relevant cut-offs (e.g. length-at-maturity). The proportion of large fish, either measured as a percentile or using an arbitrary cut-off, was the only indicator that scored high for all selection criteria (ICES, 2006b; Rice and Rochet, 2005).

Further examination by ICES has identified the following points for consideration when taking this EcoQO further:

- The choice of size cut-off has important implications for sensitivity of the indicators. It should be set at a level which includes enough large individuals in the survey to be useful while at the same time avoiding loss of robustness of the metric due to other biological variability, e.g. seasonal variation in growth and exploitation pattern.
- Both the proportion of large fish and the mean weight of fish may be confounded by changes in the abundance of small fish caused by altered migration patterns and shifting dominance among species with different growth parameters.
- ICES recognises that there are other drivers in the North Sea that may influence the metrics (e.g. long-term climate changes and global warming, regime shifts, recovery strategies, and ecological niche theory) but that fisheries are likely to be the most important driver.

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1.5.5.7 Biological effects techniques for oil spill monitoring

Request

In 2005, OSPAR requested advice on assessing the impacts of the long-term effects of oil spills.

Recommendations and advice

ICES recommends that OSPAR considers the additional information provided regarding biological effects monitoring that is essential for evaluating the impact on and recovery of marine ecosystems from oil spills.

Summary

Following the initial advice provided intersessionally, ICES has prepared a review of major oil spills and developed guidelines relating to the use of relevant biological effects techniques in the assessment of the impact of oil spill events. A range of chemical and biological effects techniques needs to be used as soon as possible after the occurrence of major oil spills in order to assess the environmental impacts of the incident. These techniques are detailed in the "scientific background."

Scientific background

Selection of appropriate biological effects techniques

Biomarkers

Some of the biomarkers proposed below are being used successfully as tools to identify biological responses after an oil spill situation. Others still require additional development before they can give a complete diagnosis of pollution effects in coastal environments. It is important to differentiate between those biomarkers which reflect acute response to acute exposure directly after the spill and those reflecting long-term effects of month and years.

Biomarkers of acute exposure are induction of biotransformation, glutathione- conjugating and antioxidant enzymes. Lysosomal membrane stability reflects the whole range of time scale in its response from very early to long term effects. Biomarkers measuring long-term effects putatively resulting in carcinogenesis and reproductive failure indicate prolonged oxidative stress, DNA damage, reduction of contaminant efflux and enzymes of steroid metabolism.

It is essential that a set of biomarkers should be used in conjunction with supporting analytical water, sediment and tissue chemistry and other biological measurements.

Bioassays

Bioassays are usually performed in oil spill situations in order to evaluate the toxicity of the water, sediments, the elutriates and the water-accommodated fraction (WAF). It should be noted that some studies have demonstrated the impact of natural light (UV) on the toxicity of elutriates and WAF (Allred and Giesy, 1985) and this may need to be taken into account in the assessment of field collected water samples.

The table below (Table 1.5.5.7.1) provides guidance on the current biological effects techniques that can be used in oil spill situations with special reference to; the type of measured response, the timescale of response of each method, the timescale of expected effect in the field, the organism used, the target tissue, the purpose of using the method and the citation for the prescribed method.

Table 1.5.5.7.1 Application of biological effects techniques after an oil spill situation.

Acute effects biomarkers	Timescale of response by method	Timescale of expected effect in field	Organism	Target tissue	Purpose	Methods
PAH bile metabolites	Hours	Days to months depending on conditions	Fish	Bile	Indicates exposure to PAH	Ariese *et al*., 2005.
Lysosomal stability	Hours	Days to months depending on conditions	Mussel fish	Blood cells liver	Sub-cellular damage	Moore and Lowe, 2004. BEEP Köhler *et al*., 2002
EROD activity Induction CP4501	Days	Days to months depending on conditions	Fish	Liver	Induction of detoxification mechanism	Galgani *et al*., 1991
GST activity	Days	Days to months depending on conditions	Fish Mussels	Liver Digestive gland	Induction of detoxification mechanism	Habig and Jakoby, 1981
Antioxidant enzymes: SOD, , CAT, GPX and GR	Days	Days to months depending on conditions	Mussels	Digestive gland	Induction of oxidative stress response enzymes	Karacoh *et al.,* 1998 Greenwald, 1985
DT-diaphorase			Fish	Liver		
Long-term effects biomarkers			**Organism**	**Target tissue**		**Methods**
Lipid peroxidation/oxidative stress	Days	Months	Molluscs fish	Digestive gland liver	Cellular response to oxidative stress	To be identified.
Lysosomal stability	Hours	Months	Mussels	Digestive gland Haemolynpha	Interference with steroid metabolism / effects of reproductive performance / endocrine disruption	Moore and Lowe, 2004. BEEP
			Fish	Liver		Köhler *et al*., 2002
ED effect Aromatase inhibition	Hours / days	Months	Imposex in mussels	Gonads		To be identified
Vitellogenin in males			Fish	serum		
MXR activity inhibition	Days	Months	Mussel fish	Gill Whole animals	Inhibition of contaminant efflux at sub-cellular level	To be identified.
Micronuclei	Days	Months	Mussels Fish	Digestive gland Liver	Genotoxic damage	Olive D.L. 1988; Akcha *et al*., 2002; Reichert *et al*., 1999; Singh *et al*., 1988; Aas *et al*., 2000; Sánchez *et al*., 2000; Taban *et al*., 2004; Nishikawa *et al*., 2005; Baršienė, 2002; Bagni *et al*., 2005; Baršienė *et al*., 2006b).
Enzyme altered foci	1+ years	1+ years	Fish	Liver	Initiation of carcinogenesis	To be identified.
Histopathology	1+ years	1+ Years	Fish Mussels	Target organs: including liver, gills and gonads	Tissue damage / neoplastic disease	Feist *et al*., 2004; Köhler, 2004.

Acute effects biomarkers	Timescale of response by method	Timescale of expected effect in field	Organism	Target tissue	Purpose	Methods
Bioassays Toxicity of fuel SFG	Days	Years	**Organism** Mussels (*M. edulis)*	Whole organism	Physiological impairment	**To be identified**
Embryo-larval test (on field samples)	Days	Days to weeks depending on conditions	Sea urchin (*Paracentrotus lividus*) Mussels (*M. galloprovincialis*) Oyster (*Crassostrea gigas*)	Whole organism	Mortality and deformity in embryos	Thain, 1991.
Algal growth inhibition test	Days	Days to weeks depending on conditions	Isochrysis galbana	Whole organism	Mortality	To be identified
DR CALUX (on field samples: water, sediment, tissue extracts)	Hours	Days to months depending on conditions	*GMO*	*In vitro*	Measure PAHs	To be identified
Sediment bioassays: Corophium spp. Arenicola spp.	Weeks	Days to months depending on conditions		Whole organism	Mortality and behaviour	

Recommendations

1) The above guidelines are recommended for use in oil spill situations and need to be used as appropriate for the type of oil spill, the conditions under which the oil spill occurred and the variable locations (i.e. type of coastline, hydrography, etc.). Therefore the methods need to be used in a fit for purpose manner and due consideration should be given to:
    2) Type of oil;
    3) Duration of spill;
    4) Geographic extent of spill;
    5) Type of habitats (rocky shore / mud / ice);
    6) Weather and hydrographic conditions;
    7) Type of clean up operations employed;
    8) Socio-economic considerations e.g. aquaculture or sensitive ecological areas vs. offshore;
    9) Statistical robustness to sampling design;
    10) Appropriate reference sites need to be identified;
    11) In areas of high risk to oil spills it is essential to establish baseline responses for the methods to be used;
    12) Appropriate integration of sampling with chemistry should be conducted according to the integrated guidelines under development (WKIMON);
    13) Toxicity profiling using specific biomarkers / bioassays of the major oil types transported in the ICES / OSPAR area should be conducted.
14) For the major oil types transported in a given region, toxicological profiling / hazard identification using bioassays should be employed to determine the responses to the given oil types. The importance of undertaking this research is to establish the applicability of biological effects techniques (bioassays and biomarkers) for risk assessment, management and policy purposes after oil spill accidents.

Source of the information

The 2006 report of the ICES Working Group on Biological Effects of Contaminants (WGBEC) and ACME deliberations.

1.5.5.8 Biological effects techniques for use in monitoring programmes

Request

Within the WKIMON process, OSPAR has asked ICES to maintain a list of recommended biological effects techniques for use in monitoring programmes, and ICES has updated this list.

Recommendations and advice

ICES recommends that sediment seawater elutriate bioassays and oxidative stress be removed from the list of techniques recommended by OSPAR, and that the determination of vitellogenin (VTG) in cod and flounder be added to the list.

Summary

A table (Table 1.5.5.8.1) outlining recommended revisions to the status of biological effects methods within the CEMP can be found on the next page.

Table 1.5.5.8.1 Recommended revision to the status of biological effects methods in the CEMP.

