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EXECUTIVE SUMMARY

The ICES Advisory Committee on Ecosystems (ACE) met from 7 to 11 June 2002. During this meeting, ACE prepared responses to requests from the European Commission Directorate General for Fisheries on the by-catch of small cetaceans in fisheries and on the occurrence of cold-water corals that may be impacted by fisheries; ACE also provided some preliminary material on issues of concern to the EC in relation to the impacts of fishing on the ecosystem. Furthermore, ACE provided a preliminary response to the Helsinki Commission with regard to a request on marine habitat classification, and, at the request of the OSPAR Commission, reviewed the evidence for the justification for the proposed OSPAR Priority List of Threatened and Declining Species and Habitats.

By-catch of small cetaceans in fisheries

ACE has reviewed the information available on the by-catch of small cetaceans, such as dolphins and harbour porpoises, in fishing gear in fisheries in the Northeast Atlantic (Section 2 of this report). Although data are not available for all fisheries, the information available indicated higher by-catches in the Danish gillnet fisheries for cod, turbot, and other species in the North Sea, as well as some by-catches in fisheries in the Irish Sea. ICES advises that reduction in overall fishing effort is likely to reduce by-catch and, therefore, be an effective mitigation measure for cetacean by-catch. ICES finds no scientific basis to support spatial or temporal closures to fishing of areas on a small scale, without overall effort reduction, as an effective mitigation strategy.

As a short- or medium-term measure, the use of pingers (acoustic deterrent devices) on fishing gear may successfully reduce cetacean by-catch. Thus, ICES recommends that the use of pingers be made mandatory in several specific bottom-set gillnet fisheries. More research needs to be conducted in relation to by-catches in pelagic trawl metiers and potential means of decreasing such by-catches.

Cold-water corals in the Northeast Atlantic

Available information on the distribution of cold-water corals, mainly *Lophelia pertusa*, in the Northeast Atlantic is summarized in Section 3 of this report. These reef-forming corals occur in oceanic waters with a temperature between 4 °C and 12 °C with relatively high water flow; they may occur at depths from 40 m in Norwegian fjords to depths greater than 1000 m off the continental shelf of Norway, off the northwest coast of the United Kingdom and the west coast of Ireland, and around the islands of Madiera and the Azores. The largest *Lophelia* reef complexes have been found off the coast of Norway. An area to the northwest of the United Kingdom contains several hundred mounds, termed the Darwin Mounds, which are covered with living *Lophelia pertusa* on their tops.

Effects of fishing on the cold-water corals arise from fishing gear physically impacting the corals or by indirect effects such as wash or sedimentation. The most obvious impact of trawling is mechanical damage caused by the gear itself, which kills the polyps and breaks up the reef structure. Trawling also causes resuspension of sediments that could affect corals growing downstream. The only way to completely prevent damage by fishing activities to areas of deep-water corals is to accurately map them and then close these areas to fisheries using towed gear that potentially impacts the bottom.

Potential impacts of current fishing practices

In Section 4 of this report, initial consideration is given to the issue of sensitive habitats in relation to the impact of current fishing practices. As the scientific information presently available is inadequate to evaluate the impact of fishing practices on sensitive habitats, ACE identifies the types of activities that are required to provide the scientific basis for advice on this subject. ACE then conducts a brief overview of selected habitat types (e.g., deep-water biogenic habitats, intertidal mudflats) that may be impacted by specific types of fishing methods, such as trawling, longlining, and dredging.

Some background is provided in Section 7 concerning an evaluation of the impact of current fishing practices on non-target species. Detailed consideration of this subject is hampered by a lack of available information on discards of non-target species; however, progress is being made with regard to a review of information on sharks and rays, which, owing to their life history characteristics, are sensitive to additional mortality.

Threats to the genetic diversity of exploited fish stocks are reviewed in Section 9, along with means for protecting the full genetic diversity within and among populations of fish affected by fishing. This section also describes management objectives for maintaining genetic diversity within a species and provides initial advice to meet these objectives.

Ecological dependence in fisheries management advice

As an initial response to a request concerning consideration of ecological dependence in management advice, ACE has prepared an overview of the issue of ecological dependence in this context (Section 8). This includes when ecological dependence is likely to be significant in management decisions, and how ecological dependence affects management advice. Examples are given of situations where ecological dependence is already considered in management advice, including Barents Sea capelin and sandeel in the Shetland area. Several stocks are also identified for which ecological dependence may need to be considered in the preparation of management advice.

Marine habitat classification and mapping

A brief overview of the issues that need to be addressed in the further development of a classification system for marine habitats and in the preparation of marine habitat maps is provided in Section 5. This relates also to the considerations in relation to the need to classify and map "sensitive habitats" with regard to fishing practices. Based on a request from the Helsinki Commission, indication is given of a way forward to adapt and extend the current habitat classification systems to the Baltic Sea Area.

Threatened and declining species and habitats

OSPAR has requested ICES to review the data on which the justification of the OSPAR Priority List of Threatened and Declining Species and Habitats will be based. The summary of the ICES advice on the adequacy of the evidence for the existence of actual declines or threats to most of the species and habitats on this list is contained in Section 6 of this report, with full details of the evaluation contained in Annex 1.

Ecological Quality Objectives

In the light of the provisions of the Bergen Declaration of the Fifth International Conference for the Protection of the North Sea agreeing to use the ecosystem approach to management in the North Sea, ACE reviewed the requirements of the Bergen Declaration and their implications in relation to the development of Ecological Quality Objectives (EcoQOs). This review, in Section 10 of this report, restates the criteria for good Ecological Quality metrics set forth in the 2001 ACE report and evaluates the ten EcoQOs selected in the Bergen Declaration for a North Sea pilot project according to these criteria. Advice is provided on possibilities to improve the performance of the EcoQ metrics, where applicable. Scientific advice is also provided on the medium-term development of additional EcoQOs that have been requested in the Bergen Declaration.

Ecosystem approach to management

In Section 11, ACE describes several national and international programmes to develop an ecosystem approach for the management of marine resources; this covers both programmes in the ICES area as well as some global initiatives. ACE then summarizes the activities common to these programmes. While there is a general consensus as to the intent of the expression "ecosystem approach", the actual definitions can vary and this must be considered when interpreting reports on the implementation of the "ecosystem approach".

1 INTRODUCTION

The Advisory Committee on Ecosystems (ACE) was created in 2000 as the Council's official body for the provision of scientific information and advice on the status and outlook for marine ecosystems, and on exploitation of living marine resources in an ecosystem context. ACE provides a focus for advice that integrates consideration of the marine environment and fisheries in an ecosystem context, such as ecosystem effects of fishing. ACE will be at the forefront of the development of advice on ecosystem management.

ACE provides advice as may be requested by ICES Member Countries, other bodies within ICES, relevant regulatory Commissions, and other organizations.

In handling the requests, ACE draws on the expertise of its own members and on the work of various expert ICES Working Groups and Study Groups. ACE considers the reports of these groups and may request them to carry out specific activities or to provide information on specific topics.

2 SMALL CETACEAN BY-CATCH IN FISHERIES

Request

The request from the European Commission, Directorate General for Fisheries, in February 2002 concerning by-catch of cetaceans states:

Develop further the basis for advice to the European Commission on cetacean by-catch and mitigation measures in EU Fisheries [EC DG FISH]

i) *Update information on by-catches of cetaceans by species, gear, and area.*
ii) *Update information on sizes and distribution of cetacean populations against which by-catches can be counted.*
iii) *Details of gears, areas, and times associated with effective closures. Potential advantages and disadvantages of a generalized use of pingers in fixed gear; technical specifications affecting the effectiveness of pingers.*
iv) *Potential advantages and disadvantages of a generalized use of pingers or other deterrents in pelagic trawls; updated information and technical specifications.*
v) *Technical details of any other possible mitigation measure.*

Source of information

The 2002 Report of the Working Group on Marine Mammal Population Dynamics and Habitats (WGMMPH) (ICES CM 2002/ACE:02).

2.1 Information on by-catch of cetaceans

2.1.1 Introduction

The ICES Working Group on Marine Mammal Population Dynamics and Habitats (WGMMPH) reviewed the impact of fisheries on marine mammals in European waters in 2001. This material was reviewed by ACE and used as a basis for preliminary advice to DG FISH (ICES, 2001). A report produced by a working group of the European Commission's Subgroup on Fishery and Environment (SGFEN) of the Scientific, Technical and Economic Committee for Fisheries (STECF) also reviewed by-catch both in the ICES area and the Mediterranean (CEC, 2002). The latter report included information that became available after ICES (2001) was written. Relevant new information from CEC (2002) is summarized below, along with information that has become available even more recently, updating ICES (2001). It is worth noting that we cannot include information on those fisheries that have not been studied.

2.1.2 Gillnets

Figures for by-catches of harbour porpoises in the dogfish, crayfish, and skate gillnet fisheries for the period 1995–1999 in seas to the west of Scotland were presented in CEC (2002). Estimated numbers of harbour porpoises in the by-catch varied annually between 209 and 22 (Table 2.1.2.1) and have declined recently due to the collapse of the crayfish tangle net fishery. The total recorded effort (days at sea) in all locally based UK set-net fisheries west of Scotland has declined from 1256 days to 697 days between 1995 and 2000, with the crayfish component going from 882 days to 53 days. There is, however, a significant gillnet fishery operating in deep water along the shelf edge, which has not been sampled, and for which, therefore, there are no estimates of mammal by-catch.

Table 2.1.2.1. Estimates of harbour porpoise by-catch to the west of Scotland. These estimates are for all locally based set-net fisheries, excluding the offshore freezer-netters, and are derived from individual estimates for each of the fisheries in each area.

Year	Extrapolated numbers by-caught	95 % confidence interval
1995	165	82–365
1996	156	74–349
1997	209	95–475
1998	45	34–83
1999	22	14–39

Updated estimates of the by-catch of porpoises in Danish gillnet fisheries for cod, hake, plaice, sole, and turbot in the North Sea were provided by Vinther and Larsen (2002) (Table 2.1.2.2). Compared to previous estimates for these fisheries, the new estimate uses an extrapolation method where changes in fish catch per unit effort have been taken into account. Total estimates range from a low of 3,887 in the most recent year's data (2001) to 7,366 in 1994. These estimates, however, do not take account of the mandatory use of pingers in the cod wreck net fishery during the third quarter of the year since 2000. Vinther and Larsen (2002) estimated that the third quarter cod wreck net fishery would have been responsible for 570 porpoise entanglements in 2000 and 405 in 2001. Assuming that the effect of pingers may have been to eliminate porpoise by-catch, the most recent estimate of total mortality of 3,887 in 2001 may, therefore, be an overestimate by as much as 405 animals.

ICES (2002) noted that some information on harbour porpoise by-catch in Dutch coastal waters exists. During 1997 and 1998, amongst the on-average 50 dead por-

Table 2.1.2.2. Estimated harbour porpoise by-catch by fishery and season (quarter of year) for Danish bottom-set gillnet fishing in the North Sea (Vinther and Larsen, 2002).

Fishery	Season	1987	1988	1989	1990	1991	1992	1993	1994
Cod, wreck	1, 2 and 4	97	99	89	104	102	117	116	123
	3	276	405	383	173	291	386	606	555
Cod, other	1 and 3	1410	1342	1217	919	1076	1307	1603	1578
	2 and 4	236	323	294	401	386	443	428	456
Hake	all	119	160	212	268	405	541	697	493
Turbot	all	2719	3229	2547	3067	3033	2577	2245	2534
Plaice	all	465	380	231	260	1018	1172	1014	1627
Sole	all	0	0	0	0	0	0	0	0
All	all	5322	5938	4973	5192	6311	6543	6709	7366

Fishery	Season	1995	1996	1997	1998	1999	2000	2001	Mean
Cod, wreck	1, 2 and 4	117	121	130	148	126	106	67	111
	3	568	475	587	738	511	570*	405*	462
Cod, other	1 and 3	1546	1472	1514	1943	1705	1420	950	1400
	2 and 4	435	445	538	565	411	413	261	402
Hake	all	381	189	119	142	217	181	158	285
Turbot	all	2366	1999	1402	1034	737	985	1144	2108
Plaice	all	1325	1292	1018	636	521	475	903	822
Sole	all	0	0	0	0	0	0	0	0
All	all	6738	5993	5308	5206	4228	4150	3888	5590

*By-catch in this fishery is overestimated, as the effect of the use of pingers in the months August–October has not been taken into account.

poises annually recovered through a stranding network, around 50 % were diagnosed as being by-caught.

2.1.3 Tuna driftnets

A ban on the use of tuna driftnets in EU waters and by EU vessels operating elsewhere came into effect at the start of 2002, partly owing to the scale of earlier dolphin by-catch. If fishing with this metier has ceased, so presumably has the related dolphin by-catch.

2.1.4 Pelagic trawls

Pierce *et al.* (2001) observed 73 days at sea in the UK pelagic fishery (including the North Sea and areas west of the UK) with no recorded by-catch in 69 hauls.

By-catch in the Irish experimental pelagic pair trawl fishery for albacore was observed in 1999 off western Ireland and the southern Bay of Biscay (BIM, 2000). A total of 313 hauls over 160 days were observed. A total of 145 cetaceans of four species of cetacean were caught (Table 2.1.4.1); more than 2/3 of these were taken in just ten hauls, with one haul accounting for 30 animals. Ninety percent of hauls had no cetacean by-catch. This highly clustered pattern of by-catch is not unusual in pelagic trawls, probably due the cohesive nature of dolphin social groups (Fertl and Leatherwood, 1997).

Table 2.1.4.1. By-catch in Irish experimental pair trawls off western Ireland and in the Bay of Biscay in 1999 (BIM, 2000).

Species	Number caught
Common dolphin	127
Striped dolphin	8
Atlantic white-sided dolphin	2
Long-finned pilot whale	8

In the UK, the Sea Mammal Research Unit (SMRU) has also monitored 195 days at sea on UK-registered pelagic trawlers during 1999–2001, covering 210 fishing operations. Target species included mackerel, herring, bass, sprats, pilchards, blue whiting, and anchovy. Of these 210 operations, cetacean by-catch (53 common dolphins) was observed in eleven hauls, all of which were in the bass fishery in the Channel.

2.1.5 Other fisheries

Silva *et al.* (2002) observed by-catch in the pole-and-line tuna fishery off the Azores that targets tuna, mostly bigeye. A total of 617 fishing trips were monitored during the three-year study, with a total of 6,554 fishing events recorded. Since there are no data on the number of fishing events per trip, the total tuna landings per trip was used as a measure of the fishing effort of the whole fleet to estimate the capture rates of cetaceans (Table 2.1.5.1). All the animals caught (hooked) were released alive (by cutting the fishing line), although it was impossible to know whether they survived the interaction. This difficulty in assessing effect has been addressed in the U.S.A. with a set of guidelines to assess whether or not injuries sustained are "serious".

2.2 New information on cetacean populations

2.2.1 Most recent abundance estimates

There have been no recent comprehensive studies on cetacean abundance or population sizes in the ICES area. The most recent abundance estimates are shown in Table 2.2.1.1. Note that the estimate of cetacean abundance in a specified survey region is not equivalent to an estimate of population size, as biological populations may extend over wider areas, or conversely may be contained within a sub-area of the survey region. Abundance estimates are usually snapshots of animal density and abundance over a short period of time. With highly mobile species such as cetaceans, the actual density or abundance of animals within a survey region may vary considerably either seasonally or inter-annually if those animals range outside the survey area. For animals with seasonal migrations, an estimate of abundance in one part of the range should not be used as an indication of abundance throughout the year. Mark-recapture technique estimates usually take longer to obtain and often result in average estimates of numbers covering longer time periods.

The variance that occurs between techniques and time of year was illustrated by Baines *et al.* (2002) for the bottlenose dolphins in Cardigan Bay, Wales. The average abundance in May–September 2001 was 135 (95 % CI = 85–214) using ship-based line transect and 213 (95 % CI = 183–279) using photographic mark-recapture. However, in the centre of this period (May to mid-July 2001), the equivalent figures were 128 (67–245) using a ship-based line transect and 112 (82–116) using photographic mark-recapture. There were fewer animals estimated using ship-based line transect later in the season (mid-July–September 2001), namely, 152 (80–287), but about the same number, i.e., 211 (169–304) using photographic mark-recapture.

The summed estimates of abundance of bottlenose dolphins listed here probably comprise the majority of these animals in the nearshore Atlantic waters of Europe. This species (along with harbour porpoise) is listed on Appendix II of the EU's Habitats Directive (Council Directive 92/43/EEC) as requiring special conservation measures. There is cause for concern that this "population" is low and declining (see Wilson *et al.*, 1999) and therefore requires particular measures to ensure that it suffers no further anthropogenic mortality.

2.3 Possible limitations on use of gear, time/area closures

2.3.1 Background

Limitations to gear use range from the complete banning of a gear type or metier, as has occurred with driftnets for large pelagics in EU waters, through partial banning on a seasonal or area basis, to limits on fishing effort, for example, limiting the length of driftnets to 2.5 km. Additionally, the imposition of technical measures as discussed below could also be required on a seasonal or area basis, as is the case in the Danish wreck net fishery for cod.

It is important to realize that a limitation on the use of fishing gear, whether total or partial, is likely to result in a redistribution of fishing effort, either into other metiers, or into adjacent areas. Any such restriction needs to target a specific goal in terms of by-catch reduction, and the effects of any likely displacement need to be considered prior to imposing the limitation if the strategy is to achieve that goal. Thus, the complete closure of a metier may eradicate by-catch by that metier, but if effort is displaced to another metier that also has a significant level of by-catch, then the overall goal of minimizing the by-catch of a species of concern may not be achieved. Similarly, if an area of high by-catch is closed to a specific metier, but effort is redistributed to adjacent areas, the total by-catch level may not be reduced to the target level.

Table 2.1.5.1. By-catch estimates for Azores (Silva *et al.*, 2002). Note that all of these animals were released alive after capture.

By-catch species	Fishery target	Gear	Season	Years	By-catch estimates	95 % confidence interval
Common, striped, and bottlenose dolphins	Tuna	Pole-and-line	May to October	1998 1999 2000	38 55 16	16.9 – 59.1 19.6 – 89.6 11.7 – 20.2

For seasonal or area restrictions to be effective, the by-catch rate within the closure should be significantly higher than the by-catch rate elsewhere. In this context, “significant” means that it should be high enough such that total by-catch will meet the management goal if fishing effort is redistributed elsewhere away from the season or area of closure or restriction. Furthermore, the difference in by-catch rates inside and outside of the season or area of closure must be consistent from year to year.

It is evident that in order for such times or areas to be identified, then there must be comprehensive by-catch observation schemes that are run from year to year. There have only been a few such observation schemes in EU waters, despite the fact that schemes are required under the Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora (known as the Habitats Directive). The lack of observation schemes means that it is generally not possible to define useful times or areas for closure. Furthermore, the limited nature of current observation schemes has the unfortunate effect that closures and effort limitations have been restricted to those fisheries where participants have consented or allowed observer schemes on their fleets.

2.3.2 Celtic Sea bottom-set gillnets

Northridge *et al.* (2000) addressed the by-catch of porpoises in the UK and Irish Celtic Sea hake gillnet fisheries, where they postulated a requirement of a 70 % reduction in by-catch rate. They examined the observed by-catch rates by area, but could find no suitable potential areas (or seasons) for closure that might achieve this goal.

2.3.3 Western Channel/Bay of Biscay pelagic trawls

In the western English Channel and the northern Bay of Biscay, there have been repeated incidents of common dolphins and other species washing up dead in late winter and early spring. In some years, there have been several hundreds of corpses, most clearly diagnosed as having died through capture in fishing nets. The origin of these animals is unclear, but the pathology of many is consistent with drowning in trawl nets. Morizur *et al.* (1999) studied by-catch using an independent observer scheme in eleven separate pelagic trawl fisheries in this area and recorded by-catch in four of them (Dutch horse mackerel, French hake, French tuna, and French sea bass). Observer effort was limited in other pelagic trawl fisheries in this area and other fisheries have arrived in the area since the study period (1993–1995).

The effect of these by-catches on the local population or populations is unknown, as is the total annual mortality. Many corpses would not wash ashore, as this is dependent on variable winds and currents, and we know almost nothing about the population structure of common dolphins in this area. We cannot therefore easily say what proportion of the population is affected or whether the by-catch is sustainable in population terms, but there is a sufficient number of corpses washing ashore to cause considerable public and political concern.

In the first quarter of 2002, there was again considerable public concern over the numbers of dead, by-caught dolphins arriving on beaches in England and France, and several sources blamed the pelagic trawl fisheries for bass. There was, however, no direct evidence on which to base this claim and, in addition, the greatest numbers of corpses were washed ashore before the start of the main bass fishery (in other words, other fisheries than the one for bass are also catching dolphins). These public concerns have led to calls for precautionary bans on pelagic trawling for bass in the English Channel, or bans on all pelagic trawling by vessels above a certain size. These arbitrary measures are unlikely to achieve the desired goal, as they may result in shifts of effort to fisheries that occur further offshore where evidence of continued cetacean by-catch would be less obvious, as discussed above. Furthermore, there is evidence (Morizur *et al.*, 1999) that cetacean by-catch in this area is not general among all pelagic trawl metiers, so that blanket restrictions on all pelagic trawls would be regarded as inequitable by the industry. Clearly, there is an urgent need for comprehensive monitoring of the numerous trawl fisheries active in this region before we can be precise about mitigation requirements.

2.3.4 Eastern central North Sea wreck fisheries

A clear peak in harbour porpoise by-catch was identified in the Danish wreck net fishery in the period August–October (Vinther, 1999). This elevated by-catch rate is the reason for the Danish wreck net fishery in this period having been selected for mandatory use of acoustic alarms. If this scheme using acoustic alarms fails (although the results so far indicate success), then this fishery might be suitable for closure in August–October. However, the utility of such a measure would depend on the specified target for by-catch reduction. Vinther and Larsen (2002) estimated that the third quarter cod wreck net fishery would have been responsible (with no pinger deployment) for just 570 porpoise by-catch deaths out of a Danish North Sea total of 4,149 porpoises (14 %) in 2000 and 405 of 3,887 (10 %) in 2001. It is not clear whether such a reduction would be sufficient, given the lack of an international management framework for porpoise by-catch reduction in the North Sea. The effect of a total seasonal closure would then also need to be weighed against the possibility of a subsequent increase in effort in other fisheries during the period of closure. It seems inconsistent that any restrictions on the cod wreck fishery should apply just to Danish fishers. However, wreck net fishing during August–October by UK vessels fishing slightly further south and east of the Danish fishing grounds had no peak in by-catch (Northridge and Hammond, 1999).

Table 2.2.1.1. Abundance estimates of small cetacean populations in EU waters within the ICES area.

Species	Year of estimate	ICES Area or geographical locality	Abundance estimate	95 % Confidence limits	Method	Reference
Harbour porpoise	1994	IIIa + b	36,046	20,276–64,083	Ship-based line transect	Hammond *et al.*, 2002
		IIIc	5,850	3,749–9,129		
	1995	24+25	599	200–3,300	Aerial survey, line transect	Hiby and Lovell, 1996
		Kiel & Mecklenberg Bights	817	300–2,400		
		IVa	98,564	66,679–145,697	Ship-based line transect	Hammond *et al.*, 2002
	1994	IVb + c	169,888	124,121–232,530		
		VIIf+g+h+j	36,280	12,828–102,604		
Bottlenose dolphin	1992	Moray Firth (southwestern IVa)	129	110–174	Photographic mark-recap.	Wilson *et al.*, 1999
	2001	French coasts VIIe, VIIIa	250–300	na	Photographic identification or direct observation	ICES, 2002
	2001	Sado Estuary, Portugal	34	na		ICES, 2002
	1991–1993	Cornwall	15	na		ICES, 1996
	1994–1995	Dorset	5	na		White and Webb, 1995
	2001	Cardigan Bay, Wales	135	85–214	Ship-based line transect	Baines *et al.*, 2002
			213	183–279	Photographic mark-recap.	
	1999	Shannon Estuary, Ireland	113	94–161		Ingram, 2000
	1995	Dingle Bay, Ireland	12	na		ICES, 1996
White-beaked and Atlantic white-sided dolphins	1994	IVa	1,685	690–4,113	Ship-based line transect	Hammond *et al.*, 2002
		IVb	9,242	5,344–15,981		
		VIIf+g+h+j	833	159–4,360		
Atlantic white-sided dolphin	1998	Faroes-Shetland channel	21,371	10,000–45,000	Ship-based line transect	Macleod, 2001
	1998	VIa (N)	74,626	35,000–160,000		
	2000	parts of VI a&b, VII b/c, VIIj&k	5,490	1,134–10,015		O'Cadhla *et al.*, 2001
Killer whale	1989	IIa, IVa,b	7,057	3,400–14,400	Ship-based line transect	Øien, 1993
Common dolphin	1994	VIIf+g+h+j	75,449	22,900–284,900	Ship-based line transect	Hammond *et al.*, 2002
	2000	parts of VI a&b, VII b/c, VIIj&k	4,496	2,414–9,320		O'Cadhla *et al.*, 2001
Long-finned pilot whale	1987	V (parts of)	29,198		Ship-based line transect	Buckland *et al.*, 1993
		VI	5,392			
	1989	V (parts of)	80,867			
	1981–1984	Bay of Biscay	9,739			Sanpera and Jover, 1987
	1987–1989	VIII (E of 15°W)	12,235	3,924–38,148		Buckland *et al.*, 1993
	1987–1989	VIII (W of 15°W)	128,080	45,241–362,640		
Striped dolphin	1993	Bay of Biscay	73,843	36,113–150,990	Ship-based line transect	Goujon *et al.*, 1993
Common dolphin	1993	Bay of Biscay	61,888	35,461–108,010	Ship-based line transect	Goujon *et al.*, 1993

2.3.5 Kattegat

The recorded by-catch in the Swedish fishery in the Kattegat and eastern Skagerrak was two harbour porpoises in 2001 (Börjesson, 2002). This is a six-fold decrease since 1996 and corresponds well with the reduction of total gillnet effort in the same period—from 60.8 million m*hours in 1996 to 10.6 million m*hours in 2000. Analysis of the distribution of 112 by-catches during the 1990s shows no clear concentrations that could be used for time/area closure.

2.3.6 Baltic Sea

It is widely agreed that the population of harbour porpoises in the Baltic Sea is seriously depleted compared with former times (e.g., Berggren *et al.*, 2002a). It is uncertain precisely what is the cause, but climatic problems (cold winters) and by-catch in fisheries are both implicated. A recent workshop held at Jastarnia, Poland (ASCOBANS, 2002) to draft a recovery plan concluded that, regardless of cause, urgent measures were required to allow recovery, and that a current severe pressure was by-catch. It further concluded that, as a matter of urgency, every effort should be made to reduce the porpoise by-catch towards zero as soon as possible. There was no agreement as to the precise balance of measures required (the workshop was only drafting the recovery plan for later consideration by the Parties to ASCOBANS). Nevertheless, tools available include reduction in fishing effort in certain fisheries, changing gear types away from those carrying a higher risk of by-catch, and the introduction of a pinger programme (at least on a short-term basis). Insufficient information on the distribution of either porpoises or fisheries meant that key areas of overlap cannot be suggested for effort restriction or closure at this time.

2.4 General use of pingers in fixed gear

2.4.1 Background

Pingers are acoustic deterrent devices that have relatively low acoustic source levels (typically less than 150 dB re 1 µPa at 1m) (Reeves *et al.*, 2001) and that can be run for periods of months or years with a small battery pack. These low-power devices are not the same as the higher-power acoustic devices (or Acoustic Harassment Devices) with source levels greater than 185 dB re 1 µPa at 1m that are used to protect coastal aquaculture sites from seal and sometimes dolphin predation. These latter generally require large power sources that need frequent recharging, and which are therefore unsuitable for deployment in gillnet and active gear fisheries.

Pingers were first shown to successfully reduce cetacean by-catch in Canada, primarily as a means to reduce baleen whale entrapment in coastal set-nets and traps (Lien *et al.*, 1992). These "whale pingers" operated at 2.5 kHz and were later applied experimentally to gillnets in the Bay of Fundy, where they appeared to minimize harbour porpoise by-catch (Trippel *et al.*, 1999).

Lien adapted the original design, using a higher frequency, to deter porpoises from gillnets in the northern Gulf of Maine in the early 1990s. Subsequently, a U.S. electronics company designed a commercial device which was tested successfully in a carefully designed gillnet fishing experiment in the Gulf of Maine (Kraus *et al.*, 1997). This device operated at 10 kHz with harmonics at higher frequencies, and is highly effective in reducing porpoise by-catch. Current U.S. National Marine Fisheries Service regulations were subsequently introduced and these specify a harbour porpoise by-catch reduction pinger (300 ms pulses of a 10 kHz tonal pulse repeated at 4-second intervals with a minimum source level of 132 dB re 1 µPa) (Baur *et al.*, 1999). This U.S. technical specification was arrived at empirically, but the statistical results of a series of observer-based studies confirm that the pingers are nevertheless effective.

Tests with captive porpoises in the Netherlands and in Denmark suggest that more aversive acoustic signals exist than the sinusoidal tone pulses specified in the U.S.A. Wide-band pulses with a dynamically changing spectrum (frequency sweep) were shown to be significantly more aversive than single tones (Lockyer *et al.*, 2001) in captive animals. These features have been incorporated into a pinger design employing digital signal synthesis (a programmable microcontroller) developed by Loughborough University in the UK (Newborough *et al.*, 2000). The device emits a variety of wide-band frequency sweep-type signals with randomized inter-pulse intervals. Prototypes of this design worked successfully in a trial in the Danish North Sea cod gillnet fishery in 1997 (Larsen, 1999). An improved version of this prototype is presently available commercially as AQUAmark100. More recent designs by a Dutch company (Cuckoo) incorporate a wider range of frequency sweeps in an acoustic deterrent device that is intended to mask echo-location clicks, rather than simply to deter animals. The design also includes a replaceable sealed battery pack that can be removed from the rest of the device and replaced without detaching it from the net.

2.4.2 Principles for the use of pingers

There are a number of fundamental principles that need to be addressed before any widespread introduction of pingers to a fishery or an area. These were considered by the Scientific Committee of the International Whaling Commission (IWC) at its annual meeting in 1999 (IWC, 2000).

Pingers are best targeted (for cost effectiveness and efficiency) at times/areas considered most likely to have overlap between "high" porpoise densities and intensive use of nets posing a risk to the cetaceans ("hotspots"). An appropriate observer programme to ensure that pingers are being properly used at sea should accompany pinger implementation.

2.4.3 Potential advantages and disadvantages of a generalized use of pingers in fixed gear

The advantages of pingers are: 1) they seem to be very effective in reducing by-catch, at least in the short term; 2) they are immediately available; and 3) they allow fishing to continue. A more generalized use would also be expected to result in more competition between different manufacturers and in lower costs. However, some potential side-effects of pinger usage affect their potential suitability as mitigation devices.

2.4.3.1 Ease of use by fishers

There are a number of issues to be considered here, including methods of attachment, robustness, effects on fishing operations, and battery life and replacement. Cost is also a significant issue. If any of these issues result in significant operational problems, there are likely to be consequent problems with implementation and effectiveness. Several of these issues were examined in detail by SMRU *et al.* (2001) and WGMMPH has not reviewed this issue in depth. There are advantages and disadvantages to all of the various devices currently on the market, with some being easier to attach to nets than others, and some having better battery life than others. Given the range of fishing strategies and gear types used even within the gillnet sector, it seems unlikely that there is any one ideal design, and a danger of being too prescriptive in device type is that this will stifle further technical innovation in the devices. The issue of the cost of devices has been addressed in the Danish fishery by the Danish Fishermen's Association buying a stock of the devices for use by its members. An education/ information programme for affected fishers on the proper use of the pingers should accompany any widespread introduction of devices.

2.4.3.2 Effects on targeted fish species

Although effects on targeted fish species are a concern of some fishers, there have been no indications of decreased fish catches due to the use of pingers in any of the European fisheries studied so far. It is generally thought that most fishes, other than clupeids, are unable to detect acoustic signals at the frequencies (>10 KHz) and source levels that are typically employed in acoustic deterrents. However, any widespread introduction of pingers should be accompanied by a research (and subsequent information) programme to determine any effect on fish catches. Such research could accompany necessary monitoring of the effects of pingers on cetacean by-catch.

2.4.3.3 Exclusion of cetaceans from habitat

Concern has been expressed that widespread use of pingers could lead to small cetaceans being excluded from habitats critical for the viability of the populations. This would be of particular concern where the cetaceans are specifically exploiting the same resources in the same areas as those used by the fishers.

There have been several studies of the effects of pingers on the use of areas by cetaceans (Koschinski and Culik, 1997; Stone *et al.*, 1997; Goodson *et al.*, 1997; Laake *et al.*, 1998; Gearin *et al.*, 2000; Culik *et al.*, 2001; Cox *et al.*, 2001; Berggren *et al.*, 2002b). In most of these studies, cetaceans were tracked visually (and sometimes also by sound) in an area containing one or more pingers. The distribution and movement of the animals were then compared when pingers were on or off. Typically, harbour porpoises were observed less frequently in areas out to between 100–500 m distant from the pingers. For example, Berggren *et al.* (2002b) studied the use of pingers on a simulated net and found that pingers (Dukane NetMark 1000™) significantly reduced the number of porpoise clicks detected within 500 m of a net. This could be partly due to movement away from the net or from reduction in click rate due to the pinger (or both), as has been noted in other studies (Cox *et al.*, 2001). The studies of Berggren *et al.* (2002b) showed that mean surfacing distance from the net in a bay (maximum offshore distance 1900 m) changed from 431 m when the pingers were off to 752 m when they were on, though some sightings were still made very close to the sound source. In general, it is likely that the area over which cetaceans are deterred from entering and/or there is a reduction in click rate will be affected by the sound transmission properties of the area and ambient noise levels.

Larsen and Hansen (2000) made a rough estimate of the amount of sea that might be affected by the use of pingers if all Danish bottom-set gillnets in the North Sea were equipped with pingers. Their results suggest that, on average, only a few percent of the North Sea would be unavailable to porpoises, but this is obviously affected by assumptions on the effective range of the pingers used. Detailed spatial information on pinger usage and area affected would be required to develop this modelling further. Further research would be required to determine the long-term effects at the population level of the widespread use of pingers. Such research would be very difficult as a small reduction in viability of a large proportion of a population could have seemingly little consequence to an individual (and therefore be difficult to detect), but have a significant effect at the population level.

Concern has been expressed that pingers lost in the sea would continue to emit signals for a considerable period and thus unnecessarily add to the areas from which small cetaceans were excluded (CEC, 2002). To avoid this risk, it would be technically feasible for some pinger types to be programmed to stop transmitting after a pre-set period of submergence. It should also be noted, however, that continued pinger activity on lost gear may facilitate its eventual recovery.

2.4.3.4 Habituation

None of the experimental trials to examine the effects of pingers on marine mammal behaviour has continued over typical periods or schedules that fishers might use commercially. Habituation may occur after prolonged use. Cox *et al.* (2001) tested for this and found that there was an initial avoidance response by harbour porpoises similar to those observed elsewhere, but after a few days (in one test 2.8 days, in another 8.5 days) avoidance distance had waned by 50 %. Nevertheless, the pingers continued to prove effective at keeping porpoises away from the net over the two weeks of experimental noise. Habituation will presumably occur at the individual level, and therefore will happen only if these individuals are repeatedly exposed to the pinger. It would therefore be likely that habituation effects would vary depending on the use that cetaceans make of an area. A resident group might be expected to habituate more readily than a transient group. The effect of habituation may, therefore, be simply to reduce the effective acoustic "exclusion zone" with time; if this becomes too small, it could result in a return to previous by-catch rates.

2.4.4 Technical specifications affecting the effectiveness of pingers

Several features that influence the effectiveness of pingers have been mentioned above. Characteristics of existing available pingers are shown in Table 2.4.4.1 (from Reeves *et al.*, 2001).

2.4.4.1 Signal

As noted above, wide-band pulses with a dynamically changing spectrum (frequency sweep) are assumed to be significantly more aversive than single tones. Random pulses (within a limit) appear to be more aversive than regular pulses. However, it is not clear that maximal aversion is the optimal strategy to adopt if the objective is to minimize by-catch while simultaneously minimizing the potential area of exclusion.

2.4.4.2 Reliability and longevity

Pingers should be regularly checked to ensure that they perform adequately. Issues such as the length of time that pingers can operate without significant maintenance (such as battery changing) are obviously important. This issue will also affect inter-pinger distance on nets (and therefore the number of pingers and their total cost). A common problem is mechanical damage to pingers when nets are set at high speed. Improved attachment arrangements and pingers that are more robust are a priority for future development.

2.4.4.3 Ease of use and cost

The most important feature of any implementation of pingers on nets is their acceptance by the fishers asked to deploy them. Without such acceptance, the difficulties of enforcement and monitoring are such that their effectiveness will be seriously compromised. This is plainly not solely a technical issue, but unless pingers are relatively inexpensive (or free) and do not add significantly to the workload of a fisher, then it seems doubtful that they will be readily adopted.

2.4.4.4 Spacing of pingers

Some redundancy is required in spacing on a net, but the work of Berggren *et al.* (2002b) suggested that most recommended net spacings (Table 2.4.4.1) were probably too close for the Dukane pinger. The louder the acoustic signal, the fewer pingers need to be applied per unit net length to achieve total deterrence, but the greater the power requirement of the devices will be, and the greater the exclusion zone around the net will be. Recommended distances are typically 100–200 m intervals, but effective distances will probably be defined empirically in future, and are likely to be further apart.

2.4.4.5 Enforcement

The problem of enforcement needs to be addressed during the implementation of any statutory pinger scheme. Enforcement procedures could either involve hauling a net to check proper deployment of pingers, or the remote acoustic sensing of pingers (though these both assume that net owners can be identified); or enforcement could be port-based assuming that appropriate legislation could be framed. Some of the newer micro-controller type pingers that are able to transmit an ID code might assist in determining the owner of deployed nets.

2.4.4.6 Balancing technical specifications

There is probably no such thing as an ideal pinger for all fisheries. There are trade-offs between factors that affect energy consumption on the one hand and longevity on the other, especially for attachment methods which require small pinger housings. One of the most important results from the EU-funded EPIC (Elimination of harbour porpoise incidental catches) project was the realization that signal length can be reduced considerably without reducing aversiveness, thus reducing energy consumption. Another aspect of prime importance for the effectiveness of pingers is appropriate use, e.g., appropriate attachment, particularly where it relates to sound propagation.

2.4.5 Summary

Pingers have been demonstrated to be effective in mitigating small cetacean by-catch in fixed gear both in controlled experiments and in fishing operations. However, pingers have only been tested on a few small cetacean species so far. The behaviour of small cetaceans varies, which can affect the reasons why they are caught

Table 2.4.4.1. Characteristics of pingers (from Reeves *et al.*, 2001).

Manufacturer	**Dukane Corp. (discontinued)**	**Aquatec Sub-Sea Ltd (C)**	**Fumunda (C)**	**Lien – L1 (H)**
Models	Net Mark 1000^{TM} (a); Netmark 2000 (b)	Aquamark 100^{TM} (a); Aquamark 200 (b); Aquamark 300 (c)	FMP 332	Gearin (L2); McPherson (L3)
Source level max/min (dB re 1µPa @ 1m)	150–130	145	134–130	132–110
Battery	4 × 'AA' alkaline	1 × 'D' alkaline	1 × lithium	4 × PP3 alkaline
Fundamental frequency	10 kHz (U.S.)	(a) 20–160 kHz frequency sweeps (DK); (b) similar to (a) but the frequency sweep tuned for dolphins (DK); (c) 10 kHz tonal (U.S.)	10 kHz (US)	(L1) 2.5 kHz; (L2) 3.5 kHz; (L3) 3.5 kHz
High-frequency harmonics	Yes	Yes	Yes (Barlow); no (Goodson)	Yes (sometimes!)
Pulse duration (nominal)	300 msec	300 msec	300 msec	300 msec
Inter-pulse period	4 second (regular)	(a, b) 4–30 second (randomized); (c) 4 second (regular)	4 second (regular)	<2 (L1) (regular)
Life (continuous operation)	~ 5 weeks	(a, b) 18 months to 2 years	12 months	3–4 weeks
Wet switch	(a) no, (b) yes	Yes	No	Yes
Battery change	Yes	No (option available soon)	Yes	Yes
Environmental (battery disposal)	None	20 % discount for returned units against replacements	None	None
Spacing along nets (maximum recommended)	100 m	200 m	100 m	<50 m

Notes: C = commercially available; H = home-made but used extensively in trials; L = derivative of Jon Lien's original design for baleen whales; U.S. = emissions specified for regulated U.S. fisheries; DK = Type 1 emissions specified for regulated Danish fisheries. Note: PICE^{TM} is not listed here, as the commercial AQUAmark 100^{TM} is an improved derivative that transmits the same wide-band randomized acoustic signals.

in nets (Cockcroft, 1994). Therefore, the efficacy of pingers is likely to vary between species, and it should not be assumed that pingers will be equally effective among all species and in all situations. For this reason, the Scientific Committee of the IWC recommended controlled experimental trials prior to implementing pingers in a management framework to test their efficacy in new fisheries and with different species. Even when their ability to limit by-catch has been proven, sea trials were also recommended in any proposed fishery to ensure that there are no unforeseen technical or operational problems in implementation. Furthermore, the IWC Scientific Committee also recommended that pingers should not be deployed in an uncontrolled manner, but that there should be a monitoring programme to accompany any widespread deployments of pingers to ensure that their efficacy is monitored and to guard against failures in the technology, in the management practices, or in the deterrent value of the devices as a result of habituation. The cost of enforcement will reduce the cost-effectiveness of the technology.

2.4.6 Areas suitable for pinger scheme implementation

ACE lists below those areas of EU waters that have by-catches of porpoises that appear to be likely to be adversely affecting porpoises at the population level. In doing this, the definition recommended by ACE in 2001 (ICES, 2001) was used: "*Using the objective of rebuilding populations to 80 % of carrying capacity, or maintaining them there, and an* R_{max} *of 4 %, an annual by-catch mortality rate of 1.7 % of a small cetacean population is the maximum that could be sustained. This value is accepted as the basis for scientific advice until improved estimates of maximum population growth rates are available for these populations, or different* *management targets are adopted.*" This also reflects Table 3.6.1 of ICES (2001) listing fisheries that give the greatest concern due to harbour porpoise by-catch. With the exception of a generalized reduction in bottom-set gillnet fishing effort (net*km*hours), no other mitigation measure than the use of pingers is presently available that is known to be effective in these waters.

2.4.6.1 Western English Channel and Celtic Shelf

Based on the current levels of by-catch, it is apparent that mitigation measures are required in the gillnet fisheries of the western English Channel and the Celtic Shelf. Northridge *et al.* (2000) found no "hotspots" for closure of the hake gillnet fishery. Pingers should thus be implemented in bottom-set gillnet fisheries within the known current range of harbour porpoises in this area. This is likely to cover approximately all shelf waters south of Ireland and west of Britain and France. The eastward limit in the English Channel and southward limit to the west of France require some further research, but the limits are likely to extend at least as far as 2°W in the Channel and north of 47°N in the Bay of Biscay. Work remains to be done to establish whether mandatory pinger use by all gillnet vessels operating in these waters can be enforced, or whether a sufficient reduction in by-catches could be achieved by targeting only boats above a certain size. This latter option would limit pinger use and enforcement to the boats using the most netting, and minimize pinger deployment among some of the hundreds of small vessels working in these waters.

2.4.6.2 Channel and Southern Bight of the North Sea

This is an area holding few harbour porpoises, but known to be depleted relative to former times. Any by-catch in this area would represent a barrier to recovery. However, given the rarity of harbour porpoises, particularly in the central part of the area (eastern Channel), little is known of the most risky fisheries, and whether all fisheries carry risk to harbour porpoises. It would, therefore, be more appropriate to deploy pingers at each end of this area (see Sections 2.4.6.1 and 2.4.6.3) in order to minimize by-catch in those areas that are likely to provide the source of any recovery. This situation should be reviewed if the status of harbour porpoises or by-catch changes in this area. The Bergen Declaration by North Sea Ministers in March 2002 committed North Sea States to drafting and implementing a recovery plan for North Sea porpoises. The Channel and Southern Bight could be the main area to benefit from such a plan.

2.4.6.3 Central/southern North Sea (including coastal)

By-catch in this area is likely to exceed rates considered to be sustainable for the population of the area. As a consequence, pingers are presently deployed in the fishery believed to have the highest by-catch per unit effort: the Danish wreck fishery for cod in the months August–October. It is, however, inconsistent that other nations carrying out similar fisheries in the same area should not apply pingers.

As indicated in Table 2.1.2.2 though, the greatest absolute by-catch by a single fishery in this area is by the turbot fishery. Pinger deployment in this fishery (both Danish and those of other nations) in this area has the potential to reduce overall by-catch by around one third. The turbot fishery is relatively small (defined from days at sea, landings by weight, and value), with a proportionally high cetacean by-catch, and ACE therefore gives a mandatory pinger use in the turbot fishery the highest priority. The Danish turbot fishery is characterized by large meshes (mainly 270 mm) and a very long soaktime. Depending on the area, turbot or monkfish is the target species. The Danish fishers also target lumpsucker by gears similar to the turbot net. The UK also has fisheries, using large meshes and long soaktimes, for turbot, monkfish, rays, and skates. For a clear definition, ACE proposes that pingers should be mandatory in all bottom-set net fisheries using large meshes. The EC regulation 850/98 uses 220 mm as the minimum mesh size for the (fish) by-catch regulation relevant to the fisheries mentioned, so ACE proposes mandatory pinger use for all fisheries using meshes ≥220 mm.

The next most numerous by-catch comes from cod fisheries other than around wrecks. However, there will probably be an effort reduction in the cod fishery as part of the "North Sea cod recovery plan" and, taking the expected major by-catch reduction in the ≥220 mm set-net fisheries into account, ACE considers that the effort reduction will be a sufficient mitigative strategy at present.

Pinger deployment could thus occur in the cod wreck fishery in the months August–October and in the ≥220 mm set-net fisheries, with a review of the situation after two years to determine the overall effect on by-catch rates. The precise geographical limits of pinger deployment need to be reviewed, but should take account of the need to particularly safeguard porpoises in the area just north of the Southern Bight (see Section 2.4.6.2).

2.4.6.4 Northern North Sea

Information on the set-net effort and by-catch level in this area is limited, mainly due to missing information from the major set-net fishing nation (Norway) in the area. To avoid effort redistribution in the cod fishery to this area, pinger use should be mandatory in the wreck fishery in the northern North Sea as well. Likewise, to prevent effort redistribution in the turbot fishery to a more northerly monkfish and turbot fishery, pingers should also be mandatory in this area for the ≥220 mm set-net fisheries.

2.4.6.5 Skagerrak, Kattegat, and the Belt Seas

Information on by-catch indicates that in the period from 1996 to 2001 there has been a six-fold decrease in by-catch and effort in the Swedish cod fishery in the Kattegat and the eastern Skagerrak. Information on the Danish fisheries is based on a sampling effort much lower than that for the North Sea, but data indicate in general a much lower by-catch except for the lumpsucker fishery. Both Sweden and Denmark have had a significant effort reduction in the cod fishery due to declining cod stocks and TAC, probably resulting in a by-catch decrease. However, the Kattegat and Belt Seas are immediately adjacent to the Baltic Sea, whose population of harbour porpoise is heavily depleted. The Baltic population structure and its connection to adjacent waters are still under debate, but a recovery might be more rapid with a supply of animals from adjacent waters. However, considering the effort reduction in the cod fishery, the apparently low by-catch, and the very high SCANS estimate of porpoise density in the Belt Seas, the need for a significant by-catch reduction from a generalized pinger use is not urgent, and will not help the Baltic porpoise population very much. The by-catch in the lumpsucker fishery might, however, be significant.

2.4.6.6 Baltic Sea

The harbour porpoise population of the Baltic Sea is heavily depleted. As a consequence, ASCOBANS is drafting a recovery plan (ASCOBANS, 2002). Its current main recommendations in relation to mitigation of this by-catch are that:

- pinger use be made mandatory in Baltic high-risk gillnet fisheries on a short-term basis (2–3 years), in at least ICES Fishing Areas 24, 25, and 26;
- trials of fish traps, fish pots, and longlines be initiated immediately, with the long-term goal of replacing gillnets in the cod fishery, particularly in areas where porpoises are known or expected to occur frequently;
- serious consideration be given to replacing driftnets with longlines in areas where porpoise by-catch is known or likely to occur.

This mix of pinger use and replacement of gear was reviewed and generally supported at the meeting of the Scientific Committee of the International Whaling Commission in 2002. It is important to note that both the ASCOBANS drafting group and the IWC Scientific Committee (IWC, 2002) consider that pinger deployment should be considered as a short-term approach to meet the objective of allowing this harbour porpoise population to recover. The rapid development of medium- and long-term approaches to mitigation (e.g., reduced fishing effort in “high risk” areas, conversion to fishing gear and practices likely to result in considerably less by-catch) is crucial and should not be compromised. Multiple mitigation measures are typically required elsewhere in meeting by-catch reduction objectives (e.g., Dawson *et al*., 1998).

2.5 General use of pingers or other modifications in pelagic trawls

Although this term of reference refers to pingers or other deterrents, ACE has chosen to generalize this to include devices that might exclude cetaceans from trawls, also. There have been two European tests of devices that might exclude cetaceans.

2.5.1 CETASEL

De Haan *et al*. (1998) reported on a three-year project (1995–1997) entitled CETASEL, co-funded by DG XIV. This project aimed to understand dolphin behaviour near to (and within) pelagic trawl nets. It then aimed to test the effects of a series of ropes hung within the pelagic trawl net to determine whether such ropes would prevent the entry of dolphins further into the net. Considerable technical difficulties meant that an effective dolphin-tracking system was not developed, so that only limited insights were made on dolphin behaviour near pelagic trawl nets. Trials of the ease of rigging the ropes within the net were completed and were reasonably successful. Tests of behaviour near equivalent sets of ropes suspended into a pool containing dolphins found that they would swim through them. However, it is not possible to generalize from this captive situation to actual situations at sea. It is not possible on the basis of the results of CETASEL to draw any conclusions on the possible effectiveness of sets of ropes used as exclusion devices.

2.5.2 UK tests in 2001/2002

Trials of an excluder device by the UK Sea Mammal Research Unit were undertaken in cooperation with Scottish pair trawl fishermen in the bass fishery in early 2002 under funding from the UK Government. This device is an exclusion grid similar to those used in many other trawl fisheries to exclude larger unwanted by-catch, and consists of a steel grid placed in the extension piece of the trawl, with an escape hatch covered by a small-meshed net immediately in front of the device. The preliminary tests were intended to ensure that the device would not hinder fishing, and that bass could still be caught with a grid in place. Although a power analysis suggested a high probability of also observing dolphins in the trawl during the projected eight-day trial, based on by-catch rates in 2001, in fact very few dolphins were observed at all in 2002, so no direct evidence of how dolphins would react to the grid was obtained. Nevertheless, the grid performed well in other ways, though it is still clearly in need of some refinements. The effectiveness of this device remains unproven as yet, but further work is planned.

2.5.3 Use of pingers

Use of pingers in pelagic trawl nets has been suggested in several places (e.g., de Haan *et al.*, 1998). Given the width of opening of pelagic trawls, it would not be sensible to place pingers around the mouth of the trawl. De Haan *et al.* (1998) suggested that it would be more sensible to place pingers around the "sharks teeth" where the net mesh narrows. De Haan *et al.* (1998) further suggested that sounds could be turned on selectively as trawls are hauled or turned. These suggestions are based on the idea (yet unproven) that many dolphin catches occur during these phases of fishing. Such usage would possibly also reduce habituation by dolphins. Until such suggestions are better supported and a clear need is demonstrated, it is not possible to assess this suggestion.

De Haan *et al.* (1998) also suggested placing pingers on all vessels and netsondes in a fleet operating pelagic trawl gear in order to deter dolphins from a wide area of sea. This suggestion cannot be supported by any existing data on widespread deterrence of dolphins from an area. The sound levels required to keep animals out of a large area may in fact place any dolphins near the source at risk of acoustic damage.

