ICES ADVICE

AVIS DU CIEM

Volume 1, Number 1

Report of the ICES Advisory Committee on Fishery Management and Advisory Committee on Ecosystems, 2004

International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

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Report of the ICES Advisory Committee on Fishery Management and
Advisory Committee on Ecosystems, 2004

Volume 1, Number 2
December 2004

Recommended format for purposes of citation:
ICES. 2004. Report of the ICES Advisory Committee on Fishery Management and
Advisory Committee on Ecosystems, 2004. ICES Advice. Volume 1, Number 2. 1544 pp.

TABLE OF CONTENTS

BOOK 1

Section **Page**

Part 1

Section	**Page**

BOOK 1

Section **Page**

Part 2

BOOK 2

Section **Page**

Part 1

Section **Page**

Book - Part 2

Book 2 - Part 3

Section **Page**

Book 2 - Part 4

Preface

This report contains the advice given by ICES to Clients regarding marine management issues in 2005. The report is produced by two advisory committees, both providing advice on behalf of the Council: the Advisory Committee on Fishery Management (ACFM) that has the prime responsibility for providing advice on fisheries management and the Advisory Committee on Ecosystems (ACE) that has the prime responsibility for providing advice on ecosystems. A third advisory committee, the Advisory Committee on the Marine Environment provides advice on human impacts on the marine environment, e.g. effects of contaminants; in 2004 this advice is published as a separate report in the new "ICES Advisory Report" Series. The integration of the advice produced by ACFM and ACE from 2004 is a result of the introduction of the Ecosystem Approach.

Both ACE and ACFM consist of one designated scientist from each of the ICES member countries and have 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 meets once every year.

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.

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

Also, this report is the first in a new publication series "ICES Advice". This new series is introduced to assist readers to find the relevant sections without having knowledge of the ICES structure and of how the tasks are allocated to each of the three advisory committees. The need for such an integrated report series was emphasised by the introduction of integrated advice under the Ecosystem Approach.

Structure of the report

The introduction of the new report format means that advice will no longer appear as the reports of three distinct advisory committees but instead as a set of books. From 2004 the report will be published in two books, each comprising one or more parts.

Book 1: This book explains the conceptual and institutional framework for the assessments and advice. It contains a general introduction to the ICES advice, responses to special requests and regional advice in the form of ecosystem overviews. The advice in the ecosystem overviews is the operational conclusions based on the stock assessments which are presented in Book 2. Book 1 targets clients and stakeholders in the decision-making process.

Book 2: This book contains a review of fish stocks and populations for which ICES provides advice. Book 2 is the documentary background for Book 1.

For fisheries all stocks belonging to a given area are placed in the area, together with an overview of the ecosystem, the state of the stocks and fisheries in that area. The report on North Atlantic Salmon to the North Atlantic Salmon Conservation Organization is found in Chapters 2.1.5 and in 4.12. The fisheries advice was restructured in the 2003 report to reflect the need to address 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. The basis for that advice as analysed from a single-stock perspective is provided in stock summaries in Section 4 as part of the documentary background material in Book 2.

Advice is given for the following areas:

- The Barents Sea (ICES Subarea I+ parts of Subarea II)
- Waters around Iceland (Division Va+ parts of Subareas XII and XIV)
- Waters around the Faroe Islands (Division Vb)
- Division IIIa (Skagerrak), Subarea IV (the North Sea), and Division VIId (Eastern Channel)
- Subarea VI (West of Scotland)
- Division VIIa (the Irish Sea), West of Ireland (Divisions VIIb,c), in the Celtic Sea and Southwest of Ireland (Divisions VIIf,g,h,j,k), Western Channel (Division VIIe), and northern parts of the Bay of Biscay (Divisions VIIIa,b,d,e)
- Division VIIc and Subareas IX and X (the Iberian Region)
- The Baltic Sea (Subdivisions 22-32)
- Deep-water south of 62ºN

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

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

There are separates chapter on elasmobranchs (chapter 4.11) and on North Atlantic Salmon (chapter 4.12).

Requests for services and advice January 2004–December 2004

The tables below are compilations of formal requests for services from ICES clients and the report contains responses to these requests. In addition to these requests ICES provides advice in accordance with MoUs between ICES and Client Commissions which may contain agreements on recurring advice. MoUs containing agreements on recurring advice beyond what is listed below are in 2004 relevant for the EC and NEAFC. Responses to the recurring advice requirements in these MoUs are provided in Section 3.

Table 1 List of non-recurrent requests

CUSTOMER	REQUEST	DATE	RESPONSE
EC			
DG Env	Contribute to the European Marine Strategy	September 2003	October 2004
DG Fish	Ecosystem Impacts of Industrial Fishing	15.12.04 (in addition to request from July 2002)	June 2004
NEAFC	Consider new information regarding Deep-sea fisheries and vulnerable deep-sea habitats	17.11.03	May 2004
IBSFC	Areas where the hydrological conditions allow for a successful Cod spawning in 2003	07.10.03	15.04.04
	Estimate of smolt production potential in wild Salmon rivers		15.06.04
	Factors that are important for smolt survival in the Gulf of Finland		
	Mortality generated on Gulf of Finland Salmon in fisheries taking place in the Main Basin		
	Evaluation of the Management Plan for the Cod stocks		
	Evaluation of the selective properties of trawls using 90° turned diamond meshes		
	Appropriateness of the mesh sizes allowed in the Herring trawl fisheries		
	Hook parameters in long line fisheries		
	Information on landings, discards and fishing mortality rates by fisheries		
OSPAR	Scientific Advice:	07.07.03	
	Support the development of EcoQo's		June 2004
	Identification of suitable biological effects monitoring techniques for CEMP, and integration of biological effects measurements with chemical monitoring		Partly June 2004. The remaining in 2005.
	Quality assurance of biological measurements in the North East Atlantic		June 2004
	Data handling:		
	Assistance in the JAMP assessment of temporal trends in contaminants in sediment and biota		November 2004
HELCOM	Include the Baltic Sea in a marine habitat classification and mapping	June 2003	2005
	Improve monitoring programme for estimation of the abundance of seal and other marine mammals		Advice given in 2003. No new advice in 2004

Table 2 List of fast track requests

CUSTOMER	REQUEST	DATE	RESPONSE
EC			
DG Fish	Compile status list of EU Fish stocks		Early February 2004
	Compile information on Rockall haddock	01.10.03	01.02.04
	Herring in Kattegat/Skagerrak - Confusion of advice with respect to autumn-spawning and spring-spawning herring	17.02.04	May 2004
	- Consequences of allowing part of the TAC to be fished in the North Sea	13.02.04	May 2004
	Request concerning Haddock in ICES Division VIIb-k and VIIa	09.07.04	20.08.04
	Influence of sonar on marine mammals and fish	25.09.03	End of year 2004
DG Env	Advice about eco-regions	27.08.04	End of year 2004
NEAFC	Review *Sebastes mentella* stock structure and modify assessment accordingly	17.11.03	October 2004
IBSFC	Review of Eastern Baltic Cod catch prognosis for 2004	07.10.03	01.02.04
MEMBER STATES			
Iceland	Provide separate advice for each app. *Sebastes mentella* components in its distribution area	26.01.04	October 2004
UK	Request for advice on Sole VIIe management	15.06.04	20.08.04
	Review the ICES advice for 2004 and 2005 for VIa and VIIa *Nephrops*	13.08.04	07.10.04
Norway	Outline likely effects of possible protective measures with regards to the sandeel stock in the North Sea	07.07.04	October 2004
Netherlands	Request for advice for North Sea plaice management	30.08.04	October 2004

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J. Nørrevang-Jensen	ICES Environment Data Scientist
H. Sparholt	ICES Fishery Assessment Scientist

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1 ICES ADVICE

1.1 Introduction

Marine management should take an integrative view and include ecosystem considerations, i.e. use an "Ecosystem Approach". ICES is implementing an Ecosystem Approach in its advisory work. This is in response to several political declarations calling for such an approach, e.g. Reykjavik 2001, Bergen 2002, and the World Summit on Sustainable Development, Johannesburg, 2003. Ecosystem considerations have been included in ICES advice in the past both as a response to requests for advice regarding ecosystems and more specifically in relation to fisheries. For example in response to requests from environmental and fisheries commissions the need to maintain a food base for predators has been the basis for advice regarding capelin and sandeel.

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

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

At the 13th ICES Dialogue Meeting (26–27 April 2004) it was discussed how ICES plans to introduce an ecosystem approach. The implementation will include stakeholder interaction and will be incremental. Beginning in 2004 ICES has introduced mechanisms on an experimental basis, allowing stakeholders to provide inputs to the assessments and to get better insight into the advisory process. The results will be evaluated in 2005 and ICES will introduce appropriate adjustments to the proposal for stakeholder involvement, taking the role of the EU Regional Advisory Councils into account. The plan accepts that our understanding of the functioning of the ecosystems is confined to certain ecosystem components and that this will remain so in the foreseeable future, although our understanding of the systems improves. 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.

1.2 New Report Format

The ICES advice will change in several aspects; these changes will require integration between the outputs of present advisory committees and will require reorganisation of the advice on an area/ecosystem basis. The objectives are:

- Provide advice on the basis of an ecosystem approach:
    - Distinguish between 1) fisheries advice in an ecosystem context and 2) advice regarding other marine-related human activities in an ecosystem context;
    - The development of the "form of advice" with fully integrated ecosystem considerations is a longer-term process;
    - The first step in this process is to present the ICES fisheries advice in an ecosystem context, i.e. to advise on an area basis and to integrate information on the ecosystem and the fisheries, including ecosystem impacts of fisheries;
    - Ecosystem advice beyond fisheries aspects should be integrated in the same ecosystem-structured format, to the extent possible;
    - In 2004 the ACE and ACFM reports are partly integrated, organised on an ecosystem (area) basis with stock summaries and background text on ecosystem and environmental issues as explanatory text in annexes;
    - In 2005 the integration of the ACE and ACFM reports will continue, and the ACME report will start to become integrated in the same format.

- For fisheries advice, transformation of the traditional stock-based advice to fisheries-based advice requires:

- That the mixed fisheries issue be dealt with, i.e. starting from the human impact (fisheries) – to the catch brought on deck (a mixture of species) – to the impact on the individual stocks;
- Fisheries are confined to an area, seldom to a stock; therefore the reform requires a reorganisation of the advice on an area basis. This reorganisation of the ACFM advice was initiated in 2003 and the committee has continued this development in 2004 by:
  - Integrating all stocks into the area advice,
  - Developing databases to underpin the fisheries/area approach,
  - Developing fisheries forecast methods,
  - If possible, presenting fleet/fisheries forecasts.

- Fisheries advice should furthermore be revised to include long-term considerations of management targets relating to *inter alia* yield by:
  - Developing concepts for management targets;
  - Identifying targets for individual stocks;
  - Developing methods to evaluate Harvest Control Rules (HCR), recovery plans, etc.;
  - Developing an advisory framework where advice is long term with short-term implications;
  - The decision on targets is a matter of policy and therefore not to be taken by ICES in an advisory capacity. However, ICES will assist policy makers in the decision process by provision of information on the choices and their likely implications.

As a consequence of these changes the ICES advice will from 2004 appear in a new integrated format as described in the Preface above.

1.3 The Scientific Basis for Advice

1.3.1 Ecosystem approach

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

Management advice under an Ecosystem Approach is a multi-step procedure which includes identification of ecosystems, identification of the relevant ecosystem components, and linking human activities to impact on the ecosystems.

For the time being, ICES implementation considers primary effects on a number of ecosystem components; it is hoped that these will be those components where impacts are most profound. This differs from having an overall ecosystem model with a single all-encompassing ecosystem health function, a proposition that ICES presently does not consider to be practical. ICES stresses that the implementation is an evolving process; therefore, it is only for the time being that the approach is confined to the evaluation of the primary effects.

The extent of knowledge differs between regions and the extent to which ICES is able to implement an ecosystem approach therefore varies between regions.

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

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

1.3.2 Sector approach

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

1.3.3 Assessment of the quality status of ecosystems

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

1.4 The Form of ICES Advice

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

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

1.4.1 Fisheries advice

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

> Single-stock exploitation boundaries are identified first. These are the boundaries for the exploitation of the individual fish stock and are identified on the basis of its status, consistent with the Precautionary Approach and, if target reference points have been defined or management plans which are precautionary have been decided, in relation to targets or plans. The single-stock boundaries also include considerations of the ecosystem implications of the harvesting of that specific species in the ecosystem whenever such implications are known to exist. These single-stock exploitation limits are presented in the stock summaries in Section 4, and collected in a table for each area in Section 3. The single-stock boundaries would apply directly as advice in the absence of mixed fisheries issues and ecosystem concerns beyond the impact of fishing on that stock.
>
> Then mixed fisheries issues are addressed. For stocks harvested in mixed fisheries the single-stock exploitation boundaries will apply to all stocks taken together simultaneously. It is thus necessary to identify the major constraints within which mixed fisheries should operate and through this analysis identify the additional constraints that further limit the fishing possibilities. Such major constraints may be stocks in the stock assemblage which are outside precautionary limits and which therefore may become the limiting factor for all fisheries exploiting that stock. This implies that the stocks which are considered to be in the most critical state may determine the advice on those stocks which are taken together with critical stocks. The second step is therefore to identify which species within mixed fisheries have the most restrictive catch limits, because these constraints, when applied across all species in mixed fisheries, further limit the fishing possibilities. The single-stock exploitation limits are combined in relation to fisheries on an area basis in Section 3.
>
> The final consideration regards those ecosystem concerns which are not related to one specific stock, but rather to mixed fisheries or to groups of stocks. Such concerns may for instance include habitat and biota impacts of dragged gear, incidental bycatches of non-commercial species, and food chain effects when such impacts are known to occur. Ecosystem concerns may represent further boundaries to fisheries beyond those implied by single-stock concerns and mixed fisheries issues.

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

Single-stock upper boundaries on exploitation

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

Risk aversion, based on the precautionary approach, defines the boundaries of management decisions for sustainable fisheries.

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

Reference points for risk aversion

For risk aversion ICES advises within the following framework:

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

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

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

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

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

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

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

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

Target reference points

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

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

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

Language of fisheries advice

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

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

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

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

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

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

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

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

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

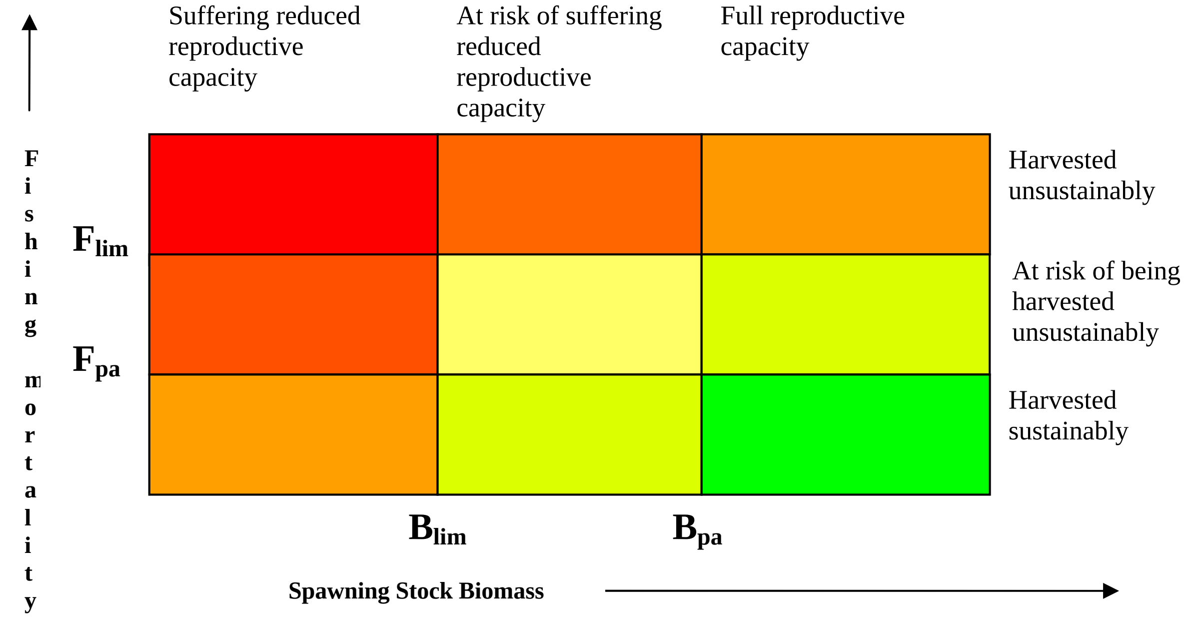
The two last categories were earlier referred to as "outside safe biological limits".

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

If $\mathbf{F<F_{pa}}$: "harvested sustainably."
If $\mathbf{F_{lim}} > \mathbf{F>F_{pa}}$: "at risk of being harvested unsustainably."
If $\mathbf{F>F_{lim}}$: "harvested unsustainably."

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

1.5 Reference Points for the Status of Fish Stocks



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

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

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

A new framework which includes target reference points relating to yield will be developed and introduced in cooperation with clients. By 2004 target reference points have only been identified for a few of the stocks for which management plans have been defined. An example is Norwegian spring-spawning herring where the target fishing mortality used in the management plan has been identified to produce an outcome which relates to both high long-term yield and maintenance of the reproductive capacity. When such management plans are consistent with the precautionary approach ICES provides advice relative to target reference points. For other stocks ICES only provides risk averse advice. Some clients have through recent MoUs, which include requests for recurring advice expressed interest in advice on “the level of catch consistent with taking high long-term yields and achieving a low risk of depleting the productive potential of the stock”. This implies that management plans which would lead to these outcomes would include parameters which could be seen as target reference points. If such management plans are of the same nature as those presently in force in the ICES area the fishing mortality used as target would be a target reference point. In the absence of such management plans ICES can identify candidates for target reference points expressed as fishing mortalities which in the longer term would be associated with high yields and a low risk of reduced reproductive potential.

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

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

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

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

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

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

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

1.7 Management Advice for Mixed Fisheries

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

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

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

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

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

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

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

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

1.7.1 The incorporation of ecosystem considerations

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

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

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

Present knowledge about ecosystem impacts is built on studies in specific ecosystems but may not represent the overall ecosystem and can only be extended to other ecosystems in a general way. Many important ecosystem considerations regarding the impacts of fisheries will therefore be of a general, not area-specific nature. Such general considerations are therefore not dealt with in the area sections in Section 3 but in the general advice in Section 2. As more specific knowledge is produced the advice on ecosystem impacts will move from the general to the area-specific sections.

1.8 Quality of Fishery Statistics

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

The assessments presented in this report are carried out using the best catch data available to ICES. These data are not necessarily identical with the official statistics but, where appropriate, include estimates of unreported landings as well as corrections for misallocation of catches by area and species. ICES seeks information on misreported or unreported landings through a range of sources, but there is no guarantee that all instances are discovered. Often the catch data used by ICES are collated on a stock rather than an area basis, and thus straightforward comparisons between these figures and the official statistics, which are provided on an area basis, are not appropriate. The catch data used in the assessments are given in the "summary table" found in Chapter 4 under each stock. In cases where there might be doubt, it has been indicated if discards, bycatches, and estimates of unreported landings are included in the assessments. Estimates of catches landed as bycatches, especially from the industrial fisheries, are included in the assessments wherever data allow it and are included in the catch options.

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

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

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

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

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

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

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

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

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

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

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

1.9 Information from the fishing industry

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

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

1.10 Environment Impact on Fish Stocks

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

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

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

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

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

Sources of information

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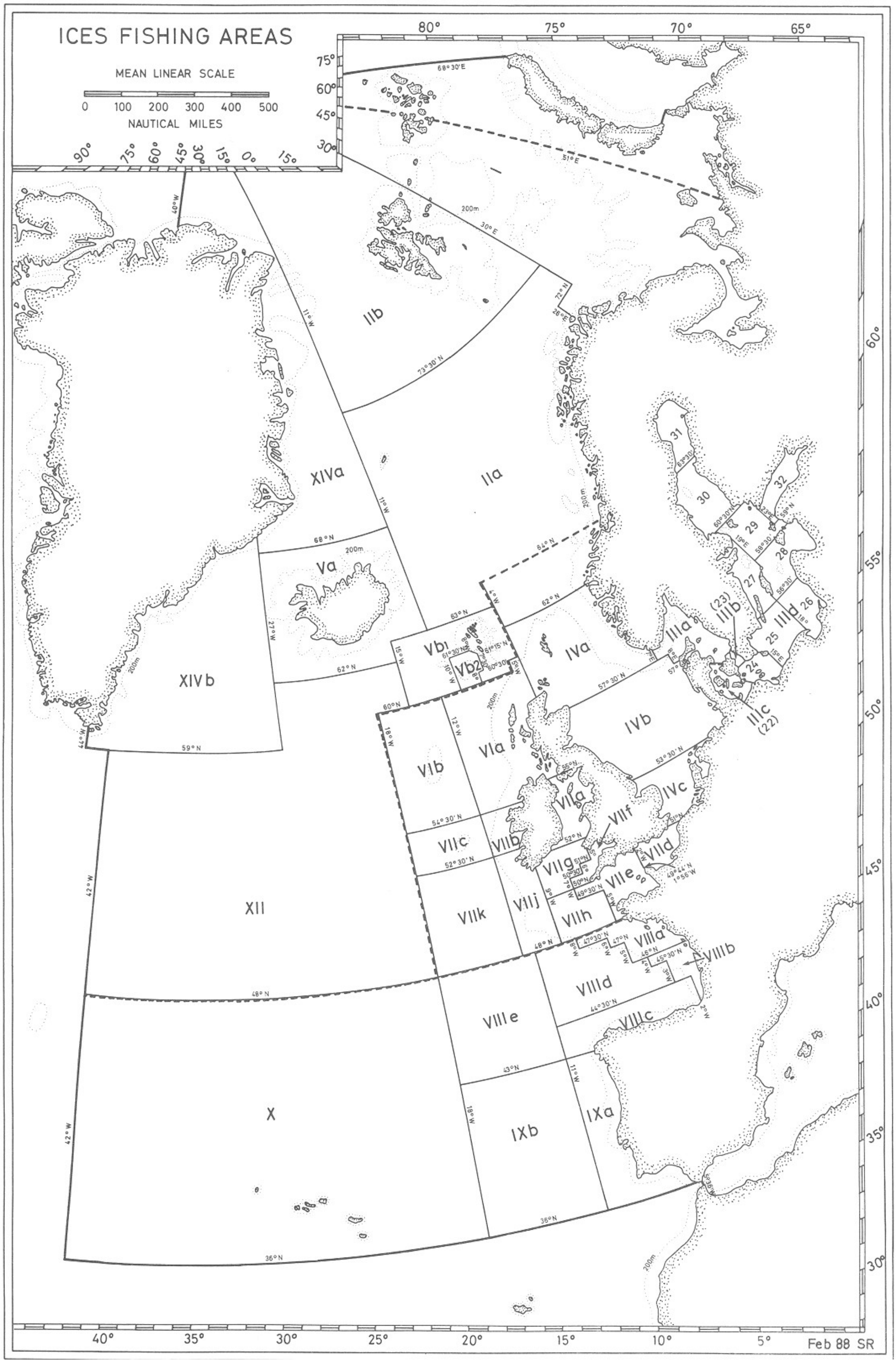
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2 General advice

2.1 Answers to Special Requests

2.1.1 EC DG Fish

2.1.1.1 Answer to special request on Rockall haddock

The following request was presented to ICES on 1 October 2003 on behalf of the European Community after consultation with Russia:

ICES is requested to review the outline Recovery Plan for Rockall Haddock in Appendix 1. ICES is especially requested to:

A. Review the targets, objectives and harvest rules in the recovery plan with respect to:

i) Principles of good conservation, management and exploitation of living aquatic resources, and the precautionary approach in particular; and

ii) Limitation of the environmental impact of fishing;

iii) Examine the consequences of a target annual survival of 38% of the spawning stock compared to the spawning stock which would survive in the absence of fishing. If required, recommend an alternative value consistent with (i) and (ii) above;

iv) Examine the consequences of a maximum annual adjustment in TAC of +/- 15%. If required, recommend an alternative value consistent with (i) and (ii) above;

v) ICES may if required, recommend an alternative value, consistent with precautionary criteria and good ecosystem practices, to long-term management of its own initiative.

B. Propose appropriate units for the measurement of effort, and any particular requirements for measuring such effort.

C. Review the closed area presently applicable for fishing Rockall Haddock and recommend any appropriate changes to improve the exploitation pattern.

D. Review the technical measures identified in the recovery plan, and develop recommendations appropriate to improving the exploitation pattern.

E. Review the report on the 'Expert Meeting on Rockall Haddock' of 10th April 2003.

F. ICES may also make any relevant comments concerning control and enforcement issues.

G. Propose the modified system of compiling of scientific and fishery data to obtain the most representative data for reliable assessment and development of advice on the management of the haddock fishery.

H. Assess discards of young haddock during the fishery for this and other fish species; and to work out advice on measures to reduce discards maximally in the future.

a: Review the targets, objectives and harvest rules in the recovery plan with respect to:

(i) Principles of good conservation, management and exploitation of living aquatic resources, and the precautionary approach in particular

The proposal sent by the European Commission to ICES for a Recovery Plan for Rockall Haddock is appended to this report (Appendix 1). The proposal states that the objectives of the Rockall Haddock Recovery Plan are to:

1. Secure the rapid recovery and long-term conservation of the stock to within safe biological limits as defined by ICES ($\mathbf{B}_{pa}$ and $\mathbf{F}_{pa}$), and,
2. Attainment of long-term sustainable yield in accordance with principles of the precautionary approach.

ICES considers that such objectives are consistent with the principles of good conservation, management and exploitation of living aquatic resources, and the precautionary approach. However, both objectives presume that biological limits such as $\mathbf{B}_{pa}$ and $\mathbf{F}_{pa}$, and targets such as long-term sustainable yield are defined for Rockall haddock. The proposal for a recovery plan for Rockall haddock was sent to ICES prior to ACFM in October 2003, where an analytical assessment of the stock was not adopted. ICES therefore does not have an accepted assessment to use as the basis for defining limits, targets, or for forecasting the stock status likely to result from instruments to manage the exploitation rate (as outlined in the Recovery Plan proposal, see also Section 0). ICES therefore has confined its comments on this ToR to a qualitative assessment of the likelihood that the proposed instruments to manage exploitation would actually control fishing mortality.

The principal instrument proposed to manage overall exploitation rate is a TAC. ICES considers that application of TACs implies that there is a simple relationship between a recorded landing of a species and the effort exerted on that species. TACs are therefore likely to be effective only if the fishery strictly adheres to them. Such assumptions are currently unlikely to be true for Rockall haddock. Furthermore, there are ways of evading TACs including mis-reporting, high grading and discarding. In the case of Rockall haddock these may occur to a large extent due to the remote nature of the fishery and the processing of catches at sea by some fleets. ICES therefore suggests that effort regulation be considered as a means of controlling fishing mortality on Rockall haddock. These points are re-iterated in Section 1. However ICES considers that TAC regulation could be used in the future provided that more objective and accurate biological and fishery information are routinely provided.

(ii) Limitation of the environmental impact of fishing

The EC has identified that the minimisation of the impact of fishing activities on marine ecosystems, and in particular non-target species and sensitive habitats, as a key management objective (COM 85/2002). ICES considered that the inclusion of such an objective in any recovery plan was appropriate and in accordance with the precautionary approach to fisheries management. The EC has identified three main management mechanisms to achieve this objective; output controls, input controls and technical measures. In order to evaluate which measures are most appropriate in the context of the Rockall haddock fishery it is firstly important to consider the fishery, the ecosystem, and the potential risks to non-target species and the wider ecosystem.

Fishery distributions and gears of each country

The development of the Rockall haddock fishery is documented in the 2001 Northern Shelf Working Group report, and in the report of an ICES experts meeting on Rockall haddock convened in January 2001. Subsequent developments have been described in more recent Northern Shelf Working Group reports.

The EU vessels targeting haddock at Rockall are mainly composed of Scottish trawlers, light trawlers, seiners, and Irish otter trawlers. The codend mesh size used by these vessels has generally increased from 90 mm in the mid-1990s to 100 mm or greater. Prior to 1999 the Scottish and Ireland fisheries had been principally summer fisheries concentrated on the bank at depths at or around 200 m. In more recent years the Scottish and Irish fishery was conducted throughout the year with the peak landings in April-May. This shift in the fishery appears to have followed the discovery of concentrations of haddock in deeper water to the west of Rockall, at depths between 200 m and 400 m. High catch rates attracted effort into that deeper water area.

Russian vessels fishing the Rockall area are considerably larger than the EU vessels and include trawlers of the 10th class of tonnage (84 m, 2000 hp) and trawlers of the 9th class of tonnage (62 m, 2400 hp). Fishing by Russian vessels has been conducted from time to time in spring targeting haddock, and in summer in the south-western part of the bank at depths of 200-300 m. The highest haddock catches were taken in April-July. In subsequent months the haddock proportion in catches decreased substantially and in some periods there was almost no haddock. The catch rate and total catch have tended to increase during recent years. The codend mesh sizes used by Russian vessels are smaller than those used by EU vessels. The Russian haddock fishery uses bottom trawls with codend mesh sizes between 40 and 100 mm (mainly 60-70 mm).

Direct impacts of fishing on the benthic ecosystem

There is limited information on the benthic environment and potentially sensitive habitats found around the Rockall bank. There are thought to be large areas of the Rockall bank where cold water coral reefs (*Lophelia* Spp.) are know to occur and these are thought to be particularly vulnerable to physical damage by fishing operations. The broad distribution of these coral reefs from fishermen's information (Hall-Spencer, pers. comm.) has recently been mapped and presented in the SGCOR report (ICES (2003); see Figure 1). SGCOR has identified that a survey of this area is a research priority. As part of any management plan at Rockall ICES would recommend that a key objective would be to protect these sensitive deepwater corals. To do this effectively further mapping distribution and an assessment of the potential impact of fishing activity on these coral reefs is required. Data from the Irish national sea bed mapping project may be useful in the identification of potential coral habitat on the southern part of the Rockall Bank, but this survey does not cover the whole bank.

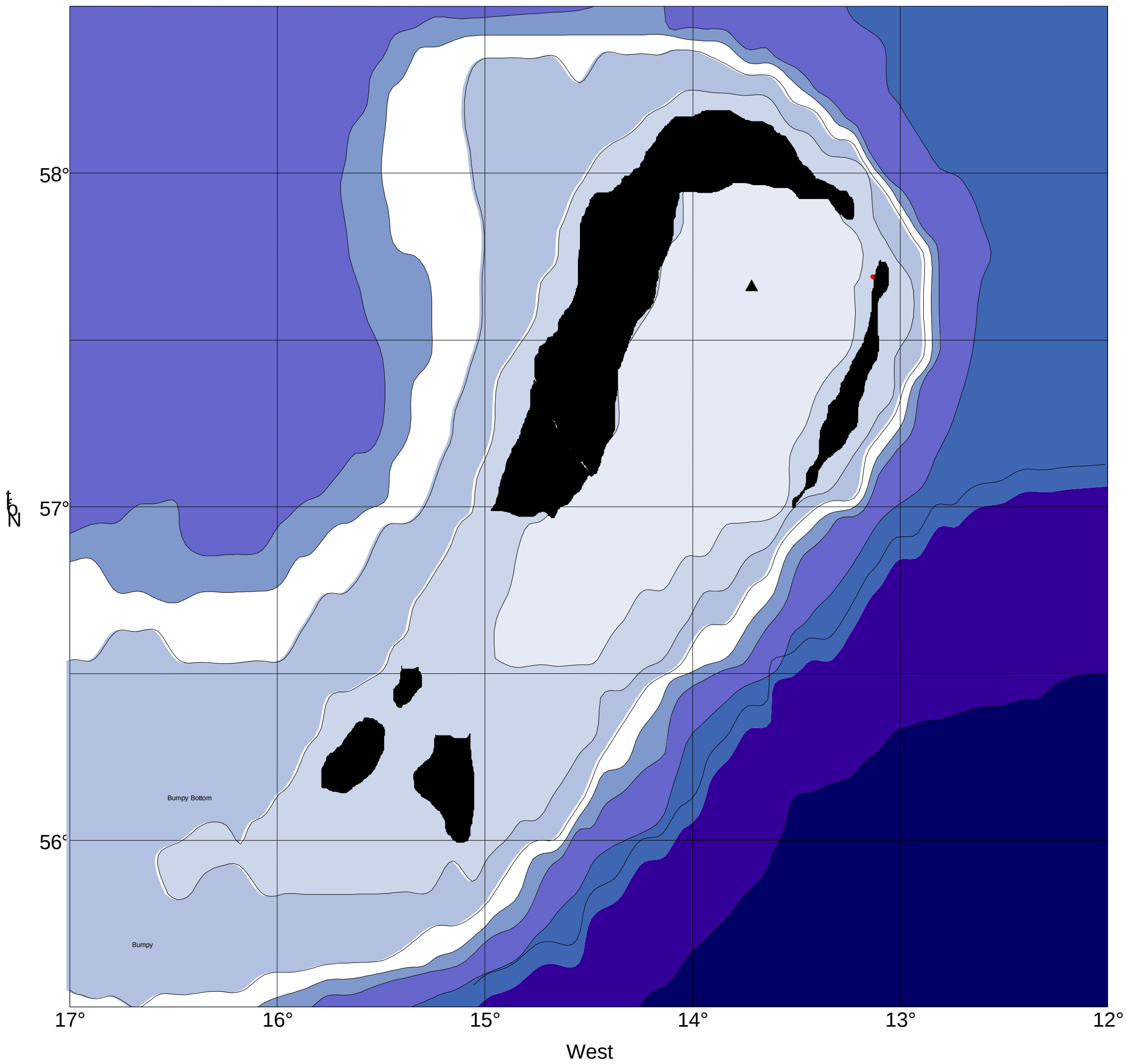

Figure 1 The distribution of coral reefs on Rockall Bank from fishermen’s records (J. Hall-Spencer, pers. comm.). The grey areas indicate presence of *Lophelia* reefs. Reproduced from: Report of the Study Group on Cold-Water Corals (May 2003), ICES CM 2003/ACE:02.

ICES notes that the existing closed areas provide no protection to coral reefs (see Section 0), and that there is an overlap between coral areas and areas of known fishing activity (see fishery distribution plots in ICES (2001)). If management agencies want to use a closed area as the main management tool then such an area should preferably be placed so that it also protects coral reefs.

Catch Composition by Gears and Country

To assess the potential impact of the haddock fishery on other non-target species ICES considered data on the catch composition. Unfortunately such an assessment was difficult, as limited data on the catch compositions by fleet were available to ICES. Furthermore, there is limited information on the abundance of other species on the bank and limited information on the mortality rates caused by commercial fisheries on non-target species. Some information on the volumes of the main species caught during observer trips is presented below by country.

Russian Federation

Russian vessels resumed fishing on the Rockall bank in 1999, at which time the main species exploited were blue whiting and grey gurnard. The proportion of haddock in the total catch was low (3-7%) (Table 1). The total Russian catch in this area for 1999-2003 made up about 218,000 tonnes. There were limited observations for catch composition and discards. However, the available fishery statistics are considered to reflect the real situation in the area owing to the almost complete absence of discards from Russian vessels.

Concentrations of grey gurnard on the Rockall Bank were first found in 1999. In 2000, the target demersal fishery for grey gurnard was started in July and lasted until December. It is worth noting that during the period that grey gurnard were targeted there was little haddock bycatch. In 2001, the total catch of grey gurnard decreased substantially. In 2002 and 2003 grey gurnard were found only as a bycatch (Table 1).

The main part of blue whiting catch (94-98%) in the Rockall area is taken by mid-water trawls at depths more than 250 m. However, large numbers of this species are also caught by bottom trawls, and in some periods this species is the main target for fishing (Table 1). Most important bycatch species were redfishes, argentine, flounders, and saithe (Table 1).

Table 1 Preliminary data on catch composition of Russian vessels (all gears) on Rockall (Division VIb) in 1999-2003. Weights in tonnes.

	1999		2000		2001		2002		2003	
Species	**Landed weight**	**%**	**Landed weight**	**%**	**Landed weight**	**%**	**Landed weight**	**%**	**Landed weight**	**%**
Blue whiting	9465	74.6%	33749	51.8%	37193	86.3%	32748	94.2%	57407	92.3%
Grey gurnard	2426	19.1%	26082	40.1%	3155	7.3%	60	0.17%	263	0.42%
Haddock	**458**	**3.6%**	**2154**	**3.3%**	**630**	**1.5%**	**1746**	**5.0%**	**4239**	**6.8%**
Other species	89	0.70%	2482	3.8%	1900	4.4%	117	0.34%	10	0.02%
Redfishes	243	1.9%	461	0.71%	88	0.20%	19	0.05%	93	0.15%
Argentine			29	0.04%	68	0.16%	29	0.08%	120	0.19%
Flounder			88	0.14%	4	0.01%	34	0.10%	53	0.09%
Saithe	3	0.02%	25	0.04%	1	0.002%	1	0.003%	6	0.01%
Ling			8	0.01%	2	0.00%	11	0.03%	14	0.02%
Cod			7	0.01%	26	0.06%				
Roughnose grenadier			8	0.01%	3	0.01%			3	0.005%
Tusk			1	0.002%	6	0.01%	1	0.003%	1	0.002%
Blue ling			3	0.005%	1	0.002%	3	0.01%	1	0.002%
Greater forkbeard			2	0.003%	4	0.01%	1	0.003%	1	0.002%
Smoothhead									5	0.01%
Black scabbard					2	0.005%				
Total	**12684**		**65099**		**43083**		**34770**		**62216**	

Scotland

Landings compositions for 2000–2002 from the Scottish fishery in ICES Division VIb indicate that there are substantial landings of fish other than haddock, and that haddock only comprise around a quarter (or less) of fish landed by weight (Table 2). These data refer not only to the directed Scottish haddock fishery, but also to occasional pelagic fisheries (for blue whiting in 2000, for example), and to deep-water fisheries which would not necessarily fish in the shallower waters on Rockall bank where haddock are found. There may also be a problem of mis-reporting by area and species, but the extent to which this has occurred is not clear. For these reasons, it is difficult to use these data to discuss issues of bycatch (and hence impact on the biotic environment) in the Scottish fishery at Rockall.

Table 2 Officially-reported landings (metric tons, nominal live weight) of all species landed from ICES Division VIb (Rockall) by UK vessels into Scotland in 2000-2002. Source: FRS Marine Laboratory, Aberdeen.

Year	Species	Landed weight (tonnes)	
2000	Blue whiting	8126	52.77%
	Haddock	**2471**	**16.05%**
	Blue ling	965	6.27%
	Witches	540	3.51%
	Ling	443	2.87%
	Other	2853	18.53%
	Total	15398	
2001	Blue ling	1803	26.79%
	Haddock	**1205**	**17.90%**
	Witches	671	9.97%
	Roundnose Grenadier	399	5.93%
	Anglerfish	365	5.43%
	Other	2289	34.00%
	Total	6732	
2002	**Haddock**	**1145**	**26.49%**
	Witches	666	15.41%
	Blue ling	482	11.16%
	Black Scabbardfish	300	6.94%
	Roundnose Grenadier	288	6.67%
	Other	1441	33.34%
	Total	4323	

Discard data from Scottish vessels are sparse, due to the expense of observer trips to Rockall and the relative unimportance (historically) of the Rockall fishery. Table 3 and Table 4 summarise the available information from Scottish discard trips between 1985 and 2001. The percentage of haddock in the landings from these trips is relatively high (between 31% and 96%), indicating that the vessels concerned were directing effort towards haddock on the Bank itself. The species composition of discards shows that most discarded fish were haddock, with only small amounts of other species (principally blue whiting, poor cod, Norway haddock, and grey gurnard). These discard data suggest that the Scottish Rockall haddock fishery is relatively clean, although sample sizes are very low and may not be representative: only six Scottish discard trips have ever been undertaken (two in 1985, one in 1999, three in 2001; (Newton *et al*., 2003)), and it would be unwise to over-interpret the results.

Table 3 Details of Scottish discard trips in the Rockall area. Source: Newton *et al.* (2003).

Trip no.	Date	Gear	No. of hauls	Hours fished	% (weight) haddock landed of catch	% (weight) discarded of haddock
1	May 85	Heavy Trawl	20	89.08	74	17.3
2	Jun 85	Heavy Trawl	28	127.17	74	18.6
3	Jun 99	Heavy Trawl	21	110.83	41	74.9
4	Apr 01	Heavy Trawl	11	47.33	96	12.4
5	Jun 01	Heavy Trawl	35	163.58	58	47.5
6	Aug 01	Heavy Trawl	26	130.08	31	69.7

Table 4 Species composition of discards (numbers) from FRS discard sampling programme, 1985-2001. Source: Newton *et al.* (2003).

Code	Species	Trip						Total	
		May 85	Jun 85	Jun 99	Apr 01	Jun 01	Aug 01		
HAD	Haddock	39424	88580	128108	31273	158292	37416	483093	72.72%
BWH	Blue whiting	21251	1160	8402	1218	4216	97	36344	5.47%
PCO	Poor Cod	14273	14333	264	0	1797	51	30718	4.62%
NHA	Norway Haddock	777	798	15262	114	11666	1043	29660	4.47%
GGU	Grey Gurnard	442	1373	5217	114	10506	5358	23010	3.46%
BLM	Blue-mouth	0	18	3771	2448	11540	1258	19035	2.87%
MEG	Megrim	261	847	5288	89	5137	4446	16068	2.42%
LSO	Lemon sole	1538	2030	1042	95	6401	2167	13273	2.00%
LAR	Lesser Argentine	0	2977	814	40	1535	137	5503	0.83%
ANG	Anglerfish	0	93	0	6	1420	1070	2589	0.39%
LRD	Long Rough Dab	0	0	228	404	472	80	1184	0.18%
WHI	Whiting	0	0	644	0	32	0	676	0.10%
CAT	Catfish	0	22	536	11	35	45	649	0.10%
GAR	Greater Argentine	55	0	177	11	360	40	643	0.10%
DRA	Dragonet	22	0	137	0	98	43	300	0.05%
LIN	Ling	56	92	0	0	68	7	223	0.03%
MLA	Softhead Rat tail	0	0	0	194	0	0	194	0.03%
RSA	Raitt’s Sandeel	0	0	0	0	166	0	166	0.02%
FME	Four-spot Megrim	0	0	0	157	0	0	157	0.02%
HMA	Horse Mackerel	0	3	100	0	26	0	129	0.02%
COD	Cod	0	5	0	0	93	0	98	0.01%
WIT	Witch	0	0	0	86	0	4	90	0.01%
TOR	Torsk	22	0	0	22	32	0	76	0.01%
TBR	Three-bearded Rockling	0	0	0	0	53	0	53	0.01%
SRA	Shagreen Ray	0	0	22	0	19	0	41	0.01%
MAC	Mackerel	0	0	40	0	0	0	40	0.01%
RGU	Red Gurnard	38	0	0	0	1	0	39	0.01%
VBE	Velvet Belly	0	0	0	38	0	0	38	0.01%
TRA	Thornback Ray	0	0	11	0	18	6	35	0.01%
GFO	Greater Forkbeard	0	0	0	6	20	6	32	0.00%
SSA	Smooth Sandeel	0	0	0	0	23	4	27	0.00%
SAI	Saithe	0	0	0	0	19	5	24	0.00%
BMD	Black Mouthed Dogfish	0	0	0	22	0	0	22	0.00%
NTO	Norwegian Topknot	0	0	0	0	12	0	12	0.00%
BLI	Blue Ling	0	0	0	11	0	0	11	0.00%
SDR	Spotted Dragonet	0	0	0	0	0	7	7	0.00%
SPO	Silvery Pout	0	0	0	6	0	0	6	0.00%
CHI	Rabbit Ratfish	0	0	0	6	0	0	6	0.00%
SAL	Salmon	0	0	0	0	3	0	3	0.00%
							Total:	664274	

Ireland

Data collected on several discard observer trips to Rockall indicate that the Irish fishery for haddock is relatively clean, with haddock comprising 69% of the sampled catches (Table 5). Discarding rates for most other commercial species are relatively low. Where discarding rates are high the species concerned comprise a minor component of the catch.

Table 5 Landings and Discards estimates at Rockall from discard observer trips conducted aboard Irish vessels between 1995 and 2001, and from an observer trip aboard the MFV *Grove* (February/March 2000). Catches from the *Grove* are estimated in kg from the number of 40kg fish boxes. The miscellaneous species discarded on the *Grove* trip included Grey gurnard, Blue whiting, Blue mouth, *Sebastes* Spp., Witch, Lemon sole, Skates, *Todarodes sagittatus*, Long rough dab, Sea cucumbers, Sea-stars, Argentines and damaged megrim. Miscellaneous species discarded on discard observer trips included Poor cod, Long rough dab, Plaice, Dab, Dragonet, Norway pout, Sandeel, Whiting, Rabbit-fish and Bib. Discard rates are calculated from discard observer trips only for all species except haddock.

	FAT/KBG/00/4		*FAT/KBG/01/2*		*FAT/KBG/93/5*	*FAT/KBG/95/1*		*FAT/KBG/95/2*		*FAT/KBG/97/7*		*FAT/KBG/97/8*		*FAT/KBG/98/4*		*Grove* Feb 2000		Discard	% of Total
Species	Landings	Discards	Landings	Discards	Landings	Landings	Discards	Landings	Discards	Landings	Discards	Landings	Discards	Landings	Discards	Landings	Discards	rate	Catch
Haddock	3021	1864	942	926	19710	12727	1146	6893	1893	14258	6625	25866	17926	23805	3687	4400	6200	27%	69%
Saithe			897	39	8.0			94		2650				2690		21080		1%	13%
Megrim	1344	80	362	38	541	210	1.0	1470	289	882	2.5	504	7.4	2184	1.2	1840		5%	4.5%
Angler	1485	24	538	10	330	358	5.5	2816	281	973		666	81	512	7.8	480		5%	3.9%
Cod	283		142		59	991	2.8	802		425	7.2	1274		1558		1000		0.2%	3.0%
Pollack								1180										0.0%	0.5%
Hake			1030															0.0%	0.5%
Torsk	181	6.3	136		27			135.6		45	4.2	90		45				2%	0.3%
Catfish		3.1	47		36			94	6.6	142	5.5	94				80		4%	0.2%
Skate/Ray	92	33		125	34			138	130				1482		13	40		87%	1.0%
Witch			294	1.0			1.9		2.0		0.4		0.8					2%	0.1%
Ling		2.4	90	47		45						45				40		22%	0.1%
John Dory			180															0.0%	0.1%
Halibut					179													0.0%	0.1%
Mackerel			120	739							5.7		9.6					86%	0.4%
Squid			40					80	0.01									0.0%	0.1%
Forkbeard			45															0.0%	0.02%
Grey gurnard		170		26			60		667		510		263		187			100%	0.9%
Scad				840					71		36		82		12			100%	0.5%
Red gurnard		183		508									18		4.1			100%	0.3%
Dogfish				643														100%	0.3%
Norway haddock							17		44		99		154		129			100%	0.2%
Argentine		72		0.2			1.4		39		68		20		63			100%	0.1%
Blue-mouth		5.2		4.7							107		43		11			100%	0.1%
Lemon sole		83					8.4		26		7.8		3.3		6.1			100%	0.1%
Redfish		84		6.0														100%	0.04%
Blue whiting		16					1.4		0.2		16		11		9.8			100%	0.02%
Spurdog				43														100%	0.02%
Misc. species		22.3		19.9			7.1		13.5		13.7		2.4		5.0		1370		0.7%

Conclusions about the nature of bycatch in the Rockall haddock fishery are strongly dependent on the source of data used. The landings data have reasonable sample sizes, but are compromised by the lack of regular discard sampling and (possibly) by mis-reporting. The mismatch in relative importance of some species (such as ling and blue ling) in the landings data compared to the discard data may indicate a problem of species mis-reporting in the landings. However, the Scottish landings data available to ICES were for ICES Division VIb and not dis-aggregated by region or fleet. They therefore include Scottish catches from separate deep-water fisheries operating in Division VIb.

Data from discard observer trips suggest that the fishery is much more selective for haddock. However, the discard data have an extremely small sample size, and may not be representative. The environmental impact of any bycatch is therefore difficult to quantify, and cannot be discounted without further data collection and analysis.

If vulnerable species are caught in this fishery the precautionary approach would imply that there is a requirement for those exploiting the fishery to prove that the bycatch mortality is sustainable for those species. As part of a proposed management plan for Rockall fisheries by catch limitations could be put in place to minimise the impact of the fishery on non-target species. ICES would advise that such a management measure would only be effective if enforced through full observer coverage. However, without improved information on the catch compositions ICES is unable to recommend specific bycatch limits.

(iii) Examine the consequences of a target annual survival of 38% of the spawning stock compared to the spawning stock which would survive in the absence of fishing. If required, recommend an alternative value consistent with (i) and (ii) above

(iv) Examine the consequences of a maximum annual adjustment in TAC of +/- 15%. If required, recommend an alternative value consistent with (i) and (ii) above

ICES was unable to produce an analytical assessment for Rockall haddock due to concerns about a) the lack of Russian catch-at-age data, b) problems caused by a very low Scottish sample size for a specific year and age, and c) significant discrepancies between estimated mean weights-at-age from Scottish and Irish sampling.

Due to the lack of an accepted assessment, ICES was unable to present definitive forecasts as requested in A: iii) and iv).

(v) ICES may if required, recommend an alternative value, consistent with precautionary criteria and good ecosystem practices, to long-term management of its own initiative

The lack of alternative assessment approaches precludes ICES from identifying potential alternative limits to exploitation that may be useful to long-term management.

b: Propose appropriate units for the measurement of effort, and any particular requirements for measuring such effort

The Rockall fishery is undertaken by vessels of vastly different capacities. In order to accommodate the differences in the fishing power of vessels participating in the fishery ICES considers it essential that effort is measured in standardised power-corrected fishing units. ICES considers that any method of power correction will require information on the entry, exit, time spent fishing, and principal vessel characteristics for demersal fishing activity in the Rockall fishery (the recording of which is suggested in the proposed Recovery Plan).

With regard to particular requirements for measuring fishing effort the distance of the Rockall fishery from ports makes monitoring and measuring effective effort very difficult. ICES therefore considers that measuring effort will require improvements to the remote Vessel Monitoring System, and strict entry & exit conditions. These issues are discussed further under Section 0.

c: Review the closed area presently applicable for fishing Rockall Haddock and recommend any appropriate changes to improve the exploitation pattern

Introduction to the evaluation of the Rockall Haddock closed area

The definition of "juvenile" in this context depends upon knowledge of the maturity ogive for the stock. The ICES WGNSDS has historically assumed that all age 1 and age 2 haddock are juveniles and all age 3 and older haddock are mature. In 2002, combined-sex maturity ogives were presented to ICES from Russian sampling in 2000 and 2001, and from Scottish sampling in 2002. New sex-disaggregated maturity data were supplied in 2003 based on Russian sampling (Table 4.2.4.1 in WGNSDS 2003 Report). The results for 2000-2002 indicate almost full maturity at age 2 and length 25 cm. However, since proportion mature in fish stocks is known to vary inter-annually as well as spatially, ICES decided that a more appropriate approach to addressing the NEAFC request was to examine distribution of fish below and above a fixed length at which most fish are likely to be mature in most years and areas. A length of 30 cm was chosen for this purpose. This also has the advantage of reflecting distribution of fish relative to the EU minimum legal landing size of 30 cm for haddock. For some surveys the data were available by age only, and distribution is given for age 1-2 and 3+ age groups.

Current and suggested locations of the closed area

In May 2001, the International Waters element of statistical rectangle 42D5, which is mainly at depths less than 200 m, was closed to all trawling activities. In Spring 2002, the EU component of this rectangle, again mostly shallow water, was also closed to trawling activities. These areas are shown in Figure 2.

At the Expert Meeting on Rockall Haddock on 10th April 2003 (Informal report by the European Commission circulated to WG members), new boundaries for the closed areas were suggested. These included statistical rectangles 42D5 (as before), 41D4 and sections of 42D4 at depths less than 400 m and sections of 41D5 at depths less than 300 m (Figure 2). These new boundaries were suggested to protect juvenile haddock, as the European fishing industry reported that they had noticed an increase in small fish to the south and west of the box.

The Russian Working Document 2 (Vinnichenko *et al*. 2003b) reports that the international bycatch of juveniles is insignificant within 42D5 at depths greater than 200 m. The authors therefore suggest altering the boundaries of these areas to include depths less than 200 m where the main concentrations of juveniles are found. The suggested boundary is based on the Scottish 1999 survey data and is shown in Figure **2**. The Scottish survey data for 1997, 2001 and 2002 also show a distribution of younger fish at depths less than 200 m (Figure 3 and Figure 5).

Spatial distribution of the fishery

Information on the haddock stock and fishery at Rockall was studied in detail at the ICES Expert Meeting on Rockall Haddock in Aberdeen in January 2001 (ICES 2001). Whilst partial information exists for the Irish fishery and Russian fishery (Section 4.2.1.3 of WG Report and Vinnichenko *et al.* (2003a), respectively), no complete information on the spatial distribution of the fishery was provided. ICES is therefore not able to update the evaluation of the ICES meeting.

Spatial distribution of haddock by size class

Several surveys have been conducted in and around the Rockall bank: the Scottish biennial survey in September 1997, 1999 and 2001, a Scottish survey of a reduced area of the Bank in September 2002, a Marine Laboratory Aberdeen partnership charter in Spring 2001, and a Russian survey in August/September 2000 (ICES 2001). The Scottish Autumn surveys mainly cover waters of the Rockall Bank at depths less than 200 m. The Scottish Spring survey covered waters of the Rockall bank at depths less than 400 m. The Russian survey covered international waters at depths less than 400 m to the south west of the bank.

The spatial distributions of the catch rates of these surveys for each haul are shown in Figure 3 to Figure 7 for haddock below and at or above 30 cm in length or for 3 age groups. Since the results are reported in different ways, absolute catch rates are not directly comparable between surveys, however, the broad spatial patterns can be compared.

In the Scottish Autumn surveys (depths less than 200 m) catch rates of haddock < 30 cm are generally high, although relative spatial distributions of catch rates vary from year to year. In the Scottish Spring survey (depths less than 400 m), catch rates of young haddock (ages 1 and 2) were high at depths less than 200 m, and young haddock were also found at deeper depths, with age 1 haddock found to the east and age 2 haddock to the southwest. In the Russian surveys (international waters), the highest catch rates of haddock < 30 cm long were in waters less than 200 m deep, and relatively small quantities of such fish were found to the southwest of the bank, mainly in statistical rectangle 41D4. Relatively small quantities of haddock < 30 cm were also found by the Russian survey in the southwest of statistical rectangle 42D4, northwest of statistical rectangle 42D5, and southwest of statistical rectangle 43D5 (Figure 6).

In the Scottish Autumn surveys (depths less than 200 m) catch rates of haddock ≥ 30 cm are generally high, with higher catch rates along the western edge of the bank. In the Scottish Spring survey (depths less than 400 m), catch rates of mature haddock (ages 3+) were high to the southwest of the bank at depths between 200-400 m, and also in the central part of the bank at depths less than 200 m. In the Russian surveys (international waters), high catch rates of haddock ≥ 30 cm were mainly concentrated in statistical rectangles 41D4 and 42D5.

The survey data is patchy, and no survey covers the whole area under consideration. Much of the area to the southwest of Rockall Bank, under consideration for closure by the Expert meeting, has only been surveyed twice, during the Russian survey and the Scottish Spring survey. It is therefore difficult to draw conclusions about the spatial distribution of the stock over this area.

Location of limits of the closed area

During the Russian survey, catch-rates of young haddock were much lower in the deeper waters of the areas surveyed than in the shallower waters of the Bank. If these data are representative of the distribution of younger fish, then closing areas at depths less than 200 m would protect the main proportion of the juvenile stock.

The Scottish and Russian research data suggest that haddock ≥ 30 cm or 3 years of age and older, are to be found at all depths less than 400 m. If these data are representative of the distribution of mature fish, then closing areas at depths less than 400 m would protect the whole stock.

Effect of closed area

No new assessment could be conducted due to deficiencies in the data (see Section 1).

Evaluation of the benefits of an area closure is difficult and it is necessary to know that there is effective compliance with the closed area regulations, and that the closed area continues to encompass a sufficient proportion of the population of young fish. It is then necessary to establish that the selection pattern of the fishery has improved, or the overall fishing mortality has been reduced, and that improved survival of young fish has occurred as a result. Hence the following data are required:

- The spatial distribution of actual fishing effort (through VMS);
- Adequate series of survey data covering the bulk of the distribution range of haddock, to provide information on spatial distribution as well as tuning data for the assessment;
- Accurate data on age-length composition of both landings and discards to allow the most accurate possible estimates of fishing mortality on each age class.

Until such data are available, ICES is unlikely to be able to advise on the effectiveness of the existing or proposed extensions to closed areas.

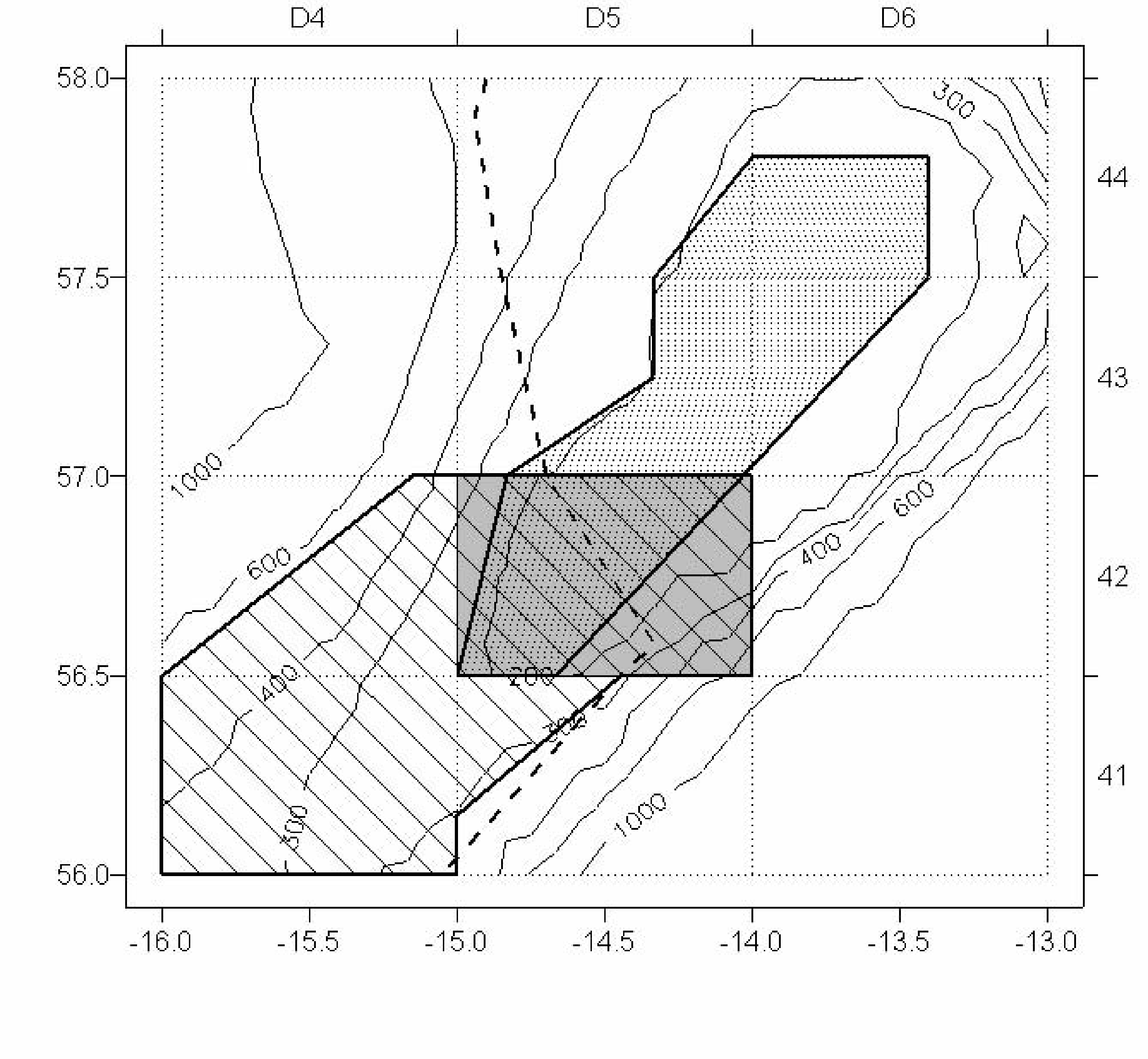

Figure 2 The current and suggested locations of the closed area to protect Rockall haddock. The boundary between EU and International Waters is marked as the short dashed line. The current location of the closed area is statistical rectangle 42D5, shaded in grey. The original location of the closed area was the international water of 42D5. The closed area suggested by WD2 is shaded with dots, and the closed area suggested by the Expert Meeting (April 2003) on Rockall haddock is shaded with diagonal lines.

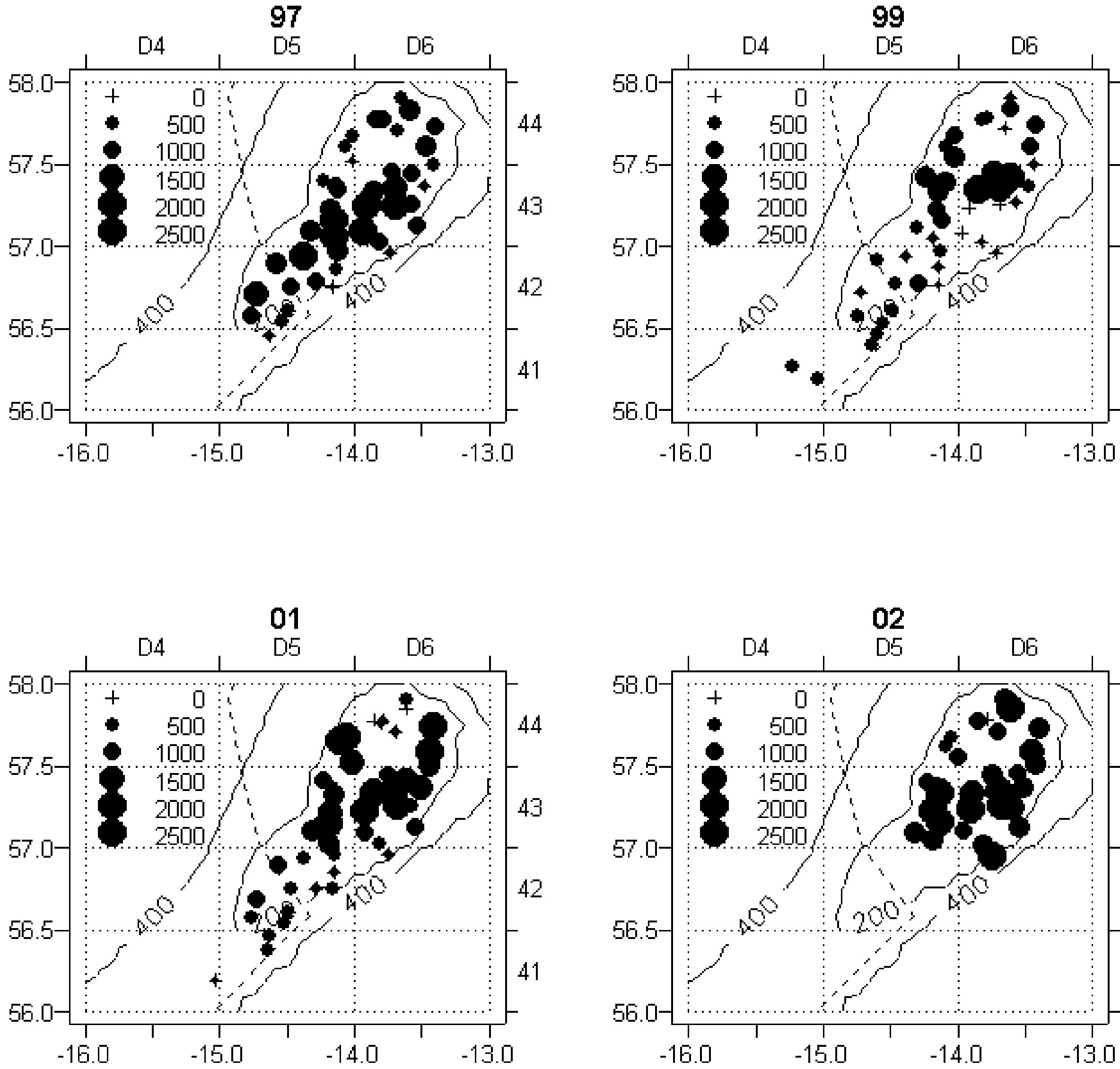

Figure 3 Catch rates (numbers per half-hour tow) of haddock < 30 cm during the biennial Scottish groundfish survey of Rockall in September 1997, 1999, and 2001. The 2002 survey data were collected during a survey designed to sample deep-water. Catch rates greater than 2500 (the approximate 90th percentile of the combined data) have been set to 2500. The EU International Waters boundary is marked as a dashed line.

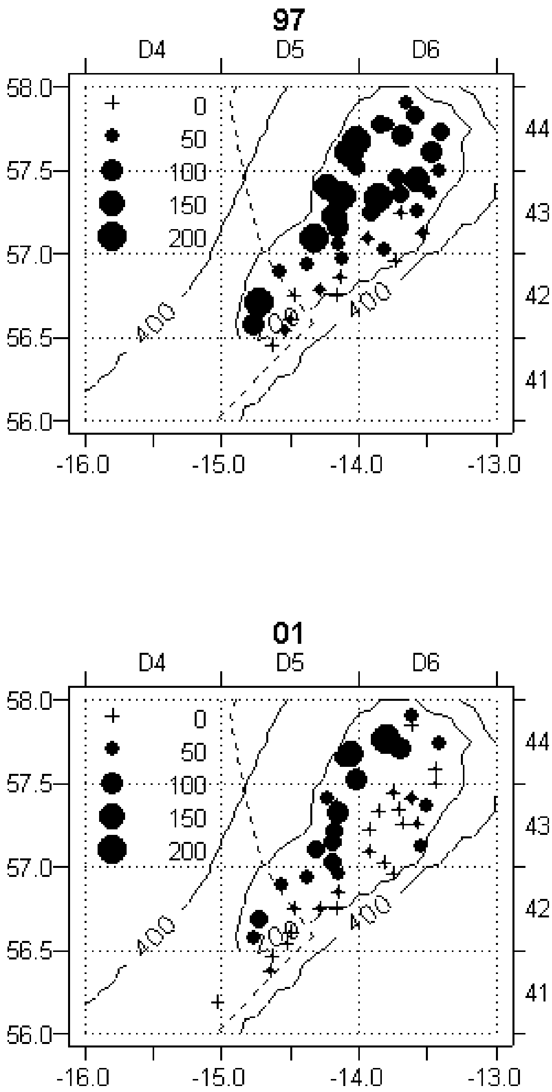

Figure 4 Catch rates (numbers per half-hour tow) of haddock ≥ 30 cm during the biennial Scottish groundfish survey of Rockall in September 1997, 1999, and 2001. The 2002 survey data were collected during a survey designed to sample deep-water. Catch rates greater than 200 (the approximate 90th percentile of the combined data) have been set to 200. The EU International Waters boundary is marked as a dashed line.

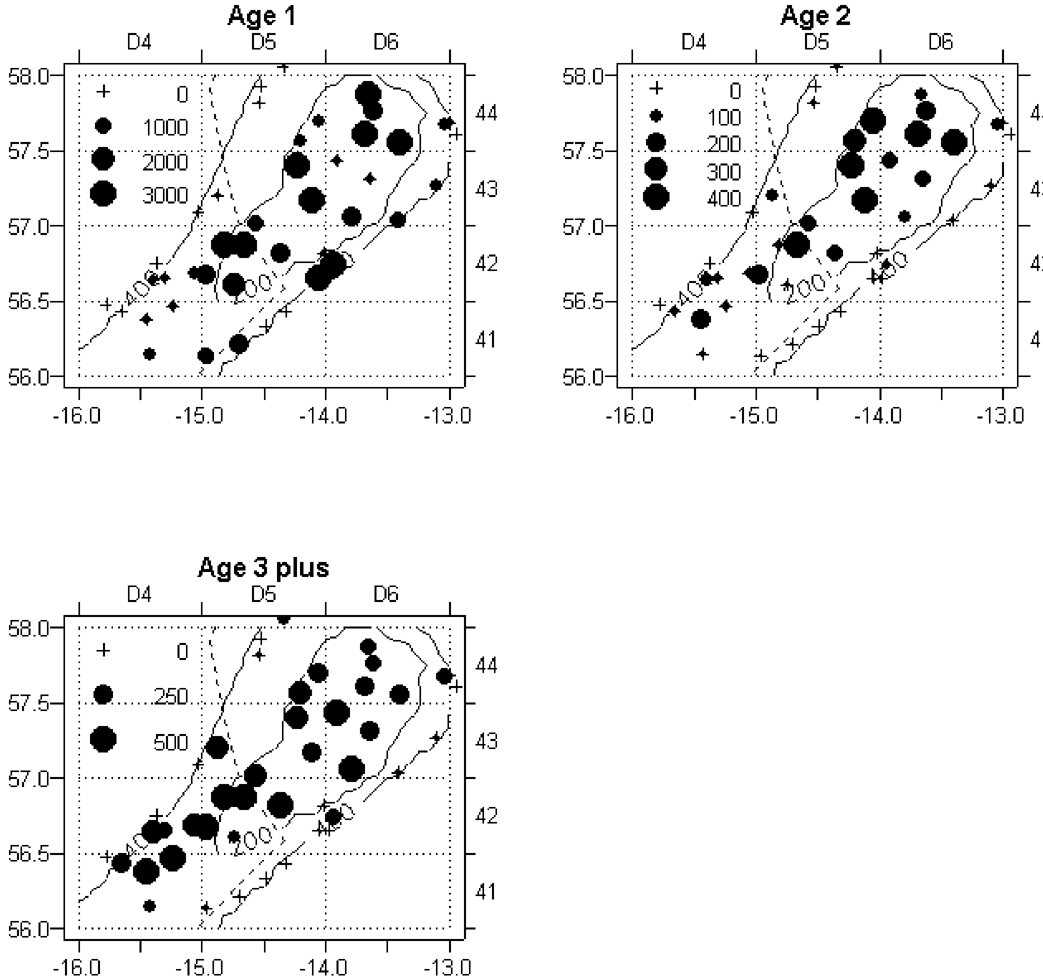

Figure 5 Catch rates (numbers per hour tow) of haddock by age during a Marine Laboratory Aberdeen partnership charter survey of Rockall in Spring 2001. Catch rates greater than the approximate 90th percentiles of the data for each age-group have been set to the 90th percentiles (3000, 400, and 500 for ages 1, 2, and 3+, respectively). The EU International Waters boundary is marked as a dashed line.

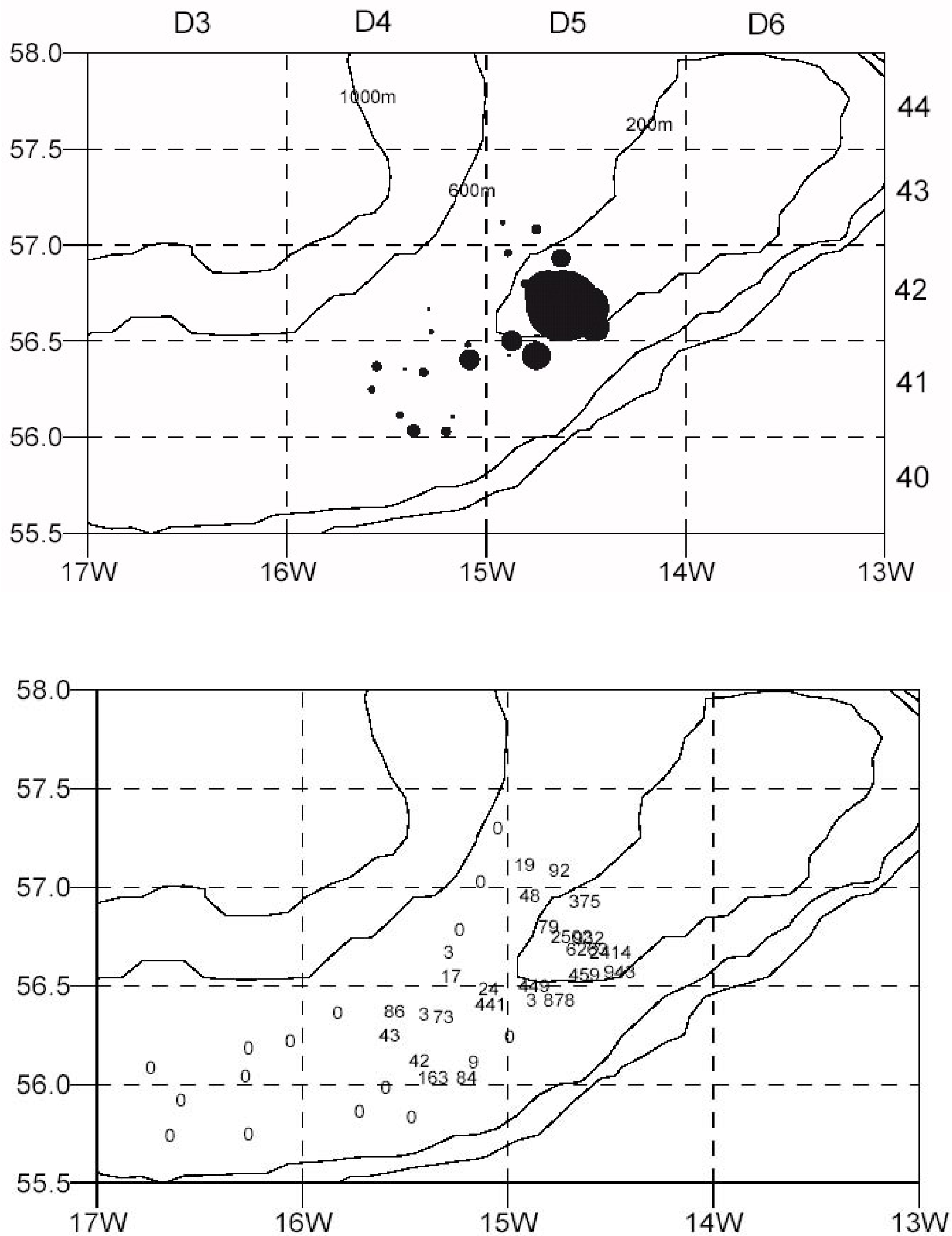

Figure 6 Catch rates of haddock < 30 cm in the Russian groundfish survey of SW Rockall in Autumn 2000. Top panel: sizes of symbols are proportional to the square-root of catch rate (maximum 345 fish). Bottom panel: numbers caught per tow. Tows are mainly of half-hour duration.

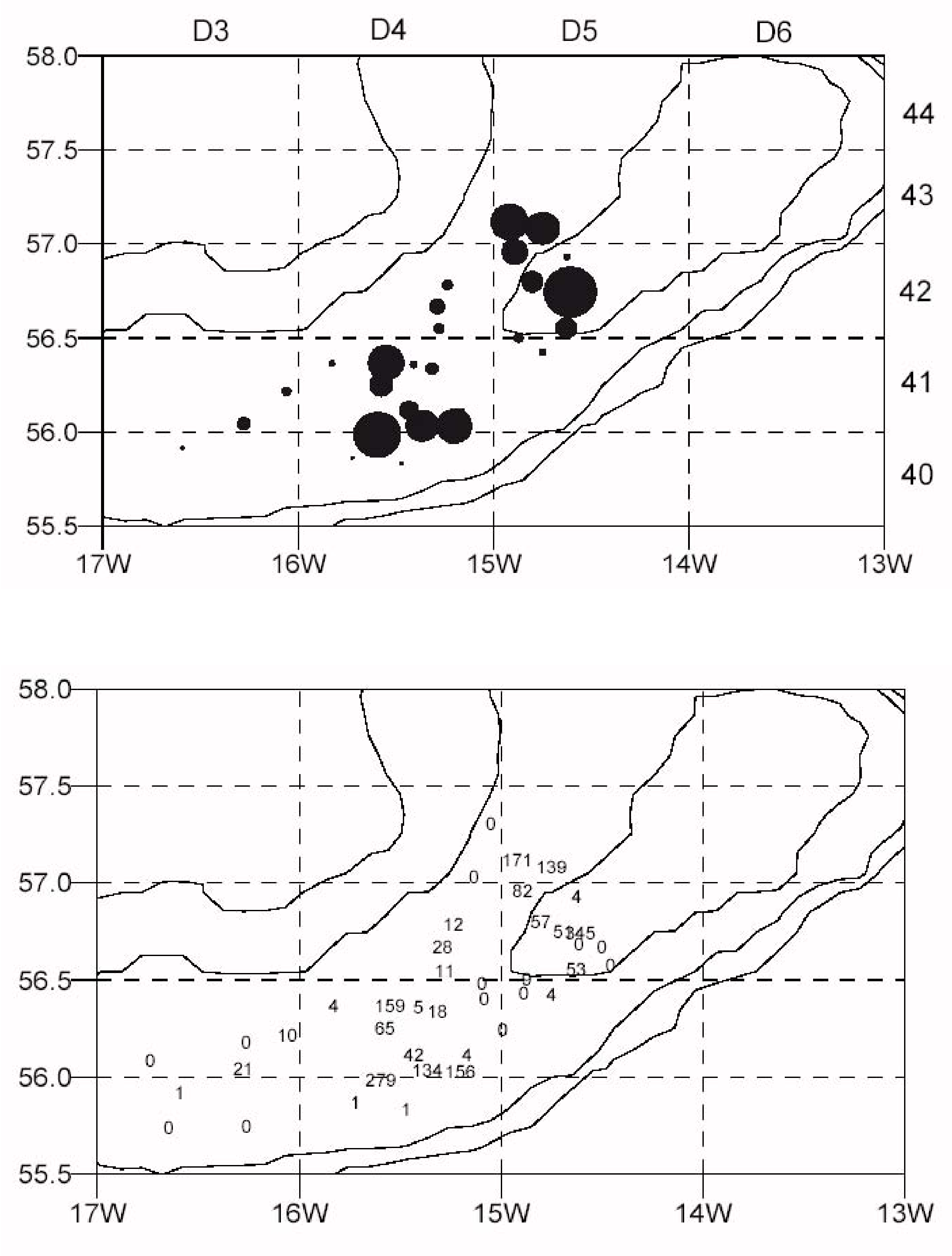

Figure 7 Catch rates of haddock ≥ 30 cm in the Russian groundfish survey of SW Rockall in Autumn 2000. Top panel: sizes of symbols are proportional to the square-root of catch rate (maximum 345 fish). Bottom panel: numbers caught per tow. Tows are mainly of half-hour duration.

d: Review the technical measures identified in the recovery plan, and develop recommendations appropriate to improving the exploitation pattern:

(a) A standard minimum mesh size, with options from 60-120 mm to be evaluated with the account of discards value and traumatism and mortality of fish escaping through a mesh

Selection characteristics of various mesh sizes

Data on selection of haddock by various mesh sizes were available from Russia (40-, 70-, and 100-mm meshes) and Scotland (100-, 110-, and 120-mm meshes).

Russian mesh selectivity

In Russian trawl samples obtained at Rockall in March-April and June 2000 haddock ranging from 18-81 cm in length were present (Figure 8). Average length varied depending on the month of fishing and trawl codend mesh size, being from 31.4 cm (April, 70-mm mesh size) to 32.7 cm (June, 100-mm mesh size). At the same time, modal length was kept within 27-33 cm (4-5 years old individuals). Thus, the size composition of catches did not substantially differ with mesh sizes varying between 70 and 100 mm. Length selectivity for smaller haddock increased when using a 40-mm mesh.

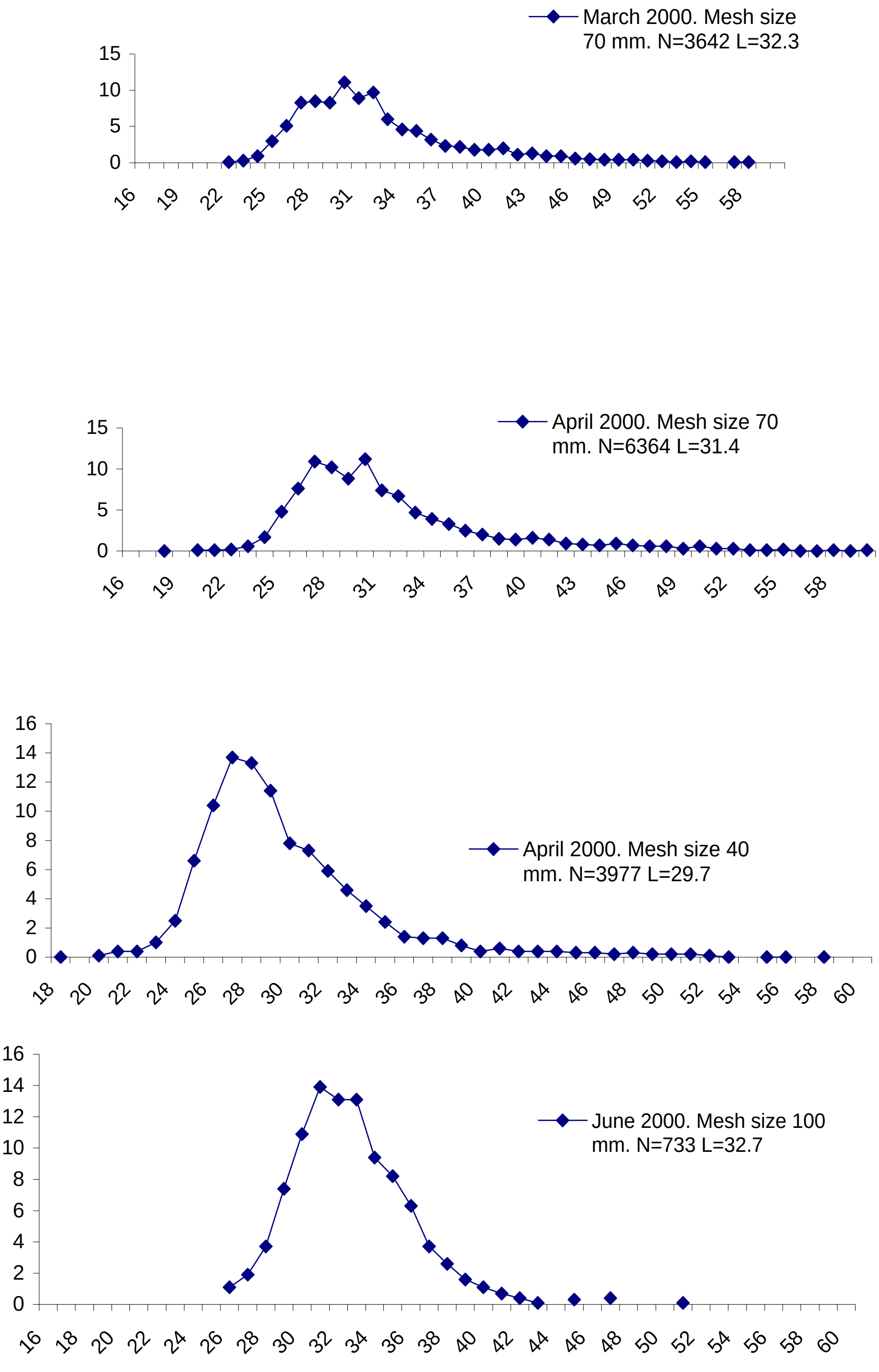

Figure 8 Length compositions of Rockall haddock caught by Russian vessels operating with mesh sizes of 40, 70, and 100 mm in March-April and June 2000.

Scottish mesh selectivity

Kunzlik (2003) presented a summary of selection parameters for haddock and whiting in the North Sea, following analyses undertaken by FRS Marine Laboratory (Aberdeen). These gave estimated selection-at-length under a series of recently-implemented technical measures, as follows:

Label	*Regulation*	*Applicability*	*Constraint on gear design*
UK 2001	SI 649/2001	UK	Maximum twine diameter in codend and 90-mm square mesh panel with restrictions on its placement
Scotland 2001	SSI 250/2001	UK (Scotland)	Ban on lifting bags and maximum number of meshes along the length of the extension piece
EU 110 or EU 120	EU 2056/2001	EU	120 mm minimum mesh size and a maximum length for the extension piece. Derogation for vessels targeting a mixed demersal gadoid fishery of 110 mm minimum mesh size in 2002, subject to rules on catch composition

The selection parameters estimated by FRS for North Sea haddock are as follows.

Regulation	L_{50}	L_{25}
EU 110	28.7	26
EU 110 + UK 2001	32.5	29.8
EU 120	32.1	29.05
EU 120 + UK 2001 + Scotland 2001	34.7	31.65

ICES was not able to evaluate the effects of different mesh sizes (as requested in ToR D). In the absence of an accepted assessment, there is no historical selection pattern on which to base analyses of the sensitivity of forecasts to different assumptions about mesh sizes. However, given the selection parameters tabulated above, an accepted assessment and a series of minimum landings sizes, it would be possible to investigate the likely impact on landings, discards and (potentially) escape mortality (see Section 1) of the use of meshes between 100 mm and 120 mm (although not smaller meshes).

However, there are several caveats to be borne in mind. Firstly, the selection characteristics of the gear and vessels used in the North Sea is likely to be different from that at Rockall. Secondly, the behavioural response of Rockall haddock to approaching gear might differ from that of North Sea haddock. And thirdly, the regulations listed above are specific to the Scottish fleet, and will not necessarily apply to the Irish or Russian fleets. Thus, unless selection work specific to the Rockall haddock fishery is carried out, any evaluation of the effects of different minimum mesh sizes must be treated with caution.

Post-escape trauma and mortality of haddock escaping the trawl

Review of past and current investigations

Three studies of post-escape mortality were available to ICES: an early Russian analysis, and two more recent studies from Norway and Scotland.

The conclusions of each of these studies are very different. The Russian work indicates that post-escape mortality is very high, particularly for the medium-sized individuals on which most fisheries depend. The Scottish work suggests the opposite, that mortality is low for all ages and particularly so for medium-sized and larger fish. The conclusions of the Norwegian study lie in between these two extremes. In order to determine which one would be the most appropriate to apply to the Rockall haddock fishery, we need to consider a) the validity of the experimental methods used in each case, and b) the relevance of the study area to the case of Rockall haddock:

a) The technique used in the Russian study was to tow a manned submersible behind the codend during trawling, and again along the trawl track after trawling, and arrive at fairly qualitative conclusions on the behaviour of fish within the codend, their manner of escape, and their fate thereafter. While the premise of high post-escape mortality is plausible, it is hard to see how an eye-witness approach of this kind could supply the empirical evidence needed to prove the hypothesis, and it is the opinion of ICES that the paper by Zaferman and Serebrov (1989) does not do this. It is also difficult to understand how the authors can estimate trawl catchability using the methods they describe, and the evidence does not support their theory of adaptive behaviour.

The Norwegian and Scottish studies use very similar methods, but there are several problems in the earlier Norwegian work which appear to have been rectified in the later Scottish analysis. It is not clear in the Norwegian study whether the net cover has been designed in such a way as to minimise water flow: without this, additional stress and injuries could occur within the cover itself. Once released, the cover nets were allowed to float unimpeded to the surface at a rate of ascent that may have caused further injury. Cages were not kept on seabed but allowed to float freely, again stressing fish. Some cages were poorly closed. Fish were not fed during captivity (which could have lead to starvation), nor were corpses removed (which could have led to infections). Skin injuries were examined, but no full post mortem to determine proximate cause of death. Only live haddock, and not dead ones, were examined for injuries. These problems, the effect of each of which would have been to increase mortality, were all avoided in the Scottish analysis. It is not therefore surprising that the Scottish estimates of mortality are much lower than the Norwegian estimates.

b) The Russian and Norwegian studies both took place in the Barents Sea, a boreal area with quite different environmental characteristics to the Rockall Bank. It may also be the case that the biological characteristics of Barents Sea haddock are different to those of Rockall haddock. The Gairloch area on the west coast of Scotland, where the Scottish work was sited, is much closer both geographically and environmentally to Rockall. Therefore, it seems reasonable to suppose *a priori* that the Scottish study would more appropriate.

ICES concludes that the results of the Scottish study are likely to be more applicable to Rockall haddock than those of the Russian or Norwegian studies. However, concerns remain. The relevance of this work to an evaluation of technical measures for Rockall haddock is difficult to determine. It may be that the biological characteristics of haddock at Rockall are sufficiently different from those to the immediate west of Scotland for any comparison to be invalid, but this cannot be decided until similar analyses are carried out at Rockall. However, the method outlined above is likely to be too dangerous and too difficult to be performed on the open sea.

If we assume for the moment that we can extrapolate from west of Scotland to Rockall, then we are faced with a conundrum: mean escape mortality appears to be low, suggesting that mesh-size increases might be appropriate, but the mortality on juveniles appears to be high, meaning that increases in mesh-size might not have the desired effect of protecting young fish. The analysis is not yet conclusive enough to allow a decision either way. Furthermore, as mentioned above it is not currently possible to determine appropriate selection parameters for the Rockall haddock fishery, which hinders further the incorporation and evaluation of post-escape mortality in Rockall haddock stock assessments and advice.

(b) Rigging with single 8-mm or double 5-mm twine

(c) Inclusion of a square-mesh panel of 50-90 mm of minimum mesh size in trawls

The combined effects of twine diameter and square mesh panels were evaluated by Kunzlik (2003) (See Section 0). However, no information was available to ICES to evaluate separately the effects of twine diameter or square mesh panels.

ICES considered that improved selection of fishing gears resulting from the incorporation of such devices is of little benefit in reducing fishing mortality unless there is good survival of the excluded fish. ICES notes that a Norwegian study of escapement mortality (Ingolfsson *et al*., 2002) indicated escapement through meshes or grids do not appear to be significant sources of mortality. Death occurs mostly through injuries incurred in the body of the net, or through exhaustion and stress. This suggests that selection devices, which prevent selected fish from entering the body of the net, are likely to result in improved post-escape survival.

(d) A minimum size for the landing or retention on board of haddock should be established that is compatible with the mesh characteristics referred to in (a) and (b), as well as with the length of a mass sex maturation of fish

In addressing this term of reference ICES first considered the appropriateness of minimum landing size (MLS) regulations in a trawl fishery such as that undertaken for Rockall haddock. ICES considers that the adoption of a MLS may only be effective in reducing fishing mortality if it results in effort being directed away from areas of juvenile/lower size aggregations. Unless such a change in fishing behaviour occurs MLS regulations are likely to alter levels of discarding but not necessarily the level of fishing mortality.

With this premise in mind ICES considered:

- whether or not such areas exist for the Rockall fishery, and,

- whether or not the length composition in such areas may be enough to direct effort away from such areas in response to a MLS.

An evaluation of available data on the spatial distribution and size distribution of Rockall haddock (see Section 0) remains inconclusive. It is therefore not possible to conclude that adoption of a MLS would be effective in directing effort away from areas of juvenile abundance.

ICES was unable to assess the selectivity of mature fish as empirically derived maturity ogives (further discussed in Section 0), and selection ogives were not available. In 2004 during the spawning season (March-April) Russian scientists plan to collect data for an histological study of maturity of Rockall haddock.

e: Review the report on the 'Expert Meeting on Rockall Haddock' of 10th April 2003

An Expert Meeting on Rockall Haddock took place in Brussels on 10th April 2003. The participants included representatives from scientific institutes and the fishing industry from Scotland and Ireland, delegates from the French processing sector, and a Commission representative. The deliberations and conclusions of the meeting are contained in an eight-page report, consisting of: an introduction, comments on compliance issues, a summary of the scientific advice from ICES, notes on the content of a management plan for the recovery of Rockall haddock (including rules for setting TACs, technical measures, and rules for effort limitation), and other considerations.