Technique	Scope	ICES recommend	Proven and widely available	Well documented	Applicable across OSPAR MA	Considered to be of value across the OSPAR MA	Data for the technique available	Guidelines/ Technical Annex Updating required	AQC	Assessment Criteria	Current CEMP cat/status	Conclusions Further work needed
INVERTEBRATES												
Whole sediment bioassays	General	Yes	Yes	SIME 6/4/8 Spain TIMES 28 and 29	Assumed but test organisms not indigenous across region	Yes	Yes	Update by Secretariat	B	To be developed by WGBEC	II	
Sediment pore water bioassays	General	Yes	Yes	SIME 6/4/8 Spain TIME 11	Yes	Yes	Data availability poor	Update by Secretariat	B	Further development needed	II	Extraction guidelines needed
Water bioassays OEB / Tisbe	General	Yes	Yes	SIME 6/4/9 NL and UK	Yes	Yes	Yes	Update by Secretariat	B	Further evaluation needed	II	Extraction guidelines needed; species used needs to be clearly defined
Scope for Growth	General	Yes	Yes	TIMES imminent [John Thain (UK) has offered to develop a BD	Yes	Yes	Data availability poor	No TA	No	Need development	not currently in CEMP	AQC and assessment criteria need development
FISH												
CYP1A	General	Yes	Yes	[in prep] Belgium? TIMES 23	Yes – but no single species	Value questionable	Yes	Update by Secretariat	B-a	Need to be developed	II	Requires review
Lysosomal stability	General	Yes	Yes	No BD TIMES 38	?	Yes	Yes but as research programmes- no external QA	Update by [lead country]	B-a	Proposed at WGBEC 05, background document to be prepared	II	AQC under BEQUALM needs to be actioned. Background doc on proposed AC needed
Liver neoplasia/ hyperplasia	General	Yes	Yes	SIME 6/4/5 UK and DE TIMES 19	Depends on availability of target species	Yes	Yes	Update by UK and DE	B	Further development by WGPDMO 2006	I – Vol.	Species differences and AC need attention

Technique	Scope	ICES recommend	Proven and widely available	Well documented	Applicable across OSPAR MA	Considered to be of value across the OSPAR MA	Data for the technique available	Guidelines/ Technical Annex Updating required	AQC	Assessment Criteria	Current CEMP cat/status	Conclusions Further work needed
Liver nodules	General	Yes	Yes	SIME 6/4/5 UK and DE TIMES 19	Depends on availability of target species	Yes	Yes	Update by UK and DE	B	Further development by WGPDMO 2006	I – Vol.	Species differences and AC need attention
Externally visible fish diseases	General	Yes	Yes	SIME 6/4/5 UK and DE TIMES 19	Depends on availability of target species	Yes	Yes	Update by UK and DE	Yes	Further development by WGPDMO 2006	I – Vol.	Species differences and AC need attention
Reproductive success	General	Yes	Yes	SIME 6/4/2 DK	No – dependent on single species	No – relevant to the Baltic area only	Yes	Update by lead country	B-a	Further evaluation needed	II	Consider adoption in alternative species outside Baltic
Metallothionein	Metal-specific	Yes	Yes	SIME 6/4/4 N TIMES 26	Not clear	Of limited use in fish to site specific issues	Yes	Update by Norway to reflect updated method	B-a	Further evaluation needed	II	Evaluation of genomic approaches to MT needed
ALA-D	Metal-specific	Yes	Yes	SIME 6/4/5 N	Further studies needed	Yes – where Pb is considered an issue	Yes but limited to Norway	Update by Norway to reflect updated method	B-a	Further evaluation of proposals by Norway needed	II	Assessment criteria need further work, limited scope for successful external QA
CYP1A-EROD	PAH-specific	Yes	Yes	[in prep] Belgium? TIMES 23	Yes – but no single species	Value questionable	Yes	Update by Secretariat	B-a	Need to be developed	II	Requires review
DNA adducts	PAH-specific	Yes	Proven but not widely available	[in prep] Belgium TIMES 25	Yes –but no single species	Yes	Yes but limited availability	yes	B-a	Need to be developed	II	Cheaper alternative methods need development AC and AQC needed
PAH metabolites	PAH-specific	Yes	Yes	TIMES 39, Background doc [in prep] Belgium?	Yes – but no single species	Yes	Yes	yes	Q-a	Need to be developed	II	Assessment criteria require development
Liver pathology	PAH-specific	Yes	Yes	SIME 6/4/5 UK and DE	Depends on availability of target	Yes	Yes	yes	B	Further development by	I – Vol.	Species differences need to be

Technique	Scope	ICES recommend	Proven and widely available	Well documented	Applicable across OSPAR MA	Considered to be of value across the OSPAR MA	Data for the technique available	Guidelines/ Technical Annex Updating required	AQC	Assessment Criteria	Current CEMP cat/status	Conclusions Further work needed
					species							addressed
Imposex/intersex in gastropods	TBT-specific	Yes	Yes	TIMES 24 and 37 OSPAR guidelines	Yes – methods and AC available for 5 species in OSPAR MA	Yes	Yes	yes	Q	WGPDMO 2006 Provisional 2004-15	I – M	
Vitellogenin in cod / flounder	Endocrine disruptors	Yes	Yes	SIME 6/4/6 UK TIMES document	dependant on species availability	Yes	Yes	[TA needs to be developed]	B-a for cod	Proposals from the UK need deveopment	not currently in CEMP	Could be applied to eelpout and other species should be investigated. AQC and AC need development

ICES recommended technique – of sufficient standing for OSPAR-wide deployment; SIME XX/XX/XX - Background document provided for SIME; TA – Technical Annex; CEMP Category rated I or II; V = Voluntary, M = Mandatory; B = Bequalm, B-a = available under BEQUALM, Q = Quasimeme, Q-a = available under Quasimeme

Scientific background

ICES supports the proposal for a third WKIMON workshop to be held in 2007, in order to provide guidance on appropriate chemical and biological effects techniques to be included within an integrated monitoring scheme, and also to provide advice on assessment criteria. To support this process, ICES has produced a draft monitoring strategy, based upon its recommended list of validated methods and the requirements of the OSPAR JAMP and CEMP programmes, using fish and mussels. ICES also intends to develop and organise a demonstration programme for integrated monitoring of fish, mussels and sediments across the OSPAR area by 2008, and encourages countries to participate. Within the JAMP and CEMP programmes, ICES considers that it is essential for technical annexes and monitoring guidelines to be reviewed on a 2-yearly basis, and revised and updated if necessary.

Source of the information

The 2006 reports of the ICES Working Group on Biological Effects of Contaminants (WGBEC) and ICES Marine Chemistry Working Group (MCWG) and ACME deliberations.

1.6 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 further recommends that Member Countries continue to fund programmes monitoring diseases in wild stocks of fish and shellfish. Information obtained is of vital importance to integrated assessments of the health of marine ecosystems and will provide baseline data, e.g., to serve as a reference prior to establishing the culture of marine species. In addition, wild fish and shellfish disease monitoring data in combination with data on mariculture-relevant diseases provide a better understanding of pathogen interactions between wild and farmed species.

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

Causes of the hyperpigmentation observed in North Sea dab (*Limanda limanda*)
the occurrence of *Francisella* sp. in farmed and wild cod (*Gadus morhua*) and of a visceral granulomatous condition in wild cod;
the identification of *Bonamia* spp. infecting introduced Asian oysters (*Crassostrea ariakensis*) and crested oysters (*Ostreolis equestris*) in the USA;
the signs of gill disease in Pacific oysters (*Crassostrea gigas*) in Germany;
disease signs in Icelandic scallops (*Chlamys islandica*) from the Barents Sea.

Summary

This section summarises 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

New outbreaks of VHSV Genotype IV in freshwater fishes in North America suggest a broader host range for this marine virus and may indicate a higher risk to fish population previously not affected. The outbreak in drum (*Aplodinotus grunniens*) in Canada was the first due to Genotype IV in freshwater fish.

Ichthyophonus sp. is an increasing disease problem in several species of fishes in Pacific coastal North America due to its potential to cause epidemics.

Early stages of *Lepeophtheirus salmonis* are commonly parasitic on threespined sticklebacks (*Gasterosteus aculeatus*) in British Columbia. The role of this host in the ecology of the parasite and its transmission to wild and farmed salmonids is not known.

A 27 year data set showed bacterial pathogens *Yersinia ruckeri* and *Aeromonas salmonicida* previously causing disease problems decreased significantly in the captive broodstock of sea run Atlantic salmon (*Salmo salar*) in Penobscot River, Maine, USA, since 1997.

The prevalence of *Anisakis simplex* larvae infection in Baltic herring (*Clupea harengus*) steadily declined since 1997 the causes of which are unknown.

The prevalence of hyperpigmentation (aggregation of pigment cells in the skin) in North Sea dab (*Limanda limanda*) continued to show a significant increase. Heavily affected fish have a lower condition factor than unaffected fish. The causes of the condition are unknown.

The impact of M74 previously causing high mortalities in offspring of wild Baltic salmon and sea trout has declined in Sweden and Finland.

Farmed Fish

An increase in the number of isolations of Infectious Pancreas Necrosis Virus (IPNV) in farmed Atlantic salmon (*Salmo salar*) is of concern in Ireland due to known impacts of the disease on salmon farming.

Salmon Pancreas Disease (PD), Heart and Skeletal Muscle Inflammation (HSMI) and Cardiomyopathy Syndrome (CMS) are virus-related diseases of growing concern for the Atlantic salmon farming industries of Ireland, Norway and Scotland due to losses involved.

Infectious Salmon Anaemia Virus (ISAV) has been detected by RT-PCR in the parasitic copepod *Caligus elongatus* taken from Atlantic salmon on a farm that was affected by an apparently non-pathogenic type of ISAV. This suggests that *C. elongatus* may serve as a vector of ISAV in the USA.

A new and increasing problem in farmed Atlantic cod (*Gadus morhua*) in Norway is associated with bacterial infections by *Francisella* sp. There is a potential link with reported disease in wild cod in Sweden where there is similar histopathology.