2.5.4 Time of day

There has been a suggestion that dolphin by-catches in pelagic trawls are more common at night (Baird, 1996), or during evening and early morning (de Haan *et al.*, 1998). As a result of this, guidelines were established for some New Zealand pelagic trawl fisheries to minimize dolphin by-catch that involved minimizing certain activities during the hours of darkness. There is little evidence in European waters to support any of the suppositions behind these guidelines, however, and observations in the bass fishery demonstrate that by-catches of common dolphins are frequent during daylight tows (ICES, 2002). It seems likely that dolphin by-catch modalities will be different in different areas, different fisheries and with different species, so that a standard set of guidelines is probably inappropriate.

2.6 Other possible mitigation measures

2.6.1 Overall effort reduction

Any reduction in fishing effort will reduce by-catch. For several years, ICES has advised reductions in directed effort for many fisheries in the EU zone. To the extent that these advised effort reductions are allocated to static net or pelagic trawl fisheries, particularly ones with high by-catches, the effort reductions themselves will contribute directly to reduced by-catch of small cetaceans, and will continue to do so in the future. ACE notes the new proposals by the European Commission to further reduce effort in nearly all fisheries in EU waters (COM (2002) 181 and COM (2002) 185).

2.6.2 Mitigation plans for individual fisheries

Experience throughout the world has shown that the most effective ways of reducing by-catch need to be tailored for individual fisheries and circumstances. This tailoring is best done by a combination of the fishers, relevant scientists, and gear technicians. In the U.S., where by-catch reduction is mandatory in a number of fisheries, take reduction teams are established to develop overall mitigation strategies. These teams include a wide range of stakeholders, such as managers, representatives of environmental groups, and residents of areas affected by the fisheries, along with those listed above (Read, 2000). The teams are pressured by there being a default option by which the Secretary of Commerce will impose a plan if no consensus is reached.

This model may not be suitable for the substantially more complex, multinational fisheries in EU waters, but the principle of bringing relevant scientists and fishers together should not be lost if any mitigation is to be effective. Similarly, the principle of timetabled default management options in the absence of effective implementation of mitigation measures is also something that could usefully be adopted in a European context, if by-catch reduction across national fleets is to be effective.

2.6.3 Protected areas

Marine Protected Areas (MPAs) are conceptually different from fishery time/area closures in that they are established for conserving marine life (and sometimes landscapes) rather than specifically to deal with fisheries impacts. In the European Union, the Habitats (92/43/EEC) and Birds (79/409/EC) Directives require establishment of areas to protect certain marine life. Under the Habitats Directive, species requiring such protection include the harbour porpoise and bottlenose dolphin. Management plans are required for these areas in order to maintain the "interest" of the site. For those sites established for harbour porpoises or bottlenose dolphins, there will inevitably be a consideration of the management of fisheries. At present, there are few and relatively small areas proposed for protection under these Directives for these small cetaceans. Such sites may be more effective in safeguarding the relatively local groups of bottlenose dolphins listed in Table 2.2.1.1, but it is difficult to see how the more wide-ranging harbour porpoises might be better protected without establishing very large areas.

2.6.4 "Reflective" gillnets

An alternative to the use of acoustic alarms on gillnets is the development of nets that have a lower probability of entangling cetaceans. One approach could be the development of a net that would be more detectable to an echo-locating marine mammal. Larsen *et al.* (2002) described a study to test whether gillnets made from monofilament impregnated with iron oxide catch fewer harbour porpoises. The trial was conducted in the Danish North Sea bottom-set gillnet fishery in 2000 and recorded a 20 % reduction in cod catch relative to nets made from conventional materials. Eight porpoises were caught in control nets and none were taken in the iron-impregnated nets, a significant reduction in by-catch. Surprisingly, acoustic testing indicated that there were no significant differences in the acoustic target strength of modified and control nets (the manufacturers considered that there was an 11 % increase in reflectivity), suggesting that the reduction in by-catch was not caused by an increase in acoustic reflectivity. It seemed likely that the modified nets caught fewer porpoises (and cod) because they were stiffer than conventional nets. If this is true, modification of net stiffness offers the potential for an inexpensive means of reducing by-catch, although this benefit may be tempered by reduced catch of target species and heavier and more bulky nets.

Further preliminary tests have been conducted in Canada and the U.S.A, but the results of these tests have yet to be fully published (Trippel *et al.*, 2000). Undoubtedly further tests are required, but if such nets prove to be effective in reducing the by-catch of small cetaceans in gillnet fisheries, *and* do not reduce the catch of target fish species, they hold great promise as a mitigation tool. The nets are unlikely to be significantly more expensive than traditional nets and, unlike pingers, they do not require additional maintenance. If some change to the physical properties of monofilament gillnets results in a lower by-catch rate of dolphins and porpoises, this modification has potential as a mitigation measure.

2.6.5 Lost nets

A large number of gillnets are lost during ordinary fishing operations. It has been demonstrated that such nets capture fish for long periods of time, in the order of years (Anon., 2000; Santos *et al.*, 2001). This means that they can be a hazard for cetaceans, also. Harbour porpoises, searching for food using a "bottom grubbing" technique (Lockyer *et al.*, 2001), may also be exposed to lost fishing nets that have sunk to the bottom. The loss frequency is estimated at 10 % per year or more in some fisheries (Anon., 2000; Santos *et al.*, 2001; ICES, 2002). With the long active life of such lost nets, they add a substantial part to the total risk of by-catch due to the gillnet fishery. An overall effort reduction is probably the most efficient way to reduce the amount of lost gears. Pinger application might help as well as a means to localize lost nets, owing to the economic value of recovered pingers. An organized recovery of lost nets should be regarded as an additional possible mitigation measure.

2.6.6 Technical measures with regard to gear specification and deployment

Factors such as reducing the numbers and lengths of nets deployed per fisher, sizes of mesh and twine, and soak duration, have been found effective in reducing the by-catch of small cetaceans in static net fisheries in the U.S. (Read, 2000). However, the U.S. results suggest that the effectiveness of the technical measures on both the by-catch of small cetaceans and impacts on gear efficiency for target species must be evaluated on a case-by-case basis before specific recommendations can be made. The effectiveness of specific technical measures for specific EU fisheries has not been investigated systematically within the Northeast Atlantic. Each fishery is more or less unique with respect to gear specification and fishing practice and most parameters, such as mesh size and twine thickness, are moreover highly correlated. Therefore, in addition to data from existing observer programmes, substantial field work using various mesh sizes, twines, hanging ratios, etc., is required to analyse the effect of one parameter.

2.7 Recommendations

1) ICES advises that monitoring programmes, using independent observers, for obtaining information on by-catch of cetaceans should be extended to all fisheries with a potentially high risk of by-catch. Without full information, it is impossible to make a full assessment of the impact of fisheries on cetacean populations.

2) Noting that the regulation EC 1543/2000 for the national collection of data in the fisheries sector does not mention cetacean by-catch, while requiring (at sea) sampling of fish discards, ICES recommends that discards sampling should be done primarily by independent observers and, where possible, be combined with sampling of marine mammal by-catch.

3) Noting that proper evaluation of cetacean by-catch (that would, therefore, use such observer schemes) is mandatory under existing EU legislation (Directive 92/43/EEC), ICES recommends effective enforcement of this requirement.

4) ICES advises that any reduction in overall fishing effort is likely to reduce by-catch and, therefore, be an effective measure.

5) Limitation on the use of fishing gear, whether total or partial, is likely to result in redistribution of fishing effort, either into other metiers, or into adjacent areas. Whether or not this results in an overall reduction in by-catch will depend on the by-catch rates of the metiers receiving the redistributed effort. Therefore, ICES does not in general recommend spatial and temporal closures on a small scale, without overall effort reduction, as an effective mitigation strategy.

6) ICES considers that the use of pingers is a short- or medium-term mitigation measure, but because the effectiveness and effects on distribution are still uncertain, pinger application must be monitored and

evaluated. Notwithstanding the concerns mentioned in Section 2.4, to contribute to a reduction in the by-catch of cetaceans in the short term, ICES recommends that the use of pingers be made mandatory in the following fisheries:

- bottom-set gillnet fisheries within the known current range of harbour porpoises in the western English Channel and Celtic Shelf (see Section 2.4.6.1 for further details) unless and until evidence is available to discriminate between by-catch in the various fisheries using the area;

- bottom-set gillnet fisheries used in the cod wreck fisheries in the months August–October and in set-net fisheries using mesh sizes ≥220 mm in the North Sea;

- bottom-set gillnet fisheries for lumpsucker in the Skagerrak, Kattegat, and Belt Seas, unless observer schemes can validate a low by-catch.

7) For pelagic trawls, ICES recommends that more research be conducted on pingers and other devices to exclude cetacean by-catches before they can be recommended as mitigation measures.

8) There is insufficient information on by-catch in pelagic trawl metiers, mostly owing to a lack of independent observer schemes, to know the relative risk that those fisheries pose to cetacean populations, or the scale of that risk. ICES recommends observer programmes for all pelagic trawl metiers.

9) In addition to observer programmes in the commercial fishery, ICES recommends that further investigations be carried out to determine the effect of gear specification and fishing practice on by-catch, to be able to understand which factors induce high by-catch rates and provide a basis for the development of alternative gears.

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3 DISTRIBUTION OF COLD-WATER CORALS IN THE NORTHEAST ATLANTIC IN RELATION TO FISHERIES

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.*"

Source of information

The 2002 Report of the Working Group on Ecosystem Effects of Fishing Activities (WGECO) (ICES CM2002/ACE:03).

The 2002 Report of the Study Group on Mapping the Occurrence of Cold-Water Corals (SGCOR) (ICES CM 2002/ACE:05).

Introduction

Many species of coral grow in cold water. If the request were interpreted widely, these corals occur throughout the ICES area and the entire ICES area would be identified. However, this request from the European Commission is to help meet recent concerns about the impacts of fishing on cold-water coral reefs. It is therefore assumed for the purposes of this report that cold-water corals refer to those coral species that contribute to reef formation in waters with temperatures less than about 20 °C. In Northeast Atlantic waters, these include the azooxanthellate scleractinarian 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 *Lophelia pertusa* and none has been found forming reefs without *Lophelia pertusa* being present. Zibrowius (1980) gave a good general review of the distribution of cold-water corals in European waters.

Lophelia pertusa can occur in a variety of forms; in larval form it can presumably move widely, but once settled it can grow upon itself to form large reefs or reef complexes. Sars (1865) was the first to suggest that *Lophelia pertusa* can build reefs. However, the use of the term "reef" has been debated in the scientific literature, and different authors suggest various terms to be applied for accumulations of azooxanthellate coral colonies and skeletons. These terms include: "reef", "massifs", "bank", "patch", "mound", and "bioherm". "Reef" is used in this report for such accumulations.

Until the very recent discovery of a larger reef, the greatest of these reefs known in the Northeast Atlantic (and globally) was on the Sula Ridge on the mid-Norwegian shelf. This structure is more than 13 km long and up to 450–500 m wide. The average height is about 15 m, but some individual sub-structures are 35 m high (Dons, 1944; Freiwald *et al.*, 1999). This reef provides a habitat for a diverse associated community of marine life, with some associated fish species at much higher densities than in surrounding waters (Jensen and Frederiksen, 1992; Mortensen *et al.*, 1995).

Spectacular reefs such as that on the Sula Ridge appear to be rare, however, and elsewhere the species forms "patches" (Wilson, 1979; Mortensen *et al.*, 1995, 2001). On the Rockall Bank, such patches have been recorded 15–30 m across and about 1.5 m high (Wilson, 1979), whereas some on the Norwegian shelf are slightly larger (Mortensen *et al.*, 1995, 2001). Wilson (1979) suggests a mechanism of growth and breakage of colonies, with subsequent growth on the fallen parts as a way that these patches might form. Elsewhere, isolated clumps of *Lophelia pertusa* have been observed.

In the Northeast Atlantic, reefs occur from the Iberian Peninsula to Ireland (Le Danois, 1948), around the Rockall Bank, the Faroe Islands (Wilson, 1979; Frederiksen *et al.*, 1992), and near the coast and on the shelf along the Norwegian coast between 60°N and 71°N (Dons, 1944). Further survey work has occurred in most of these areas and modern references are included in the following sections.

Most records of the species are samples grabbed or trawled up. Thus, the structural context in which the species is growing at most recorded sites is not known (and is likely to have been changed by the sampling or trawl gear). The precise growing habit of the species is likely to be dependent on oceanographic conditions and the degree of disturbance and turbulence at each site.

3.1 Distribution of *Lophelia pertusa*

Lophelia pertusa appears to prefer oceanic waters with a temperature of between 4 °C and 12 °C, with relatively high water flow. These conditions occur widely in the Northeast Atlantic. Broadly though, they occur at shallower depths in some Norwegian fjords (within 40 m of the surface in Trondheimsfjorden (Strømgren, 1971; Rapp and Sneli, 1999)) and at much greater depths off the Iberian peninsula. Several review papers have described the distribution in parts of the Northeast Atlantic.

3.1.1 Norway

Fosså *et al.* (2000) provided an overview of *Lophelia pertusa* distribution in Norwegian waters and estimated that between 1500 km^2 and 2000 km^2 of the Norwegian EEZ is covered in coral. Most is concentrated between 200 m and 400 m depth on the continental shelf break, but with numbers of records from the entrances to some fjords (Figure 3.1.1.1). One particularly large reef complex is found on the Sula Ridge (e.g., Ottesen *et al.*, 2000). Fosså *et al.* (2000) also surveyed, through fishermen's interviews and direct observation, the effects of trawling activity. They concluded that between one third and one half of the total reef area of Norway has been damaged to an observable extent. Given the slow growth rate of *Lophelia pertusa*, the recovery of some of these reefs will, at a minimum, take centuries and may never happen.

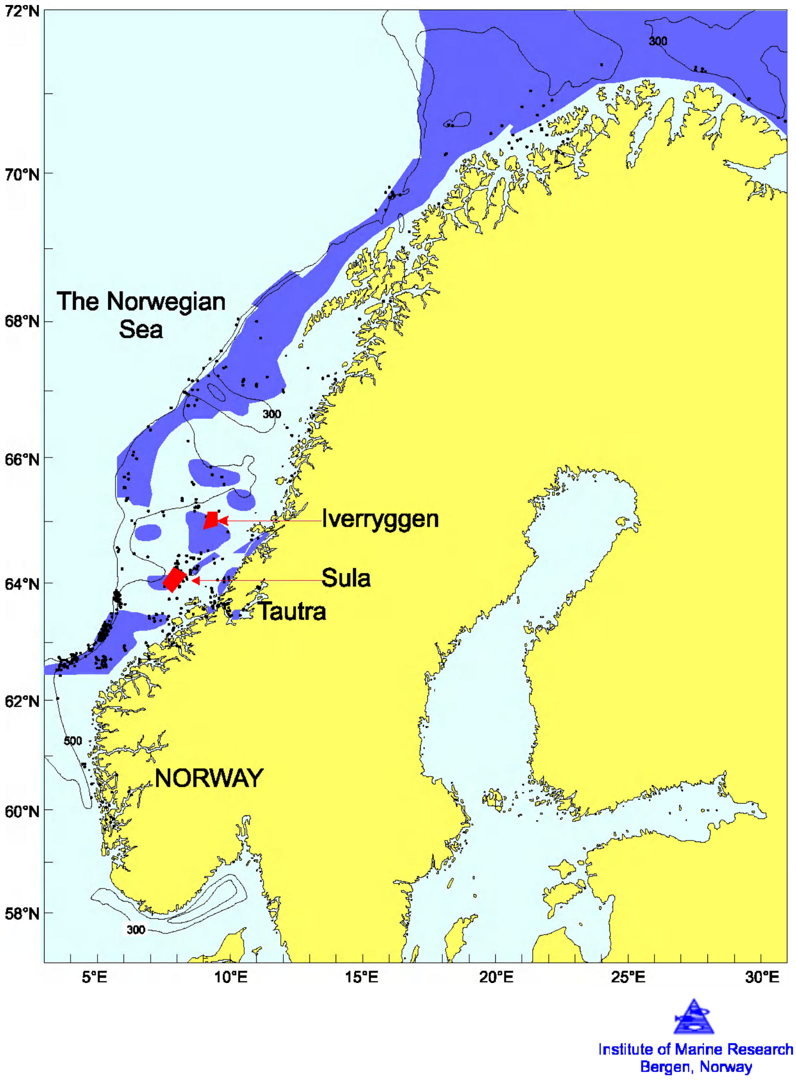
As a consequence of damage caused by fishing activities to coral reefs, two areas on the Norwegian continental shelf have been closed to fishing by towed gear to prevent further damage to previously unfished areas. These are at the Sula Ridge and at Iverryggen (Figure 3.1.1.1). The use of longlines in these areas is still allowed. Appendix 1 of Fosså *et al.* (2000) reprints the relevant regulations.

A very recent discovery, announced in June 2002 (http://www.imr.no/), is of an even larger reef than that on the Sula Ridge. This reef, 100 km west of Røst in the Lofoten Isles, is 35 km long and 3 km wide and lies between 300–400 m depth.

3.1.2 Faroes

Frederiksen *et al.* (1992) provided a review of the distribution of *Lophelia pertusa* around the Faroe Islands, including some waters within the UK 200 n.m. limit (EU fishing limits). The species occurs only in areas in contact with Northeast Atlantic water (as opposed to Arctic water), with all records in areas where the average bottom temperature ranges from 6.2 °C to 8.6 °C. The majority of records around the Faroe Islands were from, at, or near areas with a critical slope angle that would intensify mixing of bottom waters. The depth of the records ranges from about 300 m on the Rockall Bank to 750 m on the Hatton Bank. Stein Hjalti í Jákupsstovu has provided a map (Figure 3.1.2.1) based on interviews with fishermen, indicating areas of occurrence of *Lophelia pertusa* along with those areas where there is evidence of damage by fishing.

Figure 3.1.1.1. Distribution of *Lophelia pertusa* (dots) and major trawl grounds (blue) in Norwegian waters, showing the degree of overlap between coral and trawling distribution. Two areas on the shelf, Sula and Iverryggen (red), are protected from trawling gear. (Map provided by J.H. Fosså, Institute of Marine Research, Bergen.)



3.1.3 Iceland

Information on the distribution of *Lophelia pertusa* around Iceland is based on literature (Carlgren, 1939; Copley *et al*., 1996) and records from the BIOICE programme database (material identified by Helmut Zibrowius, 1998). The species occurrence is near the continental shelf break off the south and west coasts of Iceland (Figure 3.1.3.1), at a depth range of 114 m to 800 m, with bottom temperatures between 5.5 °C and 7.3 °C. Copley *et al*. (1996) found the species growing further south on the mid-Atlantic ridge.

Figure 3.1.2.1. Distribution of current (solid green) and past (hatched green) areas containing *Lophelia pertusa* reefs in waters around the Faroe Islands (map provided by S.H. í Jákupsstovu). It is assumed that reefs in the hatched areas have been lost through fishing activity. The red lines show areas presently closed for trawling, for fisheries management reasons.

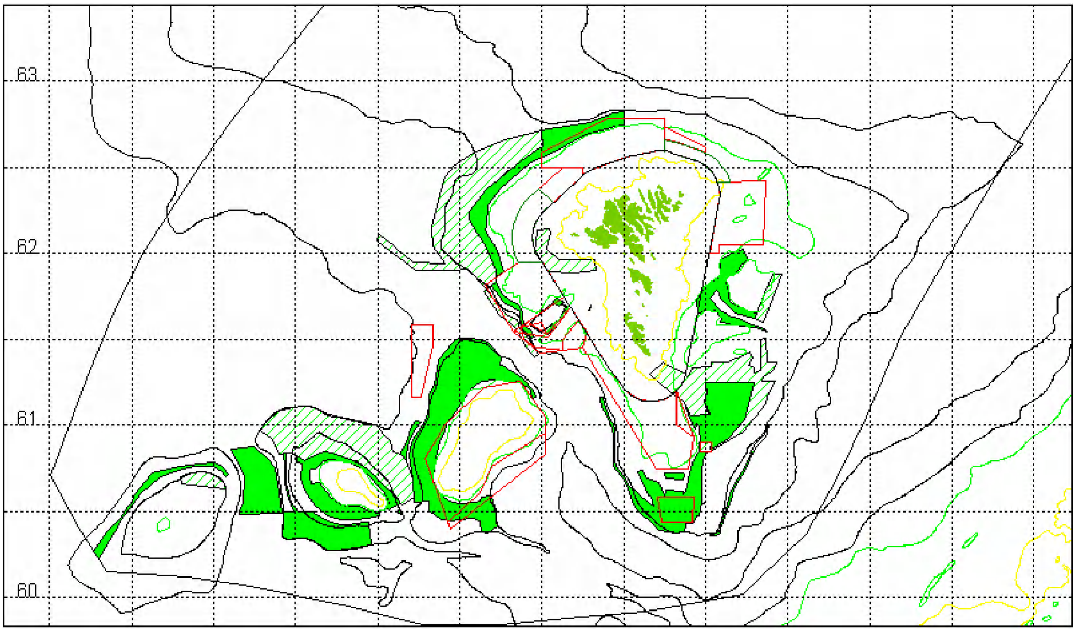
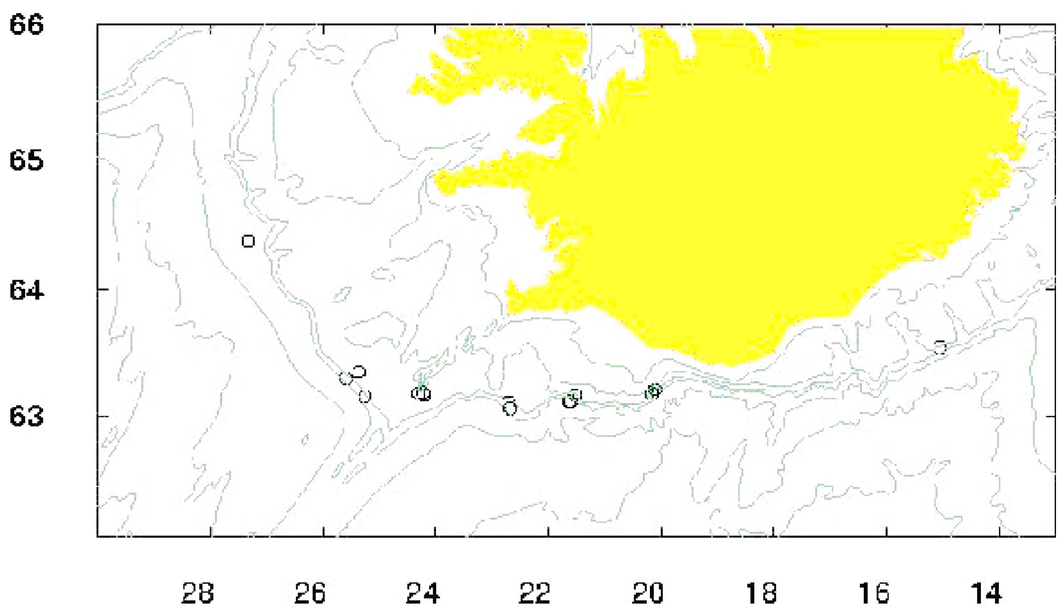


Figure 3.1.3.1. Distribution of records of *Lophelia pertusa* made during the BIOICE programme in Icelandic waters (map provided by S.A. Steingrímsson).



3.1.4 United Kingdom

Wilson (1979) was the first to review the distribution of *Lophelia pertusa* in UK waters as well as in nearby waters of the Northeast Atlantic. Both Long *et al.* (1999) and Rogers (1999) updated this review. The two main areas where the coral occurs are on the Rockall Bank and on the shelf break north and west of Scotland between 200 m and 500 m in depth (Figure 3.1.4.1). South of the Wyville Thomson ridge, the lower depth limit is deeper than to the north, due to the inability of *Lophelia pertusa* to grow in the deep, cold, Arctic waters occurring below 500 m north of the ridge. The ability of the coral to colnize newly available suitable habitats has been demonstrated by the occurrence of records from several oil platforms in the northern North Sea, including the now decommissioned Brent Spar installation (Bell and Smith, 1999).

The best-researched *Lophelia pertusa* features in UK waters are the Darwin Mounds, named after the research vessel "Charles Darwin". These are in two parts and are located in about 1000 m of water some 150 km to the northwest of Lewis (Outer Hebrides, Scotland) in the northeastern corner of the Rockall Trough, immediately south of the Wyville Thomson Ridge (Figure 3.1.4.2). The mounds cover an area of approximately 100 km^2 and contain some hundreds of mounds in two main fields (referred to as Darwin Mounds East (about 13 km × 4 km with about 75 mounds) and Darwin Mounds West (13 km × 9 km with 150 mounds)) (see Figure 3.1.4.3). Other mounds are scattered at much lower densities in nearby areas. Each of the mounds is approximately 100 m in diameter and 5 m high. Most of the mounds are also distinguished by the presence of an additional feature visible on the side-scan sonar referred to as a "tail". The tails are of a variable extent and may coalesce, but are generally a teardrop shape and are orientated southwest of the mound.

The mounds are composed mostly of sand, interpreted as sand volcanoes. These features are caused when fluidized sand "de-waters". Sand volcanoes are common in the Devonian fossil record in the UK, and in seismically active areas of the planet. In this case, tectonic activity is unlikely; some form of slumping on the southwestern side of the Wyville Thomson Ridge is a more likely cause. The tops of the mounds have living stands of *Lophelia pertusa* and blocky rubble (interpreted as coral debris).

Figure 3.1.4.1. Potential and actual distribution of *Lophelia pertusa* in northwestern waters of the United Kingdom (map courtesy of Southampton Oceanography Centre).

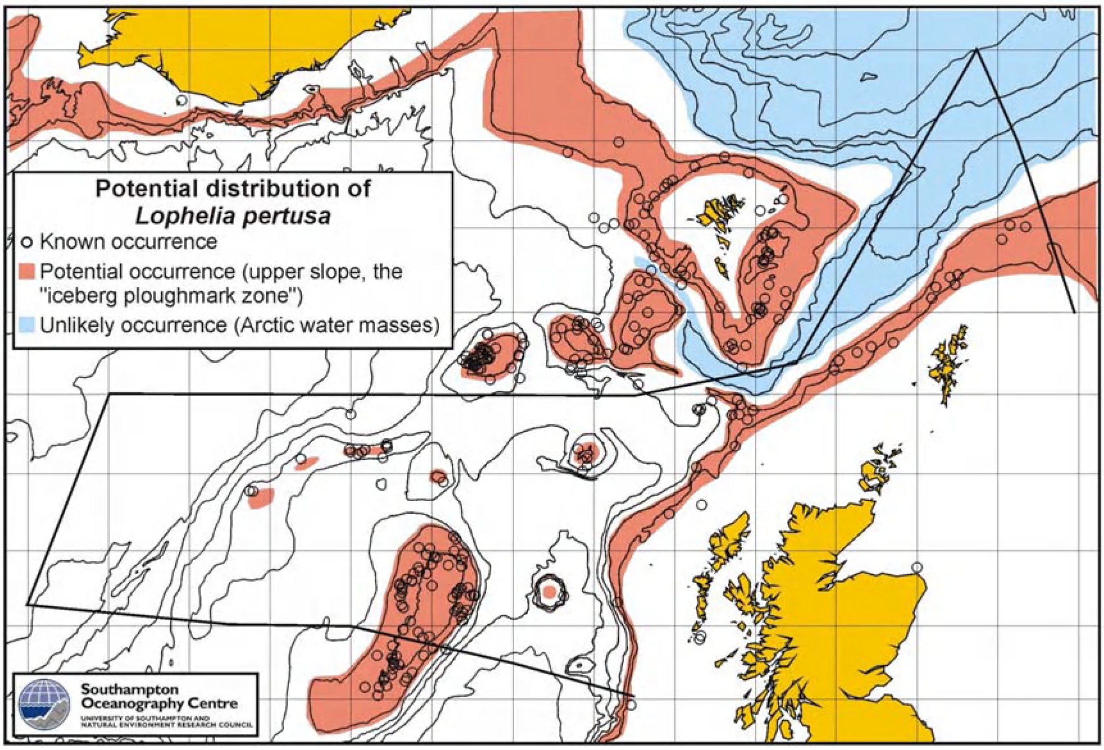


Figure 3.1.4.2. Location of Darwin Mounds in the Northeast Atlantic.

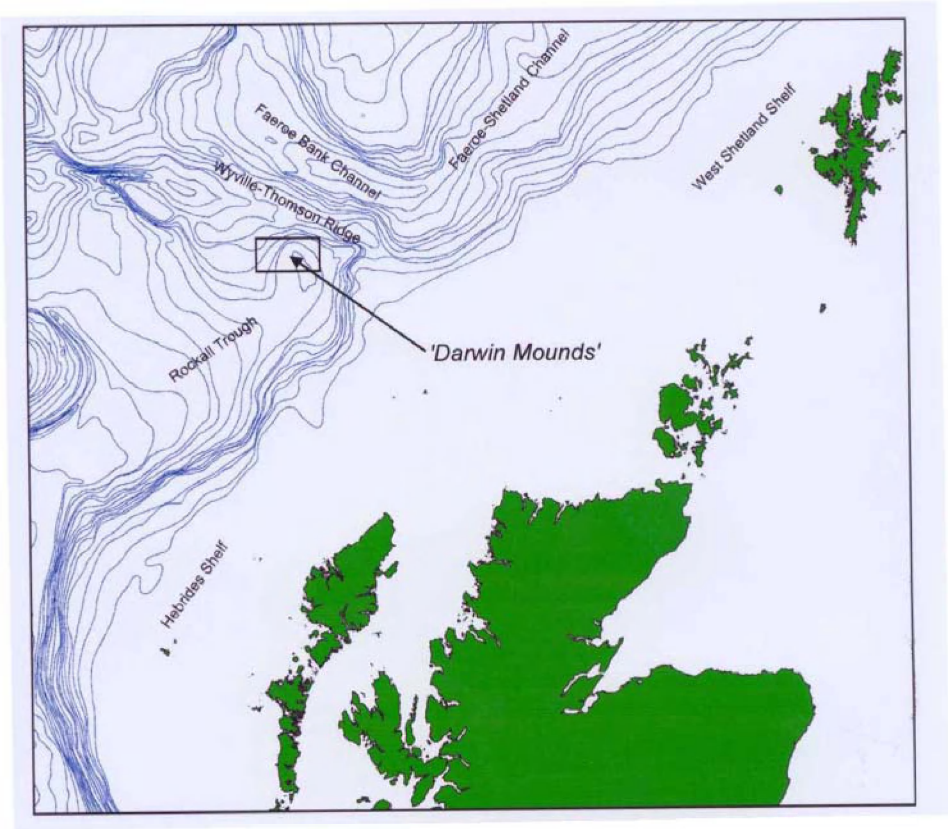
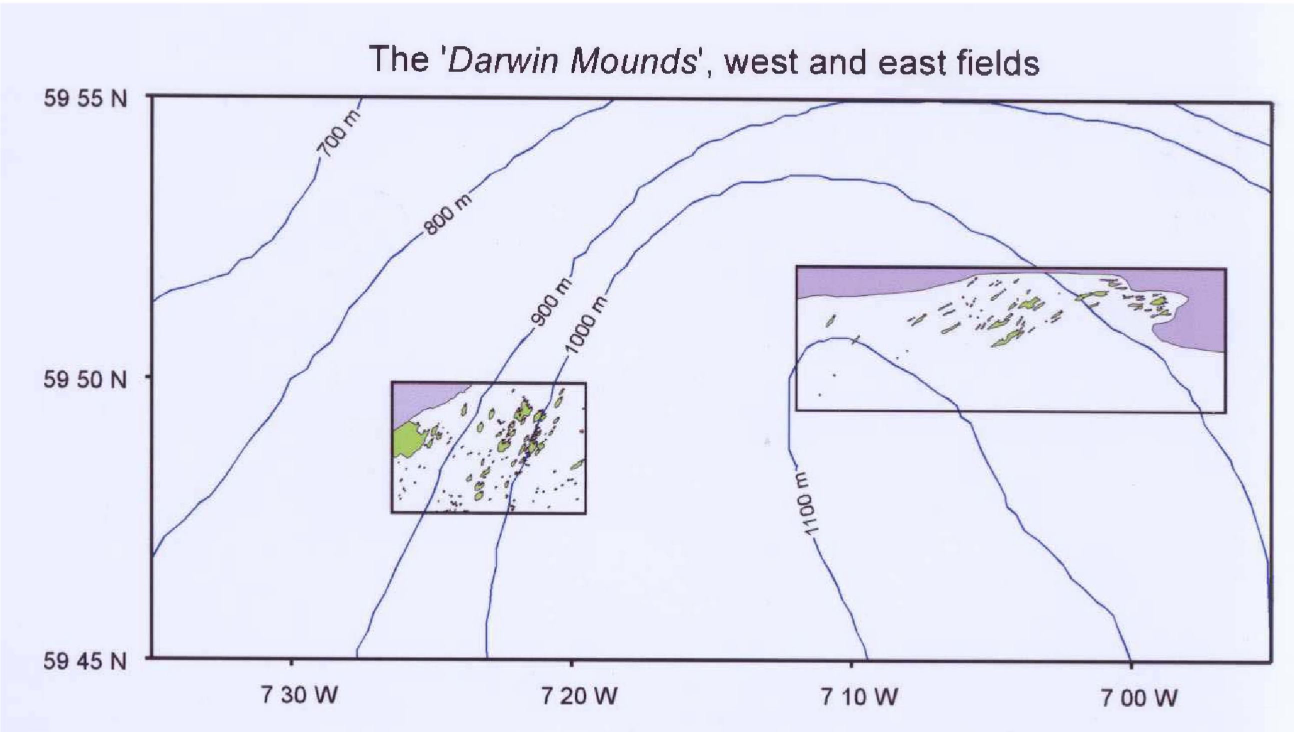


Figure 3.1.4.3. Detail of the location of the Darwin Mounds West and East fields. The red point is the mound, while the green areas are the "tails".



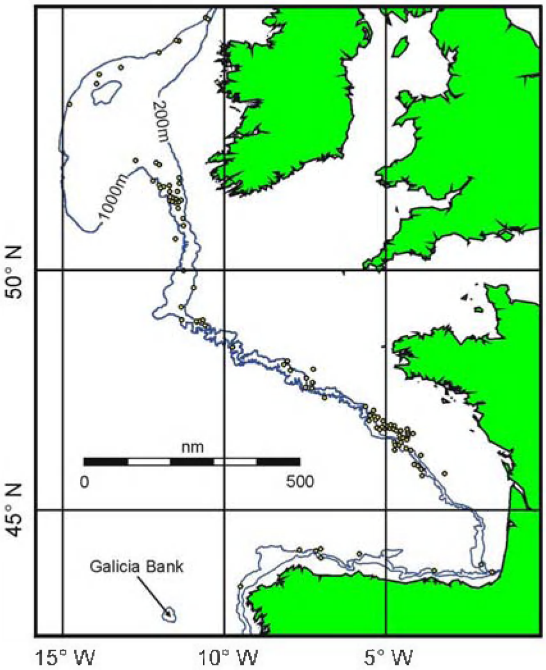
The tails also support significant populations of the xenophyophore *Syringammina fragilissima*. This is a large (15 cm diameter) single-celled organism that is widespread in deep waters, but occurs in particularly high densities on the mounds and the tails. The corals themselves provide a habitat for various species of larger sessile or near-sessile invertebrates such as sponges and brisingiids. Various fish have been observed associated with these features, but not apparently at significantly higher densities than in the background environment. This contrasts with studies at other *Lophelia pertusa* sites, where elevated numbers of saithe (*Pollachius virens*), redfish (*Sebastes* spp.) and tusk (*Brosme brosme*) have been found (Mortensen *et al*., 1995, 2001; Fosså *et al*., 2000).

The mound-tail feature of the Darwin Mounds is apparently unique globally. The mounds are also unusual in that *Lophelia pertusa* appears to be growing on sand rather than on a hard substrate. Prior to research on the mounds in 2000, it was thought that *Lophelia pertusa* required a hard substrate for attachment.

3.1.5 Ireland

There does not appear to have been a formal review of records of *Lophelia pertusa* in Irish waters, but the reviews of Wilson (1979) and Rogers (1999) contain many records (Figures 3.1.4.1 and 3.1.5.1). The southern end of the Rockall Bank and the shelf on the opposite side of the Rockall Bight (to the northwest of Donegal) and the Porcupine Seabight all hold large structures (Hovland *et al*., 1994). These larger structures were described as being "haystack" shaped, but some had a less regular shape and may extend in ridge-like forms. The base sizes are up to 1,800 m across, with a height of 65–165 m. Kenyon *et al*. (1998) studied twelve reef mounds in the Northern Porcupine Seabight. The mounds varied from approximately circular to elongate (or were compounds of these elements). The mounds were approximately 1 km in diameter, and the largest reached 120 m in height. Many of these mounds had a buried segment underlying them, indicating a long history of the structure that has included sedimentation events. Kenyon *et al*. (1998) further described a line of nineteen mounds running southwards at about 11°40'W from 51°40'N to 51°20'N (Figure 3.1.5.2). One of these (the Theresa Mound at 51°25'N, 11°46'W) is home to some of the best-developed coral (*Lophelia pertusa* and *Madrepora oculata*) ecosystems known in the Northeast Atlantic (Bett *et al*., 2001). Most of the records in the Porcupine Seabight and vicinity are from depths of 400–1000 m.

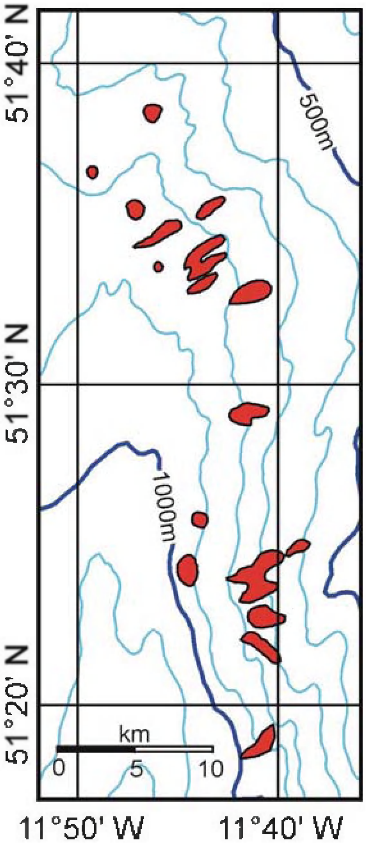
Figure 3.1.5.1. Early observations of the distribution of deep-water corals (mainly *Lophelia pertusa*) in the Porcupine Seabight and Bay of Biscay areas, compiled from the records of commercial fishing vessels. (Adapted from Teichert, 1958; after Joubin, 1922a, 1922b.) The Galicia Bank is also indicated. This site is now known to hold a significant population of *Lophelia pertusa* (G. Duineveld, pers. comm.).



3.1.6 France, Spain, and Portugal

There are a number of records from the Bay of Biscay and *Lophelia pertusa* is abundant in some areas, including the Chapelle Bank (47°30'N, 7°10'W, 48°10'N, 04°10'W) (Rogers, 1999) and on the Galicia Bank (Figure 3.1.5.1). The Galicia Bank has its summit at 500 m water depth. It is approximately 1500 m long, with a very steep eastern slope of bare rock. The western slope levels out at about 800 m to an extensive sandy plateau. Current speeds are high, producing a sea floor of coarse foraminiferal sand that is formed into mega-ripples with a wavelength of about 25 m and an amplitude of 50 cm. Surprisingly, the corals (*Lophelia* and *Madrepora*) occur in this dynamic sandy area rather than on the bare rocky slopes. The corals form longitudinal patches of about 1 m wide and 1 m high, and can run for over 10 m (ICES, 2002). *Lophelia pertusa* has also been recorded off the Canary Islands and in several sites off Portugal, and at depths mostly greater than 1000 m around the Atlantic islands of Madeira and the Azores.

Figure 3.1.5.2. Schematic representation of the large carbonate mounds (red areas) in the "Belgica Mound Province" of the Porcupine Seabight, based on 9.5 kHz OKEAN side-scan sonar data. Deep-water coral communities are known from most, if not all, of these mounds. (Adapted from Kenyon and Akhmetzhanov, 1998.)



3.1.7 Mediterranean

Rogers (1999) noted a number of records of *Lophelia pertusa* from the western basin of the Mediterranean.

3.2 Impacts on cold-water corals

3.2.1 Trawling

The use of mobile bottom fishing gears, particularly trawling, is widespread in areas holding *Lophelia*. Any fishing gear physically impacting, by direct contact or by indirect effects such as wash or sedimentation, will cause an effect. Photographic and acoustic surveys have recently located trawl marks at 200–1400 m depth all along the Northeast Atlantic shelf break area from Ireland, Scotland, and Norway (Rogers, 1999; Fosså *et al.*, 2000; Roberts *et al.*, 2000; Bett, 2000).

There have been a number of documented instances of damage to *Lophelia* reefs in Northwest European waters. These, though, must represent a small proportion of the number of instances when such reefs have been damaged, given the widespread distribution of current trawling activities, and the amount of habitat that is potentially suitable for corals in the Northeast Atlantic (Section 3.1). Another indication that damage to corals by trawling has been widespread is that many records of occurrence come from commercial trawlers hauling up broken pieces of coral.

The most obvious impact of trawling is mechanical damage caused by the gear itself. The impact of trawled gear kills the polyps and breaks up the reef structure. The breakdown of this structure will alter the hydrodynamic and sedimentary processes, and recovery may not be possible or could be seriously impaired. It may also cause a loss of shelter around the reef and organisms dependent on these features will have a less suitable habitat. The scale of effects depends on the scale and frequency of trawling operations. Damage may range from a decrease in the reef size, and a consequent decrease in abundance and diversity of associated fauna, to a complete disintegration of the reef and its replacement with a low-diversity community (Fosså *et al.*, 2000). Trawling may also have the effect of evening out the seabed by scraping off high points and infilling lows, as well as redistributing boulders. Since *Lophelia* requires some of the high points to grow initially, the seabed habitat following trawling may become unsuitable for the reestablishment of *Lophelia* reefs.

Trawls also cause resuspension of sediments that could affect corals growing downstream (including entrapment in the coral framework). Sediment loads are naturally low in areas where *Lophelia* occurs, so trawling effects may be relatively large compared to background levels. Such impacts may be proportionately greater in high-relief mound areas such as in the Porcupine Seabight, where trawling over the mounds is uncommon owing to the risk of gear damage and large unwanted by-catch. However, the sediment areas immediately adjacent to the mounds are heavily trawled.

Fosså *et al*. (2000) estimated that between one third and one half of Norway's *Lophelia* reefs are damaged or affected by fishing. Damage is illustrated from a number of areas by comparing photographs (damage is difficult to quantify by sampling because sampling itself also causes damage). Fosså *et al*. (2002) describe these surveys. To distinguish natural decay from impacts by human activities, such as bottom trawling, they looked for broken living colonies tilted, turned upside down, and/or in unexpected/awkward positions on levelled sea bottoms. The remains of trawl nets among corals and recent furrows or scars in the sea bottom were also taken to be evidence of trawling activity.

Three localities on Storegga (continental shelf break between 62°30'N and 63°50'N) were inspected between 1998 and 1999: Aktivneset, Korallneset, and Sørmannsneset. During 1999, two localities were inspected on the shelf: Maurdjupet and Iverryggen. All these localities and surrounding areas are subject to extensive bottom trawling.

Two inspections with a remotely operated vehicle (ROV) were made at Sørmannsneset, covering a vertical range from 370 m to 225 m and distances between 2.5 km and 2.9 km. The observations confirmed that the most severe damage occurred at the shallowest depths (200 m), as crushed remains of *Lophelia* skeletons were spread over the area while living corals were rarely found. Many signs of trawling were found, including wires and remains of a trawl net entangled with corals. In addition, sonargrams from the side-scan sonar detected furrows penetrating into areas of damaged corals. These were interpreted as furrows caused by trawl doors or other parts of a trawl gear cutting through the surface of the bottom. At Korallneset, almost 2.6 km of the sea bottom was inspected between 305 m and 205 m depth. Almost all corals observed were crushed or dead. Aktivneset is subject to heavy trawling and the ROV inspection showed this location to be very rich in corals all along a 7-km ROV transect between 350 m and 270 m depth. The reefs were neither large nor high, but smaller colonies were spread over large areas. However, damage was evident and furrows in the seabed were observed. Damage at Maurdjupet was severe, especially on the slopes of a smaller basin (or depression) in the shelf. Five inspections at Iverryggen revealed severe damage to colonies of *Lophelia* and other corals such as gorgonians (Figure 3.2.1.1). Every inspection verified damage exhibiting all stages of degradation, e.g., from almost intact living coral colonies to completely crushed reefs.

The Darwin Mounds were discovered using remote sensing techniques in May 1998 during surveys funded by the oil industry and steered by the Atlantic Frontier Environment Network (AFEN), a UK industry-government group (Masson and Jacobs, 1998). They have been further investigated in June 1998 (Bett, 1999), August 1999 (Bett and Jacobs, 2000), and twice during summer 2000 (Bett *et al.*, 2001; B. Bett, pers. comm.). Instruments deployed during the studies have included side-scan sonar, stills and video cameras, and piston corers.

Figure 3.2.1.1. Fragments and larger pieces of dead *Lophelia pertusa* near Iverryggen on the Norwegian continental shelf at 190 m depth. Photo taken from a height of about 2 m above the seabed on 17 May 1999. The bottom substrate is severely disturbed and the trench running across the picture from centre left to top right is apparently caused by towed trawl gear. From Fosså *et al.* (2002).

The Darwin Mounds are vulnerable to damage from bottom trawling, and evidence of new damage (since the 1998 survey) was visible over about one half of the Darwin Mounds East during summer 2000 (Wheeler *et al.*, 2001). This damage was visible as smashed coral strewn on the seabed along with visible parallel scar marks. Given that *Lophelia pertusa* appears to need (or favour) the elevation provided by sand mounds for growth in this area, it seems likely that this damage will be permanent. This site must be regarded as at particularly high risk of further permanent damage.

Hall-Spencer *et al.* (2002) found significant coral bycatch in five out of 229 hauls observed of French trawlers working in the Porcupine Seabight area. Trawling in this area is undertaken by French, Irish, and Scottish vessels for mixed species such as orange roughy (*Hoplothus atlanticus*), roundnose grenadier (*Coryphaenoides rupestris*), blue ling (*Molva dypterygia*), black scabbard (*Aphanopus carbo*), and sharks. Trawling for orange roughy has been shown to have caused major destruction of seamount corals in Tasmania and New Zealand (Koslow *et al.*, 2001).

3.2.2 Demersal longlining

Although lost longlines have been observed on video surveys of coral areas, no evidence of actual damage to reefs has been found, although coral branches could be broken off during the retrieval of longlines. In Icelandic waters, longline vessels seek out coral reefs in search of species using the structures as habitat (Steingrímsson, 2002). Species thus targeted include tusk (*Brosme brosme*), ling (*Molva molva*), blue ling (*Molva dypterygia*), and various species of redfish (*Sebastes* spp.). Off Ireland, longlining is undertaken by Norwegian vessels for ling and tusk. It is also undertaken by Spanish, UK, and Irish vessels for hake, sharks, ling and forkbeards, but few data are available.

3.2.3 Gillnetting and tangle netting

The surveys referred to in Section 3.2.1 have also found evidence of damage from gillnetting and tangle netting. The video inspections of the Storegga, Norway found lost (and ghost fishing) gillnet, an anchor, and a buoy. The nets and anchor-ropes may sometimes break down and tilt parts of the colonies. Video surveys by Southampton Oceanography Centre in 1999 and by IFREMER in 2001 showed gillnets ghost fishing on carbonate mounds/*Lophelia* reefs on the western edge of the Porcupine Bank in ICES Division VIIc. The Spanish have a traditional gillnet hake fishery in an area 60 nautical miles southwest of Valentia, Ireland, in a coral-rich area.

3.2.4 Summary

Trawling-induced damage to deep-water coral reefs has been proved in several areas, with perhaps the worst damage being evident presently on the reefs in shallower waters off Norway. However, there are several older records from continental shelf seas that appear to have suitable hydrographic conditions for *Lophelia*, and it seems likely that persistent trawling in these waters has extirpated it. This suggestion is supported by recent observations of *Lophelia* growing on undisturbed parts of oil platforms (Bell and Smith, 1999). Deeper reefs off Ireland and southwards do not seem to have suffered the same scale of damage, but are nevertheless vulnerable. The effects of other human activities are likely to be minor in comparison to those of trawling.

3.3 Mitigation/protection of corals from human activities

The EU Habitats Directive requires the statutory protection of marine reefs, such as those formed by *Lophelia*, and carbonate mounds. The only way to completely prevent damage by fishing activities to areas of deep-water coral is to accurately map them and then close them to fisheries.

Such closure may have other benefits, as a letter from the Scottish Fishermen's Federation in IntraFish recently expressed the need for better coral distribution maps so that fishermen can avoid these areas and thereby the high costs associated with damaged nets and poor fish quality. However, voluntary closures must be treated with caution. The only attempt to date to provide fishermen with detailed maps, in the Faroe Islands, did not prevent large-scale loss of *Lophelia* reefs.

In Sweden, two reef areas in the Kosterfjord are now protected and management measures have been agreed with local fishermen.

No EU Member States yet have the legal powers to designate Special Areas of Conservation (SAC) beyond territorial limits (12 n.m.), but some, including the UK and Ireland, are expected to have such powers within the next year. Thus, to date, they have been unable to employ measures to protect *Lophelia* reefs outside territorial waters. The understanding in the UK is that, once a candidate SAC has been notified to the European Commission, the Commission will be duty bound to protect that SAC from harm from those activities which it has the exclusive competence to regulate (e.g., fisheries). The relevant Minister (Margaret Beckett, Secretary of State, Department for Environment, Food and Rural Affairs) in the UK has indicated (23 October 2001) that the Darwin Mounds will be in the vanguard of any list of candidate sites notified to the European Commission.

3.3.1 Closed areas to trawling

Given that the available information suggests that cold-water coral reefs are easily damaged by certain fishing activities, that recovery following physical impacts is slow, or the damage possibly irreparable, and that this habitat is protected under European legislation, then these features must have a high priority for appropriate management.

The Icelandic study on the location of coral reefs and of trawl and longline fisheries (Steingrímsson, 2002) provides an example of one approach for identifying areas to close to fisheries if protection of *Lophelia* is required.

An area off the south and west coasts of Iceland was defined enclosing the known distribution limits of *Lophelia* in Icelandic waters ("coral" area). Fishing effort data for 1999 and 2001 for otter trawling and longlining occurring within the area were obtained from the effort database (Figure 3.3.1.1). Gear type, position (latitude, longitude), and catch composition (species, catch (kg)) were obtained from each haul. It is known that otter trawlers avoid coral areas, while longliners seek them out.

For each rectangle of 1' latitude and 1' longitude, the degree of overlap (O) between fleets (otter trawlers and longliners) was estimated using the following equation (see Horn, 1966)

$$O = 2\left(p_{aj} p_{bj}\right) / \left(p^2{}_{aj} + p^2{}_{bj}\right)$$

where P_{aj} = the proportion of haul positions in square j of fleet a. The coefficient ranges between 0 and 1; a value of 0 indicates that both fleets are fishing in completely different squares and, consequently, a value of 1 indicates that the effort of both fleets was exactly identical in a given square. Squares with an overlap coefficient close to 0 were identified and the area around them was defined as possible *Lophelia* grounds.

The defined areas were examined further for the spatial distribution of fishing effort (proportion of effort within the defined "coral" area) of both fleets (otter trawlers and longliners) during 2001. Five areas were identified where no overlap occurred between the two fleets either in 1999 or 2001 (Figure 3.3.1.2). The small-scale distribution of fishing effort within the five areas showed that insignificant otter trawling took place in 2001. However, the effort of longliners was relatively much higher. Detailed examination reveals that there are some areas where only longlining occurs (Figure 3.3.1.3). Where no overlap between fleets occurred and only longline was used, species composition of the catch and their relative abundance (% total catch) was estimated. These areas have catches characterized by *Lophelia*-associated species and are thus likely to have concentrations of *Lophelia* reefs. These areas are also likely to encounter less resistance from trawl fishermen if they are declared closed to trawl netting.