ICES has concerns about several aspects of this earlier report. For example, estimates of stock recovery times using the CS4 program are discussed, but without the input files and output diagnostics that would be required to allow a proper evaluation of the results. Broad statements were made about such aspects as the appropriate twine thickness to be used and the effectiveness of square-mesh panels, without reference to the relevant studies or data. More importantly, there are three key points about the assessment and advice for Rockall haddock which are not addressed:

1. The principal change in the Rockall haddock fishery in recent years has been the commencement of a Russian trawl fishery in the international sector of the Rockall bank, which now takes a large (though as yet unquantified) proportion of the total catch. However, there were no Russian participants at the meeting.

2. The main problem with the assessment is the lack of data, both commercial landings data (Russian data are absent, EU data are thought to be affected by mis-reporting) and research-vessel survey data (the Scottish survey has limited coverage in time and space). This lack is barely mentioned in this report.

3. There is a sharp dichotomy in views on mis-reporting, with scientific observers reporting heavy mis-reporting and industry representatives saying it rarely happens. Until such discrepancies are resolved, it is unlikely that a catch-at-age analysis based on commercial landings data will accurately reflect true stock abundance.

The report concludes that "effort limitation should not be included at this time as a component of the recovery plan because the proposed measures [closed areas] are anticipated to result in substantial effort reduction." This assumes highly effective implementation of closed-area regulations. At the present time it is not clear what the most useful closed area would be, nor how effective monitoring systems would be. It therefore seems optimistic to expect that the present closed areas alone are going to be a sufficient management tool. If this is the intention then the closed area would probably have to be larger.

Several of these points are discussed elsewhere in the current report: closed areas (Section 0), selectivity characteristics (Section 0), and poor data coverage (Section 0).

f: ICES may also make any relevant comments concerning control and enforcement issues

ICES does not have particular expertise in control and enforcement issues and therefore made limited comments under this term of reference. Comments are restricted to aspects of control and enforcement that may improve the regulation of fishing effort, redress data inadequacies and reduce the selectivity for juvenile haddock.

ICES considers that the need to limit fishing effort and to improve the data available for assessment can be addressed both through better control, and through enforcement of these regulations in the Rockall haddock fishery. Specific access requirements may be of particular benefit in limiting effort at Rockall. Within an overall restriction on the combined amount of horsepower and tonnage, access could be permitted only to vessels that agree to comply with particular conditions. These may include:

- A requirement to report within specific logbooks that record:

  - Detailed fishing vessel characteristics
  - Fishing gear characteristics
  - Spatial information on fishing activity (Catch and Effort)
  - Discard quantities (Species specific)

- Requirements to accommodate observers at sea (Both to ensure compliance and to collect data on fishing activity)

- Prior reporting of landing ports to facilitate port sampling of catches (Limitation on the number of designated landing ports is unlikely to be acceptable, due to the remote nature of the fishery and the distances travelled by vessels participating in the fishery).

  The remoteness of the Rockall fishery creates particular difficulties for control and enforcement. The high cost of deploying enforcement vessels in the area is likely to create an increased reliance on remote control and monitoring of fishing activity. ICES considers that an improvement in the effectiveness of the current remote Vessel Monitoring System (VMS) would facilitate better regulation of the Rockall haddock fishery, particularly the compliance with closed area regulation implemented to improve selectivity.

- Checks for compliance with closed area regulations would be improved through shortening the intervals between remote polling of vessels,

- Requirements to have a functioning VMS unit aboard vessels could be strengthened,

- Penalties for failing to have a serviceable VMS unit aboard vessels could be increased.

The measurement and monitoring of effort is also discussed under Section 0.

ICES considers that incentive-based management measures may be more effective than a reliance on punitive control and enforcement measures. As an example an incentive-based management measure that may improve compliance with closed area regulations could be to allow increased allocations of fishing opportunities to vessels operating in designated alternative areas (similar to a system operated in the Faeroe Islands).

g: Propose the modified system of compiling of scientific and fishery data to obtain the most representative data for reliable assessment and development of advice on the management of the haddock fishery

ICES considers that the greatest issue preventing reliable assessment of Rockall haddock and subsequent development of management advice is the lack of appropriate data. It is important to note that resolution of this problem is not simply a matter of compiling available data. Data was not collected for major components of the catch in several years and therefore can not be made available in the future. Current data collection programmes are still inadequate to support analytical assessments. ICES has therefore prepared the following summary of the data problems hampering assessment of Rockall haddock. It is hoped that increased cognisance of these issues will motivate the establishment of improved, ongoing data collection programs.

Landings	Weight	• Reports from observers and enforcement sources tend to confirm that mis-reporting of haddock from Rockall has occurred. There may also be mis-reporting of haddock caught in areas other than Rockall (WGNSDS 2003). Industry representatives have said that it is not considered a problem (Expert Group, April 2003).
	Length	• Length sampling has been carried out by Scotland and Ireland, but because of the different gears used by the Russian fleet an approximation has been made to exclude Russian catches of fish less than 30 cm in the combined catch-at-age data for assessment. The appropriateness of this methodology has not been fully evaluated. A further complication is that no length-frequency data were collected for haddock caught by the Russian fleet in 2002 when that fleet accounted for 60% of the catch.
	Age	• There has been no assessment of the quality and precision of the age data available for this stock. At the 2003 WG anomalies related to poor sampling were identified in the catch-at-age matrix.
Discards	Weight	• The results of a small number of Irish and Scottish discard sampling trips in recent years indicate that discard rates are both very high and highly variable with percentages discarded ranging from 12-75% by weight. Unaccounted for mortality due to discarding is a major source of uncertainty in this stock. • Russian vessels fishing at Rockall utilise the entire haddock catch.
	Length	• Sampling of discards by EU fleets is inadequate to generate annual discard estimates for assessments.
	Age	• There are no age compositions for the discard component of the catch.
Biological data	Maturity	• The maturity ogive used in the assessment is substantially different to those estimated in recent Russian and Scottish studies. The sensitivity of the assessment to this has not been fully evaluated.
	Weight-at-age	• There are substantial differences between the mean weights-at-age from Scotland, Ireland, and Russia and this needs to be resolved at the data compilation stage.
	Natural Mortality	• There is no information on natural mortality for this stock.
	Migration/mixing	• There is no information on migration and mixing in this stock, but it is not thought to be a major source of uncertainty in this assessment.
	Stock ID	• The stock is clearly defined and geographically separated from the VIa stock and this is not thought to be a major source of uncertainty in this assessment.
Commercial CPUE		• The commercial CPUE data available for Scottish vessels is not complete and cannot be used in the assessment. Irish and Russian data exist for only a very short time period and for few vessels. Recent changes in fishing patterns may mean that CPUE data are not reliable.
Surveys		• There are serious concerns about the coverage of the only survey index (the Scottish survey) which is limited to depths of less than 200 m while the stock occurs down to at least 400 m. There have also been gaps in the survey time- series since for some years the survey was only run every second year.

ICES has the following proposals for improvement in the collection and processing of scientific and fishery data on Rockall haddock:

1. The organisation on a regular basis of the collection of scientific and fishery data (including discard data) by observers on commercial trawlers of all participating Nations.

2. Increased reliability of fishery statistics related to effort and its spatial distribution:

   - improvement of the VMS and landing (trans-shipping) control;
   - application of the prior notification system of landing ports.

3. Improvement of groundfish survey methods on Rockall bank:

   - expansion of the survey area to depths of 400 m;
   - annual carrying out of the survey;
   - carrying out of the survey not only in the autumn, but during the spring (upon funding - on the Russian R/V).

4. Research on mesh selectivity and selective trawl devices (sorting grids, square mesh) including a study of the escape mortality.

5. Improvement of assessment methods for Rockall haddock stock:

   - standardisation (for EU and Russia) of ageing methods for haddock;
   - development of stock assessment methods that better accommodate catch taken by fleets with very different selectivity;
   - joint (EU and Russian) research on the maturity ogive;
   - investigate the application of discard ogives to the EU catch.

6. Expansion of cooperation between Russia and EU for Rockall haddock:

   - improved exchange of the scientific and fishery data;
   - a mutual exchange of scientists for participation in the groundfish surveys;
   - creation of working group on standardisation of research and assessment methods.

h: Assess discards of young haddock during the fishery for this and other fish species; and to work out advice on measures to reduce discards maximally in the future

Available discard data is presented in Section 0.

ICES advises that measures to reduce discards in the future may include:

- Closed areas,
- Effort-based management (rather than TACs),
- Selectivity devices,
- Increases in mesh size.

ICES reiterates its opinion that the adoption of a Minimum Landing Size may not be helpful in reducing discarding (See Section 0).

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Appendix 1

Text of the Proposed Recovery Plan for Rockall Haddock sent by the European Commission to ICES on 1st October 2003.

Annex A: Recovery Plan for Rockall Haddock

1. Purpose

The purpose of the Rockall Haddock Recovery Plan is to secure the rapid recovery and long-term conservation of the stock to within safe biological limits as defined by ICES ($\mathbf{B}_{pa}$ and $\mathbf{F}_{pa}$) as well as attainment of long-term sustainable yield in accordance with principles of the precautionary approach.

2. Scope

The Recovery Plan will apply to all waters within ICES Subdivision VIb.

3. Criteria

Recruitment to the Rockall Haddock stock appears to have fluctuated widely over the time-period of exploitation. Given that this high fluctuation may preclude management to any particular target biomass, it is instead chosen to manage using an exploitation-related target alone.

The value for this target is the fishing mortality rate that corresponds, in long-term equilibrium conditions with the current exploitation pattern, to the annual survival of [XX] % of the spawning stock compared to the spawning stock which would survive in the absence of fishing.

To determine this value it is necessary to obtain the most reliable and representative data and to do the corresponding calculations in accordance with the existing or newly created models of exploitation. The estimation should take into account the results of trawl surveys which, in order to obtain complete and reliable data should be performed over depths to 400 m.

4. Instruments

4.1 Instruments to manage overall exploitation rate

A TAC will be set covering all catches of haddock in ICES Division VIb. This TAC will be set according to scientific advice concerning the catch that corresponds to the target stated in paragraph 3.

In order to improve stability of the fishing activity and to make the recovery plan robust to uncertainty in the assessments under great fluctuations of the stock size, the TAC will however not be varied by more than **[**YY**]**% from one year to the next.

However, no TAC would be set that corresponds to a higher fishing mortality rate than $\mathbf{F}_{pa}$. This condition would override the +/- [YY%] limit on TAC variability.

ICES will be requested to identify each year the TAC that corresponds to this harvest rule should be determined considering the entire complex of criteria.

Levels of effort directed at Rockall Haddock will be measured and the need to establish an effort limitation scheme will be kept under review.

4.2 Technical measures for fisheries management

The existing closed area should be reviewed by ICES with respect to its suitability as an area within which a high proportion of the catch is juvenile haddock. Based on new advice, the closed area will be adapted accordingly. It is reasonable that national observers organise onboard of fishing vessels the monitoring of distribution and bycatches of young haddock, the results of which will be used for correction of the closed area.

A set of technical measures appropriate to the fisheries concerned will be established throughout Division VIb. These are :

a) A standard minimum mesh size, with options from 60 mm to 120 mm to be evaluated with the account of discards value and traumatism and mortality of fish escaping through a mesh;

b) Rigging with single 8-mm or double 5-mm twine;

c) Inclusion of a square-mesh panel[1] of 50-90 mm of minimum mesh size in trawls;

d) A minimum size for the landing or retention on board of haddock should be established that is compatible with the mesh characteristics referred to in (a) and (b), as well as with the length of a mass sex maturation of fish.

This set of measures should be reviewed and evaluated by ICES as soon as practicable. ICES is in particular asked to evaluate an appropriate minimum landing size.

5. Control Issues

Measures shall be put in place to record *inter alia* the entry, exit, time spent fishing, and principal vessel characteristics for demersal fishing activity within ICES Division VIb.

6. Additional Information

As part of the background to this issue, ICES has been provided with the report on the "Expert Meeting on Rockall Haddock" of 10th April 2003.

[1] Located in the top sheet of a net in front on any extension piece, at least three metres in length, constructed of knotless netting or netting with non-slip knots, and with the number of meshes in the anterior row equal to or greater than the number of meshes in the posterior row. The panel shall be constructed so that the meshes remain open and unobstructed.

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

The indicator chosen is the quantity of fish caught in 1994-2000, and 2002, that was taken from stocks grouped according to whether they were within or outside safe biological limits at the end of each year, i.e. 1995-2003. 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 (Bpa) 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: 1996-2003 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 ach year is higher than the SSB corresponding to the precautionary approach level, as recommended by ICES (Bpa). 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 (Fpa) or other desired levels of F serving as a guide for management. If F is higher than Fpa, then the stock is considered outside safe biological limits[2].

   - Estimates of catch per unit effort (U) and some desired level of U (Upa). 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: Nephops, prawns, flafish, 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

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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.

- 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 tabls below show 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 (Bpa and Fpa) are not management targets; they rather reflect a stock status that should trigger management action. In other words, maintaining a stock at Bpa values is not necessarily desirable or advisable.

Moreover, it should be noted that stock status as indicated by the relative values of SSBand Bpa cannot always be used to judge whether the stock is being exploited at a sustainable level. As an example, SSB2003 for blue whiting is above Bpa, 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.

Tables.

Catch by year of stocks (managed by the Community) within and outside safe biological limits (SBL).

1995	1994 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	628.00	Herring	0.00	Redfish	628.00	100.00	0.00
2	Benthic	200.71	Nephrops Flounder Pandalus	113.60	Plaice Sole Anglerfish	314.31	63.86	36.14
2	Demersal	417.84	Haddock Saithe Whiting	272.20	Cod Whiting Hake	690.04	60.55	39.45
2	Diadromous	0.00		4.71	Salmon Sea trout	4.71	0.00	100.00
2	Industrial	1757.80	Sandeel Sprat Norw. pout	0.00		1757.80	100.00	0.00
2	Pelagic	344.50	Herring (North Sea) Horse mackerel	776.00	Herring (Baltic)	1120.50	30.75	69.25
2	All	2720.86		1166.51		3887.36	69.99	30.01
3	Benthic	54.29	Megrim Sole Nephrops Anglerfish	0.00		54.29	100.00	0.00
3	Demersal	0.00		63.70	Hake	63.70	0.00	100.00
3	Pelagic	91.40	Sardine Anchovy Horse mackerel	133.00	Anchovy Biscay	224.40	40.73	59.27
3	All	145.69		196.70		342.39	42.55	57.45
1,2 and 3	Pelagic	844.00	Blue whiting Horse mackerel	823.00	Mackerel	1667.00	50.63	49.37
1,2 and 3	Demersal	8.35		157.63	Deep water fish	157.63	5.30	100.00
1,2 and 3	All	852.35		980.63		1824.63	46.71	53.74

All	Benthic	255.00		113.60		368.60	69.18	30.82
	Demersal	436.84		493.53		930.37	46.95	53.05
	Diadromous	0.00		4.71		4.71	0.00	100.00
	Industrial	1757.80		0.00		1757.80	100.00	0.00
	Pelagic	1907.90		1732.00		3639.90	52.42	47.58
All	All	4357.55		2343.83		6701.38	65.02	34.98

1996	1995 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	1077.84	Herring	0.00	Redfish	1077.84	100.00	0.00
2	Benthic	215.06	Nephrops Flounder Pandalus	100.20	Plaice Sole Anglerfish	315.26	68.22	31.78
2	Demersal	552.79	Haddock Saithe Whiting	324.59	Cod Whiting Hake	877.38	63.00	37.00
2	Diadromous	0.00		3.89	Salmon Sea trout	3.89	0.00	100.00
2	Industrial	1960.20	Sandeel Sprat Norw. pout	0.00		1960.20	100.00	0.00
2	Pelagic	343.80	Herring (North Sea) Horse mackerel	722.18	Herring (Baltic)	1065.98	32.25	67.75
2	All	3071.85		1150.87		4222.71	72.75	27.25
3	Benthic	55.36	Megrim	6.50	Sole Nephrops Anglerfish	61.86	89.49	10.51
3	Demersal	0.00		69.70	Hake	69.70	0.00	100.00
3	Pelagic	96.00	Sardine Anchovy Horse mackerel	121.00	Anchovy Biscay	217.00	44.24	55.76
3	All	151.36		197.20		348.56	43.42	56.58
1,2 and 3	Pelagic	1335.00	Mackerel Blue whiting	511.00	Horse mackerel	1846.00	72.32	27.68
1,2 and 3	Demersal	16.00		165.70	Deep water fish	165.70	9.66	100.00
1,2 and 3	All	1351.00		676.70		2011.70	67.16	33.64

All	Benthic	270.42		106.70		377.12	71.71	28.29
	Demersal	571.79		559.99		1131.78	50.52	49.48
	Diadromous	0.00		3.89		3.89	0.00	100.00
	Industrial	1960.20		0.00		1960.20	100.00	0.00
	Pelagic	2852.64		1354.18		4206.82	67.81	32.19
All	All	5655.05		2024.77		7679.81	73.64	26.36

1997	1996 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	1380.00	Herring	0.00	Redfish	1380.00	100.00	0.00
2	Benthic	157.56	Nephrops Flounder Pandalus	137.35	Plaice Sole Anglerfish	294.91	53.43	46.57
2	Demersal	416.25	Haddock Saithe Whiting	399.20	Cod Whiting Hake	815.45	51.05	48.95
2	Diadromous	0.00		6.85	Salmon Sea trout	6.85	0.00	100.00
2	Industrial	1594.40	Sandeel Sprat Norw. pout	0.00		1594.40	100.00	0.00
2	Pelagic	275.40	Herring (North Sea) Horse mackerel	551.00	Herring (Baltic)	826.40	33.33	66.67
2	All	2443.61		1094.40		3538.01	69.07	30.93
3	Benthic	51.94	Megrim	13.83	Sole Nephrops Anglerfish	65.77	78.97	21.03
3	Demersal	0.00		56.70	Hake	56.70	0.00	100.00
3	Pelagic	83.60	Sardine Anchovy Horse mackerel	111.00	Anchovy Biscay	194.60	42.96	57.04
3	All	135.54		181.53		317.07	42.75	57.25
1,2 and 3	Pelagic	1202.00	Mackerel Blue whiting	397.00	Horse mackerel	1599.00	75.17	24.83
1,2 and 3	Demersal	18.00		165.51	Deep water fish	165.51	10.88	100.00
1,2 and 3	All	1220.00		562.51		1764.51	69.14	31.88

All	Benthic	209.50		151.18		360.68	58.08	41.92
	Demersal	435.25		621.41		1056.66	41.19	58.81
	Diadromous	0.00		6.85		6.85	0.00	100.00
	Industrial	1594.40		0.00		1594.40	100.00	0.00
	Pelagic	2941.00		1059.00		4000.00	73.53	26.48
All	All	5180.15		1838.44		7018.59	73.81	26.19

1998	1997 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	1539.00	Herring	0.00	Redfish	1539.00	100.00	0.00
2	Benthic	158.89	Nephrops Flounder Pandalus	120.90	Plaice Sole Anglerfish	279.79	56.79	43.21
2	Demersal	229.75	Haddock Saithe Whiting	491.75	Cod Whiting Hake	721.50	31.84	68.16
2	Diadromous	0.00		3.93	Salmon Sea trout	3.93	0.00	100.00
2	Industrial	2080.30	Sandeel Sprat Norw. pout	0.00		2080.30	100.00	0.00
2	Pelagic	688.70	Herring (North Sea) Horse mackerel	612.60	Herring (Baltic)	1301.30	52.92	47.08
2	All	3157.64		1229.18		4386.81	71.98	28.02
3	Benthic	48.14	Megrim	13.65	Sole Nephrops Anglerfish	61.79	77.91	22.09
3	Demersal	0.00		51.80	Hake	51.80	0.00	100.00
3	Pelagic	84.20	Sardine Anchovy Horse mackerel	115.00	Anchovy Biscay	199.20	42.27	57.73
3	All	132.34		180.45		312.79	42.31	57.69
1,2 and 3	Pelagic	603.52	Blue whiting	1012.54	Mackerel Horse mackerel	1616.06	37.35	62.65
1,2 and 3	Demersal	11.00		149.71	Deep water fish	149.71	7.35	100.00
1,2 and 3	All	614.52		1162.25		1765.77	34.80	65.82

All	Benthic	207.03		134.55		341.58	60.61	39.39
	Demersal	240.75		693.26		934.00	25.78	74.22
	Diadromous	0.00		3.93		3.93	0.00	100.00
	Industrial	2080.30		0.00		2080.30	100.00	0.00
	Pelagic	2915.42		1740.14		4655.56	62.62	37.38
All	All	5443.50		2571.88		8015.37	67.91	32.09

1999 REGION	1998 catches FISH TYPE	Within SBL CATCH, ' 000 t	Dominant species	Outside SBL CATCH, ' 000 t	Dominant species	TOTAL CATCH, ' 000 t	% within SBL(catch)	% outside SBL(catch)
1	Pelagic	1342.00	Herring	0.00	Redfish	1342.00	100.00	0.00
2	Benthic	152.14	Nephrops Flounder Pandalus	126.23	Plaice Sole Anglerfish	278.37	54.65	45.35
2	Demersal	177.82	Haddock Saithe Whiting	112.58	Cod Whiting Hake	290.40	61.23	38.77
2	Diadromous	0.00		3.49	Salmon Sea trout	3.49	0.00	100.00
2	Industrial	1733.70	Sandeel Sprat Norw. pout	0.00		1733.70	100.00	0.00
2	Pelagic	643.90	Herring (North Sea) Horse mackerel	254.70	Herring (Baltic)	898.60	71.66	28.34
2	All	2707.56		497.00		3204.56	84.49	15.51
3	Benthic	51.34	Megrim	5.10	Sole Nephrops Anglerfish	56.44	90.96	9.04
3	Demersal	0.00		43.20	Hake	43.20	0.00	100.00
3	Pelagic	216.00	Sardine Anchovy Horse mackerel	0.00		216.00	100.00	0.00
3	All	267.34		48.30		315.64	84.70	15.30
1,2 and 3	Pelagic	2096.22	Mackerel Horse mackerel Blue whiting	0.00		2096.22	100.00	0.00
1,2 and 3	Demersal	11.00		138.07	Deep water fish	138.07	7.97	100.00
1,2 and 3	All	2107.22		138.07		2234.29	94.31	6.18

All	Benthic	203.48		131.33		334.81	60.77	39.23
	Demersal	188.82		293.85		482.67	39.12	60.88
	Diadromous	0.00		3.49		3.49	0.00	100.00
	Industrial	1733.70		0.00		1733.70	100.00	0.00
	Pelagic	4298.12		254.70		4552.82	94.41	5.59
All	All	6424.12		683.37		7107.48	90.39	9.61

2000	1999 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	1344.00	Herring	0.00	Redfish	1344.00	100.00	0.00
2	Benthic	168.74	Nephrops Flounder Pandalus	99.76	Plaice Sole Anglerfish	268.50	62.85	37.15
2	Demersal	155.70	Haddock Saithe Whiting	572.24	Cod Whiting Hake	727.94	21.39	78.61
2	Diadromous	0.00		5.26	Salmon Sea trout	5.26	0.00	100.00
2	Industrial	1450.70	Sandeel Sprat Norw. pout	0.00		1450.70	100.00	0.00
2	Pelagic	237.56	Herring (North Sea) Horse mackerel	626.34	Herring (Baltic)	863.90	27.50	72.50
2	All	2012.70		1303.59		3316.29	60.69	39.31
3	Benthic	50.82	Megrim	3.80	Sole Nephrops Anglerfish	54.62	93.04	6.96
3	Demersal	0.00		7.50	Hake	7.50	0.00	100.00
3	Pelagic	180.40	Sardine Anchovy Horse mackerel	0.00		180.40	100.00	0.00
3	All	231.22		11.30		242.52	95.34	4.66
1,2 and 3	Pelagic	882.93	Mackerel Horse mackerel	1256.00	Blue whiting	2138.93	41.28	58.72
1,2 and 3	Demersal	0.00		153.11	Deep water fish	153.11	0.00	100.00
1,2 and 3	All	882.93		1409.11		2292.04	38.52	61.48

All	Benthic	219.56		103.56		323.12	67.95	32.05
	Demersal	155.70		732.85		888.55	17.52	82.48
	Diadromous	0.00		5.26		5.26	0.00	100.00
	Industrial	1450.70		0.00		1450.70	100.00	0.00
	Pelagic	2644.89		1882.34		4527.23	58.42	41.58
All	All	4470.85		2724.00		7194.85	62.14	37.86

2001	2000 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	1334.00	Herring	0.00	Redfish	1334.00	100.00	0.00
2	Benthic	119.71	Nephrops Flounder Pandalus	138.18	Plaice Sole Anglerfish	257.89	46.42	53.58
2	Demersal	292.95	Haddock Saithe Whiting	356.29	Cod Whiting Hake	649.24	45.12	54.88
2	Diadromous	0.00		6.01	Salmon Sea trout	6.01	0.00	100.00
2	Industrial	1490.40	Sandeel Sprat Norw. pout	0.00		1490.40	100.00	0.00
2	Pelagic	289.00	Herring (North Sea) Horse mackerel	586.00	Herring (Baltic)	875.00	33.03	66.97
2	All	2192.06		1086.49		3278.54	66.86	33.14
3	Benthic	24.25	Megrim	24.07	Sole Nephrops Anglerfish	48.32	50.19	49.81
3	Demersal	0.00		48.70	Hake	48.70	0.00	100.00
3	Pelagic	174.50	Sardine Anchovy Horse mackerel	0.00		174.50	100.00	0.00
3	All	198.75		72.77		271.52	73.20	26.80
1,2 and 3	Pelagic	842.16	Mackerel Horse mackerel	1412.00	Blue whiting	2254.16	37.36	62.64
1,2 and 3	Demersal	0.00		160.18	Deep water fish	160.18	0.00	100.00
1,2 and 3	All	842.16		1572.18		2414.34	34.88	65.12

All	Benthic	143.96		162.25		306.21	47.01	52.99
	Demersal	292.95		565.17		858.12	34.14	65.86
	Diadromous	0.00		6.01		6.01	0.00	100.00
	Industrial	1490.40		0.00		1490.40	100.00	0.00
	Pelagic	2639.66		1998.00		4637.66	56.92	43.08
All	All	4566.97		2731.43		7298.40	62.57	37.43

2003	2002 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	809.00	Herring	132.00	Redfish	941.00	85.97	14.03
2	Benthic	178.55	Nephrops Flounder Pandalus	218.68	Plaice Sole Anglerfish	397.23	44.95	55.05
2	Demersal	301.47	Haddock Saithe Whiting	212.86	Cod Whiting Hake	514.33	58.61	41.39
2	Diadromous			3.29	Salmon Sea trout	3.29	0.00	100.00
2	Industrial	1427.79	Sandeel Sprat Norw. pout			1427.79	100.00	0.00
2	Pelagic	629.10	Herring (North Sea) Horse mackerel	182.00	Herring (Baltic)	811.10	77.56	22.44
2	All	2536.91		616.82		3153.74	80.44	19.56
3	Benthic	44.94	Megrim	11.76	Sole Nephrops Anglerfish	56.70	79.26	20.74
3	Demersal			47.00	Hake	47.00	0.00	100.00
3	Pelagic	154.80	Sardine Anchovy Horse mackerel	17.50	Anchovy Biscay	172.30	89.84	10.16
3	All	199.74		76.26		276.00	72.37	27.63
1,2 and 3	Pelagic	2444.90	Mackerel Horse mackerel Blue whiting			2444.90	100.00	0.00
1,2 and 3	Demersal			206.99	Deep water fish	206.99	0.00	100.00
1,2 and 3	All	2444.90		206.99		2651.89	92.19	7.81

All	Benthic	223.49		230.44		453.93	49.23	50.77
	Demersal	301.47		466.85		768.32	39.24	60.76
	Diadromous	0.00		3.29		3.29	0.00	100.00
	Industrial	1427.79		0.00		1427.79	100.00	0.00
	Pelagic	4037.80		331.50		4369.30	92.41	7.59
All	All	5990.55		1032.08		7022.63	85.30	14.70

2.1.1.3 Advice concerning Autumn-spawning and Spring-spawning Herring in Kattegat/Skagerrak

In the following two answers there are references to four fleets (A-D).

The fleets fishing herring in the North Sea are defined as:

Fleet A: Directed herring fisheries with purse seiners and trawlers. Bycatches in industrial fisheries by Norway are included.

Fleet B: Herring taken as bycatch under EU regulations.

The fleets fishing herring in Division IIIa are defined as:

Fleet C: Directed herring fisheries with purse seiners and trawlers.

Fleet D: Bycatches of herring caught in the small-mesh fisheries.

There are two major herring stocks involved, i.e. North Sea autumn spawners (NSAS) and Western Baltic spring spawners (WBSS).

The herring fisheries in Division IIIa (Skagerrak and Kattegat) exploit both autumn-spawning herring from the North Sea and spring-spawning herring from the Baltic Sea together with some local stocks. The important components are those from the Baltic Sea and from the North Sea.

A variable, but relatively small amount (up to about 8000 tonnes) of WBSS herring is taken in the fishery in Division IVa. This is accounted for in both the assessments on NSAS and WBSS.

DG Fish has requested ICES to:

> *"Advise whether a TAC of 80 000 t for herring in the ICES Division IIIa for 2004 is consistent with the precautionary approach"*

ICES Comments

Because the herring TAC in Division IIIa influences exploitation of both NSAS and WBSS it is only possible to evaluate whether a particular Division IIIa TAC is in accordance with the precautionary approach when considering all catch components of these stocks. The calculations provided by ICES (see Section 4.4.9a (NSAS) and Section 4.4.9b (WBSS)) describe these links, and overall TAC levels consistent with the precautionary approach are recommended in these sections.

The shares of WBSS and NSAS in Division IIIa vary among years depending on the relative strength of the two populations.

In previous years, the main constraint on the fishery in Division IIIa was the concern for the North Sea autumn-spawning herring. This situation has changed since the North Sea autumn-spawning herring now is in a good state. Hence, quotas in Division IIIa, which include both stocks, may have to be constrained by the need to restrict the exploitation of Western Baltic spring spawners.

WBSS herring are exploited by other fleets as well, in Subdivision 22-24. The advice by ICES on WBSS is on total catches for the stock, covering all areas, but including only WBSS herring in these areas. Hence, to compute the catch of NSAS by fleet corresponding to a given total catch option for WBSS, the first step will be to estimate the amount this will correspond to for the C- and D-fleets. Lacking other information, this is based on the historical share of the total catch by these fleets.

The text table below shows the historical share of the total catch in tonnes of WBSS by fleet.

	Fleet C (IIIa)	Fleet D (IIIa)	Subdiv. 22-24	Total
2001	33429 (34%)	3101 (3%)	61832 (63%)	98362
2002	38161 (38%)	8731 (9%)	53647 (53%)	100539
2003	34382 (42%)	5287 (5%)	51931 (53%)	91601
Average	38%	6%	57%	

Next, this share has to be translated to the total catch of herring for both stocks (NSAS and WBSS) for each fleet by accounting for the fraction of NSAS in the catches by these fleets. Again, this has to be based on historic experience. The text table below shows the percentage of NSAS in the catches by fleet in Division IIIa:

	Fleet C	Fleet D
2001	51%	80%
2002	31%	51%
2003	43%	68%
Average	42%	65%

For 2005, ICES advises that catches for WBSS should not exceed 92 000 tonnes. That translates into a total catch (both stocks) by the C-fleet of 60 000 tonnes. Likewise, it translates into a total catch by the D-fleet of 16 000 tonnes. The 80 000 t TAC mentioned in the request is outside these boundaries.

DG Fish and Norway have requested ICES to:

> *"Advise on the consequences in terms of biological and sustainable development of the stocks, of allowing 50% of the TAC for herring in the Skagerrak and the Kattegat in 2004 to be taken in the North Sea in addition to the TAC of 460,000 tonnes set for the herring in the North Sea in 2004".*

<u>ICES Comments</u>

ICES has analysed the effects as a partial transfer from fleet C to fleet A, which has implications for the exploitation of the stocks since the C-fleet exploits both North Sea autumn spawners (NSAS) and Western Baltic spring spawners (WBSS), while fleet A in the North Sea takes only few western Baltic herring.

There is no firm basis for predicting the fraction of NSAS in the catches of the C-fleet in future years. The ratio depends on the abundance of each stock in the area, which for NSAS is related to the strength of incoming year classes, but also to where and when the fishery is conducted. Hence, the assumption was made that the fraction would be an average over the last 3 years. The text table below shows the percentage of NSAS in the catches in recent years, and the average over the last 3 years.

	Fleet C	Fleet D
2001	51%	80%
2002	31%	51%
2003	43%	68%
Average	42%	65%

Thus, one tonne of the C-fleet total quota can be assumed to represent 0.42 tonnes of catch of NSAS. A transfer of one tonne would then imply that the catch of NSAS by the C-fleet is reduced by this amount, while the catch by the A-fleet is increased by one tonne.

For 2004 the agreed TAC for the directed fishery in Division IIIa (C-fleet) is 70 000 tonnes, of which 50% can be taken in the North Sea. This implies a transfer of 35 000 tonnes from the C-fleet to the A-fleet. Assuming that 42% of the catch by the C-fleet is NSAS, a transfer of 35 000 tonnes leads to a reduction in the outtake of NSAS by the C-fleet of approximately 15 000 tonnes, and an increase in the outtake by the A-fleet of 35 000 tonnes.

The situation is complicated by misreporting by areas. In recent years, the HAWG in its calculations has assumed that a substantial part of the catch reported as having been taken in Division IIIa was actually taken in Subarea IV. These catches have been allocated to the North Sea stock and accounted under the A-fleet. Thus, the very low partial fishing mortality by the C-fleet represents an estimate, to the best of the Working Group's ability, of the real outtake of NSAS in Division IIIa.

On this background, there is no obvious way of foreseeing how the agreed transfer will affect current practice. In particular, it is not clear to what extent this will lead to an increase in the real outtake of NSAS in the North Sea, or a real reduction in Division IIIa.

The effect of the transfer on the NSAS stock will be modest in the short term, irrespective of historic fishing practices. Adding 35 000 tonnes of catch to the A-fleet (where the $\mathbf{F_{sq}}$ already accounts for the estimated misreporting from Division IIIa), leads to an increase in $\mathbf{F_{2\text{-}6}}$ from 0.24 to 0.26, resulting in the SSB in 2004 being reduced by about 1%. The effect of the transfer on the exploitation of WBSS will, at the most, be a reduction of a similar modest magnitude.

2.1.1.4 Ecosystem Impacts of Industrial Fisheries

Request

The original request from the European Commission, Directorate General for Fisheries, is dated 31 July 2002. It was later qualified following correspondence between the EC Directorate General for Fisheries and the General Secretary of ICES. The original request and the qualified request are given below. The request was addressed in part in the 2003 ACE report (ICES, 2003a), and it was recommended that the work should be completed in 2004.

Following additional correspondence between ICES and EC DG Fisheries, ICES was asked to look at the issue of the Baltic fisheries for industrial purposes and their direct and indirect effects on the ecosystem, and to comment further on the specific request from the EC to *"Evaluate the relative benefits (in terms of economic and of ecological efficiency) of fishing 'industrial' fish for fish meal and using the product as feed, or of not fishing these species and obtaining higher yields from commercial fisheries"* (ICES letter to Mr John Farnell, EC DG Fisheries, 3 December 2003).

ICES also took the opportunity to review and comment further on the ecosystem impacts of industrial fisheries in the blue whiting fisheries, and to report new information.

The request from the European Commission, Directorate General for Fisheries, of 31 July 2002, concerning the ecosystem impacts of industrial fishing states:

We would like ICES to review the state of the knowledge about the impacts on the ecosystem of the current industrial fisheries in the ICES area. The study should cover the following areas:

1. *The removal of very large quantities of biomass from the sea and its effect on the global economy of the ecosystem;*

2. *The effects on the availability of food for important predators (other commercial fish important for human consumption, sensitive species such as marine mammals, birds, etc.);*

3. *The estimated by-catch of other commercial species and its effect on the sustainability of the stocks;*

4. *The economy (in energetic and value terms) of fishing for protein to convert it into more valuable protein in farming processes;*

5. *The relative contribution of industrial fisheries to habitat degradation as compared to other fishing activities.*

The request of 31 July 2002 was further qualified following correspondence between the EC Directorate General for Fisheries and the General Secretary of ICES, as follows:

ICES is requested to:

1. *Evaluate the effect of industrial fisheries at recent levels of fishing mortality on:*

   - *Yield and stock size of relevant and commercially important human-consumption fish,*
   - *Fauna such as marine mammals and seabirds.*

Effects should be evaluated in terms of predation, food availability and growth limitation, predation on larvae, competition, mortality due to incidental by-catches and any other effects that may be considered significant.

2. Evaluate the relative benefits (in terms of economic and of ecological efficiency) of fishing "industrial" fish for fish meal and using the product as feed, or of not fishing these species and obtaining higher yields from commercial fisheries.

3. *Comment on any major structural changes in marine ecosystems, including changes to habitat, that may be caused by fishing for industrial species, and significant consequences for fisheries or the marine environment.*

4. *For the purposes of the above, "industrial fish" means sandeel, blue whiting, Norway pout and sprat. "Human consumption" fish means all other species covered by TACs in the north-east Atlantic.*

Source of information

The 2004 report of the Working Group on Ecosystem Effects of Fishing Activities (WGECO) (ICES 2004a).

Summary

Baltic industrial fisheries

The industrial fishery for sprat in the Baltic Sea takes variable amounts of herring as by-catch and a directed herring fishery can take sprat as by-catch depending on the region. In Russia and Latvia, sprat is generally used for human consumption, but it is mainly directed to fish meal/oil production in Swedish, Danish, Polish, and Finnish landings. Herring is used both for fish meal/oil production and for human consumption. In general, the sprat and herring fisheries in the Baltic are thought to have little or no discarding of by-catch species.

It is a major problem to distinguish between the fraction of the catches in the pelagic fisheries that is landed for human consumption and the fraction that is used for reduction, because the fractions show large variations between countries and are also influenced by the market situation, and these variations are believed not to be reflected in the official landing statistics. Due to a lack of data, it is therefore not possible at present to make an assessment of the effect of industrial fisheries on the by-catch species in the Baltic Sea. However, some isolated pieces of information are available:

- ICES (2001a) has tentatively determined that the total share of by-catch of cod in the combined sprat and herring fisheries in the years 1998–2000 was within the range of 1,300–2,000 tonnes, to be compared to cod landings of 100,000–130,000 tonnes in the Baltic in the same period.

- The bulk of sprat industrial catches is taken at deep waters during the first and second quarters, with an estimated herring by-catch of 1–8%; in other seasons, occasional herring by-catch may amount to 35% by weight in coastal areas.

- Sampling indicates that most Danish pelagic catches in the Baltic are taken in targeted fisheries for sprat or herring, with relatively low by-catch of the other species.

The fish community in the open parts of the Baltic Sea is dominated by just three species: cod, herring, and sprat. Presently the abundance of cod is low, herring stocks are increasing, and the sprat stock is at a high level. It would therefore seem unlikely that industrial fisheries for its prey species are negatively affecting the food basis for the cod stock. However, by-catches of cod in the mixed pelagic fisheries are a concern in a situation where the cod management plan prescribes cod catches from the eastern Baltic cod stock to be as low as possible. The estimates available from 1998–2000 are uncertain and recent information on the extent of such by-catches is not available. ICES has provided advice in accordance with the cod management plan; see Section 3.8 of this report.

There are no records of by-catch of seabirds, seals, or harbour porpoises in any form in the industrial fisheries in the Baltic. From the information available, it is not likely that the industrial fishery on sprat is limiting the availability of food for seabirds. No information was available which could be used for the assessment of the effects of the industrial fisheries in the Baltic on food availability for marine mammals.

Recently, patterns of human consumption of sprat and herring have changed due to problems with dioxins. The Danish directed herring fishery in the Baltic Proper has been prohibited from May 2004 due to dioxin levels above prohibition limits and this problem will most certainly affect other herring fisheries as well. Sprat has higher reported concentrations of dioxins than herring. This has implications for the utilization of Baltic sprat and herring for fish meal and fish oil. Fish meal factories have recently introduced facilities to clean fish oil and are establishing facilities to extract dioxin from the fish meal. Dioxin will still affect the quality of the food supply for the predators on sprat and herring. There is no observed decrease in the dioxin concentrations in Baltic herring, and the source of exposure remains obscure.

Blue whiting

Population genetic studies have indicated partially separated stocks of blue whiting, and the lack of information on blue whiting populations and ecology is of concern, given that the species is heavily exploited. The total size of the blue whiting stock(s) indicates that the species is an important predator on lower trophic levels, and that it may be an important prey species for larger fish and other predators. However, there is little information on the indirect effects of the fisheries for blue whiting on its prey and predators. No published information has been found on the composition of the by-catch in the large, directed fisheries for blue whiting in the Northeast Atlantic.

<u>*The relative benefits, in terms of ecological efficiency, of fishing "industrial" fish for fish meal and using the product as feed, or of not fishing these species and obtaining higher yields from commercial fisheries*</u>

The production of fish protein for human consumption in aquaculture systems relies heavily on feed pellets, which are generally derived from lower trophic level fish harvested in "industrial fisheries". A study by ICES taking into account the composition of food pellets, the transfer efficiency in aquaculture systems, and the transfer efficiency and composition of natural marine food webs shows that if the only concern is about the efficiency of converting sandeel biomass to human consumption biomass, then the exploitation of sandeels by industrial fisheries for the aquaculture industry is at least as efficient ecologically. Furthermore, there is no evidence to support the contention that ceasing industrial fisheries will stimulate catches in the human consumption fisheries. If fisheries management results in a recovery of the currently depleted predator stocks in the North Sea, this conclusion would need revisiting. Model analysis of food conversion efficiency suggests that a closely regulated combination of industrial and human consumption fisheries may provide the only solution to the long-term demand for fish protein.

Recommendations and advice

Sprat and herring are large, important fisheries for the Baltic Sea countries. The paucity of information on the Baltic sprat and herring fisheries, particularly in relation to geo-location of catch, and the relatively low catch sampling effort prevent complete evaluation of the ecosystem effects of these fisheries. Given that these fisheries take considerable biomass from the Baltic ecosystem, this is of major concern and needs to be addressed, as discussed in Section 3.8 of this report.

In order to assure the usability of sprat and herring catches in the Baltic ecosystem both for human consumption and for fish feed uses, and to reduce the delivery of hazardous substances to higher predators in the ecosystem, the dioxin content should ideally be reduced in small pelagic species. The source of exposure to herring and sprat needs to be identified, and the anthropogenic source(s) of dioxins controlled. There is a HELCOM Objective (with regard to Hazardous Substances) in place to prevent pollution of the Convention Area by continuously reducing discharges, emissions, and losses of hazardous substances towards the target of their cessation by the year 2020, with the ultimate aim of achieving concentrations in the marine environment near background values for naturally occurring substances and close to zero for man-made synthetic substances.

Considering the abundance of blue whiting, and the fact that this species is simultaneously both an important predator and an important prey species, it is likely that blue whiting fulfills an important structural role in the food web on the shelf and slope and in the pelagic food web in the open sea. Research into the role of blue whiting in the ecosystem is therefore necessary.

No information was found on the by-catch in the Northeast Atlantic blue whiting fishery. While this may mean that the by-catch is insignificant, without data it is not possible to confirm this. To understand the ecosystem effects of fishing, information on the full catch is needed.

The impact of the industrial fishery on sandeel abundance should be carefully monitored as industrial fisheries continue to operate. This monitoring should be carried out at spatial and temporal scales that are relevant to the predators in question, which may or may not be recovering. Managers must ensure that food supplies for gadoids and other marine predators do not become limiting as a result of anthropogenic activities. This will ensure protection of ecologically dependent species, such as kittiwakes, and will provide adequate food for recovering gadoid populations.

Scientific background

2.1.1.4.1 Baltic industrial fisheries

The principal industrial feed-fish fisheries in the Baltic is a sprat fishery, which takes variable amounts of herring as by-catch. This fishery is considered a mixed fishery. However, sprat catches in the deep basins of the central Baltic are relatively clean of herring. There is also a directed herring fishery which can take sprat as by-catch depending on the region of the Baltic being fished.

It is difficult to state categorically that herring and sprat in a specific fishery or area are used for fish meal/oil production or for human consumption, as the ultimate use of the fish is driven to a large extent by market forces (B. Sjöstrand, pers. comm.).

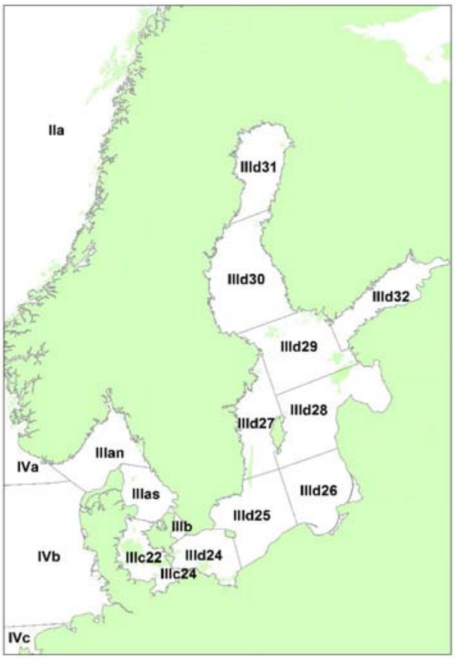

Figure 2.1.1.4.1.1 Map of the Baltic Sea and the ICES Subdivisions.

2.1.1.4.1.1 Description of the industrial fisheries

Fisheries for sprat

Sprat (*Sprattus sprattus*) is distributed through most of the Baltic Sea and is generally regarded as a single stock. Sprat spawns in open waters in the Baltic Proper, the Gulf of Riga, and the Gulf of Finland between March and August. The Gulf of Bothnia is not saline enough for sprat to spawn in.

The sprat stock is managed by one TAC agreed for the whole Baltic, and ICES classifies the stock (in Subdivisions 22–32) as being inside safe biological limits (ICES, 2003b). During the 1990s, total catches increased considerably, from 85,000 t in 1990 to 530,000 t in 1997. The increase in catches since 1992 is due to the development of the industrial pelagic fishery. In 2002, sprat catches were very similar to the 2001 level, amounting to 343,200 t. Landings were, however, 35% less than the record high level of 530,000 t in 1997. In 2002, the TAC of 380,000 t set by the International Baltic Sea Fishery Commission (IBSFC) was not realized. Pelagic trawling accounts for most of the catches. In general, it is reported that the sprat fishery is prosecuted by trawls with mesh <32 mm.

Fished sprat can be utilized for either human consumption or for feed, but it is mainly directed to fish meal/oil production in Swedish, Danish, Polish, and Finnish landings. In Russia and Latvia, sprat is generally used for human consumption (A. Dolgov, pers. comm.). Recently, patterns of human consumption of sprat (and herring) have changed due to problems with dioxins in the fish.

Fisheries for herring

Herring (*Clupea harengus*) is managed by two TACs: Subdivisions 22–29S, 32 and Subdivisions 29, 30, 31. The fishing mortality on herring has increased throughout the late 1990s (STECF, 2004). ICES classifies the stock in the Gulf of Riga as being inside safe biological limits, whereas herring in Subdivisions 25–29 and 32 (excluding Gulf of Riga herring) is considered to be harvested outside safe biological limits (ICES, 2003b; STECF, 2004). Landings in 2002 in Subdivisions 25–29 (excluding the Gulf of Riga) and Subdivision 32 were reported at 129,300 t. Harvey *et al*. (2003) determined that fishing was the chief source of mortality on herring using ECOPATH/ECOSIM modelling. However, a reduction in the biomass is not solely attributed to fishing mortality, but also, for example, to extrinsic drivers affecting recruitment (e.g., Harvey *et al*., 2003; Rahikainen *et al*., 2003). The herring trawl fisheries are generally prosecuted using a mesh size of 32–40 mm using pelagic trawls (ICES, 2000b, 2003g). A fraction of the landed herring is taken with trap nets/pound nets and gillnets during spawning time and with insignificant by-catches of sprat (ICES, 2003g).

Herring is used for either fish meal/oil production or human consumption. In Russia, herring is generally used for human consumption purposes, while in Sweden it is used for either fish meal/oil production or human consumption depending on market conditions (B. Sjöstrand, pers. comm.). Only a few Finnish vessels are reported to take herring exclusively for human consumption and approximately 70% of landings are used in animal feed (ICES, 2000b), while herring taken by Denmark and Poland usually goes to fish meal/oil production (EP, 2004).

2.1.1.4.1.2 Effects of industrial fisheries

2.1.1.4.1.2.1 Direct effects of industrial fisheries on fish

In general, the sprat and herring fisheries are thought to have little or no discarding of any by-caught species (ICES, 2000b) since the volume of catches (300–400 tonnes per trip) precludes sorting.

A major problem is to distinguish between the fraction of the catches in the pelagic fisheries that is landed for human consumption and the fraction that is used for reduction. These fractions show large variations between countries and are also influenced by the market situation. This variation is not believed to be reflected in the official landings statistics. Consequently, distinguishing between pelagic landings for human consumption and those for reduction is presently not possible for the pelagic fisheries in the Baltic Sea as a whole. Furthermore, detailed information about the species composition in the pelagic fisheries is only sporadically reported and is likely to be biased for some of the fisheries. For example, ICES (2003g) states that the separation of herring and sprat in the catches in the mixed fishery for herring and sprat is imprecise. Further, due to misreporting of sprat and herring landings, the Baltic Fisheries Assessment Working Group (ICES, 2003g) recommends that species compositions of the landed pelagic fish be historically re-evaluated/revised at national level. The proportion of herring in landings and in the Baltic Sea surveys is highly variable between countries and subdivisions, indicating that information on a detailed temporal and spatial level regarding species compositions in the pelagic fisheries will have to be available for all the countries to be able to estimate the total by-catch in these fisheries.

Due to a lack of data, therefore, it is presently not possible to make an assessment of the effect of industrial fisheries on the by-catch species in the Baltic Sea. A description of the information available about by-catches in the Baltic Sea pelagic fisheries is presented and discussed below.

Direct cod by-catch in the sprat/herring fisheries

ICES (2001a) utilized the International Baltic Sea Sampling Programme (IBSSP) to assess cod by-catches in total pelagic fisheries in the Baltic and calculated the values of by-catch and discard of cod in combined weight of herring and sprat samples, stratified by year, country, quarter, and subdivision. The spatial and temporal distribution of cod by-catch in the herring and sprat fisheries in the Baltic was thought to relate to the co-occurrence of the three species on cod and sprat pre-spawning and spawning grounds. Between the years 1998 and 2000, the highest by-catches of cod in the herring and sprat fisheries were observed in the first and second quarters. The highest by-catch occurred in Subdivisions 24–26. The estimated total by-catch of cod in combined sprat and herring fisheries in the years 1998, 1999, and 2000 amounted to 1,340 t, 1,524 t, and 2,091 t, respectively. ICES (2001a) expressed concern that it was not possible to evaluate how much cod by-catch was recorded in the official catch statistics and considered these results as tentative only. No by-catches of cod have been taken in Finnish pelagic trawl fisheries in recent years (ICES, 2004d).

Herring by-catch in the sprat fishery

The fishery in Subdivisions 22–32 directed at sprat is known to have a by-catch of herring. In the bulk of the industrial fishery for sprat in the deep areas of the Baltic Sea, by-catch was estimated at between 5–8% in Polish landings (ICES, 1999) and between 1–5% in Russian landings (ICES, 2004). In coastal areas, recent estimates of herring by-catch in the small-vessel Russian fleet were 4–29% and by-catch has elsewhere been estimated at up to 35% by weight (reported in STECF, 2004). Finland reported that in the directed sprat fishery (Subdivisions 26, 28), more than half of the herring landings are taken as by-catch in the directed fishery (ICES, 2000b).

By-catches in the Danish pelagic fisheries in the Baltic (ICES, 2002b)

The Danish pelagic fisheries in the Baltic are categorized into two fleets: industrial and human consumption. The categorization is made on the basis of the mesh size used: vessels fishing with mesh sizes of 32 mm or less are regarded as fishing for industrial purposes (i.e., for reduction to fish meal and oil), whereas those with larger mesh sizes are regarded as fishing for human consumption purposes. These classifications are not exact, as catches made by the "human consumption" fleet are sometimes used for meal and oil production depending on the market price and condition of the catch.

The estimates of the total catches by species are based on the reported species composition, which is verified by samples taken for enforcement purposes. Details of samples taken for this purpose in 2000 and 2001 are summarized in Table 2.1.1.4.1.2.1.1. The large majority of samples is consistent with a targeted sprat fishery, with catches in excess of 80% sprat; indeed, more than 50% of the samples in both years consist of at least 95% sprat. Of the remaining samples, a few can be attributed to a directed herring fishery, or to a small-bait fishery for sandeel to the east of Bornholm. This leaves nine samples which are not attributed to any of the other categories. Details of these samples are given in Table 2.1.1.4.1.2.1.2.

Of the uncategorized samples, the April 2000 sample is consistent with a directed herring fishery, as in excess of 88% of the sample consisted of herring. The six samples from Subdivision 22 contained variable proportions of sprat and herring as well as a small whitefish by-catch. The fishery in Subdivision 22 may thus best be characterized as a mixed pelagic fishery. The minimum legal mesh size in this area is 32 mm. This subdivision accounted for 10.3% of the total Danish landings of herring and sprat in 2000, and 22.5% in 2001. Of the other two uncategorized samples, one came from Subdivision 25 in May 2001. Three other samples are available from Subdivision 25 in May 2001. These all indicate catches in excess of 90% sprat, indicating that "mixed" catches may be unusual from this area and season. The remaining sample came from Subdivision 28 in December 2000. No other samples are available from Subdivision 28 in December; however, all other samples from Subdivision 28 indicate catches of sprat in excess of 95%.

On average, 1.1 samples were obtained per thousand tonnes of sprat and herring landed in 2000 and 1.2 were obtained in 2001. Details of the age sampling are given in Table 11.2.2 in ICES (2003g). According to the EC data directive, a minimum of one sample per 2000 tonnes landed must be collected. The Danish sprat fishery in the Baltic Sea takes place over a relatively short period and a small number of large vessels take by far the largest proportion of the Danish catches.

In summary, the evidence from sampling in 2000 and 2001 indicates that most Danish pelagic catches in the Baltic are taken in targeted fisheries for sprat or herring, with relatively low by-catch of the other species. The clear exception to this is Subdivision 22, where all samples indicate that the fishery in that area should be regarded as a mixed pelagic fishery.

Table 2.1.1.4.1.2.1.1. Summary of species compositions from samples from Danish pelagic catches reported from the Baltic in 2000 and 2001.

Number of samples	2000	2001
Number with 95% or more sprat	33	22
Number with between 90% and 95% sprat	11	5
Number with between 80% and 90% sprat	3	6
Number with 90% or more herring	3	1
Number with 90% or more sandeel	5	1
Others (see Table 2.1.1.4.1.2.1.2)	2	7
Total	57	42

Table 2.1.1.4.1.2.1.2. Details of samples described as "others" in Table 2.1.1.4.1.2.1.1.

Year	Month	Subdivision (Rectangle)	% Sprat	% Herring	% Other
2000	4	24 (37G2)	10.6	88.7	0.6 (cod)
2000	12	28 (42G8)	74.7	25.3	-
2001	4	22 (37G1)	10.4	72.4	17.2 (whiting+cod)
2001	4	22 (38G0)	17.8	65.0	17.2 (whiting +cod)
2001	4	22 (37G1)	45.9	49.7	4.4 (whiting +cod)
2001	5	25 (39G5)	68.5	30.3	1.2 (cod)
2001	8	22 (40G0)	78.7	16.9	4.1 (whiting +cod)
2001	8	22 (39F9)	14.7	76.3	9.0 (whiting +cod)
2001	10	22 (37G1)	69.6	29.0	1.3 (whiting +cod)

Conclusions

The issue of by-catch and assessment of the species composition in the Baltic Sea is complex and, when coupled with the apparent problems with landings data and misreporting of pelagic fish catches, it is impossible at this time to quantify by-catch. For example, detailed information obtained by ICES (2002b) shows that in Subdivision 22, percentages of sprat in 2001 ranged from 10.4–78.7% in the samples; however, the landings data available to the Working Group were aggregated at a coarse level (for all countries) that did not allow further analysis. It cannot be stated that the conclusions presented for the short-term Danish pelagic fisheries and the report on cod by-catch in the Baltic Sea are representative for the rest of the pelagic fisheries in the Baltic Sea. Detailed data on species composition and the catches are needed in order to analyse the direct effects of fishing for industrial species in the Baltic Sea.

2.1.1.4.1.2.2 Indirect effects of industrial fisheries on fish

The Study Group on Multispecies Assessment in the Baltic (ICES, 2003e) has summarized the main feeding relationships in the Baltic Sea. The fish community in the open parts of the sea is dominated by just three species: cod, herring, and sprat. The abundance of the cod stock in the Main Basin is currently low, herring stocks are increasing, and the sprat stock is at a high level. The effect of cod on prey species (herring and sprat) is therefore now at a low level. While cod biomass is low, there is the potential for herring and sprat to have an adverse effect on cod recruitment through the consumption of cod eggs and larvae. Predation mortality of sprat showed a continuous decline from the mid-1970s to the early 1990s, then levelled off. Trends in predation mortality of herring follow closely those described for sprat, but predation mortality has never been as high as that for sprat. On this basis, it would seem unlikely that industrial fisheries for the prey species (sprat, herring) are negatively affecting the predator (cod); indeed, it is possible that the inverse is true, as fisheries for sprat and herring might reduce the consumption of cod eggs and larvae.

2.1.1.4.1.2.3 Effects on seabirds

Direct effects of fisheries for Baltic sprat/herring on seabirds

The Working Group on Seabird Ecology reviewed pressures on seabirds in the Baltic in 2004 (ICES, 2004b). By-catch in industrial fisheries was not viewed as a pressure on seabird populations. A number of national or regional investigations of seabird by-catch have been undertaken, focusing mainly on gillnet fisheries (Hario, 1998; Urtans and Priednieks, 2000; Dagys and Zydelis, 2002; Stempniewicz, 1994; Kirchhoff, 1982; Schirmeister, 2003). There are no records of by-catch of seabirds in any form of industrial fishery in the Baltic Sea.

Indirect effects of industrial fisheries on seabirds

There have been no studies of possible indirect effects of industrial fishing in the Baltic Sea. There are few studies of seabird diet in the Baltic, with most records being anecdotal. One study in the mid 1990s of common guillemots (*Uria aalge*) by-caught in gillnets showed that the dominant prey item was sprat (Lyngs and Durinck, 1998). It has been suggested that cod exhibits a top-down control on sprat biomass (Harvey *et al*., 2003). Given the current low biomass of cod in the Baltic, there is probably a reduction in predation on sprat; indeed, the biomass of sprat in the Baltic is high

(ICES, 2003b) and is probably limited by bottom-up effects. It is likely that seabirds in the Baltic are not affected by the industrial fisheries mortality on sprat.

2.1.1.4.1.2.4 Effects on marine mammals

Direct effects of industrial fisheries on marine mammals

ICES reviewed the status of marine mammals in the Baltic in 2003 (ICES, 2003f). No by-catch in any form of industrial fisheries has been recorded, either for seals or harbour porpoises. A further review by ASCOBANS (Kaschner, 2003) of by-catch of harbour porpoise found no records of that species being by-caught in industrial fisheries in the Baltic.

Indirect effects of fisheries for Baltic sprat/herring on marine mammals

No studies of marine mammal diet in the Baltic were found in the time available to ICES to allow assessment of the indirect effects of the fisheries for sprat/herring.

2.1.1.4.1.2.5 Effects on seabed habitats and benthos

The towed demersal gear used in both the mixed sprat and the herring fishery comes into contact with the seabed, and almost certainly disturbs the sub-surface sediment layers. This may have physico-chemical and biological implications likely to affect the ecosystem. However, changes in the benthic habitat as a result of demersal gears used in the industrial fisheries have not been demonstrated. An analogous study (Rumohr and Krost, 1991) documented the biological responses of the invertebrate community in the Kiel Bay (Western Baltic) to otter trawling activity; thin-shelled bivalves (*Abra alba*, *Mya* spp., and *Macoma calcarea*) and starfish (*Asterias rubens*) showed damage as a result of trawling, but the thick-shelled bivalves (*Astarte borealis* and *Corbula gibba*) seemed to be more resistant to mechanical stress caused by bottom trawling. Studies are needed to quantify the impact of the industrial fisheries in the Baltic region on seabed habitats and benthos.

2.1.1.4.1.2.6 Dioxins in Baltic sprat and herring

Dioxins refer to a group of chemical compounds that share certain chemical structures and biological characteristics. Several hundred of these compounds exist and are members of three closely related families: the chlorinated dibenzo-*p*-dioxins (PCDDs), chlorinated dibenzofurans (PCDFs), and certain polychlorinated biphenyls (PCBs). The toxic effects of these substances include carcinogenic potency, immunosuppression, and reproductive toxicity (Baars *et al*., 2004). They are lipophilic compounds and accumulate in the food web (Karl *et al*., 2002).

The European Commission has endorsed the World Health Organization's initiative of establishing maximum dioxin levels (EC Directive 102/2001). The EC Directive contains the corresponding action values, setting limits for dioxin concentrations in fish oils, fish meal, and fish feeds (Table 2.1.1.4.1.2.6.1). The levels established apply to both feed fish and fish destined for human consumption.

Table 2.1.1.4.1.2.6.1. Limit and action values for dioxins in feedingstuffs.

Feedingstuff	**Maximum dioxin concentration relative to a feedingstuff with a moisture content of 12% (in ng kg^{-1})**	
	Limit value	**Action value**
Fish oil	6.00	4.50
Fish, their products and by-products	1.25	1.00
Compound feeds	0.75	0.40
Feeds for fish	2.25	1.50

Source: EC Directive 102/2001 and EC Directive 2002/32.

The dioxin levels measured in herring older than four or five years old have been above the level allowed by the European Commission for human consumption (4 pg WHO PCDD/F-TEQ g^{-1} fresh weight) (reported in ICES, 2003g). The Danish directed herring fishery in the Baltic Proper (East of Bornholm) was prohibited from 28 May 2004 due to dioxin content (according to Commission Regulation 466/2001, 8 March 2001), being both above action limits (3 ng WHO-PCDD/F-TEQ kg^{-1} fat weight) and prohibition limits, and this problem will most certainly affect other herring fisheries as well. If the dioxin content remains at high levels, it is anticipated that after the year 2006, the herring of the Bothnian Sea can no longer be utilized for human consumption (ICES, 2003g).

There are also implications regarding the utilization of herring and sprat for the production of fish meal and fish oil. The limits in Table 2.1.1.4.1.2.6.1 mean that a product such as fish oil or fish meal with a contamination level above the corresponding maximum limit will not be allowed for use in the production of feedingstuffs (e.g., fish oil with a dioxin contamination level of above 6 ng kg^{-1} or fish and fish meal with a dioxin contamination level above 1.25 ng kg^{-1} whole weight). PCBs, PCDDs, PCDFs, and other dioxin-like compounds have been found in sprat and herring in the Baltic (Strandberg *et al*., 1998; Vuorinen *et al*., 2002). Sprat and herring from regions of the Baltic Sea have the highest dioxin content compared to fish taken from other fishing grounds (regions of the North Sea, Ireland, and Norway) (Karl *et al*., 2002; Vuorinen *et al*., 2002). Sprat has higher reported concentrations of dioxins than herring, especially in the oil (Vuorinen *et al*., 2002). Fish oil provides an important nutritional supplement in fish pellets, and the concentrations of dioxins in lipid are greater than in the fresh tissue (Vuorinen *et al*., 2002). Fish oils with dioxin concentrations greater than 6 ng kg^{-1} have been reported (EP, 2004; Karl *et al*., 2002), necessitating expensive carbon filtration methods to remove the dioxins.

Kiviranta *et al.* (2003) reported that there has been no observed decrease in the dioxin content in Baltic herring, and the source of exposure of herring to PCDD/Fs and PCBs, air-zooplankton versus sediments-zooplankton or sediments-crustaceans, remains obscure.

If the long-term objective is to assure the usability of sprat and herring catches for human consumption and fish feed uses, and to reduce the delivery of toxic substances to higher predators in the ecosystem, the dioxin content should ideally be reduced in small pelagic species. The source of exposure to herring and sprat needs to be identified, and the anthropogenic source(s) of dioxins controlled. There is a HELCOM Objective (with regard to Hazardous Substances) in place to prevent pollution of the Convention Area by continuously reducing discharges, emissions, and losses of hazardous substances towards the target of their cessation by the year 2020, with the ultimate aim of achieving concentrations in the marine environment near background values for naturally occurring substances and close to zero for man-made synthetic substances.

2.1.1.4.2 Blue whiting

2.1.1.4.2.1 Description of the fishery

A more complete account of the ecosystem effects of the blue whiting fisheries is found in the 2003 ACE report (ICES, 2003a).

The main blue whiting fishery occurs in deeper shelf-slope waters to the west of Scotland, Ireland, around the Faroes, and towards Iceland. In the North Sea, the fishery for the most part occurs in the Norwegian Trench to the south and west of Norway. The fishery in the Northeast Atlantic is considered to be largely unregulated. Estimates of blue whiting by-catch/discarding in other fisheries are poor, although the species is reported as a significant constituent of catches; e.g., Pierce *et al*. (2002), in a short study in the North Atlantic, reported that approximately 10% of the overall catch in the argentine (*Argentina silus*) fishery consisted of blue whiting.

2.1.1.4.2.2 Direct effects: by-catch

Heino *et al*. (2003) reported average annual landings from the mixed Norway pout / blue whiting fishery in ICES Divisions IVa,b and IIa (North Sea and Norwegian Sea) in 2000–2002 of 109,000 t. Catches were dominated by the target species blue whiting and Norway pout. Blue whiting formed an estimated 58% of this catch, whilst Norway pout formed approximately 27%. The catches were dominated by fish of age one year, which were almost entirely juvenile blue whiting. 0-Group blue whiting started to appear in the catches during the third and fourth quarters of the year. The estimated numbers of 0-group blue whiting in the catches of the industrial fishery were 4.5×10^7, 4.0×10^6, and 1.2×10^8 individuals in 2000, 2001, and 2002, respectively. These numbers were not considered significant in comparison to the total recruitment to the stock (ICES, 2002a). However, Heino *et al*. (2003) noted that some of the blue whiting in the area fished may represent local populations, which could then be affected more strongly by the fishery. There is a need to assess the population distribution and recruitment patterns of blue whiting in EU waters. The remaining 15% of the catch, or about 16,000 t, consisted of a range of fish and invertebrates. The six most important by-catch species (in terms of landed catch) were saithe, herring, haddock, horse mackerel, whiting, and mackerel, each of which represented an annual catch of at least 1000 t in this fishery. Greater numbers of saithe were caught in the third and fourth quarters, and horse mackerel in the fourth quarter. Of the by-caught species, most individuals captured were in the length range of 25–40 cm, with herring and mackerel often slightly smaller, and saithe slightly larger. This length distribution suggests that the by-catch of herring and mackerel consisted primarily of juvenile individuals. Heino *et al*. (2003) noted that this may be a significant source of mortality on the non-target species and recommended that additional research be carried out, with increased sample size and over a longer period of time.

No published information was found on the composition of the by-catch in the larger, directed blue whiting Northeast Atlantic fishery.

2.1.1.4.2.3 Indirect effects

There are few or no assessments on the indirect effects of fishing for blue whiting on predators and prey. The species preys on zooplankton (Plekhanova and Soboleva, 1981; Plekhanova, 1990), decapod crustaceans, including *Meganyctiphanes norvegica* (Cabral and Murta, 2002; www.fishbase.org). Blue whiting also preys on fish (Dolgov, 2001; Dumke, 1983; Zilanov, 1984). In turn, blue whiting is an important prey for many fish species (Cabral and Murta, 2002; Bjelland *et al*., 2000; Hill and Borges, 2000; www.fishbase.org; Silva *et al.*, 1997) and marine mammals (Desportes and Mouritsen, 1993; Bogstad *et al*., 2000).

The lack of information on blue whiting populations and ecology when the species is heavily exploited is of concern. The current estimates of spawning stock biomass and fishing mortality are considered to be uncertain and the combined stock (Sub-areas I–IX, XII, and XIV) is likely to be harvested outside safe biological limits (ICES, 2003b). Furthermore, population genetic studies have indicated that partially separated stocks exist in the Mediterranean and in the Barents Sea (Giæver and Mork, 1995; Giæver and Stien, 1998; Mork and Giæver, 1993). If there are some relatively local stocks, the overall catch depletions could conceal community extirpation of a valuable prey resource to higher predators. The lag between loss of a local blue whiting stock and recruitment from another area is unknown. If the species is an important predator of zooplankton and small mesopelagics, and a prey for larger fish, considering its high abundance in some regions, it is likely to play an important role in the pelagic ecosystem (Heino and Godø, 2002). To reiterate the advice of ICES in 2003 (ICES, 2003a), further investigation of these ecosystem function aspects is of paramount importance.

2.1.1.4.3 Evaluation of the relative benefits, in terms of ecological efficiency, of fishing “industrial” fish for fish feed for the aquaculture industry, or of not fishing these species and obtaining higher yields from “human consumption” fisheries

2.1.1.4.3.1 Introduction

This section addresses the question: what is the most efficient way, from an ecological perspective, of utilizing lower trophic level fish resources? Is it more effective to harvest low trophic level species in industrial fisheries and convert the biomass obtained to human consumption fish protein in aquaculture systems, or is it better to leave low trophic level fish in the sea where they can be consumed by their natural predators, and then to harvest species from higher trophic levels in fisheries for human consumption?

The production of fish protein for human consumption in aquaculture systems relies heavily on feed pellets, which are generally derived from lower trophic level fish harvested from marine ecosystems by what are termed “industrial” fisheries (Naylor *et al*., 2000). In the North Sea, the exploitation of sandeels by the industrial fishery gives rise to the largest single-species annual catch, exceeding 1 million tonnes in some years, and accounting for around 40% of the total quantity of fish landed each year. Sandeels contribute approximately 80% of the total industrial fishery each year. Consequently, the remainder of this section focuses on the exploitation of sandeels by both the industrial fishery and their natural predators, and their use in the aquaculture industry.

2.1.1.4.3.2 Transfer efficiency in natural marine food webs

The transfer efficiency of both energy and carbon between trophic levels along a food chain is not 100% efficient. Energy is required for metabolism and maintenance and only a fraction of the food consumed by a predator is actually converted to predator biomass. Estimates of transfer efficiency vary from 10% (Lindeman, 1942; Slobodkin, 1961) to 20% or more (Greenstreet *et al*., 1997). Transfer efficiencies in the range 10% to 15% are generally accepted for predator-prey interactions involving fish predators in marine temperate shelf-sea food webs (Christensen and Pauly, 1993; Pauly *et al*., 2000; Jennings *et al*., 2002).

2.1.1.4.3.3 Transfer efficiency in aquaculture systems

The conversion of sandeel biomass to nutritionally complete feed pellets is generally limited by the amount of fish oil that can be derived from sandeel material. Feed pellets vary in their fish meal to fish oil ratios depending on the species for which they are intended. Feed pellets intended for carnivorous species, such as salmon, have a composition of 45% fish meal and 25% fish oil (Naylor *et al.*, 2000). One hundred tonnes of sandeel material produces 5 t of fish oil and 20 t of fish meal. From this, 20 t of nutritionally complete salmon pellet feed can be derived, utilizing all the oil, but only 9 t of the fish meal, leaving 11 t of meal for other purposes. Feed conversion ratios (the ratio of pellet feed consumed to fish biomass produced) vary between species, but for most farmed fish they tend to lie between 1.8 and 2.2 (Naylor *et al*., 2000). In the case of salmon feed, conversion ratios as high as 1.2:1 have been described. Under such circumstances, 20 t of feed pellets would produce 16.7 t of salmon biomass, a total conversion efficiency of sandeel biomass to salmon biomass of 16.7%, which is towards the top end of the range of fish predator trophic efficiencies in the wild. However, food conversion ratios closer to 2:1 are more common, for example, in the Scottish salmon farming industry. At this food conversion ratio, a total of 10 t of salmon are produced for every 100 t of sandeels processed. This gives a transfer efficiency of 10%, which is towards the lower end of the range of transfer efficiencies observed in the wild.

In the case of aquaculture salmon production, conversion of sandeel biomass to fish flesh for human consumption appears as efficient as would be the case if the sandeel were left in the marine environment to be converted, through natural trophic interactions, to fish protein harvested in the human consumption fisheries. However, the production of pellet feed for salmon production is more demanding nutritionally than the production of pellet feed suitable for other farmed species. Pellet feed for other species requires less fish oil. Nutritionally complete pellet feed for marine finfish species, such as sole, halibut, cod, haddock, etc., for example, requires a nutritionally complete food pellet mix that consists of 50% fish meal and 15% fish oil (Naylor *et al*., 2000). One hundred tonnes of sandeel will therefore still produce the same 5 t of fish oil, but 16.5 t of the fish meal produced can now be utilized to produce 33 t of pellet feed, leaving only 3.5 t of excess meal. When fed to these fish species at a food conversion ratio of 2.2:1, some 15 t of farmed marine finfish can be produced. This represents a trophic transfer efficiency of 15% from sandeel biomass to marine human consumption finfish flesh. Considering that these are the types of fish that would utilize sandeel biomass in the wild, this transfer efficiency is towards the top end of the range that might generally be expected in natural food webs.

2.1.1.4.3.4 Evaluation of the case for exploiting sandeels or leaving them in the sea

In making the comparisons of trophic transfer efficiency in natural marine food webs and aquaculture systems, only the conversion of sandeel biomass to human consumption fish protein has so far been considered. But this is by no means the only energy/material "cost" involved in the process. To produce 20 t of salmon food pellets requires 5 t of fish oil and 9 t of fish meal from 100 t of processed sandeel material. A further 6 t of other nutrient material is required. Similarly, 33 t of marine finfish feed pellets is derived from 21.5 t of sandeel material, leaving a further 11.5 t of additional material to be obtained from elsewhere. This additional material also requires processing and any energy transfer efficiencies involved have not been factored into the analysis. Furthermore, the entire process of converting sandeel biomass to feed pellets will involve a processing energy cost, and this has also not been accounted for. The unused fish meal may go some way towards redressing the balance against these additional unaccounted inputs. If the additional energy/material costs involved in the production of pellet feed for the aquaculture industry are to be taken into account, then the material/energy costs necessary for the maintenance and operation of the various human consumption and industrial fishery fleets will also need to be considered.

A further assumption has also been made, i.e., that for every 100 t of sandeel left in the sea 10 t of fish flesh suitable for human consumption will be produced. This is very unlikely. Numerous other fish predators, such as grey gurnard (Hislop, 1997) and long-rough dab (H. Fraser, FRS Aberdeen, pers. comm.), also prey on sandeels and these are generally not exploited in the human consumption fisheries. In addition, many non-fish marine predators, such as seabirds and marine mammals, also rely heavily on sandeels in their diets (Pierce *et al.*, 1990, 1991; Hammond *et al*., 1994; Tollit *et al*., 1997; Wanless *et al*., 1998). Thus, while trophic transfer efficiency in marine food chains may be around 10%, for every 100 t of sandeel left in the North Sea, the amount of fish flesh produced that is potentially exploitable by the human consumption fisheries is likely to be substantially less than 10 t.

In conclusion, in relation to the efficiency of converting sandeel biomass to human consumption fish biomass, the exploitation of sandeels by industrial fisheries for the aquaculture industry is at least as efficient energetically. The ecological consequences are also important, but have not been considered here.

2.1.1.4.3.5 The relationship between industrial fisheries and human consumption landings

Implicit in the arguments underlying the comparisons made in the sections above is the belief that landings in human consumption fisheries are directly and inversely related to catches made by the industrial fishery. It is assumed that if industrial fisheries catches are reduced, gains approaching 10% of the reduction will be made in the human consumption fishery landings. Recent runs of the Multi-Species Virtual Population Analysis (MSVPA) model provide information that can be used to examine this assumption (ICES, 2003d). In addition, data collected off the east coast of Scotland are now available and can be used to assess the direct consequences of a four-year sandeel fishing closure on local gadoid (cod, haddock, and whiting) populations.

MSVPA results

Long-term trends in the utilization of the 0-group and 1+-group sandeel resource by fish predators, seabird predators, and the industrial fishery are shown in Figure 2.1.1.4.3.5.1. Virtually no 0-group sandeels are taken by the industrial fishery. The major consumers of 0-group sandeels are fish predators and consumption has steadily increased, from around 200,000 t to approximately 500,000 t, over the period 1963 to 2001. At the start of this period, fish predators were also the principal source of mortality of 1+-aged sandeels and relatively little sandeel biomass was removed by the industrial fishery. Over this time period, however, the annual removal of 1+ sandeels by the industrial fishery has increased to approximately one million tonnes, while consumption of 1+-group sandeels by fish predators has declined from around 1.2 million tonnes to 0.8 million tonnes. Initially therefore, these two trends would seem to suggest that the industrial fishery does compete with fish predators for the 1+-aged sandeel resource. Even if this were the case, and the sandeel fishery were to be closed immediately, these data do not suggest that we could reasonably expect a gain of 100,000 t (10% of 1 million tonnes) in human consumption landings. Consumption of 1+ sandeels by fish predators has only decreased by 400,000 t, thus the best that might reasonably be expected is a gain in human consumption landings of 40,000 t. Following the calculations in the sections above, the 1 million tonnes of sandeels taken annually by the industrial fishery might be expected to produce 100,000 t of farmed salmon or 150,000 t of farmed marine finfish. Even if one accepts that the industrial fishery has limited 1+-aged sandeel consumption by fish predators, aquaculture supported by an industrial fishery would appear to be the more ecologically efficient option.

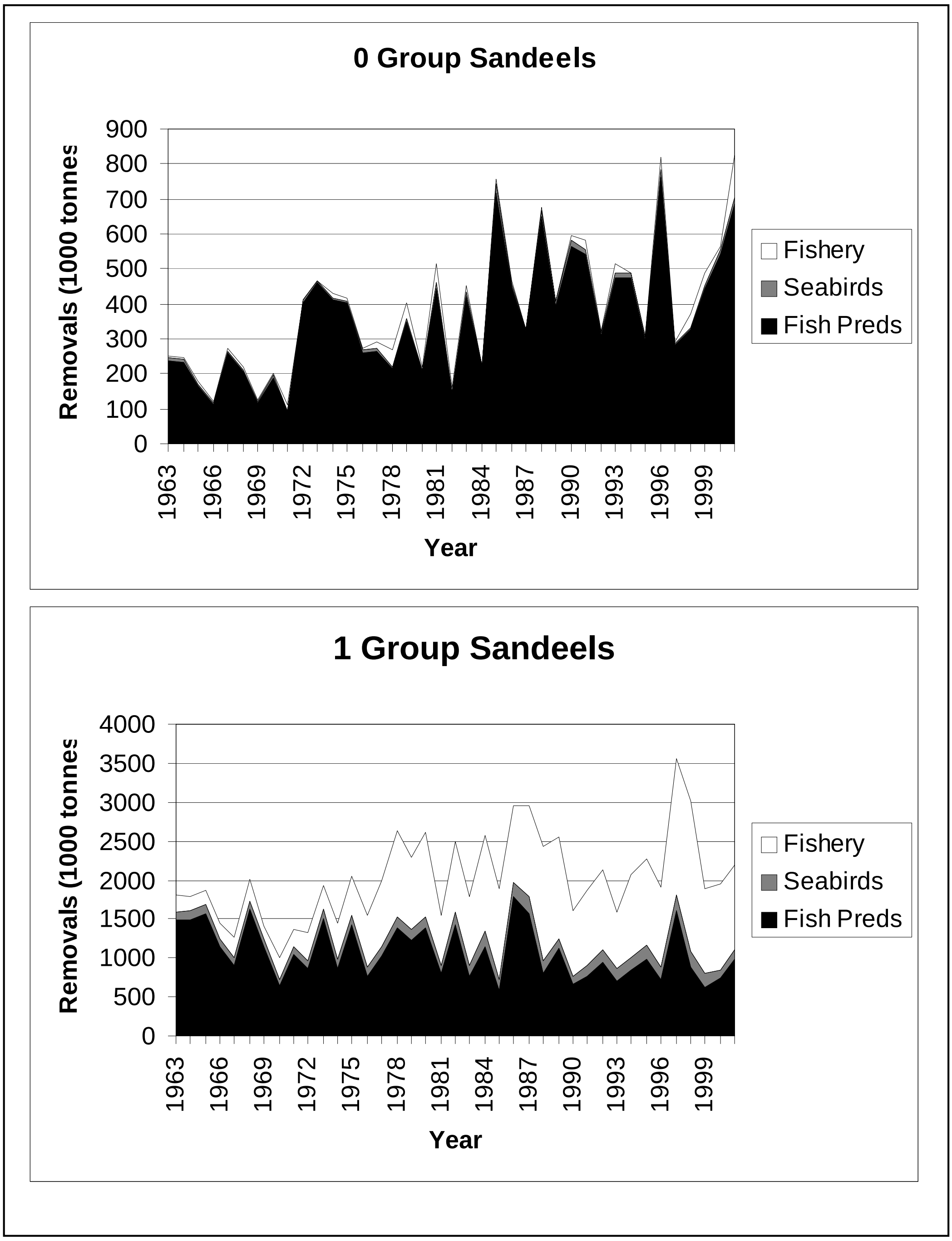

Figure 2.1.1.4.3.5.1 Long-term trends in the utilization of the 0-group and 1+-group sandeel resource by industrial fisheries and fish and seabird predators, based on data derived from the MSVPA (ICES, 2003d).

The assumption of competitive limitation of sandeel consumption by fish predators by the industrial fishery is now examined. Based on the MSVPA data, no obvious long-term trends in sandeel stock size in the North Sea are apparent (Figure 2.1.1.4.3.5.2). The increased consumption of 0-group sandeels by predatory fish does not appear to have hampered recruitment to the sandeel stock: 1-group sandeel biomass, albeit variable, shows no decline. There is certainly no indication of a decline in the overall sandeel stock size. Thus, the reduction in the consumption of 1+ sandeels by fish predators does not appear to be the result of a reduction in sandeel prey abundance caused by industrial fishing. Trends in stock biomass of the fish predators modelled by the MSVPA indicate a substantial decline in predator biomass (Figure 2.1.1.4.3.5.3). This is particularly apparent for the three main gadoid predators, cod, whiting, and haddock, as well as North Sea mackerel, which are the major piscivorous species exploited in the human consumption fisheries in the North Sea. The high levels of fishing mortality experienced by these main fish predator stocks provide the explanation for the stock declines (Figure 2.1.1.4.3.5.4). Fishing mortality on cod has continued to increase over the whole period and the stock has steadily declined. Fishing mortality on the other gadoids peaked in the mid- to late 1980s, since when declines in the stock biomass have slowed. These data suggest that, even were the sandeel fishery to stop, current levels of fishing mortality are sufficiently high so as to prevent any increase in the biomass of these major fish predators. Any gains in human consumption fishery landings as a result of a sandeel closure are therefore likely to be minimal. This premise is examined in the next section where the effect of closing the sandeel fishery off the east coast of Scotland on local gadoid predators is examined.

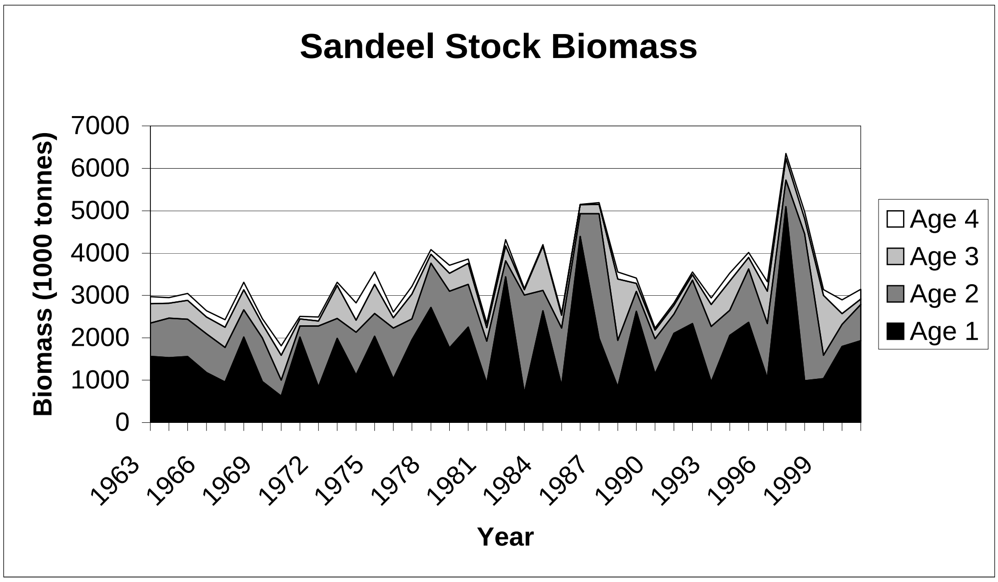

Figure 2.1.1.4.3.5.2. Long-term trend in the sandeel stock biomass in the North Sea based on data derived from the MSVPA (ICES, 2003d).

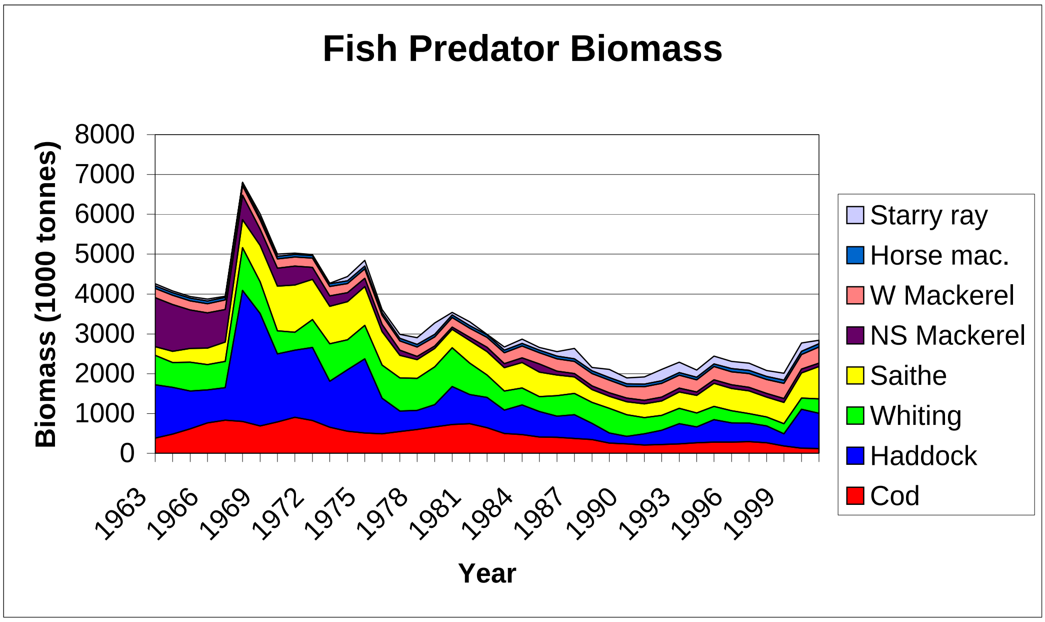

Figure 2.1.1.4.3.5.3. Long-term trends in the stock biomass of the fish predators modelled by the MSVPA (ICES, 2003d).

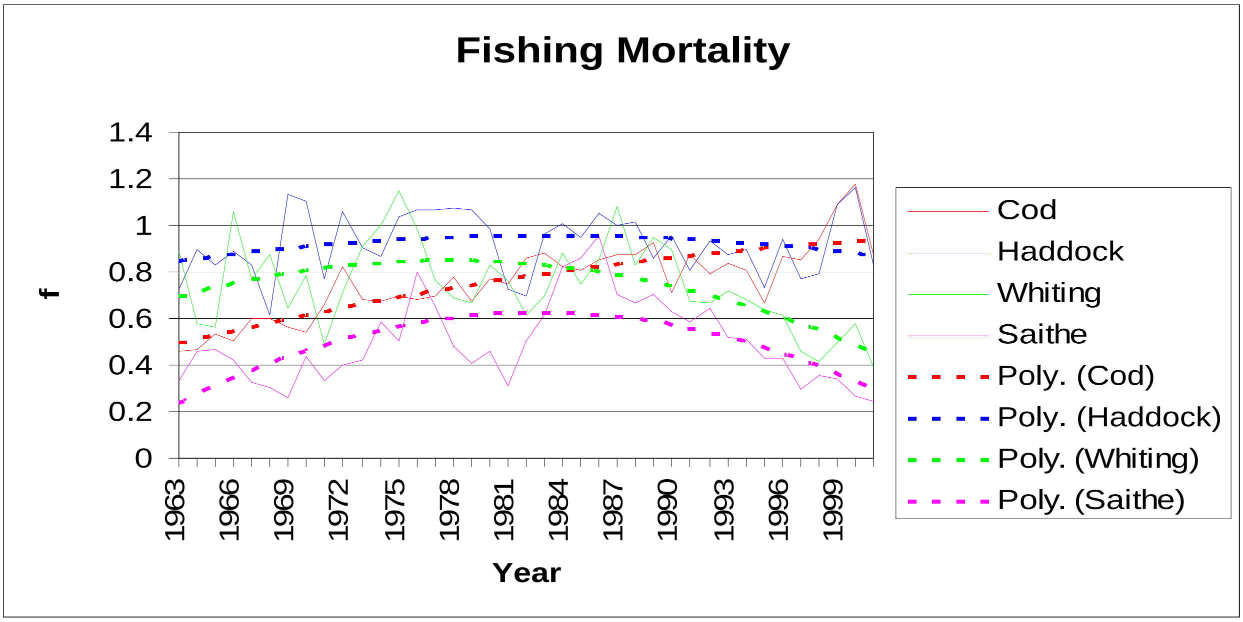

Figure 2.1.1.4.3.5.4. Long-term trends in fishing mortality for the species for which data were provided by the MSVPA model (ICES, 2003d).

2.1.1.4.3.6 Effect of closing the sandeel fishery off the east coast of Scotland on gadoid predators

In 2000, following concern over declining kittiwake breeding productivity, fishing for sandeels in an area off the east coast of Scotland was stopped (ICES, 2000a). Data on gadoid biomass, diets, food consumption rates, and body condition in an area that included the main sand banks were collected over the period 1997 to 2003. Thus, three years of data were available while the sandeel fishery was in operation, and four years of data were collected subsequent to the sandeel fishery closure. Up to 100,000 t of sandeels were removed from this area by the fishery prior to the closure (Figure 2.1.1.4.3.6.1). Following the closure, sandeel abundance in the area increased markedly (Figure 2.1.1.4.3.6.2). Sandeels featured strongly in the diets of three gadoid predators: cod, haddock, and whiting (Figure 2.1.1.4.3.6.3). Over the seven-year period, the biomass of all three predators in the area declined (Figure 2.1.1.4.3.6.4); thus, closure of the sandeel fishery had no beneficial effect on gadoid predator biomass. The percentage of sandeels in the diet of each of the predators was unaffected by the closure of the sandeel fishery and the resultant increase in sandeel abundance (Figure 2.1.1.4.3.6.5), and no increase in food consumption rates was observed (Figure 2.1.1.4.3.6.6). Consequently, predator body condition was not enhanced in the years that the closure was in force (Figure 2.1.1.4.3.6.7). Examination of the size of sandeels taken by the three gadoid predators revealed a strong dependence on 0-group sandeels (Figure 2.1.1.4.3.6.8), and this was not affected by closing the sandeel fishery (Figure 2.1.1.4.3.6.9), which primarily targeted 1+-aged sandeels. In summary, ceasing the industrial fishery for sandeels off the east coast of Scotland had no beneficial effect on the biomass, diet, feeding rate or body condition of gadoid predators in the area.