Pathogenic North American strains of the Viral Haemorrhagic Septicaemia Virus (VHSV) appear to be transmitted to farmed Atlantic salmon from Pacific herring (*Clupea pallasi*) cohabiting in net pens, increasing the risk of transmission between wild and farmed fish.

Wild And Farmed Shellfish

In 2005, the enzootic *Bonamia* spp. first identified in North Carolina, USA, in 2003 during testing of the intentionally introduced non-native Asian oyster (*Crassostrea ariakensis*) were detected 100 km south of the original site, thus extending the known range of these parasites, the natural host of which appears to be the native crested oyster (*Ostreola equestris*). This is considered to be an example of negative effects of local introductions of non-native species.

White Spot Syndrome Virus (WSSV) was detected for the first time in the blue crab (*Callinectes sapidus*) in the south-eastern USA, extending the range of known host species of this disease.

Vibrio splendidus was associated with mortality affecting great scallop (*Pecten maximus*) spat in the field. This is the first time that *V. splendidus* has been associated with scallop mortalities in France.

The marked two-year decline in prevalences of *Perkinsus marinus* and *Haplosporidium nelsoni,* significant parasites of the eastern oysters *(Crassostrea virginica*), in the mid-Atlantic estuaries of the USA ended in 2005.

Shell disease in American lobsters (*Homarus americanus*) from Rhode Island, USA, has shown an increasing trend over the past 10 years. Population effects due to the disease are uncertain although significant effects on gravid and non-gravid females have been documented. The causes of the disease are still under investigation.

Phenotypically different neoplastic cells co-occurring in individual Baltic clams (*Macoma balthica*) from the Gulf of Gdansk were described for the first time, suggesting a co-occurrence of disseminated neoplasia with what might be a fibrosarcoma.

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. The update presented in the following section is based on national reports for 2005 submitted to the ICES by Canada, Denmark, Finland, France (only for shellfish), Germany, Iceland, Ireland, Latvia, Lithuania, Norway, Poland, Russia, Sweden, The Netherlands, UK and USA. It attempts to document significant observations and to highlight the major trends in newly emerging diseases and in those identified as being important in previous years.

Wild fish

Viruses

Birnavirus – Isolations of Birnavirus II (Tellina virus) were made from three sea trout (*Salmo trutta*) broodfish in Denmark.

Infectious Haematopoietic Necrosis Virus – A database of genetic sequences of more than 600 isolates of IHNV is being established. Different patterns of diversity and evolution of IHNV in its range in the north-western USA are apparent. When complete, the database will be available for researchers to determine epidemiological features of their isolates based on comparisons with sequences in the database.

Infectious Pancreatic Necrosis Virus – No isolates of IPNV were made from 600 brood salmonids (480 Atlantic salmon (*Salmo salar*), and 120 sea trout) in Denmark. In Finland, IPNV was isolated from whitefish (*Coregonus* sp.) broodfish and sea trout with no signs of disease.

Lymphocystis – In North Sea dab (*Limanda limanda*), the second lowest prevalence from the German Bight was recorded in 2005 (2.3 %) while the prevalence remained relatively unchanged in dab in the northern North Sea and the Irish Sea, although specific sites showed slight increases and decreases from 2004. In dab from the Dutch Wadden Sea there was a slightly decreasing trend in the period 2001-2005. No new trend was recorded in flounder (*Platichthys flesus*) from the Baltic Sea. Depending on the area, the prevalence ranged from 1.0 % to 25.0 %.

Salmon Swimbladder Sarcoma Virus – Variant strain 2 was identified by RT-PCR in Atlantic salmon smolts that were held for one week in rivers in Maine (USA). This is the same strain found earlier in landlocked salmon in New York state, which, when held for years in the laboratory, showed high viraemia but no signs of disease. There were no signs of disease in the Maine fish.

Viral Haemorrhagic Septicaemia Virus – The North American strain of VHSV (Genotype IV) was isolated from stocks of freshwater drum (*Aplodinotus grunniens*) and muskellunge (*Esox masquinongy*) experiencing mortalities in Canada and USA. These are the first mortalities in freshwater species in North America due to the marine genotype, suggesting a broader host range than expected for this virus. The outbreak in Canada occurred in eastern Lake Ontario with a connection to the St. Lawrence River, and the drum may have had a link with a diadromous species. VHSV (Genotype II) is still present in wild Baltic herring (*Clupea harengus membras*) in Finland. Genotyping of the G-gene segment showed that the isolate from Atlantic herring (*Clupea harengus harengus*) in Maine reported in 2004 is 99 % homologous with the Pacific marine VHSV Genotype IV and 85 % homologous with the European Genotype III.

Bacteria

Acute/healing skin ulcerations – The prevalence of skin ulcers in Baltic cod (*Gadus morhua*) increased in 2005 in comparison to 2004, but was generally lower than in 2003. The prevalence of ulcers in cod and plaice (*Platessa platessa*) in the Barents Sea decreased in comparison to previous years. The prevalence of skin ulcers in 2005 in Baltic flounder from the Polish coast was higher than in 2004. The highest level of ulceration was noted in flounder from the Polish and Lithuanian EEZs. There was an increasing trend in ulcerations in North Sea dab from the German Bight and the Firth of Forth. In the Irish Sea, there was an increasing trend in Red Wharf Bay whereas a decreasing trend in Morecambe Bay was observed in the last two years.

Yersinia ruckeri*/*Aeromonas salmonicida – The bacteria were isolated from captive sea run Atlantic salmon from the Penobscot River, Maine, USA. *Y. ruckeri* was isolated from 51 % and *A. salmonicida* from 26 % of the fish screened between 1976 and 1997, but have not been isolated between 1998 and 2003.

Putative Bacteria - Of cod (100-400 g) caught by fyke-netfishing from a local area within the Skagerak Sea, Sweden, 15 % to 20 % had external lesions. The majority of those with lesions had whitish granulomas in liver, spleen, heart and kidney.

Parasites

MESOMYCETOZOA

Ichthyophonus hoferi – The parasite is still endemic at low prevalence in herring populations in the North Sea, the Baltic Sea and the west coast of Sweden. Prevalence in Pacific herring (*Clupea pallasi*) in Puget Sound, Washington, USA, increased from 41 % in 2000 to 59 % in 2005. Experimental exposure of naive Pacific herring resulted in 80 % mortality in 36 days. The parasite occurred in 12.5 % of 304 Puget Sound rockfish (*Sebastes emphaeus*).

MYXOSPOREA

***Myxobolus dermatobia* –** Observed in skin of 25 % to 44 % of chum salmon (*Oncorhynchus keta*) from far eastern Russia with intensities ranging from 2 to 203 cysts per fish.

MICROSPORIDIA

A decreasing trend of *Glugea stephani* was observed in dab from the Dutch North Sea coast.

MONOGENEA

Gyrodactylus salaris – Remains a major threat to Atlantic salmon in Norway. Salmon in the Norwegian rivers Steinkjerelva and Figgja became re-infected following an earlier disinfection.

DIGENEA

Stephanostomum baccatum – Prevalence of metacercariae in flatfishes (*Limanda aspera, Hippoglossoides elassodon, Cleisthenes herzensteini* and *Limanda proboscidea*) from the Sakhalin coast ranged from 12 % to 96 %.

NEMATODA

***Anisakis simplex* (larvae)** – A long-term decreasing trend in prevalence of infection of *A. simplex* among Baltic herring in the Polish and Russian EEZs was observed. The prevalence was negatively correlated with the mean mass of individual herring from Polish waters. The mean number of parasites per all fish examined (abundance) in cod from the Barents Sea increased to 17.7 from 2004.

***Pseudoterranova decipiens* (larvae) –** A decreasing trend in prevalence in cod from the Barents Sea of 40 % to 8 % between 2003 and 2005 coincided with an increase in abundance from 0.2 to 1.6.

ACANTHOCEPHALA

***Corynosoma strumosum* (larvae) –** Prevalence increased to 9.8 % in cod and to 15.7 % in flounder in the Baltic Sea (Russian EEZ, ICES Subdivision 26).

CRUSTACEA

Lepeophtheirus salmonis – The prevalence in 1,298 threespined sticklebacks (*Gasterosteus aculeatus*) collected in British Columbia, Canada, was 47.2 %, with an intensity (mean number of parasites per infected hosts in a sample) of 4.4. In 2004, the prevalence and intensity on sticklebacks was 83.6 % and 18.3, respectively. Adult stages were extremely rare.

Lepeophtheirus pectoralis – Prevalence in dab ranged from 0.8 % at Tees Bay (North Sea) to 45.9 % at Morecambe Bay (Irish Sea).

Sphyrion lumpi – In 2005, the prevalence in redfish (*Sebastes mentella*) from the Barents Sea declined, halting the increasing trend observed over the last four years.

Clavella adunca – The prevalence in North Sea whiting (*Merlangius merlangus*) from Scottish waters ranged from 28.7 % to 34 %.

Other diseases

Epidermal hyperplasia/papilloma – Prevalence in dab at most sites sampled in North Sea areas during 2005 was reduced from 2004 with the exception of Central Dogger (2.3 % from 1.7 % in 2004). In the Irish Sea (Liverpool Bay), the prevalence increased to 2.4 % from 0 % in 2004.

Liver nodules/tumours – Prevalences of liver nodules in North Sea dab from former hot-spot areas (German Bight, Dogger Bank) remained at a low level in 2005. The occurrence of liver nodules greater than 2 mm in diameter in dab 20 cm and above showed some differences from 2004 with a general decrease in prevalence detected since 2002 at West Dogger (10.8 % to 3.9 %) and North Dogger (6.4 % to 4.0 %). The prevalences at Central Dogger/Hospital Ground, Red Wharf Bay, and Morecambe Bay remain steady at approximately 4.2 %, 0.8 %, and 1.3 %, respectively. An increase in prevalence of 2.4 % to 5.4 % was seen at the Indefatigable Bank, southern North Sea. This is the highest prevalence recorded from this site and also the highest recorded in 2005. Liver nodules were observed for the second time at southeast Isle of Man (3.9 %), however it was a decrease of 1.9 % from levels recorded during 2004.