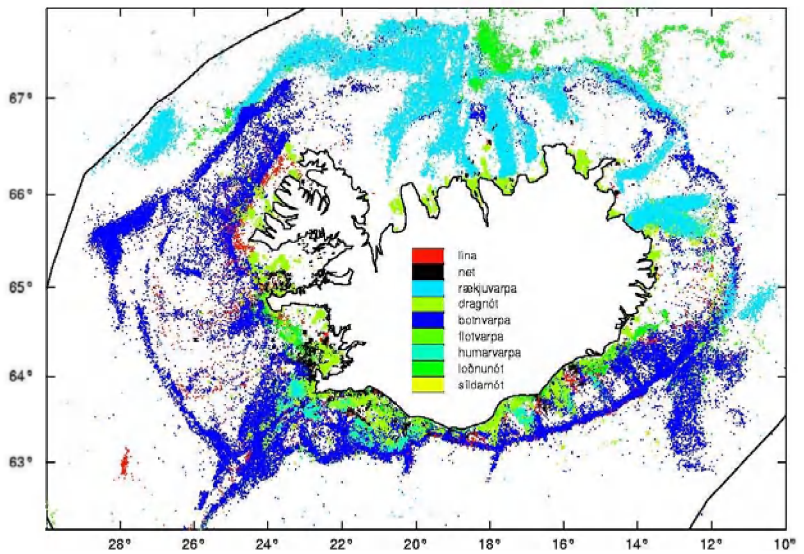


Figure 3.3.1.1. Distribution of fishing effort by all gears in Icelandic waters in 1997 (from Steingrímsson, 2002). Lina = Longline, Net = Gillnet, Rækjuvarpa = Prawn trawl, Dragnót = Seine net, Botnvarpa = Otter trawl, Flotvarpa = Pelagic trawl, Humarvarpa = *Nephrops* trawl, Lodnunót = Capelin nets, Sildarnót = Herring nets.

Detailed information such as that shown for Iceland is not available for EU waters. Nor have logbook or satellite-derived data been released beyond national authorities. Without such information, the identification of areas suitable for closure will be impossible.

Off Ireland, Grehan *et al.* (2002) has identified four areas suitable for closure to trawl fisheries (Figure 3.3.1.4) on the basis that they contain good examples of previously unimpacted carbonate mounds.

3.4 Summary and recommendations

ICES makes the following recommendations to ensure that both the short-term and long-term advice on *Lophelia* is the best possible:

1) This description of the distribution of *Lophelia* reefs (as shown in the preceding maps) represents the present state of knowledge, but several new studies are under way and new knowledge is becoming available.
2) In order to best tailor advice to actual fishing pressure, ICES Member Countries and relevant Commissions should provide access to detailed, suitably depersonalized, data on the location of fishing effort in areas known or likely to contain *Lophelia*.
3) In order to add to knowledge on the distribution of *Lophelia* and trawling impact, ICES Member Countries and relevant Commissions should ensure that by-catch recording schemes include records of *Lophelia*.
4) ICES advises that the only proven method of preventing damage to deep-water biogenic reefs from fishing activities is through spatial closures to towed gear that potentially impacts the bottom.

Figure 3.3.1.2. Five areas where there was low overlap between otter trawlers and longliners in the "coral area" to the south of Iceland. Hauls in 1999 (+) and 2001(□). (From Steingrímsson, 2002).

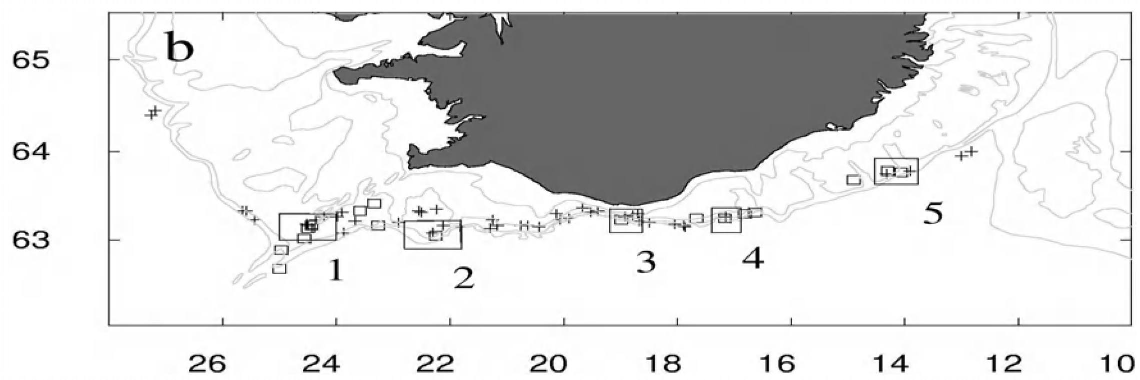


Figure 3.3.1.3. Detail of area 5 (Figure 3.3.1.2) showing an area where only longline fishing occurs. (From Steingrímsson, 2002.)

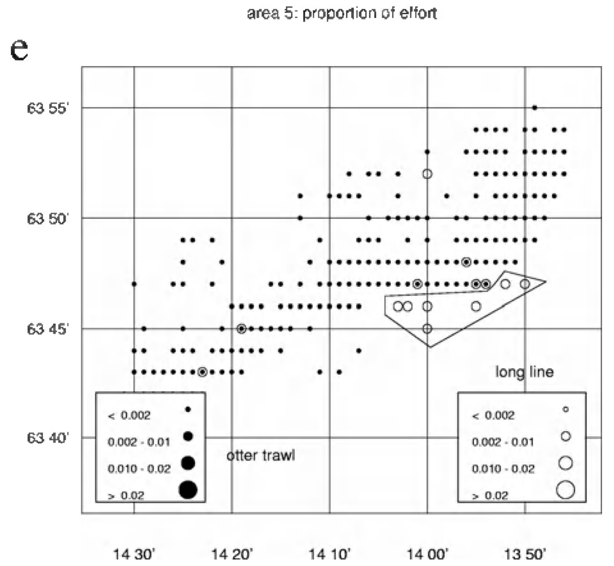
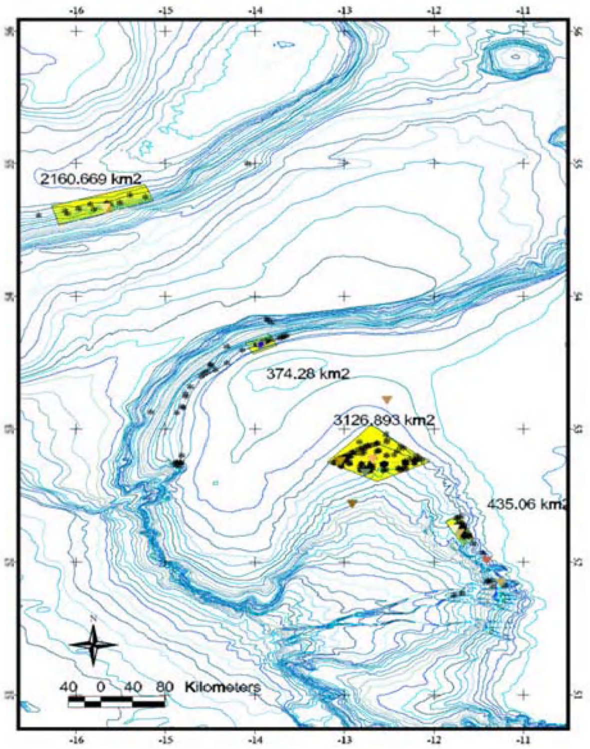


Figure 3.3.1.4. Areas to the west of Ireland containing the best examples of carbonate mounds and *Lophelia* reefs, and suitable for closure to trawl fisheries (Grehan *et al.*, 2002).



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4 SENSITIVE HABITATS, IN RELATION TO FISHING ACTIVITIES, IN THE ICES AREA

Request

The European Commission, Directorate General for Fisheries, has expressed (in a letter of 20 September 2001) its immediate interest in an "*Evaluation of the impact of current fishing practices on ... sensitive habitats, and suggestions for appropriate mitigating measures*".

Source of information

The 2002 Report of the Working Group on Ecosystem Effects of Fishing Activities (WGECO) (ICES CM 2002/ACE:03).

4.1 Introduction

There is ongoing work within ICES and OSPAR aimed at identifying and selecting a priority list of "threatened and declining" habitats. The criteria used to define such threatened and declining habitats are still in the process of development, but are likely to include a description of the regional importance of the habitat, the rate and extent of decline, the ecological importance of the habitat, and the sensitivity and recoverability of the habitat.

4.2 Habitat sensitivity

Habitat sensitivity can be defined in relation to the degree and duration of damage caused by a specified external factor. Sensitivity may refer to structural fragility of the entire habitat in relation to a physical impact, or to intolerance of individual species comprising the habitat to environmental factors such as exposure, salinity fluctuations, or temperature variation (MacDonald *et al*., 1996). In this section, the issue of habitat sensitivity is discussed in relation to the impact of current fishing practices in the ICES area.

There has been an increased interest in developing metrics to quantify habitat sensitivity, largely focused on the potential impact on habitats of activities in coastal and intertidal environments and on post-impact mitigation. In 2002, WGECO reviewed several examples of proposed schemes, including those of Gundlach and Hayes (1978), Anderson and Moore (1997), Cooke and McMath (1998), and Tyler-Walters *et al.* (2001). In general, while most methods of describing sensitivity are logical, the allocation of scores to different sensitivity categories is largely subjective and there is no clear guidance provided on how to implement the schemes. Additionally, schemes incorporating recoverability into the sensitivity scale can be problematic due to difficulties in determining whether recovery has occurred and the selection of appropriate reference and control stations.

Map-based guidelines have been developed in the U.S. and the Environmental Sensitivity Index (ESI) is widely used as a basis for assessment of the impact of oil spills (Michel and Dahlin, 1993). The ranking of habitat sensitivity is based on features such as the slope and substrate type of the shoreline, its relative exposure to wave and tidal energy, and the productivity and sensitivity of the biological community. Although the system provides a more comprehensive use of biological characteristics than other examples, the categories are still broad. The benefit of this approach is in the production of resource maps of the coastline describing biological and physical sensitivities, and thereby providing managers with a clear and easy to use spatial tool.

In 2002, WGECO also considered the so-called "Texel/Faial" criteria, developed by OSPAR, for the identification of habitats in need of protection, conservation and, where practical, restoration and/or surveillance or monitoring. This process goes further than just identifying habitat sensitivity, by incorporating a description of habitat rarity, regional importance, ecological significance, and rate of decline. The way in which habitats could be allocated to a sensitivity category is unclear and insufficient guidance is provided, merely stating that it can be assessed as a function of the effect of human activity and the time taken for recovery. It is clear from the guidance that the sensitivity of a habitat will differ according to different specific impacts of human activities and so this criterion should be applied at the end of the process. By including, and emphasizing, aspects of habitat rarity and ecological significance, the influence of habitat sensitivity in the selection of threatened and declining species is effectively down-weighted. The status of habitat decline is described in terms of severe and significant decline, in relation both to extent and quality of habitat.

It is evident that the scientific information presently available is inadequate to evaluate the impact of current fishing practices on sensitive habitats, thus precluding the provision of advice on appropriate mitigation strategies. A series of measures are required to progress this issue, including:

1) provision of detailed, spatially referenced data on fishing effort, by gear type, in the ICES area;
2) development of appropriate, scientifically based, criteria to define habitat sensitivity;
3) provision of detailed, spatially referenced data on sensitive habitats in the ICES area;
4) collection of detailed data on the nature, extent, and duration of the impact of different fishing practices on sensitive habitats;
5) collection of detailed data on the rates of recovery of different habitat types.

Until each of these is in place, the selection of habitat sensitivity is likely to continue to depend on subjective assessments.

4.3 Impact of current fishing practices on sensitive habitats and suggestions for mitigation measures

The spatial scale and magnitude of impact by fishing gears has previously been reviewed by ICES (ICES, 2000a). In summary, the primary methods of fishing within the ICES area include bottom trawling by beam trawl and otter trawl, pelagic trawling by towed gear, pelagic fishing by seine net, dredging, and the use of fixed gear such as longlines, gillnets, tangle nets, and traps.

Of the types of fishing listed above, the greatest physical impact on sensitive habitats is likely to be caused by towed gears such as dredges, otter trawls, and beam trawls through the following effects:

- destruction of complex three-dimensional habitats (e.g., coral reefs/burrows/refuges);
- disturbance of sediment structure;
- changes in topography (tracks and grooves);
- resuspension of sediment/increased turbidity (clogging gills and filter-feeding animals);
- refluxing of chemicals (contaminants and nutrients).

Ghost fishing by lost or abandoned gear may also have a significant impact.

In the absence of a clear and comprehensive definition of habitat sensitivity, and one that could be used to provide clear scientific advice for management and regulatory purposes, it is not considered possible, necessary, or even desirable at this point to select a new list of sensitive habitats in the ICES area.

4.3.1 Mitigation measures

While it is not possible at present to provide detailed, scientifically based advice on appropriate strategies to mitigate against potential negative impacts of different fishing practices on sensitive habitats, some initial considerations are given below for selected habitats. These are provided for illustrative purposes only and also serve to highlight the gaps in our knowledge that need to be filled by way of further data collection, assimilation, and synthesis.

Mitigation measures may range from technical measures that influence the way in which the gear operates, such as mesh size regulation or escape panels, to spatial closures to prevent access to certain fleets during part or all of the year. Different types of mitigation measures will be required depending on the sensitivity of the habitat and the fishing practice involved. Potentially useful mitigation measures for a number of fishing types include:

1) spatial closures;
2) rotation of effort from area to area;
3) modification of gear to reduce benthic impact;
4) modification of gear using biodegradable materials to prevent long-term ghost fishing;
5) restocking/reseeding—particularly of shellfish beds;
6) technical conservation measures—modification of gear to reduce by-catch in the water column;
7) legislation and enforcement to "land all catch";
8) avoidance of areas at certain times of year.

4.4 Assessment of the effects of fishing on selected habitat types

4.4.1 Deep-water biogenic habitats

These habitats include any structure on the deep seabed created through biogenic means (e.g., cold-water corals, deep-water sponge communities) or natural means (e.g., carbonate mounds and mid-ocean ridges with hydrothermal vents) that act as habitats for communities. A detailed description of the known distribution of cold-water corals in the ICES area and impacts on them by a range of fishing practices is presented in Section 3 of this report.

<u>Trawling</u>

Recent information shows that deep-water trawling does take place in areas of deep-water biogenic habitats. Any fishing gear physically impacting these habitats, by direct contact or by indirect effects such as wash or sedimentation, will cause an effect and therefore give rise to cause for concern (ICES, 2002a). The damage to deep-water corals off the Norwegian coast with heavy gear prior to and during fishing has been described by Hall-Spencer *et al.* (2002). There is sufficient information to suggest that the most effective way of mitigating the effect of trawling on these habitats is to close such areas to fishing. However, in order to tailor advice to actual fishing pressure, further detailed data are required on the location of fishing effort in areas known, or thought likely, to contain deep-water biogenic habitats (see the recommendations in Section 3, above).

<u>Set nets</u>

Evidence has been found of damage from gillnets on deep-water biogenic habitats (Fosså *et al.*, 2000), although the damage does not appear to be as extensive as that caused by towed gear. However, there is currently a lack of detailed data on the actual nature and extent of damage caused by gillnets and tangle nets, and further studies are required to provide these data. The most appropriate mitigation measure is likely to be selective area closures (see the recommendations in Section 3, above).

Demersal longlining

These fishing techniques take place in deep-water biogenic habitats for certain species. Although lost lines have been observed on video surveys of coral areas, no evidence of actual damage has been found. Damage may occur, however, through entanglement and subsequent breakage of coral formations. At this point, there is not sufficient information available to suggest that demersal longlining should be prohibited in deep-water biogenic habitats, but further data are required.

4.4.2 Structural benthic epifauna

This habitat occurs at the interface of the water column and the benthos in shallower water and includes sessile and other epibenthic organisms that form biogenic structures such as *Sabellaria spinulosa* reefs and sponges. The main threat to such habitats comes from towed gear, such as trawls and dredges, which physically damage the habitats and destroy the biogenic structures created by their inhabitants.

Otter trawling

Otter trawling has an adverse impact on structural benthic epifauna (Dayton *et al.*, 1995; Engel and Kvitek, 1998; Prena *et al.*, 1999; ICES, 2000b; Linnane *et al.*, 2000). Effects can be mitigated by spatial closures and/or temporal closures. Data are required on the recoverability of such habitats. Gear modification may also mitigate the direct impact to these habitats.

Beam trawling

There is evidence (Lindeboom *et al.*, 2000; Kaiser *et al.*, 1996b, 1996c, 1998a; Lindeboom and de Groot, 1998; Freese *et al.*, 1999) that beam trawling has a more profound effect upon the benthos, in terms of disturbance, displacement, and destruction, than otter trawling per unit area of impact (Philippart, 1996, 1998). Effects can be mitigated in the same way as for otter trawling, with an emphasis on spatial closures where habitats are considered to be sensitive or slow to recover. Sensitivity and recoverability need to be determined.

Demersal longlining

There is anecdotal evidence to suggest that, while demersal longlining will not have as profound an effect on biogenic habitats as trawling, the potential exists for some damage through entanglement or "ghost fishing", although this has been difficult to reference. It is clear that scientific data on the nature, extent, and duration of impact, if any, are required. Spatial and or temporal closures may be appropriate as mitigation measures.

Tangle netting

Tangle netting may cause disruption to structural benthic epifauna habitats through entanglement with structures and subsequent breakage, although, once again, convincing information to support this suggestion is lacking. Mitigation measures could be introduced by spatial and temporal closures where the habitat is known to be particularly sensitive and through modification of the gear to prevent "ghost fishing".

Pot fisheries

While there is little published literature on the effect of pot fisheries on this kind of habitat, the most likely damage to epibenthic structures would be through some limited physical damage from the placement of the gear itself. Mitigation measures could be introduced such as spatial closures where the habitat is known to be particularly sensitive and through modification of the gear to prevent "ghost fishing", although priority is likely to be low.

Dredging (epibenthic)

There is evidence (ICES, 2000b; Fox *et al.*, 1996; Linnane *et al.*, 2000; Thrush *et al.*, 1995; Kaiser *et al.*, 1998b; Turner *et al.*, 2000; Veale *et al.*, 2000) to suggest that epibenthic dredging can damage biogenic structures on the seabed. It is suggested that epibenthic dredging should be restricted by spatial closure from structural benthic epifauna habitats that are determined to be sensitive.

Dredging (hydraulic)

Since hydraulic dredging is even more likely to impact negatively on structural epibenthic communities, it should be restricted by spatial closure of structural epifauna habitats that are determined to be sensitive.

4.4.3 Benthic infauna

This habitat comprises the sediment of the seabed and communities of such burrowing animals as seapens, *Spisula*, razor clams, and other burrowing megafauna communities. It is reasonable to assume that any fishing activity that disturbs the seabed will impact on this habitat.

Otter trawling

There is published evidence to demonstrate the effect of otter trawling on benthic infauna (Engel and Kvitek, 1998; Gilkinson *et al.*, 1998). Mitigation may be carried out by spatial closures in areas determined to be of high sensitivity, and by temporal closures and gear modification in areas where habitats are determined to be more robust.

Beam trawling

A number of studies have shown an impact of beam trawling on this habitat (Bergman and Hup, 1992; Kaiser and Spencer, 1996; Kaiser *et al*., 1996a, 1996b), and the impact of this gear on benthic infauna is thought to be greater than that of otter trawling. In areas where habitats are determined to be highly sensitive, effects could be mitigated by spatial closures, with temporal closures in habitats where recovery is more likely. Data on the recovery rates of such habitats need to be determined.

Dredging (epibenthic)

This type of fishing, while specifically designed to target the epibenthos, will inevitably have an effect on benthic infauna (Currie and Parry, 1996, 1999; Hill *et al*., 1999; Kaiser *et al*., 1998b) through damage to filter-feeding mechanisms (seapens), siphons (in bivalve molluscs), and possibly through disruption of habitat integrity. Effects can be mitigated by spatial closures in areas determined to be of high sensitivity and by temporal closures in areas where recovery is determined to be more rapid.

Dredging (hydraulic)

Since this gear is specifically designed to target benthic infauna (e.g., razor clams and other burrowing molluscs), it will have one of the largest effects of all the types of fishing gear used on infaunal communities (Hall *et al*., 1990; Dayton *et al*., 1995; Tuck *et al*., 1999). Effects could be mitigated by spatial closures.

4.4.4 Mollusc beds

This habitat comprises mollusc beds (intertidal mussels, oysters, and horse mussels) that are considered to be at risk from fishing activities.

Otter trawling/beam trawling

Physical disturbance to the benthos and breakage of animal shells are the major impacts of these two fishing activities on mollusc beds (Hoffmann and Dolmer, 2000; Witbaard and Klein, 1994). Spatial and/or temporal closures and modification of the fishing gear are potential mitigation measures which could be applied to minimize impact.

Dredging (epibenthic)

As bivalve molluscs are harvested by epibenthic dredges, there is no shortage of available information which describes the impact of dredging on these habitats (Auster *et al*., 1996; Jennings and Kaiser, 1998; Watling and Norse, 1998; Bradshaw *et al*., 2000). The information also confirms that closure and reseeding of shellfish grounds for the target species involved is a practical mitigation measure.

Dredging (hydraulic)

Substantial information also exists on the effect of hydraulic dredging on mollusc beds. Chevarie *et al*. (2001) observed that hydraulic dredges affect juvenile and adult abundance at certain crucial times of year, making it imperative to select which times to operate dredges so as to minimize damage. Rotation or modification of the date of collecting the target species should be set to occur before recruitment events to minimize the effect on spatfall. Literature on this subject suggests a relatively rapid recovery or a low impact (Hall *et al*., 1990). Reseeding could be a mitigation measure for the target species, but the result of such mitigation is not well understood and further studies are necessary.

4.4.5 Nearshore communities

These habitats (*Zostera* communities, littoral chalk communities) comprise species in shallow water that are considered to be under threat (Davison and Hughes, 1998; Birkett *et al*., 1998b; Holt *et al*., 1998).

Otter trawling, beam trawling, tangle netting

The impact of otter trawls, beam trawls, and tangle netting on these habitats is not well understood and there are few published descriptions. In sensitive inshore habitats, which are vulnerable to the scouring effect of otter and beam trawls, spatial and temporal closures may be appropriate mitigating measures.

Pot fisheries

The primary impact of pot fisheries is to remove the target species, as well as some by-catch. Mitigation measures such as spatial closure or restocking may be appropriate. In general, pot fisheries have limited impacts on habitats.

Dredging (epibenthic)/dredging (hydraulic)

Dredging in *Zostera* beds will reduce the surface area for attachment by the early juvenile stage of scallops and other invertebrates (Fonseca *et al*., 1984), which can be mitigated by spatial closures. Such measures are applicable to any nearshore habitat that is deemed to be sensitive.

4.4.6 Intertidal mudflats

While not normally considered as being at risk from fishing activities, these habitats are important feeding grounds for shorebirds. Such habitats are coming under increasing pressure from bait digging, coastal construction, and other human activities related to fishing.

Beam trawling

The impact of beam trawling on intertidal mud flats, which takes place for shrimp and flatfish, will depend on the penetration depth of the gear and the degree to which the habitat is already affected by natural disturbance, which in turn will vary with the time of year (Kaiser *et al.*, 1996a).

Bottom longlining/tangle netting

While it is known that static gear, such as longlines and tangle nets, are used on intertidal mud flats to catch flatfish, their effect on the habitat will be less than with active fishing methods such as trawling and dredging.

Dredging (epibenthic)/dredging (hydraulic)

Negative impact on the benthic community of intertidal mudflats was observed, but not on a long-term basis (Kaiser *et al.*, 1996a). Spatial closure of an area is a possible and appropriate mitigating measure. The impact of fishing activities largely depends on the sediment type, since communities in mobile and coarser sediments are less likely to be disturbed (Moore, 1991). Kaiser *et al.* (1998b) suggested that, if the mechanism for recolonization is by larval settlement, a restriction on harvesting to early winter may encourage site restoration.

4.4.7 Maerl beds

Mearl beds are large aggregations of calcareous algae and in some areas are under threat primarily from dredging activities to provide maerl as a source of raw material for pharmaceutical and industrial use. They support very high species diversity and are slow-growing in European waters. They are very sensitive compared to other sedimentary bottom types (Birkett *et al.*, 1998a; Hall-Spencer and Moore, 2000). Any potential impact from fishing activities, therefore, gives cause for concern.

Otter trawling, beam trawling, dredging (epibenthic)

Some literature on the sensitivity of mearl beds related to fishing impact is available in Grall and Glémarec (1998) and Hall-Spencer and Moore (2000), and this suggests a decrease of > 70 % of live maerls after scallop dredging. No information seems to be available to suggest what mitigation measures might be taken, but the high sensitivity of these habitats and a decrease in their abundance, at least along the Scottish coast, suggest that the most effective mitigation measure should be a spatial closure. Otter trawling has less negative impact on the Maltese mearl bed than scallop dredging (BIOMAERL team, 1999).

4.5 Ghost fishing

Ghost fishing by fixed nets and longlines is not included as a usual practice of fishing activity, but under certain circumstances it can have profound effects on non-target species such marine mammals (Dayton *et al.*, 1995), crabs (Breen, 1987), gadoids and crustaceans (Kaiser *et al.*, 1996c). Evidence of ghost fishing on deep-water biogenic habitats by deep-water longlines and gillnets has already been demonstrated (ICES, 2002a), but ghost fishing will occur through pot fisheries, where lost, but unmodified, pots may continue fishing for crabs, lobsters, and whelks for a long period of time. The literature is scarce on this subject (Eno *et al.*, 1996), but Breen (1987) reported that 11 % of crab pots in the Fraser Estuary district (British Columbia, Canada) are lost, which could continue to fish up to 7 % of the biomass reported in this area. When fitted with biodegradable panels, the gear stops fishing after a period of time, and this procedure is widely applied in some areas. Further technological advances with biodegradable fishing materials used in other gears would also be a useful contribution.

4.6 Summary conclusions

Based on the above information, it is clear that:

- More work is required to develop criteria for evaluating and ranking the sensitivity of habitats with respect to fishing activities and, in this way, to identify environments which require management action. Consideration needs to be given to how the application of the criteria would use information on the structural and physical aspects of the habitat and the individual species that occupy these habitats.
- Further to the refinement of the criteria to define "sensitive habitats", detailed spatial mapping of sensitive habitats is required. In this regard, consideration needs to be given to the acquisition of the necessary physical and biological data at appropriate spatial scales.
- Further data on the post-impact rates of recovery of different habitat types are required. Some useful progress has been reported by ICES (2002b) in relation to the impacts of marine aggregate extraction on benthic habitats, but further detailed evaluation needs to be undertaken in relation to fishing impacts.
- Detailed spatial mapping of fishing effort, by gear type, is required.
- In general, sufficient information exists in the scientific literature to predict the physical effects of the majority of existing fishing practices, particularly those involving the use of towed gears that directly contact the seabed, and to suggest mitigating actions. Gaps mainly exist in relation to the effects of bottom longlining and tangle netting, and the type of mitigation measures that may be appropriate.

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5 MARINE HABITAT CLASSIFICATION AND MAPPING

Request

Item 5 of the 2002 requests from the Helsinki Commission, which is stated as follows:

From HELCOM's point of view biotope mapping is 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 marine biotope mapping in the different Baltic Sea countries.

Based on this request, the Working Group on Marine Habitat Mapping was requested to discuss whether the habitat classification system, under development, can be extended to the Baltic Sea area and, if so, to develop a draft work plan for this.

This issue is also relevant to the interest in the impact of fishing activities on sensitive habitats, as expressed by the European Commission and covered in Section 4 of this report.

Source of information

The 2002 Report of the Working Group on Marine Habitat Mapping (WGMHM) (ICES CM 2002/E:05).

The 2002 Report of the Working Group on Ecosystem Effects of Fishing Activities (WGECO) (ICES CM 2002/ACE:03).

Background

The mapping of marine habitats and marine resources is seen as being essential to the development and application of an ecosystem-based approach to the management of the human use of marine resources. In order to map the distribution of marine habitats, a system of classifying the habitats is required. This system of classifying habitats not only forms a basis for describing the habitat, it also forms the basis for interpreting other spatially referenced information and making objective inferences about the value of the habitat.

5.1 Evaluation of the practicability of classification systems

Many ICES Member Countries are planning to undertake and/or undertaking major programmes to gather various types of data that will describe the sea bottom of the ICES area. Globally, and within ICES Member Countries, scientists are experimenting with a variety of approaches to marine habitat classification. The mapping initiatives cover a broad range of activities utilizing an equally broad range of technologies. There is at least one thing that these undertakings have in common and that is that large volumes of information are being generated and a wide range of approaches are being used to process and interpret that information. At the same time, there is a demand from many regulatory groups to have access to many different types of information on marine habitats. Extensive knowledge about marine habitats is seen as the cornerstone of an ecosystem-based approach to the management of human activities in and affecting marine areas. In particular, availability of spatially referenced habitat information is required for the preparation of environmental impact assessments of a broad range of human activities.

The development and general acceptance of a classification system for marine habitats is central to the organization of this information in a manner that will facilitate exchange and communication of data and data products. ICES has supported the development of a classification system for marine habitats based on the European Nature Information System (EUNIS), including specific development of Levels 4 and 5 (ICES, 2001). This development has reached the stage that a pilot application to the North Sea is being used to evaluate the scheme.

It is apparent from the numerous mapping studies under way that the following issues need to be addressed:

- data collection standards need to be developed to facilitate the exchange or pooling of data between projects;
- standards for interpreting and presenting data are required to make amalgamation of end maps feasible; and
- there has been insufficient linking of field data with the EUNIS classification or feedback on the practicability of the EUNIS classification. Further practical testing of this classification is therefore needed.

While ICES agrees that it is possible to apply the EUNIS classification system, it also notes that there are many systems of marine habitat classification that are presently being developed and tested. ICES supports this activity since it is through this process that progress will be made on the development of a comprehensive and robust system of classification.

5.2 Progress in the development of high- and low-resolution habitat maps

There is a wide range of clients and requests for habitat maps containing various layers of information and at various scales. In general, existing information that users would like to have layered onto a habitat classification system will require considerable work for formatting and import. An effort in the ICES area of particular note in this respect is the habitat mapping project for the southern North Sea and Wadden Sea, which is implementing the EUNIS classification system. A report and habitat maps from this project should be available by the end of 2002. Another project of note is the benthos database development under the North Sea Benthos Project (NSBP). Both of these projects have had to deal with the difficulties associated with incorporating data from a variety of sources from a number of different countries.

There are a number of concerns regarding the development of habitat maps and associated thematic layers, including:

- Reliability of information on the maps. A process is needed to identify and express the level of confidence that should be placed on the data;
- Natural systems are not static and, therefore, the temporal variability of the data needs to be represented in any mapping system;
- An assessment of data quality and the scale of interpretation must be undertaken before old data are used.

It was noted that OSPAR wishes to develop both detailed maps of the North Sea and low-resolution maps of the entire OSPAR area. OSPAR is sponsoring a workshop in autumn 2002 to develop plans for these mapping initiatives. While using existing data presents problems with variations in quality and spatial coverage and with compatibility between data sets, a major new survey to obtain high quality data will be costly. However, this could be an opportunity to obtain an integrated multi-beam survey for the whole North Sea that would provide good baseline data for the preparation of habitat maps. Ultimately, it would be better to invest in a single comprehensive project than to invest piecemeal in smaller projects.

The fact that careful consideration must be given to the scale at which information is collected, stored, retrieved, and interpreted has already been addressed by ICES (ICES, 2001) but warrants further attention here. Information is collected at scales that range from centimetres to kilometres and the scale of information products based on this information will vary accordingly. Careful attention has to be given to the algorithms that are used to interpolate or average information in order to avoid grievous errors. The use of information at a scale different from that at which it was collected should always be carefully examined.

ICES notes and supports the OSPAR workshop in autumn 2002 as being essential for the timely development of an international North Sea GIS-based multilayered map.

5.3 Extension of habitat classification systems to the Baltic Sea area

ICES, through the activities of the WGMHM and its predecessor, has made significant advances in adapting the EUNIS system of classification to the marine environment. Recently, the focus has been on the application of this classification scheme to the North Sea. This application forms the basis for the North Sea Ecosystem Management project endorsed by the Ministers at the Fifth North Sea Conference in Bergen in March 2002. ICES has been asked by HELCOM to consider whether the habitat classification system under development can be extended to the Baltic Sea and, if so, to develop a draft work plan for this.

ICES agrees that it is possible to apply the principles of the EUNIS classification to the Baltic Sea. It will not be necessary to repeat a lot of the work that has already been directed at the North Sea project. Rather, the focus can be on the mapping aspect of the end product. Local classifications can be identified from the scientific literature, e.g., a local estuary study might describe a number of locally distinct communities, which could be used within the larger classification system. However, the literature may not always exist or it might be of insufficient quality, and field studies may have to be undertaken. Communities may be able to be predicted in some areas where biological data do not exist. In the Baltic Sea, driving forces, different from those prevalent in the Atlantic system, will affect the distribution of communities. The HELCOM Baltic Red List of habitats might also provide a starting point for the development of a Baltic classification system. This list, which is essentially a substrate description, does not describe the biology in sufficient detail in its present form. The biological aspects of the list would have to be developed further.

ICES is developing a discussion paper including a description of the EUNIS classification system, and a description of current and potential Baltic classification systems, which will also include the HELCOM statement of their requirements, for presentation to a wider audience of Baltic interests. This will facilitate a clearer definition of what HELCOM expects from a classification system so that focus can be given to the essential issues. The paper, to be completed by September 2002, will be placed on the ICES and HELCOM websites for comment.

Funding should be sought for a workshop to bring together national experts from Baltic countries and international classification experts. Without full participation by all Baltic countries, only limited progress can be achieved. The purpose of the workshop is to develop a detailed work plan for the development of a marine habitat classification scheme for the Baltic Sea.

5.4 Mapping sensitive habitats

ICES has been asked to propose a process to be able to summarize available information on the distribution of sensitive habitats in the ICES area, and to evaluate the adequacy of the information as a basis for scientific advice for an "evaluation of the impact of current fishing practices on … sensitive habitats, and suggestions for appropriate mitigating measures"; this should include the definition of criteria or standards for determining what is a "sensitive habitat".

Section 4 of this report responds specifically to that request; however, there are some elements of the response that relate more to the actual mapping function that need to be considered in the context of classification schemes for marine habitats. One of the expected outcomes of the development of habitat classification schemes and subsequent applications is the mapping of sensitive habitats.

It is apparent from the attempts at defining the term (see discussion in Section 4) that an objective framework for determining sensitivity will be specific to the activity being proposed. There are similar difficulties in defining essential and critical habitats—terms that are used in conjunction with the development of recovery plans of threatened or declining species and in the selection of threatened or declining habitats. The objective selection of the essential or critical habitat has to be made in the context of specific ecosystem functions or structure.

The way in which these criteria are applied and their ultimate effectiveness depends on having a suitable habitat classification system, a sufficiently detailed habitat map, and adequate data for each habitat type so that their biological and physical characteristics can be quantified.

Recommendations

ICES recommends that a workshop be held to prepare a detailed work plan for the development of a marine habitat classification scheme for the Baltic Sea area.

ICES recommends that pilot projects developing habitat classification schemes and associated databases consider developing and testing algorithms to identify sensitive and/or threatened and declining habitats. Such testing will lead to a better understanding of the information requirements and the possible limitations imposed by classification schemes.

Reference

ICES. 2001. Report of the ICES Advisory Committee on Ecosystems. ICES Cooperative Research Report, 249: 60–66.

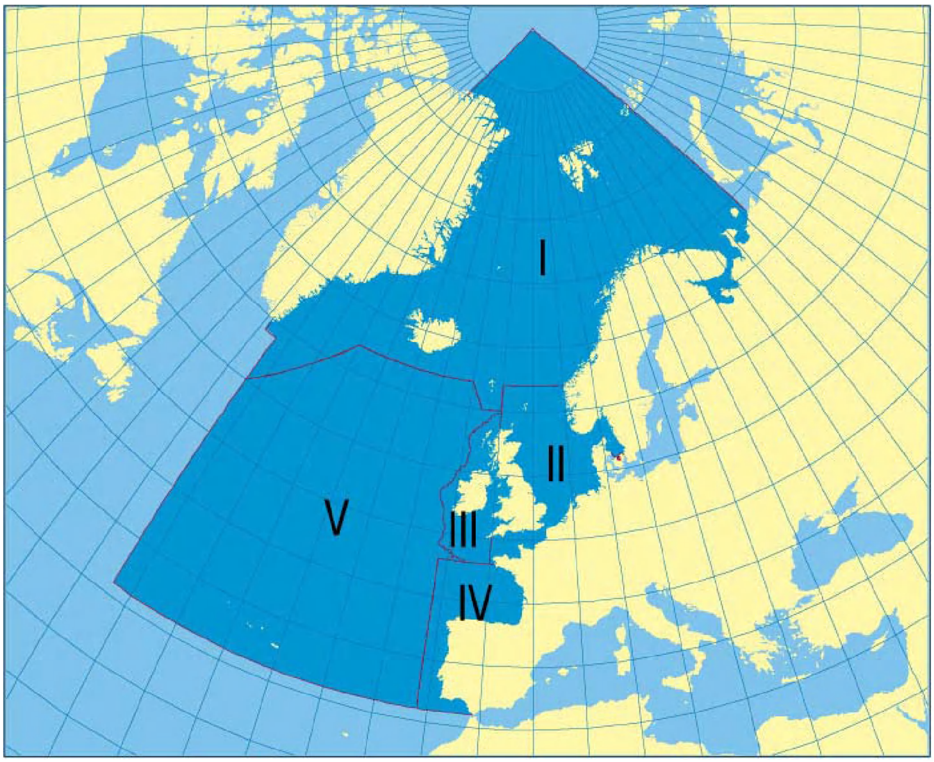
Request

In November 2001, the OSPAR Biodiversity Committee reviewed a draft priority list of threatened and declining species and habitats and agreed that this list should be further developed for approval by the Committee at its meeting in early 2003. This list must be supported by a justification of how and why the species and habitats were selected, and the Biodiversity Committee noted that Quality Assurance of the data used in identifying threatened species or habitats is very important. Hence, the OSPAR Commission requested ICES to contribute to the peer-review process.

The OSPAR request, transmitted in January 2002, was "*for the assessment by ICES by the early autumn 2002 of the data on which the justification of the OSPAR Priority List of Threatened and Declining Species will be based. The purpose of the assessment would be to ensure that the data used for producing the justification are sufficiently reliable and adequate to serve as a basis for conclusions that the species and habitats concerned can be identified, consistently with the Texel-Faial criteria, as requiring action in accordance with the OSPAR Strategy on the Protection and Conservation of the Ecosystems and Biological Diversity of the Maritime Area.*"

The draft OSPAR Priority List of Threatened and Declining Species and Habitats currently contains 29 species and habitats identified as of concern across the whole of the OSPAR maritime area, and ten identified as of concern in one or more of the five OSPAR Regions. These regions are as follows: Region I—Arctic Waters; Region II—Greater North Sea; Region III—Celtic Seas; Region IV—Bay of Biscay and Iberian waters; and Region V—Wider Atlantic (Figure 6.1). The criteria that are used in identifying species in need of protection/conservation are: i) global importance; ii) local importance; iii) rare; iv) sensitive; v) keystone species; and vi) decline.

Figure 6.1. Map showing the OSPAR regions.



Source of information

The 2002 Report of the Study Group on Elasmobranch Fishes (SGEF) (ICES CM 2002/G:08).

The 2002 Report of the Benthos Ecology Working Group (BEWG) (ICES CM 2002/E:07).

The 2001 Report of the Working Group on the Biology and Assessment of Deep-Sea Fisheries Resources (WGDEEP) (ICES CM 2001/ACFM:23).

The 2002 Report of the Working Group on Seabird Ecology (WGSE) (ICES CM 2002/C:04).

The 2002 Report of the Working Group on Marine Habitat Mapping (WGMHM) (ICES CM 2002/E:05).

The 2002 Report of the Working Group on Ecosystem Effects of Fishing Activities (WGECO) (ICES CM 2002/ACE:03).

6.1 Background and introduction

There has been recent activity in OSPAR to prepare a list of threatened and declining species and habitats, to contribute to the requirements of Annex V (on the protection and conservation of the ecosystems and biological diversity of the maritime area) of the OSPAR Convention. In parallel with the on-going process to prepare and refine a set of robust selection criteria (the Texel-Faial criteria), the Contracting Parties to OSPAR were asked to submit proposals for species and habitats which they felt were already under threat or in decline, and which therefore needed immediate management action. Evaluation of these submissions and preparation of this list was dealt with intersessionally and considered by a workshop in Leiden in September 2001.

Based on the OSPAR request to ICES in January 2002, several ICES Working Groups (WGECO, BEWG, WGMHM, SGEF, and WGSE) were requested to assess the data that were used to justify the inclusion of each species and habitat on the list. These assessments have been reviewed and are included as Annex 1 to this report. With the resources and time available, the assessments of the status and threat for each item are not comprehensive. Where necessary, reference is made to the need for additional research or literature reviews to complete the evaluations, where they were seen to be insufficient.

It must be emphasized that these Working Groups were only asked to assess the data used to produce the list of species and habitats submitted to OSPAR, and not to provide comment on the suitability, or otherwise, of the criteria used to generate that list. However, ICES noted that the species-based listings adopted by OSPAR were not consistent with the stock-based units that ICES uses for i) the assessment of commercial fish stocks, and ii) the implementation of fish stock recovery plans when the abundance has declined below specified reference points. ICES was also not asked to provide comment and suggestions for mitigation measures which may be necessary if these species and habitats are finally selected for management action.

The preparation of a list of species, such as now under consideration, should be based on extensive biogeographical information on the respective species. It is necessary to have good knowledge of the geographical distribution of the species, and of the areas where it is threatened or declining, and where it is not. Also needed is a good long-term documentation of any decline; a conclusion on decline may not be based on limited information regarding spatial and temporal dynamics of the populations involved. Special care is required for any conclusion regarding a decline of species in areas at the border of its geographical distribution range.

6.2 ICES advice

Table 6.2.1 summarizes the ICES advice as to the adequacy of the evidence on the existence of actual declines and threats to the species and habitats that ICES was able to consider. It also comments on the spatial extent of the evidence. The full details of the evaluation are contained in Annex 1.

Table 6.2.1. Summary of the adequacy of the evidence for declines in the OSPAR area and threats to the species and habitats listed in the draft OSPAR Priority List of Threatened and Declining Species and Habitats.

Threatened and/or declining species and habitats	Indication of decline	Indication of threat	Priority for whole OSPAR area or specific regions
INVERTEBRATES			
Ocean quahog (*Arctica islandica*)	Evidence of decline, at least in some locations; irregular recruitment.	Strong evidence for impact by trawling.	Regional, southern North Sea.
Barnacle (*Megabalanus azoricus*)	ICES was unable to formulate advice in the required time frame, but can comment if required in the future.		
Dogwhelk (*Nucella lapillus*)	No decline along French coast.	Good evidence for TBT leading to imposex.	?
Flat oyster (*Ostrea edulis*)	Good evidence of widespread decline.	Evidence for overexploitation and also for introduction of other (warm water) races and other oyster species. Evidence that disease and severe winters caused decline.	Region II and Belgian coast.
Limpet (*Patella ulyssiponensis aspera*)	ICES was unable to formulate advice in the required time frame, but can comment if required in the future.		
BIRDS			
Lesser black-backed gull (*Larus fuscus fuscus*)	Good evidence of decline.	Good evidence of continuing threats.	Region I.
Steller's eider (*Polystica stelleri*)	No evidence of decline in OSPAR area.	No evidence of decline in OSPAR area, but threatened elsewhere.	
Little shearwater (*Puffinus assimilis baroli*)	Probable decline in past in OSPAR area, but presently stable. Declines immediately outside OSPAR area.	Evidence of threats.	
Roseate tern (*Sterna dougallii*)	Strong evidence of decline.	Strong evidence of persistent threats.	Priority for entire area.
Guillemot, Iberian sub-species (*Uria aalge ibericus*)	Iberian subspecies may not be a valid taxon, but the population on Iberia is either extinct or near extinction.	Threats that caused decline persist.	Yes, if population level is valid (and if any birds remain).
FISH			
Sturgeon (*Acipenser sturio*)	ICES was unable to formulate advice in the required time frame, but can comment if required in the future.		
Allis shad (*Alosa alosa*)	ICES was unable to formulate advice in the required time frame, but can comment if required in the future. See comment in Annex 1.		
Basking shark (*Cetorhinus maximus*)	Trends poorly documented, but evidence suggests declines are widespread.	Documentation of threats poor, but by-catch in fisheries is documented. Vulnerability due to life history traits is well documented.	If priority, would cover large part of OSPAR area.
Houting (*Coregonus lavaretus oxyrhinchus*)	ICES was unable to formulate advice in the required time frame, but can comment if required in the future.		
Cod (*Gadus morhua*)	Sound evidence of declines in all ICES areas.	Management plans in place for all stocks, and recovery plans in place for stocks showing greatest decline.	Priority for whole area, but regional differences occur.
Couch's goby (*Gobius couchi*)	ICES was unable to formulate advice in the required time frame, but can comment if required in the future.		
Short-snouted seahorse (*Hippocampus hippocampus*)	ICES was unable to formulate advice in the required time frame, but can comment if required in the future.		
Seahorse (*Hippocampus ramulosus*)	ICES was unable to formulate advice in the required time frame, but can comment if required in the future.		

Table 6.2.1. Continued.

Threatened and/or declining species and habitats	Indication of decline	Indication of threat	Priority for whole OSPAR area or specific regions
Orange roughy (*Hoplostethus atlanticus*)	Trends unknown in many areas. Severe decline documented in one area.	Fisheries continue in many areas, and species highly vulnerable to over-exploitation.	Priority throughout the species' range, which is not the entire OSPAR area.
Sea lamprey (*Petromyzon marinus*)	ICES was unable to formulate advice in the required time frame, but can comment if required in the future.		
Common skate (*Raja batis*)	Declines widespread and well documented.	Impacts of directed fisheries and by-catches are well documented.	Priority across its full range, which is much of OSPAR area.
Spotted ray (*Raja montagui*)	Declines documented in southern and eastern North Sea, but no trends in western North Sea.	Some documentation of impacts of fisheries that take Spotted ray as by-catch.	Only some regions.
Salmon (*Salmo salar*)	Some degree of decline documented throughout range.	Good documentation for low marine survival, and fishing is fully documented. Little documentation of other threats beyond local impacts.	Priority throughout entire area, but much more serious declines for southern regions (France, Ireland, UK) than northerly regions, where recent trends are upward.
Bluefin tuna (*Thunnus thynnus*)	ICCAT should be used as the primary source of advice on the status and trends of bluefin tuna, and of threats. ICES could review ICCAT information and advise in the context of consistent application of the Texel-Faial criteria.		
REPTILES			
Loggerhead turtle (*Caretta caretta*)	ICES was unable to formulate advice in the required time frame, but can comment if required in the future.		
Leatherback turtle (*Dermochelys coriacea*)	ICES was unable to formulate advice in the required time frame, but can comment if required in the future.		
MAMMALS			
Bowhead whale (*Balaena mysticetus*)	ICES was unable to formulate advice in the required time frame, but can comment if required in the future.		
Blue whale (*Balaenoptera musculus*)	ICES was unable to formulate advice in the required time frame, but can comment if required in the future.		
Northern right whale (*Eubalaena glacialis*)	ICES was unable to formulate advice in the required time frame, but can comment if required in the future.		
Harbour porpoise (*Phocoena phocoena*)	ICES was unable to formulate advice in the required time frame, but can comment if required in the future.		
HABITATS			
Ampharete falcata sublittoral mud community	Further information required on decline.	Further information required on threats.	
Carbonate mounds	No clear evidence of declines of the mounds themselves.	Evidence of threats to mound biota; no clear evidence of threats to the mounds themselves.	Under a "precautionary approach".
Deep sea sponge aggregations	Further information required on decline.	Further information required on threats. Likely to be threatened by towed bottom gears and other physical disturbances to the sea floor.	High priority.
Intertidal mussel beds	Clear evidence of decline as a result of fisheries.	Clear evidence of threats.	Priority.
Estuarine intertidal mudflats	Clear evidence of threats and declines.	Clear evidence of threats.	High priority.
Littoral chalk communities	Clear evidence of threats and declines in some regions.	Clear evidence of threats in some regions.	Region II.
Lophelia pertusa reefs	Clear evidence of threats and declines.	Clear evidence of threats.	High priority.

Table 6.2.1. Continued.

Threatened and/or declining species and habitats	Indication of decline	Indication of threat	Priority for whole OSPAR area or specific regions
Maerl beds	Evidence of decline.	Evidence of threats from dredgers, other physical disruption of the sea floor, and extraction for pharmaceuticals.	Priority.
Modiolus modiolus beds	Further evidence needed of declines in some areas.	Clear evidence of threats from a range of activities.	Priority.
Oceanic ridges with hydrothermal effects	Very little information on which to base assessments of decline.	While threats can be hypothesized, there is no evidence of any actual threats at this time.	Low.
Ostrea edulis beds	Clear evidence of decline.	Clear evidence of threats.	
Sabellaria spinulosa reefs	Clear evidence of decline, at least in Regions II and III.	Clear evidence of threats, at least in Regions II and III.	Priority.
Seamounts	No evidence of declines in habitat, but evidence of declines in associated biota.	Threats exist but no evidence of actual impact on habitat features.	Low.
Sublittoral mud with seapens and burrowing megafauna	Further evidence of decline required.	Clear evidence of threats across whole region.	Regions II and III.
Zostera beds	Clear evidence of decline across Regions II and III.	Clear evidence of threats across Regions II and III.	Regions II and III.

7 IMPACT OF CURRENT FISHING PRACTICES ON NON-TARGET SPECIES

Request

The European Commission, Directorate General for Fisheries, has expressed (in a letter of 20 September 2001) its immediate interest in an *"Evaluation of the impact of current fishing practices on 'non-target species' ... and suggestions for appropriate mitigating measures"*.

Source of information

The 2002 Report of the Working Group on Ecosystem Effects of Fishing Activities (WGECO) (ICES CM 2002/ACE:03).

The 2002 Report of the Study Group on Discard and By-catch Information (SGDBI) (ICES CM 2002/ACFM:09).

The 2002 Report of the Study Group on Elasmobranch Fishes (SGEF) (ICES CM 2002/G:08).

7.1 Background

Although fisheries generally target a specific mix of species, the catch of other species cannot always be avoided (by-catch of non-target species). These species may represent an economic value and be landed, or they may be discarded because they have no market value or because it is illegal to land them. The terminology used by different people is sometimes confusing, because discards may include (undersized) target species and (incidental) by-catch is sometimes used specifically for non-fish taxa such as marine mammals, seabirds, and turtles. Although these obviously are non-target species, this term is generally reserved for fish species that occur frequently in the catches and that may or may not be landed. The issue is further complicated because a target species in one fishery may be a non-target species in another. Here, we define non-target species as including those fish species that are not specifically targeted in any fishery and therefore are not routinely assessed by ICES Assessment Working Groups.

Within any particular area, the list of non-target species is effectively open-ended, because any vagrant species may accidentally end up in a fishing net some day somewhere. The EC request does not specify particular species and/or areas and, therefore, the provision of a comprehensive answer would represent an almost prohibitive task, unless suitable selection criteria could be set to identify the species most likely to be affected. Many of these non-target species should not concern local management, because their stocks depend predominantly on factors beyond local control. The species list also may be suitably truncated by excluding species that are too small to be caught effectively or that are typical of untrawlable areas such as rocky coasts. By defining an appropriate resident and potentially impacted fish community, the total amount of work may be reduced considerably.

One further important selection criterion might be the total catch (landings + discards) relative to available biomass. While landings data are available for species representing some economic value, the lack of a legal obligation to report non-TAC species has led to a recent deterioration of the catch statistics for these species, at least in some countries. Also, these data are not always divided into individual species (e.g., skates and rays, miscellaneous demersal). Moreover, because of their limited market value, in many cases a relatively large fraction may be discarded. Thus, the information collected during ongoing discard sampling programmes at sea is probably essential for evaluating the impacts of fisheries on non-target species.