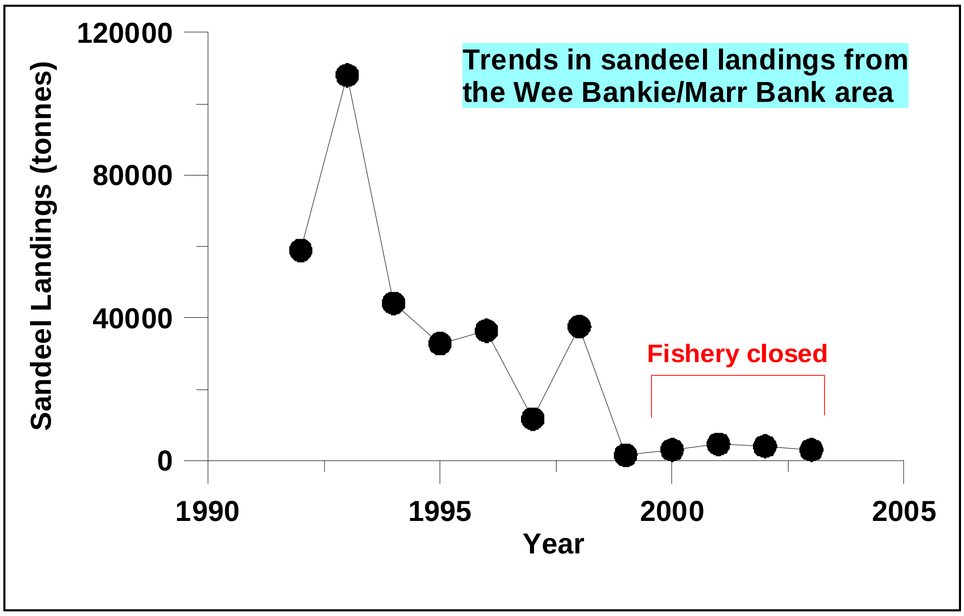

Figure 2.1.1.4.3.6.1. Trends in sandeel landings from the Wee Bankie/Marr Bank areas off the Firth of Forth, southeast Scotland.

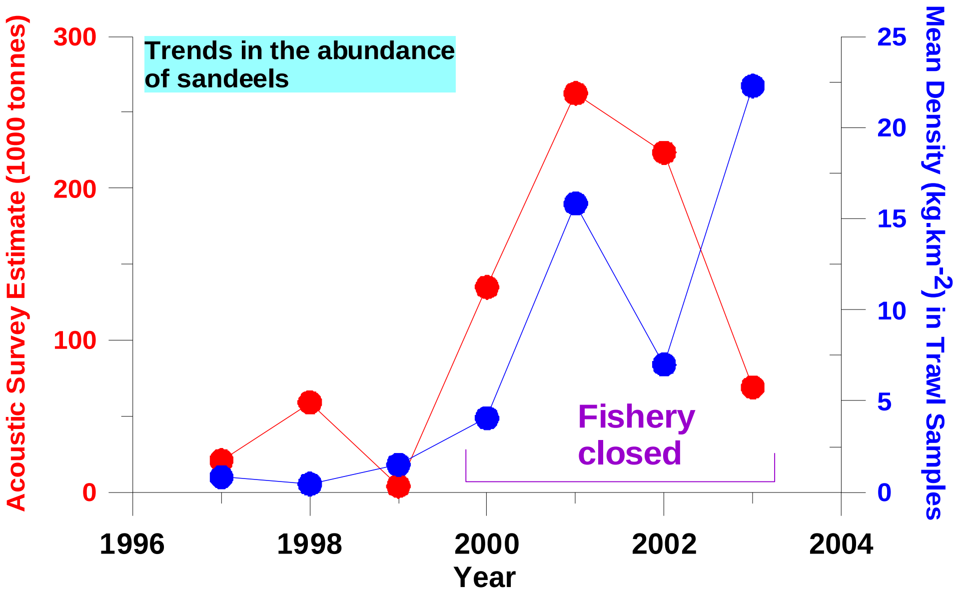

Figure 2.1.1.4.3.6.2. Trends in sandeel abundance in the Wee Bankie/Marr Bank area, off the Firth of Forth, southeast Scotland, as indicated by acoustic and demersal trawl survey indices.

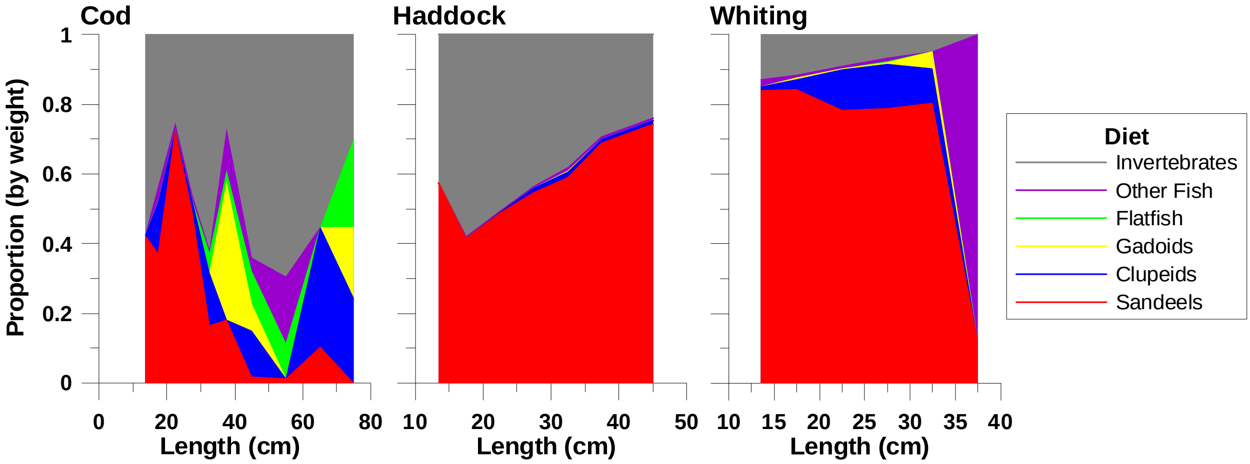

Figure 2.1.1.4.3.6.3. The effect of predator body length on the diets of cod, haddock, and whiting predators in the Wee Bankie/Marr Bank area, off the Firth of Forth, southeast Scotland.

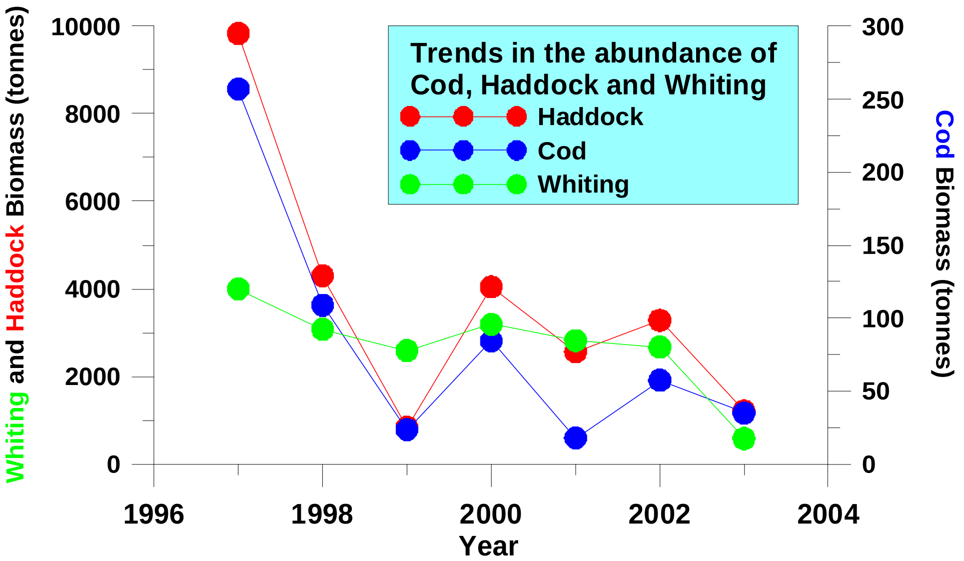

Figure 2.1.1.4.3.6.4. Trends in the biomass of cod, haddock, and whiting in the Wee Bankie/Marr Bank area, off the Firth of Forth, southeast Scotland.

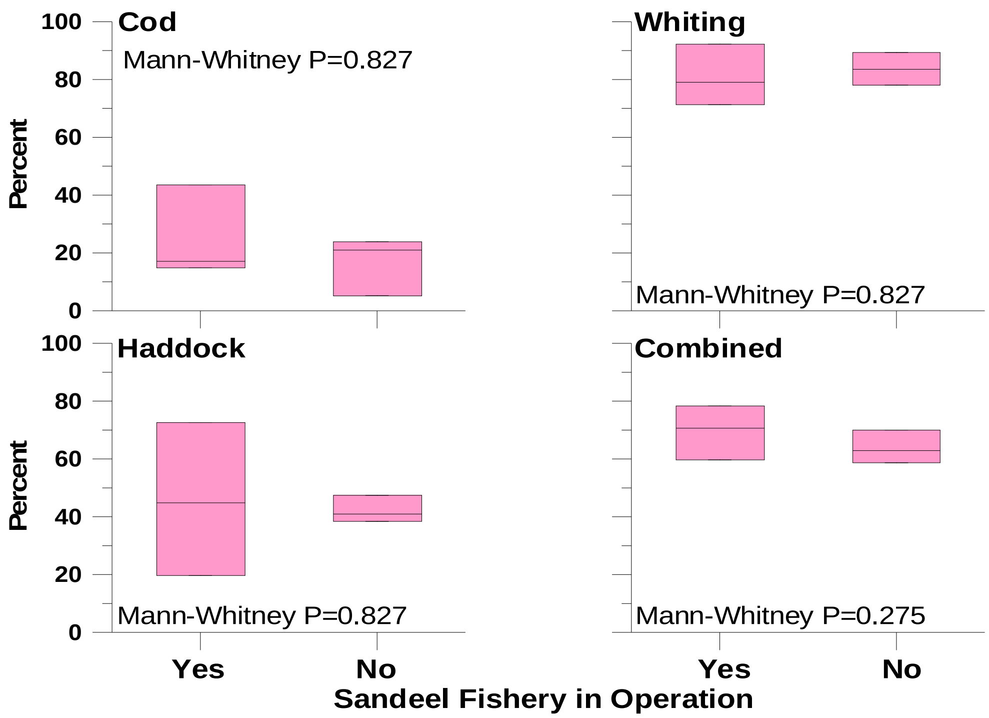

Figure 2.1.1.4.3.6.5. Variation in the percentage of sandeels in the diets of cod, haddock, and whiting in the Wee Bankie/Marr Bank area, off the Firth of Forth, southeast Scotland, in years when the sandeel fishery was in operation and years when the closure was in force.

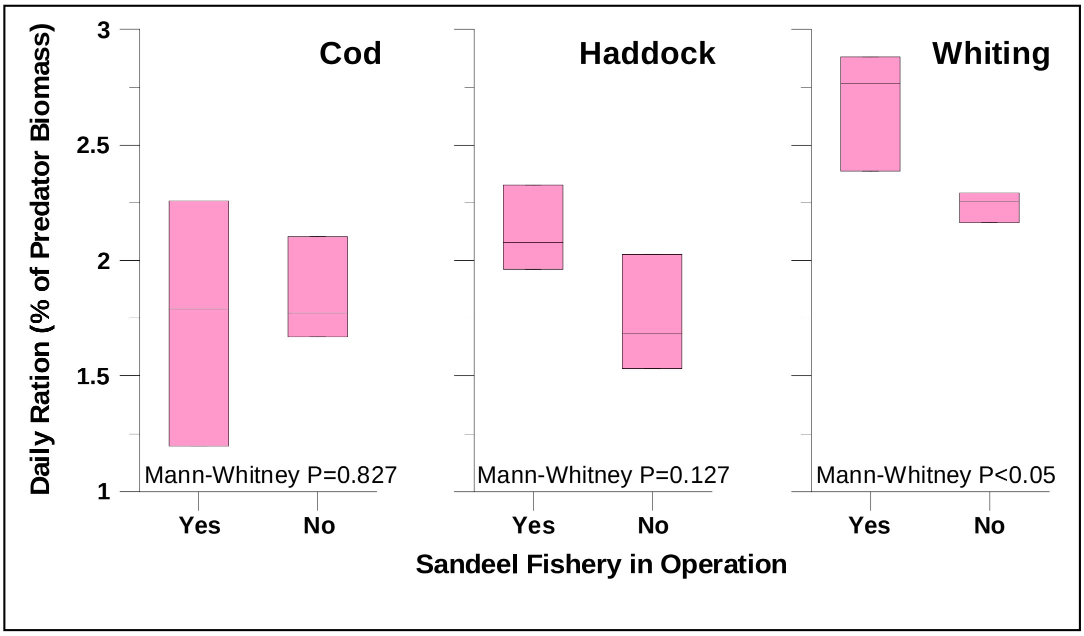

Figure 2.1.1.4.3.6.6. Variation in the daily food consumption rates of cod, haddock, and whiting in the Wee Bankie/Marr Bank area, off the Firth of Forth, southeast Scotland, in years when the sandeel fishery was in operation and years when the closure was in force.

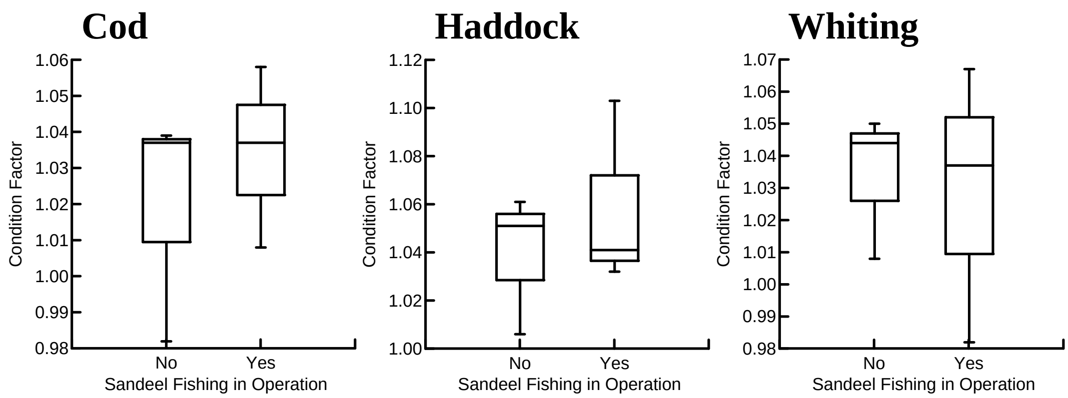

Figure 2.1.1.4.3.6.7. Variation in the body condition of cod, haddock, and whiting in the Wee Bankie/Marr Bank area, off the Firth of Forth, southeast Scotland, in years when the sandeel fishery was in operation and in years when the closure was in force. None of the comparisons were statistically significant.

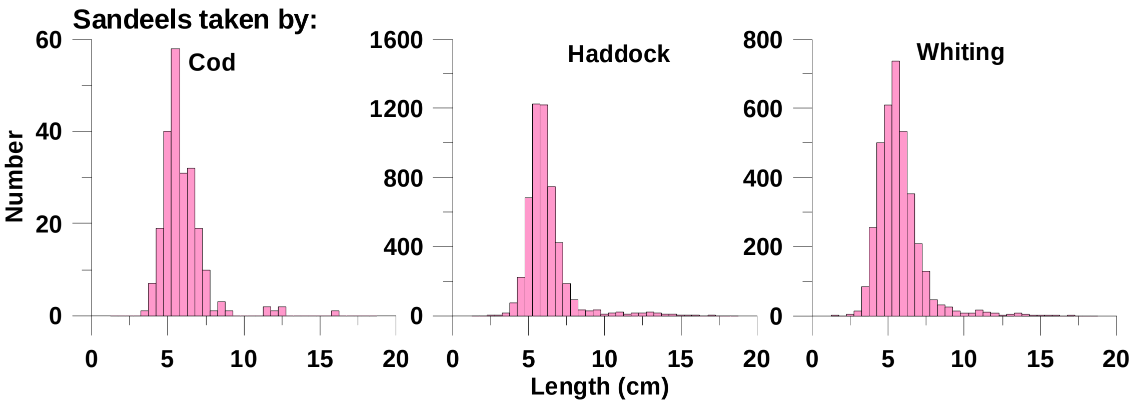

Figure 2.1.1.4.3.6.8. Length frequency distributions of sandeel prey taken by cod, haddock, and whiting in the Wee Bankie/Marr Bank area, off the Firth of Forth, southeast Scotland.

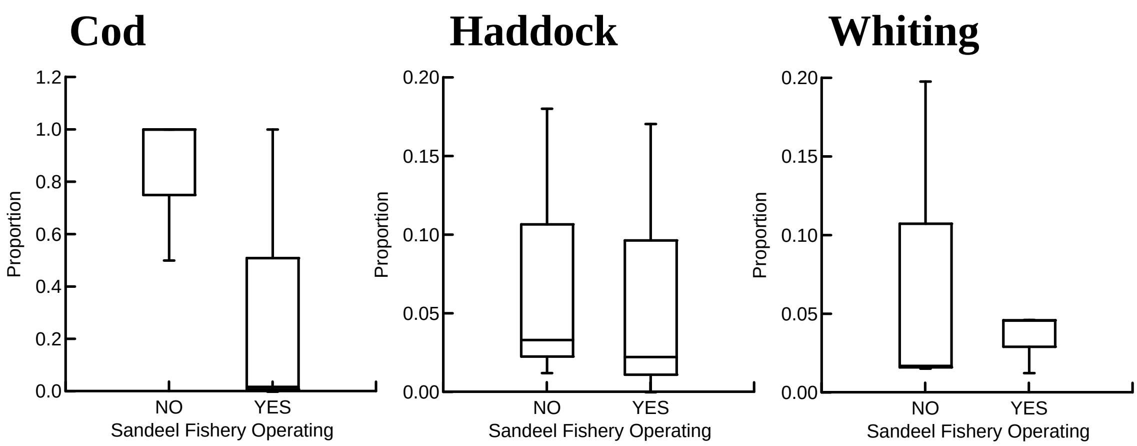

Figure 2.1.1.4.3.6.9. Variation in the proportion of sandeels taken by cod, haddock, and whiting in the Wee Bankie/Marr Bank area, off the Firth of Forth, southeast Scotland, that exceeded 8.5 cm in length in years when the sandeel fishery was in operation and in years when the closure was in force. None of the comparisons were statistically significant.

2.1.1.4.3.7 Conclusions

The results of these two case studies provide no evidence to support the contention that ceasing industrial fisheries will stimulate catches in the human consumption fisheries at the current time, and under the prevailing circumstances. Instead, the data suggest that, at current population sizes, fish in the higher trophic levels in the North Sea food web are not food limited, and thus there is no reason to expect any gain in human consumption landings following a reduction in industrial fishery catches. If fisheries management results in a recovery of the currently depleted predator stocks, such as gadoids, in the North Sea this conclusion would need revisiting. The impact of the industrial fishery on sandeel abundance should be carefully monitored as industrial fisheries continue to operate. This monitoring should be carried out at spatial and temporal scales that are relevant to the predators in question, which may or may not be recovering. Managers must ensure that food supplies for gadoids and other marine predators do not become limiting as a result of anthropogenic activities. This will ensure protection of ecologically dependent species, such as kittiwakes, and will therefore provide adequate food for recovering gadoid populations. Analysis of the MSVPA data available to date, however, suggests that, even under circumstances of increased biomass of human consumption species, a carefully managed industrial fishery should not impinge on those fisheries. Indeed, the analysis of food conversion efficiency suggests that a closely regulated combination of industrial and human consumption fisheries may provide the only solution to the long-term demand for fish protein.

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2.1.1.5 New Information on the Occurrence of and Threats to Cold-Water Corals and their Importance as Habitat

Request

The European Commission, Directorate General for Fisheries, request (letter of 5 July 2000) for the "*identification of areas where cold-water corals may be affected by fishing*".

Further, at the 90th Statutory Meeting, the Study Group on Cold-Water Corals (SGCOR) was given several additional terms of reference, including to: a) review new information on the occurrence of and threats to cold-water corals in the North Atlantic, including consideration of large slow-growing octocorals; and b) review the importance of *Lophelia pertusa* reefs as a habitat for other species.

Source of information

The 2004 report of the Study Group on Cold-Water Corals (SGCOR) (ICES CM 2004/ACE:07).

Summary

New information is presented on the present and historical distribution of cold-water corals in the Northwest Atlantic, Norway, Iceland, United Kingdom, Ireland, Spain, and Portugal. Although extensive reefs have not been documented in the Northwest Atlantic, as they have been in European waters, cold-water corals are widely distributed off Canada and the USA. New information on evidence of destruction of coral reefs by fishing activities is also presented for the USA, Canada, Norway, and Ireland; the extent of documented damage is considerable. In some cases, the only evidence of historical reefs is in the form of coral rubble. The importance of cold-water coral reefs as habitat for other species is discussed. Overall, few obligate symbionts were found associated with the corals, but several species are rarely found in other habitats. Some fish primarily use coral habitat for its physical structure (shelter, and possibly a food-concentrating mechanism), while others feed on other organisms using the same habitat. No new sites containing corals are specifically recommended by ICES for closure to fisheries activities. This is partially due to a lack of sufficient information on the extent of damage to corals and coral habitats and their vulnerability to specific gear types, in order to meet the standards demanded by some regulatory agencies in ICES Member Countries.

Recommendations and advice

Although previous ICES reports have recommended closing areas of coral reefs to fishing, this has not proved possible this year, despite new discoveries of coral reefs that are presumably vulnerable to gear damage. If the management authorities wish to protect the coral habitats, ICES reiterates previous advice, namely that the only way to protect cold-water coral habitats from fishing damage is to map the habitats precisely and to close those areas to the forms of fishing that cause damage.

Individual ICES Member Countries and/or fisheries agencies are encouraged to consider closing areas to destructive fishing activities in their waters.

The Study Group on Cold-Water Corals (SGCOR) has considered the distribution and occurrence of *Lophelia pertusa* and other colony-forming Scleractinia, and ICES recognizes the need to continue work on cold-water corals as well as to encompass other deep-sea habitats that are sensitive to fishing activities.

Scientific background

2.1.1.5.1 New information on the occurrence of cold-water corals in the North Atlantic

Cold-water corals are supposed to refer to those species that contribute to reef formation in waters less than about 20o C. In North Atlantic waters, these include the azooxanthellate scleractinian corals Desmophyllum cristagalli, Enallopsammia rostrata, Lophelia pertusa, Madrepora oculata, and Solenosmilia variabilis. The main reef-building species is Lophelia pertusa. Other coral species often occur in association with L. pertusa and only M. oculata has been found forming reefs without L. pertusa being present. Zibrowius (1980) gave a good general review of the distribution of cold-water coral in European waters. The term "reef", as used in this section, is defined by the European Union Habitat Directive (EC, 1992, 1997, 1999) as, "Submarine … rocky substrates and biogenic concretions, which arise from the sea floor in the sublittoral zone .... These reefs generally support a zonation of benthic communities of algae and animal species including concretions, encrustations and corallogenic concretions."

2.1.1.5.1.1 USA

Cold-water corals have been known along the North American east coast since at least 1862, when Verrill noted the presence of a *Primnoa* on Georges Bank (Verrill, 1862). Several other cold-water coral species from depths greater than 200 fathoms off the coasts of New England and Nova Scotia were documented by Verrill during the latter part of the 19th century (e.g., Verrill 1878a, 1878b, 1879, 1884). Coral fauna is diverse and includes several species in the octocoral group as well as hard corals (Breeze *et al*., 1997).

There are seventeen species of scleractinian corals (hard corals) known from Cape Hatteras to the Gulf of Maine (Cairns and Chapman, 2001). Only one species (*Astrangia poculata*) occurs in shallow water and 71% of the seventeen species occur deeper than 1000 m. Forty-seven percent of the scleractinian corals from the cold temperate U.S. coast are widespread species and 28% occur across the Atlantic, with only a single endemic species, *Vaughanella margaritata* (Cairns and Chapman, 2001).

Tendal (1992) summarized the known records of the giant gorgonian, *Paragorgia arborea*. In the Atlantic, it is found from the tip of Georges Bank, Greenland, Iceland, and the Faroes to northern Norway. Grasshoff (1979) showed this species to be bipolar in its distribution, being found in the colder and deeper waters of the southern hemisphere as well as in the North Atlantic and Pacific oceans.

Photographic transects of the slope and canyon fauna south of Georges Bank recorded over 25 species of both hard corals and octocorals, with several taxa dominant in the overall megafaunal community (Hecker *et al*., 1980, 1983; Valentine *et al*., 1980; Cooper *et al*., 1987; Hecker, 1990). However, seven species (two hard corals and five soft corals) tend to occur in high densities in different areas of the canyon/slope environment: *Acanella arbuscula*, *Anthomastus agassizii*, *Desmosmilia lymani*, *Eunepthya florida*, *Flabellum alabastrum*, *Paramuricea borealis* (now *P. grandis*), and *Primnoa resedaeformis* (Valentine *et al*., 1980; Hecker, 1990).

The benthic fauna of the Northeast Peak of Georges Bank has been characterized as having two octocorals, *Primnoa resedaeformis* and *Paragorgia arborea*, as common components, based on dredge sampling (Theroux and Grosslein, 1987). Wigley (1968) described *Paragorgia* as a common component of the gravel fauna of the Gulf of Maine and stated that representative gravel faunas occurred on "Cashes Ledge, parts of Great South Channel, the northeastern part of Georges Bank, western Browns Bank, Jeffreys Ledge, and numerous other smaller banks in the Gulf of Maine region."

The report by Theroux and Wigley (1998) indicates that the Alcyonaria, comprising the soft corals (Alcyonacea and Gorgonacea) and seapens (Pennatulacea) were patchily distributed primarily along the outer margin of the continental shelf and on the continental slope and rise. They were not collected in samples shallower than 50 m depth. Alcyonaceans and gorgonaceans were collected from gravel and rock outcrop habitats, while pennatulids were collected from sand-silt and silt-clay sediments (Figure 2.1.1.5.1.1.1).

Watling *et al*. (2003) have created a GIS database delineating known occurrences of deep-water corals (soft corals of the family Alcyonacea) off the northeastern United States. The data set includes 761 records from published accounts of Verrill (1862, 1878a, 1878b, 1879, 1884), Deichmann (1936), and Hecker *et al*. (1980, 1983), as well as museum records from Yale and Harvard collections, Northeast Fisheries Science Center Benthic Database records (of identified coral taxa), and observations from recent and ongoing NOAA-supported studies in 2001–2003 (NURC, Ocean Exploration projects). Figure 2.1.1.5.1.1.2 illustrates large-scale distributions across the region from this work. Note the general concordance with the distribution illustrated from the Theroux and Wigley (1998) study in Figure 2.1.1.5.1.1.1. Figure 2.1.1.5.1.1.3 illustrates detailed coral distributions in Oceanographer and Lydonia submarine canyons. Data, which are not reflected in these maps, include:

1) photographic transect studies in submarine canyons led by Richard Cooper (e.g., Valentine *et al*., 1980);

2) video records from the NURC video archive;

3) records from the Middle Atlantic region (e.g., Hecker *et al*., 1980, 1983; Alvin archive); and

4) specimens deposited in museums by the Northeast Fisheries Science Center collections and not yet identified.

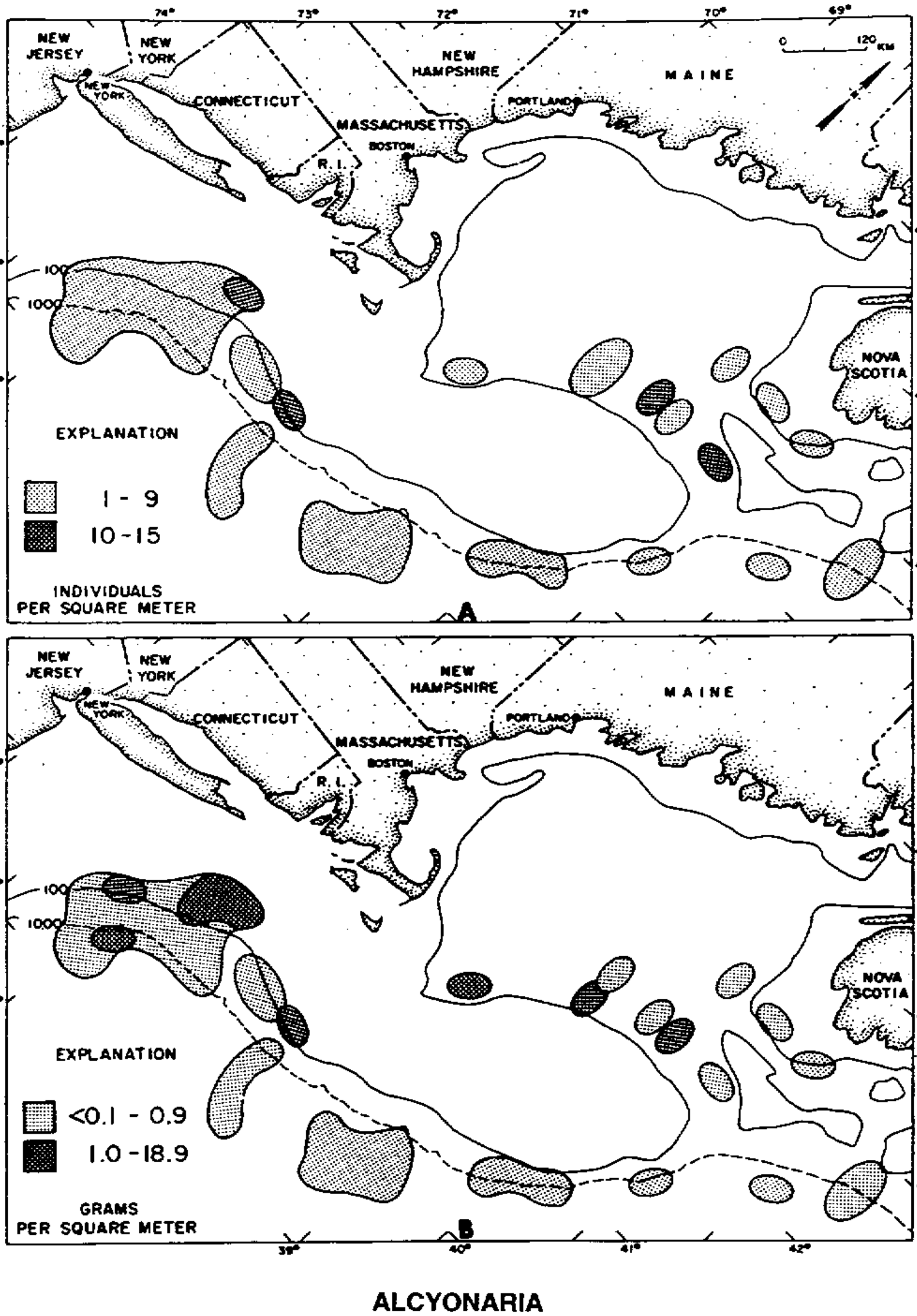

Figure 2.1.1.5.1.1.1. Geographical distribution of Alcyonarians off the northeast United States. Maps illustrate distributions in numbers of individuals m^{-2} (top) and biomass as g m^{-2} (bottom). From Theroux and Wigley (1998).

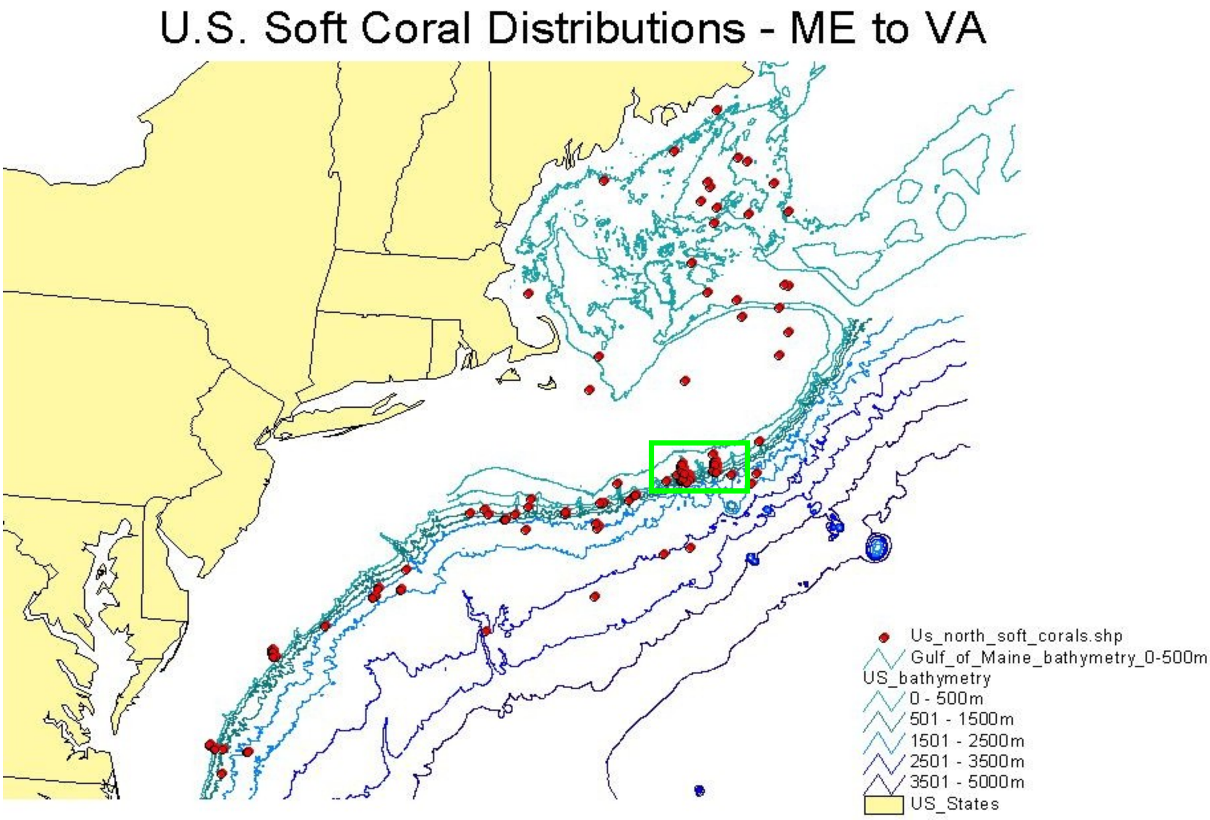

Figure 2.1.1.5.1.1.2. Regional scale distribution of Alcyonaceans across the northeast continental shelf region from Maine (ME) to Virginia (VA) based on 761 records in Watling *et al*. (2003). Note that there are overlapping records (within the green box) that are revealed with fine-scale examination of the database (see Figure 2.1.1.5.1.1.3).

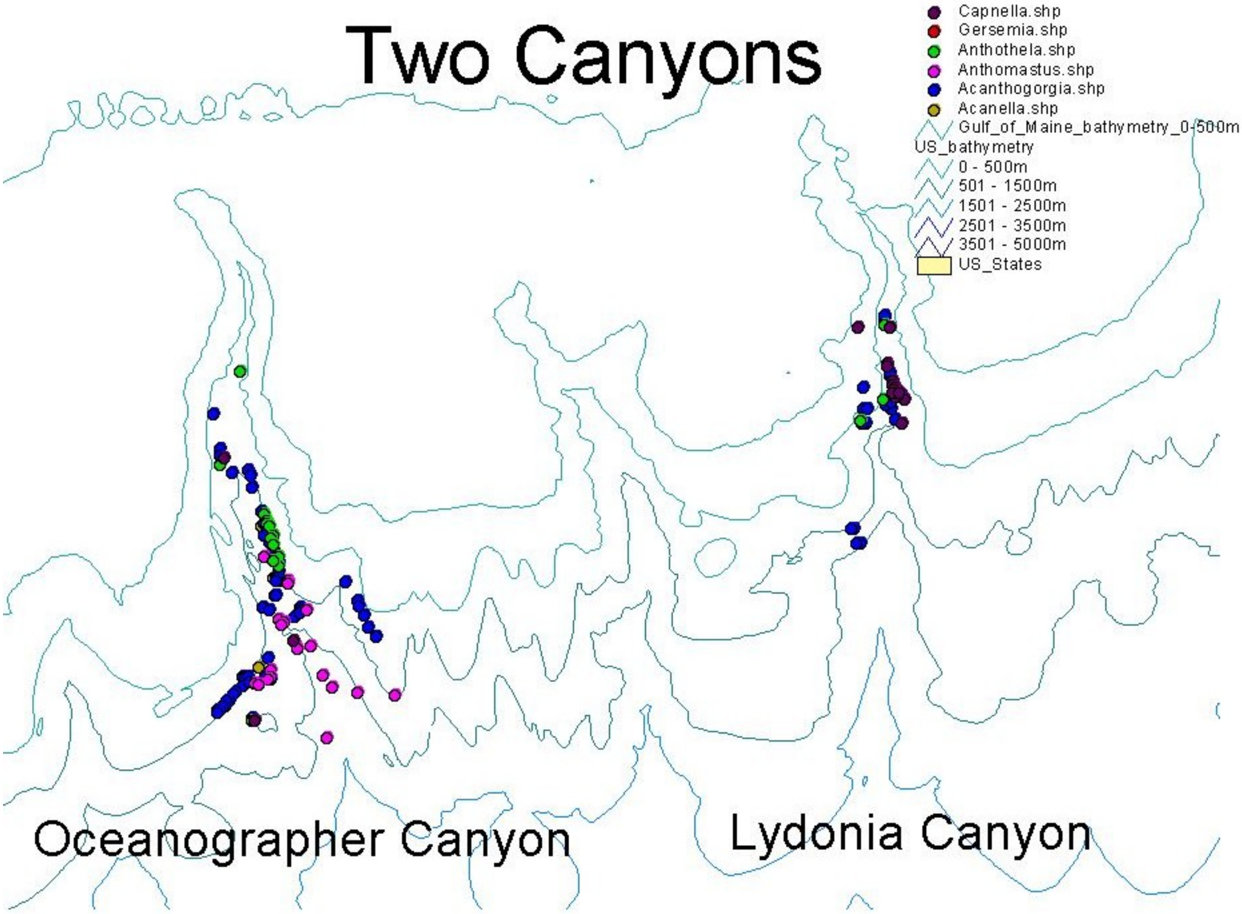

Figure 2.1.1.5.1.1.3. Fine-scale distribution of Alcyonacean corals in Oceanographer and Lydonia submarine canyons (located within the box of the map in Figure 2.1.1.5.1.1.2). From Watling *et al*. (2003).

A new project was initiated in 2003 by the United States Geological Survey to compile observations of deep-water corals along the U.S. east coast and the Gulf of Mexico in a geographical database (K. Scanlon, USGS, Woods Hole, Massachusetts).

Informal discussions with members of the fishing industry confirm that there is a good understanding of the distribution of corals in the Gulf of Maine and around the heads of submarine canyons. Compiling such knowledge would add significant information to the limited scientific sampling that has occurred over the past several decades. Breeze *et al*. (1997) is a good demonstration of how such a project was conducted in Atlantic Canada.

In addition to exploration for new coral habitats, ongoing research is focused on three primary areas: (1) the population biology of corals; (2) their role in mediating patterns of biological diversity; and (3) and their role as habitat for fishes. From an ecosystem management perspective, all three areas are important for predicting the effects of fishing and non-fishing impacts.

2.1.1.5.1.2 Canada

Deep-water corals are widespread in Atlantic Canada (Verrill, 1922; Deichman, 1936; Breeze *et al*., 1997; MacIsaac *et al*., 2001). In 2001–2003, the Environmental Studies Research Fund (ESRF) in Canada funded the Department of Fisheries and Oceans (DFO) to conduct a research programme to provide new information on deep-water corals and their associated species in Atlantic Canada. Data and samples were obtained from DFO groundfish surveys, the Fisheries Observer Program, interviews with fishers, and dedicated research cruises using DFO research vessels which visited the Northeast Channel (Figure 2.1.1.5.1.2.1), Scotian Slope, the Gully, the Laurentian Channel, and the southern Grand Banks. Prior to this project, most of the available data were anecdotal in nature and based primarily on fishing by-catch information. The summary below is based mainly on publications resulting from DFO’s coral project (Buhl-Mortensen and Mortensen, 2004a, 2004b, 2004c; Gass and Willison, 2003; Mortensen and Buhl-Mortensen, 2004a, 2004b; Mortensen *et al*., 2004a, 2004b, in prep.).

Corals are mainly found below 200 m along the edge of the continental slope, in canyons or in channels between fishing banks. A total of 23 coral taxa were observed (Mortensen *et al*., 2003), including a new species for the area (the antipatharian black coral *Bathypathes arctica*) (Gass and Willison, 2003). The observations confirm the importance of the Northeast Channel, the Gully, and the Stone Fence as prime coral habitats. They also demonstrate that corals are widespread off Newfoundland and Labrador and extend at least as far north as the Davis Straits. The area off Cape Chidley could be another coral prime habitat. The highest abundance of coral was found in the Northeast Channel, while the greatest diversity was found in the Gully.

In late 2002, living *Lophelia pertusa* was discovered for the first time in Atlantic Canada at the Stone Fence in the outer part of the Laurentian Channel. In autumn 2003, a *Lophelia* reef was discovered at the same location (Mortensen *et al*., 2004b, in prep). The reef was about 1 km long and 500 m wide and occurred at depths between 300 m and 400 m to the east of Sable Island. More than 90% of the reef was composed of dead coral, with extensive coral rubble and only small patches of live coral. It is assumed that much of the damage was bought about thirty years ago when the area was opened to trawl fishing, but there is also evidence of more recent trawling.

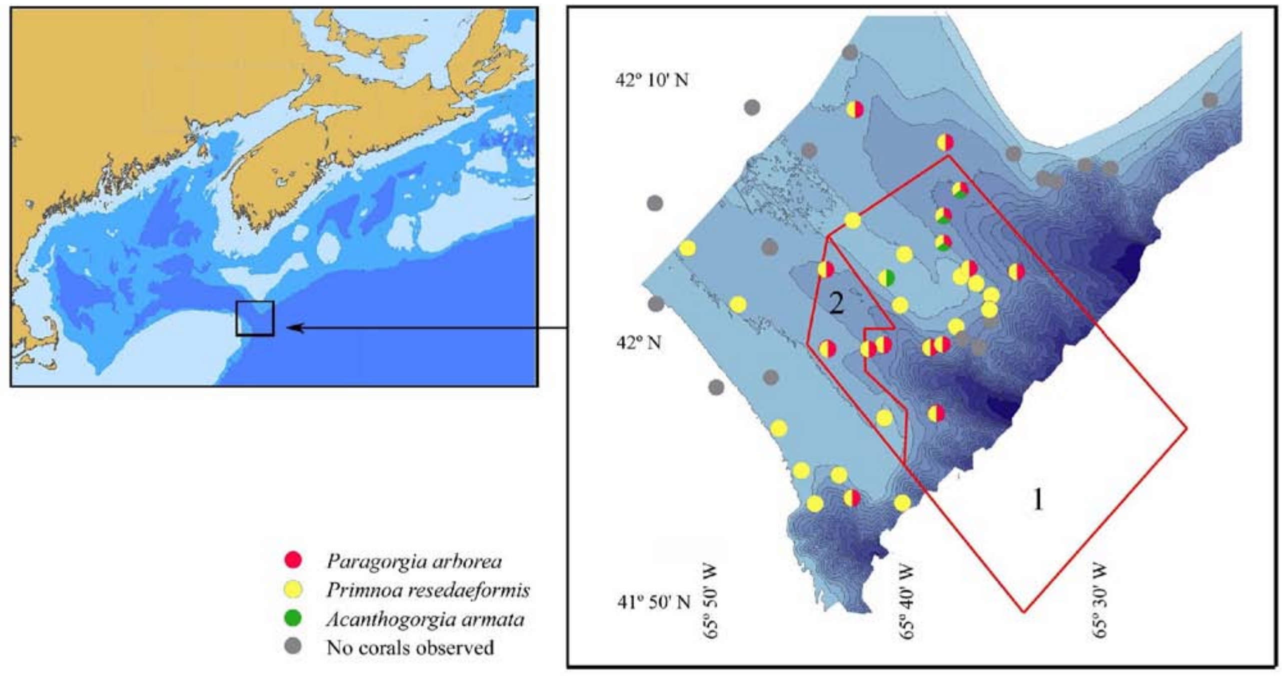

Figure 2.1.1.5.1.2.1. General location map of the Northeast Channel and detailed bathymetric map showing the distribution of gorgonians in the Northeast Channel based on video records. The coral protection area is outlined in red: 1) restricted bottom fisheries zone; 2) limited bottom fisheries zone.

2.1.1.5.1.3 Norway

A number of surveys using multibeam echosounder, remotely operated vehicles (ROVs), and cameras have been conducted in Norwegian waters in the past year. These included the area north of the Træna deep, the Røst reef, the continental break from Bleikdjupet and north to Sveinsgrunnen, and Steinavær in Andfjorden (Figure 2.1.1.5.1.3.1).

Træna deep (Trænadypet)

A 23 km × 13 km area was mapped in Træna. The multibeam maps have been examined by marine biologists and marine geologists. The results indicate that in this area there are 1447 possible coral reefs with an average length of 150 m (Figures 2.1.1.5.1.3.2, 2.1.1.5.1.3.3, and 2.1.1.5.1.3.4) in an area delineated by the following coordinates: 66°52.9’N, 10°47.6’E; 66°59.1’N, 10°47.2’E; 66°59.2’N, 11°09.1’E; 67°00.0’N, 11°09.1’E; 67°00’N, 11°18.4’E; 66°52.2’N, 11°17.8’E; 66°51.9’N, 11°00’E; 66°52.8’N, 10°59.9’E. The total area of the possible new reefs is 3.63 km^2. Not all reefs have been ground-truthed visually, but all places checked to date by ROV contained *Lophelia* corals.

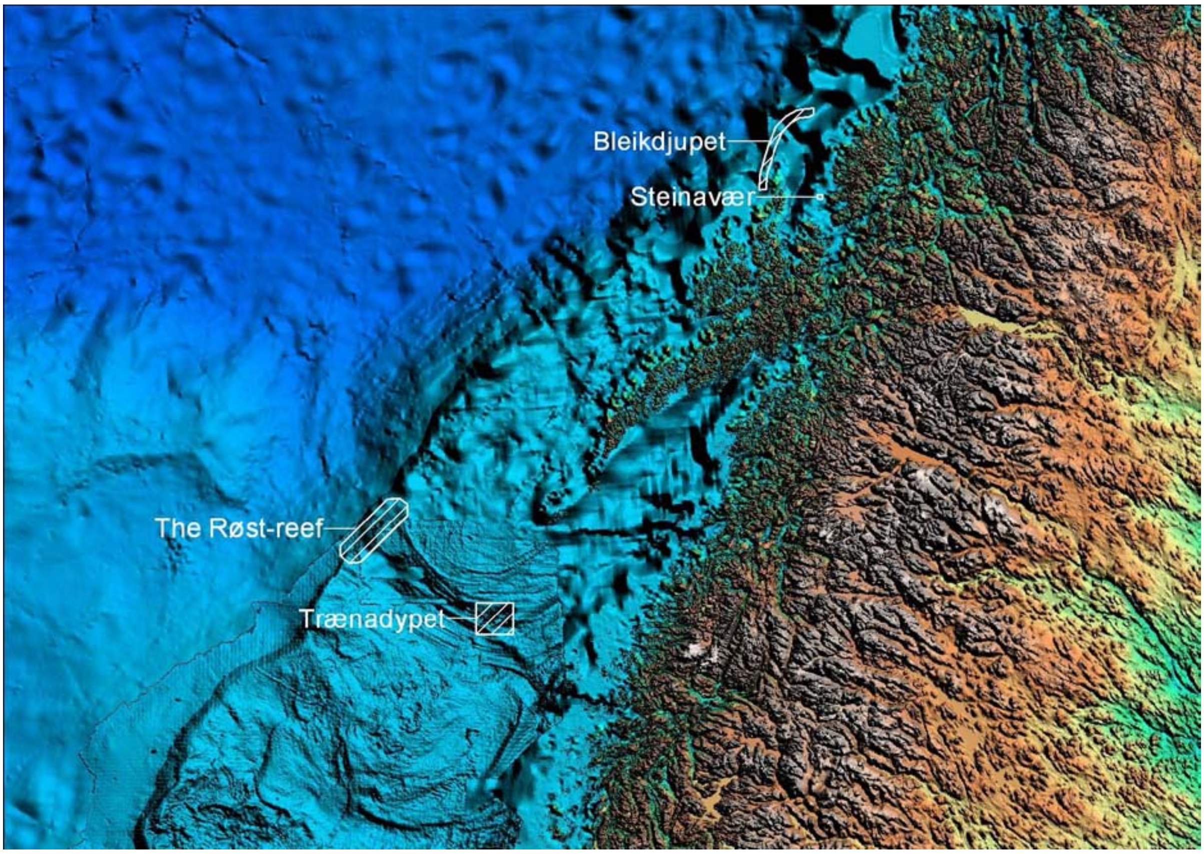

Figure 2.1.1.5.1.3.1. The Røst reef was discovered and mapped in 2002. In 2003, additional mapping was performed on the Røst reef and in the other areas marked on the map.

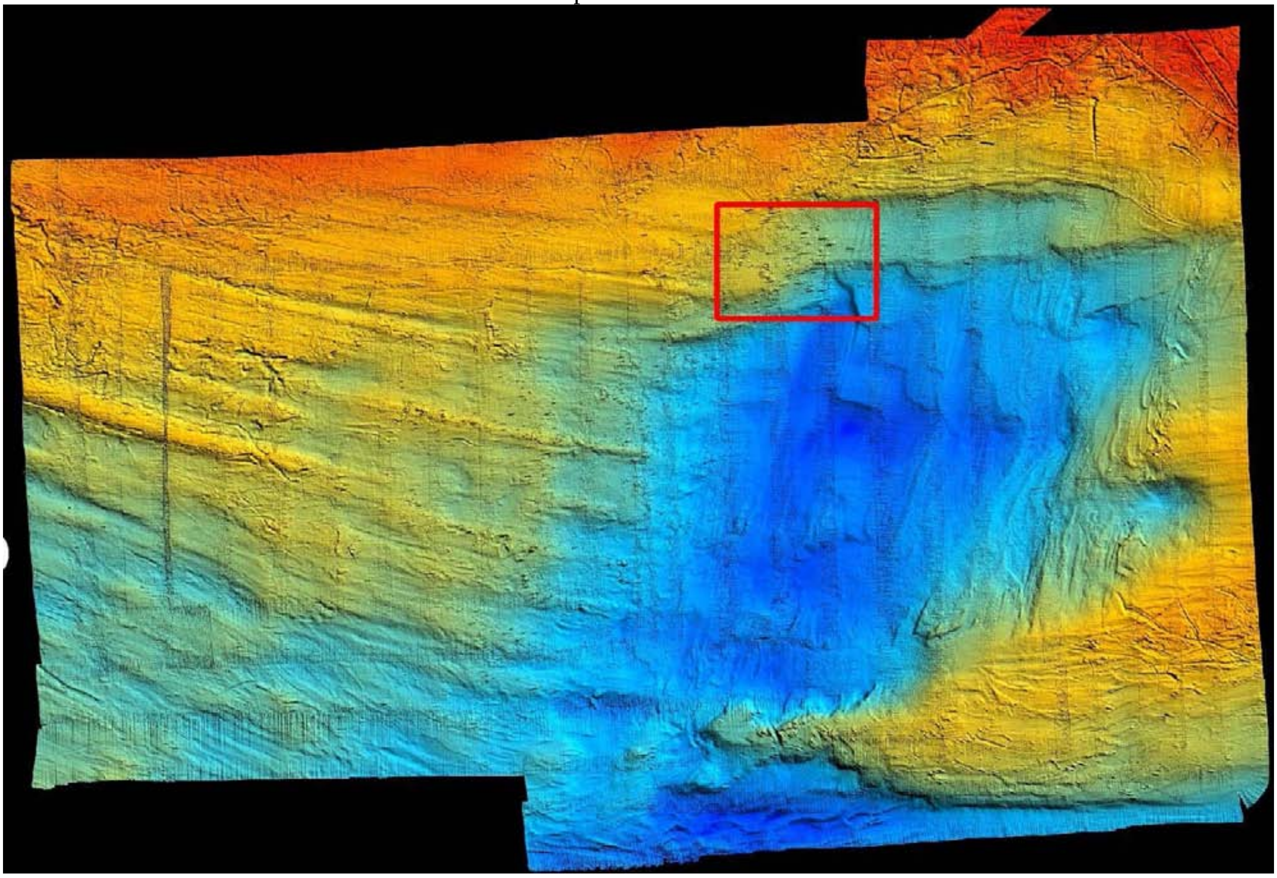

Figure 2.1.1.5.1.3.2. In Træna, a 23 km × 13 km area was mapped with multibeam echosounder. The colours indicate water depth. The darkest blue is about 400 m deep and the yellow is around 300 m. There are 1,447 possible coral reefs,

marked as dark spots, with an average length of 150 m. The map was produced in cooperation with The Geological Survey of Norway.

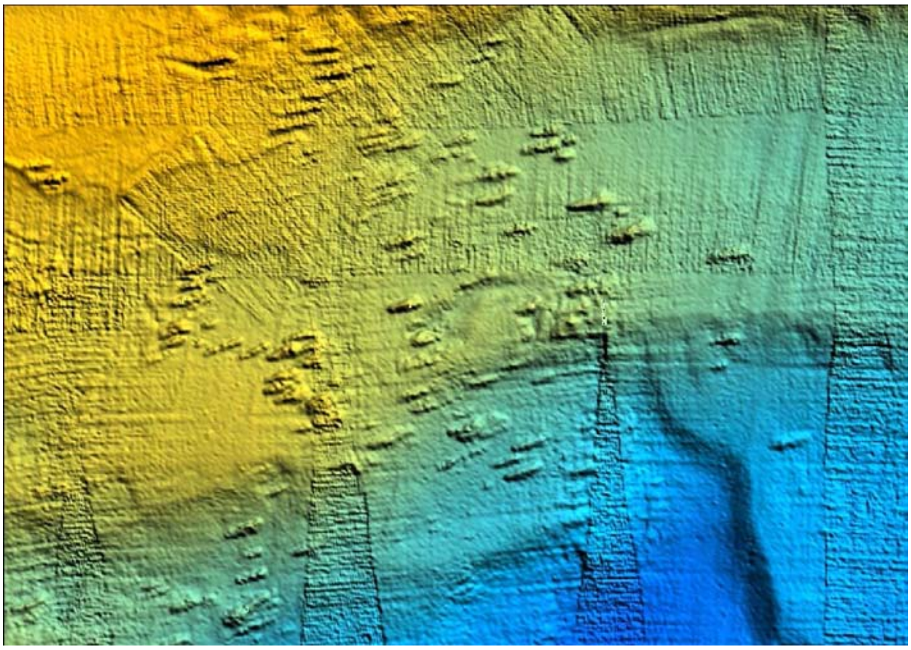

Figure 2.1.1.5.1.3.3. Magnified picture of the framed area in Figure 2.1.1.5.1.3.2. *Lophelia* corals build characteristic mounds on the sea bottom that can be recognized on a multibeam map. However, mounds of stones and till can be misinterpreted as coral mounds, so ground-truthing is necessary.

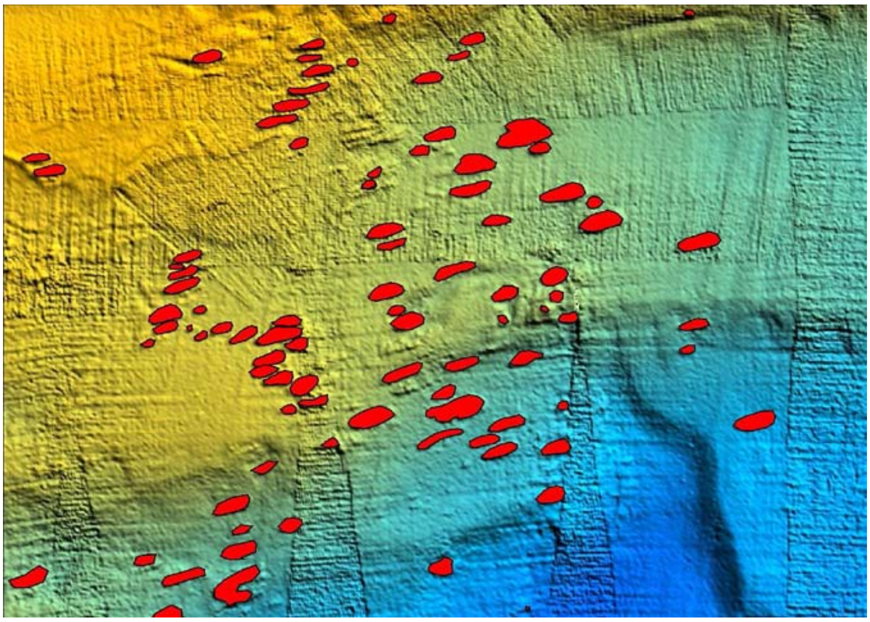

Figure 2.1.1.5.1.3.4. Magnified picture of the framed area in Figure 2.1.1.5.1.3.2. Red areas are interpreted as being coral mounds.

Røst reef

The reef is located in the upper part of a slide area along the continental break at 300–400 m depth. The mid-part of the 40 km long Røst reef was mapped in greater detail than in 2002, and video transects were obtained from 500 m to 300 m depth. This was carried out in order to describe how the growth of the coral colonies is related to the bottom structures and to the different habitat types in the slide area.

The continental break from Bleikdjupet to Sveinsgrunnen

The break was mapped from Bleikdjupet (69°18.0’N, 15°45.0’E) to Sveinsgrunnen (69°44.0’N, 16°20.0’E). Coral reefs were detected in the northern part of the mapped area at about 69°41.5’N, 16°08.5’E. Some reefs on the break were intact, but lost longlines and gillnets were found. The shelf area there is heavily trawled and all the reefs in the trawled area were damaged.

Steinavær

At Steinavær in Andfjorden, 69°14.2’N, 16°39.0’E, a superb and unusual coral reef was found on both sides of an underwater canyon (Figure 2.1.1.5.1.3.5). On the northern side of the canyon, about 500 m of ROV survey was conducted. The seabed was covered with a carpet of coral colonies, with many cod and redfish. Here, as in all coral areas, the remains of fishing activity were detected, including lost longlines and gillnets.

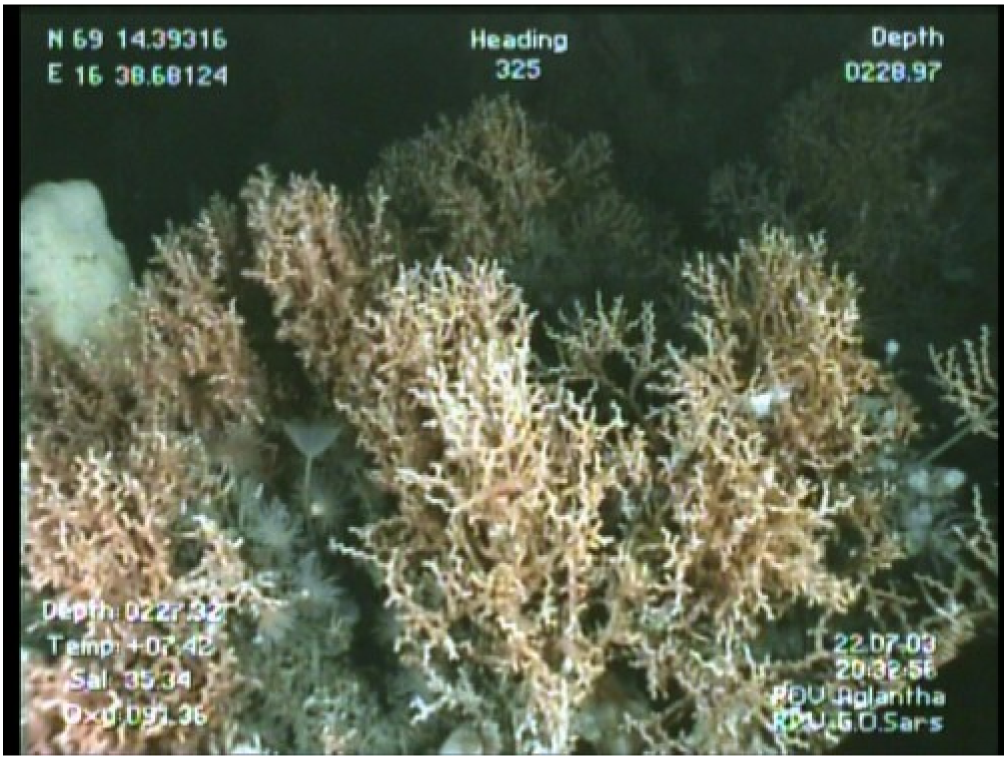

Figure 2.1.1.5.1.3.5. At Steinavær, there are well-developed stands of *Madrepora oculata* in addition to *Lophelia* at a depth of 229 m.

Southern Oslofjord reefs

In November 2003, a joint German-Swedish cruise received permission to map the distribution of *Lophelia* reefs in the southern Oslofjord area close to the Soester Islands (Figure 2.1.1.5.1.3.6). The previously known Tisler Reef and the dead coral accumulations on the Djupekrak Sill were also mapped to provide a complete overview.

Of particular interest were about 7 n.m.-long inlets on both sides of the Soester Islands. These inlets are connected to the main Oslofjord Trough in the north, and the eastward continuation of the Norwegian Channel in the south. Both inlets have a complex seabed topography, with steep inclined rock outcrops, mud-rich troughs, and drumlins as the major elements. The Western Oslofjord Inlet (WOI) consists of 140 m to 320 m deep troughs that are separated by narrow and generally less than 120 m deep thresholds. These thresholds often are moraine deposits with consolidated clays, boulder-rich drumlins, and exposed rock. These are all seabed types that generally attract a diverse epibenthic community including corals.

The Eastern Oslofjord Inlet (EOI) shows the same topographic elements; however, the troughs rarely exceed 200 m water depth. Two larger areas in the EOI are rich in corals: the inlet due east of the southern Soester Island and a narrow, confined channel about 1.5 n.m. north of the northern Soester Island. Individual reefs occur in water depths of

80 m to 110 m and are formed by *Lophelia pertusa* as the major reef-building coral. Areas dominated by dead corals are intensely overgrown by huge *Geodia* sponges. In places, forests of *Paramuricea* octocorals are common.

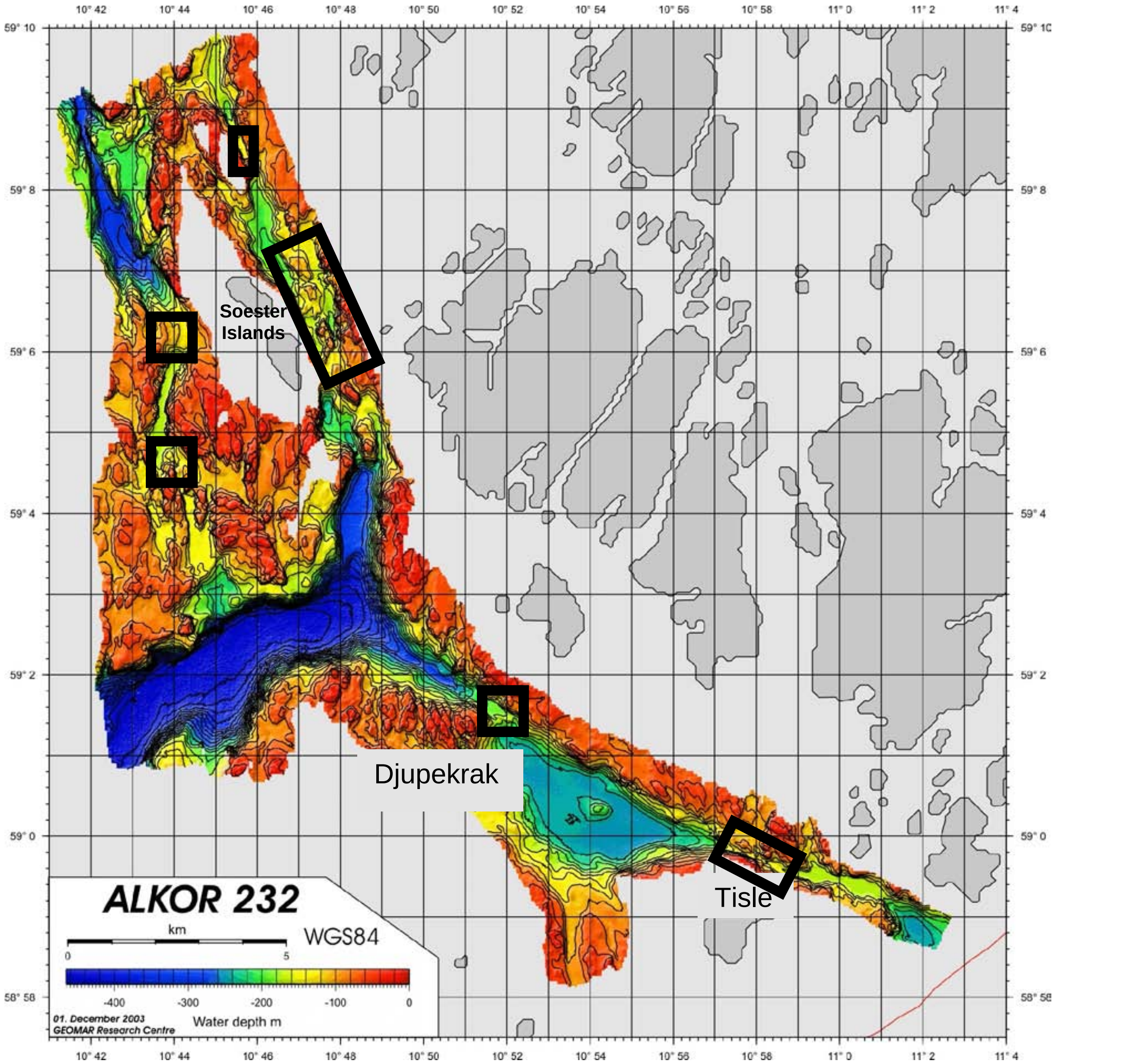

Figure 2.1.1.5.1.3.6. Multibeam map of the southern Oslofjord entrance generated during the RV "Alkor" Cruise 232 in November 2003. The coral reef sites are highlighted in the black rectangles.

2.1.1.5.1.4 Iceland

Information on existing coral aggregations off Iceland has been collected from fishermen over the past few years using questionnaires. The fishermen participating were captains on board trawlers and ships operating setnets and longlines. In 2003 more than twenty areas off southern Iceland were known to have aggregations of corals (Figures 2.1.1.5.1.4.1 to 2.1.1.5.1.4.4) distributed between Reykjanes Ridge (SW) and Rósagarður (SE), normally close to the shelf break. The surface area of eleven coral grounds could be estimated (1–38 km^2), but in twelve cases this was not possible. Considerable coral existed on the Reykjanes Ridge (Figure 2.1.1.5.1.4.1), within an area protected from bottom trawling, and relatively large areas of coral existed in the Hornafjarðardjúp deep (12 km^2) and in the Lónsdjúp deep (38 km^2) (Figure 2.1.1.5.1.4.4). Other coral grounds are small (commonly around 1 km^2).

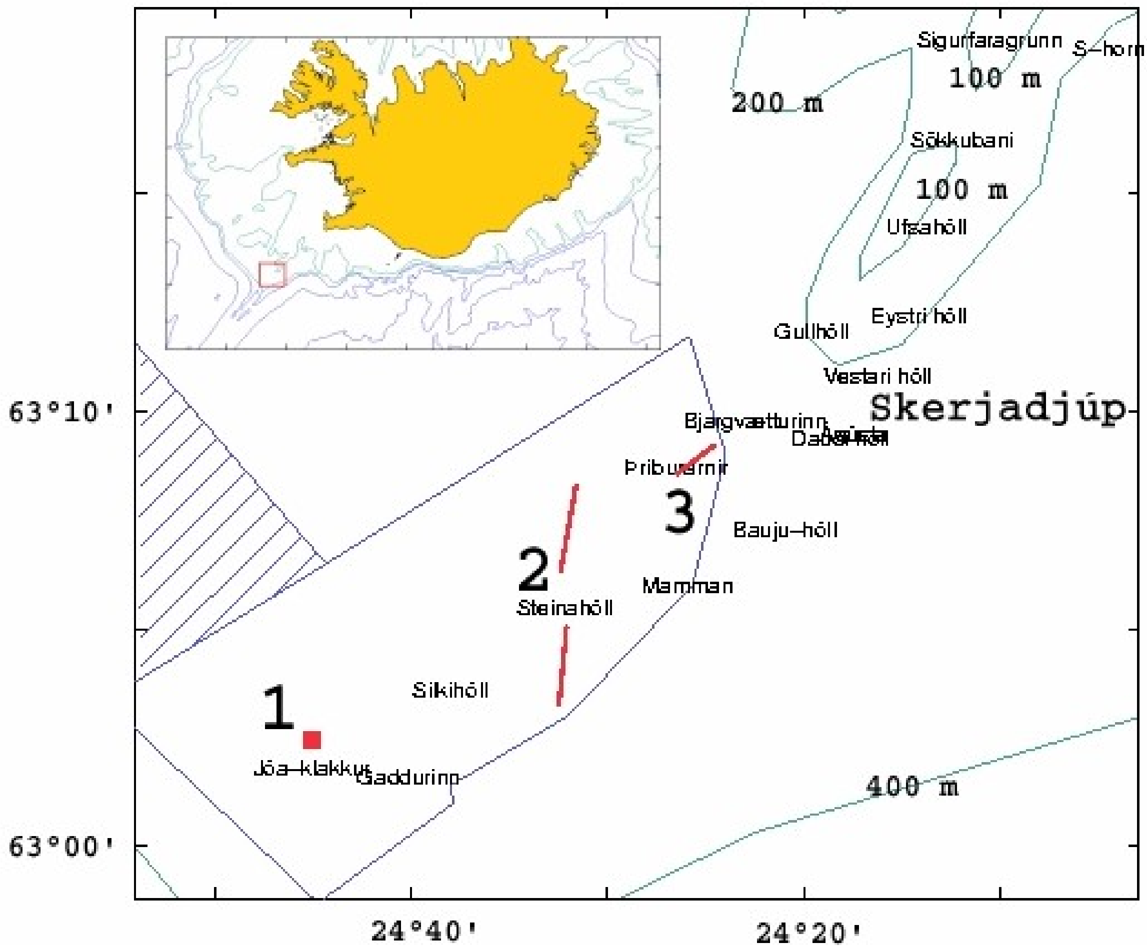

Figure 2.1.1.5.1.4.1. Present occurrence of coral on the Reykjanes Ridge. Results from a questionnaire in 2003 to fishermen, with the occurrence of coral grounds indicated with a red line or a square (longlines and set-nets, respectively). Areas closed for otter trawling are outlined with a blue line (closed throughout the year) and blue hatched area (trawling allowed 1 February–15 April: 1) Jóa–klakkur, 2) Steinahóll, 3) Þríburarnir.

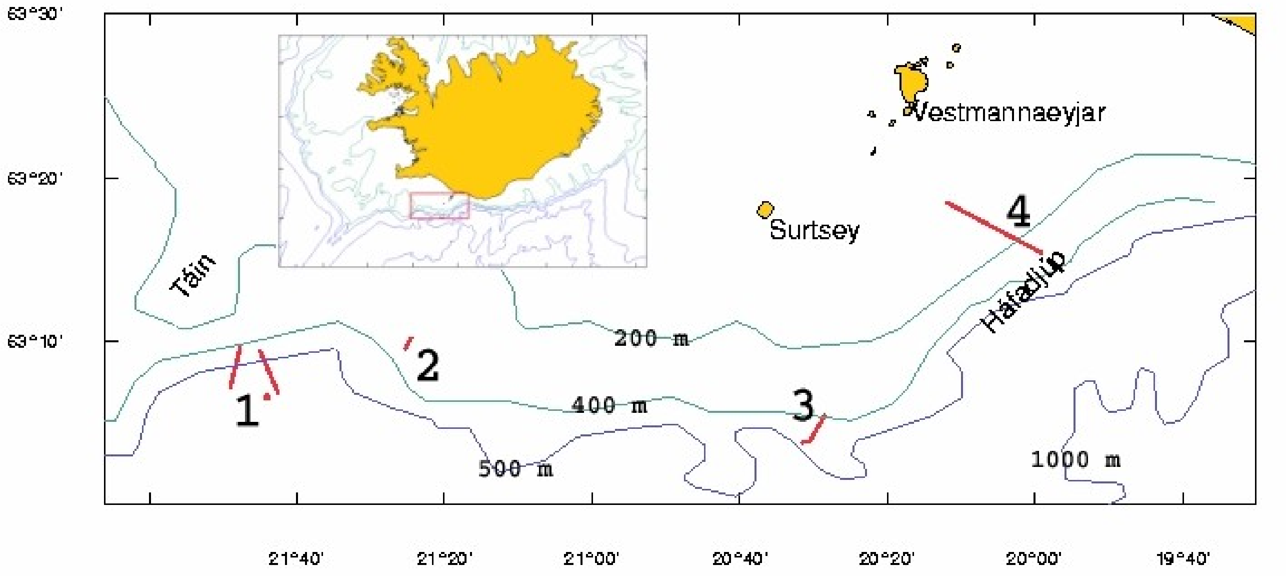

Figure 2.1.1.5.4.1.2. Present occurrence of coral in the area between the Táin and Háfadjúp deep. Results from a questionnaire in 2003 to fishermen, with the occurrence of coral grounds indicated with a red line or a square (longlines and set-nets, respectively): 1) "vesturgjá", tectonic fissure south of the Táin, 2) west of the Surtur, 3) "austurgjá", tectonic fissure south of Surtsey, 4) South Vestmannaeyjar, the western part of the shelf break of Háfadjúp deep.

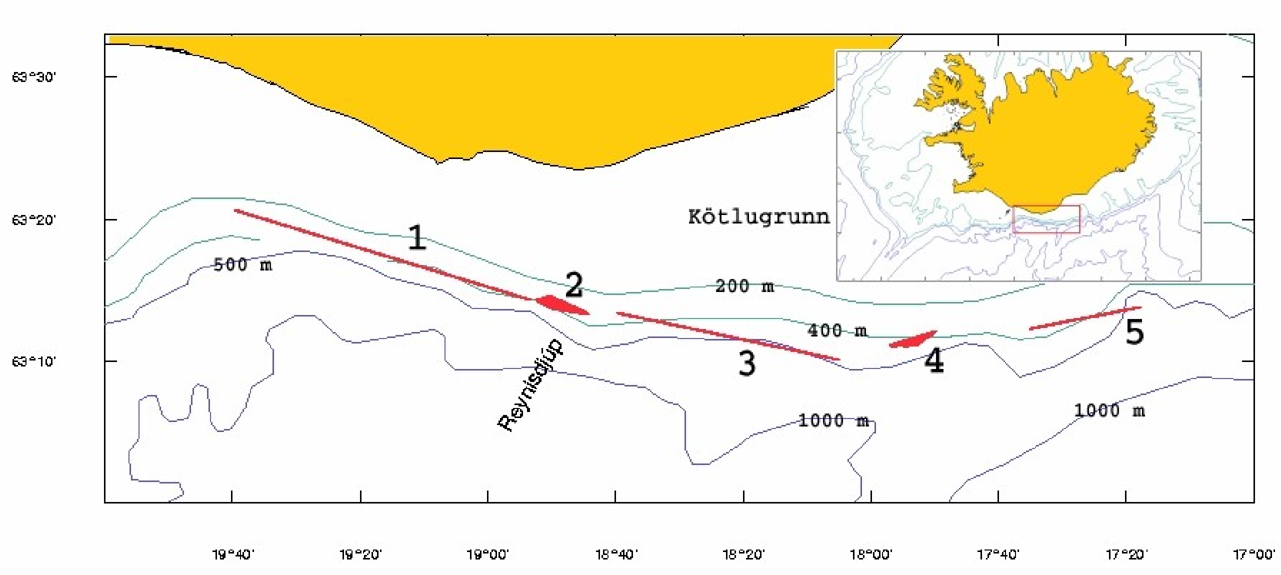

Figure 2.1.1.5.1.4.3. Present occurrence of coral in the area between the Háfadjúp deep and Síðugrunn bank. Results from a questionnaire in 2003 to fishermen, with the occurrence of coral grounds indicated with a red line or red tinted area (longlines and set-nets, respectively): 1) Shelf break SE of Vestmannaeyjar, 2) Reynisdjúp deep (5 km^2), 3) Kötlugrunn bank, 4) Skaftárdjúp deep, 5) Síðugrunn bank.

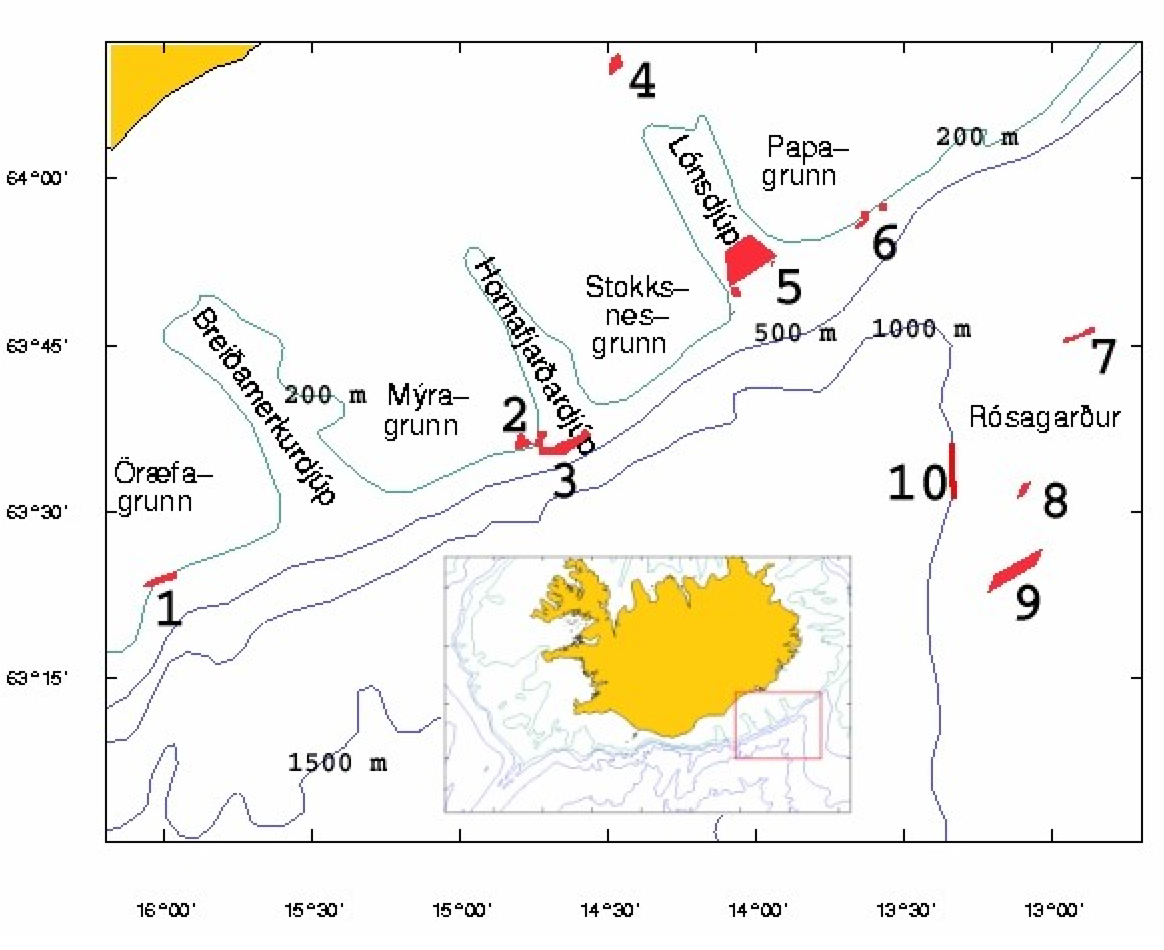

Figure 2.1.1.5.1.4.4. Present occurrence of coral in the area between the Öræfagrunn bank and the Rósagarður ("rose garden"). Results from a questionnaire in 2003 to fishermen, with the occurrence of coral grounds indicated with red tinted areas: 1) Öræfagrunn bank (5 km^2), 2) Hornafjarðardjúp deep a, 3) Hornafjarðardjúp deep b (12 km^2), 4) "Lovísa" (5 km^2), 5) Lónsdjúp deep (38 km^2), 6) Papagrunn bank, 7) Rósagarður a (3 km^2), 8) Rósagarður b (2 km^2), 9) Rósagarður c (18 km^2), 10) Rósagarður d.

A multibeam survey of the coral grounds was completed in May 2004. Some of the grounds will be surveyed with ROV in June 2004, in order to determine which species of coral are present and their status in relation to fishing activities around the coral grounds.

2.1.1.5.1.5 United Kingdom

The distribution of *Lophelia pertusa* around the UK was assessed by Roberts *et al*. (2003), who have generated and maintain a GIS database. Inshore occurrences of cold-water corals were assessed in July 2003 by a consortium led by the Scottish Association for Marine Science (Roberts *et al*., 2004). Multibeam sonar surveys (Kongsberg-Simrad EM2000) were carried out in four areas to the west of Scotland where *Lophelia pertusa* had been recorded. In one area, east of the island of Mingulay, distinctive seabed mounds were found. The mounds are up to 5 m high and 30 m in diameter in water depths of 110–180 m (Figure 2.1.1.5.1.5.1). Video images showed extensive coral reef formation and grab samples contained *L. pertusa* coral skeleton colonized by a rich epifaunal community. Skeleton samples were dated to 3,800 yr BP (SUERC-1892 & 1893; AMS ^{14}C dating) and it is anticipated that material from the base of the mounds will be significantly older, extending to the early post-glacial period (~10,000 yr BP). Quaternary studies suggest that ice retreated from this area 14,000 yr BP, but it will have taken longer for oceanographic conditions to allow coral growth to begin (Roberts *et al*., 2003). The reef structures were visible on backscatter images, which also revealed “trails” extending downstream from the mounds. The Mingulay Reef Complex is close to a primary productivity centre and mixing layer, and the coral mounds are concentrated where currents are likely to be accelerated by rocky seafloor ridges. The authors suggest that coral growth has been supported by plankton from surface production transported to the developing reef by seafloor currents. To date no surveys have been carried out to assess the “health” of these reefs or whether they have been damaged by fishing activity. However, habitat maps integrating visual ground-truthing surveys and acoustic data have been generated and integrated using a GIS database.

2.1.1.5.1.6 Ireland

The German research vessel “Meteor” conducted a reconnaissance survey of the deeper flank west of Rockall Bank within the Irish Exclusive Economic Zone. The Geological Survey of Ireland provided mapping data of suspicious mound-like structures which “Meteor” could partially ground-truth. Two seabed structures were mapped and rich coral habitats were found and documented using an underwater camera sledge system. The coral habitats occur in depths between 618 m and 950 m. Most abundantly, *Lophelia pertusa* and *Madrepora oculata* were identified as the major framework builder. Interestingly, the solitary *Caryophyllia sarsiae* lives in large quantities attached to the colonial corals. Benthic life on the adjacent muddy and rippled sand beds was much richer compared to the heavily trawled off-mound areas in the Porcupine Seabight.

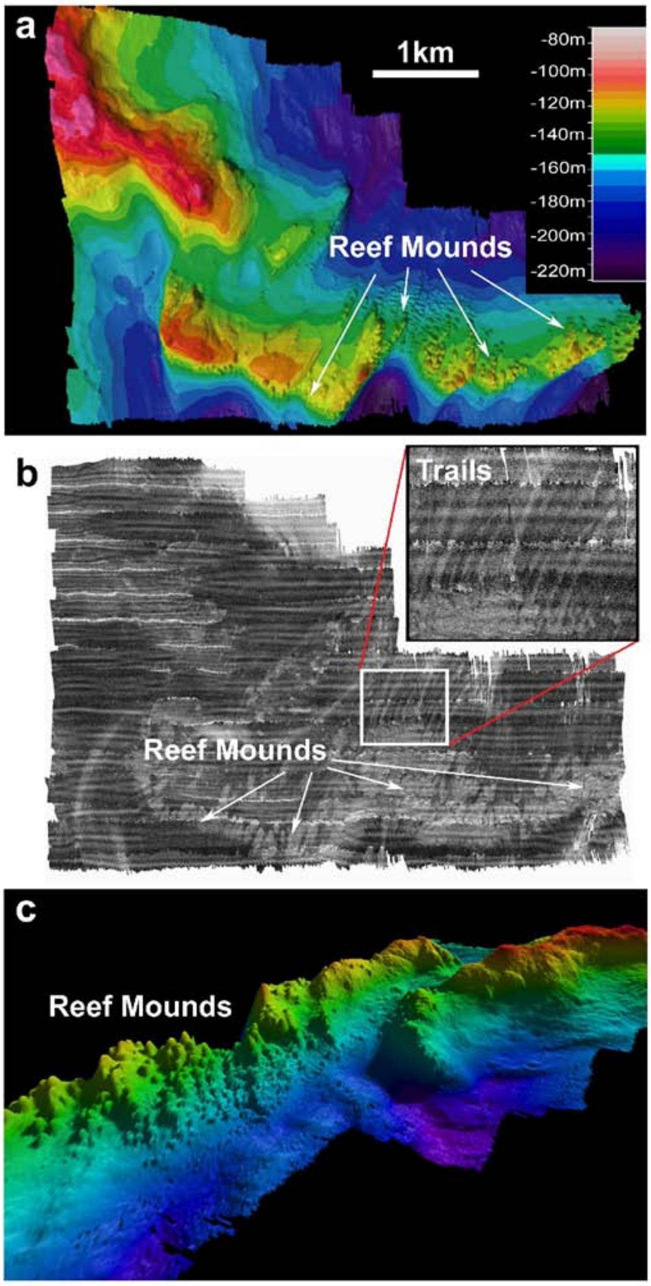

Figure 2.1.1.5.1.5.1. (a) Multibeam bathymetry showing prominent ridge features and Mingulay Reef Complex. (b) Backscatter image clearly delineates the reef mounds and reveals trails extending from them. (c) Three-dimensional view of the reef complex from the northeast (6× vertical exaggeration).

2.1.1.5.1.7 Spain

Alvarez-Perez *et al*. (2003) described deep-water coral occurrence in the Straits of Gibraltar. A total of 334 dredge samples were taken in 1994 from the Spanish Algeciras shelf and the deeps of the Straits of Gibraltar. Sixteen species of hard corals were found in the samples, with *Lophelia pertusa* and *Madrepora occulata* being the most widespread. *Caryophyllia cyathus* was the next most abundant species, with others being more restricted.

D. Hebbeln (pers. comm.) surveyed coral communities living on mud volcanoes in the Gulf of Cadiz in December 2003 (Figure 2.1.1.5.1.7.1). The most abundant habitat-forming coral was found to be *Dendrophyllia alternata* and not the usual *Lophelia/Madepora* community.

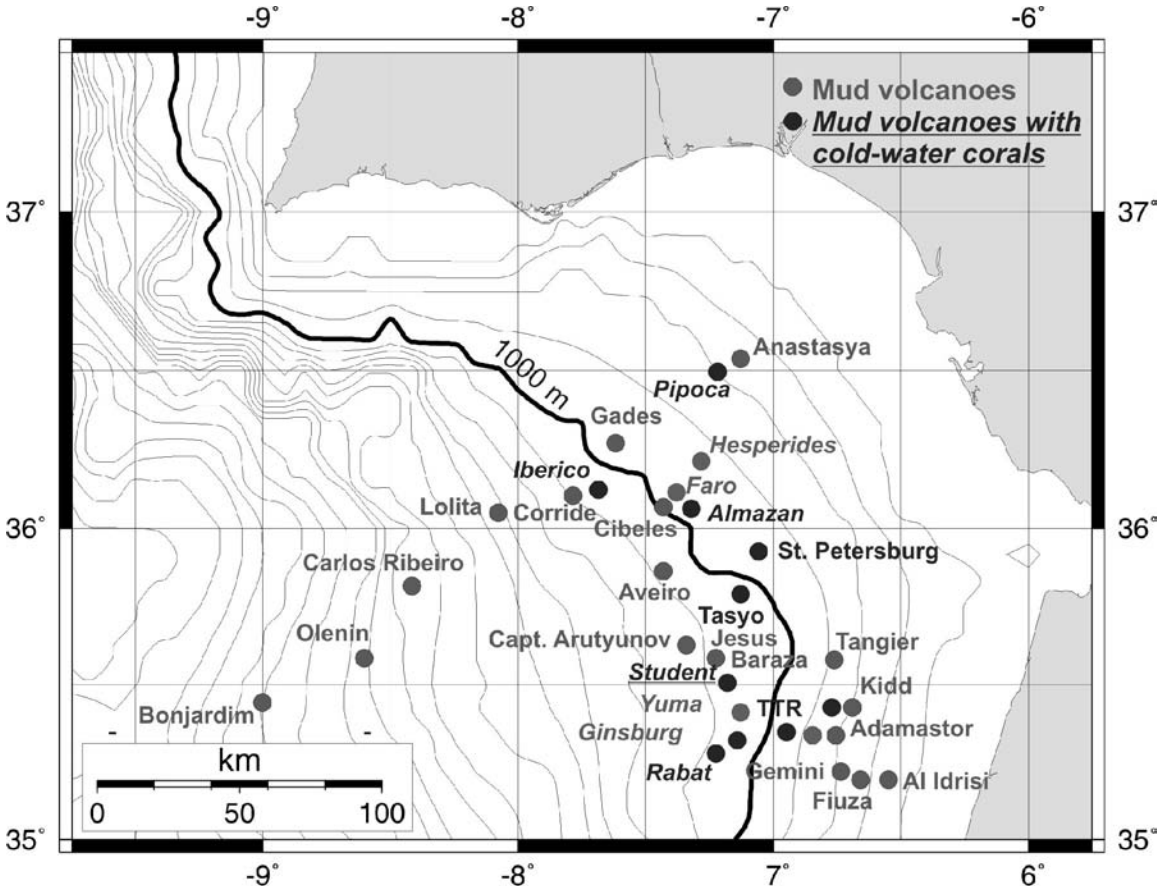

Figure 2.1.1.5.1.7.1. Mud volcanoes found in the Gulf of Cadiz, December 2003, indicating those that have cold-water corals growing on them (D. Hebbeln, pers. comm.).

2.1.1.5.1.8 Portugal

The slopes of the islands and seamounts in the Azores comprise extensive volcanic rocky bottoms in a high energy environment. These areas are ideal for sessile suspension-feeding fauna such as deep-sea, cold-water hard corals, sea fans, and sponges.

The deep-sea coral fauna of the region was studied intensively at or shortly after the turn of the twentieth century (Gravier, 1920, 1921, 1922; Jourdan, 1895; Roule, 1905), and these studies are still the most important source of knowledge about the Azores benthic fauna, outside the hydrothermal vent fields. Subsequently, other expeditions targeted the deep-sea fauna of the region and sampled many coral species around the islands. Zibrowius (1980) reviewed those reporting Scleractinia, but several other publications deal with corals from the region.

A checklist of the species reported in the Azores region (defined as a rectangle enclosing the Azores EEZ) is presently being compiled, along with a database of the geographical and bathymetric data on the stations that produced the material. The study focuses on the corals ecologically classified as biobuilders, namely the orders Stolonifera, Gorgonacea, Alcyonacea (Octocorallia), Antipatharia, and Scleractinia (Hexacorallia).

The Department of Oceanography and Fisheries of the University of the Azores (DOP/UAç) has recently launched a small-scale programme with local fishermen to collect corals that are brought to the surface by the demersal gears used in the Azores (i.e., hand-lines, bottom longlines, and cages). Material gathered in scientific cruises is also being catalogued and preserved.