Hyperpigmentation – Dab in most North Sea areas show a significant increase in prevalence of hyperpigmentation (maximum 2005 values: Dogger Bank, 42.8 %; German Bight, 49.4 %). Dab from the Irish Sea continue to show low levels of hyperpigmentation. Prevalence in Cardigan Bay (Irish Sea) in 2005 dropped from 15 % to 5.8 % after several years of an increasing trend. The condition was absent in dab from the western Baltic in 2005.

Toxic algae – Gill damage associated with *Karenia mikimotoi* blooms was observed along the north, west and south coasts of Ireland throughout the summer 2005. Associated losses of wild fish including flatfish, conger eel (*Conger conger*) and mullet (*Mugil* sp.) were noted. Blooms of *Noctiluca scintillians* affected large parts of the south and west coasts of Ireland in the summer of 2005.

Intersex condition - Previously reported from dab from the North Sea in 2004 was not detected in 2005.

M74 – In Sweden, 3 % of the batches of 2005 fry hatched from 765 female Atlantic salmon were affected, in comparison to 9 % in 2003 and 36 % in 2002. M74-associated mortality in Atlantic salmon fry in Finland between 1992 and 2002 has declined from a yearly average greater than 50 % to less than 10 % in the last three years. There is a clear decreasing trend in M74 syndrome in Sweden and Finland.

Farmed Fish

Viruses

Heart and Skeletal Muscle Inflammation (HSMI) – This condition was first described in 1999 in Norway in Atlantic salmon (*Salmo salar*). A significant increase in prevalence was reported for 2005 compared to 2004. An outbreak of disease resembling heart and skeletal muscle inflammation in farmed Scottish salmon has been reported. Additional detail is provided under report section 6.

Infectious Pancreatic Necrosis Virus (IPNV) – Clinical IPN was reported at one site with losses of 10 % Atlantic salmon in Ireland. Atlantic salmon at a farm situated on the coastal zone of Sweden supplied with pumped freshwater were found to be infected with IPNV. The farm has now been disinfected and will be fallowed for two years. IPN remains significant in sea water post smolts from Scotland but is now deregulated and consequently no longer notifiable. IPN remains one of the major diseases in Norway.

Infectious Salmon Anaemia Virus (ISAV) – ISAV continues to be detected in salmon farms in Cobscook Bay, Maine, USA. Southwest of Cobscook Bay, ISAV has been detected by RT-PCR in *Caligus elongatus* taken from fish on a farm that was affected by an apparently non-pathogenic type of ISAV. This suggests that *C. elongatus* may serve as a vector of ISAV.

Sixteen separate incidents occurred in Maine in 2005, resulting in eradication of more than 125,000 fish and early harvest of substantial numbers of salmon. Genotyping of archived samples from Maine has revealed three genotypes as compared to 15 genotypes identified in New Brunswick, Canada. A model of hydrographic and epidemiological data collected on 32 sites with 2002 year class salmon of the Cobscook Bay (Maine) and Passamaquoddy Bay (New Brunswick) region suggests the movement of ISAV by water and tidal cycles played a relatively minor role in new outbreaks that occurred during a 28 month period. The model does not account for biosecurity, husbandry, fish strain or hatchery and may not apply to other areas.

Salmon Pancreas Disease Virus (SPDV) – This is an increasing problem in farmed Atlantic salmon in Scotland, Norway and Ireland.

Viral Haemorrhagic Septicaemia Virus (VHSV) – An increase in VHS outbreaks was reported in Finland. The virus was isolated from nine rainbow trout (*Oncorhynchus mykiss*) farms in the Åland Islands, SW Finland, compared to two isolations in 2004. VHS virus or clinical disease was not found within the two other VHS-restriction areas, or in other parts of the Finnish Baltic coastal areas. The genotype is Id. The North American (NA) strain of VHSV is reported to cause low level losses in 80-90 g Atlantic salmon introduced to seawater net pens in western Canada 1.5 months previously. VHSV was detected in all three Atlantic salmon examined. VHSV isolates from Pacific herring (*Clupea pallasi*) in the same netpen (reported above) were genetically identical to the salmon isolates. VHSV was identified in seventeen farmed chinook salmon (*Oncorhynchus tshawytscha*) from three farm sites by RT-PCR and cell culture.

Bacteria

Aeromonas salmonicida* subsp. *salmonicida – One new case of mortality was reported from a rainbow trout farm (coastal area of northern Baltic, Sweden). The trout farm had a vaccination programme, but during a warm summer period mortality coincided with a bloom of cyanobacteria.

***Francisella* sp**. – This is new and increasing problem in farmed Atlantic cod (*Gadus morhua*) in Norway. There is a potential link with reported disease in wild cod in Sweden where there is similar histopathology (see above).

Moritella viscosa – Ulcerations causing significant economic losses are mainly associated with decreased flesh quality and remain a significant problem in both salmon and rainbow trout in Norway. The impact is especially high in northern Norway, probably due to low temperatures and a slow healing process. Rough treatment of fish when they are sorted or handled seems to predispose fish to infection.

Vibrio anguillarum - Serotype O2ß was responsible for losses in cod in Ireland in December 2005.

Vibrio fluvialis – This pathogen was isolated from seahorse (*Hippocampus* sp.) in an aquarium in the west of Ireland following mortalities in late 2005.

Vibrio ordalii – This pathogen was isolated from Atlantic cod for the first time in Norway with associated mortality.
Parasites

MYXOZOA

***Kudoa* sp**. - The presence of *Kudoa* was confirmed at one Irish marine site rearing Atlantic salmon.

Parvicapsula pseudobranchiola - Infections are common but mortality rates are low in Atlantic salmon Norway (2-3 % accumulated).

SARCOMASTIGOPHORA

Spironucleus sp. – A systemic infection is regularly seen in marine-farmed Arctic charr (*Salvelinus alpinus*) in Norway. The mortality is low compared to infections in Atlantic salmon. A new case of systemic spironucleosis in Atlantic salmon was recently reported in northern Norway (2006).

MONOGENEA

Gyrodactylus spp. and **Trichodinids** – Mixed infections are commonly reported from Atlantic cod farms in Norway. Both parasite types are often seen in fish reported to have "gill problems". Formalin treatment has been used successfully.

CESTODA

Eubothrium crassum – Some problems were reported with resistance to Praziquantal treatment in farmed Atlantic salmon in Norway.

CRUSTACEA

Sea lice – the potential of interactions between farmed and wild cod is a concern in Norway. Treatment of sea lice in Ireland has presented difficulties at some sites. There is concern that *Caligus elongatus* and *C. curtus* infestation in cod at certain farms are problems in Norway.

Other diseases

Algal blooms - *Noctiluca scintillians* - high losses were encountered in some marine sites in the south west of Ireland. Some losses were also reported as a result of *Karenia mikimotoi* blooms in Ireland. In 2005, four incidents were recorded in Scotland in Atlantic salmon and attributed to a combined *Thalassiosira* and *Crypophytos* spp., *Aurelia aurita*, *Pseudonitzschia* spp. and an unknown plankton/jellyfish.

Epitheliocystis – One case reported in Iceland in Atlantic halibut (*Hippoglossus hippoglossus*). This species appears to be particularly susceptible.

Wild and farmed molluscs and crustaceans

Viruses

Herpes virus – No change in bivalves in France and no new information from the USA.

Viral Gametotrophic Hypertrophy– Continued rare presence in Pacific oysters (*Crassostrea gigas)* reported in France. The condition is also found regularly, but rarely, in eastern oysters (*C. virginica*) in the USA.

White Spot Syndrome Virus - WSSV was detected for the first time in the blue crab (*Callinectes sapidus).* It was diagnosed using real time PCR and an antibody test in a single blue crab in a sample of 300 collected in South Carolina and Georgia, USA. It was transmissible in an injection bioassay.

Bacilliform virus – A potentially novel bacilliform virus infection was found in up to 8 % of pink shrimp *(Pandalus montagui*) collected from an offshore site in The Wash, UK. Light to heavy infections affected the hepatopancreas. Further work is being carried out to classify the virus and to compare it to the previously described brown shrimp (*Crangon crangon*) Bacilliform Virus (CcBV) found at the same site.

Bacteria

Vibriosis – In France, *Vibrio harveyi* was associated with two mortality episodes affecting natural stocks of the abalone (*Haliotis tuberculata).Vibrio splendidus* was associated with mortality affecting great scallop (*Pecten maximus*) spat in the field. This is the first time that *V. splendidus* has been associated with scallop mortalities in France. As in 2004, *Vibrio* spp. were isolated from wild shrimp (*Palaemon adspersus*) with brown spot disease in Denmark.

Nocardiosis – In Pacific oysters (*Crassostrea gigas*), no new trends were reported in Canada and no new information was available from the USA.

Withering syndrome – No new information on occurrence in abalone.

Juvenile Oyster Disease – No outbreaks reported in eastern oysters *(Crassostrea virginica)*.