Biomasses of non-target species are difficult to estimate accurately. Without such estimates, it is not possible to quantify and evaluate impacts in terms of by-catch mortality. Of course, other information about species status may be used to at least identify situations where measures to reduce their by-catch might be justified. For instance, survey information may indicate prolonged declines over part of their distribution area or even the entire range. In combination with relatively high by-catch rates, particularly if the data were spatially disaggregated, it might be possible to isolate cases where fisheries at least contributed to the species' decline. Such information might serve as a basis for advice on by-catch mitigation programmes, particularly if followed up by monitoring the effects of the latter. Nevertheless, evaluation of the impact on individual species might be strengthened considerably if quantitative discard data could be related to some absolute biomass estimate. However, it would be virtually impossible to collect detailed information on population structure for most of these species—whether partly landed or totally discarded—that would allow analytical assessments.

Despite many problems and shortcomings, the methods of Yang (1982) and Sparholt (1990) to transform qualitative survey data into absolute biomass estimates of all species recorded are considered to provide the best descriptions of the North Sea fish community obtained so far. Given that the database has been extended enormously since the 1980s, an update seems urgently required. However, an additional problem is that, in fact, a wide variety of surveys have been carried out with different gears with varying catchabilities for every single species. Consequently, different data sets may provide different relative biomasses and this obviously reduces their usefulness for management purposes, because their representativeness can always be questioned. What seems needed, therefore, is a coherent analysis of all surveys combined by developing suitable raising factors for comparing catches per swept area taken by different gears. This, in itself, is a major exercise, which would have to be repeated for each major management area.

Once biomass (B) estimates of standing stocks are available (preferably on an annual basis to reveal trends), quantitative information on (discarded) by-catches (C) may be used to calculate C/B ratios. Their ranking may not be entirely representative of the true impact on each species, because impact is related to the catch over production (P) ratio rather than catch over standing stock and P/B ratios vary with maximum age and size. Nevertheless, the C/B ratio, preferably by fleet, would provide an objective first estimate of the impact of the fishery. Comparison with similar estimates for regularly assessed commercial species might further help to identify the significance of the estimated impact ratios.

7.2 Potential use of discard data

The Study Group on Discard and By-catch Information (SGDBI) has concentrated so far on providing comprehensive discard information for a wide range of fisheries and areas, but priority has been given to those commercial species that are routinely assessed by ICES. As a consequence, discard information on non-target species has not yet been worked up. Also, at this stage there is no guarantee that there is enough spatial information contained in the database to allow a thorough evaluation of potentially useful mitigation measures.

7.3 Evaluation

As indicated in the preceding sections, an evaluation of fishing impact on non-target species requires a major scientific investment in the analysis of both survey and discard data. Therefore, it is not possible to provide a comprehensive overview of impacts by area and species. However, progress is being made with a specific group of non-target species: sharks and rays. This group has been given priority for evaluation, because elasmobranchs are sensitive to additional mortality owing to their life history characteristics (low fecundity, high age of maturity). The Study Group on Elasmobranch Fishes (SGEF) has selected four deep-water sharks, one pelagic shark, two dogfish, and two ray species, representing stocks in different areas of the Northeast Atlantic, for developing appropriate assessment methods that can be used in data-limited situations. The first results are expected by the end of 2002.

7.4 Mitigation measures

If the estimated impact ratio for a particular non-target species leads to management concern, the usual mitigation measures (reduction of fishing effort, gear restrictions, closed areas) might be applied. However, the most promising measures are probably those that interfere least with existing fishing practices, such as closing seasons when, and areas where, the by-catch problem is largest and the commercial yield is smallest. To evaluate appropriate mitigation measures, it is therefore important to have by-catch data available at disaggregated temporal and spatial scales.

Attention is drawn to the management advice on North Sea ray stocks given by ICES in 1997 (ICES, 1998). This has been one of the few instances so far that advice on non-target species has been provided.

References

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8 CONSIDERATION OF ECOLOGICAL DEPENDENCE IN FISHERIES MANAGEMENT ADVICE

Request

The European Commission, Directorate General for Fisheries, has expressed (in a letter of 20 September 2001) its immediate interest in a "*Consideration of ecological dependence in management advice, firstly addressing the groups of species with the ecological linkages that are known with high reliability to have strong ecological linkages*".

Source of information

The Report of the ICES Advisory Committee on Ecosystems, 2001. ICES Cooperative Research Report, 249.

The Report of the ICES Advisory Committee on Fishery Management, 2001. ICES Cooperative Research Report, 246 (Parts 1–3).

The 2002 Report of the Working Group on Ecosystem Effects of Fishing Activities (WGECO) (ICES CM 2002/ACE:03).

Background

In 2001, ACE recommended that the "precautionary reference points, as defined by ACFM, can be used as EcoQOs for target species, and their implementation will help to achieve conservation objectives for the ecosystem. However, management to B_{pa} will not ensure complete ecosystem integrity". As a result, ACE concluded that additional reference points for fish populations should be considered as part of the ecosystem approach to fisheries management. These included those for "ecologically dependent fish species (species that are so tightly linked ecologically to the target species that changes in the abundance/distribution of the target, which do not approach B_{pa}, may still compromise the status of ecologically dependent species)" (ICES, 2001a).

The understanding and provision of protection for species that are ecologically dependent on other species affected by fisheries (i.e., those with strong ecological linkages) has previously been identified as one of the three most immediate areas where management advice needs to adopt a wider "ecosystem" approach (ICES, 2001a).

Here, ACE: i) defines ecological dependence for the purposes of this request; ii) indicates when ecological dependence is likely to be significant in management decisions; iii) indicates how ecological dependence affects advice; iv) identifies situations where ecological dependence is already considered in management advice; v) identifies stocks for which ecological dependence may need to be considered in management advice; and vi) proposes a process for characterizing the significance of ecological dependence when setting management advice.

8.1 Ecological dependence

The forms of ecological dependence considered here are predator-prey relationships between target stocks and other species that result in exploitation of the target stock affecting other species. Target stocks and other species may be linked "vertically" through predator-prey interactions or "horizontally" through competition in exploiting a common food resource.

8.2 Significance of ecological dependence in management decisions

Exploiting an important forage fish resource may reduce the availability of forage fishes for dependent predators and lead to reductions in predator abundance. In contrast, exploiting a predator reduces predation mortality on its prey and this may result in prey proliferation. In this response, ACE focuses on the effect of exploiting forage fishes (as this was the focus of the EC request) although, of course, this is only one of many potential ecological interactions that occur in marine ecosystems.

Predator-prey relationships need to be understood in order to assess, for example, the effects of changes in mesh sizes on future yields. Such problems have been addressed by the Multispecies Assessment Working Group (MAWG) by collecting comprehensive diet data sets for a limited number of years and applying Multispecies Virtual Population Analysis (MSVPA). The assessment of other predator-prey relationships between non-target species and commercial fish species would also require reliable diet data, but the models to be developed might have to be coarser than MSVPA owing to a lack of detailed information on the population structure of these stocks. This suggests that there can be no general guidelines as to what data and model requirements are needed to assess ecological dependence. Rather, once specific issues have arisen, the next step will be to determine how the problem can be addressed.

8.2.1 Examples

Gislason (1999) developed a model which predicts inter-species relationships between cod, herring, and sprat in the Baltic Sea. It includes both top-down (predation mortality) and bottom-up (ration-mediated growth) effects. The Baltic fish community is relatively simple, dominated by cod, herring, and sprat. Ecological linkages are stronger when the system is dominated by a few species. Cod are cannibalistic and eat both herring and sprat. Both herring and sprat eat 0-group cod. For status quo spawning stock biomass (SSB), the magnitude of the effects of including ecological interactions can be assessed from Table 8.2.1.

Table 8.2.1. Status quo SSB (kt) and the percentage change relative to the single-species estimates (Gislason,1999).

	Cod	Herring	Sprat
Single species	221	970	628
Predation	233 (5 %)	1610 (66 %)	939 (50 %)
Predation and Ration	330 (49 %)	1510 (56 %)	826 (32 %)

The models used to estimate the interactions were the standard population (VPA) model, fish physiology models, and predation models. The data requirements for the population reconstruction are age-structured survey and catch data. The physiological models require data on energetics, growth, and maturity. The interactions are defined from fish stomach analyses. Knowledge of the rest of the ecosystem is also required, which is based mainly on surveys.

Gislason (1999) concluded that, when biological interactions are taken into account, reference limits for forage fish cannot be defined without consideration of the biomass of their predators. Similarly, reference points for the predators must include the biomass of their prey.

8.3 How ecological dependence may affect advice

Demonstrating that an ecological link exists does not clarify how advice should take account of the link. The effect of ecological dependence on advice can legitimately vary from minor to dominant, and some guidelines are needed for ensuring that ecological dependence receives the proper weight in each case. Prior to discussing how to develop such guidelines, it is useful to consider the range of weightings given to ecological linkages in recent ICES advice.

8.3.1 Generally low effect on the advice (MSVPA)

Multispecies virtual population analysis (MSVPA) has been implemented for the North Sea and the Baltic Sea. It quantifies the predation mortality inflicted by each age group of major fish predators (and, more recently, some seabirds and marine mammals) on each age of several prey, all of which are also exploited by fisheries. Some of these predation mortalities are high enough that they may meet future criteria for strong ecological linkages (ICES, 1996). Nonetheless, the Multispecies Assessment Working Group recommended (ICES, 1987, 1988), and ACFM adopted, the strategy that it remains best practice to use the single-species assessment packages as the basis for short-term annual harvest advice. The ecological interactions are captured adequately in the natural mortality term of the single-species assessment model that is based on MSVPA runs. Natural mortalities are estimated using MSVPA in the North Sea and the Baltic Sea. The natural mortality estimates for use in the annual assessments of Baltic Sea stocks are updated regularly (annually, in general), while those for the North Sea are not.

The multispecies interactions that are captured by MSVPA are not always a minor part of scientific advice, however. The Multispecies Assessment Working Group (MAWG) stressed that if major changes in mesh sizes were to be considered, for example, their consequences should be evaluated using MSVPA (or another multispecies model), rather than single-species size-yield models (ICES, 1988). This is because the medium-term consequences of mesh size changes on the size composition of fish predators in the North Sea would redistribute and increase predation mortality in ways that changed greatly the estimated direct consequences of mesh size changes. Also, some predator-prey dependencies among marine fish are strong enough that ICES has concluded that they need to be captured directly in the assessment model used for single-species harvest advice, as is the case with Northeast Arctic cod (ICES, 2000b).

8.3.2 The dominant factor in the advice (black-legged kittiwakes and sandeels)

In the case of seabirds and sandeel fisheries (Section 8.4), knowledge of ecological dependence has had a major effect on the advice to managers. This reflects the specificity of the management question and the scientific advice as much as the strength of the ecological relationship. However, management of the sandeel fishery in ICES Sub-area IV does account for the important role of sandeel as a prey species, even though the regulations are restricted to the interaction between sandeels and seabirds in a relatively small area of the North Sea. In this area, fishing can be restricted by area closures adjacent to seabird colonies (Section 8.4.3).

8.4 Situations where ecological dependence is already considered in management advice

A number of target stocks are known to be important food sources for seabirds or other species of marine fish (including other target stocks), and ecological dependence is already considered in management advice. In some cases, the strength of this ecological dependence has been quantified (at specific locations and times), while in others it has been assumed. In this section, we give three examples of such stocks.

8.4.1 Barents Sea capelin

The management strategy for this stock is to adopt a target escapement strategy, with a harvest control rule allowing (with 95 % probability) the SSB to be above B_{lim}, taking account of expected predation by cod.

ACFM has also noted that the negative influence of herring on capelin recruitment should be included in the B_{lim} rule if such a relationship can be described quantitatively. ACFM also noted that adjustments to the harvest control rule should be investigated further to take the uncertainty in the predicted amount of spawners and the role of capelin as a prey item into account (ICES, 2001b).

The Barents Sea capelin is also an important prey species for whales and seals.

8.4.2 Sandeel in the Shetland area

The current management regime consists of a TAC and seasonal closure during the months of June and July. The seasonal closure is to avoid any possibility of direct competition between the fishery and seabirds during the chick-rearing season.

ACFM noted that fishing grounds are close inshore and often adjacent to large colonies of seabirds, for which the sandeel population is an important food supply, especially during the breeding season. For some seabird species, the availability of 0-group sandeels as prey is very important. The sandeel population is also an important food source for other predator species in the Shetland area (ICES, 2001b).

8.4.3 Sandeel in Sub-area IV

In 1999, ICES provided advice on managing the Sub-area IV sandeel stock to account for the ecological dependence of seabirds on sandeels (ICES, 2000a). The ICES Study Group on Effects of Sandeel Fishing (SGSEF) concluded that there was a strong ecological linkage between some species of seabirds as predators and sandeels as prey. The linkage was particularly strong during the breeding season when the foraging range of seabirds was limited by travel time from breeding sites. In those cases, breeding failures of some species of seabirds were clearly associated with local shortages of sandeels, although breeding could fail for reasons other than shortage of sandeels, and the strength of the dependence varied among seabird species. The combination of relatively strong ecological dependence and an effective monitoring programme of kittiwake breeding success led the Study Group to conclude that kittiwake breeding success was a particularly good indicator of sandeel availability to coastal seabirds during the breeding season. After reviewing all the information, the SGSEF recommended, and ICES advised, that a decision rule be implemented in management of the sandeel fishery, to account for this ecological dependence. The rule states that when kittiwake breeding success falls below 0.5 chicks per well-built nest for three consecutive years, all sandeel fishing within 50 km of the UK coast should be stopped (ICES, 2000a), and the rule has now been implemented as an EC regulation.

However, the decision rule for sandeels in the North Sea does not deal with all the ecological interactions associated with this stock. As a result, there is ongoing research on the effects of sandeel fisheries in Sub-area IV on sandeel predators, including cod.

8.5 Stocks for which ecological dependence may need to be considered in management advice

There are a number of "forage fish" stocks for which quantitative assessments may or may not be available and which, on the basis of existing observations of the distribution and abundance of associated predators and (in some cases) their diets, may have ecologically dependent predators. Sections 8.5.1 to 8.5.6, below, provide a preliminary list of such stocks based on the reports of ACFM (ICES, 2001b), although other stocks that have not been considered here, such as sprat in the Baltic Sea and North Sea, may be ecologically important for their predators.

8.5.1 Capelin in the Iceland-East Greenland-Jan Meyen area

The fishery is managed in accordance with a two-part harvest control rule which allows for a minimum spawning stock biomass of 400,000 tonnes by the end of the fishing season, but interactions with other stocks are not taken into account (ICES, 2001b).

8.5.2 Sandeel in Division IIIa

The status of this stock and safe biological limits have not been identified, but ACFM has noted that this is an unregulated fishery for an important prey species (ICES, 2001b).

8.5.3 Norway pout in ICES Sub-area IV and Division IIIa

ACFM notes that the Norway pout stock is an important food source for other species, and the dynamics of Norway pout are more dependent on changes caused by recruitment variation and predation mortality than by the fishery.

At present, there are no management objectives for this stock. With present fishing mortality levels, the status of the stock is more determined by natural processes and less by the fishery. However, ACFM considers that there is a need to ensure that the stock remains high enough to provide food for a variety of predator species (ICES, 2001b).

8.5.4 Sandeel in Sub-area IV

At present there is no management objective for this stock, although an assessment is conducted and the biomass is above B_{pa}.

ACFM notes that the sandeels are an important prey for many marine predators and that fishing mortality should not be allowed to increase because the consequences of removing a larger fraction of the food biomass for other biota are unknown. Moreover, management of fisheries should try to prevent local depletion of sandeel aggregations, particularly in areas where predators congregate (ICES, 2001b).

8.5.5 Norway pout in Division VIa

There is a fishery targeting this stock, but no current evaluation of stock status. Based on the role of Norway pout in the North Sea, this stock is expected to provide an important food source for other species (ICES, 2001b).

8.5.6 Sandeel in Division VIa

ACFM notes that the sandeel fishing grounds are often close inshore and often adjacent to large colonies of seabirds, for which the sandeel population is an important food supply, especially during the breeding season. At present, there is no information on which to evaluate the state of this stock, and only landings data are available (ICES, 2001b).

8.5.7 Other considerations of ecological dependence

The request on ecological dependence from the EC is primarily related to concerns that the maintenance of the stock biomass of forage fishes at B_{pa} may not be sufficient to ensure that their predators have an adequate food supply. However, there are other forms of ecological dependence that may need to be considered or have already been considered elsewhere (ICES, 2002). Examples include the potentially strong competition between Norwegian spring spawning herring and blue whiting, the interactions between marine mammals and fisheries in many ecosystems, and the relationships between cod and shrimp or *Nephrops*.

8.6 A process for characterizing the significance of ecological dependence when setting management advice

At present, there is no consistent quantitative basis for assessing ecological dependence in management advice. Ecological dependence has usually been considered on a case-by-case basis when a particular ecological dependence has been identified. For example, the poor breeding success of seabirds on the Shetland Islands during periods of sandeel scarcity led to recommendations that the fishery should not excessively limit the availability of sandeel prey for seabirds (Section 8.4).

In order to take ecological dependence into account when formulating management advice, the following stages are recommended:

<u>Identify existing and potential links</u>

The extent to which one population is affected by changes in the abundance of another will depend on the abundance of alternate prey sources and the capacity of the predator to switch to the alternate food sources.

It is notable that predator-prey relationships among marine organisms are often rather flexible and few if any predators depend obligatorily on a single prey type. Thus, when populations or species are pooled, the strength of the linkages increases. In a management context, the assessment of ecological dependence should not focus solely on interactions between individual populations or species, but could also refer to larger groupings (e.g., forage fish, epifauna consumers).

Ecological links between populations, species, and groups of species are principally identified using diet analysis and a range of ecosystem models.

<u>Determine the strength of these links</u>

While establishing the existence of links between populations, species, and groups of species is straightforward, assessing the strength of these links is not. As a general rule, we might consider a linkage strong if a change in the dynamics of one species *always* resulted in a measurable change in the dynamics of the other. For example, the link between a predator and a prey population may be called strong if the predator could not maintain its average total prey consumption when the abundance of a single prey population was reduced. Such strong ecological dependence is apparent in a number of ecosystems where relatively few species dominate the total biomass. Thus, the scarcity of alternate food sources accounts for the strong ecological dependence between common guillemot, Arctic-Norwegian cod, and capelin in the Barents Sea (Vader *et al.*, 1990; Nakken, 1994).

The probability of quantifying the strength of a link will depend on the sources of data available on abundance, diet, and functional response, and the power of the analytical and sampling procedures. Existing studies, such as the MSVPA analyses described in Section 8.3.1, above, suggest that estimating the strength of ecological links will not be realistic for most interactions that are identified.

With appropriate data, it may be possible to develop empirical rules for assessing the strength of ecological dependence. For example, it may be possible to show that if a given prey accounted for more than x % of the total diet at any particular life stage, this was an appropriate criterion for (potentially) strong linkages. For this prey, a linkage might be called strong if a predator (group) accounted for a specified and significant proportion of the total natural mortality rate. Again, we might take a value, y %, as a criterion, because it would seem unlikely that other predators might replace this predation mortality completely if that predator were extirpated.

These definitions of strong linkages in predator-prey relationships may not be symmetrical: the linkage may be strong in terms of prey mortality and weak in terms of diet fraction of the predator or vice versa. The strength of a link (e.g., the proportion of the predator's diet or prey's mortality) can be assessed using food-web models that estimate the flow of energy through the trophic network. However, where data are available that allow a more direct quantification of the link (e.g., stomach analysis data), the use of these data is usually preferred.

A complicating factor is the transience of most predator-prey relationships in space and time and the influence of environmental factors on these relationships. Strong interactions over very short periods may be difficult to detect but will have a key influence on predator and prey dynamics. Moreover, even if strong interactions are accounted for, many other interactions can still complicate predictions. For example, recent analyses have shown the importance of large numbers of weak and largely unpredictable interactions in governing population dynamics.

8.7 Conclusions: guidelines for assessing ecological dependence

Managers and assessment scientists would benefit from a clear set of guidelines (but not rigid rules) for assessing the strength of ecological dependence. These guidelines are required to identify when reference points should be adjusted to account for ecological dependence. ICES is not in a position to develop a full set of guidelines at this stage, and is unwilling to offer a partial and untested set, for fear that they might make practice worse rather than better. ICES will consider and develop guidelines for considering ecological dependence in management advice within two years, and has provided a timetable to conduct this work (ICES, 2002). The process of developing guidelines for assessing ecological dependence will proceed in tandem with the ongoing process of the review of existing reference points by the stock assessment working groups.

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9 PRESERVATION OF GENETIC DIVERSITY OF EXPLOITED STOCKS

Request

The European Commission, Directorate General for Fisheries, has expressed (in a letter of 20 September 2001) its immediate interest in the "*development of advisory forms appropriate to the preservation of genetic diversity*" from detrimental impacts of fishing".

Sources of information

The 2002 Report of the Working Group on Ecosystem Effects of Fishing Activities (WGECO) (ICES CM 2002/ACE:03).

The 2002 Report of the Working Group on the Application of Genetics in Fisheries and Mariculture (WGAGFM) (ICES CM 2002/F:03).

Background

The policy mandate for addressing the effects of fishing on genetic diversity arises from the Rio Declaration and the Jakarta Convention, which call for preservation of biological diversity, including genetic diversity. Scientific justification for conserving genetic diversity within and among populations stems from several sources, including:

1) maintaining the adaptability of natural populations in the face of environmental change;
2) the future utility of genetic resources for medical and other purposes; and
3) avoiding detrimental changes in life history traits (e.g., age and size at maturation, growth) and behaviour (e.g., timing of spawning) that influence the dynamics of fish populations, energy flows in the ecosystem, and, ultimately, sustainable yield.

ICES has reviewed the scientific evidence for impacts of human activities, including fishing, on genetic diversity in the Working Group on the Application of Genetics in Fisheries and Mariculture (WGAGFM) during several meetings between 1995 and 2000, and at a meeting of the Working Group on Ecosystem Effects of Fishing Activities (WGECO).

9.1 Current status/information

9.1.1 How fishing might be a threat to genetic diversity

There are three general classes of threat to biodiversity at the gene level:

1) extinction (population or species), which results in the complete and irreversible loss of genes;
2) hybridization, which causes the rearrangement of co-adapted genes and loss of adaptability to local conditions; and
3) reduction in genetic variability within populations. This third threat can occur in a directed way due to selective fishing, or due to a decrease in population size resulting in inbreeding (Laikre and Ryman, 1996).

Normally, marine fish have very large population sizes and fisheries become non-viable long before there is serious risk of biological extinction. However, there may be exceptions for some non-target species with low resistance to elevated rates of mortality and high vulnerability as by-catch, where the fishery on the target species could be viable but the by-catch species could become severely depleted.

Commercial exploitation is also unlikely to alter the likelihood of hybridization of wild populations.

In cases where locally concentrated fisheries cause the depletion or loss of spatial population components, the population structure of the species will determine the genetic impact, if any. For populations linked by gene flow, the organization of these populations in time and space, along with the ratio of within- and among-population variation, are important to maintain in order to avoid negative genetic effects.

Aside from the special cases of severe overfishing, or spatially concentrated harvesting leading to population fragmentation, the predominant potential for loss of genetic diversity is through loss of genetic variation within populations through selection caused by fishing. For a population, it is immaterial whether the mortality induced by fishing is incidental or directed, and if by-catch mortality is a large fraction of total mortality, then fisheries may also have genetic effects on non-target species.

9.1.2 Conservation of genetic diversity in fisheries contexts

Precautionary reference points should protect the full genetic diversity within and among populations of species affected by fishing. Objectives to protect genetic diversity should be set at a population level for at least the properties of:

- number of spawning components;
- relative abundance of spawning components;
- percent change in life history traits.

However, with current knowledge it will be difficult to assign biologically meaningful reference points for these objectives.

Genetic variation among populations

There are many types of genetic population structures, ranging from complete *panmixia* where each individual has an equal probability of reproducing with any other individual of the species, to highly structured populations with complete reproductive isolation (Smedbol *et al*., 2002). Current information is highly incomplete, but indicates that both extremes are very rare in marine populations. Rather, a number of genetically distinct populations exist which are linked by exchange of some breeding individuals (gene flow). The probability of gene flow from one population to another is dependent on the geographical distance between populations, generally monotonically decreasing with increasing distance (Kimura and Weiss, 1964). In some cases, a stable population (source) contributes migrants to smaller populations (sinks) that only exist due to the recurrent contributions from the source population.

In evaluating population structure as a basis for scientific advice on minimizing the risk that fishing causes a loss of genetic diversity, when the evidence is unclear or inconsistent it is more precautionary to treat the populations as if they are distinct than to combine them (Taylor and Dizon, 1999).

Genetic variation within populations

Physical and life history traits (phenotype) are produced by the genetics of the individual, by the environment in which it lives (e.g., temperature, food availability), and by the interaction between the genes and the environment. Within a population there may be several different alleles for individual genes, with the relative frequency of the various alleles influenced by how the various alleles interact with the environmental conditions encountered by the population, and the population's history. It is generally thought that the within-population variability in allele types and frequencies is a crucial component of a population's ability to persist in a variable environment. Hence, conservation of genetic diversity includes not just preserving each allele in a population, but also not distorting the relative abundances of alleles or genomes far outside the range of normal variation. However, at present the "range of normal variation" is poorly known for almost every fish stock.

Genetic variation within populations and selection pressures

Data on fish populations from many parts of the world have shown that selective effects of fishing are common. For example, removing large fish often results in a predominance of early maturing fish with small maximum length, and in at least some cases such changes are a consequence of genetic alteration of the populations (some alleles are lost or reduced greatly in frequency) and are irreversible. In other cases, the changes can have a genetic component but be reversible (all allele frequencies remain high enough to re-establish the original frequency quickly when the selective fishing is removed). In still others, the changes may not have a genetic basis, with the remaining population encountering a different suite of environmental factors such as temperature and prey fields. Case-specific scientific study is required to determine whether there is a genetic difference between the fish removed and those left behind, and if there is, whether it is reversible.

In one well-studied case (Law, 2000; Law and Grey, 1989; Heino, 1998; and work in progress (U. Dieckmann, M. Heino, and O.R. Godø)), the impact of a decline in age-at-maturation in Northeast Arctic cod has been investigated. The phenotypic response of a decline is consistent with deterioration of genetic diversity caused by size-selective fishing since the 1930s, despite the population of cod always numbering in the many millions of individuals. The reduced age-at-maturation has a heritable component and may be linked to lower maximum size and slower growth rates. These changes have additional consequences of diminished fecundity and lower yield from the stock, which could have lasting impacts on future fisheries. Similar empirical genetic data are generally lacking in marine species, despite the fact that the evolution of life history traits is a field of great interest, both in population biology and genetics, and changes in traits like age-at-maturity are a common consequence of heavy exploitation.

Management advice also needs to acknowledge that selection pressures are not necessarily symmetric. Often trying to restore genetic stock properties by reversing selection pressures is inherently more difficult than trying to slow down changes by decreasing the selection pressures. For example, fishing can create a very strong selection gradient for early maturation, whereas in the absence of fishing, late maturity is only weakly selected for. Therefore, it may prove very difficult to re-establish an older age-composition of the spawning population even if fishing pressure is reduced.

In terms of quantitative genetics, the proportion of phenotypic variance which is inherited is referred to as the heritability of a trait (h^2). This is an important consideration, because for a given intensity of selective harvesting, traits with low values of h^2 change more slowly than those with higher values. In the absence of better information, heritabilities for life history traits in the range 0.2–0.3 can be assumed (Mousseau and Roff, 1987; Roff, 1997). This means that 20–30 % of the observed variation is due to the genes, while the remaining 70–80 % is due to effects of the environment interacting with expression of those genes. Additional metrics are under development that may allow the dependence of phenotypes on environment to be characterized in the absence of direct genetic evidence, but these metrics are not yet developed sufficiently to serve as a basis for scientific advice (Heino *et al*., 2002).

The special case of small populations

In very small populations, the frequency of particular alleles changes randomly from one generation to the next. This process, called genetic drift, may also result in loss of genetic variation. By pure chance some of the alleles that exist in the parent generation may not be passed on to their offspring. The smaller the population, the more dramatic the fluctuation of allele frequencies, and the more rapid the loss of genetic variation. Another consequence of small population size is inbreeding, i.e., the production of offspring from matings between close relatives. If a population is small and isolated, inbreeding is inevitable. In many species, inbreeding is coupled with reduced viability and reproduction, reduced mean values of meristic traits, as well as increased occurrences of diseases and defects, so-called inbreeding depression.

The rate of genetic drift and inbreeding is not determined by the total (census) population size, but by the "effective population" size, N_e. Effective population size is nearly always less than total population size because generally not all individuals in a population are reproductive at spawning time. N_e depends on such factors as sex ratio, variance in family size (i.e., variability in numbers of offspring per individual), temporal fluctuations in numbers of breeding individuals, overlapping generations, etc. Fishing practices that select one sex over the other also may, over time, cause a reduction of genetic diversity within populations.

Genetically small populations are unlikely to be of concern in marine fish with large census population sizes. For these species, commercial extinction is likely to occur long before populations are small enough to be inbred. However, hidden populations within management units may be fished to this level before the situation can be appreciated. Therefore, it is critical that the population structure of species be defined. Small population processes may also be a consideration in the management and recovery of depressed wild salmon stocks, and in evaluating impacts of by-catch and injury in fishing gear on some species of cetaceans.

9.2 Managing genetic diversity

In the medium term, ICES proposes a three-phase approach to the development of a framework for managing genetic diversity: 1) identification of management objectives; 2) identification of appropriate reference points and determination of acceptable risk; and 3) development of a monitoring programme.

9.2.1 Management objectives

Considerations for defining management objectives for maintaining genetic diversity within a species include:

1) genetic diversity among populations;
2) population structure and relative abundance;
3) within-population genetic diversity;
4) the current status of the species (endangered, threatened, etc.).

The last consideration can be used to prioritize decision-making. This will be important because the management actions that are required when populations are large and intact are different from those needed when populations are small and fragmented. Examples of management objectives that match these considerations are given in Table 9.2.1.1.

Operational management objectives must be set with an acknowledgement that genetic diversity itself (e.g., number of alleles or genotypes) is not directly "managed" but the elements that influence it can be. **ICES advises that the first priority should be to maintain populations in a natural setting to which adaptation may have occurred, and in which evolutionary forces may continue to act** (Thorpe *et al*., 1995).

With respect to genetic impoverishment caused by selective fishing, the options depend on the severity of the changes in the phenotypic characteristics of concern and (usually by inference, because genetic data are rarely available) their underlying genetic makeup. It may be necessary to **slow, stop, or reverse fisheries-induced selection** on a characteristic by which harvesting is done selectively, such as by maturation stage, sex, size, etc. If

Table 9.2.1.1. Examples of management objectives to address generic concerns related to the loss of genetic diversity in marine species.

Consideration	General management objective
1. Genetic diversity among populations	1. Maintain number of populations
2. Population structure and relative abundance	2. Maintain relative size of populations
3. Within-population genetic diversity	3.1 Maintain large abundance of individual populations
	3.2 Minimize fisheries-induced selection

the characteristic has undergone only moderate alteration, it may be adequate to just reduce fishing pressure so many individuals bearing the characteristic survive the fishery. If the characteristic has been altered so severely that the selection pressure must be reversed to re-establish the characteristic in the population, then carefully targeted management measures may be required. It is possible that this may be achieved through gear modifications (e.g., change in mesh size, separator panels) that allow the escape of fish with the characteristic that has been reduced in prevalence by the fishery. At this time, there is too little experience with real-world situations to know whether gear modifications are sufficient to reverse genetic impoverishment caused by intensive selective fisheries, or if other measures are necessary before reversal can be started.

9.2.2 Reference points

The ICES framework for applying reference points to management objectives can also be applied to genetic diversity objectives. However, precautionary reference points and limit reference points, as used by ICES to delimit boundaries of serious conservation concern, are more problematic.

Limit reference points are the value of a property of a resource that, if violated, is taken as *prima facie* evidence of "unacceptable risk of serious or irreversible harm to the resource…" (ICES, 2001). *Loss of alleles* from a species represents an *irreplaceable* component of genetic diversity. Substantial changes in *allele frequency* may be irreversible or, at best, very difficult to reverse. The *irrevocability* of genetic loss, combined with our inability to assess the consequences of not taking action, means that limit reference points unquestionably have a role in managing genetic variability within and among populations. However, at present there is insufficient scientific knowledge to determine the limit at which the genetic diversity of a resource is "harmed" but is still capable of recovering. One of the difficulties with determining minimum acceptable levels of reduction in genetic diversity (limit reference points) is that it is impossible to know precisely what aspects of genetic variability will be important for a species to be able to adapt to environmental change in the future. We can deduce that genes associated with quantitative phenotypic traits (length, growth rate, vast numbers of other traits) that are naturally under selection even without added pressure from fisheries will be important, however, very few of these have been identified for any species.

Limit reference points could be defined for some objectives, especially those applicable to threats to within-population genetic diversity due to small population size and fragmentation. For example, recent theoretical work suggests that successful breeding population sizes of 1,000 to 5,000 are required for long-term population viability (Lynch and Lande, 1998). This may be useful guidance for setting reference points for a few rare species affected as by-catch, but for all target species, abundances consistent with B_{lim} used by ICES will be far above these numbers.

ICES also uses **precautionary reference points** as tools to keep the probability of approaching a limit reference point low, given all sources of uncertainty. With present knowledge from fish populations, there is little scientific ability to quantify how risk varies with changes to population structure, or how the rate of genotypic change tracks the rate of change in a phenotypic trait. Therefore, there is no basis for establishing precautionary reference points for the effects of fishing on genetic population structure or within-population variability (even if it were possible to set limits), although the latter problem may prove tractable with additional research and modelling (Gaines *et al.*, 1999). Risk of genetic loss in small populations has been extensively explored with quantitative models (e.g., Bergman *et al.*, 1993), so it may be possible to set precautionary reference points for this aspect of the conservation of population genetics. However, as noted earlier, this is probably the least commonly encountered concern with regard to fishing effects on genetic diversity.

Target reference points are "properties of stocks/species/ecosystems which are considered to be desirable from the combined perspective of biological, social, and economic considerations" (ICES, 2001). The biological target could be no loss of genetic material, but this could be modified by social and economic considerations. If limit and/or target reference points can be established, genetic risk assessment may provide a framework for decision-making in light of uncertainty and consideration of other factors (e.g., biological, economic, and social).

9.2.3 Monitoring genetic changes

Managing genetic diversity of populations relative to reference points also requires monitoring genetic diversity. Methods selected for monitoring genetic diversity will depend upon the management objective. An effective monitoring programme requires three phases: identifying monitoring questions, identifying monitoring methods, and the analysis and interpretation of information for integration into management strategies and the refinement of management objectives. Examples of monitoring questions include: What is the genetic diversity within a population or among populations? How has habitat fragmentation affected the genetic structure of a population or species?

Once the questions are established, the monitoring methodology can be determined. Markers that are ideal for identifying population structure (e.g., so-called neutral markers such as nuclear microsatellite arrays) are not useful for monitoring traits under selection. Historic otolith collections can be a valuable source of data on past levels of genetic diversity within and among populations of many species of marine fish, but significant laboratory processing would be required to provide the necessary time series of data. In monitoring phenotypic traits, existing biological data from fisheries surveys are generally adequate to identify potential cases where fishing may have caused selection. However, it is important to take direct environmental effects into account in order to disentangle the genetic component of variation.

9.2.4 Using fisheries to "improve" the genetics of wild stocks of fish

If highly selective fisheries can reduce the genetic diversity of a population, such that the genetic basis for life history characteristics such as age-at-maturity is altered, it could be argued that fisheries could be made intentionally selective for characteristics considered desirable for some reason. For example, it has been suggested that towing mobile gears slowly might allow fast-growing fish to selectively escape the fishery. Although such genetic strategies are common in agriculture, in agriculture much of the larger "environment" is kept under tight management control through cultivation, fertilization, and watering practices. For wild stocks of fish, environmental variation is a major factor, and such variation is not under management control. Intentional selection for characteristics that may be desirable from a harvesting perspective under a specified set of conditions runs the risk of reducing the ability of the population to adapt to future environmental variation. Thus, the primary objective for the management of genetic diversity should be to avoid loss of genetic diversity, rather than to steer the choices of which genetic patterns are kept and which are lost.

9.3 Conclusions

It would be possible to develop complete advisory frameworks appropriate to the preservation of genetic diversity, but further work is needed. Some aspects can be developed with more synthesis and application of existing knowledge. ICES is currently advancing that work through its Working Group on the Application of Genetics in Fisheries and Mariculture, and the Working Group on Ecosystem Effects of Fishing Activities. The more rapid progress is expected in developing a broadly applicable science-based framework for setting limits and precautionary reference points for small populations and population fragmentation, and for advising on specific management actions to manage risks relative to such reference points.

More research is needed before it will be possible to understand, quantify, and then build advisory and management frameworks for the selective effects of fishing on within-population genetic variation, when a fishery changes phenotypic traits. These effects are likely to be widespread, and possibly lasting, when stocks are overfished. They may also be pervasive when fishing is highly selective for particular features of a population (size, maturation stage, etc.).

9.4 Advice

ICES advises that management that keeps stock sizes above their respective B_{lim}, as currently used in ICES advice, should have a high likelihood of avoiding risks associated with small population size overall.

However, this strategy does not guarantee that population fragmentation and local depletions are not a threat to stocks, when fishing is locally intense and highly patchy in distribution. Advice on how fishing should be distributed in space to keep the risk of population fragmentation and local depletions low will depend on the mobility, migration patterns, and distribution of propagules for the exploited species. When such advice is needed, for example, when fishing is known to be intense and patchy on a species that is fairly sedentary, it will have to be provided on a stock-specific basis.

Management that keeps target stock sizes above their respective B_{lim} also does not guarantee that all non-target species will necessarily remain large enough that the risks associated with small population sizes are low. However, if appropriate limit reference points (or their functional equivalents) based on population dynamics principles (such as having a high probability of a rapid and secure rebuilding) can be developed for management of the impacts on non-target species, these would almost certainly be sufficiently high that genetic risks associated with small populations would be very low.

Evidence from at least one study demonstrates that exploiting stocks at fishing mortality near and occasionally above F_{lim} has caused a loss of genetic diversity of the target stock. This is an additional reason for management to keep F well below F_{lim}. However, there is inadequate information at present to conclude that genetic diversity will usually be reduced when F is near or above F_{lim}, or that keeping F below F_{lim} is sufficient to keep the risk of reduction of within-population genetic diversity low. This risk necessarily will increase as a fishery becomes increasingly selective on any specific characteristic of the population. However, the rate of change in risk with increasing selectivity of a fishery is unknown. Given that the various characteristics are not equally heritable, there is little reason to expect that there is a single relationship between risk to genetic diversity and selectivity that can be used as a basis for future advice.

Until the scientific basis for rigorous quantitative analysis and provision of advice on this aspect of the effects of fishing on species can be developed, some common-sense rules should be applied:

1) Fishing mortality should be kept sufficiently low to maintain large populations.

2) From a genetic perspective, the harvest should be widely distributed geographically and among all the recruited populations, so that the risk of local depletions and fragmentation of populations and selective removal or modification of particular traits is kept low.

3) Genetic considerations would usually favour an overall reduction of fishing effort over alternative management approaches that result in fisheries becoming even more selective on only parts of a population, either spatially or by some life history characteristics.

4) The alternative management options have to be evaluated on a case-specific basis. For example, in establishing closed areas to protect a stock from overfishing, it often could be concluded that the benefits of protecting at least a part of a population exposed to fishing may outweigh the risks of reducing genetic diversity in the part of the population still exposed to fishing.

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10 ECOLOGICAL QUALITY OBJECTIVES

Request

The North Sea Ministers in their Declaration at the Fifth International Conference on the Protection of the North Sea, in Bergen in March 2002, established a framework to implement a set of Ecological Quality Objectives (EcoQOs) for the North Sea. Although there was no explicit request to ICES within the Ministerial Declaration, OSPAR was invited to work with ICES in a number of areas to make EcoQOs operational. For a number of areas, ICES holds the only source of information on the subjects of the EcoQOs.

Sources of information

Bergen Declaration. Fifth International Conference on the Protection of the North Sea, 20–21 March 2002, Bergen, Norway.

The 2002 Report of the Working Group on Ecosystem Effects of Fishing Activities (WGECO) (ICES CM 2002/ACE:03).

The 2001 Report of the Working Group on Ecosystem Effects of Fishing Activities (WGECO) (ICES CM 2001/ACE:01).

The 2002 Report of the Benthos Ecology Working Group (BEWG) (ICES CM 2002/E:07).

The 2002 Report of the Marine Chemistry Working Group (MCWG) (ICES CM 2002/E:01).

The 2002 Report of the Working Group on Phytoplankton Ecology (WGPE) (ICES CM 2002/C:06).

The outcome of relevant ACME deliberations in 2002.

10.1 Background

The Bergen Declaration provides the most direct context for this section. Therein, the North Sea Ministers agreed to implement an ecosystem approach to manage human activities that affect the North Sea by, *inter alia*, making use of ecological quality objectives (EcoQOs) as tools for setting clear environmental objectives directed towards specific management and serving as indicators for the ecosystem health. In order to achieve this, the EcoQOs need to be coherent and integrated. The Ministers agreed that the issues and their related elements listed in Annex 3 of the Bergen Declaration (reproduced here in Table 10.1.1) would be the set for which EcoQOs should be developed. The background documents to the Bergen Declaration and the Declaration itself make several points relevant to planning for the provision of scientific advice on EcoQs and EcoQOs:

- EcoQOs should include both the desired levels of ecological quality and baselines against which progress can be measured;
- The ecological quality baselines will be established either by using baselines already agreed, such as fish stock assessments, or by developing new baselines;
- EcoQOs must not permit any worsening of existing conditions.

The EcoQOs listed in Table 10.1.2 were taken from Annex 3 of the Bergen Declaration, where they had been chosen for application in a pilot project for the North Sea. The Declaration included a commitment that EcoQOs for the remaining elements will be developed by 2004 and applied within the framework of OSPAR, in coordination with the development of marine indicators in the European Environment Agency (EEA) and environmental objectives in the EU Water Framework Directive. This work will include agreement on the procedures necessary for the sound application of the EcoQOs.

It was agreed that the pilot project would:

a) assess the information that is, or can be made, available in order to establish whether the EcoQOs are being, or will be, met. Where the EcoQOs are not being met, the information will be used to determine the reason. Costs and practicability should be taken into account in deciding what information can be made available;

b) where an EcoQO is not being met, review any policies and practices which are contributing to that failure; and

c) if need be, reconsider the formulation of such EcoQOs.

It was agreed that coherent monitoring arrangements would be established, in order to assess progress towards meeting the EcoQOs. Such arrangements would be integrated into the OSPAR Joint Assessment and Monitoring Programme (JAMP). OSPAR was also invited to review progress in 2005, in collaboration with ICES and other relevant bodies, with the aim of adopting a comprehensive and consistent scheme of EcoQOs and to report on this to the North Sea Ministers. Thereafter, the value, use, and practicability of the scheme of EcoQOs should be periodically reviewed by OSPAR, in cooperation with ICES and other relevant bodies.

While applauding the important step forward represented by the Bergen Declaration, ACE stressed that its previous evaluation (ICES, 2001a) had found loose ends, loose language, and loose thinking to be pervasive in many documents about EcoQs, EcoQOs, etc. ICES (2001a) attempted to provide more systematic rigour and direction to the selection and implementation of EcoQs and EcoQOs, as well as suggestions for clearer terminology. These concerns have been addressed to varying extents, and the terminology and argumentation have been improved in the background documentation prepared by OSPAR for the Bergen Conference (OSPAR, 2002). However, the developments over the past year have increased the importance of strengthening the scientific framework for EcoQs and EcoQOs, and making it more operational. ACE still thinks that without substantial improvements in the rigour of the EcoQO framework, there is a risk that the framework may achieve no more than past scientific advisory and management frameworks. Therefore, ACE welcomes the opportunity to build on the work reported last year, with the more specific focus of the Bergen Declaration.

From the above, it is evident that ICES has two main roles to play. The first is to assist and advise in the implementation of the pilot project; the second is to provide medium-term advice on the establishment of remaining EcoQOs. A longer-term role lies in helping in the assessment of the effectiveness of the EcoQO framework and methodology.

ICES (2001a) provided guidance for further development of EcoQOs. This is repeated below (Section 10.1.1). We do not repeat the rationales for our various conclusions and recommendations, where they were developed adequately in ICES (2001a). Following presentation of that information, we consider the work needed to implement the pilot project. We then consider the medium- and long-term perspectives. These sections are quite detailed, as they try to provide clear descriptions of necessary work, but differ in the time scale for the necessary actions. Throughout the entire section, we do our best to avoid second-guessing the choices of EcoQ elements and EcoQOs, and offer constructive suggestions for moving ahead.

Table 10.1.1. The full set of issues and ecological quality elements that were agreed in the Bergen Declaration by North Sea Ministers.

Issue	**Ecological quality element**
1. Commercial fish species	(a) Spawning stock biomass of commercial fish species
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) Utilization 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 sandeel 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 dogwhelk *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 10.1.2. Ecological quality elements and their objectives that were agreed in the Bergen Declaration by North Sea Ministers.

Ecological quality element	**Ecological quality objective**
(a) Spawning stock biomass of commercial fish species	Above precautionary reference points[1] for commercial fish species where these have been agreed by the competent authority for fisheries management.
(c) 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.
(e) By-catch of harbour porpoises	Annual by-catch levels should be reduced to levels below 1.7 % of the best population estimate.
(f) Proportion of oiled common guillemots among those found dead or dying on beaches	The proportion of such birds should be 10 % or less of the total found dead or dying, in all areas of the North Sea.
(m) Changes/kills in zoobenthos in relation to eutrophication[2]	There should be no kills in benthic animal species as a result of oxygen deficiency and/or toxic phytoplankton species.
(n) Imposex in dogwhelks *Nucella lapillus*	A low (<2) level of imposex in female dogwhelks, as measured by the Vas Deferens Sequence Index.
(q) Phytoplankton chlorophyll *a*[2]	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.
(r) Phytoplankton indicator species for eutrophication[2]	Region/area-specific phytoplankton eutrophication indicator species should remain below respective nuisance and/or toxic elevated levels (and increased duration).
(t) Winter nutrient concentrations (dissolved inorganic nitrogen (DIN) and dissolved inorganic phosphate (DIP))[2]	Winter DIN and/or DIP should remain below elevated levels, defined as concentrations > 50 % above salinity-related and/or region-specific natural background concentrations.
(u) Oxygen[2]	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.

[1] In this context, "reference points" are those for the spawning stock biomass, also taking into account fishing mortality, used in advice given by ICES in relation to fisheries management.

[2] The ecological quality objectives for elements (m), (q), (r), (t), and (u) are an integrated set and cannot be considered in isolation. ICES will be providing further advice during the implementation phase.

10.1.1 Criteria for good Ecological Quality metrics

Deriving from several sources (Anon., 1999; Lanters *et al*., 1999; Kabuta and Enserinck, 2000; ICES, 2001e, 2001c; Piet, 2001), ACE (ICES, 2001a) identified several key features of EcoQ metrics. These were explicitly identified as neither necessary nor sufficient conditions for an EcoQ and corresponding EcoQO to be useful. In particular circumstances, one or more could be missing from a useful EcoQ – EcoQO, or some additional properties might be considered important. Nonetheless, they were considered excellent properties to use in screening potential EcoQs and EcoQOs. The more properties from this list that a candidate EcoQ and corresponding EcoQOs lacked, the more likely that the EcoQO would not be a practical and effective guide to actions by managers. If an EcoQO is ineffective at guiding management decision-making, it is not likely to contribute to better protection of marine ecosystems and more sustainable uses of them.

As reported in ICES (2001a), elements (in the sense of the Bergen Declaration) when stated factually, and EcoQOs when stated quantitatively with a reference point, of EcoQs should be:

- relatively easy to understand by non-scientists and those who will decide on their use;
- sensitive to a manageable human activity;
- relatively tightly linked in time to that activity;
- easily and accurately measured, with a low error rate;
- responsive primarily to a human activity, with low responsiveness to other causes of change;
- measurable over a large proportion of the area to which the EcoQ element is to apply;
- based on an existing body or time series of data to allow a realistic setting of objectives.

In addition, an EcoQ element may:

- relate to a state of wider environmental conditions.

10.1.2 Management system needed to implement EcoQOs

Progress towards better protection and more sustainable uses of marine ecosystems cannot be assured by simply selecting good EcoQs and EcoQOs. A management system has to use the EcoQOs. Such a management system requires a number of attributes that are not necessarily apparent in current (and recent) management frameworks. These attributes include:

- Institutional mechanisms to reconcile real or perceived incompatibilities among different objectives, whether objectives for fisheries contrasted with integrated objectives for ecosystem quality, or even ecological, economic, and social objectives for any specific use, including but not exclusively fishing;
- A peer review and advisory framework that deals explicitly with quality control of data collection and analysis used to monitor and assess the EcoQs;
- An explicit examination of the historic hit, miss, and false alarm rate of the metric used to monitor the level of the EcoQ, and an evaluation of the performance of the metric over time;
- A mechanism to ensure that advice is effective in supporting decision-making when progress on achieving numerous individual objectives is uneven;
- A mechanism to unambiguously relate specific human activities to status relative to specific EcoQOs.

10.2 The EcoQO pilot project

The Bergen Declaration noted that ICES should collaborate with OSPAR to review progress on the pilot project testing the EcoQOs, but gave no details of roles and responsibilities. ICES can offer scientific advice and input at several stages of the pilot project. First, all of the EcoQOs adopted for the pilot project could be evaluated against the criteria outlined in Section 10.1.1, above. Some of the EcoQOs were considered in 2002 by WGECO (ICES, 2002a), and these considerations are repeated in Section 10.2.1, below, with some further development.

Secondly, ICES, through the expertise of its working group and advisory process, could have a role in coordinating the monitoring required for many of the EcoQOs and/or in evaluating the results of this monitoring. Some input would have broad and general value, such as the advice on trend monitoring in Annex 9 of the 2001 ACME Report (ICES, 2001d). There are also many more specific opportunities for ICES involvement in the work associated with individual EcoQOs, as stated below.

ACE has some specific detailed concerns about the EcoQOs agreed in Bergen. These are noted in Table 10.2.1 along with some suggestions for dealing with the concerns.

10.2.1 Evaluation of EcoQOs

Table 10.2.1.1 grades the ten EcoQOs selected for the North Sea pilot project by the qualities listed in Section 10.1.1, above. Suggestions for improvements are then noted in the relevant subsequent sections.

10.2.2 Possibilities to improve the performance of the EcoQ metric

10.2.2.1 Commercial fish species

Estimation of spawning stock biomass is subject to a number of errors and biases. The occurrences of these errors and biases are well known to relevant ICES Working Groups and to Advisory Committees, and although their causes often cannot be corrected, management advice can take them into account. ICES is continually striving to improve the situation in order to provide better fish stock advice; these improvements will help to improve the performance of the EcoQ metric.

Fish stocks will always be responsive to natural factors that cannot be controlled. Understanding of the effects of these natural factors will improve through time, but full understanding is unlikely to be achieved in the near future, if ever.

10.2.2.2 Seal population trends

It is not known how sensitive seal populations are to human activities apart from direct killing, either deliberately or through fisheries by-catch (where the linkage can be modelled and is relatively tight). However, this EcoQO is designed to act as a trigger for further research to determine whether manageable human activities are the cause of any future decline. In the meantime, research on aspects of the interaction between humans and seals will continue, for instance, on establishing cause-effect relationships between pollutants and seal population health. The greatest recent cause of negative change in seal populations was due to an epizootic; the degree to which this was an indirect result of chemical pollution is the subject of debate and research. It appears that a new epizootic is starting in summer 2002, which should provide further opportunities to examine cause-effect linkages.

10.2.2.3 By-catch of harbour porpoises

Harbour porpoise by-catch is not easy to measure accurately, as it requires the deployment of independent observers on reasonable proportions of the fleets causing the by-catch. In general, recommended methods are being used in the two existing schemes (UK and Denmark) that are examining harbour porpoise by-

Table 10.2.1. Detailed comments on individual EcoQOs from the Bergen Declaration (see also Table 10.2.1.1).