A preliminary checklist of the Azores corals, based both on data mining and new records, includes more than 110 species. A geographical information system will be used to produce distribution maps of these coral occurrences. Preliminary results indicate that some oceanic seamounts (e.g., Açores, Condor, Sedlo, Cavala) support rich assemblages of deep-sea corals. An assessment of the ongoing and potential impacts of bottom gear on those fragile, complex, and diverse communities will also be developed.

2.1.1.5.2 New information on the impacts of fishing on cold-water corals

2.1.1.5.2.1 USA

Coral by-catch has not been consistently identified or enumerated during the groundfish surveys of the Northeast Fisheries Science Center, so this data set is limited in any assessment of status. The utility of such data is illustrated in an analysis of coral distributions and associated fish taxa collected during similar fishery-independent surveys in the Alaska region (Heifetz, 2002). The rarity of encounters with deep-water corals in over twenty years of submersible dives across complex habitats on the shelf and upper slope of the northeast U.S. suggests that the distribution of these species has significantly contracted since the time of the surveys conducted by Wigley, Theroux, and others (i.e., tapes in the National Undersea Research Center (NURC) video archive at the University of Connecticut and those held by NURC-supported investigators).

More than 90% of *Oculina* habitat in a reserve off the east coast of Florida has been reduced to unconsolidated rubble (Koenig *et al*., in press). These authors present evidence of recent trawling activities as one likely and major cause of the damage, but temperature extremes, excess nutrients, disease, strong currents, and other types of ship operations are also potential sources of historic mortalities.

Corals are clearly sensitive to fishing gear impacts and recovery rates are extremely slow based on our knowledge of recruitment, growth rates, and age structure. The ability to age deep-water scleractinians and octocorals is relatively new and different methods have been used in different studies. For *Primnoa resedaeformis*, a common outer shelf/upper slope species, Risk *et al*. (2002) estimated linear growth rates at the distal tips of the colonies at 1.5–2.5 mm yr^{-1}, based on comparisons of live specimens with growth rates through the base of a sub-fossil specimen collected from the Northeast Channel at 450 m. See Section 3.1 of ICES (2004) for more details.

Data on recruitment patterns are limited. A single series of observations in the Gulf of Alaska suggested that the recruitment of *Primnoa* sp. is patchy and aperiodic (Krieger, 2001). No recruitment of new colonies was observed after seven years in an area where *Primnoa* was removed by trawling. Limited observations of corals in the Gulf of Maine and in submarine canyons have not revealed any recent (or abundant) new recruits of coral taxa (Watling, Auster, and France, unpublished observations).

The reproductive biology of anthozoans is well documented with respect to gonadal morphology, gametogenesis, and reproductive cycles (reviewed by Campbell, 1974; Larkman, 1983; Fautin and Mariscal, 1991; Eckelbarger, 1994; Eckelbarger and Larson, 1992; Eckelbarger *et al*., 1998), especially for sea anemones and corals of the Subclass Zoantharia (Hexacorallia); however, very little is known about the reproductive biology of the Subclass Alcyonaria (Octocorallia). Recent studies of the reproductive biology of seapens (pennatulid octocorals) in the Gulf of Maine have added a great deal of new information to knowledge of the Anthozoa (Eckelbarger *et al*., 1998). For example, this work has found fundamental differences in the process of gametogenesis between seapens and anemones. Additional knowledge about the reproductive anatomy of deep-sea corals would fill a major void in our knowledge of the relationships among the major anthozoan groups and would allow more refined predictions to be made regarding the effects of fisheries on coral habitats.

2.1.1.5.2.2 Canada

In surveys off Canada, the most extensive damage from fishing gear was observed at the Stone Fence (Mortensen *et al*., 2004b, in prep). About 90% of the *Lophelia pertusa* reef discovered in the Stone Fence area off eastern Canada was composed of dead coral, assumed to be caused by trawl fishing, both in the recent (thirty-year) past but persisting to the present. Live colonies were either small or clearly broken in an unnatural way. Gorgonians also showed signs of disturbance, with broken colonies, small size, and unnatural occurrence on the sides of and underneath boulders. Analysis of observer data indicates that the general area of the *Lophelia* reef had been regularly fished with bottom-trawling gear between 1980 and 2003. Current fisheries operating in the area are otter trawling for redfish and long-lining for halibut. A lower level of fishing damage was observed in the Northeast Channel (Mortensen *et al*., 2004a). In total, 4% of the observed gorgonian colonies were damaged, and broken or tilted corals were observed on 29% of the 52 survey transects. Lost longlines were observed loose on the seabed or entangled in corals on 37% of these transects. Tracks on the seabed, either from longline anchors or parts of otter trawl gear, were present along three transects, while lost gillnets were observed along two transects. Analysis of effort data indicates that longline activity is widespread throughout the Channel, while otter trawling and gillnet activity are concentrated on the Georges Bank side. Very few indications of fisheries damage to corals were observed in the Gully; only a few trawl tracks and one corroded lost wire from a trawl were observed (Mortensen *et al*., 2004b).

2.1.1.5.2.3 Norway

In one locality in the southeastern corner of the mapped area in Træna, large quantities of dead corals were detected. This may be damage caused by trawling; however, no firm evidence of trawling was documented. Along the continental break between Belikdjupet and Sveinsgrunnen, which is a heavily trawled area, coral reefs on the shelf were severely damaged. Lost lines and gillnets were documented in all known coral areas surveyed by Norway in 2003.

2.1.1.5.2.4 Ireland

A total of nine dives were carried out with the IFREMER deep-sea "VICTOR 6000" Remotely Operated Vehicle (ROV) during the RV "Polarstern" expedition ARK XIX Leg 3A to the Porcupine Sea Bight and Bank to investigate carbonate mound and deep-water coral locations off the west coast of Ireland (Wheeler *et al*., in press). High resolution video and close-up digital stills were used to document the impact of fishing activity and the presence of lost gears. A series of mounds and scarps investigated along the western edge of the Porcupine Bank, in water depths of 600–1000 m, were the most severely impacted (Grehan *et al*., 2003a). One double mound system, named the Twin Mounds, appeared to be heavily trawled, as evidenced by the presence of trawl scars, barren sediment, and flattened coral rubble. On the nearby Giant Mound, images of lost trawl gear filled with coral (some of it still living) provided clear evidence that reefs are being destroyed by present fishing activities. Numerous examples of lost static gears were also found draped over corals and other protrusions on vertical cliffs associated with a several kilometre long scarp feature also in the vicinity. The lines and nets observed did not in most cases appear to have been snagged, but rather were swept over the ledges by the strong bottom currents in the area.

2.1.1.5.3 The importance of cold-water coral reefs as a habitat for other species

2.1.1.5.3.1 USA

The role of deep-water corals as particular habitats for fishes has only been recently addressed in the literature. *Primnoa*, *Lophelia*, and *Oculina* are the taxa that have been the focus of most of this work. Corals may provide structure for shelter-seeking fishes as well as enhance rates of prey capture. In the Gulf of Alaska, Krieger and Wing (2002) noted that "less than 1% of the boulders contained coral, but 85% of the large rockfish (*Sebastes* spp.) were next to boulders with corals." Data from research survey trawls off Alaska show that rockfish (*Sebastes* spp. and *Sebastolobus alascanus*) and Atka mackerel (*Pleurogrammus monopterygius*) were the most common economically important species collected with gorgonian, cup, and hydrocorals, while flounders and gadids were the most common species associated with *Gersemia* sp., a soft coral primarily in the Bering Sea (Heifetz, 2002).

While many studies have documented high densities of fishes in particular coral habitats versus adjacent non-coral areas, these patterns do not necessarily indicate whether corals are "important" habitats for fishes in a demographic sense. Frequency-dependent distribution models provide a basis for assessing the role of deep-water corals where it is necessary to understand the overall habitat-related distributions of fish species, at particular life history stages, in order to assess the particular role of corals. Examining the landscape for ecologically equivalent habitats is one approach for assessing the importance of coral habitats. Measures of the functional equivalence of habitats are demonstrated, as an example, for sites from the Gulf of Maine on the northeast United States continental shelf (Auster, in press). Fish census data based on surveys with a remotely operated vehicle in 2003 showed that communities in habitats dominated by dense corals and dense epifauna were functionally equivalent when compared with five other less complex habitats (e.g., boulder with sparse coral cover). Comparison of species-individual curves showed that sites with dense coral and dense epifauna habitats supported only moderate levels of fish diversity when compared with other sites. Further, the density of Acadian redfish (*Sebastes fasciatus*) in dense coral and dense epifauna habitats, where this species was dominant, was not statistically different but was higher than an in outcrop-boulder habitat with sparse epifauna (the only other site where this species was abundant). Such data suggest that coral habitats are not necessarily unique, but have attributes similar to other important habitats. However, the level of their importance in the demography of fish populations and communities remains to be demonstrated.

Sulak *et al*. (2003) examined the fish fauna of deep-water *Lophelia* reefs off the southeastern USA. *Lophelia* banks in this area support a distinctive fish assemblage when compared to non-coral habitats in the same depths. Sixty-five species of more than thirty families have been identified from these reefs. Economically important species included wreckfish (*Polyprion americanus*) and black-bellied rosefish (*Helicolenus dactylopterus*). *Laemonema melanurum*, *Squalus asper*, *Hoplostethus occidentalis*, and *Beryx spendens* appeared to be restricted to the reef habitat.

2.1.1.5.3.2 Canada

Buhl-Mortensen and Mortensen (2004b) described the fauna associated with the deep-sea gorgonian species *Paragorgia arborea* and *Primnoa resedaeformis* from the continental shelf and slope off eastern Canada. A total of 49 samples were collected by ROV, video grab, and bottom trawl from four areas. A total of eighty species were identified, including two crustacean species new to science. The fauna with *Paragorgia* was more diverse than that with *Primnoa*, and there were clear differences in faunal composition between the two corals. Crustaceans dominated the fauna, and although the deep-sea corals lacked the diverse decapod fauna of their tropical counterparts, the overall species richness was higher than in tropical gorgonians. Very few obligate symbionts were found (as with *Lophelia*), but several of the species found are rare in other habitats and have been recorded from the same, or similar, gorgonian species in the northeastern Atlantic.

2.1.1.5.3.3 Norway, Sweden, UK, Ireland, and Spain

As part of the EU-funded ACES (Atlantic Coral Ecosystem Study) project, analysis was undertaken of faunal samples taken from *Lophelia pertusa* reefs in these five countries (Roberts and Gage, 2003). A summary of the number of major taxa recorded is given in Table 2.1.1.5.3.3.1.

It is likely that many of the differences between sites in Table 2.1.1.5.3.3.1 are the result of the following factors:

1) Difference in the level of taxonomic resolution with which samples could be identified—this relates to both differences in sample collection technique (e.g., trawl vs. box core) and sample processing (e.g., preservation in formalin vs. air dried).

2) Difference in size classes collected—for example, the only site where the smaller size classes (32–500 µm) were analysed was the Belgica Mounds, explaining the preponderance of nematodes reported here.

3) Difference in taxonomic expertise—for example, the large number of sponges reported at Propellor Mound, where a special study of this group was undertaken, compared to the very few recorded at Belgica Mound, where this was not undertaken.

Despite the disparity in sampling methodologies and taxonomic resolution applied, a single listing of species recorded from these sites has been compiled. While some further checking may be required, this first compilation sums to a total of 1,317 species. This number may by be marginally increased or decreased by further rigorous examination of the list, but it certainly shows that the species inventory recorded on *Lophelia pertusa* reefs in the Northeast Atlantic is greater than the 886 species found by Rogers (1999). The vast majority of these species are facultative associates of *Lophelia pertusa*. To date, there has been little detailed analysis of obligate associates of cold-water corals. However, the presence of coral rubble does appear to enhance local faunal diversity significantly.

Table 2.1.1.5.3.3.1. Numbers of species of major phyla recorded at each ACES study site (* data unavailable) (ACES, unpublished).

Phylum	Sula Ridge	Kosterfjord	Darwin Mounds	Propellor Mound	Belgica Mound	Galicia Bank
Protozoa (Ciliophora)	*	1	*	*	*	*
Foraminifera	55	8	1	16	*	*
Porifera	44	43	20	104	1	1
Cnidaria	19	26	2	10	11	9
Ctenophora	*	1	*	*	*	*
Nematoda	*	*	*	*	131	*
Nemertea	*	1	1	*	*	*
Annelida	24	57	102	*	58	4
Prialupida	*	*	*	*	1	*
Sipuculida	2	4	2	*	2	1
Echiura	2	1	2	1	1	*
Arthropoda	23	37	80	7	31	22
Pycnogonida	*	2	1	*	*	*
Mollusca	39	52	61	160	13	19
Bryozoa	47	6	16	*	2	*
Echinodermata	19	29	20	4	4	3
Phoronida	1	*	*	*	*	*
Brachiopoda	5	3	5	4	3	2
Hemichordata	1	1	*	1	*	*
Chordata (Tunicata)	6	*	1	*	*	*
Chordata (Pisces)	11	26	9	21	*	6

Four hypotheses were used to examine the results of this survey:

A. Cold-water coral structures can be subdivided into a repeatable set of sub-habitats with a species composition grading into the background community.

Although a broad characterization of sub-habitats (e.g., living and non-living coral framework, exposed coral rubble and semi- and fully buried rubble) is possible, finer characterization seems to be site-specific, and depends on the growth form and the geology and topography of the seabed on which the coral is growing. However, a species composition grading into the background community, rather than an abrupt break, seemed to be a feature of some areas (e.g., Galicia Bank and Darwin Mounds) more than others (e.g., Propellor Mound), where the topography imposed a steeper environmental gradient into the "background" environment.

B. Living coral structures support a biodiversity (composition and richness) that is different from that of background areas with similar attributes of the sub-habitat (e.g., presence of hard substratum, food, and hydrodynamics).

This hypothesis could be addressed explicitly only for certain taxa (especially fish) in the context of living coral. It was possible to address this with regard to fauna associated with dead coral rubble at the Darwin Mounds compared to background areas containing hard substrata. The results indicated that no coral-specific fauna was present, with all species present being already known as associated with hard substrata such as mollusc shells and drop stones. A similar conclusion might be reached from the listing assembled by Rogers (1999), although agreement between the two species lists is surprisingly very limited. Nevertheless, even if discrepancies at the species or genus level exist, a very similar functional type may be found occupying a particular niche provided by the living, or dead, coral framework. An example of this is provided by the small suspension-feeding ophiuroid *Ophiactis balli* that is found to develop dense populations at the shallower sites (e.g., Koster Fjord and Mingulay), while in deeper water (e.g., the Darwin Mounds) the apparently functionally similar congener *O. abyssicola* is found in large numbers.

C. Species inventory is predictable at different sites regardless of geography and depth.

A proper assessment of this hypothesis is difficult as biodiversity descriptions were usually biased by the taxonomic experience of the investigator at each site. Even where similar size classes were examined, differing methodology limited the validity of making direct comparisons. Nevertheless, the hypothesis does not seem to be supported from the data available. Although species are listed that were found at nearly all sites, others seemed to reflect the usual range of the species in the background community. Because of this, the species inventories at the different sites in the Northeast Atlantic varied substantially. This is in agreement with the conclusions of Jensen and Frederiksen (1992).

D. There are species found associated with the coral that are found only in this habitat.

The results of Roberts and Gage (2003) support the view reached by Burdon-Jones and Tambs-Lyche (1960) and Jensen and Frederiksen (1992) that a true obligate fauna associated with *Lophelia*, in the sense of Dons (1944), has yet to be described. Hence, the habitat requirement of the rich associated biodiversity is provided by features of the coral framework (e.g., hard, cryptic substratum) or the habitat that is beneficial to coral (strong plankton-carrying flow), which may be equally found in other areas. Therefore, this biodiversity is composed of facultative associates that find that cold-water coral matches their habitat requirement.

Costello *et al*. (2003, in press) described the function of *Lophelia* as fish habitat, based on the results of the ACES study described above. A total of 23 species of fish from seventeen families (McCrea *et al*., 2003) were recorded over all sites studied. Four habitats were distinguished: reef, transitional, coral debris, and off-reef seabed. Multivariate analysis showed a distinct separation of assemblages at 400–600 m depth. The species diversity and abundance of fish were greater on the reef than over the surrounding seabed, with 92% of the species and 80% of abundance associated with the reef. The reefs plainly have an important function in deep-water areas in providing fish habitat.

2.1.1.5.3.4 Faroes

Jensen and Frederiksen (1992) studied associated fauna in 25 blocks of *Lophelia pertusa* weighing a total of 18.5 kg. A total of 256 species were found, with an additional 42 species from loose coral rubble. Most individuals were found in dead coral blocks, with a few species close to the terminal branches of live coral. One of these species, the foraminiferan *Pulvinulina punctulana*, lives directly as a parasite on the coral tissue. The overall faunal association was found to be as rich as that found on hermatypic branching species of coral.

2.1.1.5.3.5 Norway

Mortensen *et al*. (1995) investigated large and visible fauna on *Lophelia pertusa* reefs off Norway using video techniques. Their transects started over soft bottoms with scattered patches of stones below bioherms and finished at the top of the bioherms, some of which were 31 m high. Five habitats were defined: soft bottom, mixed stone bottom, *Lophelia* rubble, dead *Lophelia*, and living *Lophelia*. Thirty-six taxa were identified, five of which occurred only on the bioherms, and five only over the soft/stony bottoms. The *Lophelia* rubble had the lowest diversity but the highest average density of individuals. Sponges, gorgonians, squat lobsters, redfish (*Sebastes* spp.), and saithe (*Pollachius virens*) dominated in terms of individuals per area. Four species of fish were identified. Saithe were often observed feeding on the bottom, but were thought to be only temporary residents at the bioherm as they were only seen on one month of the three when surveys occurred. Redfish feed on plankton and were most common either over the live *Lophelia* or resting within the *Lophelia* structure. Tusk (*Brosme brosme*) were present as isolated individuals possibly feeding on squat lobsters present in the bioherms. *Chimera monstrosa* were seen occasionally over soft-bottom areas. In summary, no large species was an obligate associate of the *Lophelia* bioherms, and those fish occurring on or around the *Lophelia* reefs were using the structure in a variety of ways.

Husebø *et al*. (2002) carried out experimental fishing with longlines and gillnets over *Lophelia pertusa* reefs and in nearby non-coral habitats. The abundance and distribution of redfish (*Sebastes marinus*), ling (*Molva molva*), and tusk (*Brosme brosme*) were quantified in the two habitats. Significantly larger catches of fish (total for all species) were made in the coral habitat, but this was mostly caused by large catches of redfish made on longlines in coral habitats. More fish of each species were caught regardless of method in coral habitats compared with non-coral habitats, but with the exception of redfish on longlines, none of these differences were significant. Redfish, tusk, and ling caught over coral habitats were all generally larger than those caught in non-coral habitats. An examination of the stomach contents of the fish caught in these experiments supports the idea that redfish primarily use the habitat for its physical structure (shelter, and possibly a food-concentrating mechanism), while tusk feed on other organisms using the reef.

2.1.1.5.3.6 Ireland

Grehan *et al*. (2003b) examined the isotopic content of biota growing on the deep-water carbonate mounds to the west of Ireland that usually have *Lophelia* reefs associated with them. Some evidence has been published suggesting a link between some of these carbonate mounds and hydrocarbon seeps. However, the isotopic content of the carbon and nitrogen of the mound biota was consistent with a reliance on photosynthetically derived particulate organic matter, rather than hydrocarbon seepage.

Raes and Vanreusel (2003) examined the meiofauna in cold-water coral degradation zones in the Porcupine Seabight. A total of 22 meiofaunal taxa were found, of which nematodes were the dominant group. Mixed substrates containing underlying sediment as well as coral and sponge fragments had the most diverse meiofauna, but the nematode fauna was not as diverse as that taken elsewhere in non-coralligenic sediments. Nevertheless only five of the seventeen species of nematode found were known to science.

Wheeler *et al*. (in press) examined a series of carbonate mounds on the Porcupine Bank to the west of Ireland. These mounds appeared to be composed mostly of degraded dead coral. The carbonate mounds are colonized by a variety of suspension feeders and associated fauna including framework-building corals (e.g., *Lophelia pertusa* and *Madrepora oculata*), although dense coral reef-like fauna coverage is not evident at present (Figure 2.1.1.5.3.6.1 A–F). The ecology of the carbonate mounds varied widely. Sessile megafauna, such as sponges, gorgonians, and framework-building corals (e.g., *Lophelia pertusa*), were abundant on some of the carbonate mounds. Other mounds were relatively barren and appeared to be undergoing a natural senescence, with a much lower biomass of megafauna than is typical of shallow-water coral reefs. Some mounds had been damaged by demersal trawls, with smashed coral and lost gear common, whereas others appeared relatively pristine with occasional evidence of man-made litter.

2.1.1.5.4 Location of areas to protect from deep-water trawling

The results of a survey project were used by the Canadian Department of Fisheries and Oceans (DFO) in establishing a 424 km^2 coral conservation area in the Northeast Channel in 2002 and in designing the Marine Protected Area in the Gully that was formally declared in 2004. They are also being used by DFO and the fishing industry to establish protection for the *Lophelia* reef at the Stone Fence.

While no new sites were put forward for protection, in the case of Ireland, the Irish Government announced at the OSPAR Ministerial Meeting in Bremen in June 2003 its intention to designate a number of offshore sites as cold-water coral reef Special Areas of Conservation (SACs) under the EU Habitats Directive. The Irish Department of the Environment, the competent authority, is currently engaged in a data collection exercise prior to the identification of suitable sites.

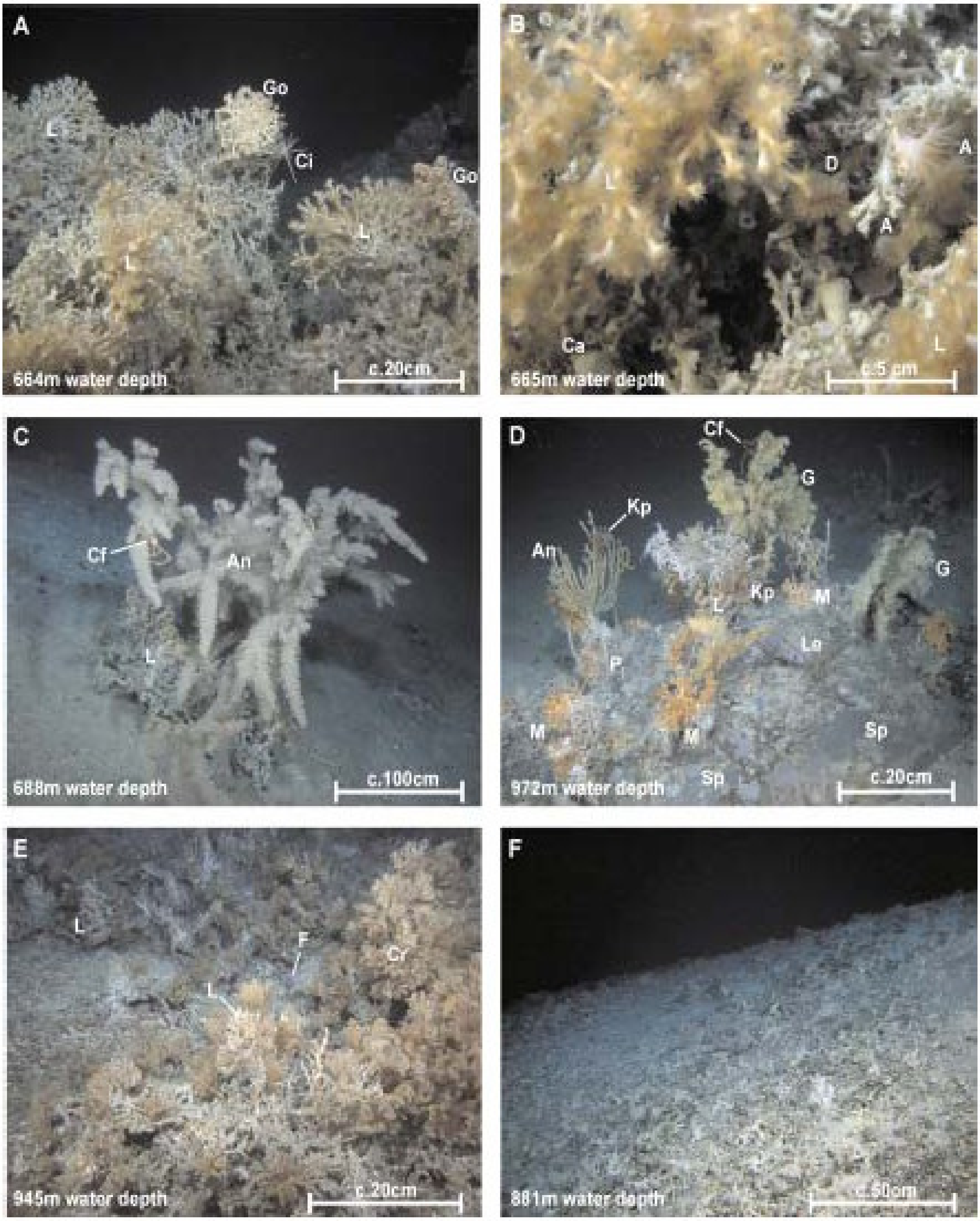

Figure 2.1.1.5.3.6.1. Selected images showing the variety of organisms and their associations encountered on the northwest Porcupine Bank.

A. *Lophelia pertusa* colonies (L) with *Gorgonocephalus* sp. (Go) and *Cidaris cidaris* (Ci).
B. Close up of *L. pertusa* colonies (L) with polyps extended. An anemone (A), a gastropod (*Calliostoma* sp.) (Ca), and *Desmopyllum cristagalli* (solitary coral) (D) are also present.
C. An antipatharian (An) with spider crabs (*Chirostylus formosus*) (Cf) attached to a *L. pertusa* colony (L).
D. Heavily colonized dropstone with several sponge species (Sp), *L. pertusa* (L), *Madrepora oculata* (M), antipatharians (An), sylasterids (*Pliobothrus* sp.) (P), crinoids (*Koehlerometra porrecta*) (Kp), and spider crabs (*Chirostylus formosus*) (Cf) attached to gorgonians (*Acanthogorgia* sp. and others) (G) as well as a fish (*Lepidion eques*) (Le).
E. Crinoids (Cr) attached to *L. pertusa* colonies (L) with a fish (F).
F. Coral rubble field as a result of demersal trawling activity.

2.1.1.5.5 References

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2.1.1.6 Special request to ICES on Haddock in ICES Divisions VII, VIII, IX, X, and COPACE 34.1.1

On 2 July 2004, the European Commission (DG Fisheries) requested ICES:

"to review the advice provided in 2003 for the fisheries in 2004 on stocks of haddock that are distributed in ICES Divisions VII, VIII, IX, X, and COPACE 34.1.1. in the light of new information.

<u>ICES Comments</u>

Haddock are taken in the mixed demersal fishery with cod, whiting, plaice, and *Nephrops* and management advice needs to be considered in that context.

The TAC for haddock is set for all of Sub-areas VII, VIII, IX and X, and is 9,600 t in 2004 with a limit of 1,500 t to be taken from Division VIIa (Irish Sea).

For haddock in Division VIIa, ICES in 2003 advised that catches should be no higher than 1500 t and the stock was classified as being harvested outside safe biological limits.

In 2003 ICES advised that while the state of Divisions VIIb-k haddock is unknown, it is considered to be at a relatively high level. The single stock exploitation boundaries for Divisions VIIb-k haddock is that "fishing mortality should not be allowed to increase".

In 2004 ICES assessed the Divisions VIIb-k haddock stock. The main conclusions were:

1. A relatively strong 2001 year-class is expected to have caused an increase in SSB from 2003 onwards. Several different survey series indicate a very strong 2002 year-class (Figure 1). UK surveys show concentrations of haddock off the Southwest of Ireland (Division VIIj), and in the Celtic Sea between Ireland and England (Division VIIg) (Figures 2 - 4); however, these surveys do not extend much into Division VIIb. The Irish 4th Quarter 2003 survey shows very large concentrations of juvenile haddock (mainly the 2002 year class) in Division VIIb with quite large concentrations of this year class also apparent in Division VIIj with lesser concentrations in Division VIIg (Figure 5). The majority of the 2002 year class remains in 2004 below the minimum landing size (MLS = 30 cm).

2. UK and Irish observer data indicate substantial discarding of haddock of the 2001 and in particular of the 2002 year class in Divisions VIIb and VIIj in 2003. Preliminary 2004 Irish discarding data indicate that substantial discarding of the 2002 year-class in Divisions VIIb and VIIj continues. Irish data suggest that discarding of the very strong 2002 year class is prevalent in the western Celtic Sea and off SW Ireland beyond the typical range of the bulk of the UK fleet. The French fleet reported that in 2004, discarding of very small fish is large, but no quantitative data are available;

3. The anticipated large increase in landings and catch rate of haddock in 2004 is not evident in reported fishery statistics from the UK fleet operating mainly in the eastern Celtic Sea and off the Southwest coast of England (Figure 6). Similarly, preliminary landings for the Irish fleet operating throughout Divisions VIIb-k do not show a large increase in landings during the first half of 2004 (Figure 7). The Irish fishery is under an output control regime and the market price for haddock in 2004 has been poor so it is difficult to make definitive conclusions about abundance based on these landings data. The TAC increased between 2003 to 2004 suggesting that the poor 2004 landings uptake may not be due to increased misreporting under restrictive quotas. French landings increased in the second half of 2003, but preliminary information for 2004 show that French landings in the first half of 2004 are very similar to those reported in previous years (Figure 8). Most of the trawlers operating in Divisions VIIe-k use mesh size equal or greater than 100 mm.

4. The 2004 ICES assessment is only tentative. Although there are discard data available there were no discard estimates from the French gadoid fleet, which accounts for up to 60% of the landings for this stock. Where available, the time series of discards are short and the estimates are highly variable between areas, year classes and fleets with a clear difference in discard length distributions between areas. Taking all these factors into account, these data were excluded from the assessment. A very limited retrospective analysis of the current assessment model indicates a tendency to underestimate fishing mortality in the most recent year and to overestimate SSB. Estimates of recruitment are noisy but show no consistent tendency to under- or overestimation. However, the results of the 2004 assessment are consistent with those obtained in 2003. As

stated above, the 2002 year class is strong; this conclusion is based on survey information and limited discard data;

5. The assessment provides only qualitative inferences regarding short-term forecasts of SSB in 2005 and 2006 and landings in 2004 and 2005. However, the combination of the two largest recorded year classes (2001 and 2002) is expected to cause a substantial increase in SSB and in fishing possibilities, even though the absolute values are poorly determined. There may be increasing availability of haddock during the remainder of 2004 as the 2002 year class increase above the MLS and directed fisheries may develop. A sensitivity analysis indicates that a TAC for 2004 of about twice that currently set would imply a low risk of overfishing the stock.

The haddock stock in Divisions VIIb-k has yielded 3,300 t – 10,800 t annually since 1993. The TAC for Subareas VII – X in 2003 was 8,185 t with a 1,500 t allocation for Division VIIa. Reported landings from Divisions VIIb-k in 2003 were 7,800 t with substantial discarding of young fish of the 2001 and 2002 year-classes recorded in 2003.

The largest landings in Divisions VIIb-k in recent years were 10,800t, reported in 1997. This followed good recruitment of the 1994 and 1995 year-classes. The 2002 year-class is estimated to be larger than the 1995 year-class, leading to the potential for landings in 2004 to substantially exceed both the 1997 reported value and the current TAC.

Conclusion

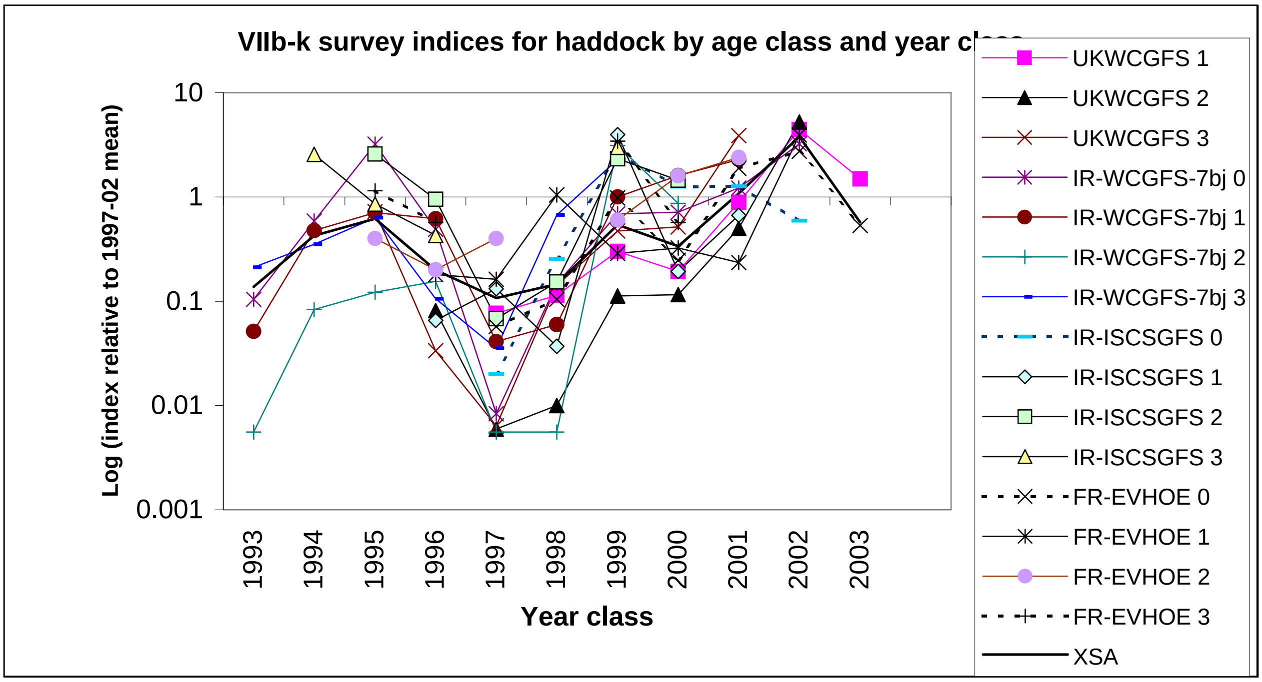
The haddock stock is increasing, but ICES is unable to confidently provide an estimate of the size of the increase, due to an unreliable forecast and the level of discard. Any forecast for this stock is extremely dependent on the strength of the 2002 year-class. Survival of this year-class through to 2005 and 2006 is uncertain due to the expected high mortality caused by discarding.

The overriding management concern in this area should be to protect stocks outside safe biological limits. Haddock are mainly caught in mixed fisheries. The fishery should only be allowed to expand if ways of harvesting haddock without jeopardising other stocks that are fished together with haddock and that are outside safe biological limits can be found.

Industry initiated programmes for developing clean haddock fisheries should be encouraged. Such programmes must include a high rate of independent observer coverage or other totally transparent methods to ensure that catches are fully and credibly reported in particularly of species harvested unsustainably or suffering reduced reproductive capacity.

The restriction on the haddock catch in Division VIIa should be maintained.

An increase in mesh size to reduce discarding of juveniles would be of significant benefit to this stock. Selection curves obtained on Division VIa haddock indicate that a minimum landing size of 30 cm corresponds to a mesh size of approximately 120 mm (L_{25}). Reducing exploitation on younger ages would avoid unnecessary discarding and would promote stock and yield increases when strong year classes occur.



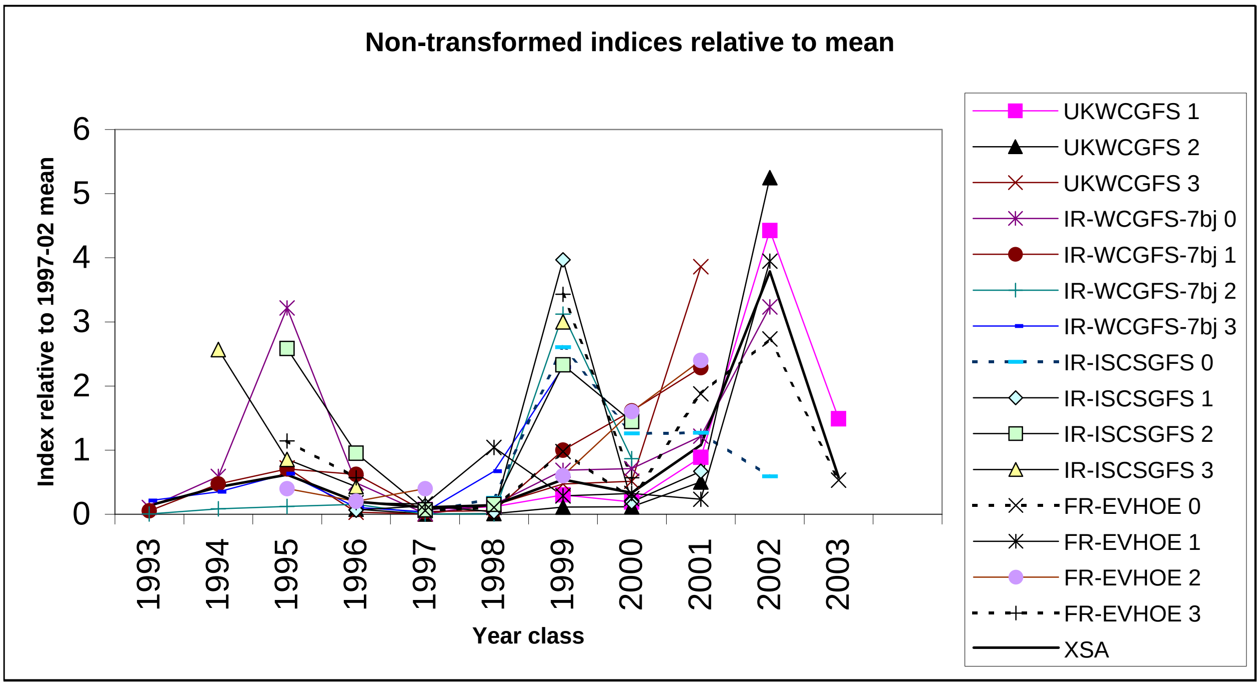


Figure 1. Time series of survey indices for Divisions VIIb-k haddock, by year class. Final number in survey acronym is the age class. XSA estimates of recruitment at age 0 from 2004 ICES Working Group on the Assessment of Southern Shelf Demersal Stocks are shown. All values expressed relative to 1997-2002 mean which is common to most series. Top panel shows log-transformed values. Data from 1st Quarter CEFAS survey in 2004 are provisional.

: Distribution and relative abundance of (a) cod *Gadus morhua*, (b) haddock *Melanogrammus aeglefinus*, (c) whiting *Merlangius merlangus* and (d) hake *Merluccius merluccius*. Data for cod are number per hour, data for haddock, whiting and hake are based on Ln (1+ number per hour).

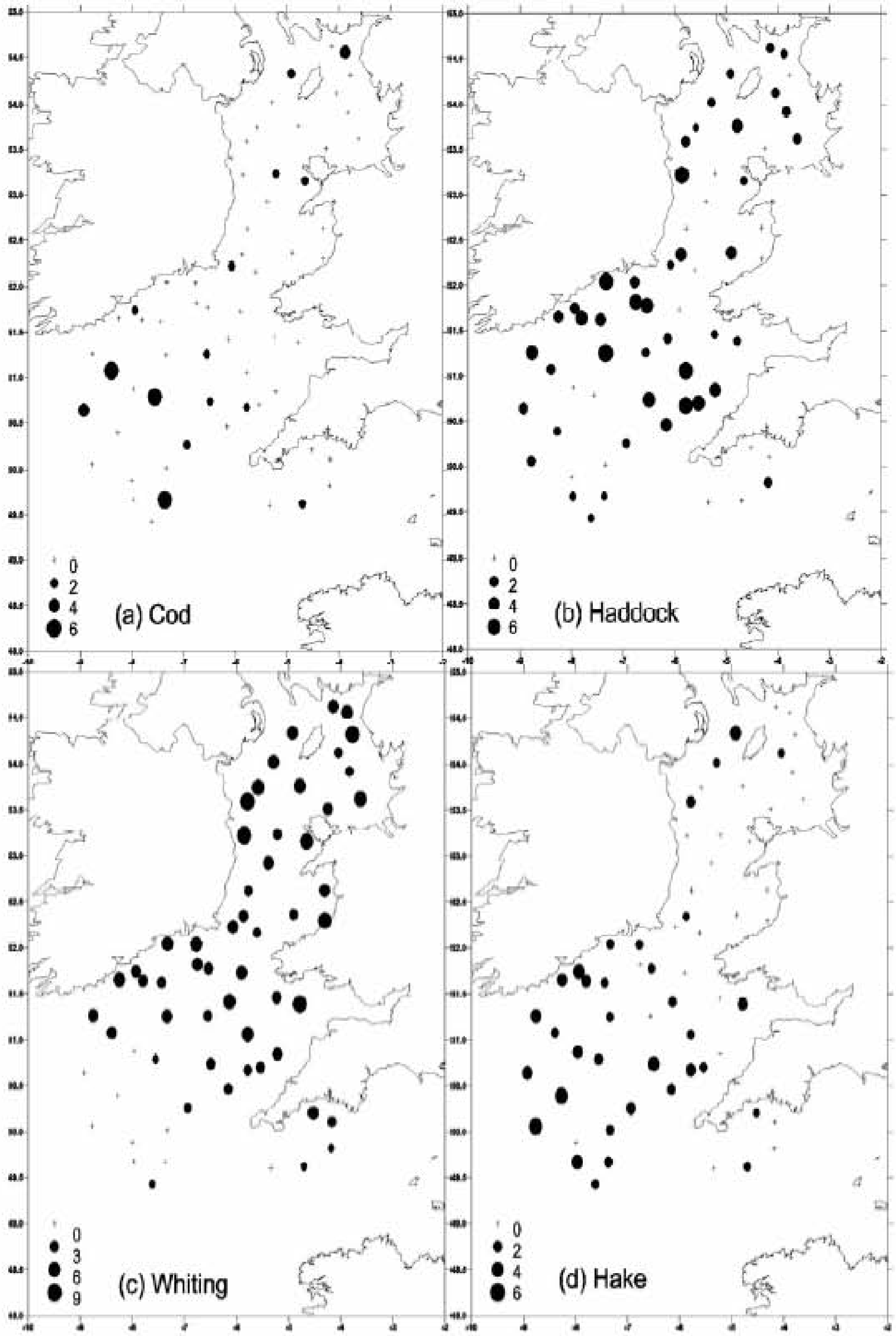


Figure 2. CEFAS 4th Quarter groundfish survey: 2003 (lift from Figure 3 in the CEFAS survey report 2004).

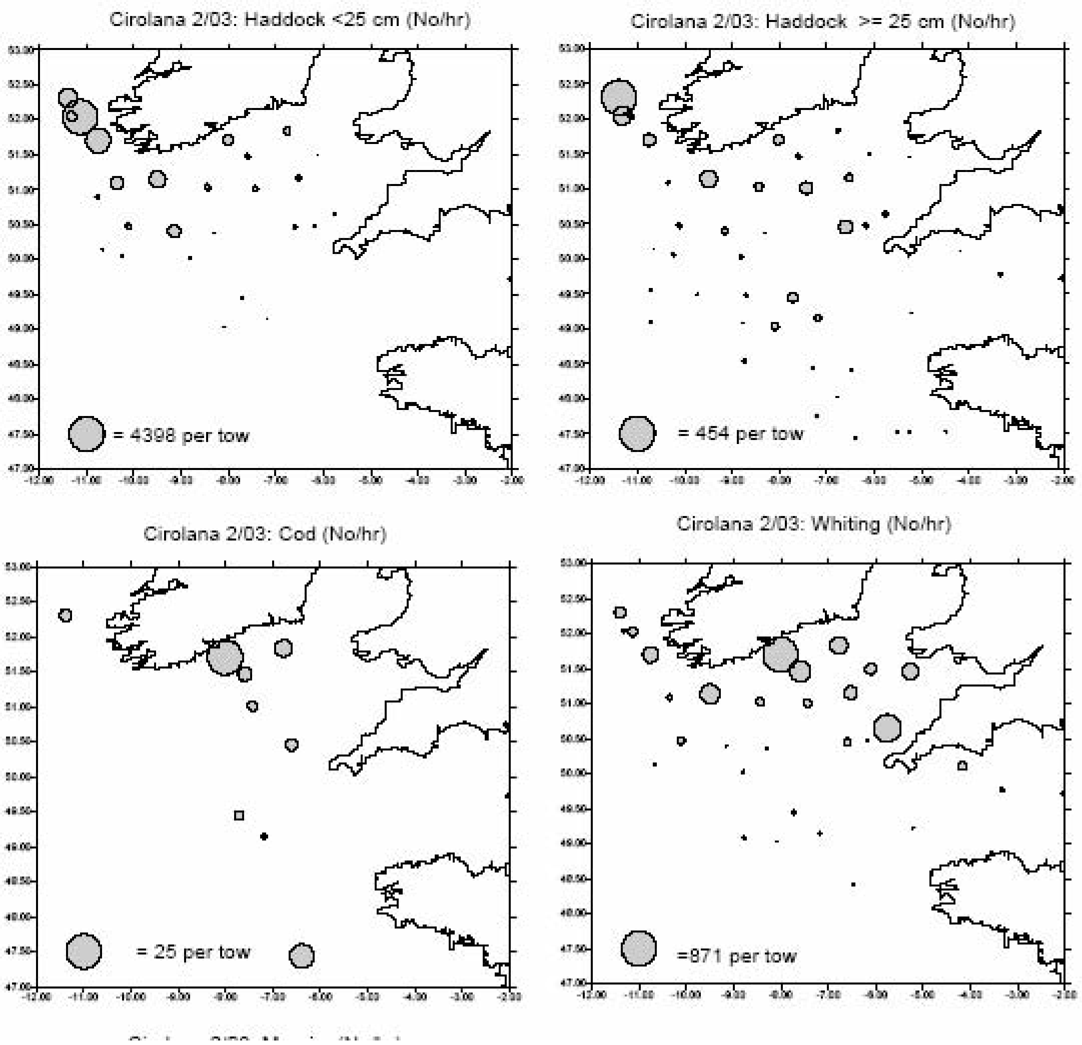


Figure 3. Catch rates of haddock, cod and whiting during Q1 CEFAS groundfish survey, 2003.

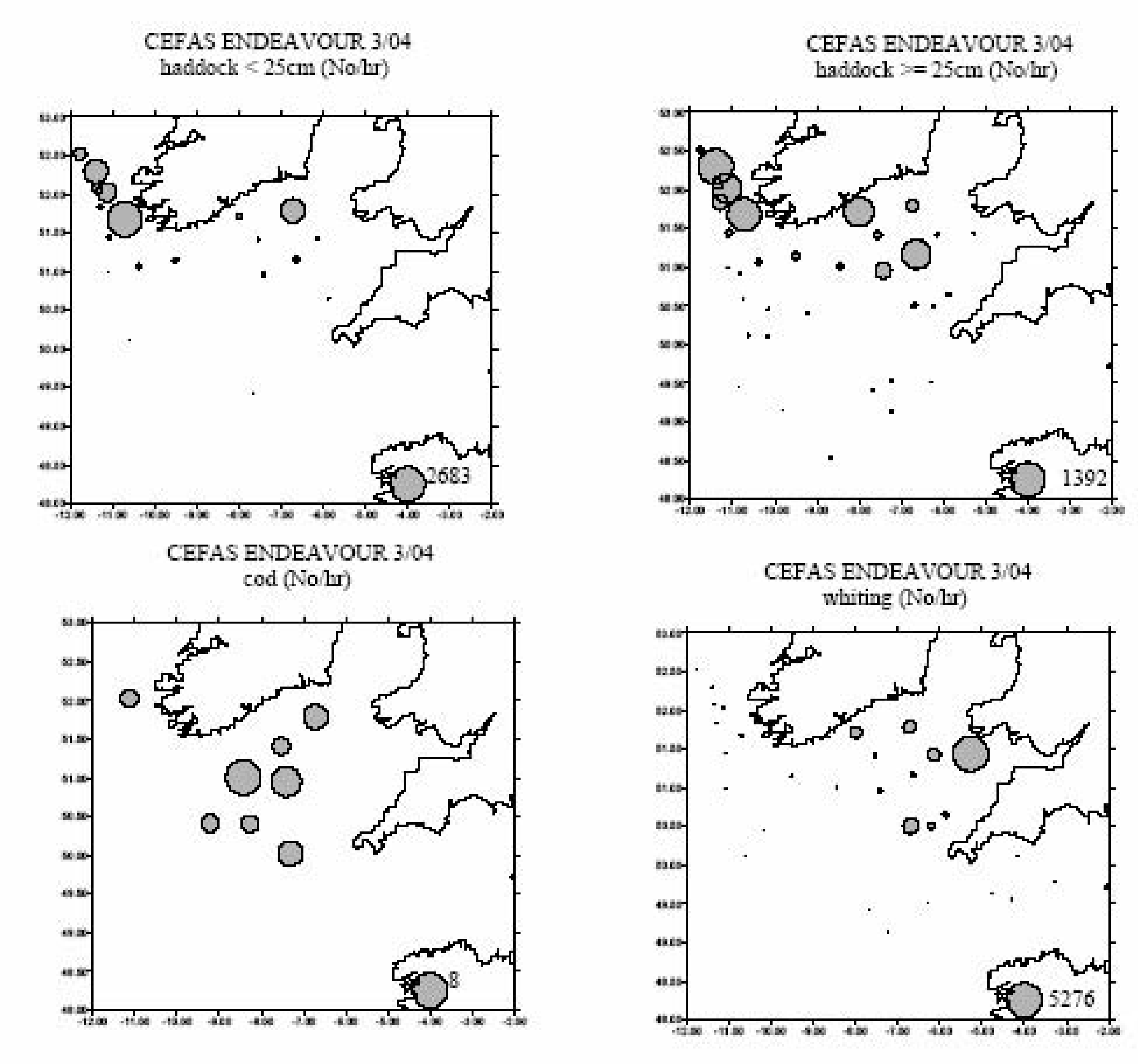


Figure 4. Catch rates of haddock, cod and whiting during 1st Quarter CEFAS groundfish survey, 2004.

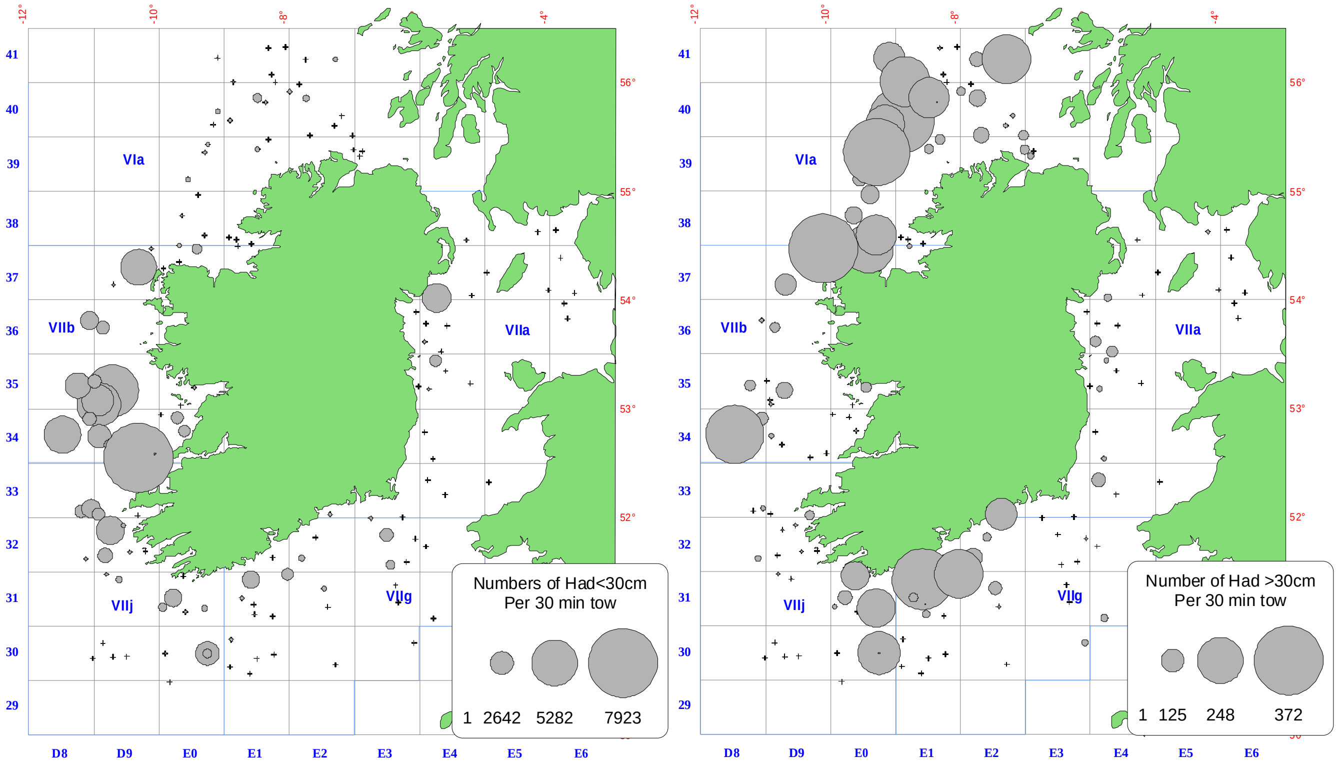


Figure 5. Catch rates of haddock less than and greater than the minimum landings size (30 cm) during the 4th Quarter Irish groundfish survey 2003. Station positions are indicated with +)

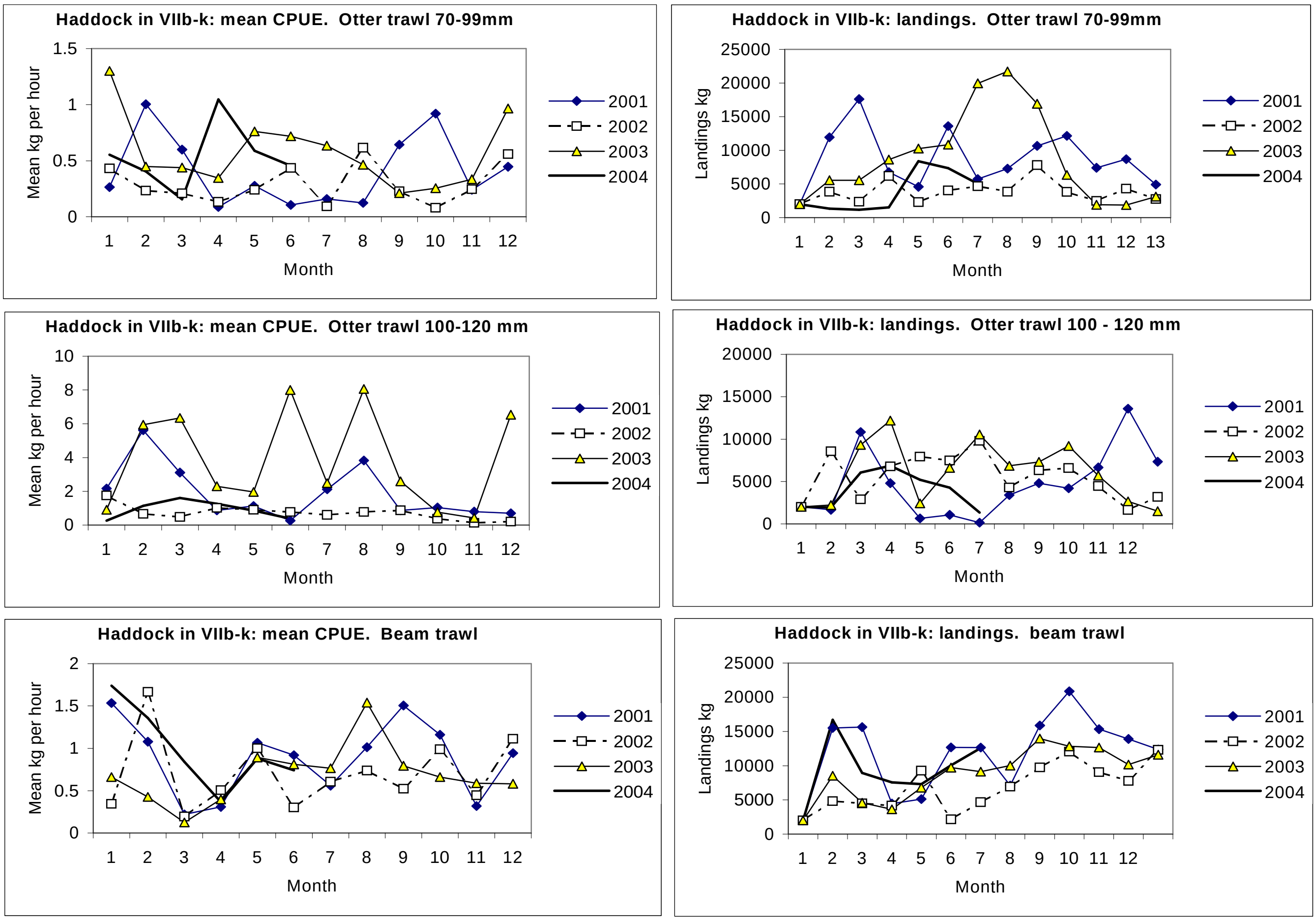


Figure 6. Monthly landings per unit effort, and total reported landings, for haddock taken in VIIb-k by UK vessels .

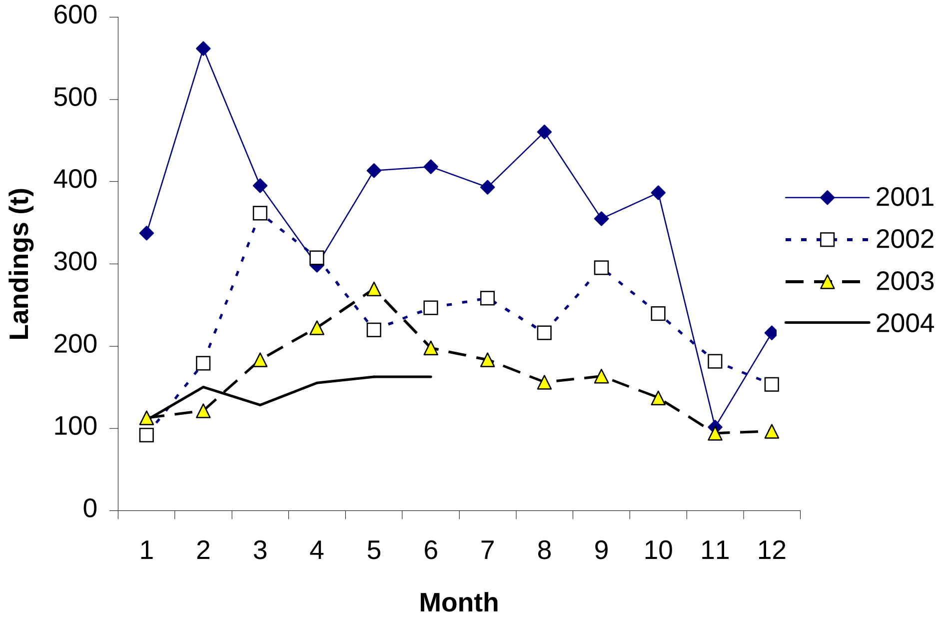


Figure 7 Monthly landings of Haddock taken in VIIb-k by Irish vessels.

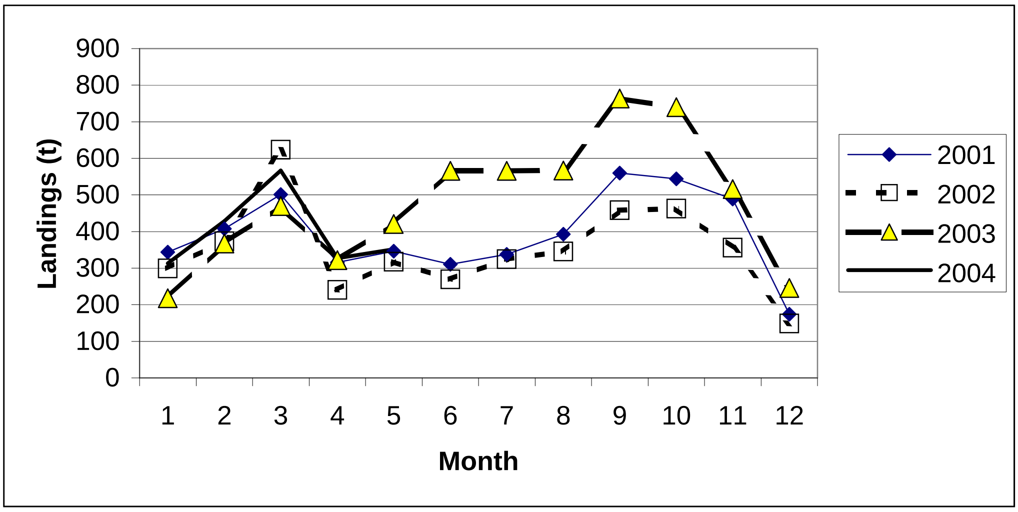


Figure 8. Monthly landings of Haddock taken in Divisions VIIb-k by French trawlers (log-books data)

2.1.2 DG Environment

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

Summary

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

Eleven eco-regions are proposed (Figure 1):

Greenland and Iceland Seas
Barents Sea
Faroes
Norwegian Sea
Celtic Seas
North Sea
South European Atlantic Shelf
Western Mediterranean Sea
Adriatic-Ionian Seas
Aegean-Levantine Seas
Oceanic northeast Atlantic

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

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

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

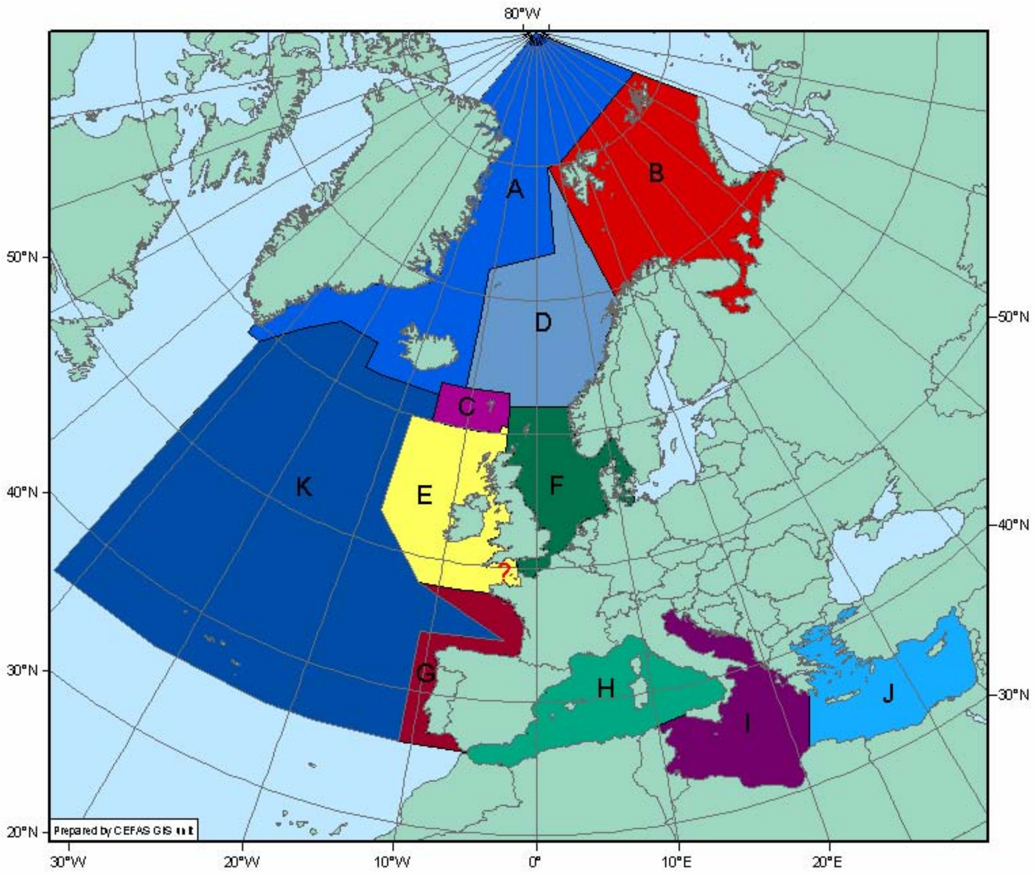


Figure 1. Proposed eco-regions for the implementation of the ecosystem approach in European waters. The eco-regions are Greenland and Iceland Seas (A), Barents Sea (B), Faroes (C), Norwegian Sea (D), Celtic Seas (E), North Sea (F), South European Atlantic Shelf (G), Western Mediterranean Sea (H), Adriatic-Ionian Seas (I), Aegean-Levantine Seas (J) and Oceanic northeast Atlantic (K). Equidistant azimuthal projection. The question mark denotes the western Channel (ICES Area VIIe), which could be placed in either the Celtic Sea or North Sea eco-region (paragraph 1.4.).

2. Request

Within the framework of the existing Memorandum of Understanding between the European Commission and ICES, ICES was asked to provide information and advice about appropriate eco-regions for the implementation of an ecosystem approach in European waters, preferably in advance of the Rotterdam Stakeholder Conference 10-12 November 2004 but not later then by the end of 2004. The European Commission submitted the following request (paragraphs 2.2. to 2.7.).

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

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

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

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

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

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

ICES convened a meeting of experts to provide a response to this request at ICES HQ Copenhagen 19-21 October 2004.

3. Geographical scope of study

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

In responding to the EC request, it was assumed that the areas to be covered are the maritime areas of the Barcelona, Bucharest, Helsinki and OSPAR Conventions - that is, the Atlantic Ocean west of a line from the south of Greenland, north of a line drawn west from the straits of Gibraltar, and east as far as longitude 51º East, to include the Baltic Sea, the Black Sea and the Mediterranean Sea (Annex 1).

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

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

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

In the landward direction, the response is based upon the recognition that the OSPAR Convention includes not only the territorial seas and exclusive economic zones (or equivalent jurisdictions) of the Contracting Parties and the relevant parts of the high seas, but also the internal waters of Contracting Parties as far as the freshwater limit. The situation is less clear in relation to the other regional seas conventions, but it seems sensible that, for the EU and EEA Member States, the definitions of the eco-regions should fit together with the areas delimited for the purposes of the EC Water Framework Directive[4]. The response to the request therefore assumes that the landward boundaries of the proposed eco-regions will be those defined as the landward boundaries of coastal waters and intermediate waters under the EC Water Framework Directive

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

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

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

Claims of Maritime Jurisdictional Zones by Member States of EU and Other States in the North-East Atlantic are summarised in Annex 2.

4. Evaluation of existing biogeographical and management regions

Consistent with the terms of the request (paragraphs 2.2.- 2.7.), eco-regions were defined as the areas for which ecological objectives would be set when implementing an ecosystem approach in European waters. The request required that the boundaries of eco-regions should be based on biogeographic and oceanographic features, taking account of existing political, social, economic and management divisions. Thus eco-regions should be characterised by greater similarity in biogeographic and oceanographic characteristics within than among regions. Moreover, the European Commission requested that the boundaries between eco-regions should be defined unambiguously to guide research, objective setting, assessment, monitoring and enforcement.

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

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

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

Category/ Criterion	Expectation in appropriate eco-region
1. Oceanography/ Biogeography/ Ecology	
a. Do the boundaries of existing or proposed eco-regions appropriately demarcate areas with identifiable oceanographic characteristics?	Clear oceanographic justification for demarcation
b. Do the boundaries of existing or proposed eco-regions appropriately demarcate the distribution of a range of species or communities that inhabit many different depths?	Boundary should demarcate distribution of both pelagic and benthic species and communities
c. Will oceanographically/ biogeographically defined boundaries of the existing or proposed eco-regions continue to apply over the time-scales used for management (decades or more)?	They would apply for decades or more
d. Would there be significant spatial variation in the response of existing or proposed eco-regions' physical characteristics, species and communities to climate variability and climate change?	Spatial variation should be low so that the rate of management adaptation to climate change can be similar throughout the eco-region
e. Is the level of exchange of materials between existing or proposed eco-regions as low as can reasonably be expected?	Low exchange, eco-region should be a relatively self sustaining system
f. Is the oceanographic and biological variability among sites within the existing or proposed eco-region smaller than variability among eco-regions?	Variability within eco-regions should be smaller than variability among regions
g. If there are sub-regions within the eco-region (oceanographically/ biogeographically identifiable regions that do not meet the criteria for eco-regions), do they nest	Eco-region should divide clearly and completely into a small number (typically ≤ 3) of sub-regions

within eco-regions without gaps or inefficiencies?	
2. Human impacts and their management	
a. Would management action in one existing or proposed eco-region negatively affect management in another eco-region?	Responses to management action on one eco-region should have a minimal or positive impacts on management actions in other eco-regions
b. Are the existing or proposed eco-regions compatible with the distributions and management of commercially exploited fish populations?	Fish populations should ideally be distributed and managed within the same eco-region
c. Are the boundaries of existing or proposed eco-regions consistent with those of existing or proposed management regions (e.g. WFD, GFCM, MAP, RACs, ICES, OSPAR)?	Consistency should be high
d. Are the boundaries of existing or proposed management and/ or eco-regions consistent with terrestrial management regions?	Boundaries should be consistent to support integration of marine and terrestrial assessment and management
e. Can research, assessment and monitoring of terrestrial and marine impacts be effectively linked at the scale of the existing or proposed eco-region?	It should be possible to link research, assessment and monitoring of terrestrial and marine impacts to effectively support integrated management
f. Are the existing or proposed eco-region boundaries compatible with patterns of land use type and change and the distribution of human populations?	There should be compatibilities between eco-region boundaries and land use type and change and the distribution of human populations since these are key drivers of impacts on the marine environment
g. If there are sub-regions within the eco-region (management regions that do not meet the criteria for eco-regions), to they nest within eco-regions without gaps or inefficiencies?	Eco-region should divide clearly and completely into a small number (typically ≤ 3) of sub-regions
h. Do contiguous shelf areas and the slope to a depth of at least 1000m fall into the same eco-region?	The shelf and slope to a depth of at least 1000m should fall within the same eco-region as human activities such as fishing have increasingly spread from shelf to slope regions.
3. Management/ Policy	
a. Do the existing or proposed eco-regions apply to the fullest possible extent to the marine environment including the coastal areas, internal waters, the territorial sea, the exclusive fishery zones and other sea areas under the sovereignty and jurisdiction of the Member States of the European Union and neighbouring countries?	Eco-regions should apply to the fullest possible extent to the marine environment
b. Are the boundaries of the existing or proposed eco-region compatible with the provisions of UNCLOS and other relevant international conventions?	Eco-region boundaries should be compatible with the provisions of UNCLOS and other relevant international conventions
c. In relation to the jurisdiction areas of regional conventions, are there any gaps within the existing or proposed eco-region?	There should be no gaps in jurisdiction
d. If a number of conventions apply in different parts of the existing or proposed eco-regions, then will the management response to any human impact be inconsistent in different parts of the eco-region?	Management responses should be consistent throughout the eco-region
e. Do the boundaries of existing or proposed eco-regions create any known impediments to effective management? (in relation to the management of, for example, aggregate extraction and mining, aquaculture, dredging, engineering and construction, fisheries, land-based impacts, military activities, oil and gas, reclamation, recreation, renewable energy, shipping)	Boundaries should not create impediments to effective management
f. Do the existing or proposed eco-regions facilitate partnerships with neighbouring countries in the Atlantic, Baltic, Mediterranean Sea and Black Sea?	The eco-regions should facilitate partnerships
g. Can the existing or proposed eco-regions be subdivided into political or management regions with as few gaps and inefficiencies as possible?	Eco-region should divide clearly and completely into political and management regions

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

There is no universally agreed method for biogeographical classification, but rather, as stated by Dinter (2001), there are as many methods as there are biogeographers. This reflects the fact that nature is continuous and that each part of nature has some uniqueness while it shares some features with other areas. There are no sharp and absolute boundaries but rather more or less clearly expressed transisition zones. Biogeographical classification, in common with other classifications such as partitioning into Large Marine Ecosystems (paragraphs 4.11.-4.13.), builds therefore to a high degree of judgements by experts who have a thorough knowledge of the areas to be classified. The experts are helped by there being discontinuities associated with transition zones. These discontinuities may reflect topographical features such as capes, peninsulas, ridges, slopes, and shelf edges that influence the ocean currents and water mass distributions. The discontinuities influence bottom and water characteristics and distribution patterns of flora and fauna. These patterns form the basis for the biogeographical classification.

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

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

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

OSPAR regions

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

(a) the Greater North Sea region (Region II) reflected the area defined for the purposes of the International Conferences on the Protection of the North Sea, so that the regional report would be directly comparable with the North Sea Quality Status Report produced in 1993;
(b) the other boundaries were intended to delimit regions that had significantly different ecological circumstances;
(c) in drawing them, however, account was also taken of the extent to which coastal States facing the Wider Atlantic (Region V) had information on that region, and Region IV (Bay of Biscay/Golfe de Gascogne and Iberian Waters) therefore included some of the deeper waters similar to the rest of Region V

ICES areas

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

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

Large marine ecosystems

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

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

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

(a) The Barents Sea LME
(b) The Norwegian Sea LME
(c) The Iceland Shelf LME
(d) The East Greenland Shelf LME
(e) The Faroe Plateau LME
(f) The North Sea LME
(g) The Baltic Sea LME
(h) The Celtic-Biscay Shelf LME
(i) The Iberian Coastal LME
(j) The Mediterranean LME
(k) The Black Sea LME

Longhurst provinces

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

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

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

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

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

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

Dinter Biogeographical regions

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

Regional Advisory Councils

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

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

These geographical regions have been defined in terms of the ICES areas and CECAF divisions, except for the Mediterranean, which includes all maritime waters of the Mediterranean Sea east of longitude 5º36´ west[5]. The geographical areas, however, have been chosen in part on the basis of the locations of the fishing fleets which are interested in them. As a result, they do not always reflect biogeographical considerations. For example, the whole of the English Channel (ICES areas VIId and VIIe) is allocated to the North-Western Waters Regional Advisory Council, while the Kattegat (ICES area IIIb) is allocated wholly to the Baltic Sea Regional Advisory Council.

5. Proposed new eco-regions

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

Greenland and Iceland Seas (A)

Barents Sea (B)

Faroes (C)

Norwegian Sea (D)

Celtic Seas (E)

North Sea (F)

South European Atlantic Shelf (G)

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

Western Mediterranean Sea (H)

Adriatic-Ionian Seas (I)

Aegean-Levantine Seas (J)

Oceanic northeast Atlantic (K)

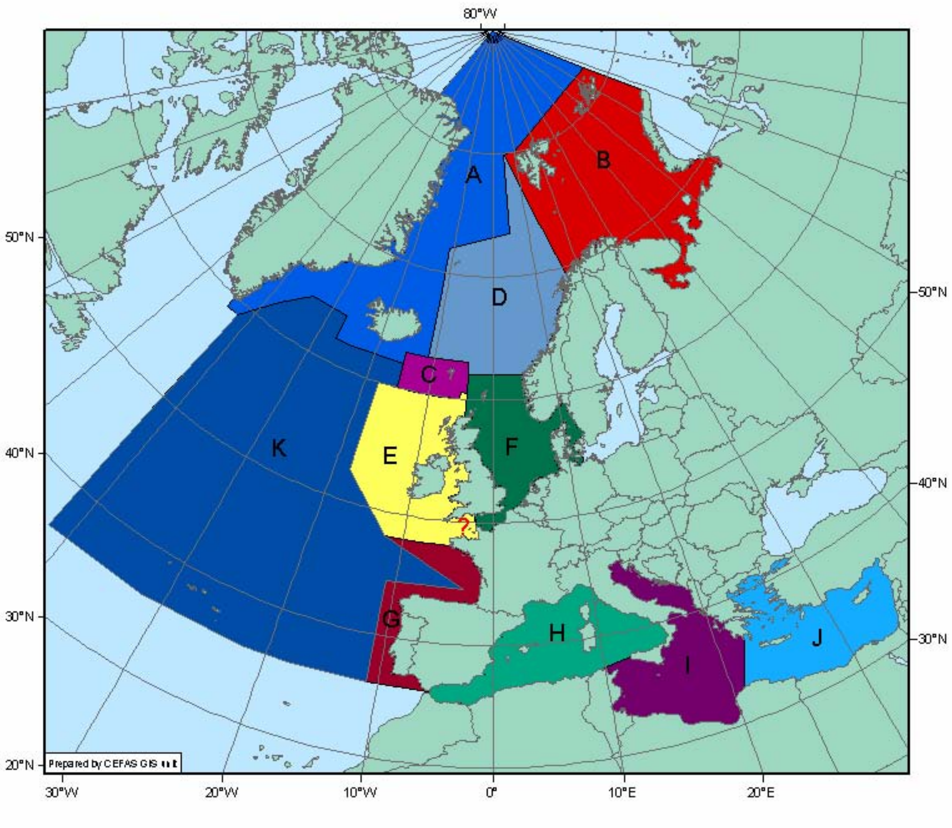


Figure 2. Proposed eco-regions for the implementation of the ecosystem approach in European waters. The eco-regions are Greenland and Iceland Seas (A), Barents Sea (B), Faroes (C), Norwegian Sea (D), Celtic Seas (E), North Sea (F), South European Atlantic Shelf (G), Western Mediterranean Sea (H), Adriatic-Ionian Seas (I), Aegean-Levantine Seas (J) and Oceanic northeast Atlantic (K). The question mark denotes the western Channel (ICES Area VIIe), which could be placed in either the Celtic Sea or North Sea eco-region (paragraphs 1.4., 6.2. and 6.11.).Equidistant azimuthal projection.

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

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

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

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

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

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

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

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

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

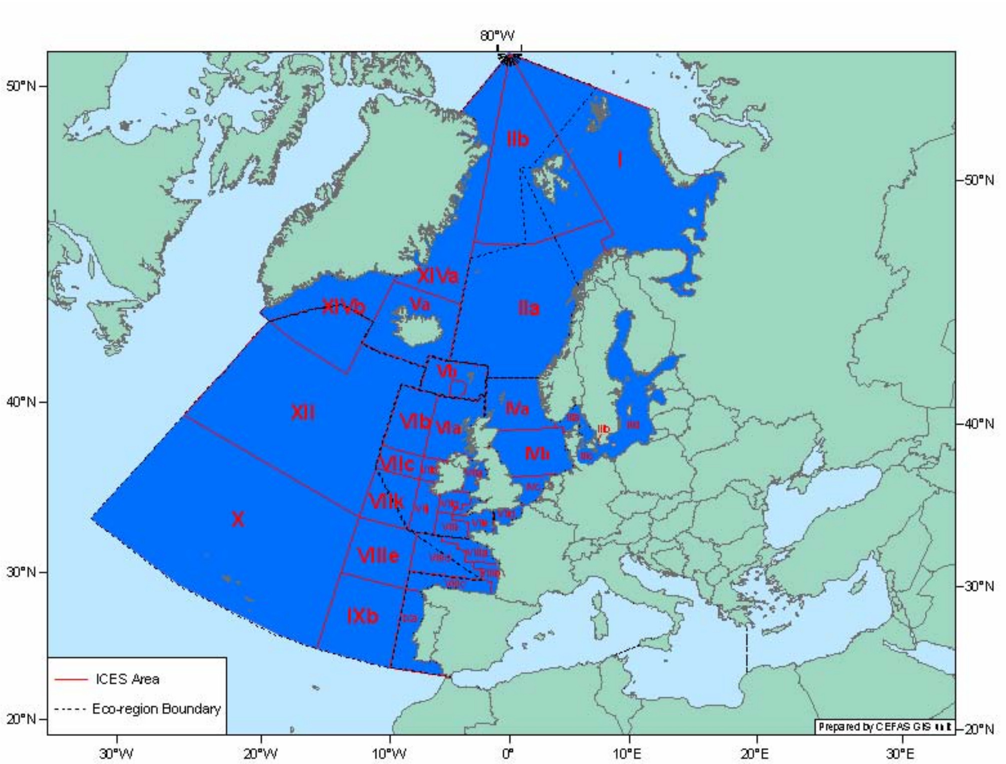


Figure 3. The boundaries of the proposed eco-regions Greenland and Iceland Seas (A), Barents Sea (B), Faroes (C), Norwegian Sea (D), Celtic Seas (E), North Sea (F), South European Atlantic Shelf (G), Western Mediterranean Sea (H), Adriatic-Ionian Seas (I), Aegean-Levantine Seas (J) and Oceanic northeast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

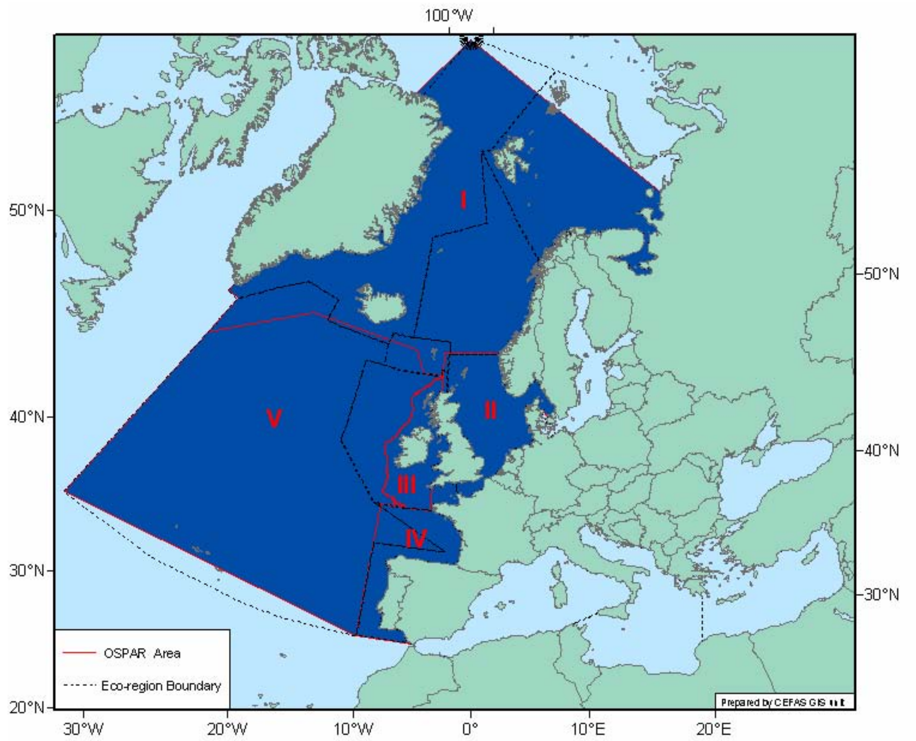


Figure 4. The boundaries of the proposed eco-regions Greenland and Iceland Seas (A), Barents Sea (B), Faroes (C), Norwegian Sea (D), Celtic Seas (E), North Sea (F), South European Atlantic Shelf (G), Western Mediterranean Sea (H), Adriatic-Ionian Seas (I), Aegean-Levantine Seas (J) and Oceanic northeast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

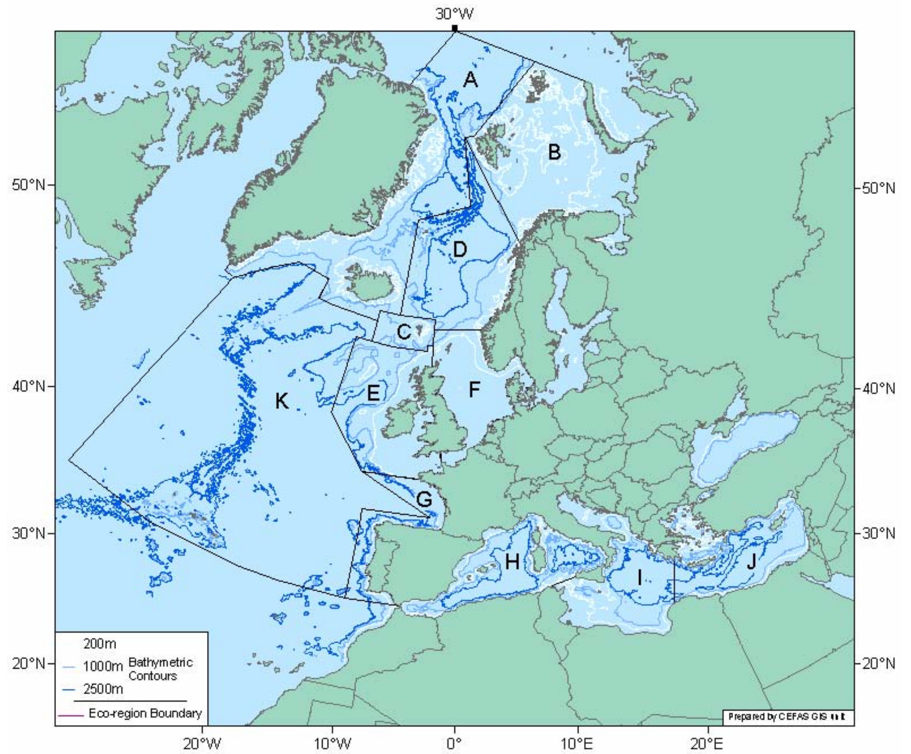


Figure 5. The boundaries of the proposed eco-regions Greenland and Iceland Seas (A), Barents Sea (B), Faroes (C), Norwegian Sea (D), Celtic Seas (E), North Sea (F), South European Atlantic Shelf (G), Western Mediterranean Sea (H), Adriatic-Ionian Seas (I), Aegean-Levantine Seas (J) and Oceanic northeast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

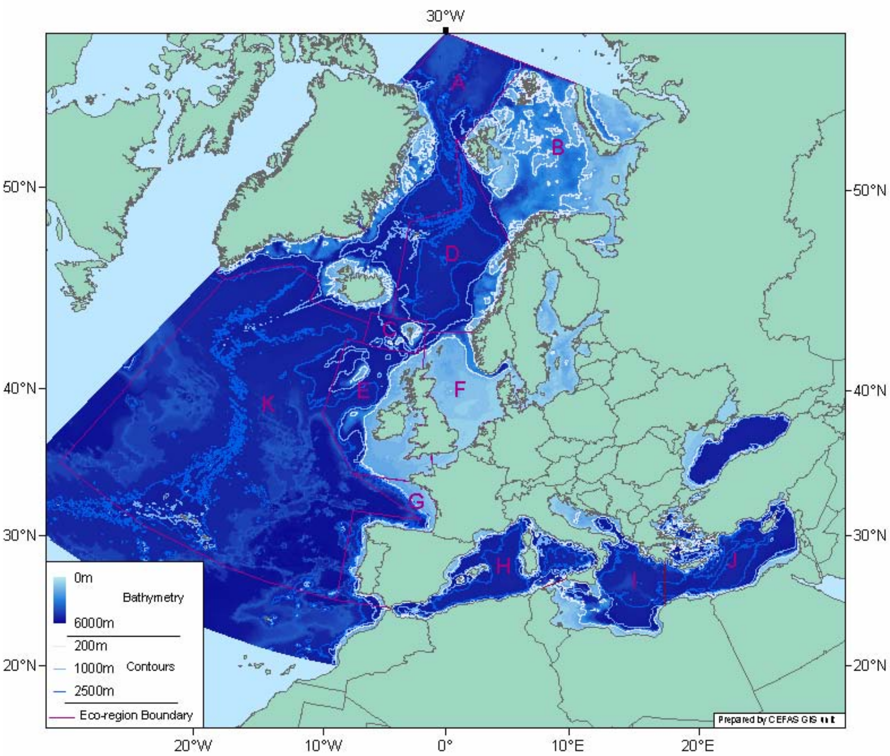


Figure 6. The boundaries of the proposed eco-regions Greenland and Iceland Seas (A), Barents Sea (B), Faroes (C), Norwegian Sea (D), Celtic Seas (E), North Sea (F), South European Atlantic Shelf (G), Western Mediterranean Sea (H), Adriatic-Ionian Seas (I), Aegean-Levantine Seas (J) and Oceanic northeast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

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

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

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

Greenland and Iceland Seas

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

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

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

Sea where they exploit the plankton production. They return to spawn by migrating with the southwards flowing East Iceland Current along the eastern side of Iceland.

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

Barents Sea

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

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

Faroes

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

Norwegian Sea

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

Celtic Seas

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

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

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

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

North Sea

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

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

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

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

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

South European Atlantic Shelf

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

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

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

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

Western Mediterranean Sea

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

Adriatic-Ionian Seas

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

Aegean-Levantine Seas

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

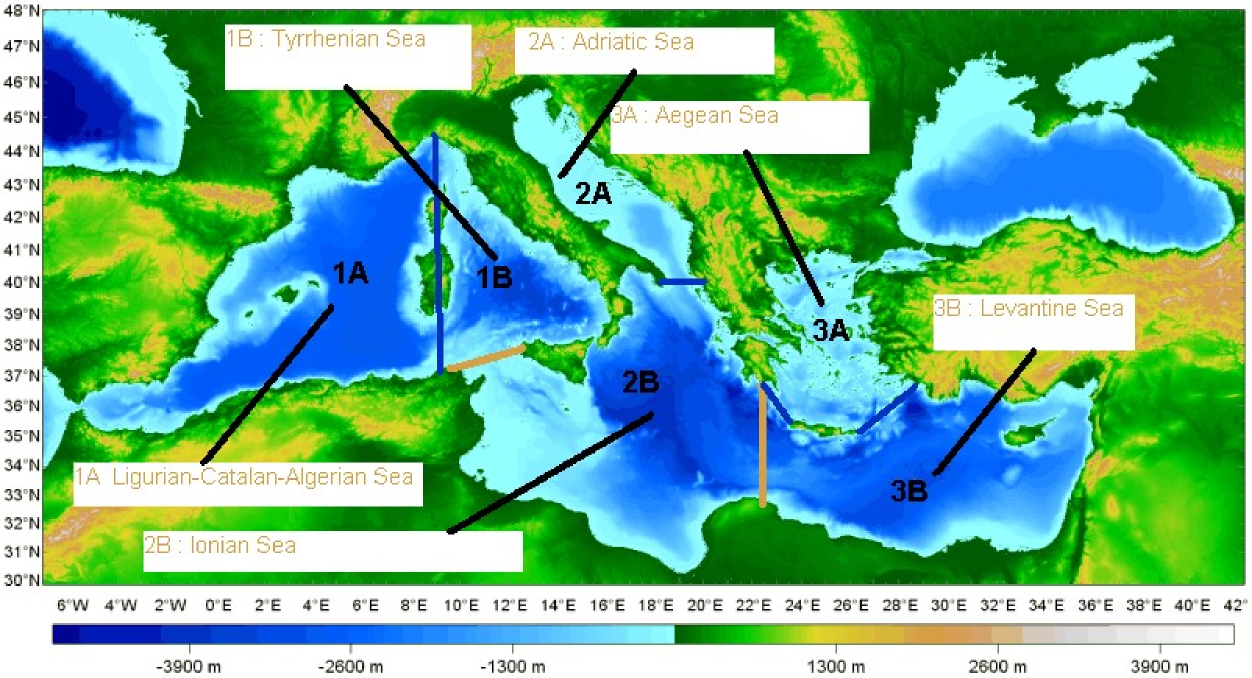


Figure 7. The three eco-Regions for the Mediterranean Sea (bordered by red lines) and the proposed divisions and names of sub-regions (bordered by blue lines).

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

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Longhurst, A. (1998) Ecological geography of the sea. Academic Press, San Diego. 398pp

Annex 1. Definitions of areas from Regional sea-conventions

BARCELONA CONVENTION

Article 1 - Geographical Coverage

1.For the purposes of this Convention, the Mediterranean Sea Area shall mean the maritime waters of the Mediterranean Sea proper, including its gulfs and seas, bounded to the west by the meridian passing through Cape Spartel lighthouse, at the entrance of the Straits of Gibraltar, and to the east by the southern limits of the Straits of the Dardanelles between Mehmetcik and Kumkale lighthouses.