Fungal infections

Fungal infection - A fungal egg pathogen in externalised egg clutches was reported in the Chinese Mitten crab (*Eriocheir sinensis)* in the UK. The fungal infection appears to replace normal yolk storage and dividing embryonic cells and culminates in complete destruction of the egg mass (with fungal hyphae spreading between adjacent eggs via sporulating bodies). The necrotic egg mass is then infested with filamentous bacteria and other non-specific pathogens. Up to 75 % of gravid females were affected at peak infection. The effect of fungal infection on fecundity in this species has not been investigated but warrants further study (e.g. to control reproduction of this invasive species).

Parasites

DINOFLAGELLATA

***Perkinsus marinus* –** After two years of marked decline in 2003 and 2004, *Perkinsus marinus* prevalence in eastern oysters (*Crassostrea virginica)* intensified somewhat in Chesapeake and Delaware Bays, USA, in 2005, but its impact was still low relative to historical levels. In these estuaries, maximum prevalence increased from 40-50 % in 2004 to 50-60 % in 2005. There was little change to the north in Long Island Sound and Narragansett Bay or to the south in South Carolina and Georgia, where prevalence remained high (≥ 80 %), although with relatively light infections and little mortality.

P. olseni – No change in France where a survey of 836 carpet-shell clams (*Ruditapes decussates)* and manila clams (*R. philippinarum)* from the French coast found a prevalence of 43 %. Prevalence was approximately equal in the two species.

***P. chesapeaki* –** The parasite remained prevalent in both soft-shell clams (*Mya arenaria*) and stout razor clams (*Tagelus plebeius*) in the upper portion of Chesapeake Bay, USA, where mortality of approximately 70 % was associated with a prevalence of 80 % in the razor clam. A *T. plebeius* sample of 20 clams collected in November 2005 from lower Delaware Bay, USA showed continued high prevalence (100 %) of probable *P. chesapeaki*, first identified in this estuary in 2004. DNA samples of the Delaware Bay clams are preserved for species identification.

LABYRINTHOMORPHA

Quahog Parasite X (QPX) – Histopathological surveys of the hard clam (*Mercenaria mercenaria)* found no change in prevalence of QPX in Massachusetts, New Jersey or Virginia, USA, but a decrease in New York. No new trends reported in Canada.

HAPLOSPORIDIA

***Bonamia ostreae* –** No change in flat oysters (*Ostrea edulis*)in France where the annual survey on the coasts of Brittany and the Mediterranean Sea found *B. ostreae* in 90 of 1,275 oysters (7 %). In the spring of 2005, *B. ostreae* was found for the first time in a sample (13 of 30) of flat oysters from Lough Foyle, Ireland, during the routine screening programme. An investigation of the epizootic is ongoing. In England, the prevalence of *B. ostreae* in native oysters at farm sites increased slightly and in wild populations decreased slightly, compared with 2004. The parasite was not detected in any of the samples taken from the Fal wild fishery, England, for the first time ever and regular surveillance shows that it has not spread to new areas, including Scotland and the Limfjorden area of Denmark. The pathogen was reported for the first time in Canada (British Columbia) in 2004 and examination of *O. edulis* from three grow-out facilities in the summer of 2005 revealed prevalences from 0.5 % to 11.1 %. Re-evaluation of historic *O. edulis* examination results between 1986 and 2000 from five locations in British Columbia and re-examination of archived samples (n = 343) collected from the reference site between 1999 and 2004 in conjunction with seed introduction records suggests that *B. ostreae* may have been inadvertently introduced into British Columbia around 2003 with *O. edulis* seed imports from enzootic areas in the Washington State, USA.

***Bonamia* sp. -** The *Bonamia* sp. pathogenic to the non-native Asian oyster (*C. ariakensis)* caused epizootic disease and mortality approaching 100 % in every deployment of seed *C. ariakensis* (< 45 mm) to Bogue Sound, North Carolina, USA, through the warmer months of 2005. There is every indication the parasite is enzootic in Bogue Sound where the native, crested oyster (*Ostreola equestris*) in which *Bonamia* sp. was also detected again in 2005, may serve as a reservoir. Maximum prevalence determined by PCR of this parasite in *C. ariakensis* in Bogue Sound was 91.7 %; maximum prevalence in *O. equestris* was 1.3 %. Infections were confirmed by histopathology. The *C. ariakensis*-pathogenic *Bonamia* sp. was also detected in *O. equestris* at Wilmington, North Carolina, over 100 km southwest of Bogue Sound and distant from any experimental deployments of *C. ariakensis*. PCR-detected prevalence was 1.5 %. Sentinel *C. ariakensis* deployed to Wilmington in late September had 82.6 % prevalence by November, and mortality was again high. The Wilmington results are significant in that they indicate an expansion of the known range of this parasite.

***Bonamia* sp. -** A second *Bonamia* sp., found in the crested oyster *O. equestris* in 2004 and never observed in *C. ariakensis*, persisted in Bogue Sound in 2005, and was also observed for the first time in Wilmington, North Carolina. Maximum prevalence determined by PCR was 1.3 % in Bogue Sound and 3.5 % at Wilmington.

Mikrocytos mackini – No new trends in the Pacific oyster (*Crassostrea gigas)* in Canada.

Haplosporidium nelsoni – The two-year decline in prevalence recorded in eastern oysters in 2003 and 2004 in the mid-Atlantic, USA, did not continue in 2005, although prevalences remained very low (< 5 %) by historical standards. Elsewhere in the range examined in the USA (Rhode Island to South Carolina), prevalences were < 10 %. In Nova Scotia, *H. nelsoni* persisted on farm sites in the Bras d'Or Lakes, where it was first discovered in Canada in 2002. In 2005, it was also confirmed in oysters from an isolated population on the north shore of Cape Breton, Nova Scotia. Although this is a new location, it does not affect the populations that remain under official protective measures elsewhere in Atlantic Canada. In France, *H. nelsoni* was detected in 6 of 450 (1.3 %) Pacific oysters in 2005. Whereas this prevalence is not unusual, the spore stage of *H. nelsoni* was found for the first time in France in one of the infected oysters.

Haplosporidium costale - None detected in eastern oysters examined in New Jersey, Maryland, Virginia, or South Carolina, USA. No new trends in Canada

***Haplosporidium* sp. –** No new trends in edible mussels (*Mytilus edulis)* in Canada.

PARAMYXEA

***Marteilia refringens* in flat oysters** – No change reported in France where the annual survey of flat oysters in Brittany and along the Mediterranean coast of France recorded a prevalence of 2.5 % (25 of 1008). Approved-zone status has been maintained for UK and Danish waters monitored for *M. refringens.*

EUGLENOSOA

***Isonema*-like parasite** – About 7 % of the edible mussel larvae from a hatchery in southern British Columbia submitted in November 2005 for examination had systemic infections with a few to overwhelming numbers of a protozoan resembling the poorly understood *Isonema*-like parasite originally reported from geoduck clam (*Panopea abrupta*) larvae in an experimental hatchery in Washington State, USA. This is the first detection of this parasite since the initial report in 1987. However, the mussel hatchery manager claims that unreported outbreaks of this parasite with associated high mortalities have occurred in British Columbia over the past three years.

MICROSPOREA

Microsporidian - Work is continuing on identification of an intranuclear microsporidian infection in edible crabs (*Cancer pagurus*) from the English Channel, UK, reported for the first time in 2004. This is the first report of an intranuclear microsporidian in an invertebrate. A very similar pathogen has also been found in hermit crabs (*Eupagurus bernhardus*) from the Irish Sea, UK.

DIGENEA

Trematodes - Cercariae and metacercariae of trematodes were described for the first time in 2005 infecting gonads of the Baltic clam (*Macoma balthica*) (>13 mm shell length) from the Gulf of Gdansk (southern Baltic Sea), Poland. The metacercariae had characteristics typical of family Gymnophallidae, genus *Gymnophallus*. At 5 m depth, average prevalence was 6 % and both cercariae and metacercaria were observed. At 45 m, prevalence was 12 % and only metacercariae were found. Infected gonads appeared highly degenerated with a reduced number of eggs when viewed microscopically.

Other Diseases

Toxic algae - The *Karenia mikimotoi* blooms along the north, south, and west coast of Ireland killed large numbers of wild cockles, mussels and clams during the summer of 2005.

Neoplasms – No new trends in disseminated neoplasia were reported in Baltic clams (*M. balthica)* populations inhabiting the Gulf of Gdansk, Poland. The disease remains present with prevalence between 10 % (shallow sites) and 26 % (deep sites) in the cold months. In one sample of 50 clams, 11 were diagnosed with neoplasia. Based on electron microscopy of these individuals, two types of neoplastic cells were described in 46 % of clams, which also had advanced neoplasia: round cells and spindle-shaped cells, both with increased frequencies of cell division. This represents the first description of phenotypically different neoplastic cells in the same individuals, suggesting a co-occurrence of disseminated neoplasia with what might be a fibrosarcoma. No new trends were reported in the USA or in Canada.

Shell disease – A 10-year database on shell disease in American lobsters (*Homarus americanus*) from Rhode Island, USA, showed an increase from 0 % (reported) in 1996 to 25-30 % in 2002-2005. Prevalences in gravid females ranged from 45 % to greater than 60 %, with no apparent trend between 1998 and 2005, whereas prevalences in non-gravid females and males steadily increased from less than 5 % in 1997 to approximately 20 % in 2005. Tag and recapture studies showed that the mean growth increment per molt of all lobsters with signs of shell disease was significantly less than that for lobsters without disease signs (7.08 mm vs. 7.79 mm, respectively). Preliminary tag and recapture data suggest a greater proportion of shell-diseased females molt prematurely than non-diseased females (4.8 % vs. 0.3 %, respectively). Although these data indicate an effect on the diseased lobsters, the impact on lobster populations due to shell disease is uncertain due to the many other factors affecting population fluctuations. The cause of shell disease remains under investigation.