EcoQ and problem	**Solution**
Spawning stock biomass of commercial fish species Precautionary fishing mortality rates are implicitly included in this objective according to the central clause of the footnote in the Bergen Declaration ("…spawning stock biomass, also taking into account fishing mortality, used in advice….”).	Specifying that the management goal would be to keep fishing mortality rates below precautionary reference levels would be consistent with the intent of the EcoQ.
Seal population trends in the North Sea a) The background document does not specify whether the objective applies to the total North Sea stocks of grey seals and common seals, respectively, or to largely reproductively isolated sub-populations. b) It is by no means clear how the objective must be interpreted: a decline > 10 % within a single year would obviously not meet the objective, even when it is followed by an increase. Moreover, the objective would allow for, e.g., a 40 % decrease over a 50-year period, if only the condition is met that the decline is so gradual that it does not exceed 10 % within 10 years.	a) Probably best to use reproductively isolated sub-populations where these can be identified. b) Since this EcoQO was suggested as a trigger for further research, precision is probably not essential.
By-catch of harbour porpoises a) There is a potential statistical problem, because the objective does not state the probability for any estimate being below 1.7 %. b) The North Sea harbour porpoise population may have some sub-divisions. The current EcoQO for the North Sea assumes a unit stock.	a) This needs to be resolved at the political level. b) Research is presently under way to address this issue. It would be safer to assume some sub-division of the North Sea, as has been done by ASCOBANS; fisheries management areas may be suitable. Adjustments would be required in the light of emerging research results.
Proportion of oiled common guillemots among those found dead or dying on beaches The background document clearly states that this objective does not refer to specific localities or events but to monitoring records integrated over areas and time. It is by no means clear which areas are distinguished or whether the temporal unit is season or year.	Beached bird surveys are currently undertaken at a monthly level in some North Sea countries and at an internationally agreed annual (February) count. It is probably best to divide the North Sea coast into 5–10 units and aim for assessment in autumn, winter, and spring (there are technical difficulties in summer).
Changes/kills in zoobenthos in relation to eutrophication This objective might put unrealistic demands on monitoring efforts.	Some kind of warning system might be developed to trigger extensive survey activities.
Imposex in dogwhelks Nucella lapillus This is an open-ended objective that might require sampling at every location where dogwhelks might occur.	A technical group is required to address sampling issues.

catches in the North Sea. Norwegian by-catches have never been monitored using reliable methods. In addition, monitoring of small-boat fisheries is problematic everywhere, and the results are less comprehensive than for the fisheries using larger boats. In all cases, greater monitoring effort is required if annual figures are to be used. This is also required for EU member states under the Habitats Directive. Recent and forthcoming proposals from the European Commission for further legislation in the area of by-catch monitoring will help this situation.

10.2.2.4 Changes/kills in zoobenthos in relation to eutrophication

Algal blooms of toxic and/or non-toxic species are not necessarily caused by eutrophication. Indeed, an increased frequency of occurrence of phytoplankton blooms has been documented over a long period of time. However, strong evidence that this increase in blooms is fully or largely of anthropogenic origin is missing. Nutrient enrichment is accepted as a potential cause, but there is no proven clear-cut direct causal relationship.

Table 10.2.1.1. Evaluation of EcoQ metrics. Metrics were graded against those features considered to be qualities of good EcoQOs (see Section 10.1.1). Fully shaded rectangles fully match the criterion, partially shaded rectangles do not fully match the criterion and further improvements (where considered possible) are discussed in the section indicated.

Ecological quality element	**a) Sensitive**	**b) Linked**	**c) Low error**	**d) Responsive**	**e) Measurable**	**f) Time series**
Spawning stock biomass of commercial fish species			10.2.2.1	10.2.2.1		
Seal population trends in the North Sea	10.2.2.2	10.2.2.2		10.2.2.2		
By-catch of harbour porpoises			10.2.2.3			
Proportion of oiled common guillemots						
Changes/kills in zoobenthos in relation to eutrophication		10.2.2.4	10.2.2.4	10.2.2.4		
Imposex in dogwhelks *Nucella lapillus*						
Phytoplankton chlorophyll *a*		10.2.2.5		10.2.2.5		10.2.2.5
Phytoplankton indicator species for eutrophication	10.2.2.5	10.2.2.5		10.2.2.5		10.2.2.5
Winter nutrient concentrations		10.2.2.5		10.2.2.5		10.2.2.5
Oxygen		10.2.2.5		10.2.2.5		10.2.2.5

Notes:
a) Sensitive to a manageable human activity.
b) Relatively tightly linked in time to that activity.
c) Easily and accurately measured, with a low error rate.
d) Responsive primarily to a human activity, with low responsiveness to other causes of change.
e) Measurable over a large proportion of the area to which the EcoQ metric is to apply.
f) Based on an existing body or time series of data to allow a realistic setting of objectives.

The effects, if any, will also be dependent on other factors, such as local or regional hydrographic conditions.

Local oxygen deficiencies and associated kills of zoobenthos may occur as a result of natural processes, especially in shallow and semi-enclosed water bodies. In this respect, the scale of occurrence of oxygen deficiencies is of importance, both temporally and spatially.

As this EcoQO is meant to be operational, the main problem is that these oxygen deficiencies and benthos kills are not uniquely related to anthropogenic influence. There may be natural causes as well, which do not necessarily require managerial actions to be taken.

A final disadvantage of this EcoQ is that it very much resembles a "post-mortem" statement, so it would only be a useful guide to management action for badly degraded habitats. In such cases, management's goal would be to reduce the frequency of such oxygen deficiencies or benthos kills, and the EcoQO might be informative about progress. However, for sites in reasonably good condition, by the time the observation of oxygen deficiency or a zoobenthos kill is being made, serious degradation would already have occurred. In the latter case, useful EcoQOs should be more sensitive at the beginning of the cause-effect chain involved.

10.2.2.5 Eutrophication issues

Eutrophication issues are treated twice within this section, because the necessary review is in response to two different requests for advice. Even with the attention from two different perspectives, ICES notes that some important issues remain to be addressed. In particular, Annex 3 of the Bergen Declaration states that the EcoQOs for eutrophication (elements (m), (q), (r), (t), and (u)) "are an integrated set, and cannot be considered in isolation." One of the greatest values of an EcoQO framework is that the status of the ecosystem relative to each EcoQO can be used as a rule-based guide to management action, or a measure of the effectiveness of past action. When several EcoQ elements can only be considered as an integrated set, there will have to be a second set of rules for how the status of the ecosystem on each EcoQ element is combined into that integrated set, to provide a single clear message on necessary management action. These rules may prove challenging to develop.

Some preliminary tabular material was made available on historical/background levels of chlorophyll *a*, the frequency of occurrence of elevated levels, and the presence and abundance of indicator species. However, the information is spatially scattered, from inconsistent historical time periods, and likely to be of variable quality. The tabular material is not yet adequate for setting reference points on EcoQOs. The scientists who prepared the tabular material also acknowledged this point.

ICES needs to:

- aid OSPAR Contracting Parties to assemble information for the assessment scheme;
- develop or contribute to the development of standardized reporting forms;
- develop and participate in implementing a coordinated monitoring programme, including standards and protocols for local adaptation where they are needed;
- participate in quality control review of reported information;
- participate in analyses, interpretation, application, and reporting of submitted information;
- classify water masses and areas into appropriate monitoring and reporting units, including identification of explicit classification criteria (e.g., coastal salinity gradient, degree of stratification), so reporting units remain meaningful and interpretable;
- develop consistent standards for the selection of indicator species for phytoplankton and benthos kills, and either apply those standards or review their application by others.

Even a review of the preliminary information provided by the OSPAR Eutrophication Committee, in the context of the provisions of the Bergen Declaration and its Annexes, reveals some potential problems that require discussion and, in some cases, action. In particular, the "Agreed Harmonized Assessment Criteria" require further clarification, and may not be relevant to all sites or all times. Inadequate provision is made for transboundary nutrient transport, which could dominate greatly over local anthropogenic inputs for some nutrients, particularly inorganic nutrients. This could be particularly problematic for seasonally varying nutrients, where both the definition of "winter concentration" and the methods for partitioning local nutrient dynamics (maximum accumulation less minimum primary productivity) do not account for potential transboundary transport effects.

The "assessment criteria" appear likely to be difficult to put into practice on local scales, certainly in a consistent manner and possibly at all. No consistent rationale appears to have been developed for setting the boundaries of "background concentrations" and "elevated concentrations", and the values as currently tabulated may not form a basis for consistent action. Linkages between monitoring results and policy actions are not apparent nor tightly connected, particularly where naturally occurring (and naturally variable) nutrients have locally varying value as diagnostics of eutrophication. Much more attention needs to be given to the spatial and temporal aspects of trend assessment (including if, when, and how to aggregate monitoring results from different sites), and to the statistical complexities of reliable, robust trend detection.

10.2.3 Development of the scientific role of ICES in relation to the pilot project on EcoQOs

ICES has expertise on the matters addressed by the selected EcoQ metrics. Broadly, once an EcoQ metric has been decided, science can help in defining the current level of that metric, reconstructing the historical trajectory of that metric, and in establishing and conducting a scientifically robust monitoring programme. Monitoring information, or other research information, might be used to determine what management actions could be taken to help meet the EcoQO, particularly when placed in the context of historical values of the metric. Some illustrations of the possible future role of ICES follow below (Sections 10.2.3.1–10.2.3.10).

ICES has a number of Working and Study Groups with expertise in the scientific disciplines relevant to the EcoQOs. Input will be needed from these groups, but at present this cannot be guaranteed as, for example, many of the experts in the Working Group on Marine Mammal Population Dynamics and Habitats (WGMMPH) and the Working Group on Seabird Ecology (WGSE) (see Sections 10.2.3.2–10.2.3.4) are generally not from institutes presently supported by governmental funds for participation in ICES. ICES and its North Sea Member Countries might need to address this issue if it wishes to attract EcoQO-related work in future.

10.2.3.1 Spawning stock biomass of commercial fish species

ICES is currently the source of scientific advice on the current and historical Spawning Stock Biomasses (SSB) for commercially exploited species in the North Sea. Although there have been some criticisms, ICES advice has been a reliable basis for management decision-making. ICES has also introduced a number of quality assurance steps to its methods for estimating stock status, including SSB, and sources of error and bias, when they occur, are generally understood. ICES has also considered the value of B_{lim} and B_{pa} as EcoQO reference levels, and recommended that B_{pa} may be an appropriate EcoQO for commercial fish species (ICES, 2001a), when viewed from a conservation perspective. However, ICES continues to encourage the development of management targets which reflect society's choices about the desired states of ecosystems. These targets would be much better EcoQOs, by focusing management actions on achieving positive goals for society, rather than on simply avoiding the negative situation of unacceptable risk of impaired recruitment. As long as the ICES intent that management decision-making keep stocks above B_{pa} with high probability is achieved, such an approach is consistent with the intent of using EcoQs and EcoQOs to maintain healthy marine ecosystems.

10.2.3.2 Seal population trends in the North Sea

WGMMPH and its predecessors have periodically assessed seal populations of the North Sea and are the only existing international group in a position to do this. Therefore, it is recommended that ICES be tasked to lead the scientific implementation of this EcoQO, collating, evaluating, and integrating the census efforts of the various countries around the North Sea. The majority of grey seals in the North Sea haul out on UK coasts and are monitored by an annual programme, using standardized methods, conducted by the Sea Mammal Research Unit. Harbour seals occur in approximately equal numbers on continental coasts and UK coasts. They are not monitored annually on UK coasts, but are monitored elsewhere. Methods are standardized. Less is known about the causes of changes in seal populations, but some projects suggested and fostered by WGMMPH will help in determining the effects of contaminants on seal populations. WGMMPH could also suggest and foster projects to examine other factors that might contribute to changes in seal populations. All monitoring must obviously reflect the defined stock structure. As specific tasks, ICES could publish: a) a standardized seal censusing manual, and b) an annual report on the state of North Sea seal populations.

10.2.3.3 By-catch of harbour porpoises

WGMMPH and its predecessors have reviewed small cetacean by-catch on three occasions, most recently in 2002 (ICES, 2002b). Again, it is recommended that ICES be tasked to lead the scientific implementation of this EcoQO, collating, evaluating, and integrating the census efforts of the various countries around the North Sea. In 1998, WGMMPH also reviewed methods for monitoring such by-catch, and recommended protocols for producing reliable results. Failure of countries to allocate greater effort to monitoring harbour porpoise by-catch will mean that the status of, and progress with, this EcoQO will be impossible to evaluate reliably.

The metric also requires assessment of by-catch against an overall population figure; the figure currently in use derives from surveys in 1994, so there is a need to update this in the near future. Plans to repeat the survey in 2003 or 2004 are being made at present. Methods are reasonably standardized by the International Whaling Commission (IWC) Scientific Committee, and ICES recommends that the protocols recommended by the IWC Scientific Committee be followed.

10.2.3.4 Proportion of oiled common guillemots among those found dead or dying on beaches

Standards for conducting beached birds surveys have been established by OSPAR (OSPAR, 1995), and ICES endorses those protocols. Currently only one international survey occurs each year (in February), with surveys at other times being more systematic in some countries than in others. Monitoring is already included in the Trilateral Monitoring and Assessment Programme (TMAP) in the Wadden Sea. Nevertheless, surveys around the North Sea could be more frequent and better coordinated, perhaps on a monthly basis. It would be appropriate for WGSE to review the sampling structure needed to ensure that reliable basin-wide information is available for the North Sea. WGSE could also collate results, establish trends, and report on status relative to historical rates of oiling.

10.2.3.5 Imposex in dogwhelks *Nucella lapillus*

This EcoQO will provide a basis for the assessment of the recovery of the marine ecosystem following implementation of the IMO restrictions on tributyltin (TBT) in antifouling paint from 2003 and the outright ban from 2008. Further examination of the scientific basis and monitoring requirements for this EcoQO would be useful.

10.2.3.6 Eutrophication issues

Based on the report of the OSPAR Eutrophication Committee, a series of EcoQ elements, EcoQOs, and metrics have been agreed to facilitate monitoring and reporting on progress towards the goals of nutrient reduction (Table 10.1.1). Ecological Qualities are identified for benthic communities, plankton communities, nutrient budgets and production, and oxygen consumption. The corresponding EcoQOs are listed in Table 10.1.2.

10.2.3.7 Phytoplankton chlorophyll *a*

Chlorophyll *a* is the best proxy currently available for the amount of phytoplankton in water. At the same time, the chlorophyll *a* concentration shows considerable variation due to the species composition and the growth conditions of the phytoplankton. Therefore, absolute values of chlorophyll *a* should be interpreted with caution. Moreover, the local hydrographic conditions will cause rapid dilution of phytoplankton as well as concentrating mechanisms that cause local blooms that are not caused by eutrophication. Due to the local hydrographic conditions, for instance, in the Wadden Sea natural "enrichment" mechanisms occur which cause strong gradients in nutrient concentrations from offshore to the coast. These gradients are caused by the subsequent remineralization of the imported organic matter from offshore. These nutrients are available for the potential growth of phytoplankton, which might be independent of eutrophication but should in such cases be regarded as a natural phenomenon. It is recommended that local levels for phytoplankton be set as metrics, with no general values for large areas. Also, a critical evaluation of historical/background values should be made to see which part of the observed variability is natural. The choice of a 50 % criterion for elevated levels is probably set for reasons of pragmatism and not based on scientific (risk) evaluation.

10.2.3.8 Phytoplankton indicator species for eutrophication

The species suggested as suitable indicators are all normally occurring phytoplankton species in the North Sea. There is no information available to show that these species do not occur under non-eutrophic conditions. There are, however, indications that *Phaeocystis* and *Noctiluca* might be stimulated disproportionately by eutrophication. The (potentially) toxic species can by no way be directly linked to eutrophication because they occur mainly in relatively low numbers and are only occasionally toxic. Therefore, to use them as indicators for eutrophication needs careful consideration. ACE is unsure whether the recommended levels are appropriate, and recommends that these be further researched.

10.2.3.9 Winter nutrient concentrations (dissolved inorganic nitrogen (DIN) and dissolved inorganic phosphate (DIP))

Within OSPAR, strategies have been developed to use the DIN and DIP winter concentrations for long-term trend analysis of nutrient inputs into specific sea areas. Part of this analysis encompasses a standardization procedure where the nutrient concentrations are linked to a specific salinity level (e.g., 20 in estuarine areas or 32 in coastal areas). This procedure has helped to indicate whether political measures to reduce nutrient inputs have had an effect in the coastal areas. To decide whether coastal regions have elevated nutrient concentrations, it would be important to clarify the status of the historical (background) concentrations and apply their derivation in a standard way. Depending on the local hydrodynamics, an assessment as to whether actual winter values are elevated can be attempted, when additional information on transboundary transport and advective transport mechanisms is available and taken into account. Transport models can be helpful in analysing local situations. If several rivers flow into a stretch of coastal water, false interpretations can easily occur if transboundary transport is not taken into account. To use a level of > 50 % for elevation is pragmatic, but difficult to derive logically.

10.2.3.10 Oxygen

Oxygen concentration can be used as a sensitive metric for the production and mineralization processes in a water body. The link to eutrophication is, however, often unclear except in some exceptional cases of sedimented blooms. Even lowered oxygen values in the Wadden Sea are primarily an indication for the natural mineralization properties of this sea area. The advantage of oxygen concentration is that it is easy to measure over relatively large areas from research vessels. The interpretation of lowered values is, however, more complicated.

10.3 Medium-term development of further EcoQOs

EcoQOs have not been proposed for several EcoQ elements chosen in the Bergen Declaration (Table 10.1.1). For such elements, in cases where there is presently adequate knowledge for setting EcoQOs, the following sub-sections provide guidance to the relevant scientific information, much of which has already been provided by ICES. In those cases, the impediment for progressing to an EcoQO seems to be decisions by managers and policy-makers not to set reference levels for the ecosystem metrics. Where appropriate, this section offers suggestions for how science can inform the discussions about the policy decision more fully.

For several elements where the current scientific knowledge is either inadequate, or possibly adequate but not properly consolidated, the sub-sections lay out as specifically as possible the steps that must be pursued to gain or consolidate the necessary scientific basis for setting EcoQOs. In some cases, those science programmes will be demanding, but they are necessary before it will be appropriate to complete the identification of specific EcoQOs.

10.3.1 Threatened and declining species

The current EcoQ element in Table 10.1.1 on this topic is: (b) presence and extent of threatened and declining species in the North Sea.

10.3.1.1 Convergence of threatened and declining species listing and EcoQO development

The general formulation of this EcoQ element implies that considerable work needs to be done to develop operational EcoQOs for this issue. The starting point for this work is the listing of threatened and declining species on the basis of the Texel/Faial criteria by the OSPAR Biodiversity Committee (BDC) (OSPAR, 2000). BDC has scheduled discussion on the final version of these criteria in the autumn of 2002. The draft criteria and guidance on how to interpret these criteria are given in Tables 10.3.1.1.1 and 10.3.1.1.2. The next step to be taken within OSPAR will be to apply these criteria in order to select species and habitats that need to be protected. However, ahead of this, BDC has recommended a set of threatened and declining species that, based on their very depleted or highly threatened state, will be selected by whatever detailed version of the criteria are eventually agreed (see also Section 6 of this report).

Several difficulties are likely to arise when applying these criteria. Elsewhere, there has been substantial debate about the appropriate criteria for evaluating marine species, particularly species exploited comercially, with regard to risk of extinction (or regional extirpations). The quantitative criteria for listing species at various categories of risk, developed by the Species Specialist Committee of the International Union for Conservation of Nature (Hudson and Mace, 1996), have been adopted, with minor variants, by the IUCN, CITES, and several countries. Reviews by fisheries experts have concluded that the criteria pose problems when applied to marine species (FAO, 1999; Powles *et al*., 2000). The criteria for absolute population numbers and absolute range may be too liberal. Marine species that are at some risk of disappearance may not meet the empirical standards, or may be impossible to sample with sufficient accuracy to evaluate on the criteria. In contrast, the decline criterion (50 % decrease in abundance in the longer of ten years or three generations) is widely considered to be too conservative. Many marine species show such fluctuations without risk of extinction or extirpation (FAO, 1999). Although the text of the IUCN rules note that “natural fluctuations” should not be grounds for listing, the burden of proof requires that there be clear evidence that the fluctuation is natural, which is rarely possible with a species exploited or taken commonly as by-catch. A special IUCN Working Group (IUCN, 1999, 2001), a team of U.S. scientists (Musick, 1998, 1999), FAO (FAO, 1999), and Hutchings (2001) all reviewed these arguments, and came to different conclusions in each case. However, all the reviews agreed on the need for clear quantitative guidelines (not rigid rules), to make the listing process as objective and consistent as possible. The qualitative approach of the BDC avoids some of the debates about the correct overall values for maximum tolerable decline, minimum population size, etc. However, it does not replace them with other objective, empirical guidelines that will make consistent application across species easier in practice. ACE expects that similar debates will occur when the Texel/Faial criteria are applied on a case-by-case basis, and differences among species must be accommodated by qualitative and, at best, semi-quantitative guidelines.

There are some inherent difficulties in using threatened and declining species as EcoQOs, regardless of which species and habitats are eventually selected by the OSPAR process. ACE considers next what properties a species listed as a threatened and declining species should have, in order to develop robust and effective EcoQOs. Where EcoQOs are set for threatened and declining species that perform poorly in the evaluation outlined below, ACE expects that difficulties may occur in implementation, monitoring, and/or evaluation of progress on the EcoQO.

In at least some cases, the areas of failure, such as ability to measure and responsiveness to human activities, may be important considerations in setting operational EcoQOs. ACE proposes a series of steps to be followed to determine which species on the OSPAR list would be suitable for robust and effective EcoQOs, applying a subset of our criteria particularly relevant to the feasibility of the pilot project. ACE stresses that this treatment should not be taken as implying that threatened and declining species that are not best suited for EcoQOs do not need conservation action. Rather, the protection and restoration of threatened and declining species that are not suitable for setting effective EcoQOs would be better achieved in other ways.

Table 10.3.1.1.1. Draft Texel/Faial criteria: selection criteria for species to be listed as threatened or declining.

1	**Global importance:** Global importance of the OSPAR Area for a species. Importance on a global scale, of the OSPAR Area, for the species is when a high proportion of a species at any time of the life cycle occurs in the OSPAR Area.
2	**Local importance**: Importance within the OSPAR Area, of the regions for the species where a high proportion of the total population of a species within the OSPAR Area for any part of its life cycle is restricted to a small number of locations in the OSPAR Area.
3	**Rarity**: A species is rare if the total population size is small. In case of a species that is sessile or of restricted mobility at any time of its life cycle, a species is rare if it occurs in a limited number of locations in the OSPAR Area, and in relatively low numbers. In case of a highly mobile species, the total population size will determine rarity.
4	**Sensitivity**: A “very sensitive” species is one if very easily adversely affected by a human activity, and/or if affected is expected to only recover over a very long period, or not at all. A “sensitive” species is one if easily adversely affected by a human activity, and/or if affected is expected to recover in a long period.
5	**Keystone species**: A species which has a controlling influence on a community.
6	**Decline**: Means an observed or indicated significant decline in numbers, extent or quality (quality refers to life history parameters). The decline may be historic, recent or current. “Significant” need not be in a statistical sense.

Table 10.3.1.1.2. Guidance on the selection criteria for species.

Criterion	Guidance
1	"High proportion" is considered to be more than 75 %, when known.
2	"High proportion" is considered to be 90 % of the population in a small number of locations of 50 km × 50 km grid squares. This is dependent on scientific judgement regarding natural abundance, range or extent and adequacy of recording. A different scale may be needed for different taxa.
3	"A limited number of locations" could be in a small number of 50 km × 50 km grid squares, but a different scale may be needed for different taxa. This is dependent on scientific judgement regarding natural abundance, range or extent and adequacy of recording. Species which are present in high abundance outside of the OSPAR Area and only occur at the edges of the OSPAR Area will not generally qualify as "rare" species.
4	A "very long period" may be considered to be more than 25 years and "long period" in the range of 5 to 25 years. The time frame should be on an appropriate scale for that species. Sensitivity to human activities is measured by: a) life history characteristics; b) dependence on other specific ecological attributes, e.g., restricted/specific habitats requirements.
5	No guidance
6	"Decline" is divided into the following categories: 1) Extirpated (extinct within the OSPAR Area): a population of a species formerly occurring in the maritime area is defined as extirpated: a) if it was still occurring in the area at any time during the last 100 years; b) and if there is a high probability, or it has been proved, that the last individuals have since died or moved away; c) or if surveys in the area have repeatedly failed to record a living individual in its former range and/or known or expected habitats at appropriate times (taking into account diurnal, seasonal, annual patterns of behaviour) for at least 10 years. 2) Severely declined: a population of species occurring in the maritime area is defined as severely declined: a) if individual numbers show an extremely high and rapid decline in the area over an appropriate time frame, or the species has already disappeared from the major part of its former range in the area; b) or if individual numbers are at a severely low level due to a long continuous and distinct general decline in the past. 3) Significantly declined: means a considerable decline in number, extent or quality beyond the natural variability and in an appropriate time frame for that species. 4) High probability of a significant decline in number, extent or quality in the future.

Step 1 – Establish whether the species occurs in the Greater North Sea (OSPAR Region II).

This is the area covered by the Bergen Declaration. Species which are vagrants or which do not occur in the Greater North Sea should not be selected for setting EcoQOs, at least under the provisions of the Bergen Declaration.

Step 2 – Establish whether the status of the species can be quantified accurately.

This step applies to the criterion that effective EcoQOs can be easily and accurately measured, with a low error rate. If the status of the species cannot be quantified accurately or precisely, it is not appropriate to set a quantitative EcoQO for that species, and it would be very difficult to monitor status relative to the EcoQO.

Note: ACE expects some of the rarest species, of potentially greatest concern, to have abundances that cannot be measured accurately, just because they will be rarely encountered in surveys. Priority should be given to developing properties of these species that can be monitored reliably, so information is available regularly on the success of efforts to conserve and recover these species at possibly greatest risk.

Step 3 – Establish why the species is threatened or declining.

This step applies the criteria of sensitive to a manageable human activity, and responsive primarily to a human activity, with low responsiveness to other causes of change. If the main causes of the decline can be established, and factors under management control play a strong enough role in the decline that it is realistic to expect population responses to management actions, then it is possible to proceed further. If the main causes are not related to manageable human activities, the species is not suitable for setting EcoQOs. Note that if the causes of a species being listed as threatened or declining are not primarily human activities, it may still be necessary for conservation measures to be implemented. Some of these might affect human activities, even if they are not the major threats. If the causes of a decline are unclear, more scientific study would be needed urgently. It would be inappropriate, though, to set EcoQOs for such species before the studies have clarified the contribution of human activities to the declines.

Step 4 – Establish whether trends in population status can be detected reliably on time frames relevant to management (perhaps over five years).

This step applies the criteria that an EcoQO should be tightly linked in time to the human activity affecting the trend, and to management actions to modify the activity. The criterion that an EcoQO should be easily and accurately measured is also relevant to this step. It should be possible to detect trends in population status reliably on time frames relevant to management (perhaps over five years). Regular monitoring and evaluation would provide feedback on the effectiveness of the management measures at improving the "environmental health" of the sea. If the outcome is positive, then it is possible to proceed with setting robust EcoQOs for the species. These would probably be associated with the abundance, range, or other property that would be taken as a secure status for the species. The values, and the process leading to selecting them, would be species specific. However, simulation modelling should be an important tool in setting such EcoQOs (Burgman *et al.*, 1992), unless there is a long time series of reliable data on population status (another of our criteria), including a time when the population was considered secure. Then regular monitoring and evaluation would provide feedback on progress towards the EcoQO, and simultaneously on the effectiveness of the management measures at improving "environmental health" of the sea.

If it is not possible to detect trends in the indicator(s) of population status over reasonable time frames, then it is not possible to evaluate status relative to an EcoQO, or the effectiveness of management. In such cases, the species is not well suited for use in the EcoQO process. Again, protection and restoration measures might still be important, but they would have to be implemented with the knowledge that feedback on their effectiveness would be available only on very long time scales.

Gubbay (2001) suggested nine classes of factors that make a species especially sensitive to decline. These include, for instance:

- species that are very large, long-lived, and/or have low fecundity;
- species that are or have been subject to over-exploitation;
- species that are subject to large-scale mass mortality.

In order to make a particularly informative set of EcoQOs for threatened and declining species, if enough species were evaluated positively on our four-step process, pilot EcoQOs could be chosen such that a broad range of these classes was covered. It is possible, though, that most or all threatened and declining species that are large, long-lived, and have low fecundity will be so rare that they score poorly at step 2, whereas many species subject to mass mortalities might score poorly on step 3 or step 4.

Clearly, many species listed according to the Texel/Faial criteria will score poorly on at least some of Steps 1–4 of the process outlined above. ACE stresses that this does not mean that these species do not need programmes of conservation and recovery. Some species may require them more urgently than listed species that do pass all four steps. The message is simply that the conservation and recovery plans ought to be developed and implemented outside the EcoQO process.

10.3.2 Marine mammals and seabirds

Table 10.3.2.1 evaluates the EcoQ metrics scheduled for development by 2006 against the qualities listed in Section 10.1.1. Suggestions for improvements are then noted in the relevant subsequent sections.

10.3.2.1 Utilization of seal breeding sites in the North Sea

As discussed in ICES (2001a), this metric would be very easily understood by the non-scientist and in most areas supported by the wider public. The factors underlying seal breeding site distribution are not researched, but are certainly partially responsive to human disturbance (the largest rookeries are in undisturbed, remote areas). The linkages between distribution and other factors are less well known. Without such knowledge, certainty in management actions will be low. Research to explore the underlying factors could be encouraged.

As with breeding numbers, WGMMPH is the only existing international group in a position to compile distributional data. Therefore, it is recommended that ICES be tasked to lead the scientific implementation of

Table 10.3.2.1. Evaluation of EcoQ metrics scheduled for development by 2006. Metrics were graded against those features considered to be qualities of good EcoQOs (see Section 10.1.1). Fully shaded rectangles fully match the criterion, partially shaded rectangles do not fully match the criterion and further improvements (where considered possible) are discussed in the section indicated.

Ecological quality element	**a) Under-standable**	**b) Sensitive**	**c) Linked**	**d) Low error**	**e) Responsive**	**f) Measurable**	**g) Time series**	**h) Wider environ-ment**
Utilization of seal breeding sites in the North Sea		10.3.2.1	10.3.2.1		10.3.2.1			10.3.2.1
Mercury concentrations in seabird eggs and feathers			10.3.2.2		10.3.2.2			
Organochlorine concentrations in seabird eggs								
Plastic particles in stomachs of seabirds			10.3.2.4	10.3.2.4			10.3.2.4	
Local sandeel availability to black-legged kittiwakes[1]		10.3.2.5	10.3.2.5		10.3.2.5			
Seabird population trends as an index of seabird community health		10.3.2.6	10.3.2.6	10.3.2.6	10.3.2.6			10.3.2.6

[1]The metric proposed was of black-legged kittiwake breeding success as an indicator of local sandeel availability to black-legged kittiwakes; this metric is evaluated in this table.

Notes:

a) Relatively easy to understand by non-scientists and those who will decide on their use.

b) Sensitive to a manageable human activity.

c) Relatively tightly linked in time to that activity.

d) Easily and accurately measured, with a low error rate.

e) Responsive primarily to a human activity, with low responsiveness to other causes of change.

f) Measurable over a large proportion of the area to which the EcoQ metric is to apply.

g) Based on an existing body or time series of data to allow a realistic setting of objectives

h) Related to wider environmental condition.

this EcoQO and integrate the work with the collation of breeding numbers around the North Sea. As specific tasks, ICES could publish: a) a standardized seal censusing manual, and b) an annual report on the state of North Sea seal populations.

10.3.2.2 Mercury concentrations in seabird eggs and feathers

Mercury input to the marine ecosystem is predominantly anthropogenic and there is a very good historical time series based on skins in museums. The persistence of mercury in marine food webs means that there would be a lag between taking action to reduce anthropogenic inputs and the response in seabird eggs and feathers. Allowance would also need to be made for species and local variations in concentrations (ICES, 2001a). Research to understand this variation may improve the performance of this EcoQO.

ICES, with its track record on advice on seabirds and on contaminant issues including mercury in other biota and sediments, would be well-placed to coordinate a North Sea monitoring programme, publish monitoring standards, and produce reports on mercury concentrations in eggs and feathers. There would be little point in producing such reports annually, but a two- or five-year review cycle might be appropriate.

10.3.2.3 Organochlorine concentrations in seabird eggs

Current monitoring programmes in the Wadden Sea have tested and standardized procedures under the aegis of the Trilateral Monitoring and Assessment Programme (TMAP). This programme could be relatively easily expanded to cover other coasts of the North Sea. The remaining shortcoming of this EcoQO is due to the long persistence of many organochlorine compounds—it will take many years before they disappear from the marine environment, even if all discharges stopped immediately.

As with mercury, ICES, with its track record on advice on seabirds and on contaminant issues including on organochlorines in other biota and sediments, would be well-placed to coordinate a North Sea monitoring programme, publish monitoring standards, and produce reports on organochlorine concentrations in seabird eggs. There would be little point in producing such reports annually, but a two- or five-year review cycle might be appropriate.

10.3.2.4 Plastic particles in stomachs of seabirds

Since the ICES recommendations were published in 2001 (ICES, 2001a), van Franeker and Meijboom (2002) have conducted a pilot project on the Netherlands coasts on plastics in the stomachs of northern fulmars. They concluded that it is feasible for the Netherlands to start an annual monitoring programme of marine litter using stomach contents of beach-washed northern fulmars. They commended such monitoring as it provides sound information on marine litter abundance in the southern North Sea and would be relatively inexpensive when conducted alongside the current Dutch beached bird survey. The annual sample size for such a programme is 40 northern fulmars from Dutch beaches.

Thus, some of the shortcomings (for instance, knowledge on variance between samples) identified by ICES (2001a) have been addressed. Coordination in the North Sea would run alongside whatever programme is established to monitor beached birds. ICES could compile and publish results through the Working Group on Seabird Ecology (WGSE).

10.3.2.5 Local sandeel availability to black-legged kittiwakes (black-legged kittiwake breeding success)

Black-legged kittiwake breeding success is sensitive to changes in food supply within their feeding area, but the food supply (sandeel almost exclusively in some areas) is only partially responsive to fishing by humans. It is thus not tightly linked to a human activity or necessarily particularly responsive to fisheries management. These weaknesses in the EcoQO are unlikely to be improved much by further research.

Monitoring of black-legged kittiwake breeding performance is already undertaken at a good sample of UK colonies in the North Sea using standardized methods (Walsh *et al.*, 1995). Advice has already been provided by ICES on appropriate levels of black-legged kittiwake breeding performance (ICES, 2000). The species also nests at Helgoland, on a Dutch gas platform, and at sites in southern Norway. It would be very easy to add these localities to the existing scheme and report on them in the current annual UK/Ireland seabird monitoring report. Advice on black-legged kittiwake breeding success might be included within advice on sandeel stocks supplied to fisheries managers.

10.3.2.6 Seabird population trends as an index of seabird community health

This "EcoQ" is in fact a multiple one, as EcoQOs could be established for each seabird species monitored reliably in the North Sea. The relationship between breeding numbers and human activities is not well known. However, when ICES advised on this potential EcoQ in 2001, it considered that it would be suitable to act as a trigger for further research to determine whether manageable human activities are the cause of any actual decline. In the meantime, research on aspects of the interaction between humans and seabirds will continue.

Such monitoring of breeding numbers is conducted for selected sites on UK coasts using standard methods (Walsh *et al.*, 1995); for some species, this monitoring is of the majority of the UK North Sea population. Monitoring is also conducted on other North Sea coasts.

These monitoring programme results are published separately and could usefully be brought together, perhaps through WGSE.

10.3.3 Fish communities

The current EcoQ element in Table 10.1.1 is: (a) changes in the proportion of large fish and hence the average weight and average maximum length of the fish community.

This ecological quality element consists of two metrics:

1) average weight of a fish in the community;
2) average maximum length of a fish in the community.

Although both metrics are considered to be indicators of the proportion of large fish in the community, it should be realized that they represent different aspects of the community and are complementary in that respect. The average weight of a fish in the community represents changes in the size structure of the community, whereas the average maximum length represents changes in the species composition (Piet, 2001).

ICES (2001e) evaluated both metrics relative to the criteria that were deemed desirable (see Section 10.1.1). In this evaluation, the same two criteria were considered to be not fully addressed by either of the metrics: 1) high response to signal from human activity compared with variation induced by other factors; and 2) tight linkage in time to that activity.

In addressing the concerns relating to the first criterion, two parts can be distinguished:

a) the degree to which the metric is representative of the changes occurring in the community (i.e., the proportion of large fish);
b) the relationship between human activity and that aspect of the community.

Several metrics have been proposed that are able to detect changes in the size structure. Most of these metrics failed on the other criteria and did not show a better signal-to-noise ratio (ICES, 2001e; Piet, 2001). Therefore, mean weight was found to perform best. The robustness and unambiguousness of this indicator is underlined by the fact that several surveys that are conducted throughout the North Sea over different periods of time show the same signal (ICES, 2002a). Thus, the mean weight can be considered the best metric to show changes in the size structure of the fish community. Further work on this metric (ICES, 2002a) showed that the signal-to-noise ratio might be further improved by selecting only those species that are adequately sampled by the gear (i.e., the demersal assemblage). It should be realized that the selection of a subset of the community or the choice of survey (and therefore gear) have implications for the setting of the reference, current, and target levels as the metric only reflects the fish community as represented by the sampling technique and/or species selection. However, the consistency among surveys and other evidence gives confidence that the metric is a true reflection of the status of the fish community.

Another aspect of the fish community is the species composition. As large and long-lived species suffer a higher mortality, the proportion of these species can be expected to decrease in an exploited community, thereby changing the species composition. By weighting a species-specific life history characteristic with the proportion of that species in the community, the change in species composition dependent on life history characteristics can be quantified. For this, several life history characteristics exist that, to a greater or lesser degree, are related. Mean maximum length expresses only the change in species composition. A good reason for choosing this metric was that this life history characteristic was available for most species and that it appeared to be relatively sensitive.

Although this does not apply for each of these metrics separately, the combination of a metric that reflects changes in size structure (mean weight) and one that reflects changes in species composition (mean maximum length) does permit discrimination between a treatment that allows individuals of exploited species to grow larger and one that changes the species composition towards a higher proportion of large and long-lived species.

In exploited fish assemblages, larger fish generally suffer higher fishing mortality than smaller individuals and the size distribution becomes skewed towards the smaller end of the spectrum (Pope and Knights, 1982; Pope *et al.*, 1988; Murawski and Idoine, 1992). There is, however, no researched relationship between fishing effort and aspects of the community that need to be preserved. This would allow an answer on questions such as what level of effort a specific community can tolerate without compromising its main characteristics or, in case changes have occurred, what measures should be taken to restore the community to a desired state.

A first attempt to further explore the relationship between fishing effort and community characteristics was carried out by WGECO at its 2002 meeting (ICES, 2002a) for different parts of the North Sea. The synthesis of these results showed that there is no straightforward relationship and an evaluation of the results revealed two factors that hampered the analysis. These factors need to be addressed if there is to be further progress on this EcoQ metric:

a) Fishing effort data: Long-term effort data with a high spatial resolution of all international fleets that fish in the area need to be available. At present, the following shortcomings apply to the data:

- They are available for only a few of the most recent years;
- They do not always include all fleets from all nationalities;
- They are expressed in a measure (i.e., days-at-sea or hours fished) that is not representative of true fishing effort and does not allow to distinguish between the impact of different gears (i.e., otter trawl versus beam trawl);
- They are at a relatively coarse resolution (ICES rectangles) which may not be a problem when assessing the effects on a mobile fish community, but will certainly apply when assessing the impact on the benthic community.

A way forward would be to use the data that are collected by the satellite-based programme that monitors the activities of all larger fishing vessels working in EU waters for enforcement purposes. In this programme, all vessels larger than 24 m are monitored at an interval of about every 2 hours and at high (< 100 m) spatial resolution. These data are available at the national inspectorates and are confidential, but should become available for scientific purposes.

b) Evaluation of management measures: Opportunities to assess the effect of fishing on communities arise when measures are taken that (partly) close areas for fishing. In assessing the subsequent changes in the community and attributing this to the change in fishing activities, a number of difficulties arise due to:

- Natural variation: in order to be able to account for natural variation, comparable areas are necessary in which no changes in effort have occurred;
- Mobility of many marine organisms: because fish often cover relatively large distances, most (semi-) closed areas will not be large enough to be able to detect change.

Provided that they are part of a properly designed experiment with areas that can be used as a reference, the closing of areas for fishing may be helpful in providing insight into the management responses needed to modify current levels. It should be realized that closed areas will not result in the protection of the fish community unless these measures are applied together with effort reductions.

It is impossible to determine a reference level (i.e., where anthropogenic influence is minimal) since monitoring commenced long after pristine conditions were perturbed. Current levels, however, are adequately determined by several surveys and the length of the time series of many of these surveys already provides enough information to set a target level for these metrics. Considering the extent of the management measures that are probably necessary to reach these target levels, it is hardly realistic to aim for levels closer to the presumed reference level.

For all fish community metrics, there is a useful role for modelling, to make greater use of historical data in identifying appropriate reference levels, and in helping to partition the role of various natural and anthropogenic factors in causing changes in the metrics.

10.3.4 Benthic communities

The current EcoQ element states: (m) changes/kills in zoobenthos in relation to eutrophication: There should be no kills in benthic animal species as a result of oxygen deficiency and/or toxic phytoplankton species.

Two of the four ecological quality elements proposed do not form part of the pilot scheme. They are:

(o) density of sensitive (e.g., fragile) species;

(p) density of opportunistic species.

ACE considered these together, because apart from the criteria used for the selection of the species to be considered under each, the approaches are identical. At its 2001 meeting (ICES, 2001e), WGECO examined the suitability of a large number of possible metrics of benthic ecosystem status. The only possible EcoQO that could be made operational for the benthos was one based on the abundance of sensitive or indicator taxa. This was adopted in the Bergen Declaration.

It is now necessary to develop robust and objective criteria for selecting sensitive and indicator species; in turn, this requires both observational data and independent criteria. The former requires the assembly of the available data on the distribution and abundance of benthic taxa in the North Sea and for this to be related to the distribution of impacting activities. ICES (2001e) provides thoughts on how to proceed in developing such objective definitions. To avoid circularity, species should be tested against these criteria using carefully planned, *a priori* comparisons (ICES, 2001e). Moreover, it is important to bear in mind that EcoQOs should be related to specific human activities. If management responses are to be targeted on specific activities, then the criteria must relate to specific, not generic, threats.

It is also likely that a sensitive species will be related to a specific activity or context. A species (e.g., bivalve) could be sensitive to an activity such as dredging, but less sensitive to other activities (e.g., eutrophication, SCUBA diving). Using sensitive species to identify the impact of anthropogenic activities could be a problem if this activity has already decreased, or even has extirpated, the sensitive species from an area.

Within the EcoQO framework, a reference level must be specified. If the reference level is to be the undisturbed state, it will be necessary to characterize the benthos community before the damaging activity has occurred. Most of the time this is impossible, and alternative approaches are required (Glasby, 1997). These may require developing an experimental design (potentially impacted site versus natural sites), or using the available data in a meta-analysis. Both of these tasks require directed scientific efforts by skilled benthic ecologists, and are likely to require some original research, not simply the repackaging of existing information.

Once a reference point is identified, it will not be straightforward to monitor status relative to it. Issues of the statistical power of the monitoring data will be very important, and weak tests may be difficult to avoid. Spatial and temporal variations of sensitive or opportunistic species must also be estimated properly if population trends and responses to management actions are to be detected. Natural variation is high in benthos communities and could lead to a false interpretation of the change in the sensitive species. To distinguish a decrease in a sensitive species, comparisons should be made with at least two control areas, owing to natural variability. If the pattern is compared with only one control area, the result will be confounded between the activity and a site effect. A monitoring programme of benthos communities in many sites (many spatial scales) and few times per year over a number of years (temporal scale) for some species is one approach to addressing these concerns.

The temporal and spatial scales will also be important for EcoQOs using sensitive or opportunistic benthos species. What is the relevant scale to sample? How important is the spatial extent of the impact? The relevant scales of sampling to detect a particular impact cannot simply be implied by modelling or monitoring physical and chemical variables, as has been done in, and recommended by, many previous studies (e.g., Spellerberg, 1991). Sampling at several scales is important given that sampling at the wrong scale may result in failure to detect an impact and given that populations may respond to disturbances in different ways at different spatial scales (Bishop *et al.*, 2002).

10.3.5 Habitats

The current EcoQ element states: (s) restore and/or maintain habitat quality.

This is a very laudable expression of intent, but in this form it is far from being operational. A key constraint at present is the lack of an agreed framework of habitat classifications for European marine habitats. There is, therefore, still an urgent need to advance the mapping of marine habitats.

The treatment of "habitat quality" as a singular term implies that it is the quality of the habitat that is being viewed in some integrated sense. If "habitat quality" is being thought of in such a conceptually unitary way, the concept cannot be made operational. It is only possible to measure "habitat" on a site-by-site basis, and there is no scientific way to calibrate "quality" across different sites with different habitat features. If the intent was to keep the habitat at every individual site from being degraded, and restoring all sites that were degraded to a healthy condition, the concept still cannot be made operational. The status of all habitats is unknown and unknowable, and it is impossible to know how every habitat is changing. It is also impossible to interpret every change in habitat as either a "recovery" or a further degradation. This EcoQ element has to be restated into a form where realistic measurement programmes of habitat features and sites would be adequate to track status, change, and compliance with reference levels, once set.

This definition would seem to exclude any deterioration of any habitat anywhere, at any time, no matter what the societal benefit of such an action; this is naïve and flies in the face of the provisions of the Convention on Biological Diversity, which allow development provided that the societal and economic benefits outweigh the negative environmental effects.

When this is converted into an EcoQO, consideration needs to be given to incorporating some quantitative conservation limits (such as B_{lim} for commercial fish stocks), rather than the ABSOLUTE standard of no change from whatever the status of a habitat was at the commencement of monitoring. These would protect habitats effectively from loss or serious damage but still allow development and sustainable utilization of environmental goods and services.

What habitats are to be restored and to what state are they to be restored? The first consideration is again naïve and impossible. It presupposes knowledge of previous (pristine? or just "healthier") states of all habitats, as well as simply mandating an imperative that all altered habitats be returned to some condition that will be specified somehow. It also presupposes the capability to engineer habitats at will, and the existence of some rules for deciding which habitats need restoration and which ones do not. The second consideration ignores the realities of open, dynamic ecosystems like the marine environment, where active restoration programmes rarely succeed or make economic sense (Frid and Clark, 1999; Hawkins *et al.*, 1999). It also presupposes either that pristine states of all habitats are known or else some rules exist for deciding how close to pristine—or how far from current levels or perturbation—it is necessary for restoration to take a site.

Despite these shortcomings, there are scientific undertakings that could be done to provide a sounder knowledge base for moving towards making the EcoQ element operational. ACE does not recommend those undertakings for the sake of making this EcoQ element operational, although we may recommend some of them on various scales, for other reasons. Rather, ACE recommends a reworking of the EcoQ element itself, into something both more feasible in the field and more conceptually tractable.

There are several considerations that might help guide the reworking of the EcoQ element. Restoration ecology is a relatively new discipline and experience in marine systems lags behind that in the terrestrial environment. However, it would also appear that marine systems, at least open coastal systems, have a great capacity for self-repair once the impacting activity is removed. Some effort needs to be afforded in establishing criteria for assigning value (on several dimensions, including ecological role, human needs, ethics, and aesthetics, etc.) to habitats, and, using those criteria, establishing a priority list of habitats. For the priority habitats, it will be necessary to gather information on what a "healthy" condition is for the habitat type and the best way to achieve the "healthy system"—active intervention (restoration) or passive monitoring only.

How does one measure a multivariate quality such as "habitat quality"? Methods commonly used to quantify habitat status (Gauch, 1982; Jongman *et al.*, 1987) can produce axes where "quality" can be identified for one habitat type. However, the same axes are not applicable to all habitats. Either different metrics of quality will be required for each habitat, or methods will have to be discovered to calibrate the position of the "healthy" state consistently across numbers of habitat axes. Even if one can find a measure for this (a multivariate statistical parameter, for example), there is currently no justification to assume that the measure will be sensitive to, and vary in a predictable way in response to, specific human impacts, which might in turn be managed.

Considerable research effort will be required to establish appropriate metrics of habitat quality. These are likely to be applicable to a limited number of habitats each; therefore, a considerable number will be required to cover the habitat types found in the North Sea.

10.4 Summary

The commitment to proceed with a pilot project for a set of EcoQOs for the conservation and protection of the North Sea ecosystem is a significant step in the implementation of an Ecosystem Approach. However, a great deal of work is needed to deliver the promise of the commitment: work on short-term, medium-term, and long-term scales.

The short-term work is required to proceed with the EcoQOs specified in Table 10.1.1. Although not all the EcoQOs are ideal, according to the objective criteria for operational EcoQOs developed last year, they provide a reasonable suite of EcoQOs for the pilot project. The ACE evaluation indicates that some additional work is needed to proceed with a few of them, but there is adequate science available at present to proceed with most of them. It is important, though, that the monitoring and evaluation in the pilot project be done carefully, and use standards to which we provide guidance in Section 10.2.

The medium-term work (Section 10.3) is required to be able to set EcoQOs for the EcoQ elements in Table 10.1.2. In some cases, ACE concludes that the scientific information is adequate for setting EcoQOs at present, and only societal choices about reference levels prevent moving ahead. For some other EcoQ elements, however, the scientific basis is very far from adequate for setting EcoQOs. ACE provides specific guidance about the scientific tasks necessary to fill in the scientific foundation for EcoQOs. In some cases, though, for instance the habitat EcoQ element, there are so many serious gaps in the science that ACE concludes that the commitment in paragraph 4iii) of the Bergen Declaration that "By 2004, EcoQOs for the remaining elements will, in the same way, be developed and applied within the framework of OSPAR …" is completely unrealistic. ACE stresses that setting EcoQOs prematurely, on an inadequate scientific foundation, is as likely to be a step backwards as a step ahead. Premature action might lead to management actions and monitoring and evaluation programmes that are doomed to be inconclusive, ineffective at improving the environmental health of the North Sea, and costly to managers, resource users, and the scientific community.

10.5 General conclusions

1) ICES offers an active role in providing scientific advice on the evolution and implementation of EcoQOs. Specifically, ICES can further help in implementing the pilot project in the North Sea and in the derivation of the next tranche of EcoQOs.

2) In relation to the pilot project, ICES recommends that:

    a) Some clarification and work are still required around the details of the EcoQOs (see Table 10.2.1). Some of this work can be aided by ICES, but some requires societal policy decisions;

    b) North Sea countries will need to establish specific EcoQO monitoring programmes. ICES can provide advice on standards for this monitoring in most cases. Some of these programmes may not be simple (or inexpensive).

    c) ICES can provide a review, synthesis, and reporting role.

3) In relation to the medium-term development of EcoQOs, ICES recommends that:

    a) Considerable further work is required to move some of the suggested EcoQOs into a state to be ready for implementation. In some cases, the time frame set by North Sea Ministers is unrealistic. In other cases, the EcoQOs have been developed and all that is required is a societal decision to implement them.

b) With regard to the EcoQ for threatened and declining species, ICES should work with OSPAR and other experts to: i) identify from the list of species designated as threatened and declining, species that would be particularly appropriate for developing robust and effective EcoQOs; ii) provide the scientific basis for setting reference levels for the EcoQOs; and iii) provide the scientific and statistical basis for estimating current levels and for the monitoring that would be part of the pilot project.

c) With regard to the EcoQ for benthos communities, ICES is willing to: i) work on the development of objective, empirical criteria for the selection of sensitive and opportunistic benthic species; and ii) contribute its expertise to the setting of appropriate levels of sensitive and opportunistic benthic species for use in setting operational EcoQOs.

d) With regard to the EcoQ for habitats, ICES is willing to: i) engage with the European Environment Agency and OSPAR in furthering the development of a marine habitat classification scheme for habitats in the OSPAR area; ii) contribute expertise to the detailed mapping of marine habitats in the OSPAR area; and iii) consider the question of what properties of habitats might eventually be useable as metrics by which efforts to restore and/or maintain habitat quality might be measured. If the results are not promising, provide the basis for discussions among ICES, OSPAR, and the larger scientific and management communities on alternative EcoQQ elements to address the issue of habitat.