2.The application of the Convention may be extended to coastal areas as defined by each Contracting Party within its own territory.

3.Any Protocol to this Convention may extend the geographical coverage to which that particular Protocol applies.

BUCHAREST CONVENTION

Article I - Area of application

1. This Convention shall apply to the Black Sea proper with the southern limit constituted for the purposes of this Convention by the line joining Capes Kelagra and Dalyan.

2. For the purposes of this Convention the reference to the Black Sea shall include the territorial sea and exclusive economic zone of each Contracting Party in the Black Sea. However, any Protocol to this Convention may provide otherwise for the purposes of that Protocol.

HELSINKI CONVENTION

Article 1 - Convention Area

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

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

OSPAR CONVENTION

Article 1 - Definitions

For the purposes of the Convention:

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

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

Annex 2. Claims of Maritime Jurisdictional Zones by Member States of EU and Other States in the North-East Atlantic (Breadth in Nautical Miles)

	TS	CZ	EEZ	FZ
Belgium*	12	24	DBC	+[6]
Cyprus*	12	24	200	
Denmark	12		200	200[7]
Estonia	12[8]		DBC	
Finland*	12	14		DBC
France*	12	24	200[9]	
Germany*	12		DBC	
Greece*	6[10]			
Iceland*	12		200	
Ireland*	12			200
Italy*	12			
Latvia	12		DLM	
Lithuania*	12		DLM	
Malta*	12	24		25
The Netherlands*	12		DBC	
Norway*	12	24	200	200[11]
Poland*	12		DLM	
Portugal*	12	24	200	
Spain*	12	24	200[12]	+[13]
Slovenia*				
Sweden*	12		+[14]	
United Kingdom*	12[15]		200[16]	200 or 12[17]

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

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

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

[6] Coterminous with the exclusive economic zone

[7] For Greenland and Foroe Islands

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

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

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

[11] Jan Mayen and Svalbard

[12] In the Atlantic Ocean

[13] In the Mediterranean Sea

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

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

[16] Bermuda, Pitcairn, South Georgia and South Sandwich Islands.

[17] 12 nautical miles in Guernsey; 200 nautical miles in United Kingdom, Anguilla, British Indian Ocean Territory, British Virgin Islands, Cayman Islands, Falkland Islands, Monserrat, St. Helena and Dependencies, and Turks and Caicos Islands.

2.1.3 Helsinki Commission

2.1.3.1 The Status of Seal Populations in the Baltic Marine Area

The Helsinki Commission requested in 2003:

To evaluate every third year the populations of seals and harbour porpoise in the Baltic marine area, including the size of the populations, distribution, migration, reproductive capacity, effects of contaminants and health status, and additional mortality owing to interactions with commercial fisheries (by-catch, intentional killing). The evaluation is based on annual submission of data to ICES from ICES member states.

Details of the status of marine mammals in the Baltic Sea were provided in the 2003 ACE report (ICES, 2003). However, new information arose shortly thereafter based on a census of grey seals in the eastern Baltic Sea and the Helsinki Commission requested ICES to review this information in 2004.

Source of information

The 2004 report of the Working Group on Marine Mammal Ecology (WGMME) (ICES CM 2004/ACE:02).

Summary

The summary table provided in the 2003 ACE report has been augmented by the new information on the current population estimate of grey seals; the revised figure is shown in **bold** type in this revised table (Table 2.1.3.1.1).

Table 2.1.3.1.1. Updated summary of the status of seals and harbour porpoise in the Baltic Sea (based on Table 2.1 of ICES (2003)).

	Baltic ringed seal	**Saimaa seal**	**Ladoga seal**	**Grey seal**	**Kalmarsund harbour seal**	**SW Baltic harbour seal**	**Harbour porpoise**
Distribution	Resident in three separate regions	Fragmented, 60% of lake area	90% of lake area	Northern and central Baltic Proper	Kalmarsund, resident	To west of 13 °E	Southern Baltic Proper, Belt Seas, Kattegat
Population size in year 1900	200,000	<1,300	10,000	100,000	5,000	10,000	Unknown but larger than at present
Current population estimate	9,000[1]	240–250	5,000	**15,950**	580[2]	4,500	36,046[3] 588[4] 599[5] 817[6]
Population trend	+5% GoB; unknown in GoR, GoF	+3–4%	Unknown	+ 7.8% SE, other areas unknown	+9%	−53% (epizootic loss)	Unknown
Current reproductive rate[7]	0.65	0.80	Unknown	>0.60	>0.85	Unknown	Unknown
Health status	Sterility, renal lesions	Normal	Skin lesions	Colonic ulcers; renal, bone lesions	Unknown	Bone lesions, skin lesions	Many lesions and parasites
By-catch (per year)	120 FIN, SE	10	Several tens	430 SE, 150 EST, c10 POL, other countries unknown	Unknown	300 SE, other countries unknown	10s Baltic Proper, 100s in Belt Sea/ Kattegat
Intentional killing	0	0	Tens poached	Quota 586, less than 50% taken. 35 pups poached in EST (2002)	0	30 DK, 6 SE	0

Key: GoB = Gulf of Bothnia; GoF = Gulf of Finland; GoR = Gulf of Riga; DK = Denmark; EST = Estonia; FIN = Finland; POL = Poland; SE = Sweden. [1]Estimated from basking population of 5,400 individuals in 1996; [2]Estimated from basking population of 2,000 in 1994; [3]ICES Divisions IIIa,b; [4]ICES Division IIIc; [5]Baltic Sea Sub-divisions 24 and 25; [6]Kiel and Mecklenburg Bight; [7]Numbers of pups produced per breeding female per year.

Scientific background

Harbour seals

The southwestern Baltic population of harbour seals, extending from the Kattegat into the southwestern Baltic Sea, was affected by the 2002 Phocine Distemper Virus (PDV) epizootic, as indicated in the 2003 ACE report. All other populations of Baltic seals remained unaffected by the PDV epizootic.

Table 2.1.3.1.2. Number of dead seals reported in the Kattegat harbour seal colonies, with the best available pre-epizootic abundance estimates of the respective areas (Reineking, 2002).

Area	Observed number of dead seals	Pre-epizootic population estimate	Observed mortality (%)
Limfjord	365	886	41
Kattegat	95	270	35
Total Baltic	**460**	**1156**	**40**

Mortality of Baltic harbour seals was similar to that of seals from most parts of the North Sea. No other seal species was affected by this disease in the Baltic Sea.

Grey seals

The waters of Estonia, Finland, Russia, and Sweden contain almost the entire present distribution of the grey seal in the Baltic Sea. A new census conducted in 2003 was available for this species.

Only censuses performed during a common two-week period at the end of May/beginning of June were used, to minimize the possibility of double-counting due to seal movement. At this time of the year, maximum numbers of grey seals haul out of the water to moult and can be counted on land or on ice. In Finland, aerial censuses aided by aerial photography are used, whereas counts from boats and from land are used in the other countries. Census results are presented by sea area (Table 2.1.3.1.3), rather than by country. It is likely that the real population size is larger than the total number counted, as some animals will not be hauled out at the time of the surveys. The almost perfect synchronization of censuses in adjacent areas with high numbers of seals minimized the risk of seals travelling long distances in a short period of time, and thus avoided the risk of double counting.

Synchronization is important in future censuses, especially in the core area of the Baltic grey seal distribution in the archipelagos off central Sweden, southwestern Finland and western Estonia, where a total of about 13,000 grey seals were counted in 2003.

Table 2.1.3.1.3 Grey seal abundance estimates in the Baltic, 2003 (Finnish Game and Fisheries Research Institute, unpublished).

Region	Estimate of abundance
Bothnian Bay and North Kvarken	710
Bothnian Sea excluding the Åland archipelago	855
Southwest Finnish archipelago including the Åland archipelago	6,880
Swedish Baltic between Gulf of Bothnia and 58°N (northern tip of Gotland)	3,980
Gulf of Finland	490
Western Estonia	2,700
Swedish Baltic south of 58°N	335
Total	**15,950**

Population trends of grey seals

The 2003 abundance estimate (15,950) is the highest in recent history, and is the fourth consecutive increase since 2000 (i.e., 9,700 in 2000, 10,300 in 2001, and 13,100 in 2002). It is likely that improvements in census methods have caused the larger than expected increase in 2003. Large-scale immigration of grey seals into the Baltic seems unlikely. Seal populations do not grow naturally at this rate.

Seal sanctuaries

Seal sanctuaries in Finland have been established principally for grey seals, although other species such as the ringed seal (*Phoca hispida botnica*) may also benefit to some extent. The first sanctuary was established in the southeastern Åland archipelago in 1998. Seven additional areas were established in 2001 in mainland Finland, covering the entire Finnish Baltic coast but concentrating in the southwestern archipelago of Finland, where the population size of the grey seal is highest.

The seal sanctuaries have been established in the haul-out sites favoured in the longer term. In the 2002 and 2003 censuses in late May/early June, 50.3% of grey seals were found in the sanctuaries off the coast of mainland Finland and 25.5% on the Åland Islands.

Harbour porpoise

A number of abundance estimates exist for harbour porpoise in the southwestern Baltic and the central Baltic or parts of it from 2002 and 2003 (Berggren *et al*., 2003; Scheidat *et al*., 2004). The validity of these estimates still needs to be evaluated by the Working Group on Marine Mammal Ecology. They will be assessed by ACE in 2005.

A study on the by-catch of harbour porpoise in German part-time fisheries suggested that fourteen porpoises are taken annually in the southwestern Baltic Sea, while seven are taken in the central Baltic (Rubsch and Kock, 2004).

References

Berggren, P., Hiby, L., Lovell, P., and Scheidat, M. 2003. Abundance of harbour porpoises in the Baltic Sea from aerial surveys conducted in summer 2002. ASCOBANS Doc/MOP4/Doc. 42 (p), 16 pp.

ICES. 2003. Report of the ICES Advisory Committee on Ecosystems, 2003. ICES Cooperative Research Report, 262: 2–22.

Reineking, B. 2002. Status report 27. http://www.waddensea-secretariat.org./news/Seals/01-seal-news.html

Rubsch, S., and Kock, K.-H. 2004. German part-time fishermen in the Baltic Sea and their by-catch of harbour porpoise. ASCOBANS AC11/Doc 10 (P), 12 pp.

Scheidat, M., Gilles, A., Kock, K.-H., and Siebert, U. 2004. Harbour porpoise (*Phocoena phocoena*) summer abundance and distribution in the German North and Baltic Seas. ASCOBANS AC11/Doc. 8 (P), Rev. 1, 10 pp.

2.1.3.2 Marine Habitat Classification and Mapping System for the Baltic Sea

Request

The Helsinki Commission requested ICES in 2004:

Following the request by the Second Meeting of the Nature Conservation and Coastal Zone Management Group (HELCOM HABITAT 2/2001) with reference to the final Minutes of the Meeting, the HABITAT Group requested ICES to include the Baltic Sea in its work on a marine habitat classification and mapping system which can become generally accepted and will cover the whole Baltic Sea area. The EUNIS classification system should be taken into consideration as well as other ongoing projects in the region such as the CHARM project on "Characterization of the Baltic Sea Ecosystem Dynamics and function of coastal types", which is connected with the EU Water Framework Directive.

From HELCOM's point of view, biotope mapping could be a useful instrument for collecting information on biotopes and habitats of the Baltic Sea. There is, however, a need to coordinate and, as appropriate, to harmonize the methods used for biotope mapping in the different Baltic Sea countries.

Source of information

The 2004 report of the Working Group on Marine Habitat Mapping (WGMHM) (ICES CM 2004/E:06).

The 2004 report of the Study Group on Baltic Ecosystem Health Issues in support of the BSRP (SGEH) (ICES CM 2004/H:02).

Summary

The HELCOM request on marine habitat classification and mapping was considered by the Working Group on Marine Habitat Mapping (WGMHM). The approaches being adopted for the North Sea and the MESH (Mapping European Seabed Habitats) project offer useful models for how to proceed in the Baltic Sea. WGMHM has offered its expertise to assist the Study Group on Baltic Ecosystem Health Issues in support of the BSRP (SGEH). Baltic participation in the work of WGMHM was encouraged.

Recommendations and advice

Considering forthcoming developments in the Baltic habitat mapping-related activities and noting the existence of the "Red List of Marine and Coastal Biotopes and Biotope Complexes of the Baltic Sea, Belt and Kattegat" (HELCOM, 1998), and being aware that the main aim of the request from HELCOM for Baltic habitat mapping is habitat protection and ecosystem-based management, ICES recommends that the Baltic Sea countries should:

- compile and complete information about ongoing habitat mapping activities;
- compile information on available data relevant to the development of Baltic habitat maps, particularly: coastline, bathymetry, seabed substrata, salinity, oxygen conditions, light penetration, temperature, ice cover, and wave/current action, drawing upon the CHARM project and other relevant initiatives;
- identify experts and key persons in the Baltic Sea area and establish a Baltic Sea sub-group on marine habitat mapping which should meet under the umbrella of the Study Group on Baltic Ecosystem Health Issues in support of the BSRP (SGEH) to develop specific proposals for a Baltic-scale project (similar in concept to the North Sea approach of the WGMHM), taking into account end-user requirements, data availability, expertise, possible scales of resourcing, and time scales;
- undertake an effort to raise funds for a Baltic Sea Large Marine Ecosystem marine habitat mapping research project by preparing a project proposal for submission to suitable funding bodies (e.g., EU FP6, Interreg, HELCOM). The organizations involved should include ICES and HELCOM and potentially the EEA. It could be a project proposal similar to the Interreg MESH (Mapping European Seabed Habitats) project for Northwest Europe (which has recently been accepted and financed);
- implement national projects on regional marine mapping scales and/or on particularly valuable sea habitats—preferably on existing and planned BSPAs (Baltic Sea Protected Areas).

Finally, ICES urges the Baltic countries to support national experts to participate in WGMHM activities. ICES particularly urges the Baltic Sea Regional Project (BSRP) to support the participation of eastern Baltic experts in WGMHM meetings.

Scientific background

No experts on marine habitat classification or mapping attended the first meeting of the Study Group on Baltic Ecosystem Health Issues in support of the BSRP (SGEH) in November 2003. Therefore, it was decided that the SGEH Chair, in cooperation with the Baltic Sea Regional Project (BSRP) Coordinator, would contact the Chair of the Working Group on Marine Habitat Mapping (WGMHM) regarding the development of a habitat classification system for the Baltic Sea. SGEH decided that the most recent developments by ICES, EEA, and HELCOM and those formulated at a national level should be taken into consideration at the next SGEH meeting. Information on the present status of habitat classification should be collected and further work harmonized.

The Working Group on Marine Habitat Mapping (WGMHM), during its 2004 meeting, discussed the HELCOM request on marine habitat mapping. The present status was described as follows:

- WGMHM is aware that many activities and data related to marine habitat mapping of the Baltic Sea exist within the Baltic countries.
- It is unfortunate that the attendance of Baltic experts in WGMHM activities is poor (as is the reporting of Baltic countries to WGMHM). As a result, relevant information on Baltic mapping activities is available to ICES only on a limited scale.
- WGMHM is willing to offer its developments and advice at various levels and in various ways, including: as direct discussion at WGMHM meetings; as papers, maps and reports; as electronic software; and as expert assistance and/or participation in Baltic habitat mapping projects.

Reference

HELCOM. 1998. Red List of Marine and Coastal Biotopes and Biotope Complexes of the Baltic Sea, Belt and Kattegat. Helsinki Commission, Baltic Sea Environment Proceedings, No. 75. 115 pp.

2.1.4 IBSFC

2.1.4.1 Areas within the Gotland Deep and the Gdansk Deep where the hydrological conditions allow for a successful cod spawning in 2004

There are two main questions that need to be answered in order to provide the relevant advice:

1) to predict how much and where the 2003 inflow will improve spawning conditions in 2004.

2) to prepare quantitative accounts of the by-catch of cod in the small-meshed fishery in the cod spawning areas.

These analyses are based on:

i. information on temporal/spatial distribution of spawning activity from BITS and pelagic trawl surveys conducted in STORE (EU financed 5th framework project),

ii. prevailing hydrographic conditions in the beginning of 2004 from hydrographic and BITS surveys,

iii. inflow patterns of saline and oxygenated water between different basins in the central Baltic as observed in previous years,

iv. oxygen depletion rates,

v. environmental conditions for egg survival will be predicted for major spawning areas of cod in the central Baltic.

Conclusion on possible closed areas in the Gdansk Deep and the Gotland Basin in 2004

While the basic hydrographic processes affecting the environmental conditions for cod egg survival are understood, it is not possible to provide reliable predictions of where and when egg survival and subsequent recruitment will be high. The reasons are mainly due to the complicated recruitment process depending on biological processes, such as distribution of spawning effort, egg mortality due to other causes than hydrography, and larval and early juvenile mortality. Also, atmospheric forcing conditions in the months to come and variability in the hydrographic response adds to the uncertainty.

The most important spawning area for Eastern Baltic Cod is the Bornholm Deep, see Figure 4.

It appears to be unlikely that hydrographic conditions in 2004 will allow high egg survival in the Gotland Basin and the Gdansk Deep. Without an additional inflow of saline and oxygenated water in early 2004, the hydrographic condition in these spawning areas, presently being still above average caused by the major 2003 inflow, will degrade prior to the main spawning season to an extent that fair egg survival is very unlikely. Thus, reproductive success will again depend largely on the Bornholm spawning ground and to a certain degree on the Slupsk Furrow. **Therefore, ICES does not consider that there is a scientific basis for suggesting closed areas in the Gdansk Deep and Gotland Basin to ensure undisturbed spawning activity of cod in the Central Baltic in 2004.**

Conclusions for designing closed areas to ensure undisturbed cod spawning

Should IBSFC consider to establish closed areas in the Gotland Basin and in the Gdansk Deep, ICES below outlines some considerations to be made when designing and implementing such areas:

1) Single spring inflow events only improve the hydrographic conditions in the Gdansk Deep and the Gotland Basin in the year of their occurrence. Conditions in the following year generally deteriorate so that successful spawning and egg survival is limited. This implies that an evaluation of the hydrographic conditions after the winter inflow period needs to be performed before potential areas with high egg survival probability in the coming spawning season can be identified. In turn, knowledge of the hydrographic conditions in March/April is sufficient to conduct this type of qualitative forecast.

2) Areas of highest egg survival probability within the different basins are in general the deepest parts of the Bornholm Basin and Gdansk Deep, while areas with likelihood of enhanced hydrographic conditions in the Gotland Basin are the southern slope areas. Consequently, any closed areas implemented to secure undisturbed cod spawning should cover these areas at times of high egg survival.

3) Closed areas to allow undisturbed spawning of cod in the Central Baltic should be large enough to cover the natural spatial variability of hydrological conditions in these areas. Otherwise they may spatially miss the most favourable conditions. In this respect it can be stated that the enforced closed area for all fisheries in the Bornholm Basin from 1995-2003 was not large enough to ensure coverage of areas with favourable hydrographic conditions, though it's position in the centre of the basin was adequate.

4) The extension of the closed area in the Bornholm Basin enforced in 2004 is not expected to increase surviving egg production significantly, as the spatial extension covers mainly eastern slope areas in which under normal circumstances neither hydrographic conditions are favourable nor the egg production is extremely high.

5) Reproductive success of cod depends not only on egg survival in relation to hydrographic conditions; other processes affecting early life stage survival are: i) egg predation by clupeids in the Bornholm Basin, ii) *Pseudocalanus* nauplii availability for first feeding cod larvae and iii) cannibalism on juveniles in years of high adult abundance. In consequence even favourable hydrographic conditions and high egg production do not guarantee reproductive success.

6) At present the cod abundance in the Gotland Basin is low. As in consequence egg production even during favourable hydrographic conditions, e.g. as in 2003, was well below historic values.

7) Mature cod appear to concentrate in areas of favourable hydrographic conditions for spawning; this implies a migration into the Bornholm Basin at unfavourable hydrographic conditions in the eastern spawning areas. However, the spawning migration into the Bornholm Basin may as well be a homing behaviour and the extent and driving forces of these migrations are not yet clear. Consequently it cannot be answered to which extent a substantial improvement of hydrographic conditions in the Gotland Basin would result in an immediate utilisation of this enhanced spawning habitat by adult fish dwelling in the area.

8) The main spawning time of cod in all major spawning areas of the Central Baltic is still in summer, i.e. from June to August, but indications exist that in the most recent years the onset of the main spawning season is earlier than in the 1990's, i.e. already in May. A shift in spawning time to earlier months of the year has substantial implications for the design of any closure. Pre-spawning concentrations of cod will gather earlier, increasing the catchability of cod in spring months in both the targeting fishery and as by-catch in the pelagic fishery.

9) At present the impact of the small meshed fishery in March/April is considered to be limited, as concentrations of cod on the spawning grounds are restricted. However, if the timing of cod spawning shifts back to earlier months of the year a high effort in the pelagic fishery in April/May in the Bornholm Basin and the Gdansk Deep may be critical. In such a case the area closure enforced in the Bornholm Basin starting in mid of May appears to be too late to prevent high by-catches.

10) An introduction of closures in the Gdansk Deep or Gotland Basin in summer months at improved hydrographic conditions does not appear to be effective at present, as i) the effort in the pelagic small meshed fishery is relatively low, ii) it targets mostly areas outside potential cod spawning areas, iii) the vertical distribution of sprat and cod is different in summer and iv) it has consequently only very limited by-catches of cod.

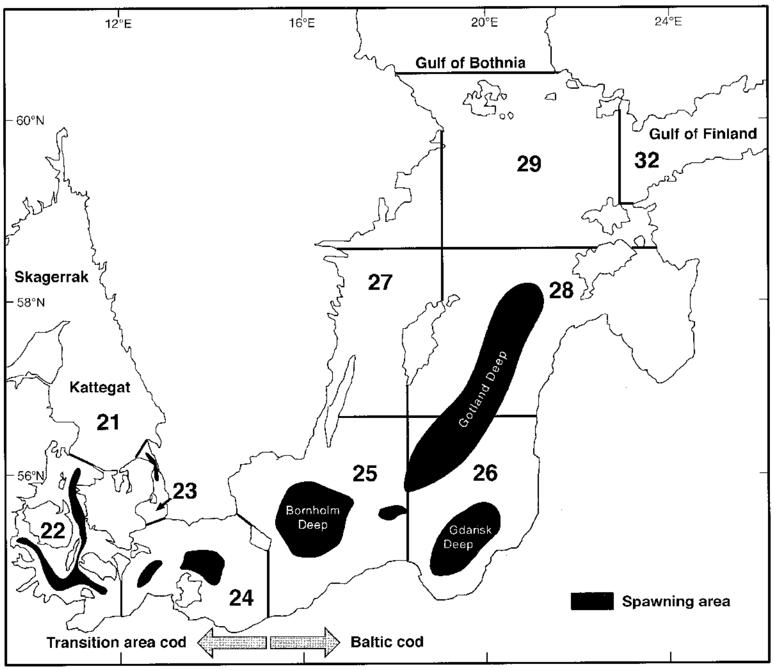


Figure 1 Historical spawning areas for cod in the Baltic Sea. From Bagge, O., Thurow, F., Steffensen, E., Bay, J. 1994. The Baltic Cod. Dana Vol. 10:1-28, modified by Aro, E. 2000. The spatial and temporal distribution patterns of cod (*Gadus morhua callarias*) in the Baltic Sea and their dependence on environmental variability – implications for fishery management. Academic dissertation. University of Helsinki and Finnish Game and Fisheries Research Institute, Helsinki 2000, ISBN-951-776-271-2, 75 pp.

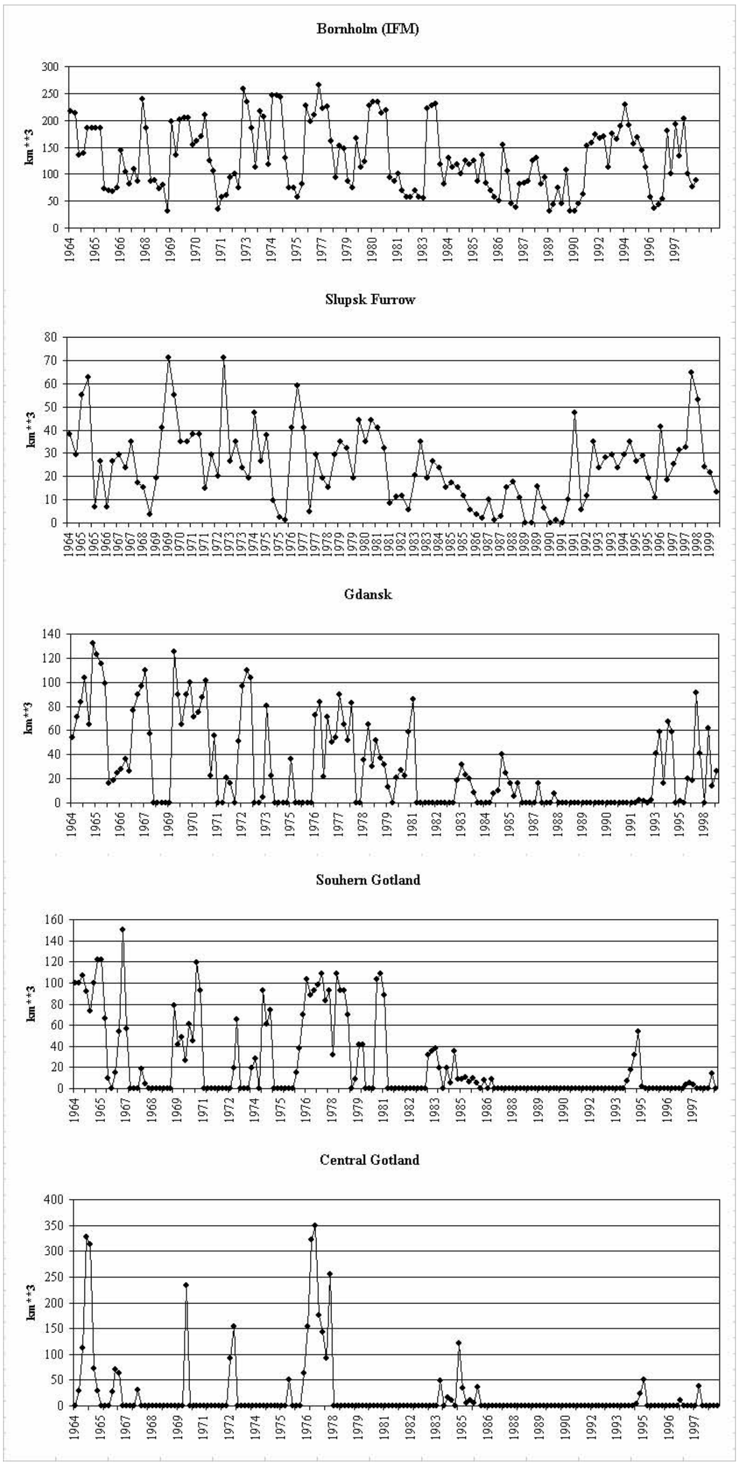


Figure 2 Time-series of reproductive volume for each spawning site. From MacKenzie, B. R., Hinrichsen, H.-H., Plikshs, M., Wieland, K., Zezera, A. 2000. Quantifying environmental heterogeneity: estimating the size of habitat for successful cod *Gadus morhua* egg development in the Baltic Sea. Marine Ecology Progress Series 193: 143-156. With updates by Maris Plikshs (Pers. Comm.).

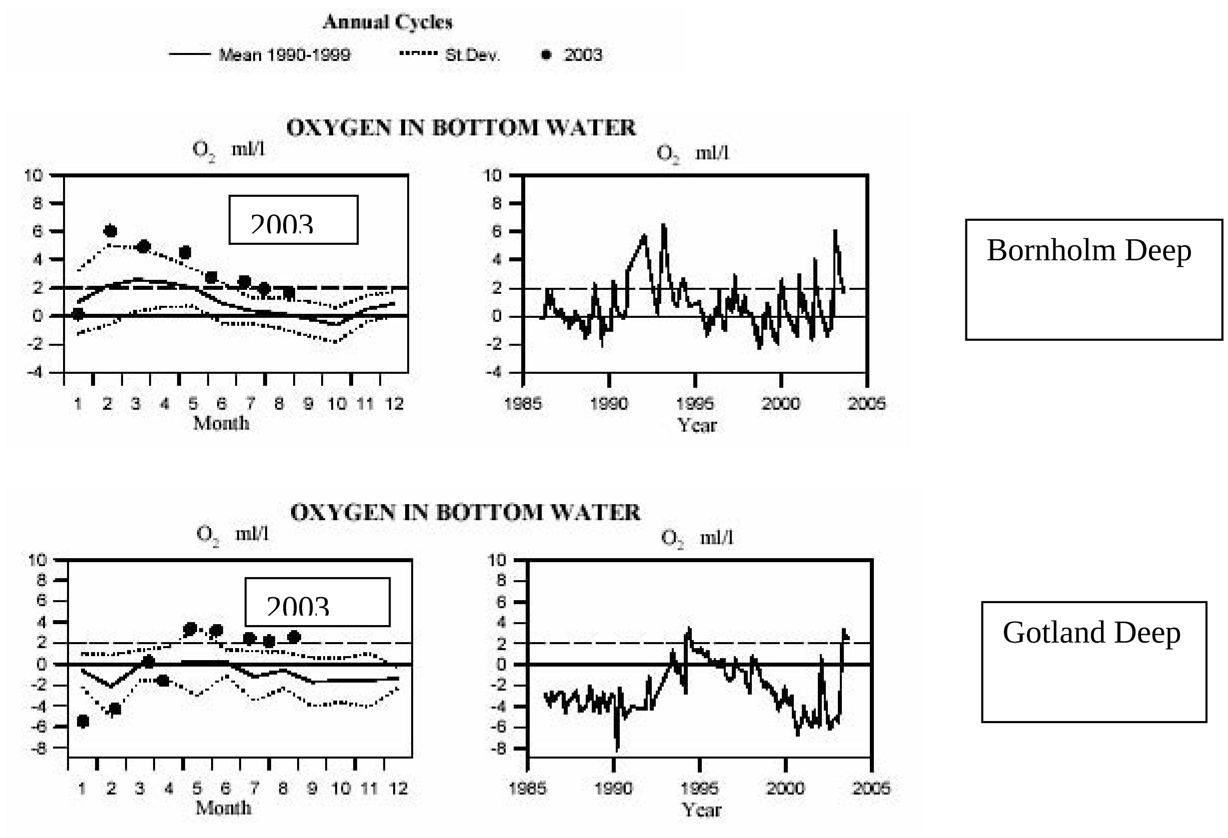


Figure 3 Oxygen content in bottom waters. From Sveriges Meteorologiska och Hydrologiska Institut; http://www.smhi.se/sgn0102/nodc/reports/cruise/recent.pdf.

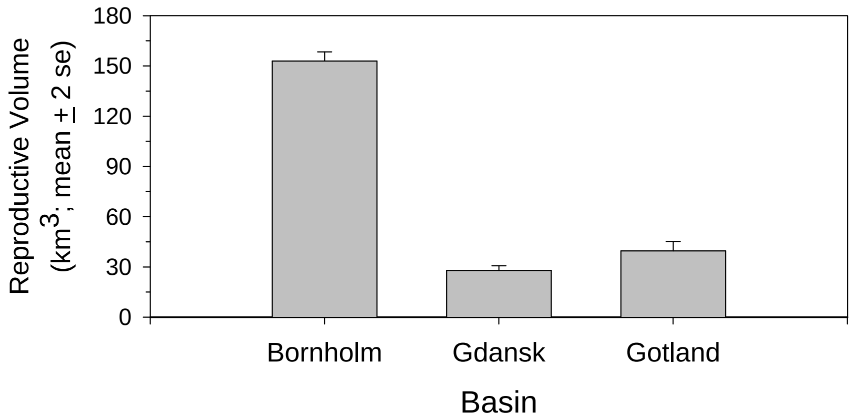


Figure 4 Long-term (Feb. 1964-Jan. 2004) mean reproductive volume in Bornholm, Gdansk and Gotland Basins.

2.1.4.2 Update of the catch forecast for the Cod stock in subdivisions 25-32 for 2004 based on information on catches in 2003

ICES notes that its management advice for the fishery in 2004 remains

> *under the recovery plan fishing mortality in 2004 should be reduced by 90% (F < 0.10) to rebuild the SSB above B_{lim} in the shorter and above B_{pa} in the medium-term. This corresponds to a catch of less than 13 000 t.*

The calculations presented below are technical updates of the prognoses.

ICES has reviewed preliminary data from the fisheries on eastern Baltic Cod in 2003 and made a preliminary summary of the 4th quarter abundance survey results. It is the first time that these survey data have been included in the evaluation of the stock. The survey only started in 1999 so at present the time series of data is too short to be used in an assessment. In addition, there is not yet an agreed approach to estimating indices from these surveys, coverage has been variable between years and not all of the 2003 data are yet available. For these reasons, caution should be used in interpreting these data. The 2003 indices indicate a relatively high abundance of 0-group fish but this year-class will not contribute to the landings during 2004. Otherwise, the indices do not indicate the presence of any particularly weak or strong year-classes in the stock at present and does not invalidate the stock estimate used in the prognosis made in May 2003.

For 2003 landings were estimated to be around 60,000 tons including non-reported landings. Estimates of misreporting during 2003 were available from a number of scientific and fishing industry sources. The scientific sources indicated a total unreported catch of around 10,300t. An estimate from an industry source indicated a slightly lower figure of approximately 7,500t. The former figure (10,300t) has been used to estimate misreporting during 2003, leading to an estimated total landing of 60,000t. The figures from the scientific and industry sources are rather similar and the choice of which one to use would make little difference to the results of the forecast. Non-reported landings at the level seen in recent years (15-30% of the reported landings) make realistic prognoses of the relationship of fishing mortality and landings impossible.

Discards were slightly higher than expected in the forecasts while mean weight at age were as expected. However, discard data from 2002 and 2003 suffer from the low sampling level in non-EC countries, and while it is quite possible that this estimated difference reflects only noise in the observations the non-selective fishing practise during the first half of 2003 makes the increased discard estimate reasonable.

On the basis of these provisional data, there are no indications that the improvement in gear selectivity anticipated. Hopefully, a decrease in discard rate will be the result of a well functioning BACOMA window and be demonstrated in the sampling in 2004.

The 2003 catch indicated by the catch forecast made in May 2003 (98,000t) is substantially higher than that indicated by the provisional data (60,000t) and this applies at all ages, so the high forecast catch for 2003 does not result from e.g. the over-estimation of a single year-class. Also, it appears that the over-estimation of the 2003 catch is not due to the use of inappropriate assumptions about weight or proportion discarded at age.

Although, there is no indication that the improvement in gear selectivity anticipated since the introduction of revised technical measures has been realised, the assumption of an improved exploitation pattern in 2004 has been maintained.

The estimates of stock size and fishing mortality at age used in the forecast may not have been appropriate and to obtain a catch forecast which is consistent with the observed catch data for 2003 it is assumed that an overall reduction in fishing mortality during 2003 took place. The stock size as estimated for the beginning of 2003 remained unchanged compared to the previous prognosis.

A catch forecast has been run which for 2003 uses weights at age and discards at age based on the provisional data available for 2003, and which assumes a significant reduction in fishing effort during 2003 compared with the fishery in 2000-2002. This reduction was assumed in order to obtain an implied catch for 2003 which is consistent with the landings observed during 2003. The parameters set for 2004 in the previous prognosis were left unchanged. This revised catch forecast is given in the Table below:

Catch forecast for 2004

Basis: Fsq =F(2000-2002) = 1.03; F(2003) = 0.46Fsq = 0.48; landings(2003) = 60.0; SSB(2004) = 138

F(2004)	Basis	Landings (2004)	Discards (2004)	SSB (2005)
0.00	0.0 Fsq	0	0.0	227
0.10	0.1 Fsq	19	0.5	209
0.21	0.2 Fsq	36	0.9	193
0.31	0.3 Fsq	52	1.3	179
0.41	0.4 Fsq	66	1.8	165
0.52	0.5 Fsq	79	2.2	153
0.60	0.58 Fsq (Fpa)	89	2.5	144
0.72	0.7 Fsq	103	3.0	132
0.82	0.8 Fsq	113	3.4	123
0.93	0.9 Fsq	122	3.8	115
1.03	Fsq	131	4.1	107

The non-reported landings and the preliminary nature of the information available make the reality value of this prognosis highly doubtful. The landing calculations presented above include non-reported landings.

2.1.4.3 Evaluation of the Management Plan for Cod stocks in the Baltic Sea with regard to the precautionary approach

The main elements in the plan are:

Objective: to maintain the stock above a target level.

Instruments:

1. A spawning stock biomass (SSB) minimum level;
2. A target fishing mortality;
3. A minimum increase in SSB in one year should the stock fall below the target SSB level;
4. A maximum variability in TAC from one year to the next;

The exploitation pattern used for evaluation of the management plan is that estimated by ICES in May 2004. ICES noted that the effects of the technical measures adopted in 2003 cannot yet be evaluated. Also, the plan includes a possibility for additional measures but these are not specified and therefore it cannot be evaluated whether these limits might restrict fishing below what is implied by the TAC. The evaluation is based on the assumption that the actual landings correspond to the TAC. For this assumption to hold the requirement is that the implementation practices of recent years are not continued. The continuous occurrences of non-reported landings in recent years illustrate that a simple TAC measure on its own is not always sufficient to ensure a fishing mortality target. Other management considerations including control and enforcements that make the use of both effort restrictions and TAC in combination may be more effective in ensuring correspondence between landings and TAC.

Below it is analysed whether the management plan will lead to the stated objective and whether these stock levels are as implied by a precautionary approach to management.

The assessments of both cod stocks have in the past generally been biased with overestimation of stock size and underestimation of fishing mortality. This is partly a result of the non-reported landings. The following evaluation is based on the assumption that in the future the assessment is unbiased and that the TAC corresponds to the landings.

The estimates of stock size, fishing mortality etc. are uncertain and obviously the estimates of uncertainties are even more uncertain. The evaluation is based on estimates of these uncertainties obtained from the assessments.

Any forward projection of this type is based on knowledge of the history of the stock dynamics. Thus, if a stock suddenly in the future shows an unexpected development for instance as a reaction to a disease outbreak, climatic changes etc., then management must be prepared to react to this, preferably in a pre-agreed way. Furthermore, the stock assessments of both of cod stocks are subject to significant variance resulting in estimates of stock and exploitation which may not be confirmed when more data become available. Unless the assessment becomes much more precise such deviations will occur and when realised management must react with compensatory actions..

Present Status

Western Baltic Cod: Based on the most recent estimates of SSB, ICES classifies the stock as being at risk of reduced reproductive capacity. In the absence of defined fishing mortality reference points, the state of the stock cannot be evaluated with regard to these. An analytical assessment demonstrates that the most recent (2003) estimated fishing mortality (1.12) exceeds the IBSFC fishing mortality reference point (1.00).

Eastern Baltic Cod: SSB cannot be estimated precisely, however, all available information indicates that SSB in the most recent years is below $\mathbf{B}_{lim}$. Based on the most recent estimates of SSB, ICES classifies the stock as suffering reduced reproductive capacity. Fishing mortality cannot be estimated precisely, however, all available information indicates that fishing mortality in the most recent years is well above $\mathbf{F}_{pa}$. Based on estimates of fishing mortality in recent years, ICES classifies the stock to be at risk of being harvested unsustainably. Recruitment since the late 1980s has been low.

The assessment of the eastern Baltic cod is particular uncertain *inter alias* due to non-reporting of significant amounts of cod. Any evaluation will therefore be subject to the uncertainties inherent in the assessment. It will in particular affect the evaluation of the initial phase, the three first years.

Deterministic calculations

The cod recovery plan includes a target SSB level an upper limit on the fishing mortality and a minimum SSB. The Minimum SSB level is the same as defined by ICES as the ICES B_{lim}.

A simple deterministic calculation (yield per recruit combined with a constant recruitment) based on the 2004 assessment – that is uncertain due to non-reporting of landings, insufficient discards data, etc. – provides the following results

Stock	Recovery Plan			Calculated (deterministic model)	
	SSB (tonnes) (target)	SSB (tonnes) (Management minimum level)	$F_{upper\ limit}$	Recruitment average 1985-2002) in'000.	Long-term
Western Baltic Cod (SD 22-24)	23,000	9,000	1.0	R_1= 54,753 (geo. mean 85-02, age 1)	SSB =23,000 t F = 0.96 Yield = 28,000 t
Eastern Baltic Cod (SD 25-29+32)	240,000	160,000	0.60	R_2= 128,807 (geo. mean 89-02, age 2)	SSB = 240,000 t F = 0.40 Yield = 95,000 t

With the current low recruitments for both stocks fishing mortality will have to be lower (for the western stock only marginally lower) than the upper limit specified in the Management Plan to keep the stocks above the SSB targets.

If the SSB improvement in especially the Eastern Baltic Cod (Subdivisions 25-29+32) materialise this might improve the recruitment even under similar bad environmental conditions in the Baltic Sea as currently is prevailing. If recruitment improves then both fishing mortality and yield can be increased compared to the values given in Table above.

The upper limits on fishing mortality and SSB targets will under current low recruitment not lead to the stated target, i.e. under these assumptions the SSB and F targets are not consistent.

These calculations also showed that there is a basic instability in the Management Plan. For Eastern Baltic Cod (Subdivisions 25-29+32) both SSB and yield went into a cyclic pattern. SSB increased to 370,000 t in 2012 and decreased to less than 240,000 t in 2017-2022, for thereafter to increase again. Yield peaked with 150,000 t in 2016 and had a minimum in 2022 with 57,000 t, for thereafter to increase.

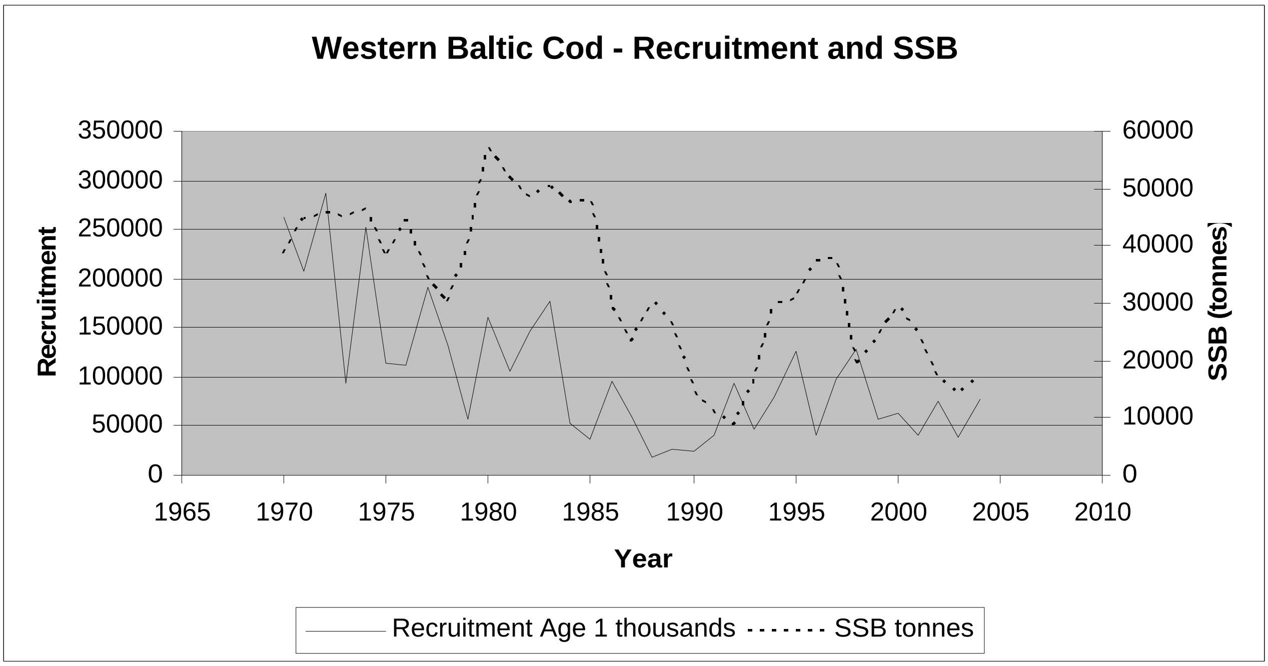
Introducing Recruitment variability - the stock recruitment relationship

It is well known that recruitment success for Baltic cod and in particularly for the eastern Baltic Cod stock depends on environmental conditions as much as the spawning stock biomass. Sufficient biomass and favourable conditions are both necessary requirements. Recent studies have provided insight in the environmental processes and in the species interactions. A full stock-recruitment model would therefore include specification of the predators on cod eggs, larvae and juvenile cod (including cannibalism) as well as the environmental conditions (e.g. temperature and salinity that defines the so-called "spawning volume".

The environmental conditions would in the short term need to be considered as contributing to the noise in the relationship. It would be possible to establish a species interaction model however, in the short term (up to 3 years) it is not expected that the stock situation would change dramatically.

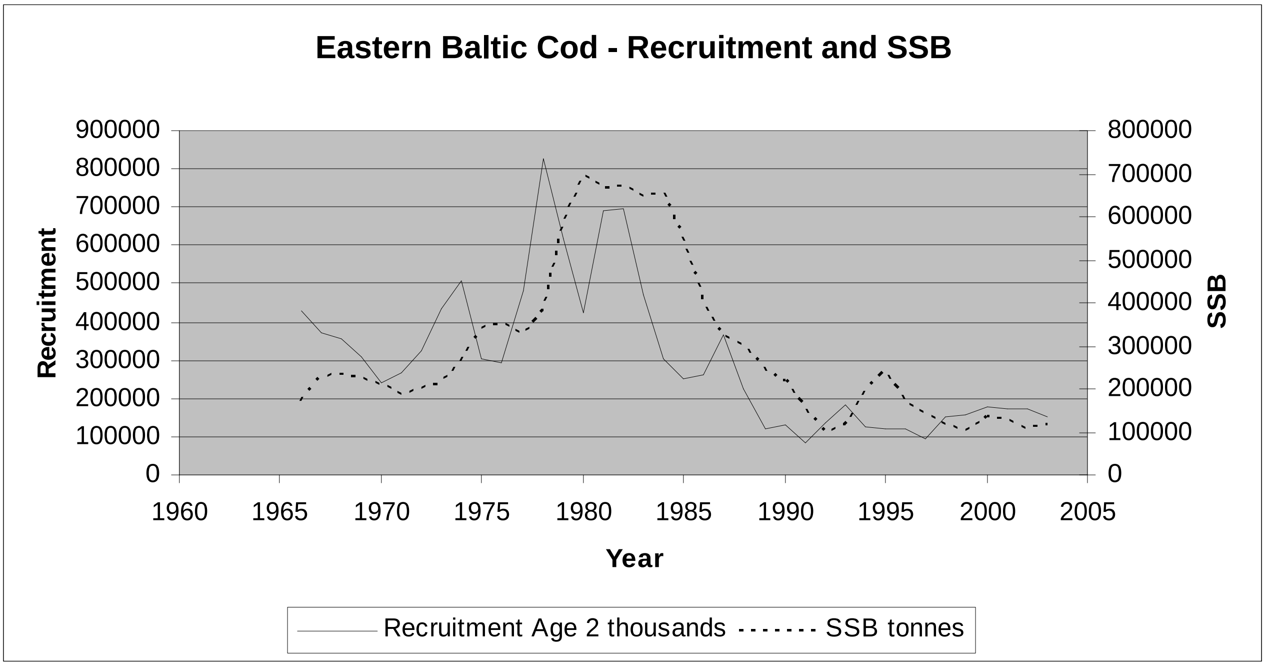
Western Baltic Cod

Recruitment for the western Baltic cod is without trend since 1984 (year class 1983) and the simulations are based on the time series for the period 1984-2003



Eastern Baltic Cod

Recruitment of Eastern Baltic Cod has been rather constant since 1989 (year class 1987) and the time series for the period 1989-2003 is used for simulation of the recruitment.



The stock-recruitment relationship that are adopted for this evaluation are a form of worse case scenarios; in reducing the fishing mortality there are two mechanism that are expected to increase the stock size 1) better usage of the growth potential of the stock, i.e. that fish are allowed to grow to a larger size before they are fished and 2) increased recruitment based on an increase in the spawning stock biomass. For the western Baltic cod the present spawning stock size is above the minimum levels and there is not expected any major increase in recruitment. For the eastern Baltic cod the spawning stock is below B_{lim} and therefore an increase in average recruitment is expected. However, recruitment and in particularly that for eastern Baltic cod depends on the environmental conditions. It may therefore be considered that the expected recruitment increase will not be realised and the recruitment is restricted by the environment conditions. The evaluation of the management plan is made using a stock-recruitment relationship that actually assumed that there is little increase in the recruitment in the short term from an increase in spawning stock biomass.

Would the management plan maintain the stock above Management Minimum Level with high probability and on average lead to a SSB above management target?

Simulations were set up to include

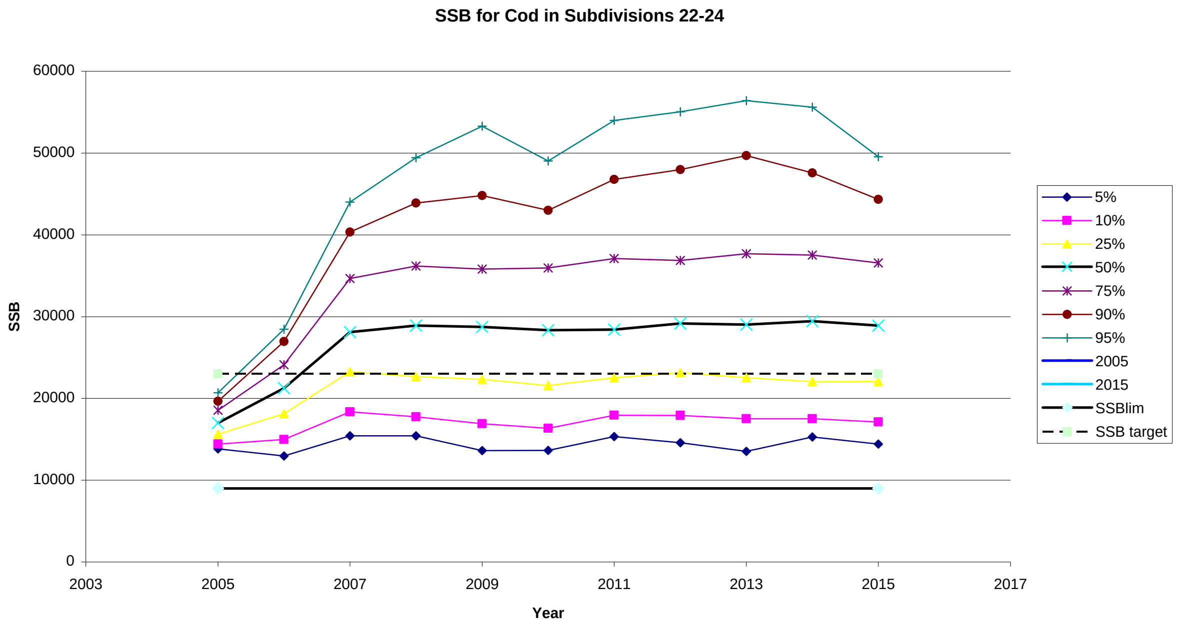
- A stock recruitment relations ship including recruitment variability (Beverton and Holt relationship and lognormal variability)
- Assessment uncertainty implying that the TAC would lead to a fishing mortality different from the one intended

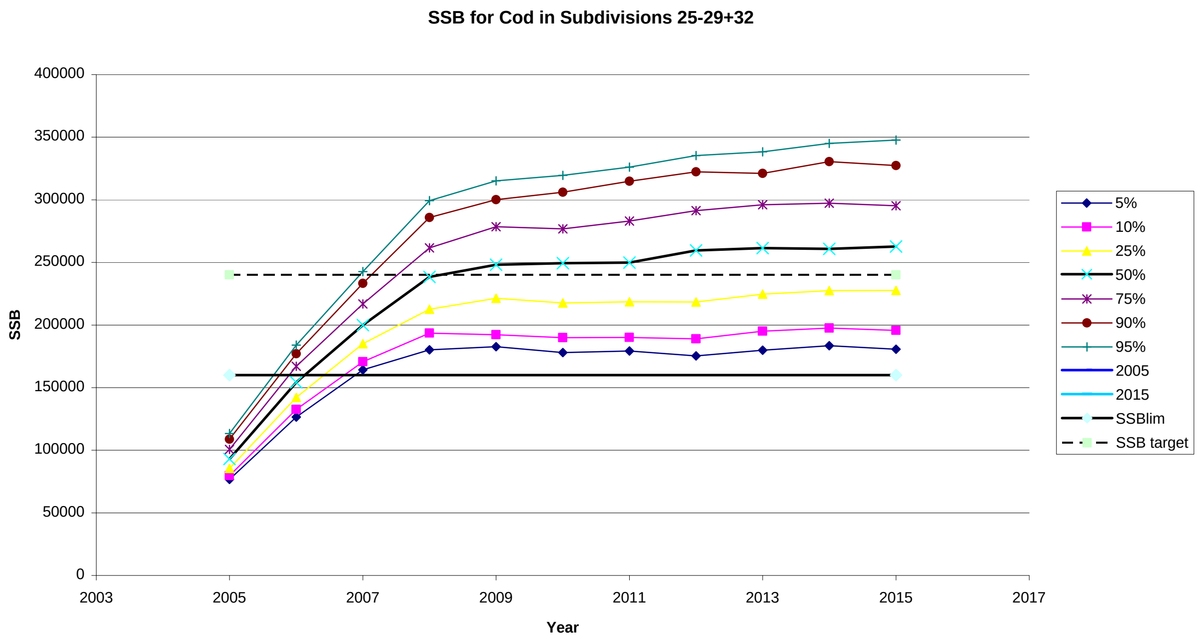
The uncertainties were set at a CV of 20 % for estimating F-at-age, Stock-at-age and mean weight-at-age. Natural mortality and maturity ogive were nominally set at a CV of 10 %. The recruitment variability was estimated to be 55 % for the western stock and 25 % for eastern stock.

The low precision of the assessments of the eastern stock may create problems in relation to measuring the actual state and will make it difficult to provide forecasts with sufficient precision as required by the management plan. It may therefore be necessary to implement the management plan based on relative measures and in a more adaptive mode in periods when measurement and prediction precision is low.

Results

1. The management plan is after an initial recovery phase (2-5 years) expected to bring the stocks above the management SSB targets and to bring SSB above B_{lim} with more than 95 % probability. This means that the additional restrictions imposed through the SSB targets are sufficient to introduce the intended increase in the stock;

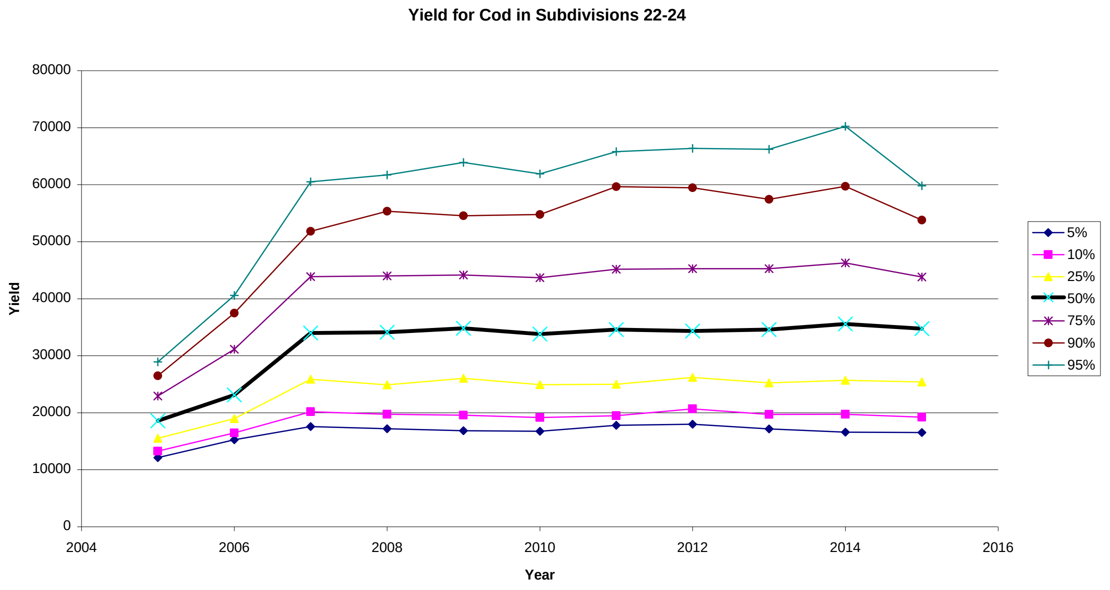


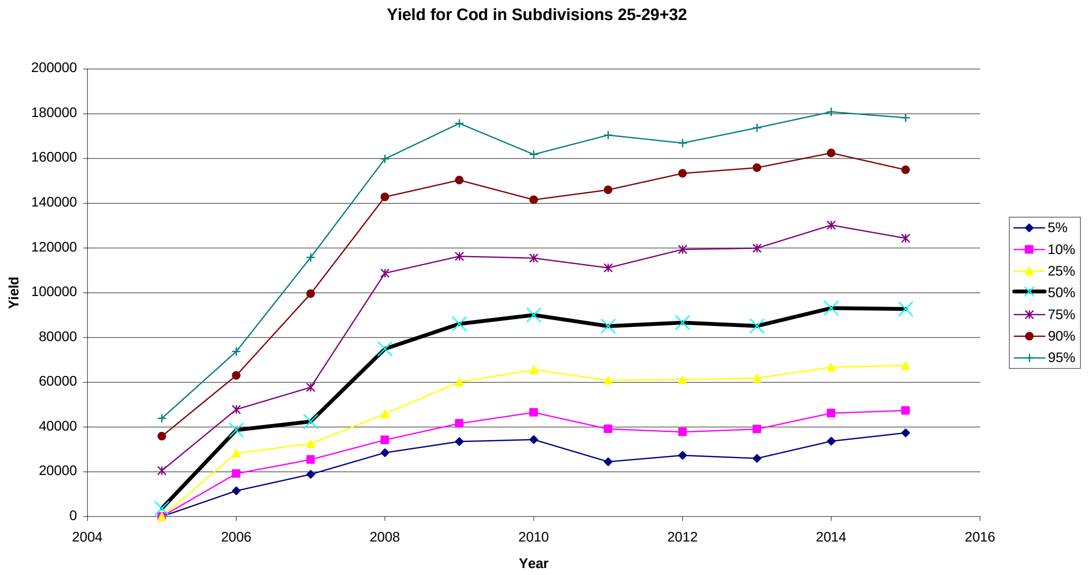


2. The SSB in western stock should within 2 years be above 23,000 tons;

3. Recovery of the Eastern Baltic Cod stock will take about 3-5 years during which time the stock with more than 50 % probability will remain below 240,000 tonnes;

4. For the first year when the plan will be in effect the management plan indicates a TAC in the range of 20-25,000 tons for the western cod stock and for the eastern Baltic stock a TAC so low that the fishery is virtually closed. The TACs will then grow to an expected TAC about 30,000 t for the western stock and around 90,000 tons for the eastern stock. Recalling earlier comments on the recruitment in relation to spawning stock biomass the eastern cod TAC hopefully will be larger based on an increase in the recruitments; this however can only be judged when these possible increases have been seen;





5. The evaluation indicates that for the eastern Baltic cod on average and under current recruitment levels it is the SSB restrictions that determine the TAC, the fishing mortality implied by the TAC is below the upper level on the fishing mortality in most situations;

6. The management plan appears to be robust to improvements in recruitment. In such situations it will be the upper limit on the fishing mortality that will determine the TAC rather than the SSB restrictions;

7. The management plan has an inherent long-term instability under current recruitment, i.e. in a situation when it is the SSB restriction that effectively determines the TAC then the plan shows long-term oscillations which in some periods bring the stock below the SSB target;

Conclusion

The low precision of the assessments of the eastern stock may create problems in relation to measuring the actual state and will make it difficult to provide forecasts with sufficient precision as required by the management plan

The objective of the management plan is in accordance with the Precautionary Approach Reference points defined by ICES;

With an average time horizon for bringing the stocks above B_{pa} (as defined by ICES) of less than 5 years ICES considers the management plan as being in accordance with the precautionary approach. ICES notes that this conclusion is subject to management being able to apply the plan with only minimal implementations errors, and that the assessments in the future are unbiased. The occurrence of considerable unreported landings in recent years indicates that present implementation is not effective and additional measures beyond the present management regime are required and will be a condition for the management plan being precautionary.

2.1.4.4 Evaluation of the appropriateness of the mesh sizes allowed in the Herring trawl fisheries in relation to the correspondence between mesh size and the Herring population size structure

Rule 10 (relevant to pelagic fishing) of IBSFC fishing rules defines minimum mesh size for pelagic fishing as follows:

f) Herring in Sub-divisions 22 to 27 32 mm

g) Herring in Sub-divisions 28 to 29, south of latitude 59^{o}30'N 28 mm

h) Herring in Sub-divisions 30 to 32 and Sub-division 29, north of latitude 59^{o}30'N 16 mm

i) Sprat in the whole Convention area 16 mm

Selective properties and escape mortality of herring trawl

An efficient selective trawl allows the fish to pass through the gear undamaged. For herring a number of authors question the viability of using cod-end selection as a principal management tool due to escape mortality; however, there is a high degree of variability in the mortality estimates between authors.

A number of Baltic herring selectivity experiments have been conducted, assessing both conventional diamond netting and alternate mesh configurations such as square and hexagonal. Estimates of the selective properties of three common mesh sizes are summarised below [from Rahikainen *et al.,* (2004)]

Mesh Size (mm)	20	24	36
L50 (cm)	*8.0*	*9.5*	*13.7*
Selection Range (cm)	*2.3*	*2.7*	*4.1*

Rahikainen *et al*., (2004) notes that the majority of vessels engaged in the Northern Bothnian Sea fishery typically use mesh sizes in the range 20-24 mm but also states that the most effective vessels fishing for the fillet market use 36 mm and that this segment of the fleet has recently increased their total share of the landings.

Meshing (Stickers)

A practical problem is to avoid meshing which is caused by mismatch between the mesh size used and the length structure of the population. Such a mismatch can result in pelagic fish becoming stuck in the meshes of the trawl, this problem is commonly referred to as stickers and is particularly problematic in pelagic fisheries due to the volume (numbers) of fish caught.

The herring fishery in the Baltic Sea exploits herring with very different growth rates and hence the size structure is very different between areas. Furthermore, the growth rate has varied over years and this would imply that the mesh size should adapt to the continuous changing growth rates. Therefore, it is not possible on the level of the IBSFC fishing rules to advice on an optimal mesh size that is best to avoid meshing.

There have been a number of industry attempts to negate this problem. Most recently, Danish and Scottish net manufacturers have been inserting sections of diamond mesh that is turned 90^0 to the normal direction of netting. This results in a more ‘open’ mesh shape due to the orientation of the knots.

Rahikainen *et al*., (2004) comment that fishermen in the Baltic are now using smaller meshes in the construction of the trawl avoid meshed fish. The authors attribute this to a reduction in the growth rate of herring in this region.

The use of turned mesh in addition to the use of a smaller mesh size should reduce the quantity of meshed fish. However, this may result in the capture of more small herring.

Conclusion

Lacking more reliable estimates of escape mortality, a "precautionary approach" should be adopted in the use of selective gears as a conservation tool, assuming until the opposite has been proven that there is some escape survival and thus benefits from mesh regulations. The current rule should thus be maintained.

Ways to prevent meshing should be dealt with by the industry and should not be a topic for regulation.

References

Rahikainen, M., Peltonen, H. and Pönni., 2004. Unaccounted mortality in Northern Baltic Sea herring fishery-magnitude and effects on estimates of stock dynamics. Fish. Res., 67: 111-127.

2.1.4.5 Evaluation of the selective properties of trawls using 90° turned diamond meshes and advice on appropriate mesh sizes corresponding to the BACOMA gear 110 mm window

ICES analysed the available data and concluded that a 110 mm cod-end constructed from "90 degree turned diamond mesh" gives the same selectivity as a 110mm BACOMA window fitted in a 105mm cod-end.

The data come from individual cruises that were not specifically designed or structured to answer the particular question posed. In addition, it was not possible to determine the effects of some other factors such as twine thickness, number of meshes in circumference and vessel type on selectivity. It is well known from other experiments for conventional diamond mesh cod-ends, that these factors can have a considerable influence on selectivity. ICES is unable to advise on these parameters, until further research aimed at quantifying some of the above mentioned effects has been conducted. The sensitivity of selectivity to these factors also opens for the possibility that the selectivity can be changed by manipulating these factors. Until the effects of these factors are better known it is not possible to advice on whether 90 degree turned mesh opens for more or less manipulation of selection properties than a 110 mm BACOMA window in a 105 mm cod-end. The answer given above is therefore the best information which can be provided at this stage, but is subject to uncertainty and the advised mesh size may be an underestimate.

2.1.4.6 Advice on hook parameters in long line fisheries that corresponds with the minimum landing size of Cod of 38 cm. Evaluation of the relations between number of hooks fished in longline settings and discards rates

ICES is not able to advise on a specific hook size and shape that corresponds to the minimum landing size of 38cm for Baltic cod as there is no selectivity data currently available that can be used to determine the appropriate hook parameters.

2.1.4.7 Revision, where appropriate, of the estimate of smolt production potential in wild Salmon rivers

ICES has provided estimates of the potential smolt production for a number of Baltic Salmon Rivers. These estimates were built on production data from the 1960s and involved extrapolation from a small river Rickleån to the much larger system River Torne and River Kalix correcting for productivity differences. Also, the estimates were developed in a period when the populations were depleted and therefore involved large extrapolations. A major source of uncertainty arises from weak evidence on the achievable peak production per unit area in major rivers in the Gulf of Bothnia.

ICES has since the first estimate was provided worked on improving these estimates. This was done through observation (electrofishing) of parr densities and the related smolt production and by applying an abundance-estimation model which provides estimates of the smolt production carrying capacity.

The plan includes

1. An inventory of the size and quality of the parr rearing habitat areas for each river according to a unified protocol.
2. Measurement of the parr and smolt production in index rivers. Because of the assumed large variation it is necessary to measure for a number of years at high production levels before estimating the potential production in a river. After a sufficiently long period stock/recruitment curves may be available from index rivers.
3. The values for the index river are transferred to other rivers in the region via measurement of habitat area and a quality gradation of them.

However, it will take a long period of time to establish potential production estimates using this method and it was therefore necessary to consider other methods of estimating potential production. These may for instance be production estimates for Atlantic salmon outside the Baltic region as well as estimates from old catch records in Baltic rivers, evidence from stocking studies of reared fish and other data. An EU Concerted Action - SALMODEL - has reported on establishing conservation limits for salmon in the North Atlantic area. A number of issues addressed in this project, such as transferability of values between rivers, influence of sea trout, usage of GIS and other questions covered in this area may aid in development of production estimates also in the Baltic area.

ICES has previously reported on smolt productions well above the estimated potential smolt product. While this is not impossible – the estimated production is a long term average with short term variability – it is a signal that must be closely investigated.

ICES approached the problem from three angles: 1) monitoring parr densities through electrofishing and extrapolating this to smolt productivity and 2) an abundance estimation model based on mark-recapture data which provides a probabilistic estimate of smolt carrying capacity and 3) a potential smolt production estimation model based on expert opinions about variables describing the physical and biological factors of the rivers, and variables describing the juvenile salmon stocks' response to the external factors.

The potential smolt production estimates as used currently are based on the third approach. In the future these uncertain estimates about the smolt production will be improved by updating them using the first and second approach. In 2003 ICES reported trial runs of the second approach have been documented. The abundance model includes post smolt mortality rates for wild and reared salmon, homing rates, and catchability coefficients. The abundance model is fitted to the time-series of smolt abundance indices and catch data from the offshore and river and coastal fisheries. The abundance model includes a stock-recruit function (either Ricker or Beverton-Holt) to predict smolt abundances from spawner abundance and incorporates scenarios for historic time-series in M74 and its impacts on the stock-recruit function. The slope at the origin of this stock-recruitment function was adapted based on data from the Northeast Atlantic Salmon stocks and this extrapolation is obviously introducing a significant amount of uncertainty. The smolt production capacity was based on the estimates of smolt production capacity as estimated by the model based on the expert opinion. This estimation procedure provided probabilistic estimates of smolt carrying capacity ranging between approximately 2.0 and 4.5 million smolts for the combined Baltic salmon stocks.

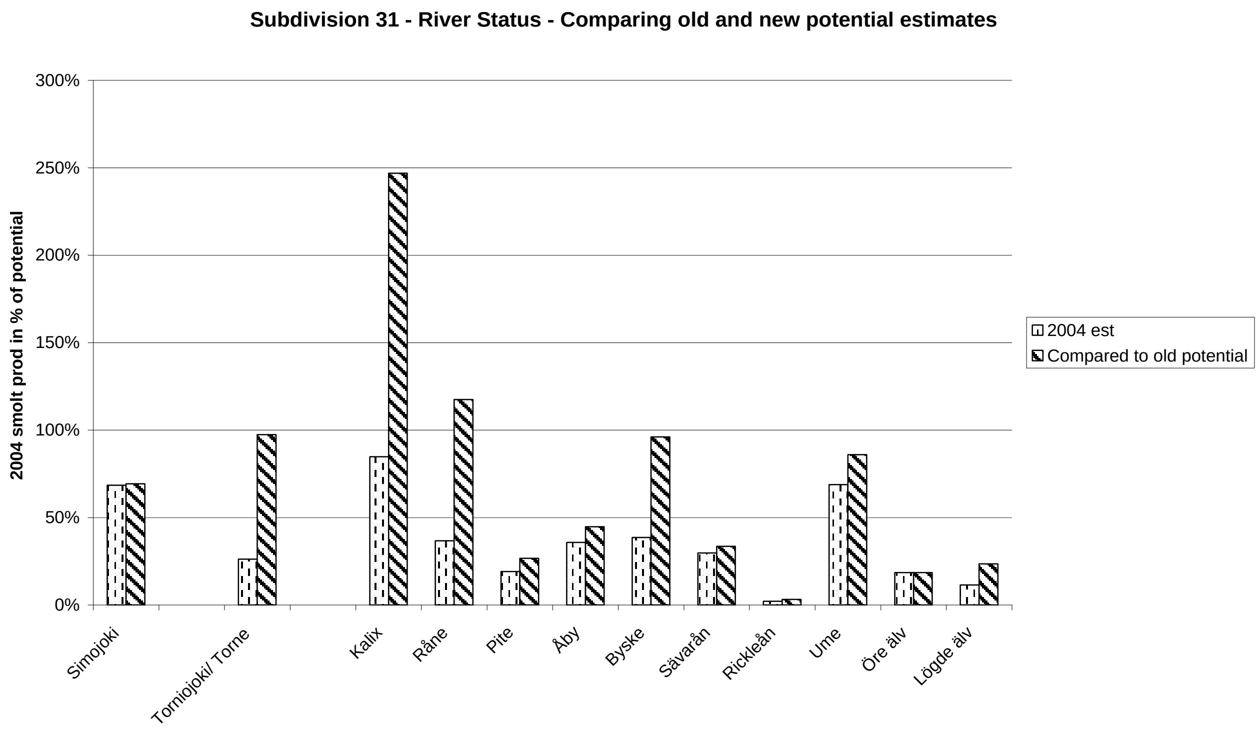
The Table below compares the old estimates with those provided by the expert estimation model. The model provides the probability distribution of the estimated potential production; the Table provides the median (50% point, there is and equal probability that the estimate is lower or is higher) of the estimated distribution.

Subdivision 31		Potential established in 1998-2000	Revised potential 2004	Smolt Production (‘000 smolts)																			
	River Type			1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2004 est
Kuivajoki	Pot	17	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0.1	0.1	0	0.1	0%
Kiiminkijoki	Pot	40	40							+	+	+	+	+	+	1	0.1	0.1	0.5	0	0.1	0.8	0%
Pyhäjoki	Pot	35	35							+	+	+	+	+	+	+	0.1	0.1	+	0.1	0	0.1	0%
Simojoki	Wild	75	76	2.54	2.24	13.1	12.7	10.8	16.6	14.3	11.9	2.59	1.93	3.37	10.3	18.9	61.6	77.6	69.8	66	52	77.1	68%
Torniojoki/ Torne	Wild	**500**	**1862**	58	77	73.9	87.9	99.3	111	185	237	147	113	95.3	116	214	549	724	594	537	487	681	26%
Kalix	Wild	**250**	**728**	39	51	50	198	292	239	374	213	177	155	96.6	164	436	529	523	495	439	617	1462	85%
Råne	Wild	**20**	**64**			2	2	2	2	2	7.1	2.8	2.2	3.7	7.2	18.3	29.7	29.1	20.3	13.1	23.5	38.5	37%
Pite	Wild	**33**	**46**			1	1	1	1	1	1	3	3	5	5.6	4.2	5.1	18	11.6	6.8	8.8	7.4	19%
Åby	Wild	**16**	**20**			3	2.4	3.0	5.0	7.0	6.2	2.7	2.7	4.8	6.0	4.7	9.2	14.5	11.0	6.5	7.2	6.1	36%
Byske	Wild	**80**	**199**			10	25.5	21.9	36.2	76.4	59.0	26.0	24.9	25.1	46.3	78.4	94.3	115.0	94.9	64.1	76.8	162	39%
Sävarån	Wild	**4**	**4.5**			0.6	0.6	0.6	0.9	0.6	0.4	0.6	0.3	0.4	1.1	0.8	1.0	1.2	1.5	1.6	1.3	1.9	30%
Rickleån	Wild	**5**	**7.5**			0.1	0.02	0.02	0.02	0.01	0.02	0.1	0.1	0.04	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.1	2%
Ume	Wild	**200**	**250**	40.6	29.8	37.4	65.6	68.3	38.9	44.7	35.2	19.3	11.1	15.1	24.8	141.8	259.6	137.0	169.2	180.6	172.0	339.1	69%
Öre älv	Wild	**20**	**20**	3.0	2.0	1.5	1.2	0.9	0.9	0.8	0.7	0.6	0.6	0.7	1.2	1.2	1.6	1.7	1.9	2.5	3.7	3.8	18%
Lögde älv	Wild	**19**	**39**	1.8	0.9	0.5	0.8	0.6	0.9	1.7	1.1	0.9	1.4	1.4	2.9	3.2	4.3	5.7	4.9	3.8	4.5	6.6	11%
Others										20	4	4	4										
Total subdiv 31		**1314**	**3408**							728	576	387	320	252	386	922	1544	1648	1475	1321	1454		43%
Subdivision 30																							
Ljungan		**20**	**5.9**					0.7	0.4	0.7	0.5	0.1	0.3	0.9	1.0	1.4	1.9	1.6	1.4	0.7	0.3	0.6	5%
Subdivisions 22-29																							
Emån	Wild	15	15			5	5	5	15	5	4.5	3	2.5	4	3.5	4	5	3	3	3	2.5		17%
Mörrumsan	Wild	100	90			120	120	120	100	90	60	30	35	60	60	76	98	70	67.7	55	75.5		84%
Pärnu	Wild	3.5	3.5											3	2	1	0.1	0.1	0.1	0	0	0	0%
Salaca	Wild	30	30							22	15	15	20	20	29	27	19	29	29	25			0%
Vitrupe	Wild		4							5	5	5	5	5	4	4	4	2	2	2			0%
Peterupe	Wild		5							5	5	5	5	5	4	4	4	2	2	2			0%
Gauja	Mixed		28							17	1	13	13	14	14	13	13	12	15	15			0%
Daugava	Mixed		10							5	5	5	5	5	5	5	5	2	5	2			0%
Irbe	Wild		4							10	10	8	7	7	7	7	7	5	5	5			0%
Venta	Mixed		15							15	15	15	15	12	12	12	12	10	12	10			0%
Saka	Wild		8							10	10	10	10	8	7	7	7	2	7	2			0%
Uzava	Wild		4							2	2	2	2	2	1	2	2	2	1	2			0%
Barta	Wild		4							2	2	2	2	2	1	1	1	2	1	2			0%
Neumunas basin	Wild	150	150							20	20	20	20	20	20	2.2	5	4.2					0%
Total Subdivs 24-29		299	371							208	155	133	142	167	170	165	182	145	150	125			0.42
Total 24-31		1633	3784																				

There are two revisions in this series: 1) Rivers in Subdivision 31 and 2) Estonian and Latvian rivers where for the first time ICES is able to provide estimates of the potential smolt production.

The revision that affects the overall picture is for the Rivers Torne and Kalix which together is about two thirds of the total production.

The figure below compares the IBSFC SAP target based on the old and the new potential smolt estimates.



Conclusion

The old estimates of the potential smolt production seem too low at least for some systems and the estimates provided in this report represent a better understanding of the potential smolt production although acknowledging the uncertainty regarding the estimates. However, the estimation is not fully satisfactory and ICES will continue to develop these estimates in the coming years. Therefore, the estimates cannot be considered to be final.

2.1.4.8 Review and evaluation of factors that are important for smolt survival in the Gulf of Finland

No estimate of initial smolt survival in wild salmon populations is available. However, for reared salmon released into the Gulf of Finland the initial smolt survival is low, similar to what is found elsewhere in the Baltic Sea and in the North Atlantic. Also, similar to observations elsewhere in the North Atlantic the post smolt survival has been lower in the last five years than in the early 1990s. Smolt survival in the Gulf of Finland is lower than elsewhere in the Baltic Sea. Estimates for the Baltic salmon range from 2-20% survival during the few months of sea life.

The reason for the high mortality soon after release is unknown. Seminars in Finland in December 2003 and in Estonia in February 2004 (participation from Estonia, Finland, and Russian Federation) considered changes in the Gulf of Finland ecosystem, particularly food web and predation (seals, cormorants), as possible factors affecting post smolt survival. Recently, the quality of reared smolts produced in hatcheries has also been discussed. The seminars concluded that feeding of post smolts, impact of thermocline and halocline shifts on food organisms, and food composition of seals and predation by cormorants are all potentially important factors. However, no conclusion was reached.

At this point in time ICES is not able to provide precise information to the question. An answer needs to wait until the scientific debate has been concluded and most probably more data collected, compiled and analysed.

2.1.4.9 Estimation of the mortality generated on Gulf of Finland salmon in fisheries taking place in the Main Basin

A share of the smolts released to the Gulf of Finland migrates from the Gulf of Finland to the Main Basin for feeding. According to tagging results from the Finnish releases to the river Kymijoki on average 22% of the recaptures of salmon were caught in the Main Basin. Tagging results from Estonian releases suggest a share of 45% being caught in the Main Basin.

The population of 2SW salmon returning to the Gulf of Finland have been exposed to a harvest rate of approximately 30% outside the Gulf of Finland.

Salmon originating from the Gulf of Bothnia and Baltic Sea Main Basin occur in the catches in the Gulf of Finland. In 2003 catch samples were collected from the Finnish commercial fishery in the western part and in the eastern part of the Gulf of Finland. Catch samples were aged by scale reading and stock proportions were estimated by genetic methods. The results indicated a high proportion of Gulf of Bothnia stocks in the catches, in particular of the wild salmon (31%). No significant change in age composition from the previous year was observed.

Table 2.1.4.9.1. Summary of observed proportions of wild salmon in the 2002 and 2003 catches.

Area	Year	Proportion of wild salmon by genetic samples	Proportion of wild salmon by scale readings
Bothnian Bay	2002	43% (summer) (n=180)	32-45% (summer) (n=331)
	2003	52% (summer) (n=203)	31-60% (summer) (n=753)
Bothnian Sea	2002	40% (summer) (n=179)	43% (summer) (n=179)
	2003	76% (summer) (n=218)	63% (summer) (n=1331)
Åland Islands	2002	69% (spring) (n=218)	58% (spring) (n=218)
	2003	76% (spring) (n=209)	57% (summer) (n=299)
Gulf of Finland East	2002	2% (summer) (n=150)	6% (summer) (n=150)
	2003	36% (summer) (n=448)	36% (summer) (n=665)
Gulf of Finland West	2002		
	2003	19% (summer) (n=148)	13% (summer-autumn) (n=321)
Main Basin	2002	48% (winter) (n=71)	34-43% (spring) (n=124) 42-52% (autumn) (n=95) 25-48% (winter) (n=327)
	2003	66% (autumn-winter) (n=215)	35-45% (spring) (n=274) 18-58% (autumn) (n=714) 41-57% (winter) (n=137)

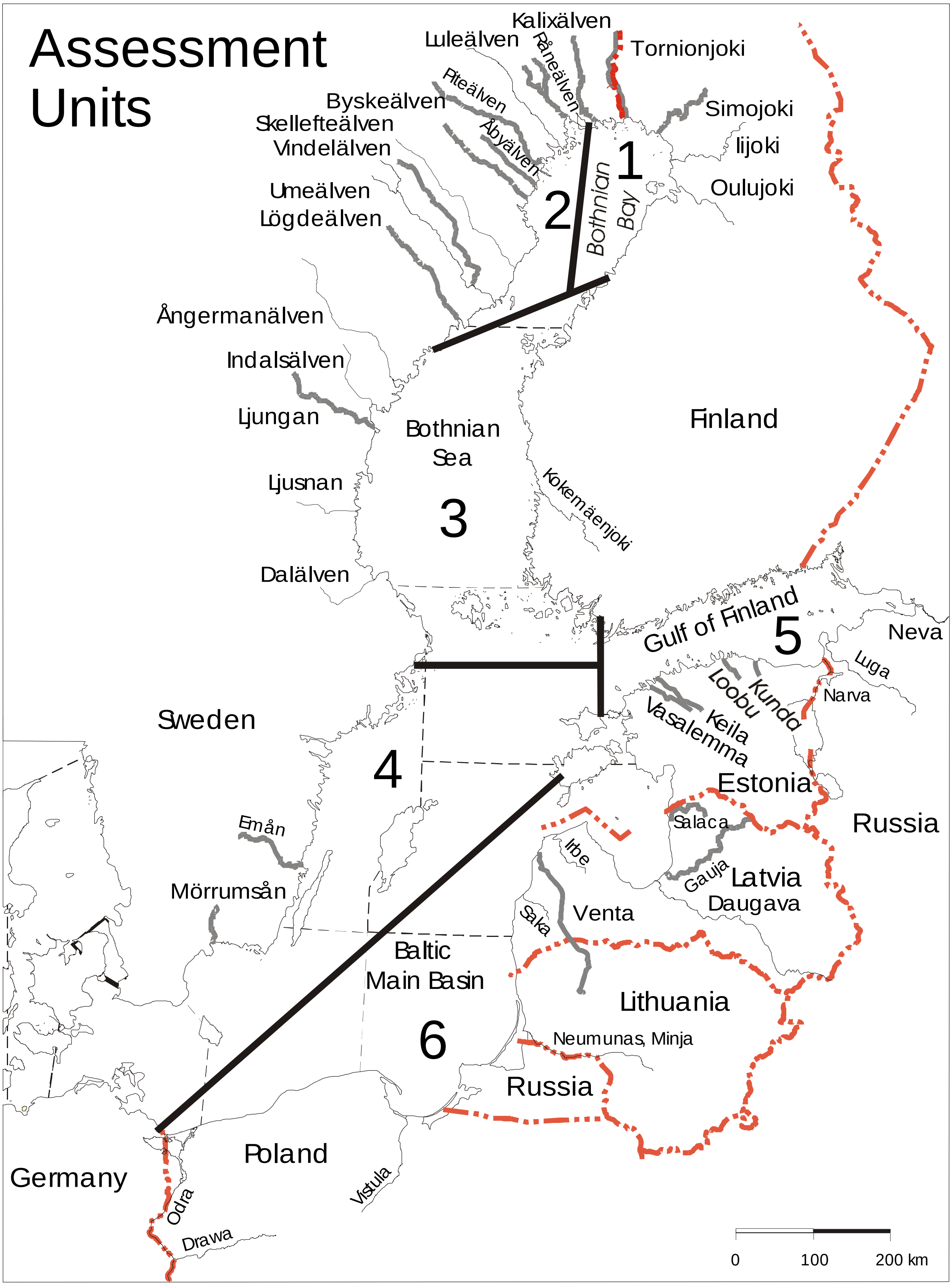


Figure 2.1.4.9.1 Baltic Salmon Stocks Assessment units. The genetic variability between stocks of an assessment unit is smaller than the genetic variability between stocks of different units. In addition, the stocks of a particular unit exhibit similar migration patterns.

2.1.4.10 Information on landings and discards by fisheries in the most recent years

The main fisheries for cod in the Baltic use demersal trawls, pelagic trawls and gillnets and cod is in all fisheries taken in a targeted fishery with minimal bycatches. There was substantial increase in gillnet fisheries in the 1990s and because of the change in stock age composition in late 1990s and early 2000, the share of the total catch of cod taken by gillnets has decreased and that of demersal trawl increased again.

The tables below show total cod landings by Sub-division and country for trawl and gillnet for Western and Eastern Baltic respectively. Similar data regarding discard are unfortunately not available to ICES. However, discard data aggregated for all countries are supplied (see discard tables below).

Pelagic fisheries in the Baltic are dominated by pelagic trawlers catching a mixture of herring and sprat. The proportion of the two species in the catches varies according to area and season. In addition, fisheries for predominantly herring are carried out with trap-nets/pound-nets and gill-nets in coastal areas and with bottom trawls in some areas.

The actual composition of pelagic catches is poorly known for some fisheries because landings in some landings statistics are assigned to species according to the target species. In **Denmark** trawlers using mesh sizes below 32 mm fish for industrial purposes, and the species composition is determined by logbooks/sale-slips and corroborated by samples. The landings not sampled are allocated to species according to a “dominant species” rule. When using meshes larger than 31 mm trawlers are assumed to fish for human consumption and species composition is based on logbooks. The landings are allocated to fishing area according to information in logbooks. In **Estonia** species composition are based on logbooks. Some (mostly visual) estimation by the Environmental Inspection is carried out. In **Finland** species compositions are by catch notifications and logbooks. Some inspections are made in harbours by regional Employment and Economic Development Centres. In **Germany** landings of herring from gillnets and trapnets with negligible amounts of sprat dominated the pelagic fishery till 2001. Thereafter a substantial increase in trawling pelagic fish has occurred. Species composition is determined by logbooks. In **Latvia** and **Lithuania** species composition is based on logbooks. In **Poland** species composition is based on logbooks and landing declarations. In **Russia** species composition is based on logbooks and sporadically checked by fishery inspectors in harbours. In **Sweden** species composition is based on logbooks. The samples taken by the Coast Guard for control purposes have so far not been used for the officially reported landings.

Previous observations have verified that discarding is insignificant in the mixed pelagic fisheries. No observers have therefore been on board vessels in these fisheries and ICES has no data to answer this request for the mixed pelagic fisheries.

Total landings (t) of the western Baltic cod stock (Sub-div. 22-24) by Sub-division and quarter.

Year: 2000 Gear: Trawl

Sub-div.	22	23	24	22-24
Country:				
Denmark	7011	0	0	7011
Germany	7461	0	6188	13649
Poland	0	0	4111	4111
Sweden	0	0	14	14
Unspec.	0	0	1559	1559
Total	14472	0	11872	26344

Total landings (t) of the western Baltic cod stock (Sub-div. 22-24) by Sub-division and quarter.

Year: 2000 0 Gear: Gillnet

Sub-div.	22	23	24	22-24
Country:				
Denmark	4462	0	12040	16502
Germany	0	0	0	0
Poland	0	0	1088	1088
Sweden	0	0	0	0
Unspec.	0	0	0	0
Total	4462	0	13128	17590

Total landings (t) of the western Baltic cod stock (Sub-div. 22-24) by Sub-division and quarter.

Year: 2001 Gear: Trawl

Sub-div.	22	23	24	22-24
Country:				
Denmark	4633	0	5638	10271
Germany	6566	0	4013	10580
Poland	0	0	73	73
Finland	0	0	191	191
Latvia	0	0	0	0
Estonia	0	0	40	40
Russia	0	0	0	0
Sweden	0	0	1353	1353
Lithuania	0	0	0	0
Unallocated	0	0	0	0
Total	11200	0	11308	22508

Total landings (t) of the western Baltic cod stock (Sub-div. 22-24) by Sub-division and quarter.

Year: 2001 0 Gear: Gillnet

Sub-div.	22	23	24	22-24
Country:				
Denmark	3777	2124	3398	9300
Germany	0	0	0	0
Poland	0	0	573	573
Finland	0	0	0	0
Latvia	0	0	0	0
Estonia	0	0	0	0
Russia	0	0	0	0
Sweden	0	693	1126	1819
Lithuania	0	0	0	0
Unallocated	0	0	0	0
Total	3777	2817	5097	11691

Total landings (t) of the western Baltic cod stock (Sub-div. 22-24) by Sub-division and quarter.

Year: 2002 Gear: Trawl

Sub-div.	22	23	24	22-24
Country:				
Denmark	3761	0	2648	6408
Germany	4943	0	2379	7322
Poland	0	0	113	113
Finland	0	0	191	191
Latvia	0	0	10	10
Estonia	0	0	0	0
Russia	0	0	0	0
Sweden	758	0	0	758
Lithuania	0	0	0	0
Unallocated	0	0	0	0
Total	9462	0	5340	14802

Total landings (t) of the western Baltic cod stock (Sub-div. 22-24) by Sub-division and quarter.

Year: 2002 0 Gear: Gillnet

Sub-div.	22	23	24	22-24
Country:				
Denmark	3264	2055	1984	7304
Germany	0	0	0	0
Poland	0	0	669	669
Finland	0	0	0	0
Latvia	0	0	0	0
Estonia	0	0	0	0
Russia	0	0	0	0
Sweden	1322	0	0	1322
Lithuania	0	0	0	0
Unallocated	0	0	0	0
Total	4586	2055	2653	9295

Total landings (t) of the western Baltic cod stock (Sub-div. 22-24) by Sub-division and quarter.

Year: 2003 Gear: Trawl

Sub-div.	22	23	24	22-24
Country:				
Denmark	2368		4930	7298
Germany	2683		1457	4140
Poland			30	30
Finland			59	59
Latvia			3	3
Estonia				
Russia				
Sweden			988	988
Lithuania				
Unallocated				
Total	5051		7467	12518

Total landings (t) of the western Baltic cod stock (Sub-div. 22-24) by Sub-division and quarter.

Year: 2003 Gear: Gillnet

Sub-div.	22	23	24	22-24
Country:				
Denmark	2816	1373	3161	7350
Germany	1706		929	2635
Poland			539	539
Finland				
Latvia				
Estonia				
Russia				
Sweden		551	910	1462
Lithuania				
Unallocated				
Total	4522	1925	5539	11986

Total landings (t) of the eastern Baltic cod stock (Sub-div. 25-32) by Sub-division and country.

Year: 2000 Gear: Trawl

Sub-div.	25	26	27	28	29	30	31	32	25-32
Country:									
Denmark	7171	367	4	7	5	0	0	0	7554
Finland	902	114	12	23	1	2	0	0	1054
Germany	1405	79	0	0	0	0	0	0	1484
Latvia	573	1029	0	332	0	0	0	0	1934
Poland	7549	4826	0	0	0	0	0	0	12375
Russia	0	1749	0	0	0	0	0	0	1749
Sweden	8284	838	735	232	0	0	0	0	10089
Estonia	303	39	0	85	0	0	0	0	427
Lithuania	0	4263	0	0	0	0	0	0	4263
Unspec.	100	0	0	0	77	0	0	0	177
Total	26287	13304	751	679	83	2	0	0	41105

Total landings (t) of the eastern Baltic cod stock (Sub-div. 25-32) by Sub-division and country.