Summer Mortality – A farm site in the River Camel, Cornwall (SW England) continues to experience occasional late summer mortality in adult (2-3 year old) Pacific oysters (*Crassostrea gigas*) without the presence of histologically detectable pathogens. It is thought that these mortalities may be due to excessive stocking densities. In France, summer mortalities continued with no change recorded. In the USA, summer mortalities continue in seed oysters in Tomales Bay, California, where oyster herpes virus is likely involved. Mortalities were also reported in Washington State.

Parasite-associated mortality - Unusually heavy mortality, of up to 70 % in some beds, was reported in cockles (*Cardium edule*) in Milford Haven, South Wales, UK, in 2004. Most individuals were infested by low numbers of digeneans or gregarines, which were not considered significant at the time. Monthly samples have been collected from August 2004 to the present to document seasonal dynamics of the parasites found and to discern any patterns that may indicate an effect of parasitism on host survivability. Two sites with similar habitats were selected: one experiencing ongoing population declines and another less impacted by mortalities. To date, a total of 10 parasites have been identified in the two sites, including *Trichodina* sp., Rickettsia-like organisms, gregarines, ciliates and six digeneans.

Two digeneans caused marked pathology in the host. In samples examined immediately after a second mortality event in 2005, the prevalence of these two digeneans decreased compared with other parasites. Additionally, whilst they were found at both sites, they were more prevalent in the affected site. It is suggested that these digeneans may play a role in the observed mortalities. Studies are on-going to determine the link between cockle survival, environmental factors and parasitism.

Gill disease signs - In September 2005, high mortalities of wild introduced Pacific oysters were noted along the coast of Lower Saxony, Germany. Macroscopically, affected oysters were characterised by shell gaping, green discolorations on the gills and the mantle as well as a thickening and brown stripes on the gills. Histopathological signs were necrosis of the gills, infiltration of haemocytes (also in the gonads), the presence of large eosinophilic inclusion bodies in the oocytes, changes in the morphology of the oocyte nuclei (e.g. condensed ring-shaped basophilic material, possibly either condensed chromatin or 'foreign' DNA). A viral etiology is suspected.

Shell anomalies – brown shrimp (*Crangon crangon*) collected at the inlet and outlet of a power plant located in the Weser estuary, Germany, were affected by white, crystal-like spots in the carapace, the composition and causes of which have so far not been identified. There seems to be a seasonal effect with elevated prevalence in late summer.

Black Spot Disease - No new trends have been reported in brown shrimp from monitoring in the German Wadden Sea.

Disease signs in Icelandic scallops – Signs of a previously unreported disease were observed in Icelandic scallops (*Chlamys islandica*) from the Svyatoy Nos area in the Barents Sea, Russia. It affects mature scallops with shell height exceeding 70 mm. Signs include soft body atrophy, a dull grey adductor muscle colour, a thin transparent mantle, change in colour of the gonad from orange to grey, light necrotic "spots" in internal organs, shell edge deformation and growth interruption marks on the inner surface of the shell. The affected scallops develop focal necrosis and dystrophy of conjunctive and muscular tissue. A histopathological investigation showed that 40 % of examined scallops had severe necrotic changes in mantle, adductor muscle and gonads. An association of the disease with mortality has not yet been determined.

Miscellaneous

The states of Maryland and Virginia, bordering Chesapeake Bay in the USA, have again delayed a decision on the introduction of the Asian oyster (*Crassostrea ariakensis*) into the Bay because numerous studies of its potential effect, including its extreme susceptibility to *Bonamia* sp., have not been completed.

In a 2003 study, *M. edulis* from offshore areas in Germany (moored suspended buoys and collectors) were free of parasitic trematodes and shell-boring polychaetes. Parasitic copepoda (*Mytilicola intestinalis*) were recorded at only one out of seven offshore sampling sites. In contrast, mussels from coastal inshore areas (moored on suspended buoys and collectors, and benthic subtidal and intertidal mussel beds) were infested by three parasite groups: (copepoda: *M. intestinalis*; trematodes: *Renicola roscovita*, *Himasthla continua*, *H. elongata*, *Psilostomum brevicole*; polychaetes: *Polydora ciliata*).

Source of the information

The 2006 report of the ICES Working Group on Pathology and Diseases of Marine Organisms (WGPDMO) and ACME deliberations

1.7 General overview of trends in the Northeast Atlantic

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 1.7.1). 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 $0^{o}C$), 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).

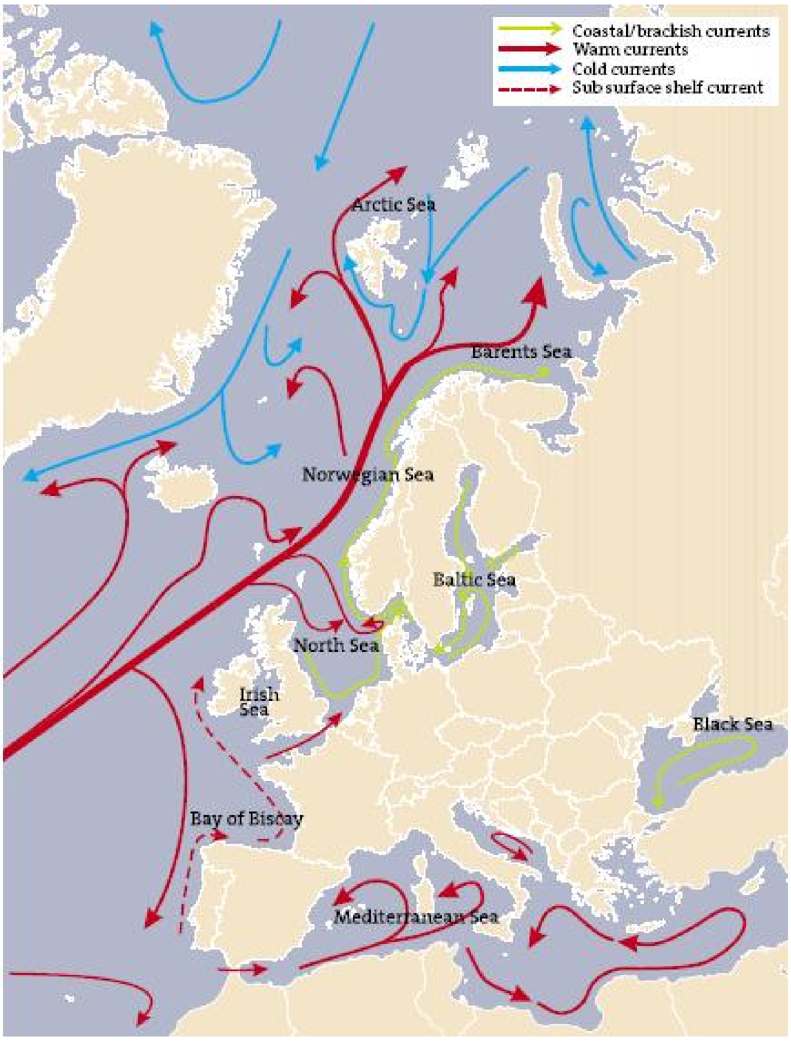

Figure 1.7.1 Water current systems in the Northeast Atlantic.

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.

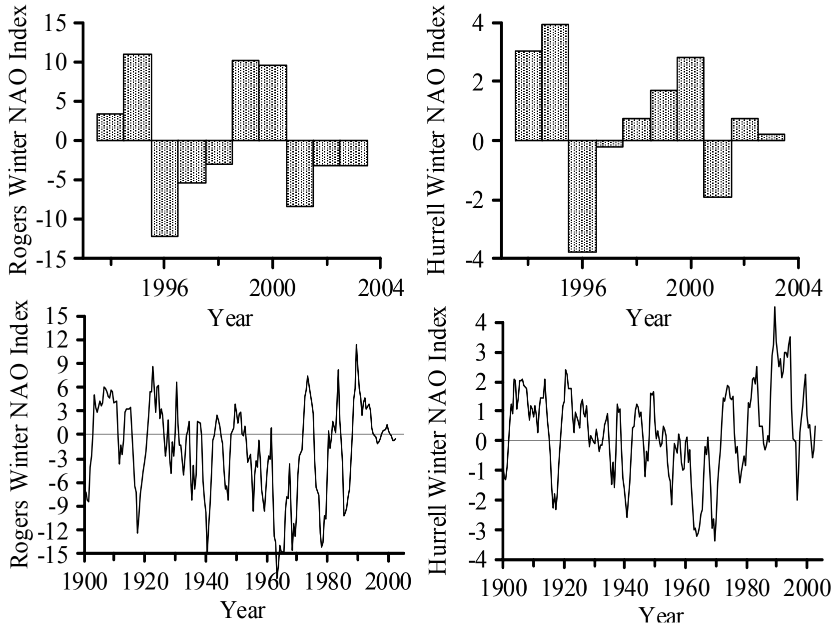

Figure 1.7.2 **T**he winter NAO index for the last decade (top) and century (bottom). The Rogers Index (left) and the Hurrell Index (right).

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 in recent years, temperature and salinity in the upper layers remained higher than the long-term average, with new records set in several regions. 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).