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11 ECOSYSTEM APPROACH TO MANAGEMENT

Request

This is an internal request by ACE to present an overview of the development of an ecosystem approach to marine management in ICES countries, the North Sea, and the Baltic Sea, and present an overview of the ACE framework for such an ecosystem approach to marine management.

Source of information

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Background and regional initiatives

Numerous large national and international programmes now exist to develop an ecosystem approach for the management of marine resources. Some of these programmes are described below according to region. It is recognized that the list of programmes described briefly here is by no means exhaustive, although it does reflect the major initiatives of which the ACE members were aware. Thereafter, a summary of common activities is presented. It is noted that there is a general consensus as to the intent of the expression "ecosystem approach". However, actual definitions of the expression can vary. ACE recognizes that this must be considered when interpreting reports on the implementation of the "ecosystem approach".

11.1 North American initiatives

11.1.1 Canada

SGEAM 2002 reports that the recent Oceans Act (OA) is the broad context of the nation's oceans management activities. The OA preamble states that "Canada promotes the understanding of ocean processes, marine resources and marine ecosystems to foster the sustainable development of the oceans and their resources…" The OA calls on the Minister of Fisheries and Oceans to lead in the design and implementation of a comprehensive oceans strategy for Canada. The Strategy is under way and it is based on the three following principles:

- Sustainable Development;
- Integrated Management; and
- Precautionary Approach.

Three core programmes have been undertaken under the Oceans Act (Figure 11.1.1.1), as the three pillars upon which the OA implementation is based:

1) Integrated Management (IM): A collaborative process to bring together interested parties to effectively plan and manage all human activities in the marine/coastal environment and to incorporate social, cultural, economic, and environmental values in ocean use planning.
2) Marine Protected Area (MPA): Programme aiming at the establishment of a national network of MPAs to conserve and protect marine resources and their habitats. The MPA programme uses a flexible approach (i.e., on a "site-by-site" basis).
3) Marine Environmental Quality (MEQ): The programme provides support and guidance to Oceans Management activities and, more specifically, to IM and MPA planning.

Four Large Oceans Management Areas (LOMAs) are priorities for the Department of Fisheries and Oceans (DFO): Gulf of St. Lawrence Integrated Management (GOSLIM), Eastern Scotian Shelf Integrated Management (ESSIM), Central Coast Integrated Management (CCIM, on the Pacific coast), and Beaufort Sea Integrated Management Planning Initiative (BSIM). All these LOMAs are facing increasing pressure due to human activities in coastal areas. LOMAs will address broad Ecosystem Objectives dealing with major ocean issues (e.g., shipping, oil and gas, species at risk). LOMAs will ultimately cover all Canada's marine environment. Ecosystem Objectives will be established for all existing LOMAs. The Ecosystem Objectives must relate to the following three key areas: biodiversity, productivity, and environmental quality.

In future developments, MEQ practitioners, ecosystem managers, decision-makers, and policy-makers must consider the following:

a) There is now an urgent need to develop environmental indicators parallel with socio-economic indicators, in an effort to address sustainable development;

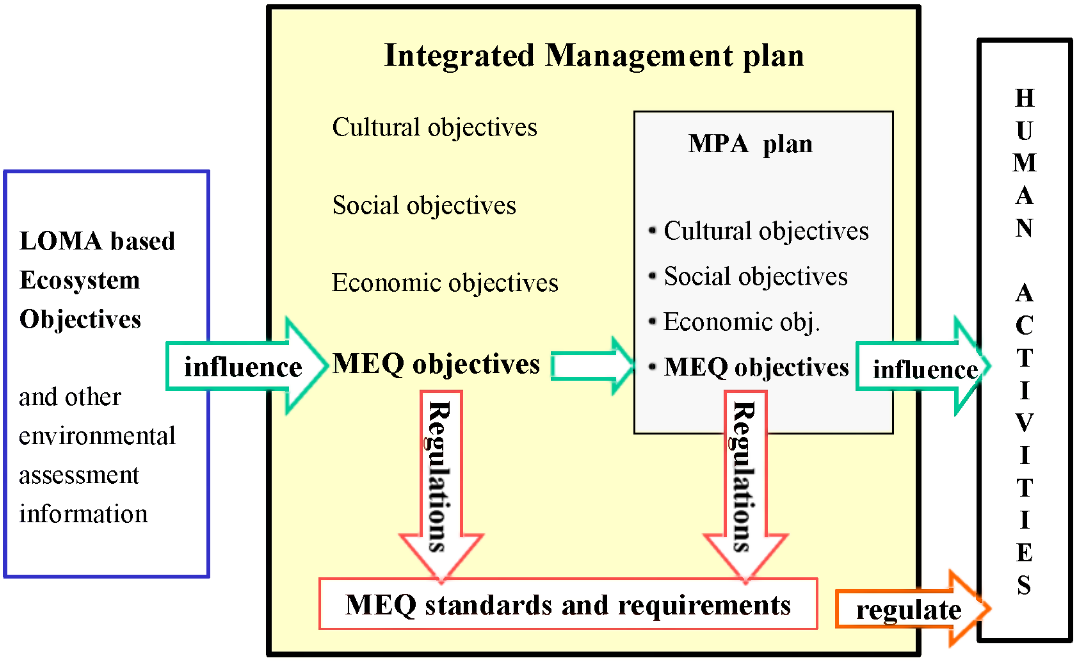
b) Integrated Management planning is starting at the local level in Canada, throughout coastal management areas. The MEQ programme has been asked to provide oceans managers and stakeholders involved in the Integrated Management process with MEQ objectives and associated metrics. Most MEQ efforts will be devoted to focusing on this task for the next years.

11.1.2 U.S.A.

In 1999, the U.S. Commerce Secretary appointed twenty fisheries experts to the NOAA Marine Fisheries Advisory Committee (MAFAC), the group that advises the Secretary on marine resources policy and programmes that affect the nation's ocean fish resources and marine mammal populations. The members include representatives from commercial and recreational fishing interests, and environmental, academic, state, tribal, consumer, and other national points of view. The appointees make recommendations regarding ongoing reauthorization of the Magnuson-Stevens Fisheries Conservation and Management Act, the Endangered Species Act, the Sustainable Fisheries Act, and the Marine Mammal Protection Act. Programme policies and activities regarding vessel monitoring systems, marine reserves, the national observer programme, stock assessments and data collection, as well as other mandates of the fisheries service, are considered by MAFAC. It is noted that continual litigation by environmental groups on one side and the industry, e.g., commercial fisheries, on the other side emphasizes the need to work diligently on implementing an ecosystem approach in U.S. fisheries.

At a meeting in spring 2002, MAFAC hosted a workshop to discuss an ecosystem-based management approach in fisheries. The participants focused on marine resources, socio-economic issues, and a fisheries ecosystem plan. MAFAC recommended that an ecosystem-based approach requires that all major actions are measured against the impact these actions will have in preventing the maintenance or achievement of important metrics

Figure 11.1.1.1. The three core programmes, Integrated Management, Marine Protected Areas, and Marine Ecological Quality, as described under the Oceans Act, are dependent upon environmental assessments and ecosystem objectives, and are guided by human activities.



that describe the desired future conditions. Therefore, a public process needs to be started to describe the desired future conditions. And, in order to assist in this process and to identify historical limits, the historical conditions need to be described, including abundance and distribution of key resources. The following outline provides more specific suggestions:

1) identify the geographical area to be addressed—natural ecological boundaries would be preferred, however, political boundaries may have to be used;
2) perform a technical analysis to investigate, evaluate, and use in trend analysis, historical data on species mix, relative abundance of key species, geographical distribution, age/size ranges;
3) repeat the activities carried out under item no. 2 in order to describe current conditions;
4) identify the differences and, if possible, quantify the differences between the historical description and current conditions;
5) through an open and public process, communicate the findings and results to the stakeholders, agencies, elected officials, and news media; and
6) implement a public process that will result in the identification and description of the desired future conditions (this could be for two time frames, such as short term (three to five years) and long term (twenty years plus)).

The Ecosystems Principles Advisory Panel (EPAP) (1999) suggested that regional Fisheries Ecosystem Plans (FEPs) be developed as a mechanism for incorporating ecosystem principles, goals, and policies into the present fisheries management structure. They maintained that FEPs must contain the information about the ecosystem that allows managers to make informed decisions, but the primary purpose of the plans is to prescribe how fisheries will be managed from an ecosystem perspective. Tentative criteria and guidelines for describing ecosystem conditions and indicators included lists for constraints, ecological indicators, and socio-economic indicators.

It is also noted that the National Marine Fisheries Service recently conducted an exercise to assess the "status" of the Northeast U.S.A. continental shelf ecosystem with respect to the distribution of fish stocks. The exercise addressed thirty metrics and noted that no single metric best described the status of the ecosystem, and that the best approach was to consider a suite of metrics simultaneously.

11.2 North Sea initiatives

11.2.1 The Bergen Declaration

The Ministers responsible for the protection of the environment of the North Sea and the Member of the European Commission responsible for environmental protection met in Bergen, Norway, on 20 and 21 March 2002, for the Fifth International Conference on the Protection of the North Sea. The Ministerial Declaration of the Fifth International Conference on the Protection of the North Sea, commonly referred to as the Bergen Declaration (2002), called for:

- establishing an ecosystem approach to management;
- conservation, restoration, and protection of species and habitats;
- sustainable fisheries;
- reducing the environmental impact from shipping;
- the prevention of pollution from hazardous substances;
- the prevention of eutrophication;
- the prevention of pollution from offshore installations;
- the prevention of pollution by radioactive substances;
- promotion of renewable energy;
- marine litter and waste management;
- cooperation in the process of spatial planning in the North Sea;
- future cooperation.

The Ministers agreed to implement an ecosystem approach by identifying and taking action on influences which are critical to the health of the North Sea ecosystem. In particular, they agreed that management will be guided by a conceptual framework, which includes:

a) the development of general and operational environmental goals;
b) best use of available scientific and technical knowledge about the structure and function of the ecosystem;
c) best use of scientific advice;
d) integrated expert assessment;
e) coordinated and integrated monitoring;
f) involvement of all stakeholders; and
g) policy decisions and control and enforcement.

To implement an ecosystem approach in line with this framework, the Ministers will:

1) develop focused research and information gathering which address the driving forces of North Sea ecosystems variability, including climatic, biological, and human factors, which are critical for maintaining ecosystem structure and function, and invite ICES,

the Global Ocean Ecosystem Dynamics (GLOBEC) programme, and other relevant scientific organizations and programmes to consider the priority science issues from the Scientific Expert Conference in Bergen, 20–22 February 2002;

2) recognize the need for shared integrated expert advice and assessments of the North Sea, including marine resources, environmental and socio-economic factors, and invite OSPAR in cooperation with the EU and ICES to propose how this might be undertaken at periodic intervals involving stakeholders and to take the first steps;

3) develop a strategy for achieving dialogue with all relevant stakeholders for the development and implementation of the ecosystem approach, including through the use of existing national and international forums;

4) improve the coordination, harmonization, and efficiency of current national and international monitoring to serve the assessment processes, including building on the OSPAR Joint Assessment and Monitoring Programme and relevant EU monitoring programmes;

5) make appropriate policy decisions, including integration of environmental protection into all sectors, implement the corresponding management actions, and ensure proper control and enforcement to deliver an ecosystem approach; and

6) make use of ecological quality objectives (EcoQOs) as a tool for setting clear operational environmental objectives directed towards specific management and serving as indicators for the ecosystem health.

For delivering an ecosystem approach for the North Sea, the Ministers emphasized the importance of developing a coherent and integrated set of Ecological Quality Objectives. Therefore, they welcomed the progress that is being made within OSPAR and ICES to develop operational ecological quality objectives. They suggest a pilot project to:

- assess the information that is, or can be made, available in order to establish whether the EcoQOs are being, or will be, met. Where the EcoQOs are not being met, the information will be used to determine the reason. Costs and practicability should be taken into account in deciding what information can be made available;
- where an EcoQO is not being met, review any policies and practices which are contributing to that failure; and
- if need be, reconsider the formulation of such EcoQOs.

The Bergen Declaration recommended that OSPAR 2005 should be invited to review progress, in collaboration with ICES and other relevant bodies, with the aim of adopting a comprehensive and consistent scheme of EcoQOs and to report on this to the North Sea Ministers. The value, use, and practicability of the scheme of EcoQOs should be periodically reviewed by OSPAR, in cooperation with ICES and other relevant bodies.

11.3 Baltic Sea

11.3.1 Baltic Marine Environment Protection Commission—Helsinki Commission (HELCOM)

SGEAM 2002 reported that the HELCOM Monitoring and Assessment Group (MONAS) has proposed to introduce new reporting requirements and working practices for the purpose of elaborating assessments of the environmental status of the Baltic Sea. There have been proposals to prepare "indicator-based assessments" and "thematic reports". They should be seen as continuous assessment production towards "periodic assessments". MONAS agreed that the year 2002 would be the pilot year during which the following indicators are elaborated:

- surface winter concentrations of inorganic NO_3 + NO_2 and PO_4;
- riverine load of total N and total P;
- summer mean chlorophyll concentrations;
- changes in depth range and distribution of bladderwrack (*Fucus vesiculosus*) and eelgrass (*Zostera marina*);
- waterborne inputs: Hg, Pb, Cd and time series for 1994–2000;
- atmospheric inputs: Hg, Pb, Cd, based on model calculations;
- biota concentrations: Hg, Pb, Cd, CBs (seven congeners) in Baltic herring.

There is a wish to develop further indicators.

11.3.2 International Baltic Sea Fisheries Commission (IBSFC)

SGEAM 2002 reported that IBSFC aims to facilitate the development of economically and socially sustainable, environmentally safe, and responsible fisheries by maintaining biologically viable fish stocks, the marine and aquatic environment, and associated biodiversity. The following indicators are intended to highlight the trends in biological systems, and the economies of the fishery-dependent communities around the Baltic Sea:

a) spawning stock biomass, fishing mortality, recruitment;

b) landings per country, number of fishing vessels per country operating in the Baltic Sea, average engine power per country, fish consumption per capita per country, number of full-time fishermen engaged in the Baltic Sea Region per country.

11.3.3 Baltic IBSFC/HELCOM Seminar

SGEAM 2002 reported that a seminar to discuss cooperation between IBSFC and HELCOM is the first case of a common effort made by an international fishery management organization and an environmental organization. The 1992 Helsinki Convention—the Convention on the Protection of the Marine Environment of the Baltic Sea Area—aims to protect the marine environment of the Baltic Sea, i.e., water body, seabed, living resources, from all sources of pollution (land, ships, airborne). According to the Gdansk Convention, IBSFC is responsible for the protection and the rational utilization of the living marine resources of the Baltic Sea. The Seminar noted that in HELCOM and IBSFC, there is professional competence available for both fisheries and environmental issues. For scientific advice, HELCOM and IBSFC both see ICES as the main advisory body and the activities of ICES include work on the effects of human activities on the ecosystem in the Baltic Sea and integration of environmental and fisheries issues. The Seminar agreed that environmental and nature conservation mid-term and long-term objectives and sector targets for the fishery are complementary. Integration of environmental and nature conservation issues into fishery policies and integration of fishery issues into environmental and nature conservation policies is an ongoing process in both HELCOM and IBSFC. The Seminar agreed that progress in the field of protection, conservation, and sustainable use of the Baltic Sea fish communities of target and non-target species for the benefits of both the fisheries and nature conservation will only be possible by applying an ecosystem-based approach and when there is a close cooperation between HELCOM and IBSFC.

11.3.4 Baltic Sea Regional Project

In the Baltic Sea Regional Project (BSRP) (2002) report, it is stated that the Global Environment Facility (GEF) Council approved the Project Brief for the Baltic Sea Regional Project in May 1998. To address the need for an ecosystem-based approach to resource management, the Baltic Sea Regional Project is designed within the principles of the Large Marine Ecosystem (LME) concept, focusing on land-based, coastal zone, and marine activities, including activities for improving ecosystem health and productivity, social and economic development, and provision of ecosystem management tools for decision-makers to address transboundary issues for the Baltic Sea. The most important aspects of the Project are its linkages between land-based activities, coastal zones, and the marine environment.

With the support of the GEF and the World Bank, Project activities will support Estonia, Latvia, Lithuania, Poland, and the Russian Federation in meeting their obligations under the Helsinki Convention and other international agreements, as well as obligations under national policies and legislation. The Project provides the basis for strengthening cooperation between the three international bodies—the Helsinki Commission (HELCOM), the International Baltic Sea Fisheries Commission (IBSFC), and the International Council for the Exploration of the Sea (ICES).

The Project is composed of four components: 1) Large Marine Ecosystem activities; 2) land and coastal management activities; 3) institutional strengthening and regional capacity building; and 4) project management. The project is expected to start in autumn 2002 and run for six years. ICES will manage the Large Marine Ecosystem component of this project, which will develop the following:

1) ecosystem-based assessments and management of the Baltic Sea;
2) coordination and integration of regional monitoring and assessment; and
3) improved management practices to increase and sustain fishery yields and biological productivity of the Baltic Sea LME.

11.4 Other European initiatives

11.4.1 United Kingdom

SGEAM 2002 reported that the Department for Environment, Food and Rural Affairs (DEFRA) has a number of overarching objectives, including:

- "to protect and improve the environment and conserve and enhance biodiversity and to integrate these policies across Government…"; and
- "to promote more sustainable management and use of natural resources in the UK…".

To support these objectives in the context of the marine environment, the Department is currently preparing a marine Stewardship Report that describes the UK's development of an approach to the management of the marine environment based upon the following principles:

- sustainable exploitation of marine resources;
- ecosystem approach to the management and protection of the environment;
- greater integration of monitoring and assessment;
- the application of the precautionary principle.

Central to this approach is the need to provide comprehensive assessments of ecosystem quality. A driving force behind this organizational change is the need to offer a framework for an ecosystem approach to the management of marine ecosystems, which can deliver "sustainable use of ecosystem goods and services and conservation of ecosystem integrity". This is an important consideration for the development of the UK strategy. The objectives of the strategy are:

a) to continue to fulfill all national and international reporting requirements;

b) to make the best use of data and resources;

c) to enable robust integrated assessments of the state of the marine environment in the UK;

d) to support the development of performance indicators for management of the marine environment.

11.4.2 Norway

SGEAM 2002 reported that the Norwegian government presented in March 2002 a "white paper" to the Norwegian Parliament that was devoted to ocean management. The white paper is called "Rent og rikt hav", a "clean and rich ocean". It summarizes briefly the present status of the Norwegian marine environment and the use of Norwegian waters for industrial purposes such as oil and gas exploitation, fisheries, and aquaculture. Important messages in the "white paper" are the introduction of, in a political context, the use of ecosystem-based management advice and the establishment of ecological quality objectives.

The government will establish a management plan for the Barents Sea where fisheries, oil and gas exploitation, shipping activities, and aquaculture and the environmental aspects of these activities as well as the socio-economic aspects are included.

11.5 Pan-European initiatives

11.5.1 European Environment Agency (EEA)

SGEAM 2002 reported that one of the main tasks of the EEA is to report on the state of the European environment. The EEA has adopted an indicator-based reporting system as its main tool for assessment, and communication to policy-makers and the public. The DPSIR (Driving force, Pressure, State, Impact, and Response) framework, combined with an issues/thematic approach, was chosen as the basis for developing indicators. A core set of 86 indicators has been proposed, covering eutrophication and organic pollution, hazardous substances, groundwater quality and quantity, water stress, climate change, drinking water quality, microbiological contamination, impacts of fishing, ecological quality, aquatic biodiversity, and integrated coastal zone management. Approximately thirty of these indicators relate to transitional and coastal waters. The core set will be modified, improved, and developed over time as more comparable and spatially extensive data sets become available and the Water Framework Directive is implemented by Member States. Fifty-nine of the indicators will be presented in a water indicator report to be published in June 2002.

11.5.2 European Union

The European Union has recently adopted its Sixth Environmental Action Programme (2001–2010), which advocates the adoption of so-called "thematic strategies" to address fundamental environmental concerns. In this context, the European Commission is preparing the grounds for a strategy to protect the marine environment, which will in itself constitute an ecosystem approach. It will list objectives, management action, and institutional adaptations in order to coordinate all sectors of activity which affect, or are affected by, the marine ecosystems, and will address the multiple pressures that come from different human economic activities. These are identified as:

- human population increase and urbanization in coastal areas;
- excessive nitrogen and phosphorus from land-based activity and from the air that may cause eutrophication;
- unsustainable development of land-based tourism;
- pollution from accidents, especially from oil and other chemical product tankers;
- pollution from shipping, for instance, cleaning out of oil tanks;
- pollution from rivers and ports;
- problems from cabling and pipelines;
- pollution caused by releases of radioactive substances from practices involving a risk from ionizing radiation;
- dumping at sea of harbour sludge and sediments;
- pressure from fisheries that threatens the long-term viability of fish stocks.

Within the process of integration of environmental protection requirements, and taking advantage of the current process of reform of the Common Fisheries Policy (CFP), the European Union has committed itself to move towards an ecosystem-based approach to fisheries management (Council conclusions of 25 April 2001).

For this purpose, the EU shall apply the precautionary principle in taking measures designed to protect and conserve aquatic living resources, to provide for their sustainable exploitation and to minimize the impact of fishing activities on marine ecosystems. It shall aim at a progressive implementation of an ecosystem-based approach to fisheries management. It shall aim to contribute to efficient fishing activities within an economically viable and competitive fisheries and aquaculture industry, providing a fair standard of living for those who depend on fishing activities and taking account of the interest of consumers.

11.6 Global initiatives

11.6.1 Global International Waters Assessment (GIWA)

SGEAM 2002 reported that the objective of the GIWA project, funded by the Global Environment Facility (GEF), UNEP and other donors, is to develop a comprehensive strategic assessment that may be used by GEF and its partners to identify priorities for remedial and mitigating actions in international waters, designed to achieve significant environmental benefits, at national, regional, and global levels. The assessment has been organized on a global scale for 66 sub-regions as basic marine and catchment area units, which are similar to the designations of Large Marine Ecosystems (LMEs). For that purpose, GIWA has been elaborating its own methodology, the so-called "Scoping and Scaling Methodology".

The next step in the GIWA process is the assessment of socio-economic drivers behind the environmental status of different sub-regions ("Casual Chain Analysis"). This is a process of analysing social and economic drivers from direct driving forces to original root causes. SGEAM noted a very high degree of integration of environmental issues within the GIWA sub-regions. Therefore, the GIWA methodology is useful for the purpose of global assessment, and might also be useful for comparison of the status of different seas and regions (e.g., on the scale of Pan-European seas). However, the high degree of agglomeration of information limits the amount of knowledge that decision-makers have to absorb and should not be commonly applied in a smaller scale for the regional seas assessments.

11.6.2 Food and Agriculture Organization (FAO)

SGEAM 2002 reported that the FAO has stated, "The overarching principles of ecosystem-based management of fisheries are an extension of the conventional principles for sustainable fisheries development to cover the ecosystem as a whole. They aim to ensure that, despite variability, uncertainty and likely natural changes in the ecosystem, the capacity of the aquatic ecosystems to produce fish food, revenues, employment and, more generally, other essential services and livelihood, is maintained indefinitely for the benefit of the present and future generations. The main implication is the need to cater both for human as well as ecosystem well-being. This implies conservation of ecosystem structures, processes and interactions through sustainable use. This implies consideration of a range of frequently conflicting objectives and the needed consensus may not be achievable without equitable distribution of benefits."

The FAO has further recognized that there is still great uncertainty as to how to implement an effective ecosystem management system in practice. As management expands its focus from target stocks to ecosystems, all of these problems increase in an exponential way and biological uncertainty becomes ecological uncertainty that is even more complex. The number of competing users increases as do the resulting conflicts of interest; objectives become more complex and conflicting, and the number of stakeholders is expanded to include all the users of all the different ecosystem components. Nevertheless, there are pragmatic ways in which to begin implementation of ecosystem-based fisheries management, even as we strive for greater knowledge of ecosystem functioning and how to deal with complex human institutions and societies.

In 2001, FAO produced a Code of Conduct for Responsible Fisheries. This Code sets out principles and international standards of behaviour for responsible practices with a view to ensuring the effective conservation, management, and development of aquatic living resources, with due respect for the ecosystem and biodiversity. The Code recognizes the nutritional, economic, social, environmental, and cultural importance of fisheries and the interests of all those concerned with the fishery sector. The Code takes into account the biological characteristics of the resources and their environment and the interests of consumers and other users.

Some further recommendations from FAO include:

- In consultation with all legitimate stakeholders and interest groups, objectives must be agreed upon for each ecosystem, and potential conflicts and inconsistencies in those objectives recognized and addressed.
- As a part of setting the objectives, sustainability indicators need to be established for each ecosystem.
- Suitable management strategies, typically consisting of a suite of management measures, should be designed to achieve the set of objectives.
- Application of the precautionary approach is particularly important in implementation of ecosystem-based management.
- An ecosystem monitoring system needs to be designed and implemented to ensure that the information necessary for tracking the sustainability indicators is collected in a reliable and timely manner.
- As with any management system, an appropriate and effective enforcement system must be implemented.

11.6.3 Reykjavik Declaration on Responsible Fisheries in the Marine Ecosystem

The Reykjavik Conference on Responsible Fisheries in the Marine Ecosystem met from 1–4 October 2001 in Reykjavik, Iceland. The conference was organized by the Government of Iceland and the United Nations Food and

Agriculture Organization (FAO), and was co-sponsored by the Government of Norway. The Conference was attended by over 400 participants, including representatives from FAO Member States and other UN Member States, UN bodies and agencies, intergovernmental and non-governmental organizations, academic and scientific institutions, and industry. The conference presented stakeholders with an opportunity to gather and review the best available knowledge on marine and ecosystem issues. It sought to establish a means by which ecosystem considerations could be included in capture fisheries management, and to identify future challenges and relevant strategies. Participants focused on key scientific issues including ecosystem considerations in fisheries management, the dynamics of marine ecosystems, the role of people in marine ecosystems, and methods to incorporate ecosystem considerations into fisheries management. The declaration maintains that fishing fleets in many regions often have a capacity that exceeds the mature fish stocks available. And although the scientific understanding of marine ecosystems remains limited, there is mounting evidence that the fisheries sector and other human activities are having a serious impact on these ecosystems.

Given these growing problems, experts have been developing new ideas and approaches to complement the conventional fisheries management approach, which considers each fish stock in isolation or several fish species but not the wider marine environment. One concept considered in recent years is how a fisheries management approach including ecosystem considerations might contribute to achieving long-term sustainability for the fisheries sector. Although the details of such an approach are still being developed, most experts agree that it should take a more holistic and integrative view of fisheries management. A fisheries management approach including ecosystems considerations should also emphasize strong stakeholder participation and focus on human behaviour as the central management dimension. In this context, a number of organizations, institutions, and government agencies have been working on the pressing question of how to include ecosystem considerations in capture fisheries management practices and procedures.

11.6.4 SCOR-IOC Report on Ecosystem Indicators

A two-day meeting, the first of the SCOR-IOC Working Group 119, was held on 5–6 October 2001 in Reykjavik, Iceland, following the FAO Conference on Responsible Fisheries in Marine Ecosystems. The meeting was attended by 28 members, plus five representatives from SCOR, IOC, GLOBEC, EC, and by an observer from NMFS/NOAA. SCOR, the Scientific Committee on Oceanic Research, is a non-governmental body based in Baltimore, MD, USA, which has forty member countries. SCOR sponsors oceanic research projects such as JGOFS and sponsors or co-sponsors many working groups. The work at this meeting focused on: 1) ecosystem theory—summarizing emergent properties in indicators, and 2) practical indicators, towards developing indicators for use in ecosystem-based fisheries management. Lists of indicators included categories for environmental indicators, ecological indicators, and fisheries indicators.

11.6.5 Rio plus 10 – The World Summit on Sustainable Development

The World Summit on Sustainable Development brought together thousands of participants, including heads of State and Government, national delegates, and leaders from non-governmental organizations (NGOs), businesses, and other major groups to focus the world's attention and direct action toward meeting difficult challenges, including improving peoples' lives and conserving our natural resources in a world that is growing in population, with ever-increasing demands for food, water, shelter, sanitation, energy, health services, and economic security. At the 1992 Earth Summit in Rio, the international community adopted Agenda 21, an unprecedented global plan of action for sustainable development. The Johannesburg Summit met in autumn 2002 to adopt concrete steps and identify quantifiable targets for better implementing Agenda 21.

11.6.6 Global Ocean Observing System (GOOS)

GOOS is conceived as a sustained, coordinated international system for gathering data about the oceans and seas of the Earth. GOOS is intended to be a system for processing such data, with other relevant data from other domains, to enable the generation of beneficial analytical and prognostic environmental information services, and the research and development on which such services depend for their improvement.

The primary objectives of GOOS are:

1) to specify the marine observational data needed on a continuing basis to meet the needs of the world community of users of the oceanic environment;
2) to develop and implement an internationally coordinated strategy for the gathering, acquisition, and exchange of these data;
3) to facilitate the development of uses and products of these data, and encourage and widen their application in the use and protection of the marine environment;
4) to facilitate means by which less-developed nations can increase their capacity to acquire and use marine data according to the GOOS framework;
5) to coordinate the ongoing operations of GOOS and ensure its integration within wider global observational and environmental management strategies.

GOOS is being implemented through five overlapping phases:

1) planning, including design and technical definition;
2) operational demonstrations and pilot experiments;
3) incorporation of suitable existing observing and related activities and new activities that can be implemented now to constitute the GOOS Initial Observing System;
4) gradual operational implementation of the "permanent" or ongoing Global Ocean Observing System;
5) continued assessment and improvement in individual aspects and in the entire system.

Support for planning and international coordination required for the design and implementation of GOOS is apportioned between the GOOS sponsoring organizations: IOC, WMO (World Meteorological Organization), UNEP (United Nations Environment Programme), and ICSU (International Council of Science); it is supplemented through them by financial, manpower, and in-kind contributions from nations with an interest in its success.

ICES activities in support of GOOS are coordinated by the ICES/IOC Steering Group on GOOS (SGGOOS). At present, the ICES focus is on an ICES-EuroGOOS North Sea Ecosystem Pilot Project (NORSEPP), which has been initiated to increase the efficiency and effectiveness of current relevant national and international monitoring systems, so as to facilitate an ecosystem approach to fisheries management. The scope of this pilot project will initially be limited to physical oceanography and fisheries, rather than including other ecosystem components at the outset of the project.

11.6.7 GLOBEC (Global Ocean Ecosystem Dynamics)

GLOBEC was initiated by SCOR and IOC in 1991, in response to the recommendations of a joint workshop which identified a need to understand how global change will affect the abundance, diversity, and productivity of marine populations comprising a major component of oceanic ecosystems. GLOBEC is one of the nine core projects of The International Geosphere-Biosphere Programme (IGBP), an interdisciplinary scientific activity established and sponsored by the International Council for Science (ICSU). GLOBEC became part of IGBP in 1995. GLOBEC focuses on zooplankton. The aim of GLOBEC is to advance our understanding of the structure and functioning of the global ocean ecosystem, its major subsystems, and its response to physical forcing so that a capability can be developed to forecast the responses of the marine ecosystem to global change.

ICES has been charged in the International GLOBEC Implementation Plan with the coordination and implementation of the North Atlantic Regional Programme of GLOBEC (principally the Cod and Climate Change Programme). A programme office was established at ICES Headquarters in August 1996 with funding provided by several countries. The aims for the North Atlantic programme are to:

- develop coupled physical/biological models for improved advice on i) exploitation and management of marine resources; ii) causes of observed changes in the plankton ecosystem, and iii) consequences of climate change on fisheries and other marine life;
- add value to national research through cooperation;
- draw a wider community of scientists (atmospheric science, climatology, modelling, biological oceanography) into the study of long-term changes in the ocean ecosystem.

Presently, the Cod and Climate Change programme is entering its last phase, which concentrates on the synthesis of results and the development of models useful for operational fisheries oceanography.

Operational oceanography, as used here, is defined (ICES, 2000) as follows:

"Operational oceanography is the activity of routinely making, disseminating, and interpreting measurements of the seas and oceans and atmosphere so as to:

- provide continuous forecasts of the future condition of the sea for as far ahead as possible (*Forecast*);
- provide the most usefully accurate description of the present state of the sea including living resources (*Nowcast*);
- assemble climatic long-term data sets which will provide data for description of past states, and time series showing trends and changes (*Hindcast*)".

The term "operational fisheries oceanography" was introduced by ICES. The term is defined here as "operational oceanography with particular application to fisheries". Thus, operational fisheries oceanography addresses long-term historical changes, and the present as well as the predicted status of fish stocks.

Reference

ICES. 2000. Report of the ICES Advisory Committee on the Marine Environment, 1999. ICES Cooperative Research Report, 239: 126–127.

ANNEX 1: REVEW OF EVIDENCE FOR JUSTIFICATION FOR THE PROPOSED OSPAR PRIORITY LIST OF THREATENED AND DECLINING SPECIES AND HABITATS

This annex contains the detailed assessments of the data used in the choice of species and habitats for the draft OSPAR Priority List of Threatened and Declining Species and Habitats. These assessments served as the basis for the ICES advice contained in Section 6 of this report, and are reproduced here as a supplement to that advice. For each species or habitat considered, the background material is a quotation from the document "Review of proposals for an initial list of threatened and declining species in the OSPAR Maritime Area", which was prepared for the Workshop on Threatened and Declining Species and Habitats that was held in Leiden, The Netherlands, on 17–18 September 2001; this material is shown in italics. The references that were reviewed in relation to the choices made during the Leiden Workshop and subsequently considered by the OSPAR Biodiversity Committee have been indicated by an asterisk (*); the other references have been provided during the ICES review.

1 SPECIES

1.1 Invertebrates

1.1.1 *Megabalanus azoricus* (Barnacle)

a) Background

"*This barnacle has been nominated for Region V. It is a sessile species with a very restricted distribution in coastal habitats around the islands of the Azores. It is thought to be endemic to the Azores although there may be some link to a similar (or the same) species found in Madeira. The barnacle is considered to be a keystone species as the shells provide a vital microhabitat for a number of fish and invertebrates.*

Threats The main threats to this species are overexploitation, degradation of suitable habitat and marine pollution.

Status The available quantitative and anecdotal information points to (at least) a significant decline in the population around the Azores, following increasing exploitation during the last two decades."

b) Literature used (*below)

c) Literature interpretation

d) ICES conclusions

e) ICES overall evaluation

No expertise was available regarding this barnacle species.

References

OSPAR. 2000. Quality Status Report 2000, Region V – Wider Atlantic. OSPAR Commission, London. 110 + xiii pp.

Peckmann, J., Reitner, J., and Neuweiler, F. 1998. Seepage related or not? Comparative analysis of phanerozoic deep-water carbonates. TTR7 Post-cruise meeting Conference. Carbonate Mud Mounds and Cold Water Reefs: Deep Biosphere-Geosphere coupling, 27.

*Regala, J.T. 1999. Contribuição para o estudo da biologia da craca dos Açores, *Megabalanus azoricus* (Pilsbry, 1916). Relatório de Tese de Licenciatura. Universidade do Algarve. 49 pp.

*Santos, R.S., Hawkins, S., Monteiro, L.R., Alves, M., and Isidro, E.J. 1995. Marine research, resources and conservation in the Azores. Aquatic Conservation: Marine and Freshwater Ecosystems, 5: 311–354.

*Southward, A.J. 1998. New observations on barnacles (Crustacea: Cirripedia) of the Azores region. Arquipélago. Life and Marine Sciences, 16A: 11–27.

WWF/IUCN. 2001. The status of natural resources on the high-seas. WWF/IUCN, Gland, Switzerland.

1.1.2 *Patella ulyssiponensis aspera* (limpet) subspecies

a) Background

"*This limpet has been nominated for Region V. The Macronesian population is most likely separated from those on the European mainland and probably has subspecies status. In the Azores it is restricted to a narrow subtidal zone on rocky substrates. It is considered to be a keystone species.*

Threats The main threats are from overexploitation and habitat degradation of shelf areas.

Status Overexploitation has caused a severe decline of the species on the rocky shores of the Azores islands."

b) Literature used (*below)

c) Literature interpretation

d) ICES conclusions

e) ICES overall evaluation

No expertise was available on this species. It was noted, however, that the species *Patella ulyssiponensis* is abundant in the Cantabrian Sea (northern Spain) as well as along exposed Norwegian shores. This indicates that decline in this species may be near the Azores. More information on the wider occurrence and development of the subspecies is therefore needed.

References

Blacker, R.W. 1957. Benthic animals as indicators of hydrographic conditions and climatic change in Svalbard waters. Fishery Investigations (London), ser. II, 20: 1–49.

*Ferraz, R.R. 1998. Avaliação do recurso de lapas - *Patella ulyssiponensis aspera* e *Patella candei candei* —no arquipélago dos Açores. Tese de Licenciatura em Biologia Marinha e Pescas. Universidade do Algarve, Faro, Portugal. 66 pp.

*Ferraz, R.R., and Santos, R.S. 2000. Análise das capturas de lapas nos Açores em 1999 e parecer para a emissão de licenças para 2000. Arquivos do DOP, série estudos, 1/2000. 17p.

1.1.3 *Arctica islandica* (Ocean quahog)

a) Background

"*The Ocean Quahog has been nominated for the entire OSPAR area as well as for Region II. It is found on sandy and muddy sand seabeds from low intertidal down to 400 m. Within the OSPAR area it has a distribution which extends from Iceland, and the Faroes to the Bay of Biscay.*

<u>Threats</u> The main threat to this species is believed to be from the impact of beam trawls. This causes shell damage and direct mortality. Irregular recruitment or survival of recruits may also be a factor affecting sensitivity of this species to impact.

<u>Status</u> Information on the distribution and density in the North Sea reveals significant changes during the last century. The mollusc was recorded at 20–30 % of sampling stations in the North Sea in 1986 compared to 45 % of the stations sampled in the early part of the century. Its density in the southern North Sea declined significantly between 1979–1980 and 1990–1994 with an absence from areas shallower than 30 m."

b) Literature used (*below)

c) Literature interpretation

d) ICES conclusions

e) ICES overall evaluation

ICES agrees that this species is impacted by bottom trawling fisheries. The decline reported by Witbaard and Klein (1994) is acknowledged, but there is no indication that this long-lived bivalve species is threatened over the whole OSPAR area. For instance, there is no decline in the Baltic Sea. The species is common along the Norwegian coast. The threat caused by bottom trawling is to a large extent of a regional nature.

A potential point of concern is that for many years there has been virtually no recruitment in the North Sea. This may be a signal of threat, although there is no clue as to the cause. One possibility could be climate change. The recruitment biology of this species should be studied in order to find possible explanations.

References

*Gubbay, S. 2001. Development of Ecological Quality Objectives for the North Sea. Threatened and declining species. 41 pp., citing: Rumohr *et al*., 1986; Witbaard, 1997; Witbaard and Klein, 1997; Murawski *et al*., 1982; Duinefeld *et al*., 1991; Bergman and van Santbrink, 2000.

*Whitbard, R., and Klein, R. 1994. Long-term trends on the effects of the southern North Sea beamtrawl fishery on the bivalve mollusc *Arctica islandica* L. (Mollusca, bivalvia). ICES Journal of Marine Science, 51: 99–105.

1.1.4 *Nucella lapillus* (Dogwhelk)

a) Background

"*The Dog Whelk has been nominated for the entire OSPAR Maritime Area as well as for the Belgian waters in Region II. It is found on wave-exposed to sheltered rocky shores from mid-shore to about 30 m depth. It is a gregarious species and common amongst barnacles and mussels on which it feeds.*

<u>Threats</u> The main threat is from pollution, specifically Tributyltin, causing imposex. The effects of TBT have been observed in dogwhelks from the coastal areas of all countries bordering the North Sea.

<u>Status</u> Nucella *populations have significantly declined at Helgoland dating back to the 1960s/1970s or possibly earlier. It used to be very common on the Belgian coast but disappeared during the end of the 1970s and early*

1980s. In other parts of its distribution area, TBT concentrations in the water are reported to be at least at, or above, the no-effect threshold in the Celtic and North Seas."

b) Literature used (*below)

c) Literature interpretation

d) ICES conclusions

e) ICES overall evaluation

ICES supports the argumentation given with respect to TBT and related compounds. However, the species does not seem to be declining or threatened along the French coast of the eastern Channel. It is unclear whether the decline at Helgoland is still apparent.

In Belgium, the species became extinct by 1987. Any recovery will be slow due to the absence of pelagic larvae, as well as the occurrence of concentrations of TBT that are still too high. *N. lapillus* is reduced in the Skagerrak and in Icelandic harbours.

References

*Daro, M.H. 1969. Etude écologique d'un brise-lames de la côte belge: 1. Description et zonation des organismes. Ann. Soc. r. Zool. Belg., 99(3-4): 111–152.

*Kerckhof, F. 1988. Over het verdwijnen van de purperslak *Nucella lapillus* (L. 1758) langs onze kust. De Strandvlo, 8(2): 82–85.

*Leloup, E. 1950. Recherches sur une moulière naturelle de la côte belge. Bulletin Institut royal d'Histoire naturelles de Belgique, 26(30): 1–27.

*OSPAR. 2000. Quality Status Report 2000 – Region II Greater North Sea, Region III Celtic Seas, Region IV Bay of Biscay and Iberian Coast. OSPAR Commission, London.

Van der Ben, C., Van der Ben, D., Van Goethem, J., and Daro, M.H. 1977. Inventaire et zonation des organismes sur les brise-lames de la côte belge. *In* Nationaal onderzoeks- en ontwikkelingsprogramma, Projekt Zee, 7: 313–332. Ed. by J.C.J. Nihoul and L. De Coninck.

1.1.5 *Ostrea edulis* (Flat oyster)

a) Background

"*The Flat Oyster has been nominated for Region II. It is a sessile, filter-feeding bivalve mollusc, associated with highly productive estuarine and shallow coastal water habitats. It is widely distributed around the British Isles and the North Sea and is considered a keystone species because it creates a habitat for other species.*

<u>Threats</u> *The main threats have been overexploitation and the introduction of other (warm water) races as well as competing oyster species. Natural causes such as disease and severe winters may also have contributed to the decline of oysters in the North Sea.*

<u>Status</u> *Stock abundance was probably greatest in the 18th and 19th centuries when there were large offshore oyster grounds in the southern North Sea and the Channel. During the 20th century, its abundance declined significantly in European waters. The northern "coldwater" population is extirpated and the southern warmer water population has declined. This species has virtually disappeared from Belgian waters.*"

b) Literature used (*below)

c) Literature interpretation

d) ICES conclusions

e) ICES overall evaluation

ICES agrees with the information and interpretation presented. This species also shows a decline along the Galician coast and in the Bay of Biscay. This is due to competition with other oysters of the genus *Crassostrea*, and parasite infections.

There are some signs of recovery, e.g., in the outer Skagerrak area, and along the Normandy coast, where specimens are occasionally found.

References

*Barry, M.D. 1981. Distribution and ecology of oysters, *Ostrea edulis* (L.) in Kilkieran and Bertraghboy Bays, Connemara, Co. Galway. Irish Fish Invest. (marine), 24: 1–18.

*Benthem Jutting, T. van, 1943. Mollusca. Lamellibranchia. *In* Fauna van Nederland. Ed. by H. Boschma. Sijthoff, Leiden.

*Cadee, G.C. 2000. Japanse oester (*Crassostrea gigas*) populaties tussen Oudeschild en Mok, Texel. Het Zeepaard, 60: 260–269.

*Drinkwaard, A.C. 1999. Introductions and developments of oysters in the North Sea area: a review. Helgoländer Meeresuntersuchungen, 52: 301–308.

*Jong, F. de *et al.* (eds.) 1999. Wadden Sea Quality Status Report. Common Wadden Sea Seretariat, Wilhelmshaven, Germany.

*Korringa, P. 1976. Farming the flat oyster of the genus *Ostrea*. Developments in Aquaculture and Fisheries Science, 3: 1–238.

*Reise, K. 1990. Karl Moebius: dredging the first community concept from the bottom of the sea. Deutsches Hydrographisches Zeitschrift, B 22: 149–152.

*Reise, K., and Schubert, A. 1987. Macrobenthic turnover in the subtidal Wadden Sea: the Norderaue revisited after 60 years. Helgoländer Meeresuntersuchungen, 41: 69–82.

*Reise, K., Herre, E., and Sturm, M. 1989. Historical changes in the benthos of the Wadden Sea around the island of Sylt in the North Sea. Helgoländer Meeresuntersuchungen, 43: 417–433.

*Svelle, M., Aarefjord, H., Heir, H.T., and Øverland, S. (eds.) 1997. Assessment report on fisheries and fisheries related species and habitats issues. Intermediate Ministerial Meeting on the Integration of Fisheries and Environmental Issues, 13–14 March 1997, Bergen, Norway. Ministry of Environment, Norway. 125 pp.

*United Kingdom Biodiversity Action Plan (*Ostrea edulis*), 1999.

*Vorberg, R. 2000. Effects of the shrimp fisheries on reefs of *Sabellaria spinulosa* (Polychaeta). ICES Journal of Marine Science, 57: 1416–1420.

1.2 Fish

1.2.1 *Acipenser sturio* (Sturgeon)

a) Description

"*The Sturgeon has been nominated for Region IV and by Belgium because of its status in the southern North Sea (Region II). It is a migratory species.*

<u>Threats</u> Obstruction of migration routes, pollution of lower river reaches, commercial fisheries and damage to spawning grounds.

<u>Status</u> The sturgeon was once widely distributed in European waters, from the Barents Sea to the Black Sea, and was abundant in rivers suitable for spawning. The decline is supposed to have started a couple of hundred years ago. The Atlantic population is now centred around the River Gironde in France, the River Guadalquiver in Spain and in Lake Ladogo in the former USSR. It was classified as a critically endangered species by IUCN in 1996."

b) Literature used (*below)

c) Literature interpretation

d) ICES conclusions

ICES did not evaluate the quality and suitability of the data for the listing of sturgeon.

e) ICES overall evaluation

ICES does not assess the status of sturgeon in the OSPAR area. If scientific advice is required on this species, ICES could address it with additional work within its existing expertise and structure.

References

*Almaça, C. 1988. On the sturgeon, *Acipenser sturio* Linnaeus 1758, in the Portuguese rivers and sea. Folia Zoologica, 37(2): 183–191.

*Almaça, C. 1990. A lampreia e o esturjão na bacia do Douro. Observatório, 1: 377–382.

*De Selys Longchamps, E. 1842. Faune belge. Première partie: indication méthodique des mammifères, oiseaux, reptiles, batraciens et poissons observés jusqu'ici en Belgique. Liège, Belgium. 320 pp.

*Gilson, G. 1921. Les poissons d'Ostende. Société Anonyme Belge d'Imprimerie. Brussels, Belgium. 113 pp.

*Poll, M. 1945. Contribution à la connaissance de la faune ichthyologique du bas Escaut. Bulletin du Musée royal d'Histoire naturelle de Belgique, Tome XXI, No. 11: 1–32.

*Poll, M. 1947. Poissons marins. Faune de Belgique. Musée Royal d'Histoire Naturelle de Belgique, Brussels, Belgium. 452 pp.

*Van Neer, W., and Ervynck, A. 1993. Archeologie en vis. Herlevend Verleden. Instituut voor Archeologisch Patrimonium, Zellik, 96 pp.

1.2.2 *Alosa alosa* (Allis shad)

a) Description

"*The Allis Shad has been nominated by Belgium because of its status in the southern North Sea (Region II). It is found along the coasts of western Europe from southern Norway to Spain and in the Mediterranean eastwards to* *northern Italy. It occurs mainly in shallow coastal waters and estuaries, but in the breeding season may penetrate large rivers to spawn.*

Threats *The main threats are from pollution, overfishing, habitat destruction and artificial river obstructions.*

Status *The population has declined significantly throughout Europe. For example, it used to be common and migrate up rivers in Belgium during April and May but, by 1947, was considered to have disappeared from the area. No specimens have been reported in Belgian coasts or rivers since then. In the UK, adult fish occur in small numbers around the coast in most years. It may now only breed in a few French rivers.*"

b) Literature used (*below)

c) Literature interpretation

d) ICES conclusions

ICES did not evaluate the quality and suitability of the data for the listing of Allis shad. However, it is noted that hybridization occurs with *Alosa falax* (Twaithe shad) and this may hamper recovery. Overexploitation no longer appears to be a threat.

e) ICES overall evaluation

ICES does not assess the status of Allis shad in the OSPAR area. If scientific advice is required on this species, ICES could address it with additional work within its existing expertise and structure.

References

Blacker, R.W. 1957. Benthic animals as indicators of hydrographic conditions and climatic change in Svalbard waters. Fishery Investigations (London), ser. II, 20: 1–49.

*De Selys Longchamps, E. 1842. Faune belge. Première partie: indication méthodique des mammifères, oiseaux, reptiles, batraciens et poissons observés jusqu'ici en Belgique. Liège, Belgium. 320 pp.

*Lameere, A. 1936. Les animaux de la Belgique. I: Introduction, Spongiaires, Coelentérés, Vertébrés, pp. 46–70. Les Naturalistes Belges.

*Poll, M. 1945. Contribution à la connaissance de la faune ichthyologique du bas Escaut. Bulletin du Musée royal d'Histoire naturelle de Belgique, Tome XXI, No. 11: 1–32.

*Poll, M., 1947. Poissons marins. Faune de Belgique. Musée Royal d'Histoire Naturelle de Belgique, Brussels, Belgium. 452 pp.

*Van Beneden, P.-J. 1871. Les poissons des côtes de Belgique, leurs parasites et leurs commensaux. Mém. Acad. Sci., Bruxelles, XXXVIII: 153–179.

1.2.3 *Cetorhinus maximus* (Basking shark)

a) Description

"*The Basking Shark has been nominated for the entire OSPAR area, as well as for Regions III and IV. This species is found in temperate waters in the north and south Pacific, and Atlantic, and in the Indian Oceans. It is possibly migratory with seasonal movements inshore to feed near tidal fronts in coastal areas.*

Threats *The main threats have been from directed fisheries. In the past, sharks were taken for their liver oil, whereas today, the fishery focuses on taking fins. Other threats are from accidental entanglement in fishing gear and collision with vessels during surface feeding.*

Status *Short-term exploitation by fisheries, namely off the coasts of Norway, Ireland and Scotland, and in areas infringing the northern and eastern parts of Region V has caused a rapid and sudden decline in the usually small and poorly known local populations. Catches in the NE Atlantic between 1946–1990s declined by 90 % from peak catches in the 1960s. There has been considerable variation in the numbers of sightings reported this century and in numbers taken by NE Atlantic fisheries which indicates longer-term, perhaps cyclical changes in summer distribution patterns. The basking shark is listed as Vulnerable by the IUCN.*"

b) Literature used (*below)

c) Literature interpretation

Several of the references listed by OSPAR do not include any documentation of status or trends in basking shark. The small amount of empirical evidence available does indicate that populations have undergone declines, although the magnitude of the declines is poorly documented, and that basking shark are not seen now in some areas where they once occurred. The life history attributes are poorly documented in the OSPAR area, but the available information is consistent with the species being able to sustain only a low mortality rate for directed fishing or as by-catch.

d) ICES conclusions

Decline: Trends are poorly quantified, but abundance decline has occurred in at least some parts of its range. Additional data sources might have some information about the status and recent population trends of basking shark but, at best, the information will be spotty and largely anecdotal. A better status designation could be made in 3–5 years, when ongoing tagging studies have provided new information, and potential sources of systematic reports of sightings and by-catches have been examined.

Threats: The main known threat is by-catch in a variety of fisheries, with collisions with ships and harassment as additional factors. Even low rates of these threats would be of particular concern because the species has late maturation and low fecundity.

e) ICES overall evaluation

It is consistent with the precautionary approach for this species to be listed. The evidence that is available does support the designation of basking shark as a species that has undergone declines in abundance and range. Although the seriousness of the decline is poorly quantified, the life history of the species implies that Basking shark is likely to be able to recover only slowly from the current declines, and would be at risk of declining further under by-catch rates of the recent past.