Year: 2000 Gear: Gillnet

Sub-div.	25	26	27	28	29	30	31	32	25-32
Country:									
Denmark	2057	106	0	0	0	0	0	0	2163
Finland	790	67	12	5	1	2	0	0	877
Germany	0	0	0	0	0	0	0	0	0
Latvia	1012	2691	0	559	0	0	0	0	4262
Poland	7579	1240	0	0	0	0	0	0	8819
Russia	0	2482	0	0	0	0	0	0	2482
Sweden	4881	182	507	242	11	0	0	0	5822
Estonia	0	0	0	0	0	0	0	0	0
Lithuania	0	0	0	0	0	0	0	0	0
Unspec.	0	0	0	0	0	0	0	0	0
Total	16319	6767	519	806	12	2	0	0	24425

Total landings (t) of the eastern Baltic cod stock (Sub-div. 25-32) by Sub-division and country.

Year: 2001 Gear: Trawl

Sub-div.	25	26	27	28	29	30	31	32	25-32
Country:									
Denmark	5181	72	1	17	0	0	0	0	5271
Germany	2157	0	0	0	0	0	0	0	2157
Poland	6585	5441	0	0	0	0	0	0	12026
Finland	1040	13	0	0	0	0	0	0	1053
Latvia	550	715	0	352	0	0	0	0	1617
Estonia	541	39	0	44	0	0	0	0	624
Russia	0	2027	0	0	0	0	0	0	2027
Sweden	9917	681	850	165	0	0	0	0	11613
Lithuania	0	3137	0	0	0	0	0	0	3137
Unallocated	0	0	0	0	0	0	0	0	0
Total	25971	12124	850	578	0	0	0	0	39524

Total landings (t) of the eastern Baltic cod stock (Sub-div. 25-32) by Sub-division and country.

Year: 2001 Gear: Gillnet

Sub-div.	25	26	27	28	29	30	31	32	25-32
Country:									
Denmark	4142	165	2	0	0	0	0	0	4309
Germany	0	0	0	0	0	0	0	0	0
Poland	8006	1314	0	0	0	0	0	0	9320
Finland	433	34	5	1	0	0	0	0	473
Latvia	914	3305	0	416	0	0	0	0	4635
Estonia	138	0	0	0	1	0	0	3	141
Russia	0	3005	0	0	0	0	0	0	3005
Sweden	4945	225	833	215	16	5	3	0	6241
Lithuania	0	0	0	0	0	0	0	0	0
Unallocated	0	0	0	0	0	0	0	0	0
Total	18578	8048	840	632	16	5	3	3	28124

Total landings (t) of the eastern Baltic cod stock (Sub-div. 25-32) by Sub-division and country.

Year: 2002 Gear: Trawl

Sub-div.	25	26	27	28	29	30	31	32	25-32
Country:									
Denmark	3871	282	0	11	0	0	0	0	4165
Germany	1418	20	0	7	0	0	0	0	1445
Poland	5176	2983	0	0	0	0	0	0	8159
Finland	1040	13	0	0	0	0	0	0	1053
Latvia	463	545	0	339	0	0	0	0	1347
Estonia	0	0	0	0	0	0	0	0	0
Russia	0	1634	0	0	0	0	0	0	1634
Sweden	7582	0	0	0	0	0	0	0	7582
Lithuania	0	3137	0	0	0	0	0	0	3137
Unallocated	0	0	0	0	0	0	0	0	0
Total	19551	8615	0	358	0	0	0	0	28523

Total landings (t) of the eastern Baltic cod stock (Sub-div. 25-32) by Sub-division and country.

Year: 2002 Gear: Gillnet

Sub-div.	25	26	27	28	29	30	31	32	25-32
Country:									
Denmark	3573	92	0	0	0	0	0	0	3665
Germany	0	0	0	0	0	0	0	0	0
Poland	5917	1030	0	0	0	0	0	0	6947
Finland	433	34	5	1	0	0	0	0	473
Latvia	716	2310	4	419	0	0	0	0	3449
Estonia	0	32	0	5	0	0	0	0	37
Russia	0	2159	0	0	0	0	0	0	2159
Sweden	4925	0	0	0	0	0	0	0	4925
Lithuania	0	0	0	0	0	0	0	0	0
Unallocated	0	0	0	0	0	0	0	0	0
Total	15564	5657	9	425	0	0	0	0	21655

Total landings (t) of the eastern Baltic cod stock (Sub-div. 25-32) by Sub-division and country.

Year: 2003 Gear: Trawl

Sub-div.	25	26	27	28	29	30	31	32	25-32
Country:									
Denmark	4643	197	31	0	0	4		2	4877
Germany	1343	11	0	9	0				1363
Poland	5420	3344							8764
Finland	539	10	2						550
Latvia	183	555		514					1252
Estonia	581	9			0				591
Russia		1634							1634
Sweden	5982	160	517	16					6675
Lithuania		2767							2767
Total	18691	8686	550	539	0	4		2	28473

Total landings (t) of the eastern Baltic cod stock (Sub-div. 25-32) by Sub-division and country.

Year: 2003 Gear: Gillnet

Sub-div.	25	26	27	28	29	30	31	32	25-32
Country:									
Denmark	2562	253	0						2816
Germany									
Poland	5533	1078							6610
Finland	462	79	8		3	4		2	558
Latvia	869	1837	8	544					3258
Estonia									
Russia		2073							2073
Sweden	4858	90	451	44	8	9			5460
Lithuania									
Total	14284	5409	467	588	11	13		2	20775

Discard (in numbers) by métier and year.

Stock	22-24

Metiér	Year							
	1996	1997	1998	1999	2000	2001	2002	2003
Gillnet	592	691	189	220	349	2114	474	12432
Trawl	25919	15723	20476	14252	14750	9256	5712	8791
Grand Total	26511	16414	20665	14472	15098	11370	6186	21223

Discard (in numbers) by gear and year.

Stock	25-32

Gear	Year							
	1996	1997	1998	1999	2000	2001	2002	2003
Gillnet	2037	2255	12772	865	14471	1920	1283	3933
Trawl	5318	15325	9565	21314	8822	9008	5841	4315
Grand Total	7355	17580	22337	22179	23293	10929	7125	8248

2.1.5 NASCO

2.1.5.1 Request for information on the status of North Atlantic Salmon

NASCO has requested ICES to provide information according to the following:

1. With respect to Atlantic salmon in the North Atlantic Area:

    1.1 provide an overview of salmon catches and landings, including unreported catches by country and catch and release, and worldwide production of farmed and ranched salmon in 2003;

    1.2 report on significant developments which might assist NASCO with the management of salmon stocks;

    1.3 provide a compilation of tag releases by country in 2003

    1.4 identify relevant data deficiencies, monitoring needs and research requirements taking into account NASCO's International Atlantic Salmon Research Board's inventory of on-going research relating to salmon mortality in the sea.

2. With respect to Atlantic salmon n the North-East Atlantic Commission area:

    2.1 describe the key events of the 2003 fisheries and the status of the stocks;

    2.2 evaluate the extent to which the objectives of any significant management measures introduced in the last five years have been achieved;

    2.3 further develop the age-specific stock conservation limits where possible based upon individual river stocks;

    2.4 provide catch options or alternative management advice, if possible based on a forecast of PFA for northern and southern stocks, with an assessment of risks relative to the objective of exceeding stock conservation limits;

    2.5 provide estimates of by-catch of salmon in pelagic fisheries and advise on their reliability.

    2.6 provide descriptions (gear type: and fishing depth, location and reason) for all pelagic fisheries that may catch Atlantic salmon.

3. With respect to Atlantic salmon in the North American Commission area:

    3.1 describe the key events of the 2002 fisheries and the status of the stocks;

    3.2 evaluate the extent to which the objectives of any significant management measures introduced in the last five years have been achieved;

    3.3 update age-specific stock conservation limits based on new information as available;

    3.4 provide catch options or alternative management advice with an assessment of risks relative to the objective of exceeding stock conservation limits;

    3.5 provide an analysis of existing biological and/or tag return data, and recommendations for required data collections, to identify the origin of Atlantic salmon caught at St Pierre and Miquelon;

    3.6 identify relevant data deficiencies, monitoring needs and research requirements.

4. With respect to Atlantic salmon in the West Greenland Commission area:

    4.1 describe the events of the 2003 fisheries and the status of the stocks;

4.2 evaluate the extent to which the objectives of any significant management measures introduced in recent years have been achieved;

4.3 provide information on the origin of Atlantic salmon caught at West Greenland at a finer resolution than continent of origin (river stocks, country or stock complexes);

4.4 provide catch options or alternative management advice with an assessment of risks relative to the objective of exceeding stock conservation limits, and advise on the implications of these options for stock rebuilding;

Notes:

1. In the responses to questions 2.1, 3.1 and 4.1 ICES is asked to provide details of catch, gear, effort, composition and origin of the catch and rates of exploitation. For homewater fisheries, the information provided should indicate the location of the catch in the following categories: in-river; estuarine; and coastal. Any new information on non-catch fishing mortality of the salmon gear used and on the by-catch of other species in salmon gear and of salmon in any existing and new fisheries for other species is also requested.

2. With regard to question4.1 ICES is requested to provide a brief summary of the status of the North American and North-East Atlantic salmon stocks. The detailed information on the status of these stocks should be provided in response to questions 2.1 and 3.1.

3. In response to questions 2.4, 3.4 and 4.4 provide a detailed explanation and critical examination of any changes to the models used to provide catch advice. With respect to stock rebuilding, consider and evaluate various alternative baseline measures for use in the risk analysis.

The information in response to the NASCO request is found in Book 2 sections 5 to 9.

2.1.6 NEAFC

2.1.6.1 Review of *Sebastes mentella* stock structure

ICES has assimilated and reviewed the results from an EU-funded research project on redfish and other, partly ongoing, scientific projects. This work was done by the *ICES Study Group on Stock Identity and Management Units of Redfishes (*31 August – 3 September 2004).

A great deal of information on the stock identity of *S. mentella* units has been compiled and summarized. However, conclusions to which all the involved scientists could agree were not reached. The analysis suffers from fundamental problems with sampling of central parts of the data and a synthesis is not obvious and might be impossible. The results offer support for any and all hypotheses, leaving ample room for subjective evaluation. Further interdisciplinary analysis of the material with a view to defining redfish stocks might not reach firm conclusions.

No consensus among the involved scientists was reached on the definition of biological stocks or practical management units. Stock definition is typically difficult, particularly when considering results from many approaches that are equivocal with respect to patterns of variability. The current analysis tried to assimilate mixed results from separate investigations, none of which were designed to test the alternative hypotheses. ICES concludes that some stock structure exists, but it is at this point in time unable to define the split of the catches that will provide the better basis for the assessments.

Therefore, ICES at the present time advises that there is inadequate evidence to revise advisory units. Therefore, ICES maintains the current advisory units until more information becomes available: a demersal unit on the continental shelf in ICES Divisions Va, Vb, and XIV (stock summary in Section 4.2.5c) and a pelagic unit in the Irminger Sea and adjacent areas (V, VI, XII, and XIV) (stock summary in Section 4.2.5d). There is a change in the nomenclature used previously: the pelagic unit now includes what was formerly known as pelagic deep-sea and oceanic *S. mentella*. The demersal unit is the deep-sea *S. mentella* occurring on the continental shelf and on the slope.

Source of information:

1. Report of the Study Group on Stock Identity and Management Units of Redfishes [SGSIMUR] 31 August – 3 September 2004.

2. Technical Minutes of the review of the Study Group on Stock Identity and Management Units of Redfishes.

2.1.6.2 Information on areas and seasons with spawning aggregations of Deep-sea species and deep-sea habitats vulnerable to fishing activities

ICES provided information on vulnerable deep-sea aggregations in Section 3.13.3.b of the ACFM report 2003 (*ICES Cooperative Research Report No. 261*).

Blue ling and orange roughy form aggregations that are vulnerable to fishing. Such aggregations occur on rather small areas and such areas can be identified using official logbooks, from biological sampling and VMS. Areas defined need to be sufficiently large to be administratively feasible, yet sufficiently defined to ensure that they achieve the desired management objective.

The following is a compilation of the available information. This information may not be complete due to lack of reporting to ICES.

Research surveys

Data from research surveys provide the best information on the position of such aggregations. However, such data are limited in extent.

Orange roughy

As part of the Irish Marine Institute Deepwater Survey Programme, a voyage was conducted on the Olympus Seamount in 1995 (Subarea X). Aggregations of orange roughy were fished on. Due to gear damage, the number of hauls was limited to 6 in total. However, this exercise allows the identification of aggregations of this species. This was the only directed survey carried out by the Irish Marine Institute, on orange roughy. Anecdotal information suggests that French vessels fished in this area in some years.

Positions of aggregations of orange roughy on the Olympus Seamount, taken from the Irish Marine Institute Deepwater Survey, in November 1995.

Latitude shot	Longitude shot	Latitude hauled	Longitude hauled	Mean depth
45:37:00	27:17:00	45:35:81	27:21:53	1400
45:37:00	27:17:00	45:35:81	27:21:53	1400
45:11.9	27:54.3	45:13:44	27:51:15	1088
45:10.6	27:50.1	45:12:19	27:46:52	975
45:35.2	27:19.9	45:34:64	27:20:72	1300
45:34.5	27:17.4	45:35:46	27:18:11	880

Survey data from France are of use in identifying aggregations of this species too, and are available for the Hebrides Terrace Seamount (Division VIa) from the PROSPEC Survey in 1996 and from recent work carried out on the slopes of the Bay of Biscay in Subarea VIII.

Blue ling

NEAFC mentions five areas in its request on management advice for blue ling. Of these five areas, the Irish Marine Institute has information on the last one. Marine Institute trawl surveys in the Rockall Trough were carried out from 1993-1997. One survey was carried out in April 1993, and spawning blue ling were found at latitude 58^0 01 55 N and $9\ ^0$40 10 W. Ripe and running fish were encountered in this area.

Commercial fisheries data

Blue ling

This species is not as commercially valuable as orange roughy. However, the positions of the spawning aggregations are also commercially sensitive.

Positional information from the fisheries are available for blue ling in Division Va. These data indicate spawning aggregations. In addition there used to be a spawning aggregation in the Storegga area at about 62^o N, in Division IIa: 62^0 30 to 64^0 N and 5^0 E on the continental slopes of the Norwegian Sea, and this aggregation supported a gillnet fishery for this species in the 1980s. There is also a spawning aggregation in the northern part of the Rockall Trough in Division VIa (see Research survey section above).

ICES Division	Area	Positions
Va	Reykjanes Ridge at the southern border of the Icelandic EEZ	61^0 N and 27^0 30 W Depth c. 500 m
Va	South of the Vestmanna Isles, in Icelandic EEZ	21^0 30 and 62^0 50 Depth c. 500 m
Vb	A location in Division Vb	
IIa	Storegga, on the continental slopes of the Norwegian Sea	63^0 64^0 N and 5^0 E Depth of 500 to 650 m

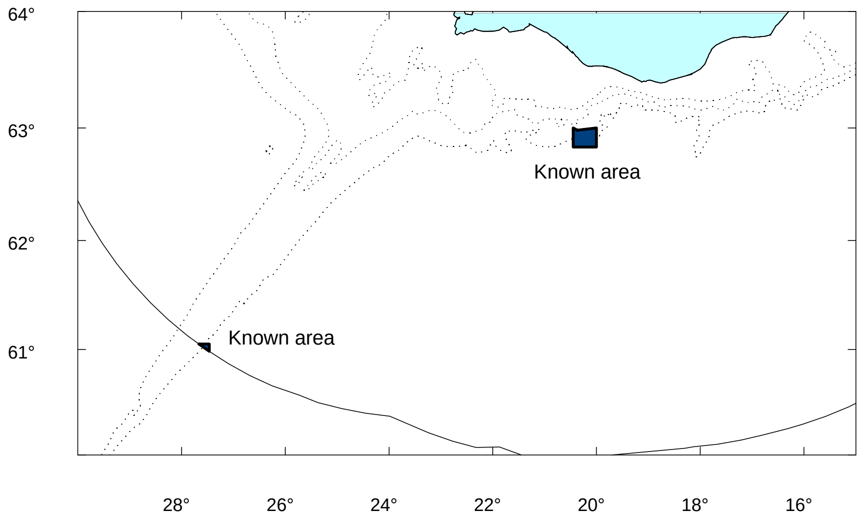


Figure 2.1.6.2.1 Map showing known spawning grounds for blue ling in Icelandic waters. It has been suggested to close these areas for fishing during the spawning period (15 February-30 April).

Orange roughy

The TAC is now restrictive in Subareas VI and VII. In 2001, the Irish Sea Fisheries Board conducted an extensive observer survey. The spatial information obtained the description of the main areas of fishing in that year in waters west of the British Isles. The positions fished are the same as those fished by the French orange roughy fishery, as the Irish fishery made extensive use of French positional information.

The catch composition in the areas shows that the clusters of fishing positions in the North Porcupine and West Porcupine areas were most important for orange roughy, and this is reflected in the CPUE from these areas.

These spatial data are presented in Figures 2.1.6.2.2.1 and 2.1.6.2.2.2. Positions presented in Table 2.1.6.2.2.1 are necessarily general, because they were taken from visual material. There may be other aggregations of this species in this area, but there is no indication of this from these maps or the catch by haul data. This information can be used to verify the catches by statistical rectangle for France and Ireland to verify that these are the main centres of orange roughy in this region.

Table 2.1.6.2.1 Positional information on aggregations of orange roughy. Positions given are defined by latitude and longitude and from the continental slopes, from the observer scheme on the Irish fishery in 2001 (BIM, WD, 2002a, Figure 2).

	Area	Position	CPUE in 2001	CPUE in 2002	Comments
1	West of Scotland	56^0 30 N 10^0 19 W	173	3	Hebrides Terrace Seamount
2	North Porcupine	54^0 10 to 54^0 30 11^0 30	426	-	Bordering VI and VII
3	North Porcupine	54^0 N 13^0 W	317	158	Southern slopes of Rockall Trough
4	West Porcupine	53^0 N 15^0 W	1532	+	Porcupine slope
5	West Porcupine	52^0 to 52^0 30 N 15^0 W	178	121	Porcupine slope
6	West Porcupine	51^0 - 51^0 43 N 15^0 W	636	139	Southwest Porcupine

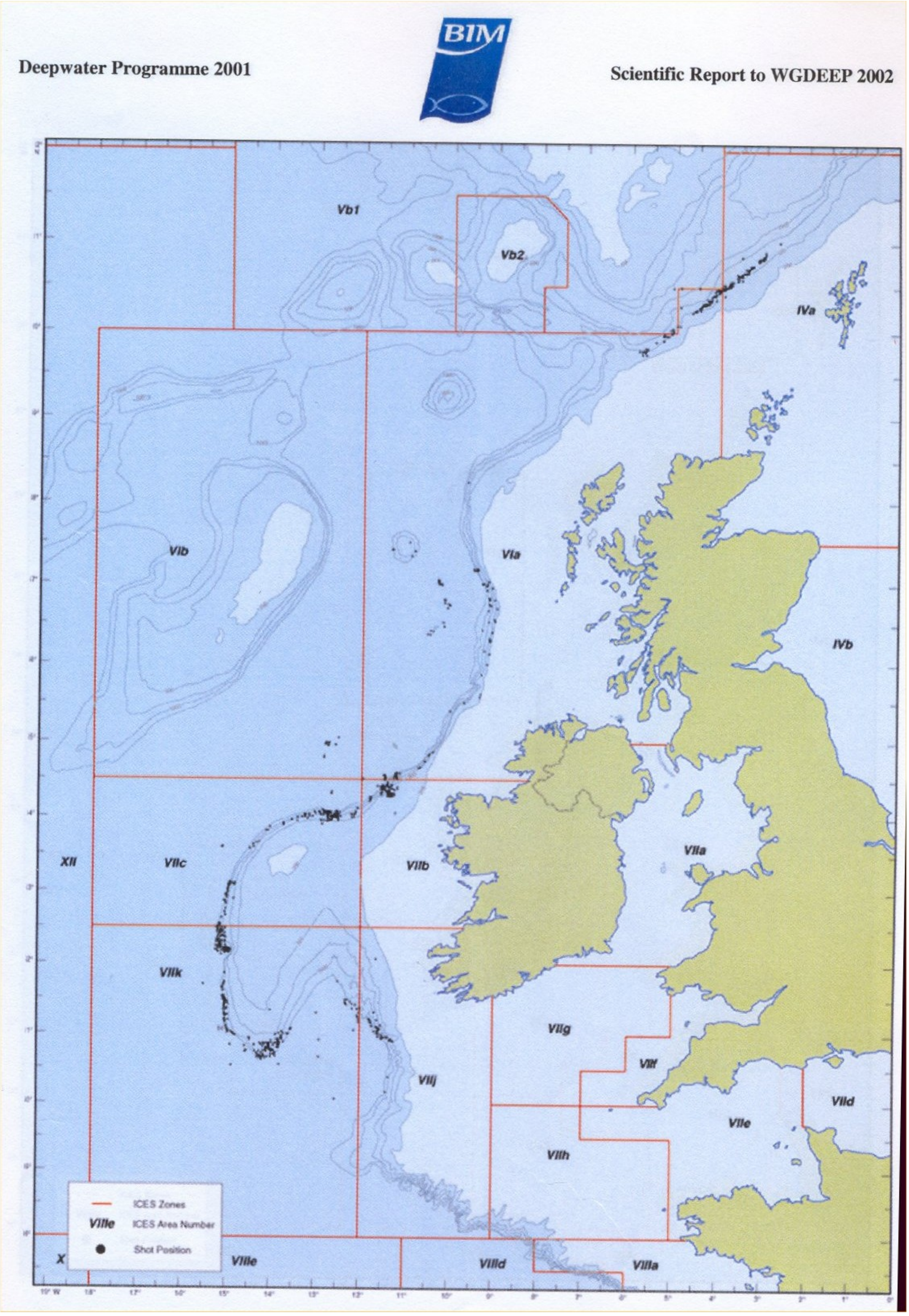


Figure 2.1.6.2.2 Location of observed fishing hauls completed in 2002. (BIM, WD, 2002a).

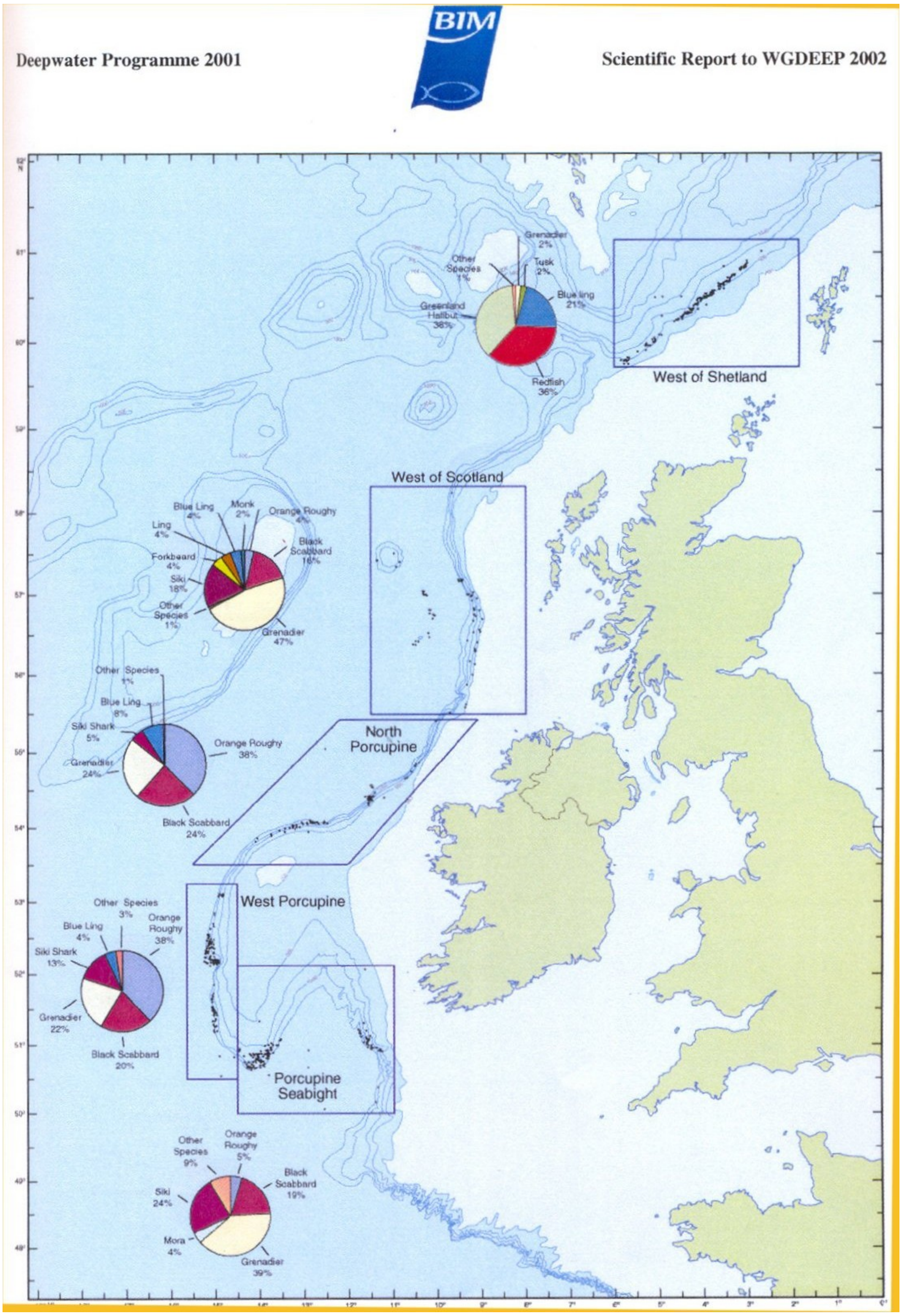


Figure 2.1.6.2.3 Catch composition of observed fishing hauls completed in 2001 (BIM, WD, 2002a).

2.1.7 OSPAR

2.1.7.1 Ecological Quality Objectives

2.1.7.1.1 Overall consideration of the approach to and framework for the response to the OSPAR requests on Ecological Quality Objectives (EcoQOs)

Request

Item 1 of the 2004 ICES Work Programme from the OSPAR Commission: *Provide the advice requested from ICES in 2004 on the development of EcoQOs specified in the 2003–2005 Work Programme for the North Sea Pilot Project on Ecological Quality Objectives*. Specific details were available in the Appendix to the original request, and these details are reproduced in the introduction to the review of each Ecological Quality (EcoQ) element or Ecological Quality Objective (EcoQO). In summary, OSPAR requested ICES to further develop the Ecological Quality elements, with some more specific requests in relation to the ten more advanced EcoQ elements, to reconsider the formulation of the EcoQOs, and to consider the development of new EcoQ elements and EcoQOs.

Source of information

A number of ICES Working Groups have discussed the various Ecological Quality elements, EcoQOs, and metrics and have provided commentary in response to specific requests. The specific expert groups with responsibility for individual EcoQ elements are referred to under the sub-sections that follow, and the Working Group on Ecosystem Effects of Fishing Activities (WGECO) has provided broad analysis and commentary on a number of the elements and/or metrics.

Summary

Details of the ICES evaluation can be found in the relevant sub-sections; however, an overview is available in Table 2.1.7.1.1.2.

This evaluation has highlighted the pressing need for the development of a framework within which EcoQOs can operate. In particular, there is concern that, over time, the number of EcoQ elements and EcoQOs could increase to become impractically large. ICES considers it important to commence discussion on how to bound the total number of EcoQOs and on how management can function effectively when pursuing large numbers of EcoQOs simultaneously. Preliminary work by ICES on this subject has led to the development of a number of important principles. Initial evaluation suggests that the DPSIR—Driver-Pressure-State-Impact-Response—framework may provide a useful structure in which to organize the selection of suites of objectives for management. Progress to date highlights the current predisposition to set EcoQOs for State properties of ecosystems, rather than EcoQOs for Drivers, Pressures, Impacts, and Responses. Decision-making will quickly become more complex as the number of EcoQOs to consider increases, and it may be important to combine the information in several EcoQOs into a smaller number that are easier to understand and present. This runs the risk of collapsing information in ways that may be misleading. Despite the request that some EcoQOs (i.e., five indicators of eutrophication) should be treated as an integrated set, there is little guidance available on how decision-support systems should undertake this. Furthermore, in the absence of an operational framework, achievement of all the aspirational EcoQOs remains subordinate to achieving any EcoQOs intended to avoid serious or irreversible harm.

Recommendations and advice

ICES advises that the specific recommendations within Sub-sections 2.1.7.1.2 to 2.1.7.1.17, below, related to the evaluation of the ten Ecological Quality Objectives and eleven Ecological Quality elements, should be adopted. Particular note should be taken of those EcoQOs that may be unsuitable as currently drafted, but which have been reformulated in the light of analysis by expert groups. On a number of occasions the evaluation of EcoQ elements and EcoQOs has highlighted opportunities for further development. It is recommended that these are used as the basis of further work programmes either in ICES or in the most appropriate expert group.

Definitions

The initiatives by OSPAR and other international bodies to develop sets of environmental indicators have inevitably led to the evolution of terms and phrases which mean different things when used by different bodies. ICES (2001) presented a detailed description of the various terms currently in use. There remains some confusion and misunderstanding in the use of some key terms and the following summary describes the definitions agreed by ICES (2001).

Issue: Ten ecological components identified in the Bergen Declaration.

Ecological Quality (EcoQ): refers to the "…. *structure and function of the marine ecosystem taking into account the biological community and natural physiographic and climatic factors as well as physical and chemical conditions including those resulting from human activities*".

Ecological Quality element (EcoQ element): One element of overall Ecological Quality (EcoQ). The Bergen Declaration has identified 21 EcoQ elements covering all ten Issues (Table 2.1.7.1.1.1).

Ecological Quality Objective (EcoQO): The desired level of an EcoQ relative to a reference level.

For reference, the full set of EcoQ elements which have been agreed by the Fifth International Conference on the Protection of the North Sea in the Bergen Declaration is reproduced in Table 2.1.7.1.1.1.

Table 2.1.7.1.1.1 The ten ecosystem components or "Issues", with the 21 associated Ecological Quality elements agreed by the Fifth North Sea Conference. Those elements for which EcoQOs have been set, and which are included in the North Sea pilot project, are shown in bold font.

Issue	Ecological quality element
1. Commercial fish species	**(a) Spawning stock biomass of commercial fish species in the North Sea**
2. Threatened and declining species	(b) Presence and extent of threatened and declining species in the North Sea
3. Sea mammals	**(c) Seal population trends in the North Sea** (d) Utilisation of seal breeding sites in the North Sea **(e) By-catch of harbour porpoises**
4. Seabirds	**(f) Proportion of oiled Common Guillemots among those found dead or dying on beaches** (g) Mercury concentrations in seabird eggs and feathers (h) Organochlorine concentrations in seabird eggs (i) Plastic particles in stomachs of seabirds (j) Local sand-eel availability to black-legged Kittiwakes (k) Seabird population trends as an index of seabird community health
5. Fish communities	(l) Changes in the proportion of large fish and hence the average weight and average maximum length of the fish community
6. Benthic communities	**(m) Changes/kills in zoobenthos in relation to eutrophication** **(n) Imposex in dogwhelks (*Nucella lapillus*)** (o) Density of sensitive (e.g., fragile) species (p) Density of opportunistic species
7. Plankton communities	**(q) Phytoplankton chlorophyll *a*** **(r) Phytoplankton indicator species for eutrophication**
8. Habitats	(s) Restore and/or maintain habitat quality
9. Nutrient budgets and production	**(t) Winter nutrient (DIN and DIP) concentrations**
10. Oxygen consumption	**(u) Oxygen**

Table 2.1.7.1.1.2 Summary of the ICES evaluation of the 21 EcoQ elements and, where relevant, the status of the EcoQO. EcoQOs in the North Sea pilot project are shown in bold font.

Ecological quality element	Good EcoQ element?	Good EcoQO?
(a) Spawning stock biomass of commercial fish species in the North Sea	Useful	Reformulation offered
(b) Presence and extent of threatened and declining species in the North Sea	Useful (modified)	Suggestion offered
(c) Seal population trends in the North Sea	Useful	Reformulation offered
(d) Utilisation of seal breeding sites in the North Sea	Useful (needs development)	Suggestion offered
(e) By-catch of harbour porpoises	Useful	Suggestion offered
(f) Proportion of oiled Common Guillemots among those found dead or dying on beaches	Useful	Reformulation offered
(g) Mercury concentrations in seabird eggs and feathers	Useful	Suggestion offered
(h) Organochlorine concentrations in seabird eggs	Useful (modified)	Suggestion offered
(i) Plastic particles in stomachs of seabirds	Useful	Suggestion offered
(j) Local sand-eel availability to black-legged Kittiwakes	Useful	Suggestion offered
(k) Seabird population trends as an index of seabird community health	Useful	Needs work
(l) Changes in the proportion of large fish and hence the average weight and average maximum length of the fish community	Useful	Suggestion offered
(m) Changes/kills in zoobenthos in relation to eutrophication	Useful	Premature
(n) Imposex in dogwhelks (*Nucella lapillus*)	Useful	Recommend adoption
(o) Density of sensitive (e.g., fragile) species	Useful (needs development)	Suggestion offered
(p) Density of opportunistic species	Not useful	–
(q) Phytoplankton chlorophyll *a*	Useful	Suggestion offered
(r) Phytoplankton indicator species for eutrophication	Useful (needs development)	Needs work
(s) Restore and/or maintain habitat quality	Useful (modified)	Needs work
(t) Winter nutrient (DIN and DIP) concentrations	Useful	Reformulation offered
(u) Oxygen	Useful	Reformulation offered

The ACE review process

In this review, a slightly modified version of the ICES template (ICES, 2003) has been used to evaluate the EcoQOs agreed for the ten EcoQ elements that are part of the North Sea pilot project (Table 2.1.7.1.1.1). The evaluations follow a standardized format whereby the recommendations state whether the EcoQO is acceptable or, in those cases where an improved formulation was available, the new EcoQO itself is presented. In the ICES template, the EcoQOs are evaluated against the seven ICES criteria, and scored using three grades: Usually, Occasionally, and Rarely. Following the technical evaluation in the template, there is a statement of the major conclusions drawn by ICES. The Conclusions section also specifies the areas of weakness and possible new formulations of some EcoQ elements or EcoQOs. Following the Conclusions, there may be a short discussion of the major additional considerations that are prompted by the EcoQO, either with regard to the reasoning behind some of the points in the Technical Evaluation, or areas where additional work is necessary to move the issue forward.

For the eleven EcoQ elements that do not yet have specific EcoQOs, the same procedure was followed. The ICES template, and the seven ICES criteria embedded within it, was used to evaluate each element. In these cases, Part 9 of the template (Advice on EcoQO options (scenarios)) has been used to suggest potential EcoQOs that may be appropriate for the element, and which could form the basis of further work. Those scenarios that have been left blank have been done so deliberately, to reflect situations where ICES has lacked policy guidance. All evaluations have been completed with the same degree of rigour; however, for some elements a considerable body of information has been made available and therefore the strengths and weaknesses can be assessed more critically. To ensure compatibility between evaluations, ICES has tried to avoid being unnecessarily over-critical when evaluations are based on a more comprehensive scientific basis.

The evaluation of EcoQOs in Sub-sections 2.1.7.1.2 to 2.1.7.1.17 has, wherever possible, taken into account the potential method of application of the different EcoQ elements in a management context. Five of the ten pilot EcoQ elements and associated EcoQOs refer to the state of the marine environment in relation to a single type of human impact, namely, eutrophication, and so have been evaluated only in this context. The technical evaluation of the five EcoQOs related to eutrophication by default often related to the EcoQ element more than the reference point specified in the EcoQO, because quantitative information on the particular values of the EcoQ element was rarely sufficient to allow an evaluation. Additional work has been completed to suggest how this integrated set could be used in an operational context. The remaining five EcoQ elements refer to the state of various other ecological components, and the evaluation is therefore made against their links to any (unstated) human activity that may be responsible for perturbation.

A guide to what follows

The sub-sections below specific to each EcoQ element or EcoQO have been designed to be comprehensive yet brief. In view of this, a summary of the conclusions of the evaluation was not considered necessary here, and the reader is encouraged to consult the relevant sub-section directly. Each of the sub-sections is structured in a standard way, and includes a statement of the request, the recommendations resulting from the evaluation, the technical evaluation itself, concluding comments, and any additional considerations.

Ecological quality objectives as part of a broader framework

ICES has begun to consider the scientific components of a broader framework for the evaluation of objectives for different aspects of management and the marine environment. There are three aspects to this task: a) the initial, careful selection and evaluation of the sets of EcoQ elements and EcoQOs; b) aggregating the information in multiple EcoQOs into a smaller number of EcoQOs; and c) guiding management decision-making using integrated sets of multiple EcoQOs.

a) The selection and evaluation of multiple EcoQOs

Suites of EcoQOs will be needed for the conservation, protection, and sustainable use of marine ecosystems, and to be operational, individual EcoQOs will have to be fairly specific. Because society has a large number of ecological, social, and economic goals, the suites of EcoQOs will have to be large to address the goals comprehensively.

At present, EcoQOs and their metrics appear to be accumulating opportunistically rather than according to a structured approach covering the full range of ecological, social, and economic goals. The disadvantage of this approach is that it may provide a management regime where managers, policy-makers, and scientific advisors are struggling to support decision-making that is constrained by many EcoQOs, some of which may be redundant or even contradictory. In addition, some important ecosystem properties (or societal goals) may not be protected or advanced by the EcoQO-based management process.

ICES considers that the DPSIR—Driver-Pressure-State-Impact-Response—framework could provide a useful structure in which to organize the selection of suites of EcoQOs for management. This framework has played a prominent role in selecting indicators and sometimes objectives in areas of environmental quality and sustainable development. Although it is the basis for work on indicator selection by the European Environment Agency in support of, for example, the Water Framework Directive (EEA, 2003), it has received little attention in many parts of the fisheries science and advisory community.

Conceptually, the DPSIR framework is compatible with evaluating the ecosystem effects of human activities. Considered individually in, for example, a fisheries context the framework could be structured as follows:

Drivers – These are the forces that exert pressure on the ecosystem and its components. They may be anthropogenic or part of the natural environment. For ecosystem effects of fishing, the direct drivers are economic and social policies of governments, and economic and social goals (implicit or explicit) of those who prosecute fisheries. Environmental drivers such as oceanographic conditions also affect fish populations and marine ecosystems, but would not be the subject of EcoQOs for keeping fisheries sustainable.

Pressures – These are the ways that the drivers are actually expressed, and the specific ways that ecosystems and their components are perturbed. For ecosystem effects of fishing, the central pressure would be Fishing Effort, of which there are many aspects and indicators.

State – These are the properties of the ecosystem itself. Where humans are considered part of the ecosystem, they are properties of the fishery. For ecosystem effects of fishing, there is a long list of potential State properties, from biomasses, total mortality rates, and size composition of targeted and non-targeted stocks through an array of biological community measures and including properties of the physical habitat. State indicators of the fishery itself include fleet size and composition, jobs provided, and landed value of catches.

Impact – These are the changes in State caused by the Pressures. For ecosystem effects of fishing, these would be things like fishing mortality and increase in the slope of the size spectrum of the fish community.

Response – These are society's actions, taken in response to impacts judged to require remediation. Examples for ecosystem effects of fishing might be a decommissioning policy for excessive fishing capacity, or a closed area to protect a specific habitat feature.

The DPSIR framework can become confusing, because the classification of at least some things as a Pressure or State or Impact can depend very much on the context. For example, to the fishery, "Catch" will be viewed as a State property, whereas to the species being exploited and the ecosystem, "Catch" will be viewed as an impact. Similarly, indicators can start off associated with one type of property but change to another with a change in management. For example, Days Fished can be an indicator of the Pressure "Fishing Effort", but once an effort control programme is introduced, Days Fished is also an indicator for the Response "Effort reduction".

A more detailed evaluation of the EcoQOs against the DPSIR framework is thought by ICES to be worthy of serious consideration. This would be a valuable exercise because, to the general public, environmental concerns are largely synonymous with concerns about State properties, and hence there would be a predisposition to set objectives for State properties of ecosystems. However, there is no guarantee that management is guided as effectively by objectives for State properties as it would be by objectives for Pressure, Impact, and possibly even Response properties. Preliminary evaluation by ICES has suggested that this framework may help not only to select individually sound EcoQOs and associated metrics, but also to identify suites of them which work together effectively and efficiently.

b) Aggregating multiple EcoQOs

Combining the information in multiple EcoQOs into a smaller number which are easier to understand and present is an important task. In its simplest form, when separate EcoQ metrics which vary tightly together measure the same ecological response, aggregation is simply pooling the results of a number of indicators. This elimination of known redundancy is different from aggregating the performance of a variety of EcoQOs and their metrics, for which the interrelationships are not known. Preliminary work in ICES suggests that combining a number of EcoQOs into a single aggregate, while avoiding the complexity of trying to interpret large amounts of information, runs the risk of collapsing information in ways that may be misleading.

Annex III-B of the Bergen Declaration includes five indicators of eutrophication, with a footnote that "The ecological quality objectives for elements (m), (q), (r), (t), and (u) are an integrated set and cannot be considered in isolation." There is, however, little formal guidance available on how decision-support systems should take account of multiple EcoQOs such as these. The Precautionary Approach could be interpreted as requiring management action to respond to the EcoQO and indicator with the highest risk of being at or outside its conservation reference point. This will be suitable for EcoQOs relating to the prevention of serious or irreversible harm; however, for EcoQOs intended to achieve desired states, an overall risk profile of all the EcoQOs and their indicators would need to be created and managed. This would present a major challenge in practice, when our analyses repeatedly have concluded that, for many important ecosystem components, we lack the basic data even to select reliable indicators and set reference points, let alone to undertake formal risk analyses.

c) Decision making

There is clear guidance from major international agreements that *all* objectives intended to avoid serious or irreversible harm to the ecosystem must be met. Thus, achievement of all the aspirational EcoQOs remains subordinate to achieving any EcoQOs intended to avoid serious or irreversible harm. For EcoQOs intended to achieve desired states of the ecosystem, management will rely on the usual multi-criteria decision-making. Under both circumstances, decision-making will rapidly become more complex as the number of EcoQOs to consider increases. A thorough evaluation against the DPSIR framework should provide the necessary rigour for the wise and effective selection of sets of EcoQOs, and should be completed as a priority. Such an analysis will address the utility of ecosystem State metrics to guide management, in comparison to EcoQOs for Pressure, Impact, and Response.

References

EEA. 2003. Environmental Performance Indicators for the European Union. http://themes.eea.eu.int/indicators/all_indicators_box.

ICES. 2001. Report of the ICES Advisory Committee on Ecosystems, 2001. ICES Cooperative Research Report, 249: 20–22.

ICES. 2003. Report of the ICES Advisory Committee on Ecosystems, 2003. ICES Cooperative Research Report, 262: 47–50.

2.1.7.1.2 EcoQO for EcoQ Element (a) Spawning stock biomass of commercial fish species in the North Sea

Request

Request to ICES from OSPAR:

ICES will be invited to reconsider the formulation of the EcoQO, determine whether a more specific EcoQO is needed in terms of its specification to the metric, time and geographical area, and as necessary propose (a) more specific EcoQO(s).

Source of information

The 2003 and 2004 reports of the Working Group on Ecosystem Effects of Fishing Activities (WGECO) (ICES CM 2003/ACE:05; ICES CM 2004/ACE:03).

Recommendations and advice

ICES recommends that there should be one EcoQO for spawning stock biomass of commercial fish species, based on the criterion that 100% percent of the stocks are estimated to be above precautionary reference points for spawning biomass and below precautionary reference points for fishing mortality. There would not be an EcoQO for every assessed stock.

The existing management approaches for individual stocks are all based on an assumption that the objective of management is to maintain or move spawning stock biomass (SSB) above the biomass conservation limit with high probability and to keep fishing mortality (F) sustainable. The EcoQO would simply condense this information into a form that gives an appropriate overview of the overall status of North Sea fish stocks. In relation to time and geographical area, a more specific EcoQO is not required. However, ICES stresses that the precautionary reference points $\mathbf{B}_{pa}$ and $\mathbf{F}_{pa}$ were initially adopted as tools to keep the risk low that the stock falls below the biomass conservation limit ($\mathbf{B}_{lim}$). ICES recommends that the wording of the EcoQO be modified to accommodate improvements to the risk management tools that ICES may use in developing advice on fisheries in the future.

ICES continues to recommend that, following ICES (2003), the wording of the EcoQO should be modified slightly and should explicitly include the proportion of stocks for which both SSB>$\mathbf{B}_{pa}$ **and** F < $\mathbf{F}_{pa}$.

The revised EcoQO would state **“For 100% of North Sea commercial fish stocks, the estimates of SSB and F should be above the precautionary spawning biomass reference point and below the precautionary fishing mortality reference point, respectively**.”

As soon as other methods for managing the risk of the stock falling below the conservation limit for biomass are adopted for North Sea stocks, the appropriate wording for the EcoQO would be:

> **“For 100% of North Sea commercial fish stocks, the estimated probability that the SSB is below the conservation limit reference point (currently identified as $\mathbf{B}_{lim}$) should be no greater than 0.05.”**

Further development of this EcoQ element (and EcoQO) could include:

a) Taking into account species interactions.

The available results from multispecies modelling studies suggest that biomass reference points are likely to be higher, and fishing mortality reference points more variable, when derived in a multispecies context. This implies that any appropriate reference points in a multispecies context will be more restrictive than the corresponding reference point based on single-species assessment alone.

b) Taking into account long-term variability in climatic forcing of stock dynamics.

There are many stocks where climatic conditions play a major role in stock productivity. In at least some cases, there is evidence that the system can shift to a new set of climatic conditions in which the previously estimated reference points no longer meet the defining conditions. However, for stocks in the North Sea, and generally for stocks in the OSPAR area, there is little reason to expect that the goal of keeping all commercially exploited stocks above their conservation limits with high probability is not attainable on biological grounds.

c) Taking into account the changes in the advisory framework for management plans used in fisheries management.

The use of precautionary reference points such as $\mathbf{B}_{pa}$ and $\mathbf{F}_{pa}$ may no longer be relevant in the context of more rule-based management plans. Approaches other than reliance on precautionary biomass reference points should be explored as ways to ensure a very low risk that the current true SSB is below the conservation limit SSB reference point. Also, consideration should be given to whether fishing mortality reference points should be maintained at all in the context of EcoQOs, if management regimes are not using this metric directly.

Technical evaluation

Table 2.1.7.1.2.1 Technical evaluation of the EcoQO for EcoQ element (a) Spawning stock biomass of commercial fish species. As this EcoQO is part of the North Sea pilot project, the EcoQO was assessed and not the EcoQ element. The science underpinning this evaluation is summarized in the supporting text.

		Comments	
1	**Issue**	1. Commercial fish species	
2	**Element**	(a) Spawning stock biomass of North Sea commercial fish species	
3	**ICES criteria**		
	Relatively easy to understand by non-scientists and those who will decide on their use	Usually	While the science and analysis underpinning this EcoQO are quite complex, the ouput is readily communicable and understood.
	Sensitive to a manageable human activity	Usually	Rates of fishing mortality are sensitive to changes in the patterns and intensity of fishing effort. Total stock biomass responds indirectly to changes in the patterns and intensity of fishing effort, but fishing mortality usually has the dominant and direct influence on spawning stock biomass.
	Relatively tightly linked in time to that activity	Usually	The rate of change in SSB following changes in F will vary for different stocks, depending on life history and environment.
	Easily and accurately measured, with a low error rate	Usually	The uncertainty in individual assessments is usually known. The status relative to a reference point is less uncertain than the assessment itself, making the aggregate EcoQO more accurate than individual estimates of SSB and F.
	Responsive primarily to a human activity with low responsiveness to other causes of change	Occasionally	Spawning biomass is primarily sensitive to changes in rates of fishing mortality, but changes in total stock biomass will also be influenced by the effects of environmental variation and change and food-web interactions.
	Measurable over a large proportion of the area to which the EcoQ metric is to apply	Usually	Exploited fish stocks assessed by ICES are widely distributed in the North Sea.
	Based on an existing body or time series of data to allow a realistic setting of objectives	Usually	Excellent time series, often covering several decades, are available.
4	**Ecological relevance/basis for the metric**	Strong. Commercially exploited stocks dominate fish community biomass.	
5	**Current and historic levels (including geographic areas)**	Presented in ICES (2003).	
6	**Reference level**	For North Sea stocks, 100% of stocks above their conservation biomass limit with high probability (i.e., > $\mathbf{B}_{pa}$).	
7	**Limit point**	Consistent with a precautionary approach, anything less than 100% of estimates of stocks above precautionary reference points for spawning biomass and below precautionary reference points for fishing mortality would be unacceptable and thus 100% would also be the limit reference point.	
8	**Time frames**	*Detection of change*	Annual changes tabulated from individual assessments.
		Management advice	Every year.
9	**Advice on EcoQO options (scenarios)**	*Scenario 1*	
		Scenario 2	
		Scenario 3	
10	**Monitoring regimes**	Routine assessments carried annually. Information readily available.	
11	**Management measures to achieve EcoQO**	Application of management rules to control exploitation by fishery.	

Conclusions

ICES continues to conclude that the biological basis for the EcoQO is sound. However, there are advantages in adopting a single aggregate EcoQO for all commercially exploited stocks, instead of using a separate EcoQO for each stock. Moreover, the exact language of the EcoQO is dependent on a specific approach to management, and will have to change as approaches to fisheries management in the North Sea evolve.

There is scope to address a number of biotic and abiotic ecosystem interactions in refinements of the tools used to express the concepts behind the EcoQO.

Further considerations

ICES notes that the present framework for providing fisheries advice is under revision as a response to plans to increase the use of formalized management plans in fisheries management in the Northeast Atlantic area. SSB-based conservation limits referring to the maintenance of the reproductive capacity of the population will still define the boundaries for management, while targets will be identified based on societal objectives within these boundaries. However, the present precautionary reference points $\mathbf{B}_{pa}$ and $\mathbf{F}_{pa}$ have been the sole risk-control measures used to trigger actions to keep SSB above the actual biomass conservation limit. $\mathbf{F}_{pa}$ and $\mathbf{B}_{pa}$ function within a specific management regime which has dominated in the Northeast Atlantic to this point. As new risk-control mechanisms are introduced within the more formalized management plans, F-based EcoQOs may no longer have relevance, and Biomass Reference Points other than $\mathbf{B}_{pa}$ may be more suitable. ICES therefore notes that SSB will remain as the basic conservation parameter and $\mathbf{B}_{lim}$ as the basic limit reference point. However, the approaches used to ensure a low risk of SSB falling below $\mathbf{B}_{lim}$ are likely to improve, and will require changes to the associated EcoQO.

ICES furthermore notes that $\mathbf{B}_{pa}$ and $\mathbf{F}_{pa}$ for the majority of stocks are both set on the basis of single-species dynamics assuming that all population dynamics parameters have constant values over time. This is clearly unrealistic and the estimates of $\mathbf{B}_{pa}$ and $\mathbf{F}_{pa}$ could be improved. While improvement of these estimates is a priority, ICES recognizes that the move towards the incorporation of climatic or multispecies information into the setting of reference points will have to be incremental. In adopting an aggregate EcoQO, it is important to consider whether it would be possible for managers with complete control of fishing activity to ensure that all stocks would be above precautionary reference points for spawning biomass and below precautionary reference points for fishing mortality with high probability. In particular, environmental variation and change will favour and disadvantage different stocks to different extents, and multispecies interactions may not allow all stocks to persist at high biomass. **It should also be investigated how to make the age structure of the spawning stocks more robust to cope with the climatic variability.**

However, with current information there is no biological reason to expect that it is impossible for all stocks to persist well above their *conservation limits* ($\mathbf{B}_{lim}$). Thus, although there is substantial scope for revision of reference points to allow for environmental effects and multispecies interactions, a limit of 100% for the aggregate EcoQO is considered appropriate.

ICES notes that it is premature to leap immediately to putting long-term climatic factors into all reference points. However, work should commence within ICES to take greater account of the effects on longer-term stock dynamics. In the short term, estimation of biological reference points needs to consider climatic forcing and work is needed to determine whether and exactly how reference points for SSB, fishing mortality, and other parameters should be estimated and used, when there is evidence of long-term, regime-scale forcing of stock dynamics. In addition, many factors affecting recruitment, growth or survivorship may show long-term directional trends. We are aware of very little work on whether and how reference points should vary with gradients in climatic conditions, or of the risks associated with failing to take account of such gradients. Given the evidence for the effects of climate change, and changes in species composition of North Sea (and other) fish communities, commencement of such work should also be a priority.

A review of the available literature on multispecies modelling implied that biomass reference points are likely to be higher, and fishing mortality reference points more variable, when derived in a multispecies context. This implies that any achievable targets in a multispecies context will be more restrictive than the corresponding target based on single-species assessment alone. Because the period for which data, as required for analytical assessments and on which present stock assessments are based, is short and generally only covers a period with high exploitation, there is not sufficient information to estimate potential targets which may be relevant in a multispecies context once stocks are rebuilding. Estimates of targets in these cases must be identified in an adaptive way on the basis of observations during the rebuilding period.

Results of a formal performance evaluation of $\mathbf{B}_{pa}$ and $\mathbf{F}_{pa}$ as guides to management action found that there was no bias in their performance on a stock-by-stock basis. Therefore, whatever the error rate for the risk-control mechanisms, an aggregate EcoQO is unlikely to be biased by pooling across stocks. Keeping all SSBs above $\mathbf{B}_{lim}$ with high probability will maintain commercially exploited stocks in conditions consistent with the intent of the EcoQO framework.

References

ICES. 2003. Report of the ICES Advisory Committee on Ecosystems, 2003. ICES Cooperative Research Report, 262: 50–62.

2.1.7.1.3 EcoQ Element (b) Presence and extent of threatened and declining species in the North Sea

Request

Request to ICES from OSPAR:

ICES has been invited to consider the potential for developing an EcoQO for this element.

Source of information

The 2003 and 2004 reports of the Working Group on Ecosystem Effects of Fishing Activities (WGECO) (ICES CM 2003/ACE:05; ICES CM 2004/ACE:03).

Recommendations and advice

The analysis highlights a number of practical problems with this EcoQ element. ICES proposes an alternative EcoQ element as a response indicator: "the proportion of all the listed species for which a recovery plan had been prepared and implemented". An appropriate EcoQO would be to achieve 100% adoption of Recovery Plans for all listed threatened species.

<u>Alternative EcoQ element</u>: The EcoQ element would be the proportion of all the listed species for which a recovery plan had been prepared and implemented. An appropriate EcoQO would be to achieve 100% adoption of recovery plans for all listed threatened species.

This EcoQ element has three advantages:

1) It does not rely on a continual updating of "the list" of threatened species, in order to avoid the exclusion of some species which may become threatened in the near future. The development of individual species Recovery Plans, which could take a number of forms depending on the availability of data, level of knowledge, etc., would be the responsibility of local or regional management bodies with involvement by relevant Contracting Parties.

2) It would place emphasis on the most important aspect of threatened and declining species, which is the mitigation of the threat, rather than assessing species rates of change.

3) It could build on existing work by, for example, the FAO Elasmobranch Action Plan, national responses to the Convention on Biological Diversity (CBD), such as the UK Biodiversity Action Plan, etc.

In response to the need for further development of this EcoQ element, the following EcoQO for this EcoQ element is proposed as one that is worth more detailed evaluation:

> **"Implementation of species Recovery Plans for all threatened and declining species."**

In the event that Recovery Plans are chosen as a management option for commercially exploited species, it will be necessary to collaborate with the appropriate fisheries managers and coordinate the presentation of the reformulated EcoQO. It will also be necessary to ensure that the framework discussed in Section 2.1.7.1.1, above, can incorporate such response indicators.

Technical evaluation

Table 2.1.7.1.3.1. *Technical evaluation of EcoQ element (b) Presence and extent of threatened and declining species in the North Sea. Since this is not part of the North Sea pilot project, the EcoQ element was assessed as no EcoQO has yet been developed. The science underpinning this evaluation is summarized in the supporting text.*

		Comments	
1	**Issue**	2. Threatened and declining species	
2	**Element**	(b) Presence and extent of threatened and declining species in the North Sea	
3	**ICES criteria**		
	Relatively easy to understand by non-scientists and those who will decide on their use	Usually	
	Sensitive to a manageable human activity	Occasionally	Depends on the cause of the decline and source of threat. If threat is by-catch, pollution, etc., it may be very sensitive. If threat is climate change, deplacement by invasive species, etc., it may not be sensitive at all.
	Relatively tightly linked in time to that activity	Occasionally	If threat is direct human-induced mortality (e.g., by-catch), can be very tightly linked. If threat is habitat degradation due to pollution, physical damage, etc., response can be much longer term. If threat is climate change, link is very long-term.
	Easily and accurately measured, with a low error rate	Occasionally	Detectability and ability to measure species trends vary from low to high. Power to detect a change in status of a rare species is very low unless there is extensive sampling.
	Responsive primarily to a human activity, with low responsiveness to other causes of change	Occasionally	Species-dependent. Depends on type of threat causing the decline (see Sensitive, above).
	Measurable over a large proportion of the area to which the EcoQ metric is to apply	Usually	See "easily and accurately measured". If the species can be measured, it can be measured over a large proportion of the area.
	Based on an existing body or time series of data to allow a realistic setting of objectives	Occasionally	Several time series of survey data exist, with additional sampling going back several decades. Identification of rare species is sometimes unreliable (Daan, 2001), and the catchability of species is highly variable.
4	**Ecological relevance/basis for the metric**	High relevance. Threatened and declining species are an important aspect of management to protect biodiversity. Presence and extent are core aspects of the status of such species.	
5	**Current and historic levels (including geographic areas)**	Information on presence and extent is highly variable, depending on the species of concern. Information on current and historic levels is certainly *not* available consistently for all species.	
6	**Reference level**	Not available for any threatened or declining species.	
7	**Limit point**	There is a large body of scientific literature on setting minimum viable population levels, but many models are untested for species with marine life histories.	
8	**Time frames**	*Detection of change*	Usually requires a number of years to detect the effectiveness of recovery plans.
		Use in advice	Specific to Recovery Plans.
9	**Advice on EcoQO options (scenarios)**	*Scenario 1*	
		Scenario 2	
		Scenario 3	
10	**Monitoring regimes**	Monitoring the status of rare and declining species requires a substantial commitment of resources. Even for species with high catchability in existing surveys, annual levels of survey effort are often inadequate to detect effects in less than a decade.	
11	**Management measures to achieve EcoQO**	Varied and possibly considerable management effort may be required to implement individual recovery plans. Often requires species-specific recovery plans. Requirements of different plans may conflict, e.g., where two threatened species are predator and prey.	

Conclusion

For clarification, threatened and declining species and habitats can be included in two ecological quality elements:

2. Threatened and declining species	(b) Presence and extent of threatened and declining species in the North Sea
8. Habitats	(s) Restore and/or maintain habitat quality

Although the summary that follows can equally well refer to both habitats and species, the objectives related to the "threatened and declining" issue strictly speaking only apply to species. There are close links between the two EcoQ elements (b) and (s).

The technical analysis highlights a number of practical problems with the EcoQ element as currently stated. In particular, some formerly abundant but vulnerable species are now too scarce to be caught during monitoring surveys. So, when conservation concern is greatest, monitoring may provide little or no information on whether species are further declining or starting to recover in response to management action. For rare and depleted species, the power to detect rapid decreases in abundance on time scales of less than ten years is poor. Moreover, even if conservation were effective and populations recovered at the maximum potential rate of increase, five to ten years of monitoring would often be required to detect recovery. Also, species-specific EcoQOs for threatened and declining species would proliferate quickly, because each species would require a separate EcoQO, and there are many candidate species, no subset of which can be considered representative of all such species. Based on this analysis, an alternative EcoQ element and associated EcoQO are recommended, as stated in the recommendations above.

Additional concerns

ICES is aware of the ongoing process in OSPAR and elsewhere to review the initial list of threatened and declining species. This process must be able to distinguish between those species that are naturally rare and those that are at low abundance as a result of the impact of human activities. It is important that managers are made aware of such species in their waters, keep up-to-date records of their status, and use the list as a basis for taking national action.

Reference

Daan, N. 2001. The IBTS database: a plea for quality control. ICES CM 2001/T:03.

2.1.7.1.4 EcoQO for EcoQ Element (c) Seal population trends in the North Sea

Request

Request to ICES from OSPAR:

ICES has been invited to consider the formulation of the EcoQO, determine whether a more specific EcoQO is needed in terms of its specification to the metrics, time and geographical area, and as necessary propose more specific EcoQO(s), taking into account the effects of the epizootic.

Source of information

The 2004 report of the Working Group on Marine Mammal Ecology (WGMME) (ICES CM 2004/ACE:02).

Recommendations and advice

ICES recommends that seal population trends are a useful EcoQ element.

Noting that the Fifth North Sea Conference agreed the following definition for an EcoQO for seal population trends in the North Sea: "*No decline in population size or pup production of ≥10% over a period of up to 10 years*", ICES recommends that separate EcoQOs be adopted for grey seals and harbour seals, based on their specific biological characteristics and taking into account the different population subunits in the North Sea. ICES suggests the following formulations:

EcoQO for the harbour seal population trend in the North Sea:

”No decline in harbour seal population size (as measured by numbers hauled out) of ≥10% as represented in a five-year running mean or point estimates (separated by up to five years) within any of eleven sub-units of the North Sea. These sub-units are: Shetland; Orkney; North and East Scotland; Southeast Scotland; Greater Wash/Scroby Sands; The Netherlands Delta area; Wadden Sea; Helgoland; Limfjord; Kattegat, Skagerrak, and Oslofjord; West coast of Norway south of 62^{o}N”.

EcoQO for the grey seal population trend in the North Sea:

”No decline in pup production of grey seals of ≥10% as represented in a five-year running mean or point estimates (separated by up to five years) within any of nine sub-units of the North Sea. These sub-units are: Orkney; Fast Castle/Isle of May; Farne Islands; Donna Nook; France; The Netherlands; Schleswig-Holstein Wadden Sea; Helgoland; Kjørholmane (Rogaland).”

Technical evaluation

Table 2.1.7.1.4.1 Technical evaluation of the reformulated EcoQOs for EcoQ element (c) Seal population trends in the North Sea. As this EcoQO is part of the North Sea pilot project, the EcoQO was assessed and not the EcoQ element. The science underpinning this evaluation is summarized in the supporting text.

		Comments	
1	**Issue**	3. Sea mammals	
2	**Element**	(c) Seal population trends in the North Sea (now recommended with separate EcoQOs for harbour seals and grey seals)	
3	**ICES criteria**		
	Relatively easy to understand by non-scientists and those who will decide on their use	Usually	
	Sensitive to a manageable human activity	Occasionally	Sensitive to intentional killing; less sensitive to exposure to chemical pollution, habitat disturbance, by-catches or overfishing.
	Relatively tightly linked in time to that activity	Usually	Linked tightly to intentional killing, but not to exposure to pollution.
	Easily and accurately measured, with a low error rate	Usually	Good standardized monitoring methodology.
	Responsive primarily to a human activity, with low responsiveness to other causes of change	Occasionally	Also sensitive to epizootic events.
	Measurable over a large proportion of the area to which the EcoQ metric is to apply	Usually	Geographical sub-units have been proposed in the suggested new formulation of the EcoQOs to obtain valid trends.
	Based on an existing body or time series of data to allow a realistic setting of objectives	Usually	Consistent methods and long time series.
4	**Ecological relevance/basis for the metric**	Seals are an important part of the North Sea ecosystem.	
5	**Current and historic levels (including geographic areas)**	Current and historic levels collected at a fine spatial scale through regular monitoring at specific sites.	
6	**Reference level**	Largely unknown.	
7	**Limit point**	Unknown.	
8	**Time frames**	*Detection of change*	The maximum survey interval is once every five years, but many surveys are annual. Power to detect change varies with species and area.
		Use in advice	Minimum is annual, but changes in advice depend on the power to detect change.
9	**Advice on EcoQO options (scenarios)**	*Scenario 1*	
		Scenario 2	
		Scenario 3	
10	**Monitoring regimes**	Well-developed on an area basis. See ICES (2003).	
11	**Management measures to achieve EcoQO**	Management measures to avoid population decrease caused by directed killing (both licensed and unlicensed) are straightforward and would be timely. For other changes, the initiation of a research programme would be necessary.	

Scientific background

Grey seals give birth in terrestrial habitats and are best counted as numbers of pups produced per year, while harbour seals give birth in intertidal habitats and are best counted as one-year-old or older seals during the period that they haul-out terrestrially to moult.

This EcoQO would be triggered rather often due to the interannual variations in numbers of seals (both pups counted or numbers on haul-outs). The probable level of "alarms" is felt to be too high, and thus a five-year running mean might be applied to these figures. Such an approach would detect long-term changes in pup production of grey seals or haul-out numbers of harbour seals. The disadvantage of this is that mortality events, such as caused by epizootics, would not trigger the EcoQO. ICES felt that this was not a major disadvantage as large mortality events are already investigated in depth, whereas more subtle long-term changes might be easily overlooked.

The EcoQO as stated in the Bergen Declaration does not differentiate between sub-units of the North Sea and it is unclear whether the EcoQO applies to the whole North Sea population or only to parts of it. It is not scientifically possible or valid to assess trends for the whole North Sea as there is a variation in counting methods depending mostly upon the habitat in which the seals are giving birth or hauling out. Scientifically consistent trends can be derived for sub-units of the North Sea, but it should be noted that these sub-units are not necessarily biologically separate.

Reference

ICES. 2003. Report of the ICES Advisory Committee on Ecosystems, 2003. ICES Cooperative Research Report, 262: 62–68.

2.1.7.1.5 EcoQ Element (d) Utilisation of seal breeding sites in the North Sea

Request

Request to ICES from OSPAR:

ICES will be invited to consider the formulation of the EcoQO, determine whether a more specific EcoQO is needed in terms of its specification to the metric, time and geographical area, and as necessary propose (a) more specific EcoQO(s).

Source of information

The 2004 report of the Working Group on Marine Mammal Ecology (WGMME) (ICES CM 2004/ACE:02).

Recommendations and advice

ICES recommends that the use of seal breeding sites in the North Sea is a useful EcoQ element, but that further development is required. Further development of this EcoQ element could include:

a) better identification of breeding sites in Shetland and France;

b) development of techniques to distinguish separate harbour seal breeding sites.

If an EcoQO is to be defined for this EcoQ element, ICES suggests that only grey seals should be considered at present and therefore suggests the following wording:

> **"There should be no decline in the number of grey seal breeding sites in Orkney, on the east coast of the UK, or the coasts of The Netherlands, Germany, and Norway."**

Technical evaluation

Table 2.1.7.1.5.1 Technical evaluation of the reformulated EcoQ element (d) Utilisation of seal breeding sites in the North Sea. Since this is not part of the North Sea pilot project, the EcoQ element was assessed, as no EcoQO has yet been developed. The science underpinning this evaluation is summarized in the supporting text.

		Comments	
1	**Issue**	3. Sea mammals	
2	**Element**	(d) Utilisation of seal breeding sites in the North Sea	
3	**ICES criteria**		
	Relatively easy to understand by non-scientists and those who will decide on their use	Usually	
	Sensitive to a manageable human activity	Occasionally	Partly to human disturbance.
	Relatively tightly linked in time to that activity	Occasionally	
	Easily and accurately measured, with a low error rate	Usually	Techniques and surveys already exist (ICES, 2003).
	Responsive primarily to a human activity, with low responsiveness to other causes of change	Rarely?	In individual cases, will be responsive, but not always.
	Measurable over a large proportion of the area to which the EcoQ metric is to apply	Usually	
	Based on an existing body or time series of data to allow a realistic setting of objectives	Usually	Reviewed by ICES WGMME and predecessors in the past.
4	**Ecological relevance/basis for the metric**	Seals are an important component of the North Sea ecosystem. Distributional range is important, alongside population size. The public may be concerned if breeding sites disappear.	
5	**Current and historic levels (including geographic areas)**	Grey seals are known to breed in the following sites in the North Sea: Orkney, Fast Castle/Isle of May, Farne Islands, Donna Nook, northwestern France, The Netherlands, Schleswig-Holstein Wadden Sea, Helgoland, Kjørholmane (Rogaland).	
6	**Reference level**	The nine sites listed above.	
7	**Limit point**	Loss of one of the above breeding sites.	
8	**Time frames**	*Detection of change*	Grey seals are surveyed in most areas of the North Sea on at least a five-year interval. Loss in any one survey would be detectable.
		Use in advice	Every five years at a minimum—biennial or triennial would be possible.
9	**Advice on EcoQO options (scenarios)**	*Scenario 1*	
		Scenario 2	
		Scenario 3	
10	**Monitoring regimes**	In most North Sea countries, monitoring capable of detecting loss of breeding site is already being carried out. Methods and survey programmes are described in a number of WGMME reports (see also, e.g., ICES, 2003).	
11	**Management measures to achieve EcoQO**	Reduction in disturbance, or maintenance of low disturbance. Many sites are already in areas protected for nature conservation purposes.	

Scientific background

No Ecological Quality Objective has been set for this EcoQ element and, as with the seal population trends (Section 2.1.7.1.4, above), the biology of the two seal species makes it sensible to separate the species. The key difference between the species for this EcoQ element is that harbour seals give birth in intertidal habitats, with the precise location apparently being influenced by both tidal and meteorological factors, while grey seals generally give birth in terrestrial habitats. The fluidity of precise breeding locations for many parts of the harbour seal population means that any definition of "site" would need to be drawn rather widely—at present there appears to be insufficient information to show how wide. In contrast, grey seal breeding sites are reasonably well-known and in the UK data exist for location usage over a number of years (OSPAR, 2004). For example, there are 24 locations where grey seals are known to have bred within Orkney (a site). Of these, breeding has ceased at only two since 1960, while breeding has started at several other locations, roughly in parallel to the growing size of the population. There are several well-known grey seal breeding sites further south and east in the North Sea on coasts of the UK, The Netherlands, Germany, and Norway, but the locations used for breeding by the Shetland and French populations are less well-known.

References

ICES. 2003. Report of the ICES Advisory Committee on Ecosystems, 2003. ICES Cooperative Research Report, 262: 23–26, 62–68.

OSPAR. 2004. Progress in the development of EcoQ elements and objectives for seals. OSPAR Biodiversity Committee, Bruges, Belgium, 16–20 February 2004, Document BDC 04/02/08. 12 pp.

2.1.7.1.6 EcoQO for EcoQ Element (e) By-catch of harbour porpoises

Request

Request to ICES from OSPAR:

ICES will be invited to reconsider the formulation of the EcoQO, determine whether a more specific EcoQO is needed in terms of its specification to the metric, time and geographical area, and as necessary propose (a) more specific EcoQO(s).

Source of information

The 2004 report of the Working Group on Marine Mammal Ecology (WGMME) (ICES CM 2004/ACE:02).

Recommendations and advice

ICES recommends that the by-catch of harbour porpoises is a very useful EcoQ element. Further development of this EcoQ element could include:

a) better definition of a by-catch reference point as relative to population dynamics vital rates;

b) development of genetic and geographical population structure references;

c) monitoring of by-catch covering the entire North Sea area.

ICES suggests that the EcoQO should be specified in relation to population sub-structure and could then be formulated as:

> **"Annual by-catch levels should be reduced to levels below 1.7% of the best abundance estimate in the North Sea, taking account of the best information on any population sub-structure."**

Technical evaluation

Table 2.1.7.1.6.1 Technical evaluation of the EcoQO for EcoQ element (e) By-catch of harbour porpoises. As this EcoQO is part of the North Sea pilot project, the EcoQO was assessed and not the EcoQ element. The science underpinning this evaluation is summarized in the supporting text.

		Comments	
1	**Issue**	3. Sea mammals	
2	**Element**	(e) By-catch of harbour porpoises	
3	**ICES criteria**		
	Relatively easy to understand by non-scientists and those who will decide on their use	Usually	
	Sensitive to a manageable human activity	Usually	
	Relatively tightly linked in time to that activity	Usually	
	Easily and accurately measured, with a low error rate	Rarely	Variance of by-catch is estimated by Vinther and Larsen (2004). CV for one abundance estimate: 14%. Risk of bias due to long intervals between assessments of population abundance.
	Responsive primarily to a human activity, with low responsiveness to other causes of change	Usually	
	Measurable over a large proportion of the area to which the EcoQ metric is to apply	Usually	Measurable, but not measured everywhere in the North Sea at present.
	Based on an existing body or time series of data to allow a realistic setting of objectives	Rarely	EcoQO is based on a single population dynamics simulation modelling, with limited use of North Sea-specific vital rates (IWC, 2000).
4	**Ecological relevance/basis for the metric**	By-catch in fisheries is the major identified source of human impact on mortality for the North Sea harbour porpoise population.	
5	**Current and historic levels (including geographic areas)**	No information on historic levels is available. Geographic borders for sub-populations are uncertain; a boundary is drawn across the northern North Sea from about Kinnairds Head (north of Aberdeen) to the Norwegian coast just north of Stavanger.	
6	**Reference level**	0% (the pre-fisheries level).	
7	**Limit point**	No limit given; 1.7% of estimated abundance is a provisional precautionary point.	
8	**Time frames**	*Detection of change*	Change in by-catch is detectable within a year.
		Use in advice	Annual.
9	**Advice on EcoQO options (scenarios)**	*Scenario 1*	Scenarios are not needed. EcoQO is specified.
		Scenario 2	
		Scenario 3	
10	**Monitoring regimes**	Abundance estimation (see Hammond *et al*., 2002); there are proposals for a 2005 abundance survey. Monitoring of by-catch in all national fisheries by season and area; techniques are described by WGMME. Description of sub-population structure (genetics and biomarkers) (see, e.g., Andersen *et al*. (2001), as well as Tolley and Heldal (2002)). Stage-structured population dynamic modelling (mature, non-mature), with feedback from population level and population structure in by-catches (discussed in IWC, 2000).	
11	**Management measures to achieve EcoQO**	If reduction in by-catch is required, it may presently be achieved by a number of measures: i) overall effort reduction, ii) use of pingers in fixed gears, iii) gear modifications of fixed gears, iv) gear modifications of pelagic trawls, and v) other mitigation measures (see ICES, 2002). Measures should apply to all North Sea areas.	

Summary

Three pieces of information are necessary for specification of the metric for the EcoQO on by-catch of North Sea harbour porpoises: (1) an estimate of by-catch, (2) an abundance estimate of harbour porpoises, and (3) information on population sub-structure in the North Sea. ICES concludes that the weakest aspect of this EcoQO is the comparatively sparse information about the genetic or geographical North Sea population sub-structure of harbour porpoises. The underlying model requires further validation.

Scientific background

It was considered that the science underpinning this EcoQO was relatively well developed at the time that it was first specified.

ICES notes that the metric to which the EcoQO is related requires three pieces of information to specify the EcoQO: (1) an estimate of by-catch, (2) an abundance estimate of harbour porpoises, and (3) information on population sub-structure in the North Sea. Further, estimates of variances are needed for each component to judge the probability of whether the EcoQO is met.

By-catch: By-catch rates are available from observer programmes in fisheries and from reported strandings. The most recently published information indicates a decline in by-catch in Danish and UK fisheries due to reduced fishing effort during the past ten years (ICES, 2002, 2003; Vinther and Larsen, 2004). However, total fishery by-catch cannot be evaluated because other fisheries (in particular Norwegian and French fisheries) are not yet monitored for by-catch. The European Commission has issued a fishery regulation that reinforces the requirement for monitoring by-catch.

Abundance: *There is only one complete estimate of harbour porpoise abundance in the North Sea, from 1994 under the SCANS I project. The North Sea harbour porpoise population was estimated at 300,000, with a CV ≈ 0.14. A new estimate under the SCANS II survey is planned for 2005. ICES (2003) noted that reconstructing the historical population development of the harbour porpoise in the North Sea was not possible due to lack of a time series of data.*

Population sub-structure: The population structure of the harbour porpoise in the North Sea is not well known; however, there is likely to be some geographical structuring (Tolley *et al*., 1999; Tolley and Heldal, 2002). Genetic studies indicate differences between porpoises in the northwestern North Sea and those in the southern North Sea, and between them and porpoises on the Celtic Shelf. There is likely to be further subdivision of the population in the waters surrounding Jutland (ICES, 2003), however the precise boundaries of this sub-structuring are not known (Andersen *et al*., 2001). A relatively arbitrary boundary has been drawn across the northern North Sea from about Kinnairds Head (north of Aberdeen) to the Norwegian coast just north of Stavanger, which is not contradicted by the most recent review (Andersen, 2003).

Both for assessing ecological status and for a more accurate calculation of the EcoQ metric, ICES therefore points to the importance of improving the definition of the North Sea harbour porpoise population substructure.

EcoQO: Based on a population dynamics model, the IWC-ASCOBANS Working Group on Harbour Porpoises recommended that the maximum annual by-catch must be less than 1.7% (IWC, 2000) to ensure a high probability of meeting the ASCOBANS interim objective. It also recommended simulations to explore the assumptions and sensitivity of the base model for potential modifications to improve it (IWC, 2000). ICES notes that the EcoQO (annual by-catch below 1.7% of the population), as expressed in the Bergen Declaration, was developed before 2001 based on a simplistic population dynamics model with very limited data on vital statistics of harbour porpoises from the North Sea. Further, ICES notes that scenario testing of the implications of harbour porpoise by-catch is possible; however, any action should await realistic population dynamics model parameters for North Sea harbour porpoises. Data on some basic population dynamics parameters may be derived from stranded or by-caught individuals. However, validation of model results requires regular assessments of the population level, but there is only one ten-year-old population estimate (based on the SCANS I survey). SCANS I cannot, therefore, serve the purpose of testing the underlying hypotheses of the harbour porpoise population dynamics. ICES has not been able to identify any possible progress in the simulation modelling of the North Sea harbour porpoise population dynamics; however, a revisiting of current models is planned for the SCANS II exercise.

References

Andersen, L.W. 2003. Harbour porpoises (*Phocoena phocoena*) in the North Atlantic: distribution and genetic population structure. *In* Harbour porpoises in the North Atlantic, pp. 11–29. Ed. by T. Haug, G. Desportes, G.A. Víkingsson, and L. Witting. NAMMCO Scientific Publications, Vol. 5. Tromsø, Norway.

Andersen, L.W., Ruzzante, D.E., Walton, M., Berggren, P., Bjørge, A., and Lockyer, C. 2001. Conservation genetics of harbour porpoises, *Phocoena phocoena*, in eastern and central North Atlantic. Conservation Genetics, 2: 309–324.

Hammond, P.S., Berggren, P., Benke, H., Borchers, D.L., Collet, A., Heide-Jørgensen, M.P., Heimlich, S., Hiby, A.R., Leopold, M.F., and Øien, N. 2002. Abundance of the harbour porpoise and other cetaceans in the North Sea and adjacent waters. Journal of Applied Ecology, 39: 361–376.

ICES. 2002. Report of the ICES Advisory Committee on Ecosystems, 2002. ICES Cooperative Research Report, 254: 2–17.

ICES. 2003. Report of the ICES Advisory Committee on Ecosystems, 2003. ICES Cooperative Research Report, 262: 68–72.

IWC. 2000. Report of the IWC-ASCOBANS Working Group on Harbour Porpoises. Journal of Cetacean Research and Management, 2 (Suppl.).

Tolley, K.A., and Heldal, H.E. 2002. Inferring ecological separation from regional differences in radioactive caesium in harbour porpoises *Phocoena phocoena*. Marine Ecology Progress Series, 228: 301–309.

Tolley, K.A., Rosel, P.E., Walton, M., Bjørge, A., and Øien, N. 1999. Genetic population structure of harbour porpoise (*Phocoena phocoena*) in the North Sea and Norwegian waters. Journal of Cetacean Research and Management, 1(3): 265–274.

Vinther, M., and Larsen, F. 2004. Updated estimates of harbour porpoise (*Phocoena phocoena*) bycatch in the Danish North Sea bottom-set gillnet fishery. Journal of Cetacean Research and Management, 6(1): 19–24.

2.1.7.1.7 EcoQO for EcoQ Element (f) Proportion of oiled common guillemots among those found dead or dying on beaches

Request

Request to ICES from OSPAR:

ICES will be invited to reconsider the formulation of the EcoQO, determine whether a more specific EcoQO is needed in terms of its specification to the metric, time and geographical area, and as necessary propose (a) more specific EcoQO(s).

Source of information

The 2004 report of the Working Group on Seabird Ecology (WGSE) (ICES CM 2004/C:05).

Recommendations and advice

ICES recommends that this is a useful EcoQ element, and advises the continuation of the beached bird surveys for monitoring oil pollution. In order to save costs, monitoring for EcoQ element (i) Plastic particles in stomachs of seabirds, can be conducted alongside this monitoring.

ICES advises the reformulation of the EcoQO as:

> **"The average proportion of oiled common guillemots should be 10% or less of the total found dead or dying in each of fifteen areas of the North Sea over a period of at least five years. Sampling should occur in all winter months (November to April) of each year."**

Technical evaluation

Table 2.1.7.1.7.1. Technical evaluation of the EcoQO for EcoQ element (f) Proportion of oiled common guillemots among those found dead or dying on beaches. As this EcoQO is part of the North Sea pilot project, the EcoQO was assessed and not the EcoQ element. The science underpinning this evaluation is summarized in the supporting text.

		Comments	
1	**Issue**	4. Seabirds	
2	**Element**	(f) Proportion of oiled common guillemots among those found dead or dying on beaches	
3	**ICES criteria**		
	Relatively easy to understand by non-scientists and those who will decide on their use	Usually	Pollution of the sea with oil should be avoided. It can often be indirectly observed through beach-washed oiled seabirds.
	Sensitive to a manageable human activity	Usually	A reduction of oil pollution at sea should lead to a reduction in the proportion of oiled birds.
	Relatively tightly linked in time to that activity	Usually	A reduction of oil pollution would usually have immediate effects on the proportion of oiled birds.
	Easily and accurately measured, with a low error rate	Usually	Meteorological conditions, and other factors such as numbers of seabirds dying of other causes, can confound the picture in the short term.
	Responsive primarily to a human activity, with low responsiveness to other causes of change	Usually	Natural seeps of oil are very rare in the North Sea, and are negligible in relation to anthropogenic inputs.
	Measurable over a large proportion of the area to which the EcoQ metric is to apply	Usually	Differences exist on an area basis.
	Based on an existing body or time series of data to allow a realistic setting of objectives	Usually	The length of time series differs with section of North Sea coast.
4	**Ecological relevance/basis for the metric**	The common guillemot occurs in most parts of the North Sea during winter months; it is an abundant species which is very vulnerable to oil pollution.	
5	**Current and historic levels (including geographic areas)**	Time series exist for some decades for some parts of the North Sea. Current levels are different according to the area.	
6	**Reference level**	A reference level would be close to zero.	
7	**Limit point**	Unknown, not relevant.	
8	**Time frames**	*Detection of change*	Conclusions on trends and on reaching the EcoQO can only be made on a medium-term level (years).
		Use in advice	The EcoQ level and trends should be judged over a time frame of five years.
9	**Advice on EcoQO options (scenarios)**	See Bergen Declaration, Fifth North Sea Conference.	
10	**Monitoring regimes**	Monitoring of beached birds has been in place for many decades in some areas around the North Sea. Large differences in oiling rates exist between different areas in the North Sea. A low sampling rate carries the risk of a bias of the result, and a high variance around the mean oiling rate. A "grand total" percentage of oiled birds is not useful, given differences in oiling rates and sample sizes in different areas. Monitoring for EcoQ element (i) Plastic particles in stomachs of seabirds, could be conducted alongside this one.	
11	**Management measures to achieve EcoQO**	Many general measures are in place. This EcoQO could indicate whether additional measures are required.	

Discussion

OSPAR (2004) describes progress with this EcoQO in the North Sea pilot project. The provision of a manual for volunteers to use when collecting information on the proportion of oiled birds has ensured standardization of information collection. An international data collation system is in place.

Two aspects not explicitly addressed in the wording of the EcoQO (but included in previous background advice) relate to regional divisions in the North Sea and the frequency of surveys. A “grand total” percentage of oiled birds would not be appropriate as this may be biased by disproportionately sized samples in some areas. In addition, knowledge of the areas of high (or low) proportions of oiled birds may help to better target any management or mitigation measures. Based on historical precedent, and therefore practicality, ICES (2003) and Camphuysen (2003, in OSPAR 2004) suggested a set of coastal sections of the North Sea. A description of the fifteen sections (after Camphuysen (2003), in OSPAR, 2004) is given in Table 2.1.7.1.7.2. Equally, previous advice has suggested that monthly samples be taken in each section for the winter months between November and April in each year. Any lower sampling rates carry the risk that external factors could severely bias the result and that variance around the mean oiling rate would be higher than ideal.

ICES (2003) advised that a period of at least five years in which an average of 10% or less oiled common guillemots has been recorded, should occur before the conclusion that the EcoQO has been reached could be justified statistically.

Table 2.1.7.1.7.2 Suggested coastal sections for recording and reporting of proportions of oiled common guillemots (after Camphuysen (2003), in OSPAR, 2004).

	Section	Boundaries	Country
1	Shetland		UK
2	Orkney	Orkney and north coast of Scotland	UK
3	East Scotland	Duncansby Head to Berwick on Tweed	UK
4	Northeast England	Berwick on Tweed to Spurn Head	UK
5	East England	Spurn Head to North Foreland	UK
6	Eastern Channel	Line between North Foreland and Belgian/French border to line from Cherbourg to Portland	UK, F
7	Western Channel	Line between Cherbourg and Portland to line from Lizard to Ouessant	UK, F
8	Eastern Southern Bight	Belgian/French border to Texel	B, NL
9	Southern German Bight	North Sea coast Frisian Islands Texel to Elbe	NL, FRG
10	Western Wadden Sea	Mainland and Wadden Sea coast Frisian Islands Texel to Elbe	NL, FRG
11	Eastern Wadden Sea	Mainland coast and Wadden Sea coast Elbe to Esbjerg	FRG, DK
12	Eastern German Bight	North Sea coast Wadden Sea Islands Elbe to Fanø	FRG, DK
13	Danish west coast	Mainland coast Esbjerg to Hanstholm	DK
14	Skagerrak/Oslofjord	East of line between Hanstholm to Kristiansand, north of a line from Skagen to Gothenburg	N, DK, S
15	Southwest Norway	Kristiansand to Stadt	N

References

Camphuysen, C.J. 2003. North Sea pilot project on Ecological Quality Objectives, Issue 4. Seabirds, EcoQO element F: Proportion of oiled Common Guillemots among those found dead or dying on beaches. Oiled-Guillemot EcoQO. Report to Biodiversity Committee (BDC) 2004. Commissioned by the North Sea Directorate, Ministry of Transport, Public Works and Water Management, The Netherlands. CSR Report 2004–011.

ICES. 2003. Report of the ICES Advisory Committee on Ecosystems, 2003. ICES Cooperative Research Report, 262: 72–80.

OSPAR. 2004. Proportion of oiled guillemots amongst those found dead or dying on beaches (North Sea Pilot Project on Ecological Quality Objectives). OSPAR Biodiversity Committee, Bruges 16–20 February 2004, Document BDC 04/02/10.

2.1.7.1.8 EcoQ Element (g) Mercury concentrations in seabird eggs and feathers

Request

Request to ICES from OSPAR:

ICES will be invited to consider the formulation of the EcoQO, determine whether a more specific EcoQO is needed in terms of its specification to the metric, time and geographical area, and as necessary propose (a) more specific EcoQO(s).

Source of information

The 2004 report of the Working Group on Seabird Ecology (WGSE) (ICES CM 2004/C:05).

The 2004 report of the Marine Chemistry Working Group (MCWG) (ICES CM 2004/E:03).

Recommendations and advice

ICES recommends that this is a useful EcoQ element, but advises a modification to use only the eggs of seabirds, preferably of common terns and oystercatchers, for this EcoQ element; although the use of seabird feathers was also originally agreed in the Bergen Declaration, they should not be used for this EcoQ element.

ICES recommends that this EcoQ element be renamed as: “Mercury concentrations in seabird eggs.”

ICES advises that sampling should be annual, with a sample size of ten eggs (one per nest) per site and species.

ICES advises that the EcoQO should be to reduce mercury levels to the lowest recorded in current monitoring schemes. Costs and time could be saved by combining the sampling with the sampling for the EcoQO on organochlorine concentrations in seabird eggs, and possibly other monitoring programmes, such as those for monitoring other organohalogen levels.

ICES advises that the EcoQO should be formulated as:

> “The average concentrations of mercury in the fresh mass of ten eggs from separate clutches of common tern and Eurasian oystercatcher breeding adjacent to the estuaries of the Rivers Elbe, Weser, Ems, Rhine/Scheldt, Thames, Humber, Tees, and Forth, should not significantly exceed concentrations in the fresh mass of ten eggs from separate clutches of the same species breeding in similar (but not industrial) habitats in southwestern Norway and in the Moray Firth.”

Technical evaluation

Table 2.1.7.1.8.1 Technical evaluation of the EcoQ element (g) Mercury concentrations in seabird eggs [and feathers]. Since this is not part of the North Sea pilot project, the EcoQ element was assessed as no EcoQO has yet been agreed. The science underpinning this evaluation is summarized in the supporting text.

			Comments
1	**Issue**	4. Seabirds	
2	**Element**	(g) Mercury concentrations in seabird eggs [and feathers]	
3	**ICES criteria**		
	Relatively easy to understand by non-scientists and those who will decide on their use	Usually	There is a clear link between the anthropogenic input of mercury into the environment and the concentration of mercury in bird eggs.
	Sensitive to a manageable human activity	Usually	Mercury in the environment is predominantly anthropogenic.
	Relatively tightly linked in time to that activity	Rarely	Mercury in the environment is very persistent, and tends to increase up food chains. Because of this persistence, a time lag would exist between applying management measures and the response in seabird eggs (and feathers).
	Easily and accurately measured, with a low error rate	Usually	Eggs are readily available and the analytical methods are well established.
	Responsive primarily to a human activity, with low responsiveness to other causes of change	Occasionally	Mercury concentrations in birds' feathers reflect dietary intake, but this is complicated by a pattern of storage of mercury in soft tissues between moults and excretion of most of the mercury into growing feathers during the moult.
	Measurable over a large proportion of the area to which the EcoQ metric is to apply	Usually	Some seabirds are common and widely distributed.
	Based on an existing body or time series of data to allow a realistic setting of objectives	Occasionally	Recent research indicates that, for establishing historic levels of trace metals, bird feathers from mounted specimens in museum collections are of limited use (Hogstad *et al*., 2003). For mercury in eggs, no historical reference material exists.
4	**Ecological relevance/basis for the metric**	Mercury is a toxic metal that is predominantly introduced into the environment through human activities. Concentrations increase up food chains.	
5	**Current and historic levels (including geographic areas)**	Levels of mercury in the eggs of several species of seabirds have been monitored for some decades. Current levels vary between areas and species.	
6	**Reference level**	Given recent evidence concerning the limited use of bird feathers from mounted specimens in museum collections for establishing reference levels (Hogstad *et al*., 2003), a reference level in bird feathers is difficult to establish. A reference level for bird eggs is not possible to establish given the lack of reference material.	
7	**Limit point**	Unknown	
8	**Time frames**	*Detection of change*	The persistence of mercury in the environment means that there is a time lag between taking action to reduce inputs and the response in seabird eggs and feathers.
		Use in advice	Reporting annually would be of little use. A two- to five-year reporting cycle would be useful.
9	**Advice on EcoQO options**	The mercury concentrations in seabird eggs in any area of the North Sea should not significantly exceed the level recorded in seabird eggs from non-industrial reference areas in the North Sea.	
10	**Monitoring regimes**	A standardization of monitoring is required; monitoring should be implemented in different selected areas, and reference areas should be chosen. The monitoring rate should be annual.	
11	**Management measures to achieve EcoQO**	Management measures to reduce the input of mercury into the environment are in place. Monitoring mercury for this EcoQO could help in establishing whether the existing measures are successful, or additional measures would be required.	