1.8 Acronyms and terminology

Term / acronym	Description
B_{lim}	Limit reference point for spawning stock biomass (SSB)
B_{pa}	Precautionary reference point for spawning stock biomass (SSB)
B_{MSY}	SSB that is associated with MSY.
$B_{trigger}$	Value of spawning stock biomass (SSB) which triggers a specific management action
Catchability	The fraction of a fish stock which is caught by a defined unit of the fishing effort
CPUE	The quantity of fish caught (in number or in weight) with one standard unit of fishing effort; e.g. number of fish taken per 1000 hooks per day or weight of fish taken per hour of trawling. CPUE is often considered an index of fish biomass (or abundance). Sometimes referred to as catch rate.
Discards	Are those components of a fish stock thrown back after capture e.g. because they are below the minimum landing size or because quota have been exhausted for that species. Most of the discarded fish will not to survive.
Ecosystem approach	Ecosystem approach to fisheries management. Management that takes into account the effects of fisheries on the ecosystem and the effects of the ecosystem on the fish stocks.
Exploitation boundary	Threshold on exploitation (catch, mortality, effort) that is consistent with a management strategy or international agreement (e.g. exploitation boundary consistent with precautionary approach)
Exploitation pattern	Distribution of fishing mortality over the age composition of the fish population, determined by the type of fishing gear, area and seasonal distribution of fishing, and the growth and migration of the fish.
F_{pa}	Precautionary reference point for fishing mortality (mean over defined age range)
F_{lim}	Limit reference point for fishing mortality (mean over defined age range)
F_{target}	Target fishing mortality in a management plan or management strategy
F_{msy}	Fishing mortality consistent with achieving Maximum Sustainable Yield (MSY)
$F_{0.1}$	The fishing mortality rate at which the marginal yield-per-recruit (i.e. the increase in yield-per-recruit in weight for an increase in one unit of fishing mortality) is only 10 percent of the marginal yield-per-recruit on the unexploited stock. The fishing mortality rate at which the slope of the yield-per-recruit curve is only one-tenth the slope of the curve at its origin.
F_{med}	Fishing mortality rate F corresponding to a SSB/R equal to the inverse of the 50th percentile of the observed R/SSB.
F_{max}	Fishing mortality rate that maximizes equilibrium yield per recruit. F_{max} is the F level often used to define growth overfishing.
F_{sq}	F status quo

Term / acronym	Description
Fecundity	In general, the potential reproductive capacity of an organism or population expressed in the number of eggs (or offspring) produced during each reproductive cycle. Fecundity usually increases with age.
Fishery	Group of vessel voyages targeting the same (assemblage of) species and/or stocks, using similar gear, during the same period of the year and within the same area (e.g. the Dutch flatfish-directed beam trawl fishery in the North Sea). See also: fleet, metier.
Fishing mortality (F)	Instantaneous Rate of Fishing Mortality. When fishing and natural mortality act concurrently, F is equal to the instantaneous total mortality rate (Z), multiplied by the ratio of fishing deaths to all deaths. Expressed on an exponential scale: F=0.5 means that 1-EXP(-0.5)=39% are removed.
Fleet	A physical group of vessels sharing similar characteristics in terms of technical features and/or major activity (e.g. the Dutch beam trawler fleet < 300 hp). See also: fishery, metier.
Harvest Control Rule	(HCR) An algorithm for pre-agreed management actions as a function of variables related to the status of the stock. For example, a control rule can specify how F or yield should vary as a function of spawning biomass. Also known as ‘decision rules’ or ‘harvest control laws’.
Harvest rate	(= harvest ratio) Ratio between landings and total stock abundance (e.g. as estimated from TV surveys for Nephrops).
High-grading	The discarding of a portion of a vessel’s legal catch that could have been sold in order to retain a higher or larger grade of fish that will bring higher prices. It may occur in quota and non-quota fisheries.
ICA	Integrated Catch Analysis; Stock assessment method
Management plan	A management plan includes the decision-making processes (harvest control rules, tactical decision making) and the sanctions on implementation and the requirements for monitoring and reporting. Management plans may also exist in the form of rebuilding plans or recovery plans.
Management strategy	Management strategies consist of objectives with associated performance criteria, the implementation measures (e.g. input or output control) and what is considered a relevant knowledge base for decisions.
Metiér	Homogeneous sub-division of a fishery by fleet (e.g. the Dutch flatfish-directed beam trawl fishery by vessels < 300 hp in the North Sea). See also: fishery, fleet.

		TRIP ID (gear, area, mesh size (target species))	
		Fishery 1	Fishery 2
VESSEL ID (homeport, size, type)	Fleet A	Métier p	Métier q
	Fleet B	Métier r	Métier s

Term / acronym	Description
MSY	Maximum Sustainable Yield. The largest average catch or yield that can continuously be taken from a stock under existing environmental conditions.
Population	A group of fish of one species which shares common ecological and genetic features. The stocks defined for the purposes of stock assessment and management do not necessarily coincide with self-contained populations.
Surplus production model	Mathematical representation of the way a stock of fish responds to the removal of its individuals. Usually a relationship between yield and/or CPUE, and fishing effort or mortality. Expressed in biomass.
Recruitment	The amount of fish added to the exploitable stock each year due to growth and/or migration into the fishing area. For example, the number of fish that grow to become vulnerable to the fishing gear in one year would be the recruitment to the fishable stock that year. This term mostly used in referring to the number of fish from a year class reaching a certain age. For example, all fish reaching their first year are age 1 recruits.
Reduced reproductive capacity	When SSB is at a level where the stock reproduction is impaired as evident from historical observations.
SSB	Spawning stock biomass. Total weight of all sexually mature fish in the stock.
Spawner per recruit	Spawning Stock Biomass per Recruit (SSB/R): expected lifetime contribution to the spawning stock biomass for a recruit of a specific age (e.g., per age 2 individual). For a given exploitation pattern, rate of growth, and natural mortality, an expected equilibrium value of SSB/R can be calculated for each level of fishing mortality.
SMS	Stochastic Multispecies Model; Stock assessment method.
Stock	A part of a fish population usually with a particular migration pattern, specific spawning grounds, and subject to a distinct fishery. In theory, a Unit Stock comprises all the individuals of fish in an area, which are part of the same reproductive process. It is self-contained, with no emigration or immigration of individuals from or to the stock. On practical grounds, a fraction of the unit stock is considered a 'stock' for management purposes (or a management unit), as long as the results of the assessments and management remain close enough to what they would be on the unit stock.
SURBA	SURvey Based Assessment. Uses only relative abundance indicator(s)
Sustainable	Can be sustained. In the light of the ICES interpretation of precautionary approach: fisheries management that keeps stock(s) above B_{pa} and fishing mortality below F_{pa}
VPA	Virtual Population Analysis. An algorithm for computing historical fishing mortality rates and stock sizes by age, based on data on catches, natural mortality, and certain assumptions about mortality for the last year and last age group. A VPA essentially reconstructs the history of each cohort, assuming that the observed catches are known without error (Powers & Restrepo, 1992). VPA is often used as a generic description of an age-based stock assessment but this is not necessarily true because many stock assessments are based on different (statistical) assumptions.
XSA	Extended Survivors Analysis; Stock assessment method.
Year class	All the fish of a stock spawned or hatched in a given year.

Term / acronym	Description
Yield per recruit	The expected lifetime yield per fish recruited in the stock at a specific age. Depends on the exploitation pattern (fishing mortality at age) or fishing regime (effort, size at first capture) and natural mortality.

The terms in this glossary are taken and adapted from a number of sources:

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Powers J.E., and V.R. Restrepo. 1992. Additional options for age-sequenced analysis. ICCAT SCRS/91/040.