References

*Basking Shark Society (http://www.isle-of-man.com/interests/shark/).

*Camhi, M., Fowler, S., Musick, J., Bräutigam, A., and Fordham, S. 1998. Sharks and their relatives: ecology and conservation. Occasional Paper of the IUCN Species Survival Commission, 20. 39 pp.

*Castro, J.I.C., Woodley, M., and Brudek, R.L. 1999. A preliminary evaluation of the status of shark species. FAO Technical Paper, 380. 72 pp.

*Compagno, L.J.V. 1984. FAO species catalogue (Vol. 4): Sharks of the world. An annotated and illustrated catalogue of shark species known to date. FAO Fisheries Synopsis, 125. 655 pp.

*ICLARM fishbase data file.

*OSPAR. 2000. Quality Status Report 2000, Region V – Wider Atlantic. OSPAR Commission, London.

*United Kingdom Biodiversity Action Plan, 1999.

*WWF leaflet (see OSPAR IMPACT 99/4/Info.4).

1.2.4 *Coregonus lavaretus oxyrhinchus* (Houting)

a) Description

"*The Houting has been nominated by Belgium for the southern North Sea (Region II).*

<u>Threats</u> The main threats are from the obstruction of migration routes, pollution of lower river reaches, and damage to spawning and nursery grounds.

<u>Status</u> This species is no longer recorded in the southern North Sea. It was fished in the Scheldt estuary in the 19th century but was reported as uncommon along the Belgian coast in the mid-1800s. There have been no records from Belgian waters since the mid-1900s and it is also thought to be extinct in British waters. The houting is listed by IUCN as Endangered."

b) Literature used (*below)

c) Literature interpretation

d) ICES conclusions

ICES did not evaluate the quality and suitability of the data for the listing of houting.

e) ICES overall evaluation

ICES does not assess the status of houting in the OSPAR area. If scientific advice is required on this species, ICES could address it within its existing expertise and structure.

References

*De Selys Longchamps, E. 1842. Faune belge. Première partie: indication méthodique des mammifères, oiseaux, reptiles, batraciens et poissons observés jusqu'ici en Belgique. Liège, Belgium. 320 pp.

*Gilson, G. 1921. Les poissons d'Ostende. Société Anonyme Belge d'Imprimerie, Brussels, Belgium. 113 pp.

*Poll, M. 1945. Contribution à la connaissance de la faune ichthyologique du bas Escaut. Bulletin du Musée royal d'Histoire naturelle de Belgique, Tome XXI, No. 11: 1–32.

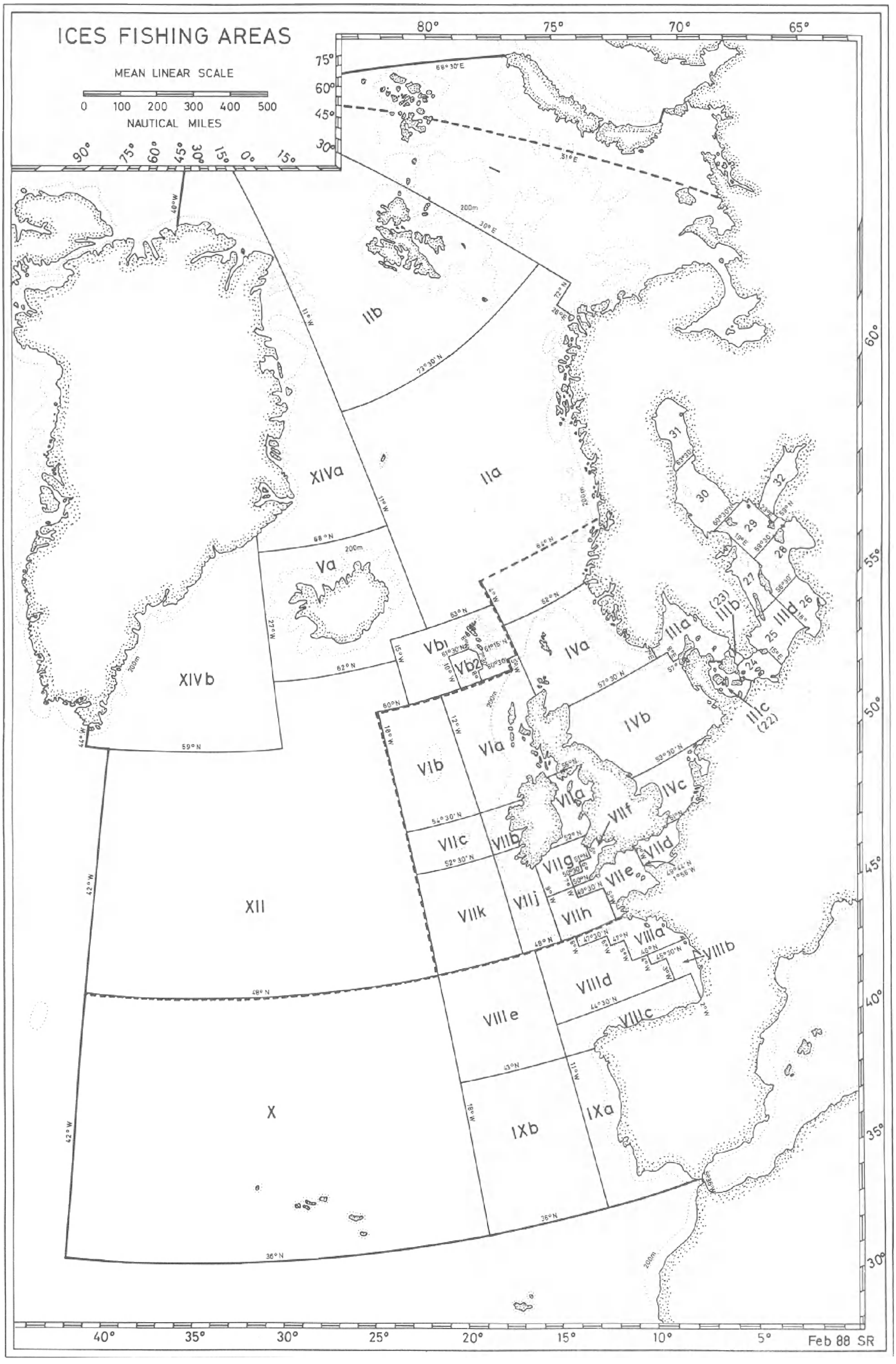
*Poll, M. 1947. Poissons marins. Faune de Belgique. Musée Royal d'Histoire Naturelle de Belgique, Brussels, Belgium. 452 pp.

*Van Beneden, P.-J. 1871. Les poissons des côtes de Belgique, leurs parasites et leurs commensaux. Mém. Acad. Sci., Bruxelles, XXXVIII: 153–179.

1.2.5 *Gadus morhua* (Cod)

a) Description

"*The Cod has been nominated for the entire OSPAR Maritime Area. It is a widely distributed species found close to the shore and well down the continental shelf. To*


ICES FISHING AREAS
MEAN LINEAR SCALE
0 100 200 300 400 500
NAUTICAL MILES
IIb
IIa
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the south of its range, it is found in shallow water only during the winter, and there, as elsewhere, it is the younger smaller fish which live close inshore. Adults make considerable migrations to reach spawning grounds. There are a number of stocks in the North Atlantic.

<u>Threats</u> Overfishing in directed fisheries as well as by-catch in mixed fisheries. Depletion of food sources and global warming have also been suggested as possible reasons for the decline.

<u>Status</u> Stocks in ICES areas IV, VIId & IIIa which cover the northern and central North Sea and Skagerrak are considered to be below Safe Biological Limits."

b) Literature used (*below)

c) Literature interpretation

The literature listed by OSPAR is just a small portion of the literature relevant to evaluating the status and trends of cod stocks in the OSPAR area, and threats to cod. By far the most directly relevant information on the status and trends of cod stocks in the OSPAR area comes from the ICES annual assessments. The ICES website is listed as a source of information, but the date of 2000 suggests that the evaluations of the stocks used assessments that are one to two years out of date.

The stocks that were assessed as outside safe biological limits by ICES in 2000 were correctly reported by OSPAR. The evidence that depletion of food supplies and global warming have played an important role in declines of cod stocks is incomplete and sometimes speculative. Although cod stocks are clearly affected by ocean conditions and food supply, evidence that these factors would have caused major declines in cod stocks, without overfishing, is weak.

d) ICES conclusions

Location: The OSPAR proposals do not specify all the cod stocks that occur within the OSPAR area, nor are there justifications for the proposed exclusion of some stocks off Norway from designation along with the other cod stocks. There are additional cod stocks in the Baltic Sea and the Northwest Atlantic, and many of these stocks are also very low, compared to historic sizes.

Decline:

Icelandic cod (Va) – Safe biological limits have not been defined for this stock; spawning biomass has been relatively stable for nearly twenty years, but is lower than biomasses observed prior to the 1980s.

Faroe Plateau cod (Vb1) – The spawning stock biomass (SSB) is above safe biological limits, but fishing mortality is so high that it is being harvested outside of safe biological limits.

Faroe Bank cod (Vb2) – Safe biological limits have not been determined for this stock but the biomass is above the long-term average.

Northeast Arctic cod (I and II) – The stock is outside safe biological limits, and SSB declined substantially through the 1990s.

Kattegat cod – The stock is outside safe biological limits, and SSB has declined substantially from the 1970s to the 1990s, with a few brief periods of improved status.

North Sea and Skagerrak cod (IV, VIId, and IIIa) – The stock is outside safe biological limits. SSB has declined fairly consistently since the 1970s.

Cod West of Scotland (VIa) – The stock is outside safe biological limits. SSB has declined markedly since the 1980s.

Cod in the Irish Sea (VIIa) – The stock is outside safe biological limits. SSB declined markedly between 1989 and 1990, and slightly more thereafter.

Cod in Western Channel and Celtic Sea (VIIe–k) – The stock is outside safe biological limits. SSB has undergone two periods of increase and subsequent decrease since the late 1970s, and is currently near its historic low.

Threats: By far the largest threat to cod stocks comes from fisheries. The effect of fishing may have been amplified by environmentally induced changes in productivity, but evidence for this threat is incomplete. Rebuilding plans for these stocks have focused on tools to reduce fishing mortality.

e) ICES overall evaluation

There is no question that cod stocks have declined substantially overall in the OSPAR area, and the status of many individual stocks is poor. Even for the most depressed stocks, populations are sufficiently large that there is no risk of extirpation, and for most or all stocks, declines appear to have ceased. However, the rebuilding of these stocks has been slow, and in many cases promising increases in abundance in the 1980s or 1990s did not prove to be lasting improvements in stock status.

All stocks are already addressed by management plans, and several, including North Sea cod and Irish Sea cod, have Rebuilding Plans in place. ICES does not consider that the recovery of these stocks would be aided further through measures that arise from a designation of cod as "threatened or declining".

References

*Cohen, 1990. http://www.fishbase.org (Ref. No. 1371).

*ICES. http://www.ices.dk/committe/acfm/comwork/report/asp/acfmrep.asp

ICES. 2001. Report of the ICES Advisory Committee on Fishery Management, 2001. ICES Cooperative Research Report, 246.

*OSPAR. 2000. Quality Status Report 2000, Region II – Greater North Sea. OSPAR Commission, London.

*Muus and Nielsen, 1999. http://www.fishbase.org (Ref. No. 35388).

1.2.6 *Gobius couchi* (Couch's goby)

a) Description

b) Literature used (*below)

c) Literature interpretation

d) ICES conclusions

ICES did not evaluate the quality and suitability of the data for the listing of Couch's goby.

e) ICES overall evaluation

ICES does not assess the status of Couch's goby in the OSPAR area. If scientific advice is required on this species, ICES could address it with additional work within its existing expertise and structure.

References

1.2.7 *Hoplostethus atlanticus* (Orange roughy)

a) Description

"*The Orange Roughy has been nominated for Region V. It is a benthopelagic species which inhabits deep, cold waters over steep continental slopes, ocean ridges and seamounts. It appears to be dispersed in depths of 180–1,809 m. Little is known of the biology of the larvae and juveniles which are probably confined to deep water.*

Threats The main threat is from overfishing of the dense spawning and non-spawning aggregations which form sporadically.

Status Catch statistics show a decline in biomass in the traditional fishing areas. The stocks in ICES sub-area VI (NE area of OSPAR Region V) are outside safe biological limits. The situation in ICES sub-area VII appears to be less serious. The state of stocks in other areas is not known."

b) Literature used (*below)

c) Literature interpretation

The ICES assessments are reported correctly.

d) ICES conclusions

Location: The description of the range of orange roughy is consistent with the information available, although the information in much of Region V is incomplete, and there may be areas where orange roughy is present but has not been documented.

Decline: The stock in ICES Sub-area VI is outside safe biological limits. The status of stocks in other areas is unquantified, but the available evidence suggests that many have been depleted.

Threats: Fishing is the main threat to orange roughy. The species is vulnerable to fishing both because of its life history and because it is a densely aggregating species. There has been a pattern in some parts of the OSPAR area and other parts of the world for aggregations to be discovered, exploited intensively, and depleted faster than the information needed for managing the fisheries sustainably can be collected and effective management implemented.

e) ICES overall evaluation

The status of the stock, where known, is consistent with the designation.

References

*ICES ACFM Report 2000, section 3.12.6.g.

*ICLARM fishbase and references/literature referred to therein.

*Koslow, J.A., Boehlert, G.W., Gordon, J.D.M., Haedrich, L., Lorance, P., and Parin, N. 2000. Continental slope and deep-sea fisheries: implications for a fragile ecosystem. ICES Journal of Marine Science, 57: 548–557.

*OSPAR. 2000. Quality Status Report 2000, Region V – Wider Atlantic. OSPAR Commission, London.

1.2.8 *Petromyzon marinus* (Sea Lamprey)

a) Description

"*The Sea Lamprey has been nominated for the southern North Sea (Region II) by Belgium. It is an anadromous species, breeding in fresh waters. Little is known of its life at sea except that it feeds as a parasite on a wide range of fishes and cetaceans. The species is found in the North Atlantic from Portugal to the North and Baltic Seas, along the Norwegian coast to the Barents Sea, and from Iceland and Labrador to Florida.*

Threats *The main threats to this species are from the obstruction of migration routes, pollution of lower river reaches, and damage to spawning and nursery grounds.*

Status *Compared to the situation in the 19th century, the species has disappeared or almost disappeared along the Belgian coast and in the Scheldt Estuary. It is only rarely caught these days from this area.*"

b) Literature used (*below)

c) Literature interpretation

d) ICES conclusions

ICES did not evaluate the quality and suitability of the data for the listing of sea lamprey.

e) ICES overall evaluation

ICES does not assess the status of sea lamprey in the OSPAR area. If scientific advice is required on this species, ICES could address it with additional work within its existing expertise and structure.

Reference

*Poll, M. 1945. Contribution à la connaissance de la faune ichthyologique du bas Escaut. Bulletin du Musée royal d'Histoire naturelle de Belgique, Tome XXI, No. 11: 1–32.

1.2.9 *Raja batis* (Common skate)

a) Description

"*The Common Skate has been nominated for the entire OSPAR Maritime Area. It is the largest and heaviest European ray and an active predator feeding in mid-water as well as close to the seabed. Adults mostly live between 90–220 m and young fish in shallower water. The Greater North Sea/Celtic Sea was thought to be the most important region for this species, amounting to around 75 % of the population, but further confirmation is required.*

Threats *The main threat to this species is from directed fisheries and by-catch, with the added possibility that fishing in spawning areas may increase embryo mortality. Bioaccumulation is also thought to be a threat.*

Status *The Common Skate is considered to be a globally endangered species by IUCN. It is no longer abundant in Region II, although single specimens are occasionally encountered. This species was considered common in Belgian waters in the early 1900s, although not very close inshore. However, there are no recent records.*"

b) Literature used (*below)

c) Literature interpretation

The literature used in the OSPAR designation was in general interpreted correctly, although a number of the references listed did not contain any original information on the status of the common skate. However, the OSPAR use of the literature focused primarily on Belgian waters, and information is available on the status and trends over much larger parts of the OSPAR area. The identification of common skate as a species highly sensitive to mortality (due to fishing) is consistent with the scientific evidence they consulted.

d) ICES conclusions

Location: Common skate is widespread in the OSPAR area, from the Iberian Peninsula and Bay of Biscay to, at least, the northern North Sea. Its westward distribution is less well documented, but it is being found in developing fisheries in the mid-Atlantic Ridge, and in deeper areas of Sub-areas VI and VII.

Decline: Common skate has declined throughout its range. The magnitude of decline is differentially well documented in various areas, but it is known to have severely declined in most shelf areas.

Threats: Directed and by-catch fishing mortality is the major threat to common skate. Its vulnerable life history makes the threat to population status posed by even only by-catch mortality potentially serious. The recent expansion of fishing into deep-water areas of ICES Sub-areas VI and VII, and along the Mid-Atlantic Ridge, exploits previously unharvested portions of this species. Depending on unknown relationships between deep-water and shelf "populations" of skates, it is possible that these fisheries could be reducing the remaining spawning population for common skate. The threat listed by OSPAR that trawling on spawning areas may increase risk by damaging embryos is speculative, but warrants investigation. The proposed threat of bioaccumulation of contaminants is highly speculative, and although further research could increase the documentation of this threat, conservation efforts should focus on measures to address fishing.

e) ICES overall evaluation

The designation of common skate as threatened or declining is consistent with the scientific evidence.

References

*Brander, K. 1981. Disappearance of common skate *Raja batis* from Irish Sea. Nature, 290: 48–49.

*Camhi, 1998. http://www.fishbase.org. (Ref. No. 27952).

*Gilson, G. 1921. Les poissons d'Ostende. Société Anonyme Belge d'Imprimerie, Brussels, Belgium. 113 pp.

*ICES. 1998. Report of the ICES Advisory Committee on Fishery Management, 1997, Part 1, Section 3.5.16 Rays and skates in Sub-area IV (North Sea). ICES Cooperative Research Report, 223: 171–172.

*Knijn, R.J., Boon, T.W., Heessen, H.J.L., and Hislop, J.R.G. 1993. Atlas of North Sea Fishes based on Bottom Trawl Survey Data from the Years 1985–1987. ICES Cooperative Research Report, 194. 268 pp.

*Lameere, A. 1936. Les animaux de la Belgique. I: Introduction, Spongiaires, Coelentérés, Vertébrés, pp. 46–70. Les Naturalistes Belges.

*OSPAR. 2000. Quality Status Report 2000, Region II – Greater North Sea. OSPAR Commission, London.

*Poll, M. 1947. Poissons marins. Faune de Belgique. Musée Royal d'Histoire Naturelle de Belgique, Brussels. 452 pp.

*Rumohr, H. 1998. http://www.fishbase.org.

*United Kingdom Biodiversity Action Plan for *Raja batis*, 1999.

*Walker, P.A. 1998. Fleeting Images, dynamics of North Sea ray populations. Thesis, Faculty of Biology, University of Amsterdam.

*Walker, P.A., and Heessen, H.J.L. 1996. Long-term changes in ray populations in the North Sea. ICES Journal of Marine Science, 53: 1085–1093.

*Walker, P.A., and Hislop, J.R.G. 1998. Sensitive skates or resilient rays? Spatial and temporal shifts in ray species composition in the central and north-western North Sea between 1930 and the present day. ICES Journal of Marine Science, 55: 392–402.

*Wheeler, A. 1978. Key to the Fishes of Northern Europe. Frederick Warne & Co. Ltd. 380 pp.

1.2.10 *Raja montagui* (Spotted ray)

a) Description

"*The Spotted Ray has been nominated by Belgium for the southern North Sea (Region II). It is a species that lives in moderately deep water (60–120 m) and is most common on sandy seabed. It feeds almost entirely on crustaceans when young, but as it grows the diet includes crabs.*

Threats The main threat is from fisheries.

Status There has been a severe decline in the abundance of this species in Belgian waters during the 20th century. It was considered common in the mid-1900s. Today it is only observed very rarely in Belgian waters."

b) Literature used (*below)

c) Literature interpretation

The OSPAR treatment focused on information about the status of spotted ray near Belgium. Information is available on its status over a much wider area of the North Sea and adjacent waters. In many other areas, spotted ray shows different trends than those observed in the waters off Belgium. The identification of spotted ray as a species highly sensitive to mortality (due to fishing) is consistent with the scientific evidence they consulted.

d) ICES conclusions

Location: The spotted ray is widely distributed through the North Sea and adjacent shelf waters.

Decline: The spotted ray has declined in some areas in the eastern and southern North Sea, but is still common with little evidence of decline in the western North Sea.

Threats: Mortality as by-catch in fisheries is the primary threat to spotted ray.

e) ICES overall evaluation

Observations across the full range of this species have not shown marked overall declines, even if the status has declined in some areas. The designation as threatened and declining in the North Sea is not appropriate.

References

*Gilson, G. 1921. Les poissons d'Ostende. Société Anonyme Belge d'Imprimerie, Brussels, Belgium. 113 pp.

*Haelters, J., and Kerckhof, F. personal observation.

*Poll, M. 1947. Poissons marins. Faune de Belgique. Musée Royal d'Histoire Naturelle de Belgique, Brussels, Belgium. 452 pp.

*Rappé, G., and Eneman, E. 1988. De zeevissen van België. De Strandvlo 5(extra nummer), 48 pp.

1.2.11 *Salmo salar* (Salmon)

a) Description

"*The Atlantic Salmon has been nominated for the entire OSPAR Maritime Area.*

<u>*Threats*</u> *The main threats are from aquaculture, which is a source of parasites and other diseases, chemical pollution and special breeds which escape and interbreed with wild salmon populations. Pollution, salmon as by-catch, and targeted salmon fisheries are other threats.*

<u>*Status*</u> *The stock status for 40 monitored rivers in the NEAC area shows that the recovery of salmon stocks observed in 1998 from a period of low attainment (1994–1997) did not continue in 1999. Adult returns in northern European rivers show declining counts in the last ten years. There has also been a significant decreasing trend in smolt outputs during the past ten years.*"

b) Literature used (*below)

c) Literature interpretation

There are many more papers on the status and trends of Atlantic salmon than were cited by OSPAR, However, the main sources of information on these factors would be the ICES scientific advice and the NASCO documents. These were used, but the material cited is two years out of date.

The interpretation of status and trends in salmon stocks is generally consistent with the expert scientific advice from ICES, and conclusions of NASCO, although the rationale for excluding Norway and Iceland is weak and not readily reconciled with the assessment material. It is true that trends in Norwegian rivers are not all downward, but that is true for rivers of many other countries.

The interpretation of threats is not consistent with the information, particularly from ICES. Among the important factors in salmon declines, where they have occurred, are loss or deterioriation of freshwater habitats for pre-smolts and an overall decrease in marine survival for reasons that are poorly known. Exploitation has also not been kept below sustainable rates, with high probability, in many areas. To designate aquaculture, chemical pollution, and escapees as the main threats is incorrect, although in specific cases each of those factors may have played a role.

d) ICES conclusions

Location: Atlantic salmon are found in rivers from the Bay of Biscay north to Iceland and Russia. In addition to their egg through juvenile period in fresh water, salmon spend at least one winter at sea, with some reaching as far west in the Atlantic as Greenland. In past centuries, salmon populations were lost from many rivers, due probably to habitat alteration associated with agriculture, industrial development, and human population increase, as well as unregulated exploitation. For several decades, however, salmon have been a highly valued species culturally, and significant efforts have been taken to protect rivers which support salmon, and to regulate harvests.

Decline: Although there is variation among rivers, in general, the total returns of salmon and spawning stock to rivers in the northern NEAC area (Finland, Iceland, Norway, Russia, Sweden) have fluctuated for the past twenty years, but show an increase in recent years. In contrast, salmon stocks in Iceland show a decline since the 1980s. Salmon stocks in the southern NEAC area show a consistent decline over the past 20–30 years. This relates especially to salmon which spend more than one winter at sea.

Threats: Marine survival of wild (and hatchery-reared) smolts in both northern and southern NEAC areas (which cover the OSPAR Maritime Area) shows a constant decline over the past twenty years. The steepest decline is in the wild smolts in the southern NEAC area (France, Ireland, UK). The survival of both wild and hatchery fish returning after two winters at sea in the northern NEAC area has increased slightly in most recent years. The causes of this decline in marine survival are unknown, but they cannot be explained solely as a consequence of mariculture and coastal pollution.

e) ICES overall evaluation

Overall, salmon does not qualify as a threatened or declining species throughout the OSPAR area. Such designations might be appropriate for some individual rivers or groups of rivers, particularly in more southern areas. However, declines in marine survival have been compensated for, at least partially, by decreases in harvest, to maintain spawning escapement to rivers. Significant scientific effort, management actions, and community-based conservation programmes are already implemented for salmon throughout much of its range.

References

*Gowen, R.J., and Rosenthal, H. 1993. The environmental consequences of intensive coastal aquaculture in developed countries; what lessons can be learnt, pp. 102–115. Ed. by R.S.V. Pullin, H. Rosenthal, and J.L. Maclean.

*Environment and aquaculture in developing countries. ICLARM Conference Proceedings, 31. 359 pp.

*ICES. 2000. http://www.ices.dk/committee/acfm/comwork/report/2000/contents.html.

ICES. 2002. Report of the ICES Advisory Committee on Fishery Management, 2002. ICES Cooperative Research Report. 255.

ICES. 2002. Report of the Working Group on North Atlantic Salmon. ICES CM 2002/ACFM:14.

*NASCO (North Atlantic Salmon Conservation Organization). 1999. Report on the Activities of the North Atlantic Salmon Conservation Organization in 1998–1999. NASCO, Edinburgh.

*NASCO (North Atlantic Salmon Conservation Organization). 2000. Report of the annual meeting of the council. Seventeenth annual meeting. Miramichi, Canada, CNL (00)57. NASCO, Edinburgh.

*OSPAR. 2000. Quality Status Report 2000, Region II – Greater North Sea. OSPAR Commission, London.

1.2.12 *Thunnus thynnus* (Bluefin tuna)

a) Description

"*The Bluefin tuna has been nominated for Region V. This is an oceanic species that comes close to shore on a seasonal basis. They school by size, sometimes together with other species of tuna, and prey on small schooling fishes or on squid and red crabs.*

Threats The main threats are from overexploitation of older fish and a high fishing pressure on small fish despite minimum size restrictions. Bluefin tuna are also a by-catch of some longline fisheries.

Status Western and Eastern Atlantic stocks mix, so the status of these stocks are not independent of each other. Current evaluations by ICCAT indicate that current catch levels are not sustainable and that a reduction to 75 % of the 1994 level is not sufficient to halt a continuing decline in the spawning stock. In the Eastern Atlantic there was a period of relatively stable abundance in the 1980s, but this has been followed by a strong decline in number and biomass of older fish since 1993. Estimates need to be viewed with caution as it is difficult to obtain and interpret data on landings of this species. In addition, most of the ICCAT statistics and projections treat the smaller Eastern Atlantic stock together with the larger Mediterranean stock."

b) Literature used (*below)

c) Literature interpretation

d) ICES conclusions

ICES did not evaluate the quality and suitability of the data for the listing of bluefin tuna.

e) ICES overall evaluation

ICES could provide an independent review of the assessments and information from ICCAT, and scientific advice in the specific context of designations of threatened and declining species. ICCAT would be the appropriate authority on the abundance and trajectory of bluefin tuna populations.

References

Reports of the International Commission for the Conservation of Atlantic Tuna (ICCAT).

1.2.13 *Hippocampus hippocampus* (short-snouted seahorse)

a) Description

"*The Short-snouted seahorse has been nominated for Region IV. It is rare in northern European waters. It occurs mostly in shallow inshore waters among algae, but may overwinter in deeper water.*

Threats The main threats are from habitat destruction (of seagrass beds) and overfishing for the curio trade.

Status The species is classified as vulnerable on Fishbase."

b) Literature used (*below)

c) Literature interpretation

d) ICES conclusions

ICES did not evaluate the quality and suitability of the data for the listing of short-snouted seahorse.

e) ICES overall evaluation

ICES does not assess the status of short-snouted seahorse in the OSPAR area. If scientific advice is required on this species, ICES could address it with additional work within its existing expertise and structure.

References

1.2.14 *Hippocampus ramulosus* (Seahorse)

a) Description

"*This seahorse has been nominated for Region IV This species is a rare visitor to northern European waters and possibly only occurring as a result of a northerly summertime migration. It is found in inshore waters amongst eelgrass and fine algae, but has also been captured floating in the open sea near the surface.*

Threats The main threats are from habitat destruction (of seagrass beds) and overfishing for the curio trade.

Status ?"

b) Literature used (*below)

c) Literature interpretation

d) ICES conclusions

ICES did not evaluate the quality and suitability of the data for the listing of this seahorse.

e) ICES overall evaluation

ICES does not assess the status of seahorse in the OSPAR area. If scientific advice is required on this species, ICES could address it with additional work within its existing expertise and structure.

References

1.3 Birds

1.3.1 *Polystica stelleri* (Steller's eider)

a) Description

"*Steller's eider has been nominated for Region I. This species breeds along the Arctic coast of Alaska and the eastern half of Siberia. The main European site, used by non-breeding birds in summer and by wintering birds, is the Varangerfjord in northern Norway.*

Threats Oil spills can, and have, affected this species which is particularly vulnerable because of the large congregations of non-breeding birds in restricted areas. Fishing nets also known to have trapped and drowned birds.

Status The European wintering population is thought to number around 14,000 birds, 80–90 % of which use the Varangerfjord in Norway. The general trend in Europe is one of stable/fluctuating or increasing numbers. Elsewhere, outside the OSPAR Area, there has been a severe decline in the wintering population in Alaska."

b) Literature used (*below)

One literature reference (Nygard *et al.*, in prep) was supplied to support this nomination. Several further key references are cited below.

c) Literature interpretation

ICES is unable to comment on the listed reference as this manuscript is not available in the public domain, and we have no knowledge of the content.

d) ICES conclusions

Location: Nygard *et al.* (1995) estimated the population of Steller's eiders in the Barents Sea to be between 25,000 and 40,000 wintering birds. This represents 15–20 % of the world population of this species. The wintering population is predominantly found within the Varanger Fjord, northern Norway, and along the Murman coast, so it is fairly concentrated.

Decline: Bustnes, Bianki and Koryakin, in Anker-Nilssen *et al.* (2000) summarized the population trend as "reasonably stable". They report that there are some indications of an increase in the wintering population off the eastern Murman coast.

Threats: Steller's eiders are vulnerable to drowning in fishing gear, especially nets set for lumpsuckers in spring (Frantzen and Henriksen, 1992). They are also vulnerable to oil pollution. Increased tanker traffic offshore from the Murman coast represents a hazard to this highly concentrated population.

e) ICES overall evaluation

It is not explicit from the text why this species has been selected for priority list inclusion, given that it appears to have a stable, or possibly increasing, population within the OSPAR area. The status of this species elsewhere in the world may be relevant (ACE could not decide from the rather unclearly expressed criteria for selection how much OSPAR wishes to take that factor into account). The Steller's eider is a red-listed species for the Bering Sea (references to this are not included in the OSPAR reference list for the species). It is not clear whether OSPAR wishes to list this species because it has a severely threatened status elsewhere in the world, despite its apparently healthy population status within the OSPAR area.

References

Anker-Nilssen, T., Bakken, V., Strøm, H., Golovkin, A.N., Bianki, V.V., and Tatarinkova, I.P. 2000. The status of marine birds breeding in the Barents Sea region. Report No. 113. Norsk Polarinstitutt, Tromsø. 213 pp.

Frantzen, B., and Henriksen, G. 1992. Steller's eider in Finmark (Stellerand i Finmark). Fauna 45: 100–107. (In Norwegian)

Nygard, T., Frantzen, B., and Svazas, S. 1995. Steller's eider *Polystica stelleri* wintering in Europe: number, distribution and origin. Wildfowl, 46: 140–155.

1.3.2 *Puffinus assimilis baroli* (Little shearwater)

a) Description

"*The Little Shearwater has been nominated for OSPAR Region V. The species has a fragmented distribution in all three world oceans, with most of its range in the southern hemisphere.* P.a. baroli *is an endemic European race which breeds in the archipelagos of Madeira, Azores and the Canaries.*

<u>Threats</u> *The main threats are from disturbance of breeding birds, depredation by introduced predators such as cats, dogs, rats, mustelides and, most importantly, predation by Yellow-Legged Gulls. Oil pollution can be a threat when birds are feeding at sea.*

<u>Status</u> *There is a small total population of the European race (between 2,700–3,900 pairs) and over 60 % of these breed in the Madeiran archipelago where numbers are probably stable. In the Canaries, the population declined rapidly between 1970–1990. The entire population in the OSPAR region is found at and around four sites in the Azores and probably represents around 15 % of the European population. The number of breeding birds using these islands and surrounding waters is believed to have fallen dramatically in historic times. The pattern and extent of the decrease in recent times is uncertain, but the current breeding population in the Azores is believed to be between 840–1,530 pairs.*"

b) Literature used (*below)

The Monteiro *et al.* (1999) paper is missing from the OSPAR references listed for this species but provides the most up-to-date assessment of the population within the OSPAR area. The reference listed as Harrison (1983) does not seem to be relevant.

c) Literature interpretation

d) ICES conclusions

Location: Monteiro *et al.* (1999) located several previously unknown colonies of little shearwater in the Azores during seabird surveys in the late 1990s. They estimated that there were 840–1,530 pairs of little shearwaters in the Azores. This represents the entire known breeding population within the OSPAR area.

Decline: Evidence for a decline in breeding numbers within the OSPAR area is based on relatively poorly documented population trends in the Azores (Monteiro *et al.*, 1996a). However, there is very strong circumstantial evidence indicating that most areas of the Azores have become unsuitable as breeding habitat due to rats and cats introduced by human colonization and established settlement on the main islands. Almost all remaining colonies of little shearwaters are on rat- and cat-free islets or on relatively inaccessible cliffs.

Threats: Little shearwaters are clearly threatened by mammalian predators, such as rats and cats. Yellow-legged gulls may also kill some birds, and yellow-legged gull numbers appear to be increasing in the Azores.

e) ICES overall evaluation

The little shearwater as a species is widely distributed and is not considered to be endangered or threatened. Thus, ICES assumes that OSPAR is considering only the subspecies *baroli* for priority listing. Numbers of this subspecies outside the OSPAR area are rather larger than numbers within the OSPAR area, but the population in Cape Verde appears to be declining and threatened, while that in Madeira is currently stable but has probably declined in the past. It is not clear how much the status and trends outside the OSPAR area should affect a decision to list this subspecies within OSPAR.

References

*Bannerman, D.A., and Bannerman, W.M. 1966. Birds of the Atlantic islands, 3: a history of the birds of the Azores. Oliver & Boyd, Edinburgh.

*Bourne W.R.P. 1955. Birds of the Cape Verde Islands. Ibis, 97: 508–556.

*Cramp, S., and Simmons, K.E.L. 1977. The birds of the Western Palearctic, Volume 1. Oxford University Press.

*Croxall, J.P., Evans, P.G.H., and Schreiber, R.W. 1982. Status and Conservation of the World's Seabirds. International Council for Bird Preservation, Technical Publication No. 2. Cambridge, UK.

*Harrison, P. 1983. Seabirds: an identification guide. Croom Helm, Beckenham, UK.

*Heath, M.F., and Evans, M.I. (eds.) 2000. Important Bird Areas in Europe. Priority Sites for conservation. Vol. 2, Southern Europe. BirdLife Conservation Series No. 8. BirdLife International, Cambridge, UK.

*Le Grand, G., Emmerson, K., and Martin, A. 1984. The status and conservation of seabirds in the Macronesian Islands. *In* Status and conservation of the world's seabirds, pp. 377–391. Ed. by J.P. Croxhall, P.J.H. Evans, and R.W. Schreibe. International Council for Bird Preservation, Technical Publication No. 2. Cambridge, UK.

Monteiro, L.R., Ramos, J.A., and Furness, R.W. 1996a. Past and present status and conservation of the seabirds breeding in the Azores archipelago. Biological Conservation, 78: 319–328.

Monteiro, L.R., Ramos, J.A., Furness, R.W., and del Nevo, A.J. 1996b. Movements, morphology, breeding, molt, diet and feeding of seabirds in the Azores. Colonial Waterbirds, 19: 82–97.

Monteiro, L.R., Ramos, J.A., Pereira, J.R.C., Monteiro, P.R., Feio, R.S., Thompson, D.R., Bearhop, S., Furness, R.W., Laranjo, M., Hilton, G., Neves, V.C., Groz, M.P., and Thompson, K.R. 1999. Status and distribution of Fea's petrel, Bulwer's petrel, Manx shearwater, little shearwater and band-rumped storm-petrel in the Azores archipelago. Waterbirds, 22: 358–366.

*Mougin, J.-L., Jouanin, C., and Roux, F. 1992. [Breeding chronology of little shearwater and Audubon's shearwater]. Oiseau et RFO, 62: 247–277.

*Snow, D.W., and Perins, C.M. 1998. The Birds of the Western Palearctic. Volume I, Non-Passerines. Oxford University Press, New York.

*Tucker, G.M., and Heath, M.F. 1994. Birds in Europe. Their conservation status. BirdLife Conservation Series No. 3. BirdLife International, Cambridge, UK.

1.3.3 *Sterna dougallii* (Roseate tern)

a) Description

"*The Roseate Tern has been nominated for Region V, as well as the entire OSPAR Maritime Area It is a migratory species, with the European birds moving from breeding areas in August–September to Gulf of Guinea where they remain until November or December. Their whereabouts are unknown after this until they return to the northern breeding colonies in April–June.*

<u>Threats</u> *The main threats to these species on land are disturbance, and introduced predators such as cats, dogs, rats and mustelids. At sea the species is vulnerable to oil pollution due to its highly concentrated distribution around breeding colonies. Fisheries effects on prey species, inter-specific competition for food and the danger of being caught as by-catch on longlines are other threats.*

<u>Status</u> *The world population is estimated to comprise between 25,000 and 50,000 pairs. Between 3–6 % of these birds breed in the OSPAR Area, of which 66 % breed on the Azores with remaining birds using the west coasts of Britain and Ireland and the north coast of France. The Roseate Tern declined in the 19th century but then showed some recovery in the 20th century due to protection. For example, in Britain and Ireland it was close to extinction in 1900 but increased to around 3,500 pairs in 1962. However, the birds suffered a dramatic population decline more recently between 1969 and 1987 through much of their European range, particularly in the northwest. The Azorean population is also believed to have declined, although the pattern of the decrease is uncertain.*"

b) Literature used (*below)

The spelling of author's names is inaccurate in the OSPAR reference list. In particular, del Nivo should be del Nevo, Perins should be Perrins. These spellings have been corrected in the references cited here.

c) Literature interpretation

The reference listed as Avery *et al.* (in prep.) is unavailable, so we cannot comment on its content. The del Nevo (1990) reference to a report not generally available appears to be the same work as del Nevo *et al.* (1993) in a journal; if so, only the latter should be listed.

d) ICES conclusions

Location: The nominate subspecies breeds in Europe, in the Azores, France, Ireland, and the United Kingdom. About 379–1,051 pairs of roseate terns have nested in the Azores between 1985 and 2000, and represent the largest part of the population of this subspecies. There are now about 70 pairs in France, 618 pairs in Ireland, and 50 pairs in the United Kingdom (data for 2000 or 2001). Counts vary considerably from year to year and it is not clear how much of the variation is due to counting difficulties, and how much to birds choosing not to breed in some years, perhaps in response to changes in food availability. Certainly, the distribution of pairs around the Azores can change considerably from year to year, suggesting that birds are responding by moving site according to conditions. This may also be influenced by predation impacts at particular colonies. The Azores population has consistently been by far the largest in the OSPAR area in recent years, but may have been overtaken by the colony at Rockabill, Ireland, in the past two or three years.

Decline: Counts of breeding pairs of roseate terns in the Azores in the period 1995–2001 have been only about 50 % of those in 1985–1995. Long-term declines have been well documented in Britain, Ireland, and France (Lloyd *et al.*, 1991; JNCC reports). The numbers in Britain and Ireland fell by 70–75 % between 1969 and 1985, for example, although conservation efforts at Rockabill have led to an important increase in numbers there over the last few years.

Threats: Killing of terns in West Africa is a major concern. There is strong evidence to implicate trapping as the primary cause of population decline (Lloyd *et al.*, 1991). Other threats include predators at colonies, including foxes, rats, gulls, egg collectors, and peregrine falcons in Britain, Ireland, and France (Lloyd *et al.*, 1991). Birds in the Azores are killed at colonies by common buzzards and yellow-legged gulls, and eggs are taken by European starlings. Human disturbance can be a problem at colonies, although most sites have legal protection. This is not very effective in the Azores, where fishermen and tourists may visit nesting islets and cause serious disturbance.

e) ICES overall evaluation

The text on this species appears to be accurate and reasonably complete. The recent annual counts of roseate terns in the Azores suggest that numbers have decreased by about 50 % over the past fifteen years. There is evidence of predation on eggs and chicks by European starlings and common buzzards at some Azores colonies (to add to the list of threats in the OSPAR text), but breeding productivity has not been quantified accurately. Although OSPAR lists cats, dogs, rats, and mustelids as threats to colonies, most roseate tern colonies are located on predator-free islets.

The roseate tern is a very clear case for listing as a priority species due to a well-documented and severe population decline within the OSPAR Maritime Area. It has also declined seriously in numbers in several other parts of the world. There is some evidence that birds can move between the OSPAR area and North American colonies, but since both have adverse conservation status, such movements will do little to mitigate population declines.

References

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*Cramp, S. 1985. The birds of the Western Palearctic, Volume 4. Oxford University Press.

*Croxall, J.P., Evans, P.G.H., and Schreiber, R.W. 1982. Status and Conservation of the World's Seabirds. International Council for Bird Preservation. Technical Publication No. 2. Cambridge, UK.

*del Nevo, A.J., Dunn, E.K., Medeiros, F.M., Le Grand, G., Akers, P., and Monteiro, L.R. 1990. Status, distribution and conservation of Garajau Rosado and Garajau Comum in the Azores. Report to RSPB.

*del Nevo, A.J., Dunn, E.K., Medeiros, F.M., Le Grand, G., Akers, P., and Monteiro, L.R. 1993. The status of roseate terns and common terns in the Azores. Seabird, 15: 30–37.

*Dunn, E.K., and Mead, C.J. 1982. Relationship between sardine fisheries and recovery rates of ringed terns in West Africa. Seabird, 6: 98–104.

*Heath, M.F., and Evans, M.I. (eds.) 2000. Important Bird Areas in Europe. Priority Sites for conservation. Vol. 2, Southern Europe. BirdLife Conservation Series No. 8. BirdLife International, Cambridge, UK.

Lloyd, C., Tasker, M.L., and Partridge, K. 1991. The status of seabirds in Britain and Ireland. T. and A.D. Poyser, London.

Monteiro, L.R., Ramos, J.A., and Furness, R.W. 1996. Past and present status and conservation of the seabirds breeding in the Azores archipelago. Biological Conservation, 78: 319–328.

Monteiro, L.R., Ramos, J.A., Sola, E., Furness, R.W., Feio, R., Monteiro, P., Ratcliffe, N.R., Thompson, D.R., Bearhop, S., Pereira, J., Wilson, L., Hewitson, L., Tavares, A., and Laranjo, M. 1997. Exploracao e censos de aves marinhas no arquipelago dos Acores. 1 Congresso da Sociedade Portuguesa para o Estudos das Aves, Vila Nova de Cerveira, 1-3/11/96.

*Ntiamoa-Baidu, Y. 1991. Species protection as a strategy for conservation action in Africa: the case of the roseate tern in Ghana. *In* Conserving migratory birds, pp. 169–175. Ed. by T. Salathé. ICBP Technical Publication, 12.

*OSPAR. 2000. Quality Status Report: Region V – the Wider Atlantic, p. 76. OSPAR Commission, London.

*Snow, D.W., and Perrins, C.M. 1998. The Birds of the Western Palearctic. Volume I, Non-Passerines. Oxford University Press, New York.

*Tucker, G.M., and Heath, M.F. 1994. Birds in Europe: their conservation status. BirdLife International Conservation Series No. 3.

Annual reports on the numbers and breeding success of roseate terns in Britain and Ireland have been published by the Joint Nature Conservation Committee (JNCC). These also indicate population trends. The most recent of these annual reports are:

Mavor, R.A., Pickerell, G., Heubeck, M., and Thompson, K.R. 2001. Seabird numbers and breeding success in Britain and Ireland, 2000. UK Nature Conservation, No. 25. Joint Nature Conservation Committee, Peterborough, UK.

Upton, A.J., Pickerell, G., and Heubeck, M. 2000. Seabird numbers and breeding success in Britain and Ireland, 1999. UK Nature Conservation, No. 24. Joint Nature Conservation Committee, Peterborough, UK.

1.3.4 *Uria aalge ibericus* (Guillemot, Iberian subspecies – exact name to be checked)

a) Description

"*The guillemot has been nominated for Region IV.*

<u>Threats</u> The main threats are from entanglement and oil pollution and predation by Herring Gulls.

<u>Status</u> The great majority of common guillemots in the North Sea breed in the UK. Here they have increased markedly since the mid-1980s; in southeast Scotland and northeast England, annual population growth was 3.9 % and 4.8 %, respectively. The small population in France has also been increasing since 1955. The wintering population in the North Sea is thought to be around 1,562,400 with a breeding population of around 680,434 individuals. By way of contrast, there is a low breeding success in the Azores and Madeira and, as a consequence, the population in these areas has declined severely."

b) Literature used (*below)

The only reference cited by OSPAR for the "*ibericus*" guillemot (Rufino *et al.*, 1989) is a Portuguese bird atlas, which was unavailable for use.

c) Literature interpretation

The OSPAR review provides no evidence that the common guillemot in Iberia can be defined as a distinct subspecies. This taxonomic treatment has not been followed in more recent definitive texts such as del Hoyo *et al.* (1996) or Cramp (1985), or in a recent major monograph on the auks (Gaston and Jones, 1998), which all recognize only three subspecies of the common guillemot, *aalge*, *albionis*, and *hyperborea*. The subspecies *Uria aalge ibericus* was first proposed by Solomomsen in the 1930s, but was retracted by him in his later works as not being a sufficiently distinct form to merit subspecific recognition. The subspecies "*ibericus*" was supported by Bernis (1949) and subsequently accepted by the standard text on these birds of the 1960s and early 1970s (Tuck, 1960). It would thus have been in use when the EU Directive on the conservation of wild birds (79/409/EEC) (the Birds Directive) was initially drawn up in the 1970s and was presumably used when the Annexes to the Directive were amended when Spain and Portugal joined the European Union. The Birds Directive thus lists *U.a. ibericus* in Annex 1, indicating that it needs special conservation measures.

There is thus a difficulty: the form of guillemot in Iberia may or may not be taxonomically separable from other forms, and most experts consider that it is not. It nevertheless is (or was) an outlier population (the next nearest breeding group is 500 km to the north).

ICES addresses both issues of the whole common guillemot population, sub-sections in each OSPAR region and the "*ibericus*" population.

The OSPAR reference list for common guillemot cites only one reference, to an atlas of breeding birds of Portugal. There is, as far as we are aware, no recent scientific justification for separating guillemots from Iberia as a distinct subspecies. The current treatment is to group Iberian guillemots with those from France, Ireland, England, and southern Scotland as subspecies *Uria aalge albionis* (Gaston and Jones, 1998).

The text in the OSPAR documents describing the status of the common guillemot fails to deal with the relevant Iberian population as a unit, but describes numbers in the UK and the North Sea, details of little relevance to the question of listing Iberian guillemots for special status. The statement "there is a low breeding success in the Azores and Madeira and as a consequence the population in these areas has declined severely" is misleading. The common guillemot does not breed (and never has bred) in the Azores or Madeira. Possibly the text was intended to read "in Portugal and Spain"?

d) ICES conclusions

Location: The common guillemot is an abundant and widespread breeding seabird throughout much of the OSPAR area. The current breeding population is around 3.5 million pairs, with about half of these in OSPAR Region I, and most of the rest in OSPAR Regions II and III. Numbers breeding in OSPAR Region IV are extremely small (these are all of the putative *ibericus*) and they may now be extinct, and none breed in OSPAR Region V.

Decline: Common guillemot numbers have declined drastically in OSPAR Region IV and may now be extinct in Iberia and in one part of OSPAR Region I (Barents Sea and Norwegian Sea). In the remaining OSPAR areas, numbers have increased over the past 20–30 years.

Threats: Common guillemots are very sensitive to oil pollution. There have been major problems with drowning in set nets, particularly salmon nets and gillnets for cod. As a specialist piscivore feeding on small, shoaling, lipid-rich fish in winter as well as in summer, common guillemots can show mass mortality of fully-grown birds, especially during winter, if stocks of these food fish are low. For example, well over half of the common guillemots in the Barents Sea died in winter 1986/1987 when the capelin stock collapsed (Vader *et al.*, 1990; Lorentsen, 2001). Colonies in the extreme south of the species' breeding range (France–Iberia) have declined and may now be extinct, apparently as a result of combined impacts of egg collecting (in the past), capture of unfledged young to keep as pets (Berlengas), taking of adult birds for food, shooting (off northern coasts of Spain), by-catch in fishing nets, oil spills, and predation at colonies by introduced mammals, large gulls, and other birds (Bárcena *et al.*, 1984).

e) ICES overall evaluation

There is clearly a case for identifying the common guillemot in Iberia as requiring urgent conservation action, first to assess its status and, if not already extinct, to draw up and implement a recovery plan.

The division by OSPAR of the OSPAR marine area into five regions has created a huge "Arctic" Region I, compared to the much smaller Regions II, III, and IV. This creates some difficulty when looking at declines that are of conservation concern but are geographically restricted to an area that does not coincide with OSPAR regional boundaries. In the case of the common guillemot, there are highly divergent population trends for common guillemots in different sectors of OSPAR Region I. In the eastern sector (Barents Sea and Norwegian Sea), common guillemot numbers have decreased drastically, whereas in the western part of Region I (e.g., Iceland) numbers appear to be fairly stable. A strong case could be made for identifying the common guillemot in the Barents Sea region (including the Norwegian coast south to the Lofoten Islands) as a priority for listing as a seriously declined population.

References

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Bernis, F. 1949. Las aves de las Islas Sisargas en junio. Bol. Soc. Hist. Nat., 46: 647–648.

Cramp, S. 1985. The birds of the western Palearctic, Vol. IV. Oxford University Press.

del Hoyo, J., Elliott, A., and Sargatal, J. 1996. Handbook of the birds of the World. Vol. 3, Hoatzin to auks. Lynx Edicions, Barcelona.

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*Rufino, R. *et al.* 1989. Atlas das Aves que nidificam em Portugal. SNPRCN. 215 pp.

Sandoval, A., Torres, A., Martínez-Lago, M., and Martínez-Lago, S. (in press). *Rissa tridactyla* and *Uria aalge*. *In* VII Anuario das Aves de Galicia 1999. Sociedade Galega de Ornitoloxía. Santiago de Compostela. Ed. by R. Salvadores and C. Vidal.

Tuck, L.M. 1960. The murres: their distribution, populations and biology, a study of the genus *Uria*. Canadian Wildlife Services Monograph, No. 1. Ottawa, Canada.

References to decline in OSPAR Region I:

Lorentsen, S.-H. 2001. The national monitoring programme for seabirds. Results including the breeding season 2001. NINA Oppdragsmelding, 726: 1–36. Norwegian Institute for Nature Research, Trondheim.

Vader, W., Barrett, R.T., Erikstad, K.E., and Strann, K.B. 1990. Differential responses of common and thick-billed murres to a crash in the capelin stock in the southern Barents Sea. Studies in Avian Biology, 14: 175–180.