Scientific background

Mercury in the environment is predominantly anthropogenic. Mercury is toxic, very persistent, and tends to accumulate up the food chain. Some measures to reduce the input of mercury are in place. In previous years, ICES recommended that mercury concentrations in bird feathers should be used as a metric for mercury levels in the environment. However, a publication on the effect of the common method to conserve birds for museum collections (washing with detergent and treatment with Eulan U-33) has indicated that, depending on the bird species and feather type, trace metals were at least partly lost during the treatment (Hogstad *et al*., 2003). Therefore, the use of bird skins to obtain historical trace metal data is limited. For mercury in eggs, a reference level is not possible to establish, given the lack of reference material (ICES, 2003).

Mercury concentrations in birds' eggs provide a very reliable measure of trends over years in local contamination, and are very suitable for comparisons between areas and over periods of years. The highest mercury concentrations were found in birds from the Baltic Sea area, whilst the lowest mercury concentrations were found in the Dollard estuary area, the Belt Sea, and Greenland.

For monitoring purposes, it is necessary that a limited selection of species is made. Useful species are the common tern (*Sterna hirundo*) and Eurasian oystercatcher (*Haematopus ostralegus*). They are two common and widely distributed species, characterized by different foraging strategies and food chains.

In order to cover hot spots of mercury emissions and especially of riverine inputs (e.g., Becker *et al*., 2001), sampling sites should be chosen near estuaries, important cities or industrial areas. Useful sampling sites are sites near the estuaries of the Rivers Elbe, Weser, Ems, Rhine/Scheldt, Thames, Humber, Tees, and Forth. In parallel, the northern parts of the North Sea should be covered as reference areas where lower mercury levels are to be expected compared to the estuaries listed above. Useful sampling sites would be (non-industrial) habitats in southwestern Norway and the Moray Firth.

Given the fact that for mercury in eggs no historical reference level can be established, the EcoQO could be to reduce levels to the lowest recorded in current monitoring schemes (oystercatcher: 0.1 mg kg^{-1} fresh weight; common tern 0.2 mg kg^{-1} fresh weight (Becker *et al*., 2001)). Costs and time could be saved by combining sampling with that for the EcoQO on organochlorine concentrations in seabird eggs, and perhaps other monitoring programmes, such as those for monitoring other contaminants such as organohalogens. Sampling should be annual with a sample size of ten eggs (one per nest) per site and species (OSPAR, 1997). Less frequent sampling would increase the period needed to understand whether the EcoQO has been met or not.

References

Becker, P.H., Munoz Cifuentes, J., Behrends, B., and Schmieder, K.R. 2001. Contaminants in bird eggs in the Wadden Sea. Temporal and spatial trends 1991–2000. Wadden Sea Ecosystem, No. 11. Common Wadden Sea Secretariat, Trilateral Monitoring and Assessment Group, Wilhelmshaven, Germany.

Hogstad, O., Nygård, T., Gätzschmann, P., Lierhagen, S., and Thingstad, P.G. 2003. Bird skins in museum collections: are they suitable as indicators of environmental metal load after conservation procedures? Environmental Monitoring and Assessment, 87: 47–56.

ICES. 2003. Report of the ICES Advisory Committee on Ecosystems, 2003. ICES Cooperative Research Report,. 262: 83–89.

OSPAR. 1997. JAMP guidelines for monitoring contaminants in biota. OSPAR Commission, London.

2.1.7.1.9 EcoQ Element (h) Organochlorine concentrations in seabird eggs

Request

Request to ICES from OSPAR:

ICES will be invited to consider the formulation of the EcoQO, determine whether a more specific EcoQO is needed in terms of its specification to the metric, time and geographical area, and as necessary propose (a) more specific EcoQO(s).

Source of information

The 2004 report of the Working Group on Seabird Ecology (WGSE) (ICES CM 2004/C:05).

The 2004 report of the Marine Chemistry Working Group (MCWG) (ICES CM 2004/E:03).

Review from the 2004 meeting of the Advisory Committee on the Marine Environment (ACME).

Recommendations and advice

ICES recommends that this EcoQ element be widened to include the following organohalogens, which should also be included in monitoring programmes:

1) A range of bromodiphenylether (BDE) congeners intended to cover the three major polybrominated diphenylether (PBDE) formulations which have been, or are still being, used as flame retardants in Europe (minimum of BDE47, BDE99, BDE100 (penta-mix), BDE183 (octa-mix), BDE209 (deca-mix), plus HBCD (hexabromocyclododecane), and TBBP-A (tetrabromobisphenol-A));

2) A suite of dioxins and furans (PCDDs/PCDFs).

If these are included, the name of the EcoQ element should be changed accordingly, to "Organohalogen concentrations in seabird eggs".

ICES recommends that, in order to save costs (and time), sampling be combined with sampling for the EcoQO on mercury concentrations in seabird eggs.

ICES recommends that this is a useful EcoQ element, and advises that, for monitoring purposes, two species of birds should be selected, and that methods and ways in which data are expressed should be further standardized. There should also be a further refining of the geographical specificity of monitoring by focusing on areas of high riverine input and other hot spots of organohalogen inputs. This wider standardization of species, monitoring locations, and methods would facilitate broadscale comparisons.

ICES (2003) considered the proposed EcoQO as consistent with the current scientific information on levels and trends of these substances. The EcoQO for some organohalogens could be formulated as:

"For each site, the average concentrations in fresh mass of the eggs of common tern and Eurasian oystercatcher should not exceed: 20 ng g^{-1} of PCBs; 10 ng g^{-1} of DDT and metabolites; and 2 ng g^{-1} of HCB and of HCH. Sampling should be of ten eggs of each species from separate clutches of birds breeding adjacent to the estuaries of the Rivers Elbe, Weser, Ems, Rhine/Scheldt, Thames, Humber, Tees, and Forth, and in similar (but not industrial) habitats in southwestern Norway and in the Moray Firth."

Technical evaluation

Table 2.1.7.1.9.1 Technical evaluation of the EcoQ element (g) Organochlorine concentrations in the eggs of North Sea seabirds. Since this is not part of the North Sea pilot project, the EcoQ element was assessed as no EcoQO has yet been agreed. The science underpinning this evaluation is summarized in the supporting text.

		Comments	
1	**Issue**	4. Seabirds	
2	**Element**	(h) Organochlorine concentrations in seabird eggs	
3	**ICES criteria**		
	Relatively easy to understand by non-scientists and those who will decide on their use	Usually	Most organohalogens are man-made substances; their level in birds' eggs provides an indication of their level and trends in the ecosystem.
	Sensitive to a manageable human activity	Usually	Most of these substances enter the ecosystem entirely through human activities.
	Relatively tightly linked in time to that activity	Occasionall y	Bioaccumulation and persistence in ecosystems mean that some linkage will occur, but not always.
	Easily and accurately measured, with a low error rate	Usually	A standardization of methods and ways to express the data is necessary.
	Responsive primarily to a human activity, with low responsiveness to other causes of change	Usually	Due to the persistence of many of these compounds, it will take many years before they disappear from the environment.
	Measurable over a large proportion of the area to which the EcoQ metric is to apply	Usually	Some seabirds are common and widely distributed.
	Based on an existing body or time series of data to allow a realistic setting of objectives	Usually	For most of these substances, the historic level is zero. For certain substances, time series exist (decades).
4	**Ecological relevance/basis for the metric**	Organochlorines, and organohalogens in general, are for the most part man-made, and in many cases are highly toxic substances with long half-lives. Seabird eggs offer a reliable way of measuring the levels and trends of these substances in the environment.	
5	**Current and historic levels (including geographic areas)**	Time series exist for some decades for some organochlorines for some parts of the North Sea. Monitoring for other substances has only started recently. Current levels are different in different areas of the North Sea.	
6	**Reference level**	Most reference levels would be zero, given the fact that most of these substances are exclusively man-made.	
7	**Limit point**	Unknown in most cases.	
8	**Time frames**	*Detection of change*	Given the persistence of most of these substances, firm conclusions on trends and on reaching the EcoQOs can only be made on a relatively long time frame (years).
		Use in advice	Reporting should be on a two- to five-year period.
9	**Advice on EcoQO options (scenarios)**	*Scenario 1*	The level of most of these contaminants in the environment should be zero, given the fact that they are entirely man-made. Dioxins, however, can arise from combustion, including forest fires, and so have a natural "background" level. Given the long half-lives and the continued, sometimes indirect input into the environment of some of these substances, it is not likely that EcoQOs can be reached in a short or even medium term after cessation of the input.
		Scenario 2	For each site, the average concentrations in fresh mass of the eggs of common tern and Eurasian oystercatcher should not exceed 20 ng g^{-1} of PCBs; 10 ng g^{-1} of DDT and metabolites; and 2 ng g^{-1} of HCB and of HCH. For other substances, EcoQOs (maximum levels) should be established.

		Scenario 3	There should be a downward trend in the levels of these substances in bird eggs in all areas of the North Sea. Levels should reach, or fall below the current levels in non-industrial reference areas.
10	**Monitoring regimes**	For monitoring purposes, a limited selection of bird species (non-migrating, present in a wide area) should be made, and a further standardization of methods is needed. Also, there should be a further refining of the geographical specificity of monitoring by focusing on areas of high riverine input and other hot spots of organohalogen inputs. With respect to the ongoing atmospheric inputs (especially of PCBs), reference areas where lower organohalogen levels are to be expected should be covered.	
11	**Management measures to achieve EcoQO**	A number of general measures are in place for the substances currently monitored, but additional measures for certain substances are required. This EcoQO could indicate where additional measures are required, or for which substances, and in which areas reasons for concern exist.	

Scientific background

The aim of this EcoQ element is to record any change in ecosystem contamination with organohalogens by using seabird eggs as indicators of accumulation. Organochlorines, and organohalogens in general, are (predominantly) man-made, persistent, toxic chemicals. Many organochlorines (PCBs, DDT, chlordanes) have been banned for a long time, but the strong spatial trends of concentrations in seabird eggs at the southern North Sea in recent times and local erratic increases indicate continuing inputs into the marine environment (e.g., Becker *et al.*, 2001). Remobilization of contaminants from sediments by sea currents or by dredging harbours and dumping of the spoil might be possible causes for these trends and fluctuations. Furthermore, currently unpublished data from the Wadden Sea Trilateral Monitoring and Assessment Programme (TMAP) on contaminants in bird eggs show significant increases of PCBs, DDTs, and chlordanes in the western part of the Wadden Sea from 1998 to 2003. Other compounds such as HCB or HCHs, which are in use and emitted, further demonstrate the relevance of this EcoQO and of further monitoring as an early warning system that could help authorities to take appropriate measures to protect the marine environment.

The OSPAR Biodiversity Committee (OSPAR, 2004) has commented that it would prefer to have an EcoQO that tracked organochlorines for which further management action remained to be taken, rather than an EcoQO that tracked the speed at which PCBs and DDT flushed out of the environment. However, ICES considers that knowledge of the rate at which “banned” substances leave biota is also of interest and relevance, particularly in ensuring that bans remain effective.

At the 2004 MCWG meeting, recent information on contaminants in eggs of a total of ten bird species (including gulls, terns, oystercatchers, and guillemots) from four areas (Wadden Sea, Irish coast, Baltic Sea (Sweden), and the Western Scheldt) was reviewed. Organochlorine contaminants for which data were available included PCBs, HCB, HCHs, DDTs, PCDD/Fs, chlordane, nonachlor, and toxaphene. Problems with the overall interpretation of the collated data resulted from the different ways in which the data were expressed (on the basis of fresh weight, dry weight, or lipid weight; as the sum of different suites of CB congeners, etc.). Frequently, large standard deviations were observed for specific compounds (CVs ranged from 10% to 100%). When pooling recent monitoring data (from different locations and species), very large variations are observed. A wider standardization (if possible) would facilitate broadscale comparisons.

For monitoring purposes, a limited selection of bird species (non-migrating, present in a wide area) should be chosen. Also, there should be a further refining of the geographical specificity of monitoring (and therefore of the EcoQO) by focusing on areas of high riverine input and other hot spots of organochlorine inputs. Sampling sites could be chosen adjacent to the Rivers Elbe, Weser, Ems, Rhine/Scheldt, Thames, Humber, Tees, and Forth. With respect to the ongoing atmospheric inputs (especially of PCBs), reference areas where lower organochlorine levels are to be expected should be covered. Suitable reference areas are similar (but non-industrial) habitats in southwestern Norway and the Moray Firth.

*Oystercatcher (*Haematopus ostralegus*) and common tern (*Sterna hirundo*) are common and widely distributed species which offer adequate colony sites for sampling under these requirements (see the Trilateral Monitoring and Assessment Programme (TMAP) in the Wadden Sea as an example, Becker* et al.*, 2001), but also common eider (*Somateria mollissima*), northern gannet (*Sula bassana*), and common guillemot (*Uria aalge*) could be used (ICES, 2003). Costs (and time) could be saved by combining sampling with the monitoring under the EcoQO on mercury concentrations in seabird eggs, and with other monitoring programmes such as those for other organohalogens (see below). Sampling* *should be annual with a sample size of ten eggs (one per nest) per site and species (OSPAR, 1997). Less frequent sampling would increase the period needed to understand whether the EcoQO has been met or not.*

ICES (2003) confirmed that practical EcoQOs of <20 ng total PCBs g^{-1} egg fresh mass, <10 ng DDT and metabolites g^{-1} egg fresh mass, <2 ng HCB g^{-1} egg fresh mass, and <2 ng HCH g^{-1} egg fresh mass would be consistent with current scientific information on levels and trends of these substances.

The 2004 meetings of MCWG and ACME reviewed the compounds which should be considered for inclusion within the monitoring programmes in which seabird eggs are used. As agreed by ACME, the following compounds should be considered:

1) A range of bromodiphenylether (BDE) congeners intended to cover the three major PBDE formulations which have been, or are still being, used in Europe (minimum of BDE47, BDE99, BDE100 (penta-mix), BDE183 (octa-mix), BDE209 (deca-mix), plus HBCD (hexabromocyclododecane), and TBBP-A (tetrabromobisphenol-A)). This would allow the evolution of temporal trends for all of these flame retardant products to be studied at a high trophic level. Underpinning quality assurance (QA) for these measurements is either in place, or could be put in place in the near future.

2) A suite of dioxins and furans. These should be included, particularly as it now seems that analysis of these compounds can be undertaken using GC-low resolution MS/MS, which should considerably reduce the costs of analysis.

Such additions would permit an evaluation of whether management actions taken in the recent past and possibly in the future are leading to declines in environmental concentrations. Recent work on brominated flame retardants in bird tissues and eggs has been reviewed in Law *et al*. (2003, 2004).

References

Becker, P.H., Munoz Cifuentes, J., Behrends, B., and Schmieder, K.R. 2001. Contaminants in bird eggs in the Wadden Sea. Temporal and spatial trends 1991–2000. Wadden Sea Ecosystem, No. 11. Common Wadden Sea Secretariat, Trilateral Monitoring and Assessment Group, Wilhelmshaven, Germany.

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Law, R.J., Alaee, M., Allchin, C.R., Boon, J.P., Lebeuf, M., Lepom, P., and Stern, G.A. 2003. Levels and trends of polybrominated diphenylethers (PBDEs) and other brominated flame retardants in wildlife. Environment International, 29(6): 757–770.

Law, R.J., Allchin, C.R., de Boer, J., Covaci, A., Herzke, D., Lepom, P., Morris, S., and de Wit, C. 2004. Levels and trends of brominated flame retardants in the European environment. Proceedings of BFR2004. In press.

OSPAR. 1997. JAMP guidelines for monitoring contaminants in biota. OSPAR Commission, London.

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2.1.7.1.10 EcoQ Element (i) Plastic particles in stomachs of seabirds

Request

Request to ICES from OSPAR:

ICES will be invited to consider the formulation of the EcoQO, determine whether a more specific EcoQO is needed in terms of its specification to the metric, time and geographical area, and as necessary propose (a) more specific EcoQO(s).

Source of information

The 2004 report of the Working Group on Seabird Ecology (WGSE) (ICES CM 2004/C:05).

Recommendations and advice

In 2003, ICES endorsed the conclusions of Van Franeker and Meijboom (2002, 2003) that stomach contents analysis of beach-washed northern fulmars (*Fulmarus glacialis*) offers a reliable monitoring tool for changes in the abundance of plastic litter at sea. ICES maintains this position and further advises that an EcoQO could be formulated as:

> **“There should be less than 2% of northern fulmars 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.”**

ICES recommends that the work started by the EU-funded “Save the North Sea” project be continued after its present end date in December 2004. ICES also recommends further investigations into the amount of variability in plastic loadings between years.

Technical evaluation

Table 2.1.7.1.10.1 Technical evaluation of the EcoQ element (i) Plastic particles in stomachs of seabirds. Since this is not part of the North Sea pilot project, the EcoQ element was assessed as no EcoQO has yet been agreed. The science underpinning this evaluation is summarized in the supporting text.

		Comments	
1	**Issue**	4. Seabirds	
2	**Element**	(i) Plastic particles in stomachs of seabirds	
3	**ICES criteria**		
	Relatively easy to understand by non-scientists and those who will decide on their use	Usually	
	Sensitive to a manageable human activity	Usually	
	Relatively tightly linked in time to that activity	Rarely	There would be a time delay from taking action to reduce plastic input due to the amount and persistence of plastic currently in the system.
	Easily and accurately measured, with a low error rate	Usually	
	Responsive primarily to a human activity, with low responsiveness to other causes of change	Usually	
	Measurable over a large proportion of the area to which the EcoQ metric is to apply	Usually	
	Based on an existing body or time series of data to allow a realistic setting of objectives	Usually	
4	**Ecological relevance/basis for the metric**	Plastic should not be in the ocean and can have a negative effect on a wide range of organisms. Population-level effects are not known.	
5	**Current and historic levels (including geographic areas)**	Historical level would be zero, current levels are known; patchy data in between.	
6	**Reference level**	Zero	
7	**Limit point**	Unknown	
8	**Time frames**	*Detection of change*	Not known
		Use in advice	If all plastic litter discharge ceased, the persistence of plastics would mean that it would be a few years (possibly five) for reductions to be detectable in birds.
9	**Advice on EcoQO options (scenarios)**	*Scenario 1*	No plastic particles in 50–100 fulmar stomachs.
		Scenario 2	<2% of fulmars have ten or more plastic particles in their stomachs.
		Scenario 3	
10	**Monitoring regimes**	Established and cost-effective, especially if conducted alongside oiled bird surveys.	
11	**Management measures to achieve EcoQO**	Management actions are in place, but are not enforced or are difficult to enforce. Enforcement of port waste collection and tightening of litter control from landward sources would probably be most effective.	

Scientific background

ICES (2003) endorsed the conclusions of Van Franeker and Meijboom (2002, 2003) that stomach contents analysis of beach-washed northern fulmars (*Fulmarus glacialis*) offers a reliable monitoring tool for changes in the abundance of plastic litter at sea.

Following earlier recommendations, a study running from May 2002 to December 2004 has been established as part of the EC-funded "Save the North Sea" project (EU Interreg IIIB J-No 1–16–31–7-502–02) and material is being collected in seven countries around the North Sea and in adjacent waters[18]. This project is providing further data on the suitability of this EcoQ element. This project has an international network of collaborators (temporarily) in place, and has a fully operational agreed standard methodology. If this EcoQ element is to be given an EcoQO, it would seem logical to maintain this infrastructure. ICES therefore recommends the continuation of this work after the current end of the "Save the North Sea" project in December 2004.

The northern fulmar was chosen over other seabird species due to its well-documented propensity to accumulate plastic particles in its stomach (Van Franeker, 1985; Moser and Lee, 1992). It is also an abundant species with a "guaranteed" annual supply of sufficient (some tens to hundreds) of beach-washed corpses in most North Sea countries. No other species meets both of these conditions in the North Sea ("Save the North Sea" project, unpubl. data 2002–2003). An important further advantage of the northern fulmar is the availability of a data set from the early 1980s, which enables the development of time-related trends (Van Franeker, 1985).

ICES continues to recommend that the metric should be related to the number and mass of plastic particles of each defined type ("industrial plastic particles", "user-plastic particles", and mass of "inert chemical material") in the stomachs of samples of 50 to 100 beach-washed northern fulmars. These fulmars should be collected during winter from areas of the North Sea where such sampling can be achieved as part of beached-bird surveys. ICES recommended (see Section 2.1.7.1.7) that the proportion of oiled common guillemots should be monitored in fifteen sections of the North Sea coast (see Table 2.1.7.1.7.2) and considers it logical that the same sections of coast be used to monitor plastic particle contamination.

The present level is that around 60% of northern fulmars in the southern North Sea samples have more than ten plastic particles in the stomach. In line with previous discussions, the EcoQO should be to achieve a target of as little plastic in fulmar stomachs as possible (the "natural level" of this metric should be nil). A value of less than 2% of northern fulmars having ten or more plastic particles in the stomach seems a reasonable and pragmatic choice of target.

With regard to the geographical variation in levels of marine litter, ICES notes that residence times of plastic in northern fulmar stomachs are not known, though they are likely to be at least in the order of many weeks or months. These long periods achieve an integration of plastic contamination over extended periods prior to the death of the birds collected. If northern fulmars move into the North Sea *en masse* from less contaminated areas of the North Atlantic, then the numbers of plastic items may be reduced in samples taken from North Sea beaches where plastic contamination is probably higher. Only if northern fulmars tend to remain within one area of the North Sea, will they have levels of plastic contamination representative of local pollution. A study of geographical variation in northern fulmar contamination around the North Sea is therefore only helpful in quantifying the spatial pattern of litter distribution if large influxes of "foreign" birds can be identified. The protocol currently deployed in the "Save the North Sea" project includes systematic observations of colour phase, biometrics, and age from which the geographical origin and age profile of stranded material may be evaluated. With this information, influxes and other anomalies can be identified.

Van Franeker and Meijboom (2002) also recommended that funds should be made available for analysis of the chemical composition of the inert "chemical" substances found in a proportion of the northern fulmars. ICES agrees that the "chemical material" found in many northern fulmar stomachs could usefully receive further analysis to determine its nature, likely origins, and toxic hazard. Potential technical problems with this specific aspect or any financial implications should, however, not hinder the successful implementation of this EcoQO where quantities of plastic are the important parameter to be monitored.

With regard to the oiled seabirds EcoQO, ICES recommended in 2003 (ICES, 2003) that trends might be most easily reported as five-year running mean percentages of oiled birds. In line with this, ICES (2003) advised that a period of at least five years in which an average of 10% oiled common guillemots has been recorded should occur before the conclusion that the EcoQO has been reached could be justified statistically. There are no baseline data on the plastic particles in northern fulmars, so annual variability cannot be examined yet. ICES therefore recommends further investigations into the amount of variability in plastic loadings between years. Currently and in line with the oiled

[18] see http://marine-litter.gpa.unep.org/regional/Nederland/nl_results.htm

seabirds EcoQO, ICES suggests that a period of five years, over which a value of less than 2% of northern fulmars having ten or more plastic particles in the stomach in samples of at least 50 corpses, should occur before the conclusion that the EcoQO has been reached could be justified statistically.

References

ICES. 2003 Report of the ICES Advisory Committee on Ecosystems, 2003. ICES Cooperative Research Report, 262: 72-80, 93–95.

Moser, M.L., and Lee, D.S. 1992. A fourteen-year survey of plastic ingestion by Western North Atlantic seabirds. Colonial Waterbirds, 15: 83–94.

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2.1.7.1.11 EcoQ Element (j) Local sandeel availability to black-legged Kittiwakes

Request

Request to ICES from OSPAR:

ICES will be invited to consider the formulation of the EcoQO, determine whether a more specific EcoQO is needed in terms of its specification to the metric, time and geographical area, and as necessary propose (a) more specific EcoQO(s).

Source of information

The 2004 report of the Working Group on Ecosystem Effects of Fishing Activities (WGECO) (ICES CM 2004/ACE:03).

The 2004 report of the Working Group on Seabird Ecology (WGSE) (ICES CM 2004/C:05).

Recommendations and advice

ICES recommends that the black-legged kittiwake can be used as an indicator species for the predators that depend on sandeels (*Ammodytes marinus*) as an important food resource. ICES proposes an EcoQO for this EcoQ element as follows:

> **"Black-legged kittiwake breeding success should exceed (as a three-year running mean) 0.6 chicks per nest per year in each of the following coastal segments: Shetland, north Scotland, east Scotland, and east England."**

Further, once a scientifically sound method has been developed to measure changes in sandeel availability, the relationship of the indicator, i.e., the breeding success of black-legged kittiwakes, to the abundance of sandeel should be quantified further and a test of the performance of the EcoQO as a guide to management should be carried out.

Technical evaluation

Table 2.1.7.1.11.1 Technical evaluation of EcoQ element (j) Local sandeel availability to black-legged kittiwakes. Since this is not part of the North Sea pilot project, the EcoQ element was assessed as no EcoQO has yet been developed. The science underpinning this evaluation is summarized in the supporting text.

		Comments	
1	**Issue**	4. Seabirds	
2	**Element**	(j) Local sandeel availability to black-legged Kittiwakes	
3	**ICES criteria**		
	Relatively easy to understand by non-scientists and those who will decide on their use	Usually	Number of chicks fledged as an indicator of food availability is relatively easy to understand. Linkage to the status of sandeel stocks is less obvious.
	Sensitive to a manageable human activity	Occasionally	Only sensitive when sandeels are at very low abundance in areas close to breeding colonies (ICES, 2000).
	Relatively tightly linked in time to that activity	Rarely	The effect on breeding success is reflected on a yearly basis; the indicator is only triggered after three years, and benefits of management actions will accrue only in subsequent years.
	Easily and accurately measured, with a low error rate	Usually	Protocol for monitoring chick breeding success is tested and documented.
	Responsive primarily to a human activity, with low responsiveness to other causes of change	Occasionally	Many factors affect chick breeding success. However, the requirement of a three-year average for the indicator means that the EcoQO is likely to be triggered only by persistent low abundance of sandeel in coastal areas.
	Measurable over a large proportion of the area to which the EcoQ metric is to apply	Rarely for fishery; Usually for kittiwakes	Applies in areas of Shetland, north Scotland, east Scotland, east England. These are the main kittiwake breeding areas but they only partly overlap with the areas of sandeel fisheries (ICES, 2000).
	Based on an existing body or time series of data to allow a realistic setting of objectives	Usually	See 2004 WGSE report.
4	**Ecological relevance/basis for the metric**	High relevance. Black-legged kittiwakes in the above-mentioned areas are considered to feed primarily on sandeels. If kittiwakes are unable to breed successfully for a series of years, it is likely that sandeel abundance is low, which in turn is likely to have adverse effects on many animal species that prey on sandeels.	
5	**Current and historic levels (including geographic areas)**	See 2004 WGSE report.	
6	**Reference level**	Estimated from long-term monitoring to be above 0.6 chicks per nest, measured as a running mean over a three-year period.	
7	**Limit point**		
8	**Time frames**	*Detection of change*	Minimum of three years.
		Use in advice	Quantify chick production annually. Each year that production is low, examine information on possible causes.
9	**Advice on EcoQO options (scenarios)**	*Scenario 1*	Scenarios are not needed. EcoQO is specified.
		Scenario 2	
		Scenario 3	
10	**Monitoring regimes**	The number of chicks in nests can easily be monitored. Standard protocols are well established and widely used (Walsh *et al.*, 1995; Mavor *et al.*, 2002).	
11	**Management measures to achieve EcoQO**	Review information on causes of breeding failure of kittiwakes, and trigger research action as appropriate. Consider excluding the sandeel fishery from coastal areas used heavily for seabird foraging.	

Scientific background

This EcoQ element uses the black-legged kittiwake (*Rissa tridactyla*) as an indicator species for the community of predator species that depends on sandeels (*Ammodytes marinus*) as an important food resource. The EcoQ element assumes that if black-legged kittiwakes are unable to breed successfully for several years in succession, then it is likely that sandeel abundance is low, representing a serious risk of adverse effects on many animal species. This use of black-legged kittiwakes as a sentinel assumes that a) the breeding success of black-legged kittiwakes can easily be monitored with a high level of accuracy, and b) black-legged kittiwake breeding success is low when sandeel availability is low within 50 km of the breeding sites. These prerequisites have been evaluated by ICES, based on standard criteria for the requirements for a useful EcoQO.

Based on a number of considerations and the results of our analyses, ICES proposes that this EcoQO should be formulated as "black-legged kittiwake breeding success should exceed (as a three-year running mean) 0.6 chicks per nest per year in each of the following coastal segments: Shetland, north Scotland, east Scotland, and east England".

Conclusions

The proposed EcoQO is considered to be generally sound as a strategy to protect seabirds in part of the North Sea coastal areas from consistent local depletion of sandeels by industrial fishing, and from competition with fisheries in times when food supply is low for three consecutive years or longer. However, it provides no protection against short-term and local unavailability of sandeels, whatever the cause, and provides no information about the ecosystem effects of the fishery in much of the North Sea. Short-term depletions of food supply are not considered to pose a threat of serious or irreversible harm to kittiwake populations unless the depletions are persistent (three years or longer).

Additional considerations

Environmental influences cause substantial variation in the abundance of small pelagic fish and low sandeel abundance can have many causes other than depletion by industrial fishing. Likewise, unfavourable weather events can cause high mortality of kittiwake chicks, such that a single year of failed breeding is not necessarily indicative of inadequate food supply. Historic evidence indicates that repeated poor fledging over several consecutive years is, however, likely to be the result of inadequate food supply and unlikely to be caused by storms, predators or non-food-related factors. Under the conditions of consistently poor food supply, it is appropriate to consider measures that reduce any potential competition between kittiwakes (and other predators on sandeels) and industrial fisheries, even when the fisheries are not demonstrably the cause of the low availability of sandeels.

ICES has re-examined the relationship between sandeel abundance and black-legged kittiwake breeding productivity. The initial relationship between black-legged kittiwake productivity and sandeel abundance was based on correlational studies using estimates of sandeels from ICES stock assessments (Furness, 1999). This relationship was contested by Wright *et al*. (2002). However, ICES found that this relationship held in subsequent years around Shetland based on two measures of sandeel abundance and, in addition, a relationship was found in southeast Scotland with a trawl survey-based index. Both the assessment and the survey-based indices were strongly influenced by the abundance of 1+-aged sandeels. Overall, there is strong evidence that variation in black-legged kittiwake breeding productivity can provide an indication of local variation in the abundance of their fish prey, in this case specifically one-year-old and older sandeels.

Clearly establishing the mechanistic link between 1+-aged sandeel abundance early in the breeding season and subsequent black-legged kittiwake breeding productivity would strengthen the case that this metric is sensitive to a manageable human activity, since the sandeel fishery primarily targets 1+-aged sandeels. Similarly, if 1+ sandeel abundance was to be critically reduced by a fishery at the same time that adult black-legged kittiwakes, building up to breeding condition, were utilizing the same resource, then one might expect the metric to be tightly linked in time to the fishing activity. Breeding productivity two months later on in the same season would be compromised. The performance of this metric with respect to the criterion that it be primarily responsive to a human activity would also be strengthened, but this would still remain the weakest aspect.

References

Furness, R.W. 1999. Does harvesting a million metric tonnes of sand lance per year from the North Sea threaten seabird populations? *In* Ecosystem Approaches for Fisheries Management, pp. 407–424. Alaska Sea Grant College Program, AK-SG-99-01, Fairbanks, Alaska.

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Mavor, R.A., Pickerell, G., Heubeck, M., and Mitchell, P.I. 2002. Seabird numbers and breeding success in Britain and Ireland, 2000. Joint Nature Conservation Committee, Peterborough. UK Nature Conservation, No. 26.

Walsh, P.M., Halley, D.J., Harris, M.P., del Nevo, A., Sim, I.M.W., and Tasker, M.L. 1995. Seabird monitoring handbook for Britain and Ireland. JNCC / RSPB / ITE / Seabird Group, Peterborough.

Wright, P.J., Jensen, H., Mosegaard, H., Dalskov, J., and Wanless, S. 2002. European Commission's annual report on the impact of the Northeast sandeel fishery closure and status report on the monitoring fishery in 2000 and 2001. European Commission, Brussels.

2.1.7.1.12 EcoQ Element (k) Seabird population trends as an index of seabird community health

Request

Request to ICES from OSPAR:

ICES will be invited to consider the formulation of the EcoQO, determine whether a more specific EcoQO is needed in terms of its specification to the metric, time and geographical area, and as necessary propose (a) more specific EcoQO(s).

Source of information

The 2004 report of the Working Group on Seabird Ecology (WGSE) (ICES CM 2004/C:05).

Recommendations and advice

ICES recommends that this is a useful EcoQ element, and that a detailed analysis of trends in individual colonies of kittiwakes should be carried out on the existing data (predominantly from UK seabird surveys and monitoring). This could provide for a better understanding of how colony selection may be made to render an EcoQ metric that is representative of the North Sea as a whole. The EcoQO previously suggested by ICES (≤ 20% decline over ≥ 20 years) could act as a precautionary limit to trigger further investigation, but would need to fit into a more advanced framework for EcoQOs before becoming operational.

Technical evaluation

Table 2.1.7.1.12.1 Technical evaluation of EcoQ element (k) Seabird population trends as an index of seabird community health. Since this is not part of the North Sea pilot project, the EcoQ element was assessed as no EcoQO has yet been developed. The science underpinning this evaluation is summarized in the supporting text.

		Comments	
1	**Issue**	4. Seabirds	
2	**Element**	(k) Seabird population trends as an index of seabird community health	
3	**ICES criteria**		
	Relatively easy to understand by non-scientists and those who will decide on their use	Usually	
	Sensitive to a manageable human activity	Occasionally	Some human activities directly affect numbers, but most changes are less easily related to any particular factor.
	Relatively tightly linked in time to that activity	Occasionally	Some human activities are tightly linked, but see point above.
	Easily and accurately measured, with a low error rate	Usually	Variable precision and ease of measurement between each species, but generally good.
	Responsive primarily to a human activity, with low responsiveness to other causes of change	Rarely	Variable (again); some changes can be linked, but many cannot.
	Measurable over a large proportion of the area to which the EcoQ metric is to apply	Usually	
	Based on an existing body or time series of data to allow a realistic setting of objectives	Usually	Those species for which EcoQOs can be established have a good historical body of information.
4	**Ecological relevance/basis for the metric**	Seabirds are an important part of the North Sea predator and scavenger community.	
5	**Current and historic levels (including geographic areas)**	Species-dependent, see Mitchell *et al*. (2004) and references therein for up-to-date information.	
6	**Reference level**	Usually available at a species level.	
7	**Limit point**	Potentially this could be extirpation or loss of a major colony.	
8	**Time frames**	*Detection of change*	For some species, annual monitoring would enable detection of relatively rapid and certain change in status (e.g., less than five years), but for other species decadal monitoring would mean that twenty years might be needed.
		Use in advice	As above.
9	**Advice on EcoQO options (scenarios)**	*Scenario 1*	
		Scenario 2	
		Scenario 3	
10	**Monitoring regimes**	There are sufficient, quality-assured monitoring regimes in place around the North Sea to be able to provide information to evaluate the state of the EcoQ. If an increase in frequency of monitoring is required, then further resources would be necessary.	
11	**Management measures to achieve EcoQO**	Species- and case-specific. Some examples exist in the North Sea already. The most expedient way of generating these would be through a “species recovery” or “species action plan” process. The triggering of the EcoQO might lead to further research.	

Scientific background

As advised by ICES (2003), more detailed analyses of the empirical data on seabird population trends and individual colony trends are required to fully evaluate the expected performance of the proposed EcoQO on seabird population trends in the North Sea as an index of seabird community health. However, the main rationale for this EcoQ element is the general public concern for declining seabird populations. This makes it practical to define a certain level of population decrease that, when exceeded, should trigger investigations to explore the most likely causes for the decline and considerations of possible countermeasures.

At any one time, natural variability would lead half the seabird populations at these latitudes to increase and the other half to decrease, but our ability to detect changes over the short term depends both on the magnitude and the variability of changes in time and space as well as the method(s) used. However, monitoring of breeding seabirds aims to cover at least 10% of the total population of the targeted species and the methods are considered highly standardized and reasonably robust. The target level previously suggested for an EcoQO (≤ 20% decline over ≥ 20 years) is also justified by the fact that seabirds are generally long-lived and reproduce slowly. Consequently, rapid changes in their numbers are not expected and might indicate that some human-induced factor(s) is affecting the population to an extent that is not associated with a healthy seabird community and require(s) immediate management actions. The reference level for seabird population trends would typically be less than half the maximum target rate (i.e., in the order of ≤ 10% decline over ≥ 20 years).

One possible option to make this EcoQO more specific is to identify the most suitable target species and key sites that could be used as a proxy for the whole North Sea seabird community, since obtaining sufficiently frequent and accurate counts of the whole North Sea population of breeding seabirds is not a practical proposition. A set of principles for making such a selection of appropriate species and populations would have to take into account the distribution of seabirds throughout different parts of the North Sea and include the most representative in terms of their ecology, numbers, distribution, and feasibility for monitoring (accessibility and counting accuracy). However, there are many different ways of grouping species according to their ecology (e.g., by feeding habitat and/or dietary preferences), and changes in the populations of species within different groups might indicate changes in the health of different components of the ecosystem.

Although categorizing species with respect to their ecology is certainly informative when exploring the reasons for widespread changes in populations, ICES proposes not to apply an *a priori* categorization for the purposes of monitoring in any area of the North Sea. Rather, monitoring should encompass the full suite of species that occur in significant numbers, and which can be practically monitored to the levels required for effective analysis. When this is not possible, however, ICES recommends that special consideration be taken to ensure that the selection of species includes as many ecotypes as possible. If changes are detected in more than one species of seabird population, then exploration of the possible reasons may be directed at possible common causes in the ecosystem as well as at reasons that may apply only to individual species.

There is a need to assess in more detail to what extent the present level of monitoring in the North Sea countries is adequate to fulfill the suggested EcoQO. This assessment should take into account the representativeness of the sample of populations in relation to the overall seabird community. In particular, it should be investigated whether the selection of species reflects the main ecological groups of seabirds in terms of their range of diets, habitat use, and life-history strategies, and whether the national programmes need to be adjusted in order to ensure that a sufficient part of the North Sea population of the selected target species is being monitored. However, as total bird counts are only made on a very irregular basis, a regular assessment of this EcoQO is forced to be limited to a selection of reference areas/colonies (“key sites”). The identification of the most suitable areas/colonies in this context will be a time-consuming issue that needs to be addressed carefully in the assessments suggested above.

References

ICES. 2003. Report of the ICES Advisory Committee on Ecosystems, 2003. ICES Cooperative Research Report, 262: 95–97.

Mitchell, P.I., Newton, S.F., Ratcliffe, N., and Dunn, T.E. (compilers). 2004. Seabird populations of Britain and Ireland. T. & A.D. Poyser, London.

2.1.7.1.13 EcoQ Element (l) Changes in the proportion of large fish and hence the average weight and average maximum length of the fish community

Request

Request to ICES from OSPAR:

ICES is invited to:

a) *Where possible and appropriate, reconstruct the historic trajectory of the metrics and determine their historic performance (hit, miss, or false alarm) relative to the objective being measured, as a basis for evaluating their relationship to management;*

b) *Taking into account all potential sources of relevant information, determine what information it will be possible to collect in future to assess whether the EcoQO is being met (taking into account practicability and costs), and develop draft guidelines, including monitoring protocols and assessment methods, for evaluating the status of, and compliance with, those EcoQOs;*

c) *Develop draft guidelines, including monitoring protocols and assessment methods, for evaluating the status of, and compliance with, the EcoQO.*

Source of information

The 2004 report of the Working Group on Fish Ecology (WGFE) (ICES CM 2004/G:09).

The 2004 report of the Working Group on Ecosystem Effects of Fishing Activities (WGECO) (ICES CM 2004/ACE:03).

Recommendations and advice

The EcoQ element "proportion of large fish" is meaningful, and further development of the metrics mean weight and mean maximum length of fish is required. These will need to be survey- and area-specific. Reference points that could be developed would therefore also be specific to these surveys and areas. Historic trends in this metric appear to respond slowly and inconsistently to management actions.

Technical evaluation

Table 2.1.7.1.13.1 Technical evaluation of EcoQ element (l) Changes in the proportion of large fish and hence the average weight and average maximum length of the fish community. Since this is not part of the North Sea pilot project, the EcoQ element was assessed as no EcoQO has yet been developed. The science underpinning this evaluation is summarized in the supporting text.

		Comments	
1	**Issue**	5. Fish communities	
2	**Element**	(l) Changes in the proportion of large fish and hence the average weight and average maximum length of the fish community	
3	**ICES criteria**		
	Relatively easy to understand by non-scientists and those who will decide on their use	Usually	The public clearly understands the importance of the size of fish as a measure of impact.
	Sensitive to a manageable human activity	Usually	
	Relatively tightly linked in time to that activity	Occasionally	Response time can be slow and the response is often non-linear.
	Easily and accurately measured, with a low error rate	Usually	Measurement is straightforward and well-established protocols and surveys exist, usually with an element of quality control.
	Responsive primarily to a human activity, with low responsiveness to other causes of change	Usually	Metric is significantly influenced by climate as well as fishing in some ecosystems: in other ecosystems, fishing effects appear to outweigh those of climate.
	Measurable over a large proportion of the area to which the EcoQ metric is to apply	Usually	
	Based on an existing body or time series of data to allow a realistic setting of objectives	Rarely	Many time series exist in many regions, but they will not necessarily help with the process of setting EcoQOs.
4	**Ecological relevance/basis for the metric**	Effects of fishing on fish populations may reflect effects of fishing on other ecosystem components.	
5	**Current and historic levels (including geographic areas)**	Trends have been reported by ICES (2003a, 2003b) for the whole North Sea and subunits of the North Sea. Trends demonstrate that average weight and mean maximum length have declined over the period studied.	
6	**Reference level**	Not available	
7	**Limit point**	Not available	
8	**Time frames**	*Detection of change*	Typically more than five years, in some cases more than fifteen years (survey-, metric-, and area-specific), are needed to detect expected responses to management actions.
		Use in advice	Typically more than five years would elapse following a management action before the success of management could be judged.
9	**Advice on EcoQO options (scenarios)**	*Scenario 1*	Not available, but would simply be a value of weight and length.
		Scenario 2	Not available
		Scenario 3	Not available
10	**Monitoring regimes**	Suitable data for calculating these metrics are already collated on a number of fisheries surveys in the North Sea (ICES, 2003b).	
11	**Management measures to achieve EcoQO**	Regulation of the spatial and temporal distribution and intensity of fishing effort.	

Scientific background

On the scale of the North Sea, there is a relationship between the intensity of fisheries exploitation and the metrics of both mean weight and mean maximum length of fish in the community. However, on smaller spatial scales and over shorter time periods, the response of these metrics has not been so consistent. The relationship is, however, not straightforward, not well understood, and certainly not tightly linked in space and time. As such, these two metrics will be poor short-term performance metrics, and should preferably be used for longer-term surveillance of the fish community.

It is not yet possible to predict what average weight or average maximum length of the fish community might be obtained from a specific survey for a specific reduction in exploitation rate of the fish community, or the values that might be expected in a non-exploited system. The relationship between a metric and estimates of exploitation may reflect delayed responses of the fish community that integrate short-term direct effects and longer-term indirect effects. In addition, there may be an even longer-term (decadal) genetic effect (ICES, 2002). These effects are then superimposed on annual (random) variations in recruitment to all species in the assemblage sampled by the survey gear.

For these reasons, the predictive value of any empirical relationship is very limited, and extrapolations outside the observed range of values are not warranted. Thus, a sensible reference level should be within the observed range. Given that none of the available surveys extend into periods when communities can be considered as unexploited, the reference level will only indicate the state of an exploited ecosystem and, therefore, should be used as a limit reference level.

Additional concerns

The two metrics proposed clearly integrate direct and indirect effects of fishing, but as such do not provide information on which of the two effects (or both) are responsible for observed trends. While different but spatially comparable surveys have shown similar trends, the actual levels of the metrics have varied considerably. This is not surprising because each gear samples a specific assemblage within the total fish community present, with the bias dependent on the relative catchabilities for individual species. While the absolute bias is unknown, the relative bias among different gears might be evaluated, but this would be a major exercise. At present, we have to accept that different surveys reveal different patterns, and selecting a particular survey as the basis for an EcoQO for a broader area would be arbitrary and involve a specific bias. As different surveys cover different time periods and/or areas, a cross-calibration of surveys would allow an expansion of the spatial extent of coverage.

ICES (2003a) tested the power of a large-scale annual trawl survey (North Sea International Bottom Trawl Survey, IBTS) to detect trends in mean weight and mean maximum length. The analyses showed that the power of the trawl survey to detect short-term trends (five years) in these metrics was generally poor. Thus, while the community metrics did provide good long-term indicators of changes in fish community structure, they would only support long-term rather than short-term management decisions.

There are also concerns with these indicators that the theoretical understanding of their response to fishing is not well developed, because the spatial processes underlying changes in fish community structure are not understood and they are influenced by both direct and indirect fishing effects.

References

ICES. 2002. Report of the ICES Advisory Committee on Ecosystems, 2002. ICES Cooperative Research Report, 254: 54–59.

ICES. 2003a. Report of the Working Group on Ecosystem Effects of Fishing Activities. ICES CM 2003/ACE:05.

ICES. 2003b. Report of the Working Group on Fish Ecology. ICES CM 2003/G:04.

2.1.7.1.14 EcoQO for EcoQ Element (n) Imposex in dogwhelks *Nucella lapillus*

Request

Request to ICES from OSPAR:

ICES will be invited to reconsider the formulation of the EcoQO, determine whether a more specific EcoQO is needed in terms of its specification to the metric, time and geographical area, and as necessary propose (a) more specific EcoQO(s).

Source of information

The 2004 report of the Working Group on Biological Effects of Contaminants (WGBEC) (ICES CM 2004/E:04).

The 2004 report of the Marine Chemistry Working Group (MCWG) (ICES CM 2004/E:03).

Review from the 2004 meeting of the Advisory Committee on the Marine Environment (ACME).

Recommendations and advice

> **ICES noted that the following EcoQO was agreed by the Fifth North Sea Conference in the Bergen Declaration:**
>
> **"A low (<2) level of imposex in female dogwhelks, as measured by the Vas Deferens Sequence Index."**

ICES recommends the adoption of the proposed revised EcoQO (VDSI <2) as being the level of TBT-specific effects on dogwhelks that indicates exposure to TBT concentrations below the ecotoxicological assessment criteria (EAC) derived for TBT.

OSPAR should note that, while achievement of this proposed EcoQO will protect the most sensitive species from adverse effects, it may not be perceived to be equivalent to the OSPAR target of close to zero concentrations of TBT in the marine environment.

Technical evaluation

Table 2.1.7.1.14.1 Technical evaluation of the EcoQO for EcoQ element (n) Imposex in dogwhelks *Nucella lapillus*. As this EcoQO is part of the North Sea pilot project, the EcoQO was assessed and not the EcoQ element. The science underpinning this evaluation is summarized in the supporting text.

		Comments	
1	**Issue**	5. Benthic communities	
2	**Element**	(n) Imposex in dogwhelks *Nucella lapillus*	
3	**ICES criteria**		
	Relatively easy to understand by non-scientists and those who will decide on their use	Usually	Dogwhelks are very sensitive to TBT. A number of scientific reports documenting this are available.
	Sensitive to a manageable human activity	Usually	There are several reports of recovery in dogwhelk populations after the use of TBT has decreased.
	Relatively tightly linked in time to that activity	Usually	
	Easily and accurately measured, with a low error rate	Usually	There is a standard method (VDSI).
	Responsive primarily to a human activity, with low responsiveness to other causes of change	Usually	The cause-and-effect relationship between the presence of TBT and imposex in dogwhelks is “clear”.
	Measurable over a large proportion of the area to which the EcoQ metric is to apply	Usually or occasionally	Dogwhelks are widely distributed in the North Sea area, but only on rocky substrates and predominantly intertidally.
	Based on an existing body or time series of data to allow a realistic setting of objectives	Usually	Data exist from “pristine areas” where TBT concentrations are zero or almost zero.
4	**Ecological relevance/basis for the metric**	The cause-and-effect relationship between the presence of TBT and imposex in dogwhelks is “clear” and direct.	
5	**Current and historic levels (including geographic areas)**	The “historical level” of TBT is zero, with a corresponding VDSI<0.3. At present, elevated levels occur in many coastal areas. Trends are now decreasing due to regulations on TBT use.	
6	**Reference level**	Reference level for TBT concentration (and imposex) is zero (VDSI<0.3).	
7	**Limit point**	VDSI > 5, which means that dogwhelks cannot reproduce.	
8	**Time frames**	*Detection of change*	Less than ten years.
		Use in advice	
9	**Advice on EcoQO options (scenarios)**	*Scenario 1*	
		Scenario 2	
		Scenario 3	
10	**Monitoring regimes**	Monitoring should be focused on areas where the risk of high TBT concentrations is evident (harbours, etc.).	
11	**Management measures to achieve EcoQO**	There is already an IMO resolution that TBT cannot be used in antifouling paints after 2008. Dumping of dredge spoil from harbours should be avoided in cases where these contain high amounts of TBT. Spoil materials should be assessed for TBT.	

Scientific background

In some marine snails, tributyltin (TBT) causes a condition known as imposex whereby females develop part of the male reproductive system, including a penis and vas deferens, which becomes superimposed on the female system. Sterility can occur in severe cases. The best known example of imposex is seen in the dogwhelk *Nucella lapillus*. The dogwhelk became locally extinct on some shores adjacent to areas of high shipping activity during the period of high TBT contamination in the 1980s and early 1990s. Toxicological effects of TBT occur at very low concentrations in sea water, below the levels that can be routinely measured by chemical analysis in most laboratories. Implementation of the International Maritime Organization (IMO) restrictions on TBT in antifouling paint from 1990 for vessels smaller than 25 m, and the restriction on the application of TBT-based antifouling paint from 2003 for all ships flying flags of the EU countries, have been a positive development. Dogwhelk populations have recovered dramatically in many areas since environmental concentrations of TBT have declined. However, dogwhelks have not returned to some areas, due to the lack of pelagic life stages, which hampers recolonization. Serious TBT pollution is now confined almost entirely to ports and harbours, and effects of TBT are highly localized.

The level and severity of imposex in dogwhelks is measured by the Vas Deferens Sequence Index (VDSI). The proposed EcoQO is currently set at the level of VDSI<2. This means that the level of imposex can be moderate (30–100% of the females having imposex), indicating exposure to low-level TBT concentrations, but adverse effects on the population level of this sensitive species are predicted to be unlikely to occur. The risk of adverse effects, such as reduced growth and recruitment, increases when the VDSI value is between 2 and 4. At even higher values (VDSI ≥5), dogwhelk populations are unable to reproduce.

OSPAR has a general target that concentrations of hazardous substances in the marine environment should be near background values (naturally occurring substances) or close to zero (man-made substances). At TBT concentrations below the proposed EcoQO (VDSI <2), the incidence of imposex in dogwhelk populations can be up to 30–100%. It could be argued that a “near-zero” concentration of a hazardous substance should result in “near-zero” effects. Therefore, achieving the proposed EcoQO may not be perceived to meet the OSPAR target of close to zero concentrations of hazardous substances, such as TBT, in the OSPAR area.

2.1.7.1.15 EcoQ Element (o) Density of sensitive (e.g., fragile) species and EcoQ Element (p) Density of opportunistic species

Request

Request to ICES from OSPAR:

ICES is invited to:

a) *Where possible and appropriate, reconstruct the historic trajectory of the metric and determine its historic performance (hit, miss or false alarm) relative to the objective being measured, as a basis for deciding the relationship to management. This requires the collection of the relevant available historic data/information;*

b) *Taking into account all potential sources of relevant information, determine what information it will be possible to collect in future to assess whether the EcoQO is being met (taking into account practicability and costs);*

c) *Develop draft guidelines, including monitoring protocols and assessment methods, for evaluating the status of, and compliance with, the EcoQO.*

Source of information

The 2004 report of the Study Group on Ecological Quality Objectives for Sensitive and for Opportunistic Benthos Species (SGSOBS) (ICES CM 2004/ACE:01).

The 2004 report of the Working Group on Ecosystem Effects of Fishing Activities (WGECO) (ICES CM 2004/ACE:03).

The 2004 report of the Benthos Ecology Working Group (BEWG) (ICES CM 2004/E:09).

Summary

Previous work has shown 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. ICES recommends that OSPAR consider dropping EcoQ element (p) on the density of opportunistic species.

A more useful formulation of EcoQ element (o), on the density of sensitive (e.g., fragile) species, would make use of a limited selection of sentinel species rather than extensive lists of such species. This could be made operational, at least for the physical impacts of towed fishing gears on the benthos. This would require, amongst others, a further examination of the behaviour of metrics on a range of different scales, and the development of a set of criteria for the rational selection of sensitive species. This could be a productive area for further work for the relevant expert group.

Recommendations and advice

ICES recommends that OSPAR consider dropping the EcoQ element (p) Density of opportunistic species, as these species are ubiquitous and provide no close link to human impacting activities.

ICES recommends examining, using the 1986 and 2000 data from the North Sea Benthos Survey and Project, the ability to apply metrics on the regional scale as opposed to either a North Sea scale or at the assemblage level.

Technical evaluation

Table 2.1.7.1.15.1 Technical evaluation of EcoQ element (o) Density of sensitive (e.g., fragile) species. Since this is not part of the North Sea pilot project, the EcoQ element was assessed as no EcoQO has yet been developed. The science underpinning this evaluation is summarized in the supporting text.

		Comments	
1	**Issue**	5. Benthic communities	
2	**Element**	(o) Density of sensitive (e.g., fragile) species	
3	**ICES criteria**		
	Relatively easy to understand by non-scientists and those who will decide on their use	Usually	The public has some understanding of "fragile" and "sensitive", but this may not correspond to the interpretation of the term among technical experts. Technical experts do not always agree on what constitutes a "sensitive species" (WGECO, BEWG).
	Sensitive to a manageable human activity	Occasionally	Some good examples exist, but the selection of species to be used in the evaluation is important.
	Relatively tightly linked in time to that activity	Occasionally	When threats to the species are primarily owing to damage by human activities, such as mobile fishing gears and some pollutants, they can be very tightly linked. Broad-scale oceanographic and climatic changes are also responsible for changes in the abundance of many sensitive species.
	Easily and accurately measured, with a low error rate	Rarely or occasionally	Likely to be highly species-dependent. Further research is needed on selected "sentinel" species. Analysis of the pattern of spatial distribution of a number of taxa of bivalves and polychaetes, and seapen species indicated that at the scale of the North Sea, the survey would have little power to detect a change.
	Responsive primarily to a human activity, with low responsiveness to other causes of change	Species-dependent	Highly species-dependent. Disruptive human activities are likely to affect the most sensitive species, but many sensitive species are also likely to be affected by biotic and abiotic interactions.
	Measurable over a large proportion of the area to which the EcoQ metric is to apply	Occasionally	Species-dependent. For species which can be measured well, they are likely to be able to be measured over their full range of distribution.
	Based on an existing body or time series of data to allow a realistic setting of objectives	Rarely	Few time series of zoobenthos exist.
4	**Ecological relevance/basis for the metric**	Impact on sensitive species is an important issue and these species can play an important ecological role. Life-history traits of sensitive species mean that often many occur together, so site-based protection is therefore important.	
5	**Current and historic levels (including geographic areas)**	There are limited historical data to identify historical abundance levels. Current levels are completely species-dependent.	
6	**Reference level**	No long-term and lasting changes of sensitive species in a given benthos community.	
7	**Limit point**	Reduction of species to abundances where the viability of the population is at risk.	
8	**Time frames**	*Detection of change*	Although impact may be instantaneous, assessment of density change relies on regular sampling. If sampling is reliable, detection of effects can be rapid.
		Use in advice	Advice would be to cease or move activity causing the impact.
9	**Advice on EcoQO options (scenarios)**	*Scenario 1*	Status of a species x (one which is readily sampled).
		Scenario 2	Status of species y (one which is very difficult to sample).
		Scenario 3	Status of species z (one which varies greatly in response to environmental forcing).
10	**Monitoring regimes**	Strategy not yet established for many species in this category, but ICES has provided guidance on appropriate sampling (e.g., North Sea Groundfish Survey).	
11	**Management measures to achieve EcoQO**	Regulation of human activities would be required to mitigate impact.	

Conclusions

This EcoQ element has the potential to be developed into effective EcoQOs, but only through wise selection of the species to be used as indicators. However, depending on the technical details taken into consideration, any number of taxa from a few tens to hundreds may qualify as "sensitive". In spite of the very large total pool of species placed on lists of sensitive species by groups of experts all working on the North Sea zoobenthos, the number of species common to all the lists was remarkably small. ICES has warned against the adoption of the proposed metrics for extensive lists of all species that meet the criteria for "sensitive", due to the logistical problems of having a large number of separate management targets.

Overall, ICES concludes that EcoQ element (o) on the density of sensitive (e.g., fragile) species should be advanced by the use of a selection of a very limited suite of "sentinel" species. A basis for the selection of appropriate species can be found in past ICES Working Group reports (see, e.g., BEWG, WGECO).

Additional considerations

As such, the term "sensitivity" takes into account both the tolerance to and the time needed for recovery from the stressor. Fragile species are considered to be especially susceptible to physical/mechanical disturbance.

When choosing sensitive species for individual EcoQOs, priority should be given to the monitoring of species that play a key role in the structure and functioning of structural habitats, e.g., *Modiolus* beds (horse mussel), *Lophelia* reefs (cold-water corals), and *Sabellaria* reefs (polychaete). This is especially relevant for protection purposes because any impact on these kinds of structural habitats may have cascading effects which may be irreversible.

If an EcoQO is applied over all sampling points in the North Sea, spatial distribution of sensitive species means that the variance will be higher, and hence the survey power less, to detect a change in the EcoQO metric of density. To improve this situation, the number of EcoQOs must be increased. At the most biologically realistic scale, the assemblage types defined by the North Sea Benthos Survey, there would be eight EcoQOs for each species with a North Sea-wide distribution; however, most species would not occur in all eight assemblage types.

Technical evaluation

Table 2.1.7.1.15.2 Technical evaluation of EcoQ element (p) Density of opportunistic species. Since this is not part of the North Sea pilot project, the EcoQ element was assessed as no EcoQO has yet been developed. The science underpinning this evaluation is summarized in the supporting text.

		Comments	
1	**Issue**	5. Benthic communities	
2	**Element**	(p) Density of opportunistic species	
3	**ICES criteria**		
	Relatively easy to understand by non-scientists and those who will decide on their use	Rarely	"Opportunistic" species is not a concept familiar to the public, and technical experts often have trouble developing non-circular definitions of "opportunistic".
	Sensitive to a manageable human activity	Occasionally	Sometimes can respond quickly to human activities that disturb "old" communities, but if already common in an area, they may not show any response at all to further perturbation.
	Relatively tightly linked in time to that activity	Occasionally	Many definitions of "opportunistic" mean that they necessarily respond rapidly to *any* major change. Abundances are likely to be highly patchy in space and variable in time.
	Easily and accurately measured, with a low error rate	Rarely	With a sample size of one, temporal variance cannot be estimated. Hence, comparing annual survey data will require an alternative approach, and simple temporal trend analysis of annual means may be more appropriate. Alternatively, one could perhaps aggregate years of data, and compare the means of five annual mean density estimates between two groups of five years of data, deriving the temporal variance from each set of five individual annual means.
	Responsive primarily to a human activity, with low responsiveness to other causes of change	Rarely	Environmental factors are also responsible for change in the density of opportunistic species and it is very difficult to partition effects of human activities.
	Measurable over a large proportion of the area to which the EcoQ metric is to apply	Usually	Changes can be measured if sampling programmes exist.
	Based on an existing body or time series of data to allow a realistic setting of objectives	Rarely	Few time series of zoobenthos exist.
4	**Ecological relevance/basis for the metric**	There are many causes of change of opportunistic species, including human activity. These changes can be ecologically important.	
5	**Current and historic levels (including geographic areas)**	Historical levels of sampling are insufficient to identify time series changes. The whole concept of a "natural" level of abundance for an opportunistic species may be questionable.	
6	**Reference level**	Inappropriate concept.	
7	**Limit point**	Inappropriate concept.	
8	**Time frames**	*Detection of change*	Within weeks/months.
		Use in advice	Cease or reduce perturbation which is making conditions suitable for opportunistic species.
9	**Advice on EcoQO options (scenarios)**	*Scenario 1*	
		Scenario 2	
		Scenario 3	
10	**Monitoring regimes**	Although impact may be instantaneous, assessment of density change relies on regular sampling. Few monitoring regimes are currently in place for any zoobenthos.	
11	**Management measures to achieve EcoQO**	Cessation or relocation of activities.	

Conclusion

Opportunistic species are ubiquitous and hard to define unambiguously. Their status is difficult to quantify with accuracy and precision, and changes in abundance are not closely linked to specific human impacts; thus, they may fail to correctly trigger management actions. ICES recommends that OSPAR consider dropping EcoQ element (p) on the density of opportunistic species.

2.1.7.1.16 EcoQ Element (s) Restore and/or maintain habitat quality

Request

Request to ICES from OSPAR:

ICES is invited to:

a) *Consider the habitats on the Draft OSPAR list of threatened and declining habitats for their relevance and usefulness as a basis for possible EcoQOs for the North Sea;*

b) *Commence development, on the basis of the criteria for sound EcoQOs established by ICES in 2001, of related metrics, objectives and reference levels for this possible EcoQO.*

Source of information

The 2003 report of the Working Group on Ecosystem Effects of Fishing Activities (WGECO) (ICES CM 2003/ACE:05).

The 2004 report of the Working Group on Ecosystem Effects of Fishing Activities (WGECO) (ICES CM 2004/03).

Recommendations and advice

ICES encountered problems with the definition of habitat quality, and recommends that this EcoQ element be changed to:

"Restore and/or maintain the extent of threatened habitats".

ICES recommends that features of flat oyster beds, intertidal mudflats, and littoral chalk communities should be further developed as a basis for an EcoQO for this revised EcoQ element. ICES recommends that features of two other threatened and declining habitats in the North Sea, i.e., seapen and burrowing megafauna communities and seagrass beds, should not at present be used as a basis for EcoQOs.

For oysters and oyster beds, littoral chalk communities, and intertidal mudflats, the most obvious metric to describe their status will be the abundance and density of the habitat relative to a reference level that reflects an earlier more abundant state. An EcoQO to increase the spatial extent may still be valid even though accurate estimates of the extent of the pre-impacted habitat do not exist. The precise formulation of an EcoQO for this revised element still needs further work.

Management measures taken to ensure that the benthic environment is not significantly physically altered (e.g., by sediment deposition and trawling impacts) and ensure that water column quality is favourable to these habitats will promote the restoration and/or maintenance of the habitat.

Technical evaluation

Table 2.1.7.1.16.1 Technical evaluation of EcoQ element (s) Restore and/or maintain habitat quality. Since this is not part of the North Sea pilot project, the EcoQ element was assessed as no EcoQO has yet been developed. The science underpinning this evaluation is summarized in the supporting text.

		Comments	
1	**Issue**	8. Habitats	
2	**Element**	(s) Restore and/or maintain habitat quality	
3	**ICES Criteria**		
	Relatively easy to understand by non-scientists and those who will decide on their use	Usually	Public awareness for protecting "habitat quality" is high. However, the definition of quality is lacking, and there are significant challenges to developing an unambiguous science-based definition.
	Sensitive to a manageable human activity	Usually for oyster beds, littoral chalk communities, and intertidal mudflats	The decline is due to damage by fishing activities, and land reclamation and littoral structures. In general, many types of habitats can be sensitive to management activity, particularly in natural "low energy" environments (not exposed to frequent natural disturbance by waves, storms, strong currents, etc.).
	Relatively tightly linked in time to that activity	Occasionally	The status of oyster beds is closely linked in time with fishing and overexploitation. Littoral chalk community status is directly linked to land reclamation and littoral defence structures.
	Responsive primarily to a human activity, with low responsiveness to other causes of change	Usually	The threats are significant primarily as a result of the relatively restricted distribution and small total area of these habitat types.
	Easily and accurately measured, with a low error rate	Usually	Mapping procedures are well known.
	Measurable over a large proportion of the area to which the EcoQ metric is to apply	Usually	There is good evidence of decline in the oyster beds and littoral chalk communities, and threats to intertidal mudflats in the North Sea. Overall habitat mapping is only partially completed for the North Sea area.
	Based on an existing body or time series of data to allow a realistic setting of objectives	Occasionally	***An EcoQO to increase spatial extent may be valid even though accurate estimates of pre-impacted habitats do not exist.***
4	**Ecological relevance/basis for the metric**	Although generally of limited extent, many of the habitats specified by OSPAR are important parts of the coastal zone.	
5	**Current and historic levels (including geographic areas)**	There is a good evidence for decline in the North Sea of the habitats specified above. Historic data are in most cases not available.	
6	**Reference level**	There is no quantitative basis for identifying historical abundances, but these habitats were known to be more extensive, and some quantitative information is available for many habitat types.	
7	**Limit point (thresholds)**	To be developed.	
8	**Time frames**	*Detection of change*	Detection of impact can be rapid.
		Use in advice	Detection of response to remediation is likely to require at least five years.
9	**Advice on EcoQO options (scenarios)**	*Scenario 1*	
		Scenario 2	
		Scenario 3	
10	**Monitoring regimes**	Detailed habitat mapping will be needed to record the current extent of the habitats. Monitoring of areas where management measures are in place can be tractable and cost-effective.	
11	**Management measures to achieve EcoQO**	Cease or relocate disruptive activity. Sometimes habitat-specific rehabilitation may be possible. Management measures taken to ensure that the benthic environment is not significantly physically altered (e.g., by sediment deposition or trawling impacts) and ensure that water column quality is favourable to these habitats will promote the restoration/maintenance of habitat quality.	

Additional considerations

ICES (2002) recommended a four-step process for the evaluation of the usefulness of habitats on the OSPAR list of threatened and declining habitats in developing EcoQOs. In the first step, habitats that occurred outside the Greater North Sea were eliminated. Results of the evaluation for the subsequent steps are presented below for the other habitats.

Table 2.1.7.1.16.2 Review of threatened and declining habitats in the Greater North Sea concerning whether they pass (P), possibly pass (PP), possibly fail (PF), and fail (F) any one of the three ICES steps (see text). The time-scale in years during which recovery may become evident for those habitats which fail is marked in the column against Step 4 (ICES, 2003).

Scientific Name	**Common Name**	**Step 2: Can the threatened or declining status of the habitat be quantified accurately?**	**Step 3: Can we establish why a habitat is threatened or declining?**	**Step 4: Can trends in habitat status be detected reliably on short time frames (about five years) relevant to management?**
	Intertidal mudflats	P	P	F (>10)
	Littoral chalk communities	P	P	P
Ostrea edulis	Flat oyster beds	P	P	P
	Seapen and burrowing megafauna communities	F	PF	F (5-10)
Zostera beds	Seagrass beds	P	PP	F (5-10)

Two habitats failed to pass all three steps to confirm their threatened and declining status, the cause of the threat, and their likely responsiveness to management action. There is no strong evidence that “seapen and burrowing megafauna communities” are undergoing decline in the North Sea. The decline of *Zostera* beds is well documented for the North Sea, and the threats, both natural and anthropogenic, are well described, but there are insufficient data on the recovery rates of *Zostera* beds, and a lack of clear causative links with a manageable human activity. This suggests that trends will not be readily identifiable on a reasonable time scale (ICES, 2003).

There is good evidence of decline in and threat to intertidal mudflats and littoral chalk communities in the North Sea. These threats are significant due to the restricted distribution and small total area of these habitat types; any loss must be regarded as significant in conservation terms (ICES, 2003).

There is clear evidence of decline in *Ostrea edulis* beds. While ICES is not able to provide a detailed specification of the monitoring strategy for each of the habitats that have passed the four steps described above, there are a number of general principles that should be mentioned. For *Ostrea edulis* beds, littoral chalk communities, and intertidal mudflats, the most obvious metric to describe their status will be the abundance and density of the habitat, relative to a reference level that reflects an earlier more abundant state. Although it is unlikely that accurate estimates of pre-impacted habitat extents exist, for some local areas in the OSPAR regions it may be possible to access historical data and descriptions of a state towards which it may be sensible to move. Even if such estimates are not available, an EcoQO to increase spatial extent without prior knowledge of the reference level will still be valid. For all such metrics, detailed high-resolution mapping technology can be used to describe areas of habitat, and to assess progress towards the objective of reversing the downward trend. Management measures taken to ensure that the benthic environment is not significantly physically altered (e.g., by sediment deposition or trawling impacts) and that water column quality is favourable to these habitats will promote the restoration and maintenance of habitat quality. An additional point to mention is that the Pacific oyster (*Crassostrea gigas*), which is now common in the southern part of the North Sea (Reise, 1998; Dankers *et al*., 2004), could possibly affect a recovery of the native flat oyster beds in certain areas.

Recent studies of the principal North Sea and temperate benthic data sets have highlighted the importance of the sediment in determining benthic community distribution (Frid and Hall, 2001; Freeman and Rogers, 2003). Healthy, natural benthic communities can only flourish in areas where the water quality is sufficient (i.e., free from pollution) and where the pelagic system allows normal bentho-pelagic coupling to proceed. This suggests that management measures taken to ensure that the benthic environment is not significantly physically altered (e.g., by sediment deposition or trawling impacts) and ensure that water column quality is managed, will by default assure the maintenance of habitat quality (Frid and Hall, 2001).

Management by spatial areas provides a simple mechanism for developing integration. This is likely to be effective when combined with risk assessment-based protocols whereby the different threats could be explicitly considered in a unified framework (Fogarty *et al.*, 1992; Barnthouse, 1994; Francis and Shotton, 1997) and resources directed at mitigating or controlling the most significant threats. ICES is aware that the political will to implement spatial management measures or Marine Protected Areas is growing stronger, and considers that this would be a useful approach.

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2.1.7.1.17 EcoQ Elements related to eutrophication

2.1.7.1.17.1 General considerations

Request

Request to ICES from OSPAR:

In relation to the five Ecological Quality Elements related to eutrophication, i.e., EcoQ element (m) Changes/kills in zoobenthos in relation to eutrophication, EcoQ element (q) Phytoplankton chlorophyll *a*, EcoQ element (r) Phytoplankton indicator species for eutrophication, EcoQ element (t) Winter nutrient (DIN and DIP) concentrations, and EcoQ element (u) Oxygen:

ICES will be invited to:

a) give advice on the use and implementation of the current integrated set of five ecological quality elements and related EcoQOs to the whole OSPAR maritime area;

b) *reconsider the formulation of the EcoQO, determine whether a more specific EcoQO is needed in terms of its specification to the metric, time and geographical area, and as necessary propose (a) more specific EcoQO(s).*

Source of information

The 2004 report of the Study Group to Review Ecological Quality Objectives for Eutrophication (SGEUT) (ICES CM 2004/ACE:04).

The 2004 report of the Working Group on Ecosystem Effects of Fishing Activities (WGECO) (ICES CM 2004/ACE:03).

Review from the 2004 meeting of the Advisory Committee on the Marine Environment (ACME).

General considerations

The ICES technical analyses supported the development of all five proposed EcoQ elements for eutrophication into EcoQOs, although additional work will be required for each of them. Evaluations on technical grounds were hampered by inadequate data, but to the extent that evaluations were possible, the proposed EcoQ elements performed well.

The major concern of ICES was that when EcoQOs were being set for each EcoQ element, global EcoQOs for the entire North Sea or OSPAR Area were usually inappropriate. OSPAR recognizes this, and the pilot EcoQOs which have been specified usually are phrased as specific percentages of “area-specific historic background concentrations” or other similar terminology. However, the need to take account of area-specific conditions poses major logistic challenges to widespread implementation of the EcoQ element as area-specific EcoQOs. Not only are many areas lacking area-specific data to use as a basis for setting area-specific EcoQOs, but there is only partial guidance on the conditions under which data can be extrapolated from source areas to other areas. This circumstance makes it difficult to conduct a scientifically sound evaluation of the percentages of background levels which are specified in the pilot EcoQOs, because the data necessary to provide a quantitative basis for the review of these EcoQOs area by area are not available. Therefore, ICES conducted the entire formal evaluation at the scale of the EcoQ element, and evaluated the specific EcoQOs only to the extent that information allowed a sound evaluation at more area-specific levels. However, following most of the evaluations of the EcoQ elements, specific proposals are made with regard to both: 1) how existing information should be used by groups of local experts to set area-specific EcoQOs, when such information exists; and 2) priority areas for further research, monitoring or analyses of time series, to make rapid progress towards having an information base for setting EcoQOs for as many areas as possible

ICES also notes that the appropriate spatial scale on which to set EcoQOs for eutrophication is not clear nor straightforward to determine, although it will certainly not be at the scale of the entire OSPAR Area, or even individual OSPAR Regions. The correct spatial scale is not likely to be constant, in fact, but will likely vary with a variety of oceanographic and bathymetric features. ICES uses the phrase “area-specific” throughout this section, without any specific spatial scale intended by “area”. Rather, as the recommended work is conducted to allow the development of area-specific EcoQOs, the proper interpretation of “area” in each case is one of the things which will need to be clarified.

The need to apply the EcoQ elements as an integrated set was also confirmed. Section 2.1.7.1.1, above, on ecological quality objectives as part of a broader framework, is intended to accelerate planning and dialogue for actually integrating the use of the individual EcoQOs. The framework must be developed if the goal of using the EcoQOs as an integrated set is to be realized.

The work done in the ICES review was important, because it contributed to clarifying the degree to which the EcoQ element could be implemented as area-specific EcoQOs with present knowledge. With many management initiatives to address eutrophication planned for the near future, it is important to develop rapidly the scientific basis for EcoQOs to address eutrophication, and for approaches which use them formally as an integrated set. ICES has made proposals within its work planning process to make progress on both topics. In addition, general recommendations can be made with regard to the development and use of the suite of EcoQOs for eutrophication.

Recommendations and advice

With regard to application of the EcoQ elements for eutrophication as an integrated set:

a) ICES supports the application of the five EcoQ elements for eutrophication as an integrated set. However, ICES recommends that the cause-and-effect principles used by OSPAR (Figure 1, Annex 3 EUC 03/5/5-E) should be amended as follows.

   i) Toxic algal blooms in response to eutrophication should be considered to be second-order rather than first-order responses.

   ii) Organic matter should be treated as having a direct effect on zoobenthos (through deposition) in addition to the indirect effects recognized.

   ICES also discussed the possible use of primary production in response to eutrophication as a potentially new and primary response EcoQ element. ICES acknowledges the great biological importance of primary production. However, methodological problems with quantifying primary production under field conditions led ICES to conclude that primary production is not suitable as an EcoQ element for development into an EcoQO at this time. Models are being developed which may allow EcoQOs to be developed for primary production in the future.

   ICES notes that the principles applied by the National Estuarine Eutrophication Assessment of the U.S. National Oceanic and Atmospheric Administration should be reviewed as a potential approach for the development of the EcoQ elements as an integrated set.

With regard to dealing with annual cycles of pelagic EcoQ elements:

ICES recommends that, whenever sampling of eutrophication EcoQ elements is accomplished at "key stations", all pelagic EcoQ elements (chlorophyll, phytoplankton species, nutrients, and oxygen) should be sampled at the same time using standard oceanographic methods. This is in order to determine the annual cycle of the pelagic EcoQ elements, which may give important support for the assessment of all of the eutrophication EcoQ elements including zoobenthos.

Terminological problems

In the process of attempting to review these EcoQOs as an integrated set, and more generally in seeking consistency, to the extent possible, in the advice given on different EcoQ elements and EcoQOs that dealt with similar ecosystem components, ICES found the terminology used often confusing and sometimes confused. The situation was particularly problematic with EcoQ elements and EcoQOs for plankton and nutrients. These terminological issues may appear to be minor technical details, but in scientific terms alternative interpretations may have significant implications. This is illustrated below.

The original Bergen Declaration states the following:

Issue	Element
7. Plankton communities	(q) Phytoplankton chlorophyll *a* (r) Phytoplankton indicator species for eutrophication
9. Nutrient budgets and production	(t) Winter nutrient (DIN and DIP) concentrations
10. Oxygen consumption	(u) Oxygen

Whereas to make the issues scientifically tractable, the EcoQ elements had to be made much more explicit and clear, as follows:

Issue	Element
7. Plankton communities	(q) Typical maximum phytoplankton chlorophyll *a* concentration (r) Phytoplankton indicator species for eutrophication
9. Nutrient budgets and production	(t) Typical winter nutrient (DIN and DIP) concentrations in a defined area (area-specific; see "General Considerations", above) (New 1) Total winter anthropogenic nutrient loads to a defined area (New 2) Total winter non-anthropogenic nutrient loads to a defined area (New 3) Typical primary production within a defined area
10. Oxygen consumption	(u) Typical minimum oxygen concentration in a defined area (New 4) Typical oxygen consumption in a defined region

ICES notes that in translating the original text to be tractable to formal analysis, some fundamental differences in units have arisen:

Element	**Metric units**
(q) Phytoplankton chlorophyll a	**Mass per unit volume**
(r) Phytoplankton indicator species for eutrophication	**Numbers per unit volume**
(t) Winter nutrient (DIN and DIP) concentrations	**Mass per unit volume**
(New 1) Winter anthropogenic nutrient loads	**Mass per unit time**
(New 2) Winter non-anthropogenic nutrient loads	**Mass per unit time**
(New 3) Primary production	**Mass per unit time**
(u) Oxygen concentration	**Mass per unit volume**
(New 4) Oxygen consumption	**Mass per unit time**

These differences suggest that particularly careful dialogue among ICES, OSPAR, and the clients of both organizations may be needed first to clarify exactly the intent of potential users of the EcoQ elements and EcoQOs, and then to ensure that correct metrics and terms are employed in each case.

2.1.7.1.17.2 EcoQ Element (m) Changes/kills in zoobenthos in relation to eutrophication

ICES could not conduct a technical evaluation of the specific OSPAR EcoQO:

> "There should be no kills in benthic animal species as a result of oxygen deficiency and/or toxic phytoplankton species."

Area-specific data on rates of benthic kills due to oxygen deficiency and toxic phytoplankton species are lacking for many areas, and there is little guidance on the conditions under which data can be extrapolated from source areas to other areas. This circumstance made it impossible to conduct a scientifically sound evaluation of the rates of kills of benthic species as an indicator of eutrophication, because the data necessary to provide a quantitative basis for the review of the EcoQO area by area are not available. Therefore, ICES conducted the entire formal evaluation at the scale of the EcoQ element.

Recommendations and advice

ICES recommends that this EcoQ element be retained, because the macrozoobenthos community provides an integrated response to processes in the water column. **However, the proposed specific EcoQO for this element is premature.** Rather, the scientific basis for setting specific EcoQOs needs further development and implementation. Important lines of further research are described in the conclusions.

Technical evaluation

Table 2.1.7.1.17.2.1 Technical evaluation of the EcoQ element (m) Changes/kills in zoobenthos in relation to eutrophication. Although this is part of the North Sea pilot project, the EcoQ element was assessed and not the EcoQO as there was inadequate information to permit a technical evaluation of the EcoQO. The science underpinning this evaluation is summarized in the supporting text.

		Comments	
1	**Issue**	6. Benthic communities	
2	**Element**	(m) Changes/kills in zoobenthos in relation to eutrophication	
3	**ICES criteria**		
	Relatively easy to understand by non-scientists and those who will decide on their use	Usually	Changes in zoobenthos are already widely in use in monitoring of human impact on the marine environment. However, the public and many managers are uninformed about the significance of benthic species. Kill events can receive substantial public awareness if they occur in accessible areas.
	Sensitive to a manageable human activity	Occasionally	Zoobenthos change or kills can be the result of processes NOT associated with eutrophication (e.g., sudden temperature/salinity changes, oxygen depletion NOT associated with eutrophication, changes in predator populations, pollution incidents, disturbance (e.g., dredge spoil dumping, beam trawling)). This risk of misinterpretation of the cause of changes in the zoobenthos community is substantially reduced when zoobenthos is monitored together with other parameters, e.g., nutrients, phytoplankton and near-bottom oxygen concentration. Also, some causes of eutrophication-related kills, such as atmospheric deposition of nitrogen compounds, may not be readily manageable.
	Relatively tightly linked in time to that activity	Occasionally	Benthic populations in temperate latitudes normally show one-year cycles, with responses to perturbation in the scale of months or years When kills are the result of eutrophication, they will be linked closely in time to oxygen depletion, but oxygen depletion may not be linked closely in time to anthropogenic causes of eutrophication. Some biota will respond quickly to changes in oxygen conditions; others may respond slowly and the effects of perturbations may not be detectable for years.
	Easily and accurately measured with a low error rate	Occasionally	Monitoring experience shows that, with a feasible standard sampling regime designed to account for spatial variability, changes are measured with low error.
	Responsive primarily to a human activity, with low responsiveness to other causes of change	Occasionally	The main sources of stress to the zoobenthos are human activities, e.g., physical disturbance (due to fisheries or other activities), anoxia, sedimentation, etc. Hence, the use of zoobenthos as an indicator of eutrophication alone is problematic. The effects on the zoobenthos from hypoxia, increased organic load, and climate change can sometimes be difficult to discriminate from changes due to other sources of disturbance (sediment contamination, dredging, disposal of dredged materials, bottom trawl fishing, etc.).
	Measurable over a large proportion of the area to which the EcoQ metric is to apply	Usually	Measurable in all waters where eutrophication is a problem.

	Based on an existing body or time series of data to allow a realistic setting of objectives	Occasionally	Time series of zoobenthos kills are not numerous, but are also not necessary for setting realistic EcoQOs. Sound monitoring regimes have been developed which can allow the incidence of kills to be detected. Interpreting the meaning of a kill event requires knowledge of the cause of the kill (see "Sensitive to a manageable human activity") more than historical rates.
4	**Ecological relevance/basis for the metric**	The zoobenthos community provides an integrated response to processes including eutrophication in the water column and in the sediments; thus, responses in the zoobenthos community are useful as an EcoQO of eutrophication, so long as other factors causing zoobenthos change are taken into account. It should be related to the other eutrophication EcoQs.	
5	**Current and historic levels (including geographic areas)**	Time series analyses should be conducted to establish a baseline as well as natural oscillations in benthic community structure and biomass. For a number of OSPAR areas, the frequency and spatial coverage of monitoring for indirect or other possible effect assessment parameters need to be reconsidered. Where changes/kills in zoobenthos and fish kills as affected by eutrophication have been used by Contracting Parties, this parameter has been applied in a qualitative, descriptive way.	
6	**Reference level**	No kills of species or substantial changes in the benthic community, caused by eutrophication.	
7	**Limit point**	Kills on scales or with frequencies that place the continuity of the zoobenthos community at risk of irreversible change.	
8	**Time frames**	*Detection of change*	Depends on factors such as water depth, community type. Zoobenthos kills may require months to years of oxygen depletion to develop.
		Use in advice	Annual monitoring, which would allow annual advice. Opportunistic investigation of kills might allow "fast-track" advice.
9	**Advice on EcoQO options (scenarios)**	*Scenario 1*	
		Scenario 2	
		Scenario 3	
10	**Monitoring regimes**	For sampling, see Rumohr (1999). For monitoring of hard-bottom benthos, video transects and photo documentation are widely used but standard procedures are not available. To be able to document the maximum effects of eutrophication on the zoobenthos, sampling should be undertaken annually just after the annual bottom oxygen minimum period, in addition to a reference monitoring in late spring. Determining the time for optimal sampling may be facilitated by ancillary measurements, e.g., concentrations of nutrients, chlorophyll *a*, and organic matter in the upper mixed layer, sedimentation rates of particles to the benthos.	
11	**Management measures to achieve EcoQO**	Control of nutrient discharges from diffuse sources, point sources, and atmospheric deposition if eutrophication is identified as a cause of zoobenthos change. Control of sources of atmospheric emissions could be particularly problematic. Feedback on the effectiveness of management action will be very slow, so the zoobenthos community may remain at risk for a long time unless additional rehabilitation measures are feasible, and are implemented.	

Conclusions

ICES concludes that the zoobenthos community provides an integrated response to processes in the water column and thus is important as an EcoQ element. However, EcoQOs for this element need further development and implementation. Specific actions needed include:

- Identification of macrozoobenthos species or species groups which are particularly sensitive to oxygen depletion and eutrophication, and the geographical ranges in which they are appropriate;

- Identification of reference levels and conservation limits for those species and areas;

- Relating zoobenthos species and community properties of candidate EcoQOs for eutrophication to zoobenthos species and community properties being developed as EcoQOs for sensitive species (EcoQ element (o)), and threatened and declining species (EcoQ element (b)).

Additional considerations

To be able to document the maximum effects of eutrophication on the zoobenthos, sampling should be undertaken both in late Spring and just after the annual bottom oxygen minimum period, whenever that occurs There has been interest in adopting a marine benthic biotic index for use as a measure of the ecological quality of benthic communities in response to changes in nutrient and organic fluxes. Further work and area-specific verification are needed before such biotic indices should be used.

Reference

Rumohr, H. 1999. Soft bottom macrofauna: Collection, treatment, and quality assurance of samples (Revision of No. 8). ICES Techniques in Marine Environmental Sciences, 27. 19 pp.

2.1.7.1.17.3 EcoQ Element (q) Phytoplankton chlorophyll *a*

ICES could not conduct a technical evaluation of the specific OSPAR EcoQO:

> "Maximum and mean chlorophyll *a* concentrations during the growing season should remain below elevated levels, defined as concentrations > 50% above the spatial (offshore) and/or historical background concentration."

Area-specific data on maximum and mean chlorophyll *a* concentrations during the growing season are lacking for many areas, and there is little guidance on the conditions under which data can be extrapolated from source areas to other areas. This circumstance made it impossible to conduct a scientifically sound evaluation of the suitability of a 50% elevation from background level as an indicator of eutrophication, because the data necessary to provide a quantitative basis for the review of this EcoQO area by area are not available. Therefore, ICES conducted the entire formal evaluation at the scale of the EcoQ element,

Recommendations and advice

ICES concludes that conceptually chlorophyll is a useful indicator of nutrient conditions and should be included in the suite of eutrophication indicator variables. **However, ecosystem complexity makes it scientifically unsound to adopt a single EcoQO for the entire North Sea or OSPAR area. Rather, ICES recommends that chlorophyll *a* is suitable for development as an EcoQO only on area-specific scales, and the development of EcoQOs at area-specific scales should take a pragmatic approach, as described in the conclusions.**

Correspondingly, ICES expresses reservations concerning the specific EcoQO proposed for this EcoQ element of "concentrations > 50% above the spatial (offshore) and/or historical background concentration", as it may not be appropriate for all circumstances, but further work is needed on this issue.

Technical evaluation

Table 2.1.7.1.17.3.1 Technical evaluation of the EcoQ element (q) Phytoplankton chlorophyll *a*. Although this is part of the North Sea pilot project, the EcoQ element was assessed and not the EcoQO as there was inadequate information to permit a technical evaluation of the EcoQO. The science underpinning this evaluation is summarized in the supporting text.

		Comments	
1	**Issue**	7. Plankton communities	
2	**Element**	(q) Phytoplankton chlorophyll *a*	
3	**ICES Criteria**		
	Relatively easy to understand by non-scientists and those who will decide on their use	Occasionally	The public and managers have little awareness of the importance of chlorophyll *a* in water bodies. They are sensitive to and concerned about the consequences of its variation, but generally are not aware of chlorophyll *a* as an entity itself.
	Sensitive to a manageable human activity	Usually in clear waters Rarely in turbid waters See comments about exceptions	Chlorophyll *a* will respond to management in clear-water areas, but not in other areas where waters are turbid (parts of the Wadden Sea), or where grazers, viruses and other controlling factors keep chlorophyll *a* low. In these areas, the nutrient load increases the secondary production signal rather than the primary production signal.
	Relatively tightly linked in time to that activity (i.e., nutrient loading)	Usually (if no other limiting factors) Rarely (where other factors are limiting, i.e., light and or grazing)	This EcoQ element assumes that phytoplankton production can be determined by measuring the concentration of chlorophyll *a* in a water body. This is only true to varying extents in different coastal water bodies, and reasons for the variation are poorly understood. There also may be lag effects due to ecosystem responses, particularly of the grazers (including the ratio of pelagic to microbial loop grazers), to changes in phytoplankton productivity.
	Responsive primarily to a human activity, with low responsiveness to other causes of change	Occasionally See comment for “tightly linked”	This EcoQ element also assumes that as anthropogenic nutrient loads increase, phytoplankton growth will be stimulated. This is also true to varying extents in different coastal water bodies, and reasons for the variation are poorly understood. There may be additional complications from climate change.
	Easily and accurately measured, with a low error rate	Usually	Analytical and sampling procedures are very well known for chlorophyll *a*. Direct measurement of primary production is difficult and rarely performed, so indirect measures are generally used instead. Hence, linkages between chlorophyll *a* concentration and production are generally unknown.
	Measurable over a large proportion of the area to which the EcoQ metric is to apply	Usually	Satellite remote-sensing technology enables estimates of chlorophyll *a* concentrations over large areas. Conceptually, there are no impediments to measurement over large areas. However, there are significant area-specific variations, and variability in annual and seasonal chlorophyll levels characterize North Sea habitats. There are pronounced area-specific (i.e., within the same habitat) differences in interannual chlorophyll patterns, long-term trends, time, magnitude and duration of the annual bloom maximum, and in the primary factors controlling chlorophyll abundance and dynamics. Therefore, generalizing and extrapolating results from local sampling programmes is impossible.

	Based on an existing body or time series of data to allow a realistic setting of objectives	Usually (in clear waters) Rarely in turbid or other situations (i.e., high grazing)	Remote sensing information may be available for reconstructing historical series, but usually only for offshore areas.
4	**Ecological relevance/basis for the metric**	Chlorophyll *a* responds directly to nutrients through the growth of phytoplankton, which consume oxygen during decomposition and are consumed by grazers. To the extent that it reflects primary productivity of an area, it indicates the basic potential productivity of the entire ecosystem.	
5	**Current and historic levels (including geographic areas)**	If possible, use historical data. If not available, use modelling results or offshore data. Tested models exist which could be parameterized to serve this purpose for some areas.	
6	**Reference level**	See comment for 5). These should be made relevant to the area that is being described.	
7	**Limit point (thresholds)**	Need to be developed for specific geographical locations	Ecosystem complexity makes it difficult to recommend a specific chlorophyll threshold level for general use, the periods and frequency of measurement during the annual cycle to be followed, or to encourage the search for a common chlorophyll standard for area-specific application.
8	**Time frames**	Need to be developed for specific geographical locations	See discussion.
9	**Advice on EcoQO options (scenarios)**		
10	**Monitoring regimes**	Should take at least monthly samples, and sometimes sample even more closely in time; the spatial coverage should be adequate to describe the conditions within the entire water body. A small number of monitoring programmes exist, but coverage is inadequate for most of the OSPAR area. Local monitoring should be complemented with satellite remote sensing data, when possible.	
11	**Management measures to achieve EcoQO**	Reduction of nutrient discharges from the relevant diffuse sources, point sources, and atmospheric deposition.	

Conclusions

ICES concludes that chlorophyll *a* is a useful indicator of phytoplankton biomass and should be included in the suite of eutrophication indicator variables. However, phytoplankton biomass is only occasionally an indicator of eutrophication. Moreover, although conceptually chlorophyll is a useful indicator of phytoplankton concentration, ecosystem complexity makes it difficult to recommend a specific chlorophyll threshold level for general use, the periods and frequency of measurement during the annual cycle to be followed, or to encourage the search for a common chlorophyll standard for area-specific application. Rather**, a pragmatic approach is recommended that takes into account the overall area-specific, seasonal and interannual chlorophyll patterns, and the area-specific nutrifying and habitat conditions, including riverine discharge, thus characterizing the ecosystem under consideration**. Hence, chlorophyll *a* is suitable for development as an EcoQO only on area-specific scales.