1.9 Maps

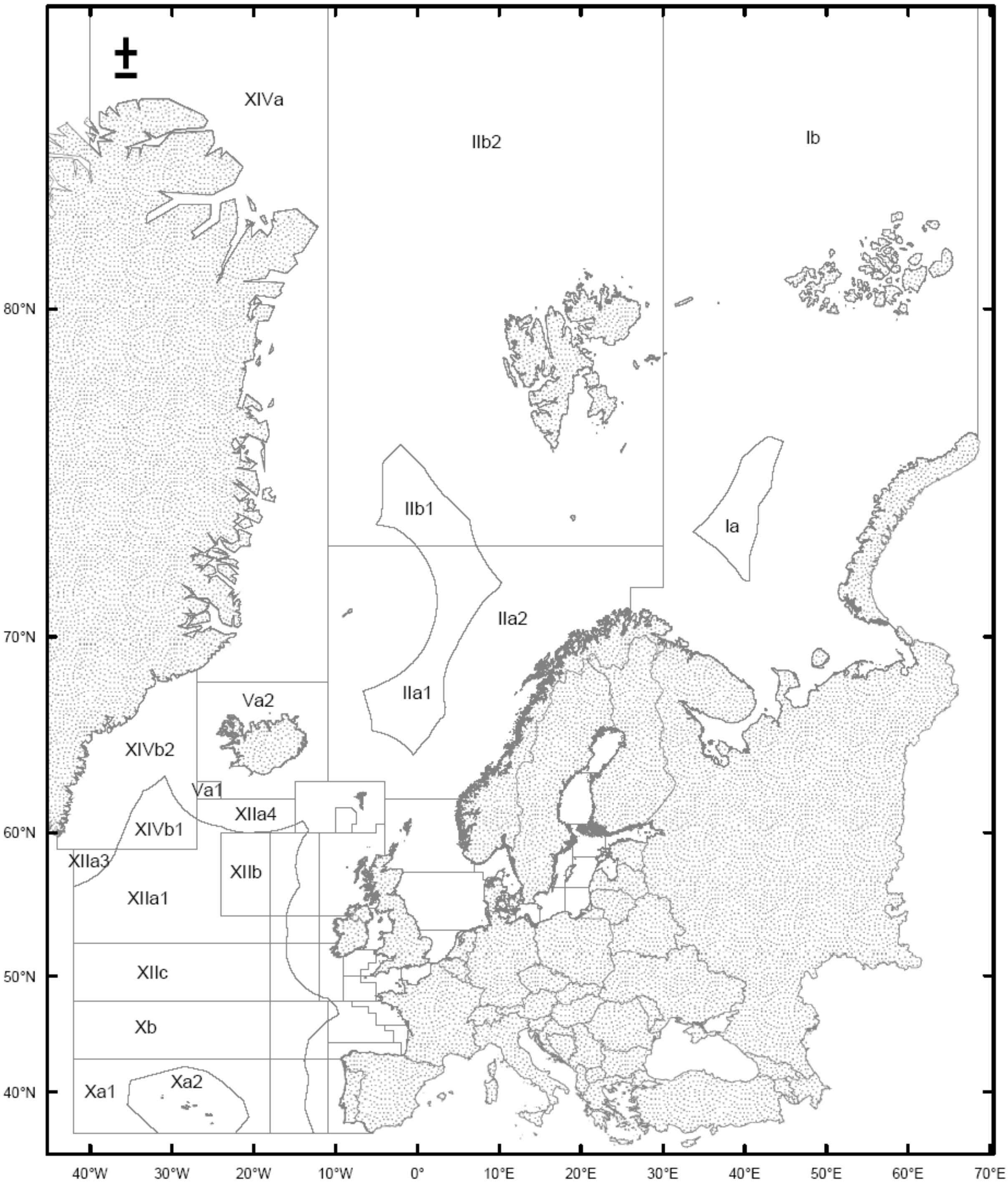

Figure 1.9.1 ICES Areas in the Northeast Atlantic

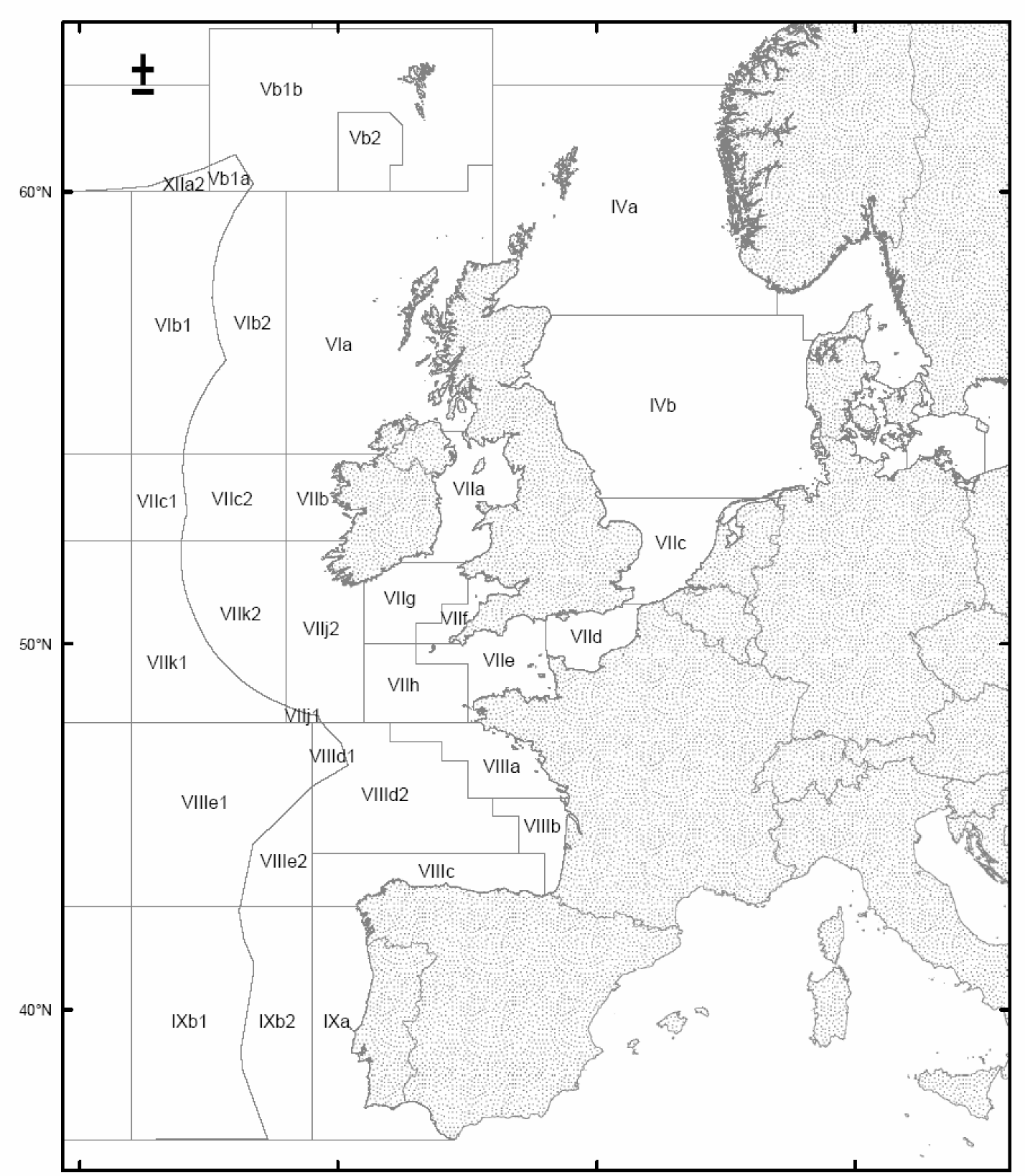

Figure 1.9.2 ICES Areas in the Northeast Atlantic (detail)

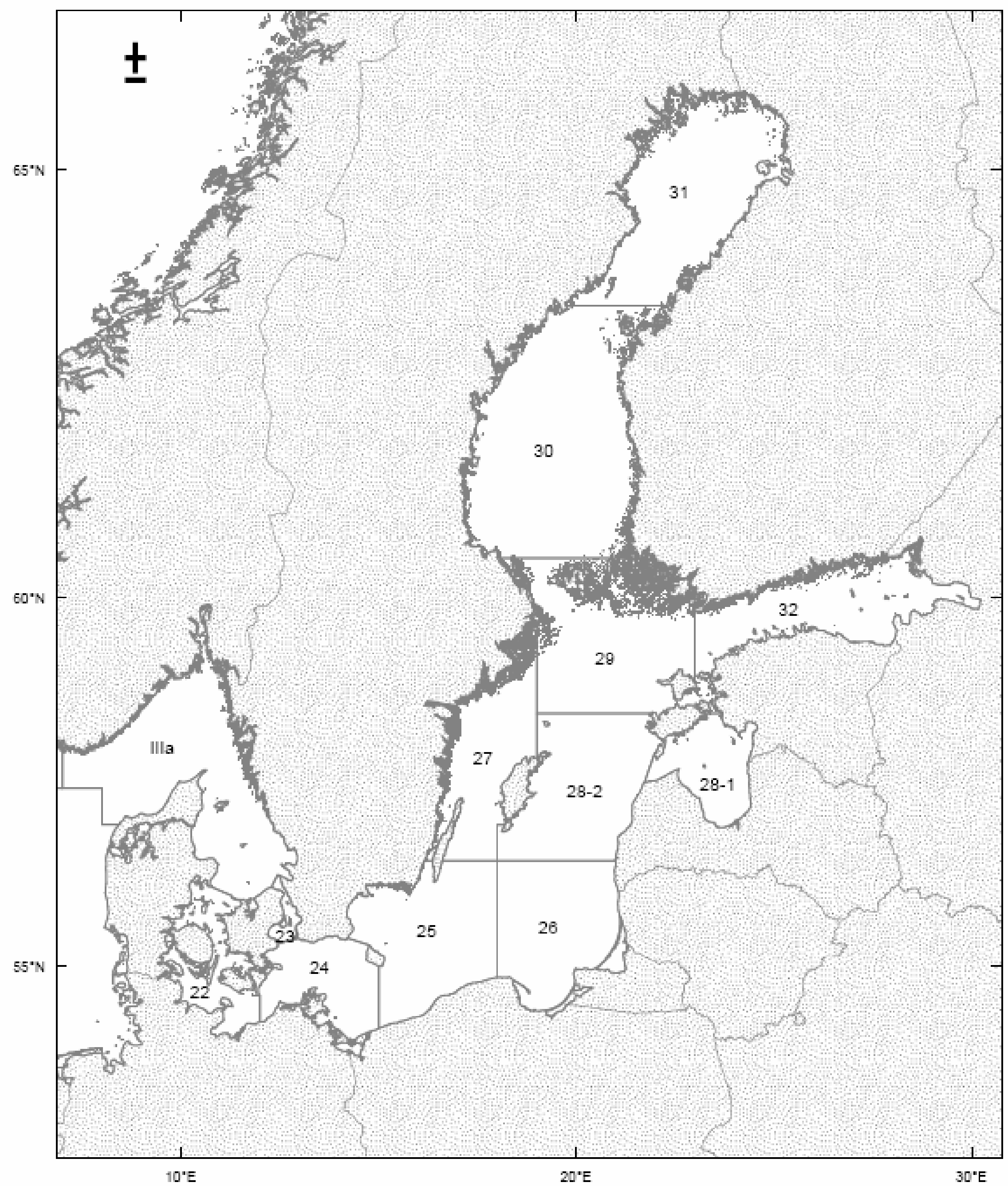

Figure 1.9.3 ICES areas in the Baltic.

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