The robustness of using a constant value of 50% above natural background conditions should be explored for a range of local conditions, to evaluate whether there are circumstances where a different value than 50% should be used to achieve the intent of this EcoQO.

Additional considerations

Although there is no fixed relationship between chlorophyll *a* and nutrients that can be generally applied, there is a positive trend whereby concentrations of chlorophyll *a* are seen to increase with increasing nutrient inputs. This makes interpretation of chlorophyll *a* as an indicator of eutrophication difficult to apply in any consistent manner.

Reference conditions should be determined by type and threshold or limit points, which will be dependent upon the area-specific conditions in the different types of systems.

To detect and apply representative chlorophyll criteria for use as an EcoQ indicator, it is essential that representative yearly chlorophyll determinations be made for a period of at least ten years to detect signals of change that are masked in the intrinsic variability characterizing phytoplankton cycles and species successions. Establishment of specific chlorophyll levels for EcoQO application to the different ecosystem types in the North Sea region would be greatly facilitated by a retrospective analysis of time series data available for this region.

Lag effects can occur before changes in chlorophyll can be detected in response to eutrophication conditions. This impediment may be further compromised by the effects of climate change, including changes in temperature and river runoff volume. Chlorophyll dynamics are an ecosystem-regulated response and not the result of a simple, linear response, e.g., nutrients to phytoplankton growth to biomass (i.e., chlorophyll). Rather, this linkage can be (and is) controlled variably by the type and abundance of the grazer communities.

2.1.7.1.17.4 EcoQ Element (r) Phytoplankton indicator species for eutrophication

ICES could not conduct a technical evaluation of the specific OSPAR EcoQO:

> "Region/area-specific phytoplankton eutrophication indicator species should remain below respective nuisance and/or toxic elevated levels (and increased duration)."

Area-specific data on nuisance and/or toxic elevated levels of phytoplankton are lacking for many areas, and there is little guidance on the conditions under which data can be extrapolated from source areas to other areas. This circumstance made it impossible to conduct a scientifically sound evaluation of the suitability of unspecified phytoplankton species remaining below those levels as an indicator of eutrophication, because the data necessary to provide a quantitative basis for the review of this EcoQO area by area are not available. Therefore, ICES conducted the entire formal evaluation at the scale of the EcoQ element.

Recommendations and advice

ICES concludes that conceptually this EcoQ element may be a sound basis for development into an EcoQO. However, logistically it is premature to commence setting specific EcoQOs, and ICES recommends that further work be done to develop the scientific basis for setting EcoQOs, before specific EcoQOs are adopted. Key priorities for development are identified in the conclusions.

Technical evaluation

Table 2.1.7.1.17.4.1 Technical evaluation of the EcoQ element (r) Phytoplankton indicator species for eutrophication. Although this is part of the North Sea pilot project, the EcoQ element was assessed and not the EcoQO as there was inadequate information to permit a technical evaluation of the EcoQO. The science underpinning this evaluation is summarized in the supporting text.

		Comments	
1	**Issue**	7. Plankton communities	
2	**Element**	(r) Phytoplankton indicator species for eutrophication	
3	**ICES criteria**		
	Relatively easy to understand by non-scientists and those who will decide on their use	Occasionally	Individual species are easy to understand but there is low public awareness of the importance of individual species. Grouping of individual taxa into functional groups has less variability than individual species dynamics (especially if linked to primary production). Functional groups may have less or more meaning to non-technical audiences, depending on function.
	Sensitive to a manageable human activity	Occasionally	Highly species- and group-specific. Individual species have been demonstrated to be related to known human activities in certain areas. Certain functional groups will respond to eutrophic conditions in a consistent pattern. Potentially, the use of functional groups can smooth out noise in the link between phytoplankton groups and eutrophic conditions. Harmful algal blooms (HABs) most often have no direct relevance to eutrophication, and should be regarded as a second-order effect of eutrophication. Even where a plankton species is known to respond to anthropogenic nutrient levels, the human activity may not be readily responsive to management.
	Relatively tightly linked in time to that activity	Usually (for the right species)	Phytoplankton is the initial and most relevant response to nutrient enrichment. The type of changes can be composition, abundance or production rates. Species that are rapid responders should be chosen.
	Easily and accurately measured, with a low error rate	Accurately – can be usually; Easily – rarely	There is high natural variability for most species, so to measure accurately there must be good and frequent long-term sampling to avoid large errors in data. Can be done reliably with good reference data for each area. Laboratory analysis is accurate with specialist people; however, it is time-consuming, so not *easily* measured. Presently no automatic systems exist for species identification, although some are being examined.
	Responsive primarily to a human activity, with low responsiveness to other causes of change	Occasionally	In defined areas, with known nutrient loading data, the response can be linked to nutrient enrichment. May be more difficult to link in open waters with high water exchange. Potentially, climate change can be an influencing factor as well. In addition, any introductions of exotic species can alter the relevance of historical data for the current situation.
	Measurable over a large proportion of the area to which the EcoQ metric is to apply	Usually	Phytoplankton are measurable over all waters, but it is costly and time-consuming to do so.

	Based on an existing body or time series of data to allow a realistic setting of objectives	Occasionally	The use of individual phytoplankton species or groups as environmental indicators has been a classical objective of phytoplankton ecologists. These efforts have been very unsuccessful, but this may partly be a consequence of inadequate databases or time series. Time series of plankton sampling do not cover the OSPAR area well, and many of the existing time series have not been analysed fully with regard to species composition.
4	**Ecological relevance/basis for the metric**	Phytoplankton is the primary response variable to nutrient change and as such is fundamental for any other associated effects. Understanding of phytoplankton dynamics (both individual species and functional groups) and primary production is essential in defining ecological structure. However, phytoplankton dynamics are highly variable in space and time, and need to be related to specific areas and functional seasons. Observed changes need to be stable over time to be conclusive. Caution is advised in using HABs as indicators of eutrophication.	
5	**Current and historic levels (including geographic areas)**	There exist a few long, high-quality time series on phytoplankton occurrence (>25 years).	
6	**Reference level**	Dependent on area. Expert groups responsible for monitoring in each area should define reference conditions and action levels for issues of concern. In addition, area-specific information will define the choice of indicator (indicator could be individual species or functional group or relative abundance or a set of such). This is similar to the process being undertaken for WFD for estuaries and coastal waters.	
7	**Limit point**	"Limit" in this case may be *upper* limit for abundance of indicator species. Limits will have to be species- and area-specific, and data to set limits are unlikely to be available for many parts of the OSPAR area.	
8	**Time frames**	*Detection of change*	Observed changes need to be stable over time to be conclusive. They should deviate substantially from a reference trend. Dependent on the natural variability in the area; responses rarely detectable on time scales of less than five to ten years.
		Use in advice	Unknown until better developed, but likely to require assessments on an annual basis.
9	**Advice on EcoQO options (scenarios)**	*Scenario 1*	
		Scenario 2	
		Scenario 3	
10	**Monitoring regimes**	Selection of main observation areas for sampling, usually with need for taxonomic expertise to be available where samples are processed.	
11	**Management measures to achieve EcoQO**	Reduction of nutrient discharges from diffuse sources, point sources, and atmospheric deposition.	

Conclusions

ICES concludes that conceptually this EcoQ element may be a sound basis for development into an EcoQO. However, setting area-specific EcoQOs presupposes knowledge of the composition and abundance of the phytoplankton community (functional groups) in the area and knowledge of levels of nuisance phytoplankton species which would be considered elevated, and related to eutrophication processes in specific areas. These requirements make it logistically premature to commence setting specific EcoQOs.

Instead, the following activities should be conducted:

a) Existing time series should be reanalysed with emphasis on groups of algae, species or ratios between functional groups that can be linked to nutrient loads.

b) Relationships should be determined on an area-specific basis where time series are available, and thresholds should be determined according to natural variation in each area. EcoQOs which trigger management action should be species abundances that deviate consistently from reference data, and persist over time. Area-specific indicators to be determined could be amplitude, duration, frequency, and spatial extent of regular blooms, diatom/flagellate ratios, and occurrence of a set of functionally defined algal species shown to respond to nutrient loads.

Additional considerations

The evidence is not encouraging that phytoplankton indicator species or community floristic responses to increased nutrient loading will be found. However, there are clear lines of research that should be pursued to confirm or reject the thrust of the EcoQ element that such species (communities) occur and can be applied. In evaluating this, such relationships should be determined locally for areas where time series are available, with potential thresholds determined giving due consideration to the natural variation of the proposed indicator species, community or functional group ratios in each area. There is information in existing long-term data series available for European and U.S. coastal waters that can be mined in the search for phytoplankton indicator species, communities, and functional group responses to elevated nutrient levels and other anthropogenic modifications of water quality.

2.1.7.1.17.5 EcoQ Element (t) Winter nutrient concentrations

ICES could not conduct a technical evaluation of the specific OSPAR EcoQO:

> "Winter DIN and/or DIP should remain below elevated levels, defined as concentrations > 50% above salinity-related and/or region-specific natural background concentrations."

Area-specific data on winter DIN and/or DIP concentrations are lacking for many areas, and there is little guidance on the conditions under which data can be extrapolated from source areas to other areas. This circumstance made it impossible to conduct a scientifically sound evaluation of the suitability of a 50% elevation above salinity-related and/or region-specific natural background concentrations as an indicator of eutrophication, because the data necessary to provide a quantitative basis for the review of this EcoQO area by area are not available. Therefore, ICES conducted the entire formal evaluation at the scale of the EcoQ element.

Recommendations and advice

ICES recommends that winter nutrient concentrations are a very useful EcoQ element but that the EcoQO should be developed only at area-specific scales, and that assessments should include the entire water column and salinity gradient in order to be able to determine the concentrations at a relevant, area-specific reference salinity.

ICES acknowledges that the proposed quantitative value for the EcoQO of "concentrations > 50% above salinity-related and/or area-specific natural background concentrations" is to some extent arbitrary, but has no basis to propose that other values would be more appropriate.

Technical evaluation

Table 2.1.7.1.17.5.1 Technical evaluation of the EcoQ element (t) Winter nutrient (DIN, DIP) concentrations. Although this is part of the North Sea pilot project, the EcoQ element was assessed and not the EcoQO as there was inadequate information to permit a technical evaluation of the EcoQO. The science underpinning this evaluation is summarized in the supporting text.

		Comments	
1	**Issue**	9. Nutrient budgets and production	
2	**Element**	(t) Winter nutrient (DIN, DIP) concentrations	
3	**ICES criteria**		
	Relatively easy to understand by non-scientists and those who will decide on their use	Occasionally	Some public awareness has been raised about the importance of nutrient levels in ecosystems. Understanding of the specific metric/indicator is weak, however.
	Sensitive to a manageable human activity	Usually (where anthropogenic loading is a substantial part of nutrient levels)	A ban on phosphate in detergents in some countries is reflected in reduced riverine loads and lower DIP concentrations. Better agricultural practice has led to reduced nitrogen inputs and DIN concentrations in certain areas. Improved wastewater treatment has supported these developments.
	Relatively tightly linked in time to that activity	Usually (same qualifications as in “sensitive to manageable human activity”)	Nutrient concentrations are likely to increase in response to increases in inputs faster than they decrease in response to management measures intended to reduce loading. However, present trends in continental rivers show a decrease after measures have been taken to reduce inputs, and decreased concentrations of winter salinity-normalized nutrients are observed in some coastal areas.
	Easily and accurately measured, with a low error rate	Usually	Salinity-normalized winter nutrient concentrations can be measured using standard oceanographic methods. Coastal area flushing rates are more problematic.
	Responsive primarily to a human activity, with low responsiveness to other causes of change	Occasionally (Usually, where flushing rate is low)	Winter nutrient concentrations in coastal waters (corrected to a standard salinity) are sensitive to: 1) nutrient load, 2) flushing rate, and 3) offshore nutrient concentrations. Flushing rates can be dependent on processes such as freshwater runoff, wind, and tidal range, where human activities often have a small influence. Also, nutrients from atmospheric deposition and seabird colonies are not produced by manageable human activities, but may be large inputs.
	Measurable over a large proportion of the area to which the EcoQ metric is to apply	Usually	The measurement of coastal nutrients is standard in many monitoring programmes. The measurement of offshore nutrient concentrations is less common. The measurement of flushing rate is extremely rare. Reference to coastal circulation models may be necessary. Winter has to be specified on an area-specific basis, i.e., two months prior to the normal onset of the spring bloom.
	Based on an existing body or time series of data to allow a realistic setting of objectives	Occasionally	Most available data are from the period after anthropogenic sources began to increase. Some information which can be used to estimate historical inputs and, possibly, concentrations is available.

4	**Ecological relevance/basis for the metric**	High relevance, as nutrients are at the basis of phytoplankton biomass formation.	
5	**Current and historic levels (including geographic areas)**	At present, there are elevated concentrations to a varying degree in some coastal areas, compared to historical levels. Historical levels are poorly known for almost all areas, however. Coupled oceanographic/nutrient models can be used to estimate appropriate levels, in cases where historical nutrient levels are known.	
6	**Reference level**	Two options: either use offshore (unaffected) values or a salinity-dependent approach based on reconstructing or extrapolating to historical loads. The EcoQO should be developed on an area-specific scale.	
7	**Limit point**	Values are only meaningful on an area-specific scale. Area-specific chlorophyll limits beyond which winter nutrient data should not be included in assessments have to be defined as the spring bloom may start earlier.	
8	**Time frames**	*Detection of change*	About ten years. If correction for runoff is possible, maybe five years.
		Use in advice	Application on an area-specific scale.
9	**Advice on EcoQO options (scenarios)**	*Scenario 1*	
		Scenario 2	
		Scenario 3	
10	**Monitoring regimes**	High spatial coverage in winter focusing on the salinity gradient. Higher frequency and geographical coverage at coastal stations where higher dynamics can be expected.	
11	**Management measures to achieve EcoQO**	Reduction of anthropogenic nutrient discharges from diffuse sources, point sources, and atmospheric deposition. Where elevations are detected, the desired management actions are ones that would reduce nutrient inflow. However, sources of nutrients are often difficult to determine, and measures to reduce their outputs may also be difficult to identify and implement.	

Conclusion

ICES concludes that winter nutrient concentrations directly respond to nutrient loads and therefore are a very useful EcoQ element. **ICES recommends that the EcoQ element should be developed as an EcoQO at area-specific scales, and that assessments should include the entire water column and salinity gradient in order to be able to determine the concentrations at a relevant, area-specific reference salinity.**

The robustness of using a constant value of 50% above natural background conditions should be explored for a range of local conditions, to evaluate whether there are circumstances where a different value than 50% should be used to achieve the intent of this EcoQO.

2.1.7.1.17.6 EcoQ Element (u) Oxygen

ICES could not conduct a technical evaluation of the specific OSPAR EcoQO:

> “Oxygen concentration, decreased as an indirect effect of nutrient enrichment, should remain above region-specific oxygen deficiency levels, ranging from 4–6 mg oxygen per litre.”

Area-specific data on oxygen concentrations and oxygen deficiency levels are lacking for many areas, and there is little guidance on the conditions under which data can be extrapolated from source areas to other areas. This circumstance made it impossible to conduct a scientifically sound evaluation of the suitability of region-specific oxygen deficiency levels as an indicator of eutrophication, and whether they were in the range from 4–6 mg oxygen per litre, because the data necessary to provide a quantitative basis for the review of this EcoQO area by area are not available. Therefore, ICES conducted the entire formal evaluation at the scale of the EcoQ element.

Recommendations and advice

ICES concludes that conceptually oxygen is a useful indicator of potential eutrophication conditions and should be included in the suite of eutrophication indicator variables. **ICES recommends that the development of EcoQOs at area-specific scales should proceed, taking full account of a number of complexities that are listed in the conclusions.**

ICES acknowledges that the proposed quantitative value for the EcoQO of "ranging from 4–6 mg oxygen per litre" is to some extent arbitrary, but has no basis to propose that other values would be more appropriate as rough benchmarks for "area-specific oxygen deficiency levels".

Technical evaluation

Table 2.1.7.1.17.6.1 Technical evaluation of the EcoQ element (u) Oxygen. Although this is part of the North Sea pilot project, the EcoQ element was assessed and not the EcoQO as there was inadequate information to permit a technical evaluation of the EcoQO. The science underpinning this evaluation is summarized in the supporting text.

		Comments	
1	**Issue**	10. Oxygen consumption	
2	**Element**	(u) Oxygen	
3	**ICES criteria**		
	Relatively easy to understand by non-scientists and those who will decide on their use	Usually	The public and decision-makers are generally aware of the importance of oxygen in water, and the possible undesirable consequences when the oxygen levels are depleted.
	Sensitive to a manageable human activity	Occasionally	In some areas, a higher anthropogenic nutrient load gives higher production of organic matter, which increases the oxygen consumption during its decomposition. However, many environmental factors can also affect oxygen concentration and consumption. Oxygen saturation may be more useful than concentrations in some areas, e.g., where temperatures are high or highly variable.
	Relatively tightly linked in time to that activity	Occasionally	It may not be relevant in some areas where cause-effect relationships cannot be established, e.g., in bottom water along the Norwegian Skagerrak coast. Severe oxygen depletion may occur far away (in space and time) from the causal nutrient source due to ocean circulation and stagnation.
	Easily and accurately measured, with a low error rate	Usually	Methods for measuring oxygen are well known and standardized. However, the current methods with which oxygen is measured (concentration, consumption, saturation, etc.) may cause confusion among different users.
	Responsive primarily to a human activity, with low responsiveness to other causes of change	Rarely	Bottom-water oxygen concentrations are determined by a number of different processes besides consumption, i.e., vertical mixing, stratification, horizontal bottom-water exchange, etc. Also, gathering of over-wintering fish stocks in relatively small areas may cause severe oxygen depletion.
	Measurable over a large proportion of the area to which the EcoQ metric is to apply	Usually	Pre-eutrophication levels, consumption rates and their variability can be determined by the use of 3D coupled numerical models if “natural” riverine and atmospheric nutrient loads can be determined.
	Based on an existing body or time series of data to allow a realistic setting of objectives	Occasionally	For some areas, time series dating back to the 1960s or earlier exist.
4	**Ecological relevance/basis for the metric**	Oxygen values vary regionally, depending on cause-effect relationships. However, the amount of oxygen in the water can be a critically important property of local areas.	
5	**Current and historic levels (including geographic areas)**	Area-specific values.	
6	**Reference level**	Area-specific pre-eutrophication levels and natural variability. Can be determined by the use of numerical models.	
7	**Limit point**	Area-specific limit points. Use concentrations/ saturation/ consumption rates as applicable.	
8	**Time frames**	*Detection of change*	Five to ten years (two to three years through 50-year model simulations).
		Use in advice	Depends on local oxygen dynamics; may require frequent sampling, at least at some times and places.
9	**Advice on EcoQO options (scenarios)**	*Scenario 1*	
		Scenario 2	
		Scenario 3	

10	**Monitoring regimes**	A few representative stations sampled at standard depths during the annual minimum (autumn), and more intensive sampling during critical periods (blooms and stratification). Sampling and analyses are relatively inexpensive. Measurements should be obtained during the annual minimum (autumn), but the annual cycle in oxygen should also be described. Oxygen profiles with depth should be examined.
11	**Management measures to achieve EcoQO**	Reduction of nutrient discharges from diffuse sources, point sources, and atmospheric deposition, where relevant, and to levels necessary to remove oxygen depletion problems.

Conclusions

In developing area-specific EcoQOs, a number of specific considerations must be taken into account, including:

a) The dose-response relationship between eutrophication and oxygen consumption is not clear.

b) Oxygen saturation may be more useful than concentrations in some areas, e.g., where temperatures are high or highly variable.

c) Potential oxygen minimum at intermediate depths should be identified.

d) Pre-eutrophication levels, reference levels, and limit points should be specified on an area basis.

In using this EcoQO on area-specific scales:

a) Measurements should be taken as close to the bottom as possible.

b) Measurements should be obtained during the annual minimum (autumn), but the annual cycle in oxygen should also be described.

The robustness of using a range of 4–6 mg oxygen per litre to encompass the range of area-specific oxygen deficiency levels should be explored for a range of local conditions, to evaluate whether there are circumstances where the appropriate value to achieve the intent of this EcoQO may be outside this range. In all cases, the best area-specific information should be used as the basis for EcoQOs.

Other considerations

The language used in describing oxygen levels in the marine environment is variable, and sometimes appears inconsistent among different parts of the material exchanged between ICES and OSPAR on this topic. Concerns highlighted in Section 2.1.7.1.17.7, below, are particularly relevant here.

Studies of temporal trends in oxygen levels are mostly carried out by linear regression analyses, which assume a gradual dose-response function between nutrient loads and oxygen concentrations. However, whether applying direct biological parameters, such as algal biomass and algal species composition, or indirect parameters, such as oxygen consumption and oxygen concentrations, to assess the impact of eutrophication on marine ecosystems, it is essential to know the exact dose-response relationship as well as the natural variability of the various parameters.

2.1.7.1.17.7 Potential new EcoQ elements/EcoQOs related to eutrophication

Source of information

The 2004 report of the Study Group to Review Ecological Quality Objectives for Eutrophication (SGEUT) (ICES CM 2004/ACE:04).

The 2004 report of the Workshop on Future Directions in Modelling Physical-Biological Interactions (WKFDPBI) (ICES CM 2004/C:02).

Review from the 2004 meeting of the Advisory Committee on the Marine Environment (ACME).

Recommendations and advice

ICES recommends that the measured and modelled N/P ratio (in May) might be suitable for use as an EcoQ element, with further scientifically based development into EcoQOs.

ICES also considered whether nutrient loads could serve as a new EcoQ element. ICES felt that this may be a promising subject for an EcoQ element. Again, however, data are required to allow this ecosystem property to be investigated further with regard to its suitability as an EcoQ element. ICES recommends that OSPAR make available existing compilations of riverine freshwater and nutrient loads, and develop data collection with a minimum monthly time resolution. It might be possible to use these data to define a new EcoQ element, with further development into scientifically based EcoQOs.

ICES considered the potential value of primary production and the occurrence of harmful algal events as possible EcoQ elements, and concluded that neither was promising as potential EcoQ elements, at least at this time. For primary production, the main consideration was serious methodological problems in the absolute determination of primary production, and a scarcity of time series of direct measurements of it. Harmful algal blooms most often have no direct relevance to eutrophication, and should be regarded as a second-order effect of eutrophication.

ICES considered both benthic microphytes and macrophytes (including other seaweeds) and partial pressure CO_2 for the development of new EcoQ elements. Both require substantial work before there would be a scientific basis to judge whether they could be developed into practical EcoQ elements.

Scientific background

N/P ratio as a new EcoQ element

After the well-known oceanic harmful algal bloom of *Chrysochromulina polylepis* in the eastern North Sea in 1988, much attention has been given to the potential negative effects of changed nutrient compositions. It was found that increased N/P ratios (or lack of phosphorus) might have been the cause for triggering the algae to develop harmful toxins. The management decision to reduce the loads of nitrogen and phosphorus to the North Sea by 50% compared to the loads in 1985 has been successful with respect to phosphorus, but not with respect to nitrogen. This has led to an increase in the N/P ratio, which is likely to modify the species composition of the phytoplankton. Due to the very high concentrations of nitrogen in the continental rivers, the N/P ratio (especially during spring/early summer) is a strong indicator of water in the North Sea affected by continental rivers. Three-dimensional numerical ecosystem model results suggest that potential changes in the river loads due to management actions will have significant effects on the N/P ratios, especially at some distance from the sources. Therefore, this may be a sensitive element for checking the effect of management. However, while applicable to the North Sea and the Baltic Sea, this criterion may not be useable in other areas.

Nutrient loads as a new EcoQ element

The EcoQ elements related to eutrophication have to be assessed in relation to the nutrient loads to the system. One of the most useful methods of recording the total nutrient input to the system is to develop a “pressure” indicator using the loads of nutrients entering marine waters. These are assessed routinely and reported as part of the OSPAR riverine and direct inputs (RID) programme and to meet the requirements of a number of EU Directives. The riverine nutrient loads could be developed into new EcoQ elements as total loads for individual major rivers, and integrated over given coastal lengths (including estimates of diffuse loads). The quantification of nutrient loads in specific areas would be enhanced if atmospheric nitrogen deposition could be compiled on a monthly basis, and (where relevant) the possibility to determine transboundary nutrient transports evaluated. The latter requires the input from numerical ocean circulation models which for more operational reasons requests near real-time inputs of riverine loads of fresh water and nutrients. Therefore, it is suggested that hydrological models be developed to provide real-time and predictions of daily freshwater supplies to the ocean, with statistical relations to support the nutrient loads.

References

Markarger, S., and Storm, L. 2003. Miljøeffektvurdering for havmiljøet del 1: Empirisk modellering av miljøtilsanden i de åpne farvande. Report from the National Environmental Research Institute, Denmark. 60 pp. (in Danish).

Skogen, M.D., Søiland, H., and Svendsen, E. 2004. Abstract in the Report of the Workshop on Future Directions in Modelling Physical-Biological Interactions (WKFDPBI), Barcelona, 8–9 March 2004.

2.1.7.2 Existing methods of identifying rare, threatened and declining fish species

Request

This is a follow-up to an OSPAR request from January 2002 to assess "*the data on which the justification of the OSPAR Priority List of Threatened and Declining Species and Habitats will be based.*"

Source of information

The 2004 report of the Working Group on Fish Ecology (WGFE) (ICES CM 2004/G:09).

Scientific background

The Texel-Faial criteria, on which the OSPAR Priority List of Threatened and Declining Species is based, represent just one classification system among the many used internationally, regionally, and nationally (for an extensive review, see Section 3 of the 2004 WGFE report). Most of these represent subtle variations of the system developed by the World Conservation Union (IUCN), which explicitly defines categories such as endangered and threatened, and bases assignment to each category on the strict application of quantitative criteria. In comparison, the Texel-Faial criteria and attributes are only loosely formulated, allowing for different interpretations and inconsistent applications. For instance, it is not self-evident what is meant by "threatened and declining species" and the definition of "threatened" in this context deviates from other definitions in international and national legislation. This seems most unfortunate, because application of the Texel-Faial framework provides little guidance on whether special protection is required for species which meet the criteria. Harmonizing the Texel-Faial criteria with existing and widely used classification systems should have a high priority. Also, the suitability of the criteria (both currently and when harmonized with criteria of other agencies) for marine species should be evaluated. Where the potential for unsuitable performance is identified, sounder criteria should be developed, tested, and proposed for adoption.

The existing IUCN criteria and derivatives are largely based on terrestrial biota and recently their application to marine biota has been questioned. Several organizations including the IUCN itself, CITES, and some individual countries (including Canada within the ICES community) are currently conducting formal reviews of the IUCN criteria. It would seem appropriate to await the outcome of these reviews before further evaluating the OSPAR List of Threatened and Declining Species. However, at present ICES concludes that:

1) When the Texel-Faial criteria are applied to marine species, there are serious risks that many operational problems with consistency of performance and potentially inappropriate designations may occur.

2) ICES is well placed and willing to conduct an objective and rigorous review of the Texel-Faial criteria, with regard to their performance on marine species.

3) A review of the criteria and their performance on marine species would best be undertaken when the results of the current reviews by at least IUCN and CITES have been completed. This would allow ICES to benefit from the extensive work done elsewhere, while placing the results in a European context.

2.1.8 Governments

2.1.8.1 Netherlands – Request for advice on North Sea Plaice management

The Netherlands has requested from ICES the following:

- *An evaluation of the current levels of reference points (**B_{lim}**, **F_{lim}**, **B_{pa}**, **F_{pa}**) during the ICES Working Group NSSK of September 2004 and the development of proposals for updated levels, based on the most recent knowledge.*

- *Advice on what levels of F are required to restore the North Sea plaice stock to safe biological levels over a period of about 5-10 years.*

ICES Comments

ICES has considered this request as part of the North Sea plaice assessment and has revised the reference points **B_{lim}** and **B_{pa}** to be consistent with the revised assessment procedure, which now includes discards. The assessment including the revisions is presented in section 4.4.4b.

Advice on what levels of F are required to restore the North Sea plaice stock to safe biological levels over a period of about 5-10 years has not been explored by ICES, given the short time frame between the reception of the request and the meeting of the relevant Working Group. ICES notes that the current fishing mortality (**F_{sq}**) is estimated as 0.71, which is well above levels that would lead to high long-term yields (**F_{max}**=0.17) and low risk of stock depletion.

An EU-Norway expert group has for a number of North Sea stocks, among which is North Sea plaice, recently formulated possible candidates of harvest control rules and evaluated their potential effects, see http://fish.jrc.cec.eu.int/fisheries/stecf/eu-norway/multiannual.html. ICES has not received a finalised proposal nor has it been asked to evaluate any specific proposal and is not in a position to comment on whether these proposals are in accordance with the Precautionary Approach.

2.1.8.2 Iceland – Provide separate advice for each of the appropriate *Sebastes mentella* components in their distribution area

NEAFC requested the same information as part of its annual request to ICES. ICES has considered redfish stock identification with regard to implications for assessment and advice on pelagic *Sebastes mentella* and demersal *Sebastes mentella* in Section 2.1.6.1.

For information on advice relating to management of fisheries on *Sebastes mentella* in 2005, see Sections 4.2.5.c and 4.2.5.d.

2.1.8.3 UK - Sole in Division VIIe (Western Channel)

UK has requested ICES as follows to provide information on sole in Division VIIe (Western part of the Channel)

A) To note the much lower values of $\mathbf{F}_{pa}$ and $\mathbf{F}_{lim}$ for Division VIIe sole compared with sole stocks in the North Sea, Divisions VIId, VIIf+g, VIIa and in the Bay of Biscay, and to advise on the reasons and reliability of such a difference;

B) To explicitly compare, and report on, the catch compositions and estimated age compositions of these sole stocks, and advise on the significance of the comparisons for the relative status of the Division VIIe sole;

C) To advise on what levels of F are required to restore the stock to safe biological levels over periods of about 5-10 years, including options which increase beam-trawl mesh size to 90mm.

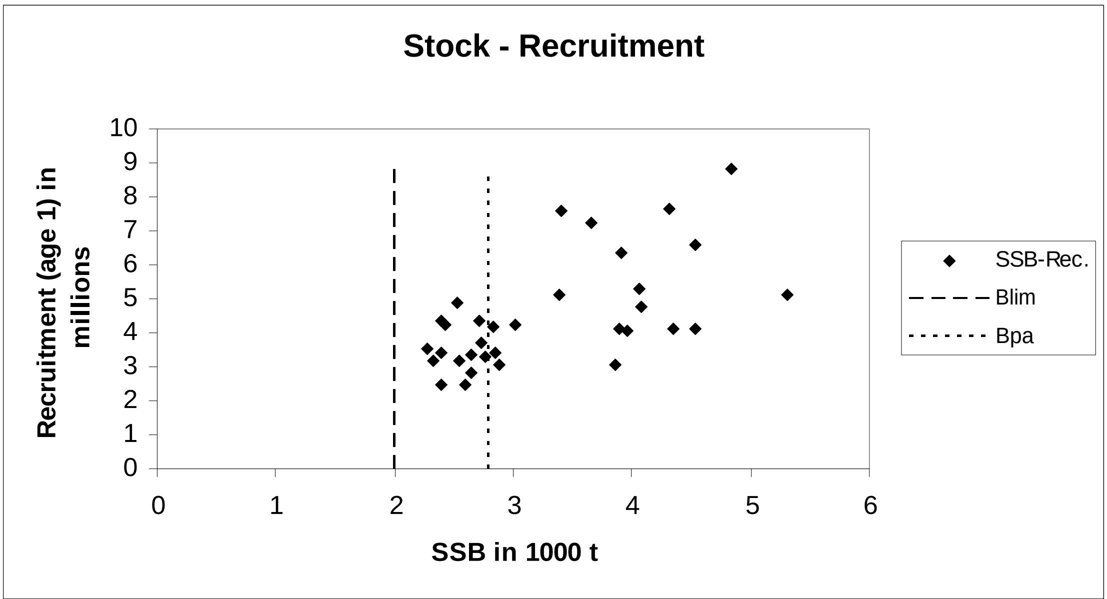
<u>ICES Comments</u>

In 2003 ICES expressed concerns that the stock may be in critical condition due to a decline of SSB below $\mathbf{B}_{pa}$ and fishing mortality levels well in excess of $\mathbf{F}_{pa}$. ICES also considered that there is a major uncertainty about the levels of recent landings due to misallocation and under-reporting. Landings data were revised in 2002 to allow for misallocation of landings into Division VIId, but under-reporting is thought to have been significant in the 1990s. Therefore, the biomass reference points are unreliable. The fishing mortality reference points are less affected by the uncertainty.

In contrast, other indicators of stock status, such as the age structure and levels of fishing mortality when compared to other stocks of sole, indicate that the Division VIIe sole stock could be in less danger of being outside safe levels than would be implied by comparison with the currently accepted reference points.

The Precautionary Approach reference points for the sole in Division VIIe stock were revised in 2001. The re-evaluation of the reference points meant that $\mathbf{B}_{lim}$ was changed from 1 800 t to 2 000 t, $\mathbf{B}_{pa}$ from 2 500 t to 2 800 t. $\mathbf{F}_{lim}$ was changed from 0.36 to 0.28 and $\mathbf{F}_{pa}$ from 0.26 to 0.2.

The current (2 000 t) $\mathbf{B}_{lim}$ is based on the observed SSB on the declining part of the SSB curve close to the current time. However, the interpretation of the stock-recruitment plot for this specific stock is not straightforward. The plot could be interpreted as either reflecting a regime shift or a linear relationship between recruitment and SSB with increasing variability for larger SSB. The latter would imply higher reference points than those presently used. Thus, there may be good reasons to re-consider these reference points. The Figure below shows the SSB-R plot. The lack of a plateau in the SSB-R plot below and the consequent uncertainties regarding biomass based reference points indicates that fishing mortality information might be the better option for proper advice. The present stock is influenced by a strong year class and at such recruitment levels the $\mathbf{F}_{pa}$ fishing mortality leads to a more restrictive TAC than is indicated by the $\mathbf{B}_{pa}$ reference point. However, these recruitment levels may not be maintained. In the face of the uncertain reference points, an adaptive approach to recovery plans should be taken, whereby responses to recovery measures are used to inform on future decisions on further possible recovery measures.



ICES is presently revising its approach to reference points as an integral part of the move from short term advice to advice relating to longer term management plans. The reference points for this stock will be reconsidered as a part of that process.

F_{pa} and F_{lim} for Division VIIe sole

ICES was asked "to note the much lower values of $\mathbf{F}_{pa}$ and $\mathbf{F}_{lim}$ for VIIe sole compared with sole stocks in the North Sea, Divisions VIId, VIIf+g, VIIa and Bay off Biscay, and to advise on the reasons and reliability of such a difference".

The fishing mortality (F) reference points for various sole stocks are indicated in the table below.

Stock	$\mathbf{F}_{pa}$	$\mathbf{F}_{lim}$	**Basis for** $\mathbf{F}_{pa}$	$\mathbf{F}_{pa}/\mathbf{F}_{lim}$
VIIe	0.2	0.28	($\mathbf{F}_{lim}$=$\mathbf{F}_{loss}$); $\mathbf{F}_{lim}$*0.72	0.72
VIId	0.4	0.55	Betw. $\mathbf{F}_{med}$ & 5% fractile $\mathbf{F}_{loss}$;	0.73
IV	0.4	-	P(SSB_{MT}<$\mathbf{B}_{pa}$) <10%	-
VIIa	0.3	0.4	($\mathbf{F}_{lim}$ based on hist.); P(high) avoiding	0.75
VIIfg	0.37	0.52	($\mathbf{F}_{lim}$=$\mathbf{F}_{loss}$); $\mathbf{F}_{lim}$*0.72; P(SSB_{MT}<$\mathbf{B}_{pa}$)	0.72
VIIIab	0.36	0.50	($\mathbf{F}_{lim}$ based on hist.); $\mathbf{F}_{lim}$*0.72	0.72

$\mathbf{F}_{lim}$ and $\mathbf{F}_{pa}$ for Division VIIe sole are the lowest of all the sole stocks compared. Although the basis for $\mathbf{F}_{pa}$ varies, in 4 of the 6 stocks it is set to avoid $\mathbf{B}_{lim}$ with some margin or probability.

The F reference points are dependent on the interplay between recruitment, mortality and SSB. Some of the factors which contribute to the differences in reference points between stocks are discussed below.

<u>Assessment uncertainty</u>

Reference points account for assessment uncertainty, which may be larger for some stocks than for others, stocks for which there is more uncertainty would have $\mathbf{F}_{pa}$ set at lower levels relative to $\mathbf{F}_{lim}$. In the case of VIIe sole, the level of assessment uncertainty was not considered particularly large. Thus in this case it was not a major factor in explaining the relatively low value of $\mathbf{F}_{pa}$ and as the above table shows that the ratio between $\mathbf{F}_{pa}$ and $\mathbf{F}_{lim}$ are almost identical for the sole stocks.

<u>Biological considerations</u>

An important factor in determining Precautionary Reference points is the biological productivity (recruitment, growth and mortality) of the stock. The size of nursery habitat is likely to be one of the major factors driving recruitment in flatfish stocks and it appears that the Division VIIe Sole differs from the other sole stocks in this respect.

In comparison with most of the other sole stocks, Division VIIe sole stock has a smaller nursery habitat relative to the distribution area. The Division VIIe sole nursery habitat, although poorly defined, seems to be limited by the topography of the western channel with a lack of major estuaries and the maximum possible recruitment to the Western Channel sole stock may be more limited than for other stocks. Therefore, lower levels of F would then be required to sustain spawning biomass above a minimum level because the chance of a very strong year class for the VIIe sole is smaller than for other sole stocks.

<u>Conclusion</u>

While comparisons between stocks with similar ecology may provide guidance on expected levels of sustainable fishing mortality such comparisons must be qualified by stock-specific sensitivities and, in relation to the $\mathbf{F}_{pa}$ reference points, also by differences in estimation and forecast uncertainties. Thus, it is not appropriate to determine reference points for Division VIIe sole only by comparison with other stocks.

Catch Compositions and Estimated Age Compositions

ICES was asked to "explicitly compare, and report on, the catch compositions and estimated age compositions of these sole stocks, and advise on the significance of the comparisons for the relative status of the VIIe sole".

In general, a wider age structure is considered to be indicative of lower mortalities and/or a better exploitation pattern in a stock, and if F is considered to be responsible for a large portion of this mortality (as is the case in all sole stocks) a better age structure is indicative of a 'healthier' stock. Division VIIe sole has a wide range of ages (Figure 1), with the largest percentage of older fish in the stock compared to other sole stocks (Table below).

Sole Stock	Average (2001-2003) percentages Stock numbers ages 7+ in percent of stock numbers ages 2+
IV	1.6
VIIa	6.7
VIId	4.0
VIIe	8.9
VIIfg	1.7
VIIIab	1.9

Conclusion

The trend in the proportion of sole at older ages (8+) in the stock (Figure 2), similar to that in the catches, implies that overall levels of mortality have been lower for this stock than in other sole stocks. The age structure of sole suggests that this stock is less likely to be outside 'safe biological limits' than other sole stocks.

Restore the Stock to Safe Biological Levels

ICES was asked "to advise on what levels of F are required to restore the stock to safe biological levels over periods of about 5–10 years, including options which increase beam trawl mesh size to 90mm".

As noted in the introduction above, the reference points are under discussion. However, for the purpose of this review the present Precautionary Approach reference points are used to define 'safe biological limits' and, furthermore, even with the uncertainty of the reference points and the uncertainty in the state of the stock, ICES considers a move to previously observed stock levels, i.e. an increase in SSB, to be a sound and pragmatic approach to management.

The 2002 year-class is estimated to be the largest in the time series. SSB is projected to increase above 2 800 t by 2006 under the current exploitation levels. Thus, ICES considers that specific protection of this exceptional year-class prior to maturity would be the most beneficial approach for the stock.

The present stock is influenced by a strong year class and in the short term SSB is expected to increase above $\mathbf{B}_{pa}$ even at the present fishing mortality. However, in the long-term, fishing mortality must be reduced to below 70 % of its current level if the stock on average (50% fractile) shall maintain SBB above $\mathbf{B}_{pa}$ (2 800 t) and to 40 % of its current level if the fishing mortality shall be reduced below $\mathbf{F}_{pa}$ (0.2). The Table below presents simulations for four levels of fishing mortality based on unchanged fishing mortality in 2004 and unchanged exploitation pattern in the following years.

Fishing mortality	Rel. to Present level	SSB_{2006} t	SSB_{2010} (50% fractile) t	$Yield_{2005}$ t
0.2	0.4	3 767	4 454	695
0.25	0.5	3 623	3 825	851
0.29	0.6	3 481	3 377	1 000
0.34	0.7	3 351	2 937	1 144
0.49	1 (Present level)	2 987	2 047	1 540

The medium term projection is presented in Figure 3a.

Improving the selection pattern would provide recovery slightly faster and to slightly higher SSB levels. This is illustrated by two sets of simulations presented below. The first is based on the assumption by 2005 and onwards all gears are set to the same change in selectivity pattern as observed for a change from 80mm to 90mm in the UK beam trawl fleet.

Fishing mortality	Rel. to Present level	SSB_{2006} t	SSB_{2010} (50% fractile) t	$Yield_{2005}$ t
0.2	0.4	4 018	5 395	412
0.25	0.5	3 929	4 823	508
0.29	0.6	3 843	4 410	601
0.34	0.7	3 752	3 975	691
0.49	1 (Present level)	3 513	3 025	947

The medium term forecast for this option is presented on Figure 3b.

In a second set of simulations, UK beam trawl selectivity was changed from 80mm to 90mm mesh with all other gears retaining original selectivity, simulations are presented in the table below.

Fishing mortality	Rel. to Present level	SSB_{2006} t	SSB_{2010} (50% fractile) t	$Yield_{2005}$ t
0.2	0.4	3 924	5 000	518
0.25	0.5	3 814	4 398	637
0.29	0.6	3 702	3 961	752
0.34	0.7	3 600	3 514	863
0.49	1 (Present level)	3 314	2 579	1 174

The medium term projection for this option is presented in Figure 3c.

Mesh Size Changes

In order to simulate the possible outcomes of a mesh size change several potential scenarios for changes to the exploitation pattern in the fishery were evaluated. The length frequency information for 2003 catches was split by fleet and by quarter so that the changes in selection and closed seasons could be evaluated. From the modified length frequencies, modified exploitation patterns were calculated to produce stochastic forecast trajectories from 2005. Five scenarios were tested to show the effects of different options taking into account some of the data deficiencies and options put forward by the French and UK industry.

All 90mm equivalent: all gears set to the same change in selectivity pattern as observed for a change from 80mm to 90mm in the UK beam trawl fleet.

BT 90 only: UK beam trawl selectivity changed from 80mm to 90mm mesh with all other gears retaining original selectivity

All 100mm equivalent: all gears set to the same change in selectivity pattern as observed for a change from 80mm to 100mm in the UK beam trawl fleet.

BT 100 only: UK beam trawl selectivity changed from 80mm to 100mm mesh with all other gears retaining original selectivity

BT 90, TR90, NQ1=0: UK beam trawl selectivity and French otter trawl selectivity set to a change equivalent to a mesh change from 80mm-90mm. However, it is noted here that it is unlikely that the change in selectivity is transferable between the two trawl gears. French netter landings set to 0 for the first quarter, equivalent to protecting the spawning aggregations.

BT 90, TR 26MLS,NQ1=0: UK beam trawl selectivity set to a change equivalent to a mesh change from 80mm-90mm. French otter trawl selectivity set to knife edge selection at 26cm equivalent to a raising of the minimum landing size. Of course, the increase in MLS will have to be accompanied by appropriate mesh changes to ensure reductions in mortality. French netter landings set to 0 for the first quarter, equivalent to protecting the spawning aggregations.

Status Quo: No change to selection patterns or F-multipliers, as medium term projection in 2004 assessment.

The projected results in terms of SSB and yield are given in Figures 4 and 5.

<u>Summary of Projections involving Mesh Size Changes</u>

All scenarios result in a relatively stable long-term yield of just under 1000t by 2014. Due to good recruitment from the 2002 year-class, short-term losses of yield are negligible for all scenarios, bar the “all 100mm equivalent”, which incurs a temporary decline in yield by 40% in 2005, but returning to 85% of current levels by 2007. For other scenarios short-term yields are projected to rise for 2006 and 2007 by roughly 20% before dropping to the long-term yield.

The long-term stable biomasses vary greatly between 1 850 t for status quo fishing to close to 4000t for ‘all 100mm equivalent’. Three of the scenarios “BT 90, TR90, NQ1=0”, “BT 90, TR 26MLS,NQ1” and “BT 100mm only” indicate a level of SSB close to 2 800 t. All projections indicate an at least temporary rise in SSB due to the 2002 year-class. The scenarios indicate that reducing the number of immature fish taken in the fishery can result in substantial increases in SSB.

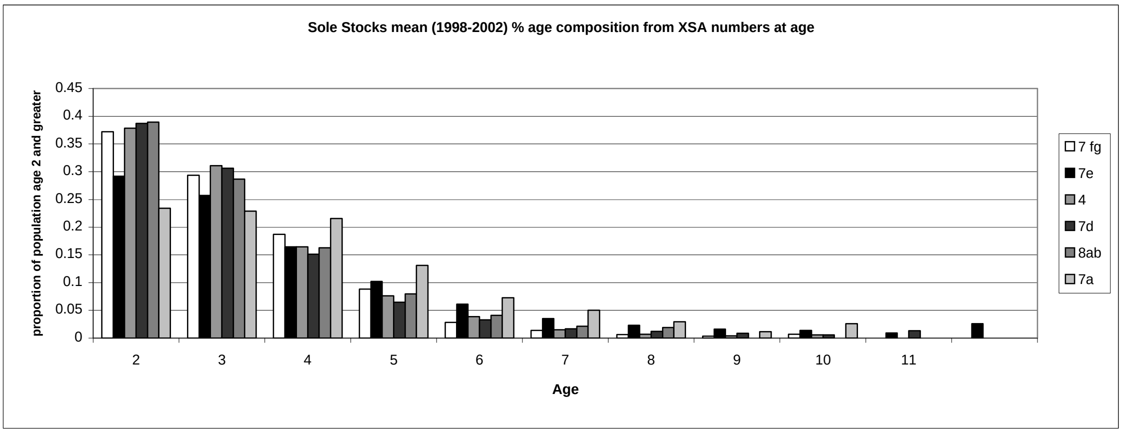


Figure 1: Comparison of sole age structure indicating the number of fish older than 6 years as a proportion of the numbers older than one year for different sole stocks.

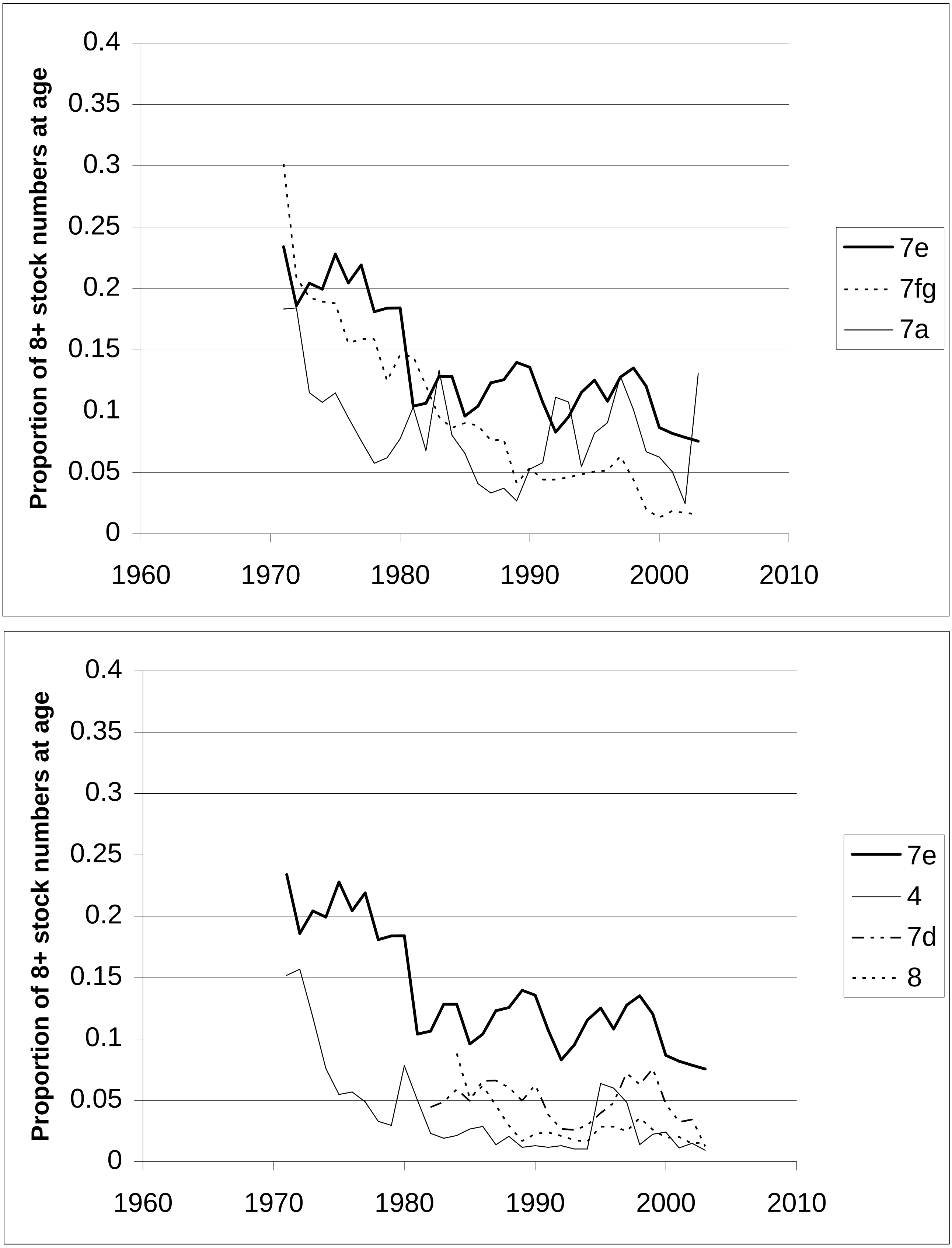


Figure 2. Proportion of no. of fish in the stock at ages 8 and older, for various sole stocks.

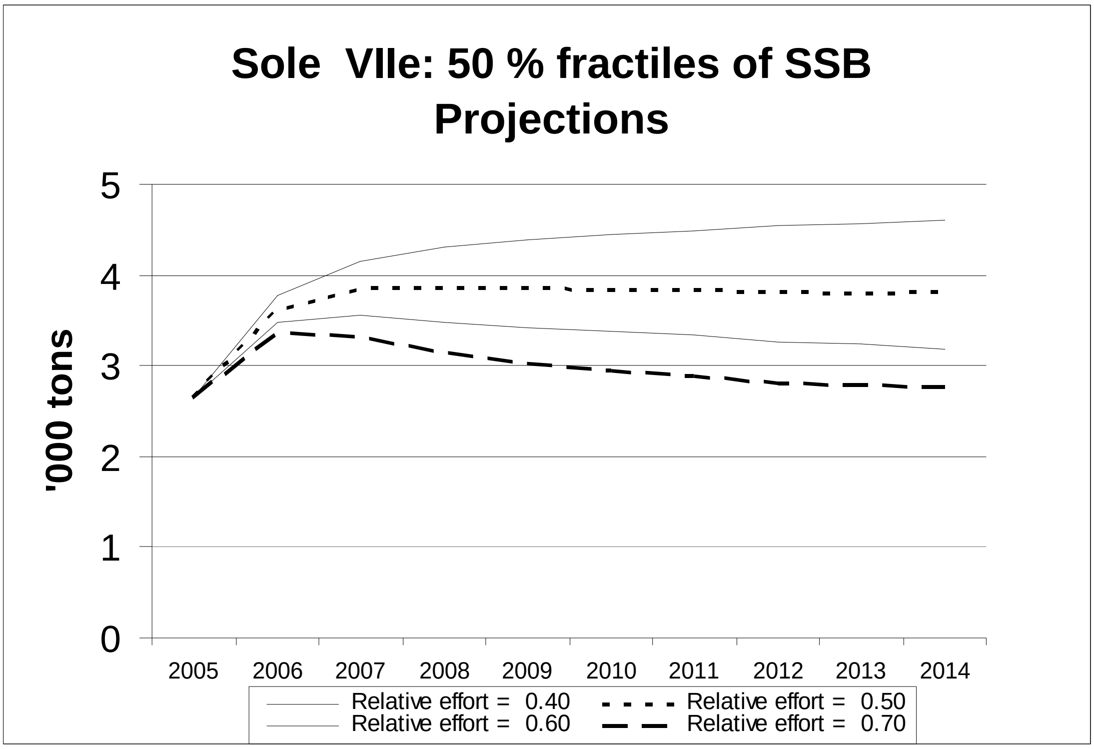


Figure 3a. SSB projections for three levels of fishing mortality that with a 50 % probability produce SSB> Bpa (=2 800 tonnes) in the long-term.

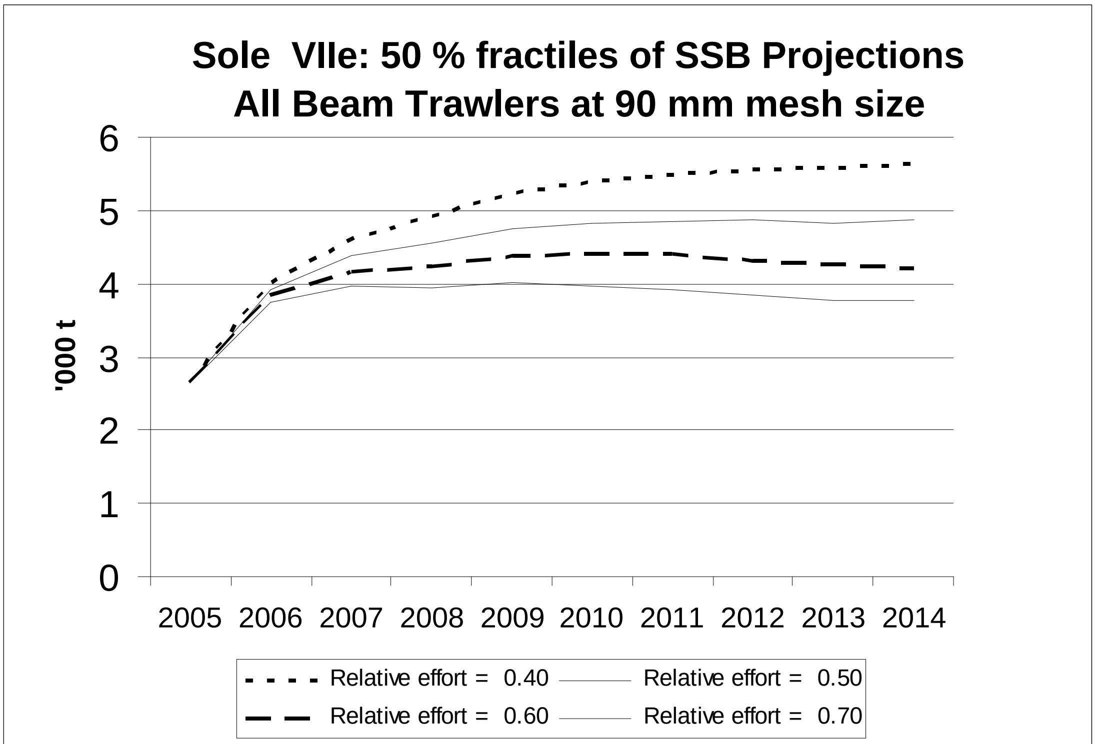


Figure 3b. SSB projections for three levels of fishing mortality that with a 50 % probability give SSB>$\mathbf{B}_{pa}$ (=2 800 tonnes) in the long-term. All gears set to the same change in selectivity pattern as observed for a change from 80mm to 90mm in the UK beam trawl fleet.

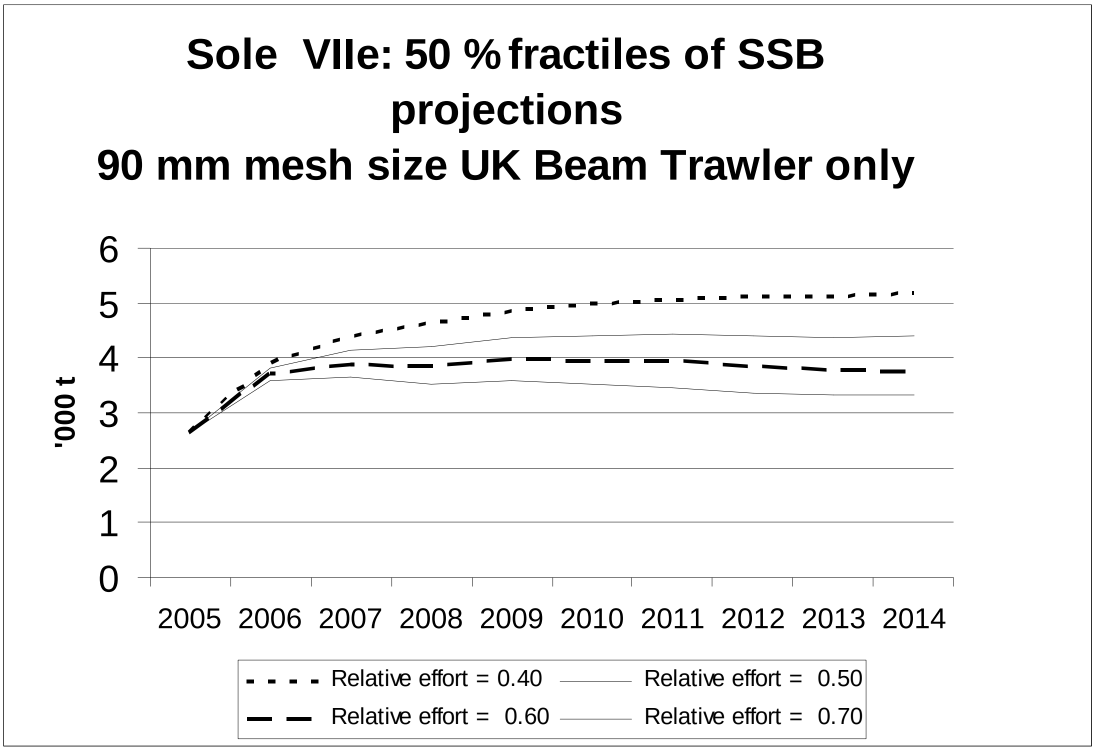


Figure 3c SSB projections for three levels of fishing mortality that with a 50 % probability give SSB>$\mathbf{B}_{pa}$ (=2 800 tonnes) in the long-term. Exploitation pattern for UK beam trawlers fishing with 90 mm mesh, all other fleets with unchanged exploitation pattern.

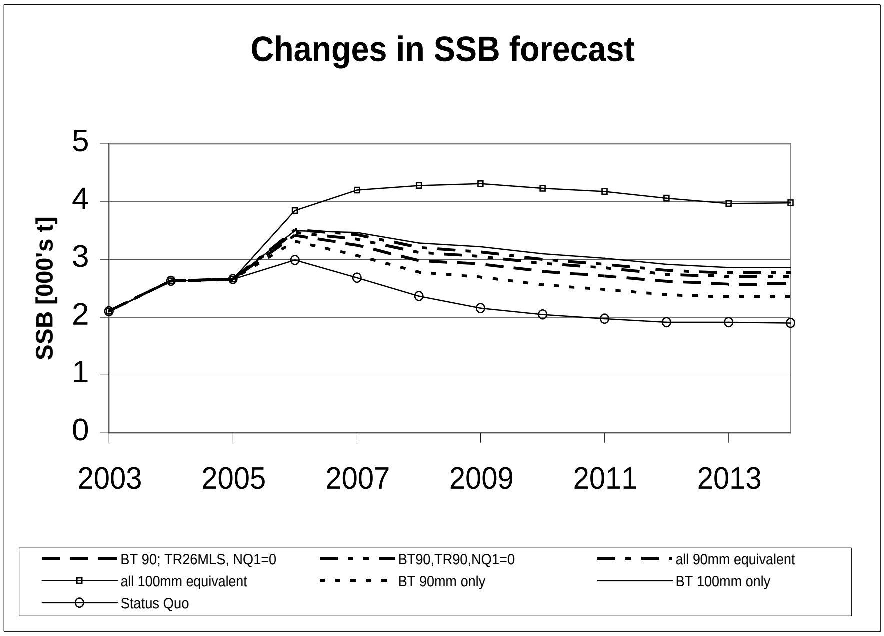


Figure 4 SSB forecast predictions for various management scenarios involving mesh size changes.

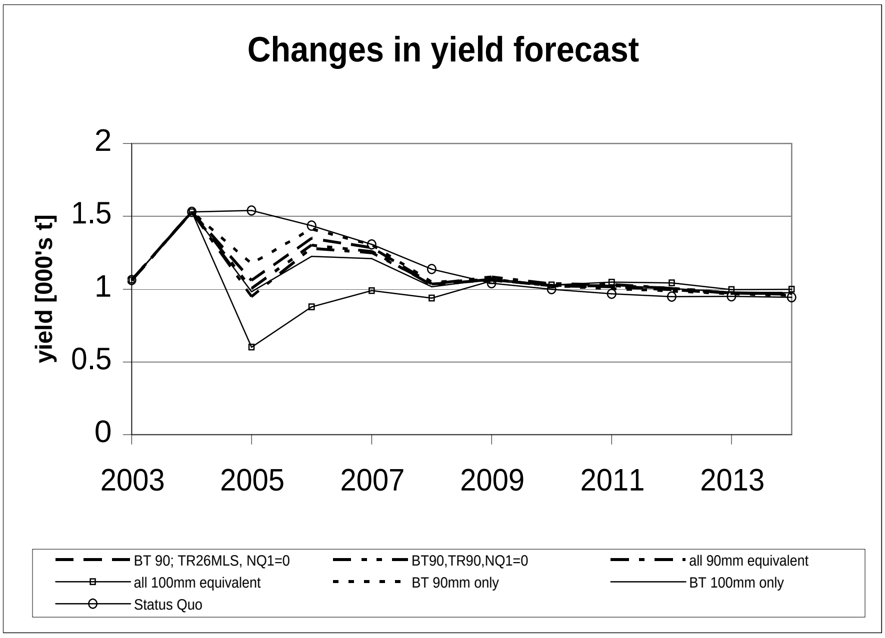


Figure 5. Yield forecast predictions for various management scenarios involving mesh size changes.

2.1.8.4 UK Request for advice on VIa and VIIa *Nephrops*

UK has requested ICES to:

> *Review the advice for 2004 and 2005, in the light of additional information, and consider whether the previous advice should be revised, taking into account any implications for other vulnerable stocks.*

ICES Comments

***Nephrops* in Division VIIa (Management Area J)**

The additional information that has become available since the advice was prepared in 2003 includes a single survey (Lordan *et al*., 2004). The survey is the first of its kind and is still in its development phase. This first survey demonstrates promise to contribute to assessments of these stocks in the future when data from more than one year is available and the method has been consolidated. However, after this first experimental survey the data should, as stated in Lordan et al 2004 'be considered very preliminary'.

Conclusion:

The additional information available is not an adequate basis for revising the assessment and advice that was presented by ICES in 2003 and the advice for a *Nephrops* TAC in 2005 for Division VIIa (Irish Sea) remains unchanged:

The TAC from this Management Area in 2004 and 2005 be kept at the level recommended in 2001, i.e. 9 550 t.

***Nephrops* in Division VIa (Management Area C)**

There are three Functional Units in this Management Area: a) North Minch (FU 11), b) South Minch (FU 12) and c) Clyde (FU 13).

Hitherto, ICES has assessed the *Nephrops* stocks on bi-annual circle. The next regular assessment is scheduled for 2005 with a view to provide advice for 2006.

ICES in 2003 advised that the recent fishing mortality was around F_{max} and that there therefore was no basis to revise the advice given previously of a Management Area TAC of 11 300 t for 2004 and 2005. All stocks in this Management Area were classified as being exploited at sustainable levels.

The *Nephrops* trawlers also land smaller quantities of haddock, cod, whiting, and small saithe, but in some areas and periods large amounts of whiting and haddock are discarded. In 2003 ICES classified the whiting stock in this Division as being outside safe biological limits.

Since ICES provided the most recent advice for these *Nephrops* functional units in 2003 results from underwater TV surveys of the three stocks done in 2003 have become available (Tuck et al 2004). The results showed increases in abundance in FU 11 and FU 13 since 2000, and stable but high abundance in FU12. An increase in harvestable biomass would result in an increase in landings with the same fishing mortality.

The current analysis (see results from analysis below) suggests that the calculated landing for the same fishing mortality as used in the advice is between 11 to 33 % above the prediction on which the 2003 advice is based. The two estimates differ by including catch data (a cohort analysis as was the basis for the advice in the past) or rely entirely on the survey data.

The ICES advice provided in 2003 was based on an analytical assessment showing that the fishing mortality was around F_{max}. On that basis ICES considered that all stocks in the management area C to be exploited at sustainable levels.. The Commission TAC and Quota Regulation for 2004 notes this TAC as being precautionary. ICES, however bases its further considerations on the analytical assessment it presented in 2003.

Changing the assessment procedure must be justified by demonstration of the inappropriateness of the assessment approach which is not the case for this *Nephrops* assessment. Therefore, the most appropriate basis for a revision would be the 11% increase prediction. Revising the advice based on new data is only justified when there is firm evidence of significant changes in stock status. There is considerable uncertainty about landings, discard and effort data for these stocks. An increase in the predicted landings (for the same fishing mortality) in the order of 10% is within the uncertainty in the assessments.

Conclusion

The overriding management concern in this area should be to protect stocks that are harvested unsustainably or suffering reduced reproductive capacity. The fishery should only be allowed to expand if ways of harvesting *Nephrops* without jeopardising other stocks that are fished together with *Nephrops* and that are harvested unsustainably or suffering reduced reproductive capacity can be found.

Although the 2003 surveys indicate higher stock abundance than used in the assessment, they lead to predictions which are within the uncertainty of the 2003 assessment.

ICES, therefore, maintains its advice given in 2003 for TACs for 2004 and 2005 of a Management Area TAC of 11 300 t for 2004 and 2005.

Background:

In this advice ICES has considered two different setups to predict the landings in 2003 and 2004:

- **Setup A is similar with the approach used for the last stock assessment and took into account:**
  - Total Biomass from VPA (ICES, 2003).
  - Trawl Landings
  - Burrow density from TV surveys
  - Yield/TB.
- **Setup B emphasises the survey data by not including VPA results:**
  - Total Landings
  - Burrow density from the TV surveys
  - Landings/burrow density was used as an index of the exploitation rate.
  - Results from VPA were not considered.

The resulting predictions are compared to the mean landings from the period 1994-2000. The recommended TAC was 11300 through this period and the average landings were 11400 t in the period.

The comparisons of the results are shown in Table 1.

Table 1 Predicted landings in Management area C under two different setups for prediction.

		Management area C Predicted landings (tonnes)	
		Prediction setup	
	Year	**A**	**B**
	1993	11332	11332
	1994	11101	11101
	1995	12785	12785
	1996	11165	11165
	1997	11253	11253
	1998	11171	11171
	1999	11492	11492
	2000	11037	11037
	2001	10861	10861
	2002	10467	10467
	2003	**12660**	**15182**
	2004	**12660**	**15182**
	% change 94-00	**11%**	**33%**
Total Biomass (TB)		**x**	**not used**
TV/TB ratio		**x**	**not used**
Landings		**x**	**x**
2003 Burrow density		mean 01-03	mean 01-03
TB/landings 2003		mean 93-02	not used
Landings/density		**not used**	**1993-2002**

According to the working document of Tuck *et al*, 2004, the TV surveys results showed substantial increases in abundance in FU11 and FU13 since 2000, and stable but high abundance in FU12. Taking all the three stocks together, the recent estimates (2001-2003) are around 30% higher than historical estimates (1994-2000). This is reflected in setup B which largely relies on the survey data. Setup B uses average burrow density (2001-2003) in the projection, rather than the single estimate for 2003, and provides an estimated increase in landings in line with the increase in burrow density (33% when compared over the same sets of years). However, it should be noted that the projected 15000 t landings is probably overoptimistic, as, owing to recruitment, the increase in abundance may not be fully realised in terms of harvestable biomass.

Setup A is thus overall considered the most realistic as it takes account of this through use of Total Biomass estimates from VPA. Under this setup a smaller increase is projected (11% compared with 1994-2000), giving expected landings of around 13000 t. The predicted landings by FU for this option is shown in Table 2.

Table 2 Predicted landings with Setup A by FUs

Setup A					
	Trawl landings				
Year	FU11	FU12	FU13	All	**Total**
1993	2784	3797	2798	9379	11332
1994	3160	4001	2084	9245	11101
1995	3006	3846	3593	10445	12785
1996	2445	3387	3601	9433	11165
1997	2623	3774	3092	9489	11253
1998	2063	3089	4313	9465	11171
1999	2831	3408	3392	9631	11492
2000	2714	3197	3110	9021	11037
2001	2681	3189	2847	8717	10861
2002	2820	2525	3200	8545	10467
2003	**3541**	**3340**	**3611**	**10492**	**12660**
2004	**3541**	**3340**	**3611**	**10492**	**12660**

Sources of information

Background analysis to UK request for *Nephrops* advice in Management Area C prepared by an ICES review group consisting of Fatima Cardador, Mike Bell, Nick Bailey and Colm Lordan.

ICES, 2003. Report of the Working Group on *Nephrops* Stocks, Galway, Ireland, 19-29 March 2003. ICES CM 2003/ACFM:18.

Lordan,, C., Doyle, J. and Briggs, R. 2004 Preliminary Report of the joint MI-DARD UWTV Survey on the Western Irish Sea Nephrops Grounds. Working Document to the Report of the Working Group on Nephrops Stocks, Lisbon, Portugal, 28 March-1 April 2004.ICES CM 2004/ACFM:19.

Tuck, I., Bailey, N. & Weetman, A., 2004. New survey information on Scottish *Nephrops* stocks. Working Document to the Report of the Working Group on *Nephrops* Stocks, Lisbon, Portugal, 28 March-1 April 2004.ICES CM 2004/ACFM:19.

2.1.8.5 Norwegian request for advice on sandeel stock on the North Sea

Norway has requested ICES as follows:

> *Given the uncertainty regarding the present state of the stock of sandeel in the North Sea, and the concern that incoming year class may be poor, ICES is requested to outline likely effects of possible protective measures, notably minimum landing size, closed areas and closed seasons.*

<u>ICES Comments</u>

The Norwegian request asks for advice on the effects of three possible technical measures; minimum landing sizes, closed areas, or closed seasons. Clearly, devising any such measure should take account of information on the seasonal availability and population structure of North Sea sandeels. At present, there is insufficient information to quantify the possible effect of such measures. Therefore, the following sections will review the potential benefits of each measure in relation to the current understanding of the stock.

The status of the sandeel stock in the North Sea and advice for 2005 is reported on in Section 4.4.14.b.

Summary

While several sandeel (Ammodytes spp) species occur in the North Sea, sandeel landings from the North Sea consist almost entirely of the lesser sandeel (*Ammodytes marinus*).

Seasonal closures can have a protective effect in two ways:

- 1-group sandeel have a rapid increase in weight and oil content from April until June. It is therefore possible to achieve the same value in weight and oil by postponing the season and then catching fewer specimens.

- The 0-group is only fished in the autumn. Hence, to protect the 0-group, a closure of the fishery in the second half of the year may be considered as a precautionary measure. It is unknown to what extent preventing fishery on the 0-group will benefit the stock.

The implementation of a *minimum landing size* would be aimed at decreasing fishing mortality on 0-group sandeels. The nature of the fishery – fishing with small-mesh trawls and landing for reduction purposes – suggests that the effective implementation of a minimum landing size may only be possible through implementation of closed areas and seasons.

Area closures: The distribution of sandeel is patchy, and the sandeel is quite sedentary once it has settled to the bottom. Hence, there is a risk of local depletion in areas with intense fishing. At the larval stage there is an exchange between areas, which is dependent on the hydrographical conditions. The present knowledge is insufficient to outline specific areas that might be candidates for regional management. Also, cannibalism might mitigate any long-term positive effects on the production in a closed area.

All these measures need to be considered further in the broader context of a management strategy. In this years advice, ICES suggests a further development of such a management strategy.

Background, biology, and fishery

While several sandeel (Ammodytes spp) species occur in the North Sea, sandeel landings from the North Sea consist almost entirely of the lesser sandeel (*Ammodytes marinus*) and only this species is described below.

Sandeels have bank-affiliated resident juvenile and adult life stages coupled to specific areas of sediment. The patchy distribution of this sediment is a key constraint on the distributional extent of sandeels, following settlement. The eggs are also demersal and are spawned directly onto the sandy areas they inhabit. Consequently, dispersal between patches of suitable sediment is confined to the pelagic larval stage, which lasts between 1 and 3 months. Estimates of passive transport during this phase indicate varying levels of exchange between spawning grounds. As a result inter-mixing across sandeel aggregations within the North Sea stock is limited. Furthermore, the relative geographic and hydrographic isolation of some sandeel aggregations, such as near the Firth of Forth, make them dependent on local spawning. Given the potential for differences in recruitment and mortality between local populations, the present management of the stock by a single TAC covering the whole North Sea potentially makes these populations vulnerable to regional-specific overexploitation.

There is considerable variation in size and maturity-at-age between regions and banks within the North Sea. Sandeels in coastal areas off Shetland, Norway, and off the Firth of Forth have much lower growth rates than those living offshore. These regional differences have implications for the maximum fishing mortality an area will support and for the recovery time from a local collapse, but little specific information is available. For example, although sandeels occur very patchy and densities can be very high, density-dependent effects on growth and mortality have not been demonstrated for sandeels in the North Sea.

Growth rates within the North Sea stock vary substantially between regions and between years, and the patterns of emergence and thus the availability of sandeels to the fishery is also highly variable. This has strong implications for the effect of management actions on the sandeel stock dynamics.

Cannibalism of immature sandeels on the early life stages of sandeels has been demonstrated for other sandeel species with a similar life cycle and behaviour as that of *A. marinus* in the North Sea, and cannibalism has a major impact on the recruitment pattern.

Minimum landing sizes

The nature of the fishery – fishing with small-mesh trawls and landing for reduction purposes – suggests that the effective implementation of a minimum landing size may only be possible through implementation of closed areas and seasons. Avoiding catch of small sandeel could increase the yield over a fishing season due to the rapid growth of sandeel during the fishing season. Also it is possible to decrease fishing mortality on 0-group sandeels as these only occur in the catches from late in the summer and may dominate the catches towards the end of the fishing season.

Very small sandeels are low in oil content and their economic value is low, this is already a practical limiting factor for a directed fishery on small sandeels. Because of this quality constraint almost all fishing on 0-group takes place late in the year and is mostly limited to areas where 0-group growth rates are very high, such as Fisher banks. The directed fishery for 0-group sandeels is carried out by a small number of vessels and targets a small part of the sandeel areas. A minimum landing size restriction late in the season could reduce mortality on 0-group sandeels in the areas where this fishery occurs. This may reduce fishing mortality per landed tonnes provided that fishing effort is displaced to areas where larger sandeels are taken, rather than catches of undersized fish being discarded or slipped. A real-time control rule of the type that “fishing should cease in an area if catches are composed of x% sandeels < y cm in z hauls” would be required.

Closed seasons

In the Shetland assessment area a closed season approach has been applied in the past to reduce fishing pressure on 0-group sandeels at times when they are important to local seabird predators. In this area the protection of 0-group sandeels was considered important since historically the fishery took a large proportion of that age-group.

In contrast to Shetland, 0-group sandeels only comprise a small proportion of the North Sea landings. However, given the small size of the 2002 year class and the less-than-average size of the 2003 year class, reducing 0-group mortality on the 2004 and 2005 year classes may help in stock recovery. The quantification of the effect on the sandeel stock by decreasing the mortality of 0-group sandeels is not possible at the present time due to the lack of knowledge on cannibalism and other sources of natural mortality.

1-group sandeel have a rapid increase in weight and oil content from April until June. Postponing the start of the fishery has the potential of increasing the yield (in weight) and yield in the form of oil even more.

Closed areas

Closing an area to a fishery will potentially help to conserve fish stocks, particularly if the area encompasses a large spawning congregation that provides a source of recruits for many surrounding areas, or if it contains a resident and reproductively isolated population. There is evidence of a resident and reproductively isolated sandeel population off the northeast UK (Firth of Forth). This information, together with a decline in the breeding success of sandeel-dependent seabirds and particularly kittiwakes in this region following the development of a fishery in the 1990s, led to a closure of the area in 2000. The concern was that any reduction of the local sandeel population below a level where it affected breeding success of sandeel-dependent seabirds could potentially affect other top predators. The direct impact of the closure is still uncertain and the decision rules for re-opening have yet to be agreed.

The closed area approach has also been applied to the small Shetland sandeel assessment area in the early 1990s, and since the re-opening in 1995 there has been a precautionary TAC and limit on the size of vessels operating. The initial total closure in 1991 was in response to a succession of poor year classes in the managed region, which was associated with almost complete breeding failure in local seabird colonies. The stock did recover during the closure, but the primary reason for this appeared to be due to immigration of 0-group from outside the assessed region. In spite of the low fishing pressure, the stock has suffered poor recruitment in recent years.

These two examples of closed areas highlight the importance of understanding how different patches of sandeels are linked by larval dispersal. Identifying and protecting source populations and small reproductively-isolated resident populations could help in achieving sustainable management of the North Sea stock.

Regional area TACs

In light of the changed perception of the geographical status of the North Sea sandeel stock it might be more appropriate to set separate TACs to cover identified separate sandeel populations. In the first instance, such TACs would be intended to ensure the persistence of the sandeel populations and support a viable fishery in the identified regions. This proposal requires that assessments are disaggregated accordingly. Initial work has been done on assessing three units separately, but more work is required to be confident that regional assessments can be done adequately. It is essential that appropriate fishery data on catch and effort are collected. It is also important that at least one abundance survey is initiated for stock assessment purposes. Further, it is essential that the population units to be assessed separately can be defined based upon knowledge on sandeel biology and distribution pattern.

Sources of information

Bell, E. Response to sandeel request – 2005 Sandeel assessment. Working Paper 14 to the Working Group on Demersal Stocks in the North Sea and Skagerrak (ICES 2004).

ICES 2004. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak, 7–16 September 2004 (ICES CM 2005/ACFM:07).

Johannessen, T., E. Johnsen, K. Korsbrekke, and D. Skagen. Yield and sustainability in the sandeel fishery in the North Sea. Working Paper 13 to the Working Group on Demersal Stocks in the North Sea and Skagerrak (ICES 2004).

Wright, P. and H. Jensen. Potential effects of technical management measures for the sandeel stock in the North Sea. Working Paper 9 to the Working Group on Demersal Stocks in the North Sea and Skagerrak (ICES 2004).

2.1.8.6 Evaluation of the Harvest Control Rule Northeast Arctic Cod and Haddock

At the 31st meeting of the Joint Russian-Norwegian Fisheries Commission (JRNFC) in November 2002, the following decision was made:

"The Parties agreed that the management strategies for cod and haddock should take into account the following:

- *conditions for high long-term yield from the stocks*
- *achievement of year-to-year stability in TACs*
- *full utilisation of all available information on stock development*

On this basis, the Parties determined the following decision rules for setting the annual fishing quota (TAC) for Northeast Arctic cod (NEA cod) from 2004 and onwards:

- *estimate the average TAC level for the coming 3 years based on* $\boldsymbol{F}_{pa}$*. TAC for the next year will be set to this level as a starting value for the 3-year period.*
- *the year after, the TAC calculation for the next 3 years is repeated based on the updated information about the stock development, however the TAC should not be changed by more than +/- 10% compared with the previous year's TAC.*
- *if the spawning stock falls below* $\boldsymbol{B}_{pa}$*, the Parties should consider a lower TAC than the decision rules would imply.*

The Parties agreed on similar decision rules for haddock, based on $\boldsymbol{F}_{pa}$ *and* $\boldsymbol{B}_{pa}$ *for haddock, and with a fluctuation in TAC from year to year of no more than +/-25% (due to larger stock fluctuations).*

The Parties agreed that the working group, which worked out the "Basic Document regarding the main principles and criteria for long term, sustainable management of living marine resources in the Barents and Norwegian Seas" during the following year should illustrate how these decision rules will work. The working group shall, in particular, evaluate what level of percentage change in TAC from year to year will be reasonable

The Norwegian Ministry of Fisheries sent a letter to ICES (February 2003), requesting that the advice for TAC on cod and haddock should correspond to the decision rule given in Section 2.1.

Although the letter contained a request that ICES should give advice according to the decision rules established by the Commission, ICES was not asked to evaluate if the decision rules are in accordance with the precautionary approach (PA). However, for any catch option, ICES will routinely state whether it is compatible with the PA, depending on the resulting fishing mortality.

Due to time constraints ICES was not able to evaluate the rule for haddock and only the rule for cod was considered

Rule characteristics

In principle, the rule is incomplete because it does not specify what specific action will be taken when the stock falls below $\mathbf{B}_{pa}$. For a harvest control rule to be in compliance with the precautionary approach, it is necessary to specify actions it this situation that will secure stock rebuilding. Therefore, as the rule is undefined for part of the SSB range it cannot be tested as it stands in a PA context.

Possible ways to complete the rule

The following elements were included to complete the possible rule in the simulations:

1. assume that the fishing mortality will be reduced linearly towards zero when SSB is between $\mathbf{B}_{pa}$ and $\mathbf{B}_{lim}$ ("linear");

2. assume that the TAC is set according the 3-year rule ("flat") and ignoring the constraint on changes in TAC between successive years;

A default assumption that the 10% constraint on the TAC would be maintained if SSB<$\mathbf{B}_{pa}$ has not been tested. Other kind of action could also be evaluated and in that context.

Simulation procedures

For the evaluation a population simulation program PROST was developed which provides stochastic forecasts. This is a stochastic stock projection program for the medium – long term. It simulates the harvest rule, and projects a "true" simulated stock forwards with removals as emerging from the implementation of the rule. The stochastic elements are recruitments according to a stochastic stock-recruitment function, weights, maturities and assessment and implementation error. Assessment and implementation errors are assumed, as there is no full assessment simulated within the model.

The 'default' model included density-dependent weight at age in the stock except for age groups where density-dependence was not found, the full recruitment model included uncertainty, dependence of recruitment on stock weights at age and periodic fluctuation in the recruitment success. No cannibalism was included; the exploitation pattern was the average 2000-2002 with uncertainty in implementation. It also included an assessment error with a CV of 0.25 or 0.35, but no bias. No uncertainty in weight at age, maturity at age or natural mortality at age
Several variants of the population model were tried. In all cases, 1000 simulations for the period 2003-2103 were performed and the results for the last 80 years of this period were considered. This is done in order to exclude the effect of the initial values.

Bias in assessments (systematic under or overestimation) and implementation error (non compliance with TAC's) has not been accounted for.

Tested Runs

The runs tested are below.

		Rule				Model	
Run No	**F**	**3-year rule used**	**F below $\mathbf{B}_{pa}$**	**percent change increase**	**percent change decrease**	**CV stock number**	**High M age 3, 4 (0.7 and 0.4)**
1	0.40	Yes	Linear	10	10	0.25	No
2	0.40	No	Linear	10	10	0.25	No
3	0.40	Yes	Flat	10	10	0.25	No
4	0.40	Yes	Linear	20	20	0.25	No
5	0.40	Yes	Linear	30	30	0.25	No
6	0.40	Yes	Linear	40	40	0.25	No
7	0.40	Yes	Linear	10	10	0.35	No
8	0.40	Yes	Linear	10	10	0.25	Yes
9	0.50	Yes	Linear	10	10	0.25	No
10	0.50	Yes	Linear	10	10	0.25	Yes
11	0.50	Yes	Linear	10	10	0.35	Yes
12	0.50	No	Linear	10	10	0.35	Yes

The different variants of the 3-year rule are with a 10% constraint on a change of TAC in successive years are highlighted in the table above. The other runs differ from the specified part of the rule (e.g. higher F, less reconstructions on change in TAC)

Results

Output is given in Table 1.

All simulations with F=$\mathbf{F}_{pa}$ indicate that the risk of bringing the stock below $\mathbf{B}_{lim}$ is very low. This would also have been expected when the PA reference points are chosen correctly.

The probability of bringing the stock below $\mathbf{B}_{pa}$, which is used as a trigger biomass for action, is also low. This implies that the situations where other management decisions have to be taken are rare. In particular the omission of assuming bias in the assessment and implementation error (for instance by implementing an F of 20% or 40% higher than intended) should be further investigated before the rule can be considered to be fully in accordance with the Precautionary Approach. Also testing the performance of the HCR to rebuild the stock in poor stock situations should be further investigated.

The rule was also tested with F=0.5 instead of $\mathbf{F}_{pa}$(0.4). This leads to high probability of SSB<$\mathbf{B}_{pa}$ (40%). The analyses support the choice of the value $\mathbf{F}_{pa}$ to be consisted with $\mathbf{B}_{pa}$. The F =0.5 run can be considered as a proxy test of an implementation error or an assessment error of 20%. What really matters is that the "true" simulated stock does not drop below $\mathbf{B}_{lim}$. However, the high probability of SSB<$\mathbf{B}_{pa}$ implies that action to reduce the fishing mortality would have to be taken quite often. Then performance of the rule will depend on the type of action that is taken. At the assumed actions tested when SSB<$\mathbf{B}_{pa}$ the risk is still low that SSB<$\mathbf{B}_{lim}$. This illustrates the effect of a modest assessment error or implementation error.

Conclusion

The catch rule agreed by the Russian-Norwegian Fishery Commission has been tested through simulations. For the rule to be consistent with the precautionary approach, it needs to contain some pre-agreed measures to ensure rebuilding in cases when the SSB estimates fall below $\mathbf{B}_{pa}$. These measures need to be specified first before a complete evaluation can be carried out. A simple rule allowing for a reduction of F towards zero when the estimated SSB approaches $\mathbf{B}_{lim}$, is sufficient for bringing the existing rule in line with the precautionary approach.

In the simulations done so far to test the rule, it has been assumed that fishing mortality would be reduced linearly below $\mathbf{B}_{pa}$ to 0 at $\mathbf{B}_{lim}$. Alteratively simulations were done assuming higher annual reduction than 10% when SSB was below $\mathbf{B}_{pa}$.

The simulations indicate that, when the rule has been established for a number of years, the probability of SSB falling below $\mathbf{B}_{pa}$ or $\mathbf{B}_{lim}$ is very low and that the rule could be consistent with the precautionary approach. However a number of factors such as lack of compliance to TAC and possible bias in future assessments were not taken into account in the simulations and would prevent achieving the expected objective of the rule. The present occurrence of high levels of unreported landings indicate that such factors presently exist.

The studies presented indicate that the HCR proposed by the Commission is in agreement with the precautionary approach, provided that the limit on annual change of TAC is not applied for SSB < $\mathbf{B}_{pa}$. It has not been thoroughly tested whether it is also a condition that the F is reduced for SSB < $\mathbf{B}_{pa}$ for the HCR to be in agreement with the precautionary approach.

Let y be the year for which a TAC advice should be given, y-1 is then the intermediate year (and y-2 the assessment year). The following rule is proposed and considered to be precautionary:

F(y) set by 3-year rule(0.40, 10) if SSB(y) > $\mathbf{B}_{pa}$ and SSB(y-1) > $\mathbf{B}_{pa}$
F(y) set by 3-year rule(0.40, no limit) if SSB(y) > $\mathbf{B}_{pa}$ and SSB(y-1) < $\mathbf{B}_{pa}$

F(y) set by 3-year rule($0.40\frac{SSB(y)-B_{\lim}}{B_{pa}-B_{\lim}}$,no limit) if $\mathbf{B}_{lim}$< SSB(y)< $\mathbf{B}_{pa}$

F(y)=0 if SSB(y) < $\mathbf{B}_{lim}$

This harvest control rule also applies for a rebuilding situation..

Since the 10%-rule is found precautionary, also less restrictive rules (higher than 10% change) for allowed changes in TAC from year to year will be, since this allows for a more rapid action in case the stock is decreasing.
Comments:

The condition F(y) set by 3-year rule(0.40, no limit) if SSB(y) > $\mathbf{B}_{pa}$ and SSB(y-1) < $\mathbf{B}_{pa}$ is included in order to account for the following situation: If SSB(y-1) < $\mathbf{B}_{lim}$ (in the assessment made in year *y-2*, which decided the quota for year *y-1*), the quota for year *y-1* will be zero. Thus, in order to allow for the quota to increase again, a maximum year-to-year percentage change clause cannot be applied in this case. For simplicity, we decided to ignore the maximum year-to-year percentage change clause in all cases where SSB(y) > $\mathbf{B}_{pa}$ and SSB(y-1) < $\mathbf{B}_{pa.}$ (referring to the assessment made in year *y-1*).

The rule does not consider the level of SSB after the TAC has been taken.

Table 1 Results of long-term stochastic simulations using the approach presented in WD3.

Run no	F	3-year rule used (Rule)	F below B_{pa} (Rule)	percent change increase (Rule)	percent change decrease (Rule)	CV stock number (Model)	High M age 3, 4 (0.7 and 0.4) (Model)
1	0.40	Yes	Linear	10	10	0.25	No
2	0.40	No	Linear	10	10	0.25	No
3	0.40	Yes	Flat	10	10	0.25	No
4	0.40	Yes	Linear	20	20	0.25	No
5	0.40	Yes	Linear	30	30	0.25	No
6	0.40	Yes	Linear	40	40	0.25	No
7	0.40	Yes	Linear	10	10	0.35	No
8	0.40	Yes	Linear	10	10	0.25	Yes
9	0.50	Yes	Linear	10	10	0.25	No
10	0.50	Yes	Linear	10	10	0.25	Yes
11	0.50	Yes	Linear	10	10	0.35	Yes
12	0.50	No	Linear	10	10	0.35	Yes

Results

Run no	% of runs SSB<B_{lim} in any year	Realised F	Catch 1000 tonnes	SSB 1000 tonnes	TSB 1000 tonnes	Recruits million age 3	%annual change in TAC (abs. value)	% Years SSB<B_{lim}	% Years SSB<B_{pa}	% Years where various parts of HCR decide TAC: *SSB above B_{pa}* *3-year rule*	*SSB above B_{pa}* *%increase*	*SSB above B_{pa}* *%decrease*	*SSB below B_{pa}*
1	0.0	0.406	885	1018	3452	674	7.7	0.00	0.1	46.2	28.8	24.8	0.2
2	0.0	0.408	886	1039	3485	674	10.0	0.00	0.9	35.1	34.7	29.0	1.2
3	0.0	0.406	885	1019	3452	673	7.6	0.00	0.1	46.1	28.9	24.8	0.2
4	0.0	0.407	884	1006	3433	674	11.0	0.00	0.0	78.9	13.3	7.8	0.0
5	0.0	0.409	883	999	3421	673	12.6	0.00	0.0	92.2	6.1	1.6	0.0
6	0.0	0.410	884	996	3419	675	13.2	0.00	0.0	97.3	2.5	0.2	0.0
7	0.0	0.418	891	1046	3497	678	8.8	0.00	0.3	36.4	33.3	29.5	0.8
8	0.1	0.402	497	581	2104	714	15.2	0.00	13.2	45.5	15.1	22.1	17.3
9	0.8	0.518	832	722	2899	634	10.6	0.01	3.6	44.3	24.5	25.7	5.5
10	1.1	0.454	478	482	1915	689	35.0	0.01	44.6	35.3	4.4	13.7	46.6
11	5.2	0.465	482	501	1950	693	60.1	0.07	39.4	35.1	7.6	14.1	43.1
12	16.4	0.485	481	486	1925	688	116.2	0.22	44.4	34.9	6.3	11.4	47.3