1.3.5 *Larus fuscus fuscus* (Lesser black-backed gull)—Arctic

a) Description

"*The Lesser Black-Backed Gull (Subspecies* Larus fuscus fuscus*) has been nominated for three of the five OSPAR regions. The species breeds in scattered colonies along* *the coasts as well as in inland areas, and migrates south to the Black Sea and the eastern part of the Mediterranean and Africa from August.*

Threats *The principal threats are thought to be man-made pollution (such as accumulation of PCBs), decline in prey species, and competition and predation by the Herring Gull.*

Status *The number of breeding birds in Europe was thought to be between 200,000–240,000 in 1990. About 40 % of these were found in the UK, with other major concentrations in Iceland, the Netherlands and France. Between 1970 and 1990, the numbers breeding in the UK, Iceland, France, and the Netherlands all increased, with an overall upward trend in countries bordering the southern North Sea. The increase in Iceland was accompanied by a marked expansion in range. At the same time, numbers declined in northern areas (Faroes, Norway, Sweden, Finland, Russia, and Estonia) with the population in Norway estimated to have declined by 90 % since 1970. Overall, a quarter of the population is considered to be in decline.*"

b) Literature used (*below)

The references listed in support of the nomination of *Larus fuscus fuscus* include several papers that deal only with other subspecies, and so have little or no relevance to *L. f fuscus*. These include papers by Camphuysen (1995), Reid *et al.* (2001), Stone *et al.* (1992), Verbeek (1977), and Webb *et al.* (1990), which should be removed from the reference list for this subspecies. The key reference by Strann and Vader (1992) should be inserted.

c) Literature interpretation

The OSPAR species description text states that *Larus fuscus fuscus* has been nominated for three of the five OSPAR regions. This must be a mistake, since this subspecies only occurs in OSPAR Region I. The other nominations must presumably be for other subspecies of this gull, or may be a misreading of tables as there seems to have been three nominations for the mew gull, which is in an adjacent row in the table. Listed threats seem to refer to other subspecies of this gull, and may not be applicable to *L. f fuscus*. Threats to *L. f fuscus* are summarized by Anker-Nilssen *et al.* (2000). The status reported in the OSPAR text refers predominantly to *L. f graellsii* or *L. f intermedius*. This provides a misleading picture as regards the particular subspecies of concern.

d) ICES conclusions

Location: Five subspecies of the lesser black-backed gull have been described and the classification is widely accepted. Three subspecies, *L. f fuscus*, *L. f intermedius*, and *L. f graellsii*, breed entirely or partly within the OSPAR area. The subspecies *Larus fuscus fuscus* breeds in Sweden and northern Norway to the western part of the Kola Peninsula and the western White Sea (Strann, Semashko, and Cherenkov, in Anker-Nilssen *et al.*, 2000). The total population of this subspecies is under 15,000 pairs, of which about 2,500 pairs breed within the Barents Sea on Norwegian and Russian coasts (Anker-Nilssen *et al.*, 2000). In late summer, these birds migrate following a southeasterly route to the Black Sea and east Africa.

Decline: The evidence for a marked decline in breeding numbers of *L. f fuscus* in northern Norway is very strong. The species has also disappeared from the Murman coast and the northwestern White Sea (Anker-Nilssen *et al.*, 2000).

Threats: Causes of the decline of *L. f fuscus* are not known (Anker-Nilssen *et al.*, 2000). Strann and Vader (1992) suggested that a change in food resources in breeding areas (particularly the long-term lack of young herring) was the main reason.

e) ICES overall evaluation

The evidence that numbers of *L. f fuscus* have declined is compelling, and this subspecies is a strong candidate for inclusion as a priority of concern for OSPAR.

References

*Anker-Nilssen, T. *et al.* 2000. The status of marine birds breeding in the Barents Sea region. Norwegian Polar Institute Report. No. 113. 213 pp.

*Lorentsen, S.-H. 2000. The national monitoring programme for seabirds. Results including the breeding season 2000. NINA Oppdragsmelding 670: 1–30.

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*Thingstad, P.G. 1986. The Lesser Black-Backed Gull; a pilot project of an endangered subspecies. Økoforsk Utredning 1986, 3: 1–50.

1.3.6 General comments on taxa of birds not taken forward to the priority list

ICES feels that the scientific case for including the Bulwer's petrel and Madeiran storm-petrel in the priority list of declining and threatened species within the OSPAR area would be strong, and that these cases might merit further evaluation.

ICES would have found it helpful to see more explicit criteria for taxon selection. It appears that subspecies have been selected as equivalent to the selection of a species, but ICES found no explanation in the OSPAR criteria as to how subspecies should be considered. A list of species that are endemic to the OSPAR area, or for which most of the world population occurs within the OSPAR area, would also be a useful document, since that would focus some attention on endemic biodiversity, regardless of whether such species (or subspecies) have declining or threatened populations. The only seabird endemic to the OSPAR area is the great skua (*Catharacta skua*). ICES found no mention of this species in any of the papers from OSPAR; although relatively rare and localized (total population only about 13,000 breeding pairs), the species is considered to have secure conservation status. Several other seabirds have very high proportions of their global population within the OSPAR area, including the northern gannet and European storm-petrel. Tabulation of these percentages and population trends/threats would be useful, though certainly less urgent than the priority list of declining and threatened taxa currently being prepared.

It was not clear from reading the criteria how much the status of a taxon outside the OSPAR area should be considered when deciding to list taxa. It seems that the adverse status of Steller's eider in the Bering Sea might have been the main reason for listing this species, since it has apparently a healthy population within the OSPAR area. It seems that there is a need for clearer expression of selection criteria to make such selections transparent rather than apparently arbitrary.

ICES, via the Working Group on Seabird Ecology (WGSE), would be willing to peer review OSPAR texts on the final selection of bird taxa for the priority list of declining and threatened "species", if this would be considered useful.

2 Habitats

2.1 Priority list of threatened and/or declining habitats

2.1.1 Carbonate mounds

a) Description

Priority for whole OSPAR area.

"*Carbonate mounds occur in small, localized clusters, mainly on the eastern margin of the North Atlantic. Most are dominated by filter-feeding communities and can support rich deep-sea coral communities, which form secondary, biogenic hard substrate for an abundant and diverse epibenthic fauna.*

Threats *Although sound scientific information about carbonate mounds is scarce, it can be expected that benthic trawling operations have a serious mechanical impact from which the habitat and the associated ecosystem might not, or only very slowly, recover.*

Status *In areas where commercial benthic fisheries are carried out, there is a high probability of significant decline.*"

b) Literature used (*below)

The literature used (WWF/IUCN, 2001; OSPAR QSR for Region V) was not sufficient to support the nomination.

c) Literature interpretation

The references used provide no information on carbonate mounds as a biological habitat, only as geological features. There is no evidence in these references of either a threat to the geological feature itself, or to any decline. Mounds are referred to as structures on which *Lophelia* (see Section 2.1.5, below) and other corals grow. These reefs are threatened and declining (see Section 2.1.5, below), but there is no evidence that carbonate mound substrates are at any greater risk than other reef-supporting substrates (in fact, they may be at lower risk than, e.g., the sand mounds underlying the Darwin mounds).

d) ICES assessment

This nomination requires additional literature if it is to be justified. However, no literature beyond that cited by WWF/IUCN (2001) was found. Research on carbonate mounds to the west of Ireland is under way in three EU-funded projects at present, but ICES was unaware of any early results indicating a threat to or decline of the mounds.

Location: The literature on the distribution of carbonate mounds indicates that they have been found only in OSPAR Region V off Ireland, but it is unclear whether mounds may exist elsewhere in the OSPAR area.

Decline: There is no literature on the decline in the extent of carbonate mounds.

Threats: There is no evidence of direct "clear and present" threats to the mounds. There is evidence of a threat to biota growing on the mounds from fishing activities. It is conceivable that if these mounds formed by bacteria growing on hydrocarbon seepage (Peckmann *et al.*, 1998), then exploitation of that hydrocarbon may affect the structure.

e) ICES overall evaluation

OSPAR (2001) considered this habitat to have priority for the whole OSPAR area. The Leiden Workshop concluded that evidence for the decline and threat were "unclear" and "reasonable", respectively. ICES found no data on either a threat to or a decline in the carbon mounds and concluded that there is insufficient evidence for the nomination.

References

*OSPAR. 2000. Quality Status Report 2000, Region V – Wider Atlantic. OSPAR Commission, London. 110 + xiii pp.

Peckmann, J., Reitner, J., and Neuweiler, F. 1998. Seepage related or not? Comparative analysis of phanerozoic deep-water carbonates. TTR7 Postcruise meeting Conference. Carbonate Mud Mounds and Cold Water Reefs: Deep Biosphere-Geosphere coupling. 27.

*WWF/IUCN. 2001. The status of natural resources on the high-seas. WWF/IUCN, Gland, Switzerland.

2.1.2 Deep-sea sponge aggregation

a) Description

Priority for whole OSPAR area.

"*Deep sea sponge aggregations form a secondary, biogenic hard substrate and are usually limited to small, restricted areas where hydrographic conditions are favourable. The habitat and its rich, diverse epibenthic fauna will recover only very slowly after being adversely affected.*

Threats Benthic fisheries and trawling operations can destroy sponge aggregations mechanically or by smothering them with sediments.

Status More information needed to assess the status of this habitat."

b) Literature used (*below)

The literature used (OSPAR QSR for Region V) was not sufficient to support the nomination. The limited primary literature available was not used.

c) Literature interpretation

In the literature used, there were no references cited dealing specifically with the habitat in question.

d) ICES assessment

The nomination requires additional literature if it is to be justified. More details describing the spatial extent of deep-sea sponge aggregations throughout the OSPAR area are required to justify their inclusion as threatened throughout the OSPAR region. Data are also required giving quantitative information on decline or threat.

Location: There are no reports available which give a comprehensive overview of the distribution of deep-sea sponge aggregations within the OSPAR area or from other waters. However, dense aggregations are known to occur in various places in the Northeast Atlantic (Klitgaard and Tendal, 2001). Deep-sea sponge aggregations are reported to occur close to the shelf break (250 m to 500 m depth) around the Faroe Islands (OSPAR Region I, Klitgaard and Tendal, 2001). Sponge aggregations have also been recorded along the Norwegian coast (OSPAR Region I) up to West Spitzbergen and Bjørnoya (Blacker, 1957; Dyer *et al.*, 1984; Fosså and Mortensen, 1998) and from the Porcupine Seabight (OSPAR Region III; Rice *et al.*, 1990).

Decline: No quantitative data on decline of sponge aggregations are available. Results of a questionnaire to local fishermen in the Faroe Islands indicate that, although such a habitat has existed in the past, fewer areas now have high concentrations of sponge aggregations (Klitgaard and Tendal, 2001).

Threats: There is no evidence of clear and present threats to deep-sea sponge aggregations. In terms of threat, the QSR mentions anecdotal reports indicating mechanical disturbance to biogenic structures in general.

Vulnerability to future threat: In the literature available, no information is presented on future developments of threats. Information indicates that dominant sponge species are slow growing and take several decades to reach large size (Klitgaard and Tendal, 2001). In many areas, there is a common pattern of bottom trawling in increasingly deeper water where sponge aggregations are known to occur. Taking this into account, it seems reasonable to expect that the vulnerability and threat to the habitat is high.

e) ICES overall evaluation

OSPAR (2001) considered this habitat to have priority for the whole OSPAR area. The Leiden Workshop concluded that evidence was "unclear", both for decline and for threat. ICES finds that there are no quantitative data on either a threat to or decline in the habitat and concludes that there is insufficient evidence for the nomination. However, a single report from OSPAR Region I indicates a decline.

References

Blacker, R.W. 1957. Benthic animals as indicators of hydrographic conditions and climatic change in Svalbard waters. Fishery Investigations (London), ser. II, 20: 1–49.

Dyer, M.F., Cranmer, G.J., Fry, P.D., and Fry, W.G. 1984. The distribution of benthic hydrographic indicator species in Svalbard waters, 1878–1981. Journal of the Marine Biological Association of the United Kingdom, 64: 667–677.

Fosså, J.H., and Mortensen, P.B. 1998. Artsmangfoldet på *Lophelia*-korallrev og metoder for overvåkning. Fisken og Havet, No. 17. 95 pp.

Klitgaard, A.B. 1995. The fauna associated with outer shelf and upper slope sponges (Porifera, Demospongiae) at the Faroe Islands, northeastern Atlantic. Sarsia, 80: 1–22.

Klitgaard, A.B., and Tendal, O.S. 2001. "Ostur"-"cheese bottoms"-sponge dominated areas in Faroese shelf and slope areas. *In* Marine biological investigations and assemblages of benthic invertebrates from the Faroe Island, pp. 13–21. Ed. by G. Gruntse and O.S. Tendal. Kaldbak Marine Biological Laboratory, the Faroe Islands.

Klitgaard, A.B., Tendal, O.S., and Westerberg, H. 1997. Mass occurrences of large-sized sponges (Porifera) in Faroe Island (NE-Atlantic) shelf and slope areas: characteristics, distribution and possible causes. *In* The Responses of Marine Organisms to their Environments, pp. 129–142. Ed. by A.C. Jensen, M. Sheader, and J.A. Williams. Proceedings of the 30th European Marine Biology Symposium, University of Southampton. 362 pp.

*OSPAR. 2000. Quality Status Report 2000, Region V – Wider Atlantic. OSPAR Commission, London. 110 + xiii pp.

Rice, A.L., Thurston, M.H., and New, A.L. 1990. Dense aggregations of a hexactinellid sponge, *Pheronema carpenteri*, in the Porcupine Seabight (northeast Atlantic Ocean) and possible causes. Progress in Oceanography, 24: 179–206.

2.1.3 Estuarine intertidal mudflats

a) Description

Priority for whole OSPAR area.

"*Mudflats are sedimentary intertidal habitats created by deposition in low energy coastal environments, particularly estuaries and other sheltered areas. Their sediment consists mostly of silts and clays with a high organic content. They are characterized by high biological productivity and abundance of organisms, but low diversity with few rare species. The largest continuous area of intertidal mudflats in the OSPAR area is in Region II bordering the North Sea coasts of Denmark, Germany and the Netherlands in the Wadden Sea and covering around 499,000 ha.*

Threats *Land claim for agricultural use has been a threat to this habitat in the past. Today it is more likely to be linked to maritime developments such as urban and transport infrastructure and for industry. Sea level rise is a current threat especially in areas where the land is sinking such as southern and southeast England, and any associated increased storm frequency, resulting from climate change, may further affect the sedimentation patterns of mudflats and estuaries. Fishing and bait digging can have an adverse impact on community structure and substratum, e.g., suction dredging for shellfish or juvenile flatfish by-catch from shrimp fisheries may have a significant effect on important predator populations.*

Status *Reductions in the area of intertidal mudflats have occurred in many parts of the OSPAR area with locations at the heads of estuaries particularly favoured for land claim. A review carried out in the late 1980s noted that parts of at least 88 % of British estuaries had lost intertidal habitat to agricultural land claim in the past. Specific examples include the loss of over 80 % of the intertidal flat claimed for agriculture, industry and ports since 1720 in the Tees estuary, and in the Tyne estuary where no intertidal flats remain.*"

b) Literature used (*below)

The literature that is cited as supporting this application (Doody *et al.*, 1991; Jones *et al.*, 2000; OSPAR, 2000; UKBAP, 2000) is dominated by grey literature. The coverage of the primary literature by them is often very selective and restricted. The summary is also factually inaccurate, as there is one intertidal mudflat still present in the Tyne Estuary.

c) Literature interpretation

The majority of the literature is correctly interpreted, but in some cases the threats are exaggerated or used out of context.

d) ICES assessment

There are sufficient primary sources accessible from the cited works to carry out the assessment.

Location: There is good evidence that intertidal mudflats occur throughout the OSPAR area and that the threats are similar in all areas.

Decline: The literature provides good evidence of declines in the extent of this habitat, but does not specify clearly whether the emphasis is on coastal intertidal mudflats or within estuarine habitats.

Threats: There are apparent threats to the existence of estuarine intertidal habitats. These arise from a range of activities from land claim, building of coastal defences, sea level rise and coastal squeeze, pollution/waste disposal, fishing activities (particularly shellfish dredging and beam trawling), bait collection, and recreational visitors. A number of members of ICES had extensive experience in the ecology of intertidal mudflats and the associated populations of birds and fish. The analysis presented here relies heavily on this knowledge of the original research studies as well as the regional context provided by the grey literature reports cited.

e) ICES overall evaluation

OSPAR (2001) considered this habitat to have priority for the whole OSPAR area. The Leiden Workshop concluded that evidence was "strong", for both the decline and the threat. ICES finds that there is good evidence of declines and threat to estuarine intertidal mudflats throughout the OSPAR area.

References

*Doody, J.P., Johnston, C., and Smith, B. 1991. Directory of the North Sea Coastal Margin. Coastal Conservation Branch, Joint Nature Conservation Committee, Peterborough, UK. 419 pp.

*Jones, L.A., Hiscock, K., and Connor, D.W. 2000. Marine habitat reviews. A summary of ecological requirements and sensitivity characteristics for the conservation and management of marine SACs. Joint Nature Conservation Committee, Peterborough. (UK Marine SACs Project report).

*OSPAR. 2000. Quality Status Report 2000, Region II – Greater North Sea. OSPAR Commission, London. 110 + xiii pp.

*UKBAP. 2000. UK Biodiversity Group Tranche 2 Action Plans. Volume V – maritime species and habitats. English Nature, Northminster House PE1 1UA. ISBN 1 85716 467 9. 242 pp.

2.1.4 Littoral chalk communities

a) Description

Priority for whole OSPAR area.

"*The erosion of chalk exposures at the coast has resulted in the formation of vertical cliffs and gently sloping shore platforms with a range of micro-habitats of biological importance. Littoral fringe and supralittoral chalk cliffs and sea caves support algal communities unique to the substrate. The generally soft nature of the chalk results in the presence of a characteristic flora and fauna, notably rock-boring invertebrates. Littoral chalk also supports distinct successive zones of algae and animals. Coastal exposures of chalk are a rare habitat in Europe with the greatest proportion (57 %) and many of the best examples of littoral chalk habitats located on the coast of England.*

Threats The main threats to littoral chalk communities are from coast protection works, toxic contaminants and physical loss. Coast protection works have resulted in the loss of micro-habitats on the upper shore and the removal of splash-zone communities, including the unique algal communities. The deterioration of water quality by pollutants and nutrients has caused, respectively, the replacement of fucoid-dominated biotopes by mussel-dominated biotopes, and the occurrence of nuisance Enteromorpha *spp. blooms. Sea level rise and post-glacial land adjustment will submerge areas of the intertidal chalk platforms.*

Status A recent survey of chalk cliffs throughout England revealed that 56 % of coastal chalk in Kent, and 33 % in Sussex have been modified by coastal defence and other works. On the Isle of Thanet (Kent) this increases to 74 %. There has been less alteration of chalk at lower shore levels except at some large port and harbour developments (e.g., Dover and Folkestone). Elsewhere in England, coastal chalk remains in a largely natural state."

b) Literature used (*below)

The original references are referred to on the status of chalk habitats in OSPAR regions, and they contain specific data which support the overall conclusion (Doody *et al.*, 1991; Laffoley *et al.*, 2000; UKBAP, 2000).

c) Literature interpretation

The conclusions cited in the literature are translated directly and accurately.

d) ICES assessment

The literature quoted is convincing and it is not considered that further justification is necessary, although an assessment of the status of chalk communities elsewhere in European coastal waters would be helpful.

Primary literature on these habitats is very limited. However, the available primary and grey literature provides a good basis for assessing the extent and status of these habitats.

Location: Regional – the literature on the distribution of marine chalk habitats provides good coverage and clearly demonstrates that this environment is restricted to a limited number of locations in the OSPAR area.

Decline: There is limited literature on the decline in the extent of chalk habitats. It is clear from the available literature that some areas of habitat have been lost to development and coastal protection works, but in many other areas the habitat has undergone a degree of modification.

Threats: There is a clear and present danger to the existence of these habitats. This comes primarily from physical threats such as development of ports or coastal protection works and from water quality threats, including those arising from maritime accidents, as many of the sites are in regions of high shipping activity.

The report considers these threats to be significant primarily as a result of the relatively restricted distribution and small total area of this habitat type. As a result, any loss must be regarded as significant in conservation terms. The available literature would confirm the factual basis of this statement, but the "conservation significance" of any further loss is a matter of societal choice.

e) ICES overall evaluation

OSPAR (2001) considered this habitat to have priority for the whole OSPAR area. The Leiden Workshop concluded that evidence was "strong", for both the decline and the threat. ICES finds that there is good evidence of declines and threat in some OSPAR regions and the precautionary approach would see this consideration extended to the whole OSPAR area.

References

*Doody, J.P., Johnston, C., and Smith, B. 1991. Directory of the North Sea Coastal Margin. Coastal Conservation Branch, Joint Nature Conservation Committee, Peterborough, UK. 419 pp.

*Laffoley, D., Connor, D.W., Tasker, M.L., and Bines, T. 2000. Nationally important seascapes, habitats and species. A recommended approach to their identification, conservation and protection. Prepared for the DETR Working Group on the Review of Marine Nature Conservation by English Nature and Joint Nature Conservation Committee. English Nature Research Report, No. 392. English Nature, Peterborough, UK.

*UKBAP. 2000. UK Biodiversity Group Tranche 2 Action Plans. Volume V – maritime species and habitats. English Nature, Northminster House PE1 1UA. ISBN 1 85716 467 9. 242 pp.

2.1.5 *Lophelia pertusa* reefs

a) Description

Priority for whole OSPAR area.

"L. pertusa *has a wide geographical distribution, ranging from 55 °S to 70 °N and is present in the Atlantic, Pacific and Indian Oceans and in the Mediterranean, although most of the records come from the NE Atlantic. In Norwegian waters* L. pertusa *reefs occur on the shelf and shelf break off the western and northern parts on local elevations of the seafloor and on the edges of escarpments. The diversity of the taxa associated with the reefs is around three times as high as that of the surrounding soft sediment seabed, indicating that these reefs create biodiversity hotspots and increased densities of associated species.*

Threats *Offshore fisheries using bottom trawls are known to severely damage* L. pertusa *reefs. Corals are known to be susceptible to pollution and silting although the extent to which* Lophelia *may be affected is not clear at the present time. Petroleum industry developments with associated discharges of drilling mud and drill cuttings may negatively affect the corals.*

Status *The OSPAR area appears to be important for* L. pertusa *as a high proportion of the known occurrences of reefs are from this area. The widely scattered reported occurrences from other ocean areas indicate considerable uncertainty as to how well the distribution of* L. pertusa *has been mapped. Bottom trawling has destroyed large proportions of reefs along the Storegga shelf break and on banks on the Norwegian shelf An assessment based on a study in Norway has indicated that approximately 30–50 % of coral reefs may have suffered some damage."*

b) Literature used (*below)

The following references were quoted by the questionnaire returns used by the Leiden Workshop: UKBAP (2000); OSPAR BDC (2000); Dons (1944); Fosså and Mortensen (1998); Gubbay (2000); OSPAR (2000); Rogers (1999); Strømgren (1971); and WWF/IUCN (2001). These references are sufficient, especially OSPAR BDC (2000) that contains an annex written by two experts on *Lophelia* using many original references.

c) Literature interpretation

The conclusions cited in the literature are translated directly and accurately. There is additional evidence that *Lophelia* reefs off the UK (OSPAR Regions III and V) and the Faroes (OSPAR Region I) have also been destroyed by trawling, which is not noted in the Leiden Workshop summary. Reefs off Ireland (OSPAR Region III) are also being affected by trawling.

d) ICES assessment

Primary literature on *Lophelia* reefs is extensive and growing rapidly. There is considerable further material available on this habitat (see, e.g., Section 3 of this report), but the material used in this assessment is sufficient and reliable without further support.

Location: The distribution of *Lophelia* reefs in the OSPAR area is reasonably well known, although further surveys in some areas (e.g., Rockall and Hatton Banks, and the mid-Atlantic ridge) would improve this knowledge. The distribution covers all OSPAR regions.

Decline: There is good evidence of decline in OSPAR Regions I, II, III, and V. Occurrence in Region IV is not well known, but given the distribution of deep-water trawling it is likely that damage/decline has occurred there as well.

Threats: There is good evidence that the principal current threat comes from bottom trawling. As the technology to undertake such trawling in hard habitats has developed further, areas of *Lophelia* reefs have come under threat.

e) ICES overall evaluation

OSPAR (2001) considered this habitat to have priority for the whole OSPAR area. The Leiden Workshop concluded that evidence was "strong", for both the decline and the threat. ICES finds that there is good evidence of declines and threat throughout the OSPAR area.

References

*Dons, C. 1944. Norges korallrev. Det Kongelige Norske Videnskabers Selskabs Forhandlinger, 16: 37–82.

*Fosså, J.H., and Mortensen, P.B. 1998. Artsmangfoldet på *Lophelia*-korallrev og metoder for overvåkning. Fisken og Havet, No. 17. 95 pp.

*Gubbay, S. 2000. Offshore Directory. Review of a selection of habitats, communities and species of the North-East Atlantic. Report to WWF-UK.

*OSPAR BDC. 2000. Testing of the Faial criteria for the selection of species and habitats which need to be protected with the deep-water and habitat-forming coral reef species *Lophelia pertusa*. Paper BDC 00/6/5 presented by Norway to the OSPAR Biodiversity Committee in 2000.

*OSPAR. 2000. Quality Status Report 2000, Region V – Wider Atlantic. OSPAR Commission, London. 110 + xiii pp.

*Rogers, A.D. 1999. The biology of *Lophelia pertusa* (Linnaeus 1758) and other deep-water reef-forming corals and impacts from human activities. International Review of Hydrobiology, 84: 315–406.

*Strømgren, T. 1971. Vertical and horizontal distribution of *Lophelia pertusa* (Linne) in Trondheimsfjorden on the west coast of Norway. Det Kongelige Norske Videnskabers Selskabs Skrifter, 6: 1–9.

*UKBAP. 2000. UK Biodiversity Group Tranche 2 Action Plans. Volume V – maritime species and habitats. English Nature, Northminster House PE1 1UA. ISBN 1 85716 467 9. 242 pp.

*WWF/IUCN. 2001. The status of natural resources on the high-seas. WWF/IUCN, Gland, Switzerland.

2.1.6 Oceanic ridges with hydrothermal effects

a) Description

Priority for whole OSPAR area.

"*The hydrothermal vent fields of Menez Gwen, Lucky Strike, Rainbow and Saldanha are known important locations for these features. They cover very small areas in relatively shallow depths (compared to fields outside the OSPAR Maritime Area) of 850–2,300 m.*

Threats Scientific research and sampling activities can cause deliberate or accidental, long-lasting or irreversible damage to active chimneys and to the highly adapted, endemic fauna which depends on energy derived from sulphur-containing inorganic compounds.

Status Most if not all known hydrothermal vent fields within the OSPAR maritime area are located in Region V. The ecological quality of these vent habitats might significantly decline if no protection or management measures are taken."

b) Literature used (*below)

The literature supports a comprehensive review of literature available to date published by WWF/IUCN (2001) and OSPAR (2000).

c) Literature interpretation

The references used provide no information demonstrating the rate of decline or the extent of the habitat.

d) ICES assessment

The reference quoted by OSPAR appears to have reviewed the bulk of the available literature.

Location: There is sufficient evidence to support the conclusion that such vents occur in OSPAR Region V, and indeed throughout the world.

Decline: Simply because our knowledge of the extent of these habitats is unknown, there is no empirical evidence to suggest that they are in decline. As WWF/IUCN states in their 2001 report, "Vast tracts of ridge crest remain unstudied and the abundance of vents is unknown; only 10 % of the 50,000 miles of ridge system has been explored."

Threats: This habitat has not been proven to be under threat from present-day human activities. WWF/IUCN (2001) cites no immediate potential for commercial exploitation (e.g., "to date, relatively few seafloor sulphide deposits have been shown to be of sufficient size and quality to be potential candidates for commercial exploitation") and suggests that any threats will occur as human technologies develop in the future. There is evidence presented for future threat to this habitat from sources of novel products for biotechnological applications, i.e., bioprospecting. (Jannasch, 1992), mining of polymetallic sulphide crusts within the next 10–15 years (Glowka, 1999), and tourism (Herring *et al.*, 1999) – although ICES considers that this will be localized and of relatively low impact.

e) ICES overall evaluation.

There are insufficient data to support this nomination.

OSPAR (2001) considered this habitat to have priority for the whole OSPAR area. The Leiden Workshop concluded that evidence for the decline and threat were "unclear" and "strong", respectively. ICES finds that there is no empirical evidence presented in the literature to suggest either decline or immediate threat to this habitat, although future threats could exist as human technology improves our capacity to reach them. ICES concludes that there is insufficient evidence for the nomination.

References

*OSPAR. 2000. Quality Status Report 2000, Region V – Wider Atlantic. OSPAR Commission, London. 110 + xiii pp.

*WWF/IUCN. 2001. The status of natural resources on the high-seas. WWF/IUCN, Gland, Switzerland.

2.1.7 Seamounts

a) Description

Priority for whole OSPAR area.

"*Surrounded by abyssal plains, seamounts have special hydrographic/substrate conditions and act as 'islands' for epibenthic and pelagic faunas. They have a high rate of endemic species, are used as 'stepping stones' for the trans-oceanic dispersion of shelf species and as reproduction/feeding grounds for migratory species. Being of volcanic origin, the majority of seamounts lie along the Mid-Atlantic Ridge between Iceland and the Hayes fracture zone.*

Threats *Seamount habitats are very sensitive to the physical impact of trawling and to the removal of benthic and pelagic key species by commercial fisheries. Being isolated and confined to small areas, seamount habitats and faunas will be able to recover only over long time periods by the sporadic re-colonization from nearby seamounts and shelf areas. Where this is not possible (e.g., highly endemic species), disturbance might lead to extinction.*

Status *Although there is a large seamount fishery in the Wider Atlantic, no information is available about the state of the seamount habitats/faunas in OSPAR Region V.*"

b) Literature used (*below)

The nomination is not sufficiently supported, as the literature used (WWF/IUCN, 2001; OSPAR QSR for Region V) does not cite primary references with original data regarding the OSPAR area.

c) Literature interpretation

The literature is incorrectly interpreted. The source used provides information on declines in seamount biota in the Pacific, but no information on either a threat to the biological habitats of seamounts within the OSPAR area or to their decline. Similarly, there is no evidence for threat to structural aspects of the habitat.

d) ICES assessment

This nomination requires more supporting evidence if it is to be justified.

Location: The literature provided gives evidence that seamounts are found throughout the Atlantic Ocean, including in OSPAR Region V.

Decline: There is no evidence of a decline in seamounts within the OSPAR area and information on decline of associated biota is related to areas outside the OSPAR area.

Threats: There is no evidence of direct threats to seamounts, and information on potential/actual threats to the biota they support is related to areas outside the OSPAR area. Under a precautionary approach, these might be considered likely within the OSPAR area, but there is at present no documented evidence of such impacts. Inclusion of this habitat should be considered on the grounds of "precaution" until further data are available.

e) ICES overall evaluation

OSPAR (2001) considered this habitat to have priority for the whole OSPAR area. The Leiden Workshop concluded that evidence for the decline and threat was "unclear" and "reasonable", respectively. ICES finds no data on either a threat or decline to the seamounts within the OSPAR area, and concludes that there is insufficient evidence for the nomination at this time.

References

*OSPAR. 2000. Quality Status Report 2000, Region V – Wider Atlantic. OSPAR Commission, London. 110 + xiii pp.

*WWF/IUCN. 2001. The status of natural resources on the high-seas. WWF/IUCN, Gland, Switzerland.

2.2 List of threatened and/or declining species and habitats in the OSPAR maritime area

2.2.1 *Ampharete falcata* sublittoral mud community

a) Description

Threatened and/or declining habitat for whole OSPAR area.

"*Habitat characterized by dense stands of* A. falcata *tubes which protrude from muddy sediments, appearing as a turf or meadow in localized areas. These areas seem to occur on a crucial point on a depositional gradient between areas of tide-swept mobile sands and quiescent stratifying muds. Dense populations of the small* Parvicardium ovale *occur in the superficial sediment. Substantial populations of mobile epifauna such as* Pandalus montagui *and small fish also occur, together with those that can cling to the tubes.*

Threats *This biotope develops on undisturbed mud habitats. The main threats are therefore those that disturb the seabed such as benthic fisheries and seabed development.*

Status *This biotope has been recorded on the seabed beneath the Irish Sea Front where* A. falcata *was found at densities of approximately 3,000/m^2 in 1986. Although there has been no detailed mapping showing change in extent, it is a biotope that is likely to have been affected by the activities described above. This has been reported in some personal observations.*"

b) Literature used (*below)

The literature used was not sufficient to support the classification that the *Ampharete falcata* sublittoral mud community is threatened or declining across the whole OSPAR area. The only references cited are the QSR 2000 Regions II and V reports, which do not refer to the habitat specifically and are not references to primary literature.

c) Literature interpretation

The literature was interpreted correctly insofar as evidence for both habitat status and presence of threat is unclear. It is not possible to draw the conclusion that the *Ampharete falcata* sublittoral mud community is threatened or declining across the whole OSPAR area from these reports.

d) ICES assessment

While abundant information exists to demonstrate the detrimental effects of trawl fishing on a range of muddy benthic communities (de Groot and Lindeboom, 1994; Jennings and Kaiser, 1998; Jones *et al.*, 2000; Linnane *et al.*, 2000), none of the information cited in the working paper or other references available to ICES illustrates the distribution of the habitat, or direct evidence of impact. While it is acknowledged that there is clear potential for these impacts to occur, there is insufficient evidence presented here to support this as a threatened and/or declining habitat.

Location: There is insufficient evidence to indicate the geographical distribution of this particular habitat within the OSPAR area.

Decline: There is insufficient evidence presented to indicate that this habitat is in decline.

Threats: There is insufficient evidence presented to argue that this habit is under threat, either immediately, or from future activities.

e) ICES overall evaluation

OSPAR (2001) considered this habitat to be threatened and/or declining across the whole OSPAR area. The Leiden Workshop concluded that evidence for the decline of and threat to this habitat across the whole OSPAR area was "unclear". ICES agrees that the evidence for both is insufficient.

References

de Groot, S.J., and Lindeboom, H.J. 1994. Environmental impact of bottom gears on benthic fauna in relation to natural resources management and protection of the North Sea. Reports of the Netherlands Institute for Sea Research, Texel.

Jennings, S., and Kaiser, M.J. 1998. The effects of fishing on marine ecosystems. Advances in Marine Biology, 34: 201–352.

Jones, L.A., Hiscock, K., and Connor, D.W. 2000. Marine habitat reviews. A summary of ecological requirements and sensitivity characteristics for the conservation and management of marine SACs. Joint Nature Conservation Committee, Peterborough. (UK Marine SACs Project report).

Linnane, A., Ball, B., Munday, B., van Marlen, B., Bergman, M., and Fonteyne, R. 2000. A review of potential techniques to reduce the environmental impact of demersal trawls. Irish Fisheries Investigations (New Series), No. 7. Marine Institute, Dublin. 39 pp.

*OSPAR. 2000. Quality Status Report 2000, Region II – Greater North Sea. OSPAR Commission, London.

*OSPAR. 2000. Quality Status Report 2000, Region V – Wider Atlantic. OSPAR Commission, London. 110 + xiii pp.

2.2.2 Intertidal mussel beds

a) Description

Threatened and/or declining habitat across the whole OSPAR area.

"*Intertidal mussel beds of* M. edulis *are specific to the OSPAR region with the majority in the Wadden Sea and British coastal waters. Elsewhere different species form mussel beds. The beds are important in the sediment dynamics of coastal systems as well as being an important food source for birds. Mussel beds also provide shelter for a large number of organisms and form a rare hard substrate in a soft-bottom environment.*

Threats The main threat to mussel beds is from fisheries. These are for seed mussels and occasionally on mature beds. When mature beds are destroyed, recovery is difficult.

Status Mature beds have been destroyed by fishing during periods with low spatfall and are only recovering very slowly, if at all. In the Wadden Sea, there has been no recovery of some areas in the past 12 years. Less than 10 % of the original area is now present."

b) Literature used (*below)

The literature used is not sufficient to support the classification that intertidal mussel beds are declining or under threat across the whole OSPAR area, since most of the references used are from the Wadden Sea (Dankers *et al.*, 1999; Ruth, 1994; Ssymank and Dankers, 1996). The evidence for threat from fishing activities is sufficient with the literature used and is supported by other studies not cited here.

c) Literature interpretation

The literature used has been correctly interpreted regarding strong evidence of threat, but not for the entire OSPAR area, for which additional literature is required.

d) ICES assessment

This assessment requires additional information on which to assess the status of this habitat. There is, however, a large amount of literature on this subject (see below), but it was not used or cited in the document. Further details are necessary to identify specific areas under threat from fisheries activity throughout the OSPAR area. Suggestions of possible references are given below.

Location: It is reported that mussel beds are present all along the coast of Europe (Jones *et al.*, 2000). Mussels occur in beds all around the UK (OSPAR Regions II and III) (Jones *et al.*, 2000), while in Germany, a series of surveys covering the whole littoral of Niedersachsen (OSPAR Region II, Germany) revealed a decrease in the extent of beds and more drastically in biomass (Dankers *et al.*, 1999). Dankers (1993) observed that beds in the Ameland region disappeared after intensive fisheries. Details on the mussel populations of Schleswig-Holstein for a period of nine years are also available (Ruth, 1994). Dankers *et al.* (1999) reported a decrease in biomass of approximately 50 % between 1989 and 1990. The decline seems to be due to intensive fisheries and to low recruitment events. In France, mussel beds occur along the coast of France but no precise locations have been cited (Jones *et al.*, 2000). In the Netherlands, Higler *et al.* (1998) observed a serious decline in the populations of mussels between 1988 and 1990, mainly caused by fisheries. The extent of mussel beds decreased from the 1970s to the 1990s and Dankers *et al.* (1999) suggested that the reduction was mainly due to intensive fisheries during a period of low recruitment events. In Denmark, intensive fisheries during 1984 to 1987 almost led to a complete disappearance of the mussel population (Kristensen, 1994, 1995).

Decline: Jones *et al.* (2000) and other literature cited here showed clear evidence for a decline of mussel beds in areas of intensive fisheries, especially when associated with low recruitment events. Intertidal mussel beds have been placed on the red list of biotopes and biotope complexes of the Wadden Sea (Ssymank and Dankers, 1996).

Threats: The extensive, heavily exploited mussel fisheries (especially spat collecting for aquaculture), such as in the Wadden Sea, removed close to the entire stock between 1988 and 1990 (Dankers *et al.*, 1999), resulting in increased mortality for seabirds (e.g., eider ducks) (Kaiser *et al.*, 1998) and affecting the benthic diversity. Jones *et al.* (2000), Dankers *et al.* (1999), and other references consider that this habitat is under pressure from fisheries activities.

Vulnerability to future threat: Mussel beds are considered vulnerable to fisheries, especially when the settlement of spatfall is low. It is well recognized that phytoplankton blooms, produced by nutrient enrichment (e.g., industrial and residential sewage discharge, agriculture), could have consequences on mussel beds. Nutrient enrichment and increases in phytoplankton production have been observed by de Jonge (1997) in the Wadden Sea. Jones *et al.* (2000) suggested that mussel beds could also have intermediate sensitivity to anti-fouling substances and heavy metal contaminants. The decrease of mussel beds has profound effects on predators such as eider ducks and oystercatchers (Kaiser *et al.*, 1998).

e) ICES overall evaluation

OSPAR (2001) considered this habitat to be threatened and/or in decline across the whole OSPAR area. The Leiden Workshop concluded that evidence for the decline of and threat to intertidal mussel beds was "strong" across the whole OSPAR area. ICES has found sufficient evidence for the decline of and threat to this habitat over the whole OSPAR area.

References

Dankers, N. 1993. Integrated estuarine management—obtaining a sustainable yield of bivalve resources while maintaining environmental quality. *In* Bivalve filter feeders in estuarine and coastal ecosystem processes. Ed. by R.F. Dame. NATO ASI Ser., Subser. G: Ecological Sciences, 33: 479–511.

*Dankers, N., Herlyn, M., Sand Kristensen, P., Michaelis, H., Millat, G., Nehls, G., and Ruth, M. 1999. Blue mussels and blue mussel beds in the littoral. *In* Wadden Sea quality status report, pp. 141–145. Ed. by V.N. de Jonge *et al.* Wadden Sea Ecosystem No. 9. Common Wadden Sea Secretariat, Wilhelmshaven, Germany.

de Jonge, V.N. 1997. High remaining productivity in the Dutch western Wadden Sea despite decreasing nutrient inputs from riverine sources. Marine Pollution Bulletin, 34: 7427–7436.

Higler, B., Dankers, N., Smaal, A., and de Jonge, V.N. 1998. Evaluatie van de ecologische effecten van het reguleren van schlpdievisserij in Waddenzee en Delta op bodemorganismen en vogels. *In* Structuurnota Zee- en Kustvisserij, van de maatregelen in de kustvisserij gedurende de erste fase (1993–1997). Appendix 5, pp. 17. Ed. by J.J. van Dijk and R. Heling.

Jones, L.A., Hiscock, K., and Connor, D.W. 2000. Marine habitat reviews: a summary of ecological requirements and sensitivity characteristics for the management of marine SACs. JNCC, Peterborough, UK.

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2.2.3 Maerl beds

a) Description

<u>Threatened and/or declining habitat across the whole OSPAR area</u>.

"*Maerl is a collective term for several species of calcified red seaweed. It grows as unattached nodules on the seabed and can form extensive beds in favourable conditions. Live maerl has been found at depths of 40 m but beds are typically much shallower, above 20 m and extending to the low tide level. They are an important habitat for a wide variety of marine animals and plants which live amongst or are attached to the branches, or which burrow in the coarse gravel or dead maerl beneath the top living layer.*

<u>*Threats*</u> *Commercial extraction of maerl is a threat to maerl beds in some areas, They are also threatened by benthic fisheries, fish farms and poor water quality. Studies have shown impact from scallop dredging, for example, which caused serious declines of both maerl, by breaking and burying the thin layer of living maerl, and the associated species. Other types of mobile fishing gear are also likely to damage the living layer of maerl on top of the bed. In Brittany, eutrophication is known to have damaged maerl communities as this has caused smothering of the maerl by excess growth of other seaweeds and increased sedimentation. The discharge of nutrients from finfish farms into sealochs and the dispersal of chemicals used by fish farms into the marine environment may also affect the fauna associated with maerl beds.*

<u>*Status*</u> *Maerl is common on Atlantic coasts from Norway and Denmark in the north, to Portugal in the south. It is particularly abundant in Brittany. Spanish maerl deposits are confined mainly to the Ria de Vigo and Ria de Arosa. In Ireland, maerl is widely distributed in the south and southwest. It is absent from large areas of Europe, such as most of the North Sea, the Baltic, the Irish Sea and eastern English Channel, presumably due to environmental constraints. Major changes have been reported from some sites that have been studied in detail.*"

b) Literature used (*below)

The literature used (Birkett *et al.,* 1998; Jones *et al.*, 2000; Hall-Spencer and Moore, 2000; UKBAP, 2000) was not sufficient to support the classification that maerl beds are under threat or decline across the whole OSPAR region.

c) Literature interpretation

The literature used was not interpreted correctly. While strong indications of threat and decline in discrete areas were cited, this threat and decline were not indicated across the whole OSPAR area.

d) ICES assessment

This classification is supported by hard evidence on the distribution of maerl beds across the entire OSPAR area but not by hard evidence of threat or decline on a large scale. It is therefore recommended that the classification be modified to be confined to OSPAR Region III until further hard evidence becomes available.

Location: The UK Biodiversity Action Plan reports that maerl beds occur off the southern and western coasts of the British Isles, north to Shetland. It also reports maerl beds occurring in other western European waters, from the Mediterranean to Scandinavia. This is supported by Jones *et al.* (2000), who report on maerl beds in the waters all around Europe. Birkett *et al.* (1998) report maerl over a broad geographical range, from Arctic Russia to the Mediterranean. The Leiden classification is therefore correct in referring to the entire OSPAR area.

Decline: Evidence that this habitat is undergoing decline at least in one small area is given in Hall-Spencer and Moore (2000), which recorded declines on a maerl bed off the west coast of Scotland related to the expansion of the scallop fishing industry there. Similar evidence exists off the Irish coast, where the situation was complicated as species came and went on maerl beds according to seasonal influences. It is therefore logical to suggest from the literature that maerl beds may be in decline as a result of various activities across the OSPAR area as a whole.

Threats: Evidence from the literature (Hall-Spencer and Moore, 2000) shows that a threat exists from scallop dredging activities on the beds studied. Evidence presented by Birkett *et al.* (1998) also describes threats from scallop dredging, as well as from extraction, suction dredging, and pollution in nearshore waters. Evidence in the literature also states that maerl is slow growing in European waters and therefore slow to recover from disturbance, all of which supports the Leiden classification that this is a habitat under threat.

Vulnerability to future threat: If fishing activity with towed gears increases in future, then the threat to this habitat will increase. Furthermore, the threat also exists from extraction of maerl for pharmaceutical and other uses (De Grave *et al.*, 2000), from pollution by finfish and shellfish aquaculture operations in inshore waters, and suction dredging for bivalves.

e) ICES overall evaluation

OSPAR (2001) considered this habitat to be threatened and/or declining over the whole OSPAR area. The Leiden Workshop concluded that evidence for the decline of and threat to maerl beds was “strong” over the whole OSPAR area. ICES agrees that evidence for decline of and threat to this habitat is sufficient, but only for the OSPAR Region III area.

References

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2.2.4 *Modiolus modiolus* beds

a) Description

Threatened and/or declining habitat across the whole OSPAR area.

"*The Horse Mussel (*M. modiolus*) forms dense beds at depths of 5–70 m in fully saline, often moderately tide-swept areas. Although it is a widespread and common species, true beds forming a distinctive biotope are much more limited. The composition of the biotopes is variable and is influenced by the depth, degree of water movement, substrate and densities, however, there can be an abundant epifauna and infauna and it has been considered to support one of the most diverse sublittoral communities in northwest Europe.*

Threats *The main threat is from fishing, particularly using trawls and dredges. They are also likely to be badly damaged by other physical impacts such as aggregate extraction, trenching and pipe/cable-laying, dumping of spoil/cuttings or use of jack-up drilling rigs. The Horse Mussel is known to accumulate contaminants such as heavy metals in spoil disposal areas but the effects on condition, reproduction and mortality rates are unknown.*

Status M. modiolus *is an Arctic-Boreal species whose distribution extends from the seas around Scandinavia and Iceland down to the Bay of Biscay. Within the OSPAR area it is particularly abundant in the Barents and White Seas, Iceland, Norway and the northern coasts of Britain. Scallop dredging is known to have caused widespread and long-lasting damage to beds in Strangford Lough, Northern Ireland and off the south-east of the Isle of Man.*"

b) Literature used (*below)

The literature used was not totally relevant to supporting the case that this habitat is under threat or decline across the entire OSPAR area. The UK Biodiversity Action Plan (2000) contains a description of the status of the *Modiolus* beds but did not discuss the sensitivity of this habitat. Furthermore, the OSPAR QSR for Region II never mentions specifically this species of mussel. However, Magorrian *et al.* (1995) observed damage to *Modiolus* beds in Strangford Lough, resulting from queen scallop trawling. These authors described three components in a bed. The most important component is the very rich community of sessile and free-living epifauna. The diversity of benthic species increased with the size and the number of mussel complexes (Ojeda and Dearborn, 1989). Jones *et al.* (2000) suggested from limited data that reef areas of mussels would have greater diversity of fauna than non-reef areas. Fishing activities, especially scallop dredging, have been found to damage a large amount of the epibenthic species living in association with *Modiolus* beds (Magorrian *et al.*, 1995). There is a need to identify the rate of recovery of this habitat after severe damage. There have been no studies on this subject.

c) Literature interpretation

The literature used was interpreted only partially correctly, leading to the conclusion that evidence of habitat status is unclear. There was too much generality, with the information rarely available on the status of this habitat across the whole OSPAR area.

d) ICES assessment

The classification as to "strong evidence presented on threat" in relation to the fragility of *Modiolus* beds in all OSPAR regions is not supported by the scientific literature available. However, some areas showed evidence of threat supported by the literature. The need for more information on this habitat is essential and, under the concept of precaution, the inclusion of this habitat should be considered as sensible, until more research on the status of this habitat is completed.

Location: Jones *et al.* (2000) reported that *Modiolus* beds occur in most areas of the North Atlantic, even if not listed in the Wadden Sea. Brown (1984) used some organisms in four different locations, north and south of Norway, Sweden, and Ireland (OSPAR Regions I, II, and III) for his study. *Modiolus modiolus* is a northern species and is more tolerant to low water temperature. For this reason, it seems that the southern limit of aggregation is around the British coast (Jones *et al.*, 2000). In the Wadden Sea, *Modiolus* is reported present, but no detailed information is available (Jones *et al.*, 2000). In France, *Modiolus* beds occur along the coast of France but no precise locations are cited (Jones *et al.*, 2000). *Modiolus* is also present along the east coast of Canada and the USA. In the Gulf of Maine, the diversity of benthic organisms associated with *Modiolus* beds increased with the size of the bed (Ojeda and Dearborn, 1989).

Decline: From the literature used in the OSPAR report, there is no clear evidence of a decline in all areas mentioned above. The lack of information on the extent of this habitat and its actual status could be the cause of non-evidence of a decline for some areas. However, studies along the coast of the UK showed a clear decrease of this habitat (Magorrian *et al.*, 1995; Hill *et al.*, 1997). Jones *et al.* (2000) suggest that there is a significant decrease in the extent of this habitat. Furthermore, there has been a shift from large long-lived benthic species to smaller and more opportunistic species (Lindeboom and de Groot, 1998).

Threats: Scallop dredging in the Strangford Lough considerably damaged *Modiolus* beds and the associated epifauna. Some other areas could be under threat, but more information is needed.

Vulnerability to future threat: The biology of this species (long-lived and slow growing) places it in a vulnerable position, especially if you add the lack of information on its extent in the OSPAR area. Global warming and any phenomena that increase the water temperature could also have an effect on this northern species.

e) ICES overall evaluation

OSPAR (2001) considered this habitat to be threatened and/or declining across the whole OSPAR area. The Leiden Workshop concluded that evidence for the decline of and threat to *Modiolus modiolus* beds was "strong" across the whole OSPAR area. ICES agrees that evidence for both decline of and threat to this habitat is sufficient across the whole OSPAR area.

References

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2.2.5 *Ostrea edulis* beds

a) Description

Threatened and/or declining habitat.

"*Oyster beds are found locally in estuarine areas from 0–6 m depth on sheltered but not muddy sediments, where clean and hard substrates are available for settlement. Populations also used to occur in deeper water, down to 50 m in the North Sea in places such as the Oyster Grounds. Juveniles usually settle on the shells of adult oysters so their decline reduces suitable settlement areas for subsequent generations.*

Threats *Activities which disturb the seabed such as beam trawling and dredging have affected this habitat as well as overexploitation of the oysters themselves and the introduction of other (warm water) races of* O. edulis *and other oyster species in cultures.*

Status *Oyster beds were common in the North Sea and coastal waters. They have now virtually disappeared and only occur in some small remnant areas with populations occurring in deeper water in the North Sea, having disappeared gradually during the 19th and 20th centuries.*"

b) Literature used (*below)

The reference used (UKBAP, 2000) adequately supports the nominations.

c) Literature interpretation

The literature is correctly interpreted.

d) ICES assessment

Further details are necessary to identify the extent of *Ostrea edulis* throughout the OSPAR area.

Location: Native *Ostrea edulis* is widely distributed in Europe but seems to have disappeared from the Wadden Sea (OSPAR Region II) after overexploitation by the oyster fishery (Reise, 1982). *O. edulis* is cultured in the southwest of the Netherlands, in Norway (OSPAR Region I), along the coasts of Normandy and Brittany, Germany, and in several estuaries on the southeast coast of England (OSPAR Region II). *Ostrea* beds could be found in the rivers and flats bordering the Thames Estuary, The Solent, River Fal, the west coast of Scotland and Lough Foyle (OSPAR Region II). The *Ostrea* population was thought to be extinct in the

Wadden Sea after 1940 but a small number was found in 1992 (Dankers *et al.*, 1999). Furthermore, exotic species, such as *Crassostrea gigas*, are expanding in the German Wadden Sea and replacing the native *O. edulis* (Nehring, 1998).

Decline: A dramatic decrease in the population caused by fishery activities, again in the Wadden Sea, is bringing the population close to extinction. There are also reports of a reduction in the middle of the last century, which was caused by overexploitation. Other studies in North America have reached the same conclusion, which is that destructive harvesting and overfishing can reduce the habitat extent of oyster reefs. Most of the results showed a decline in the extent of natural oyster reefs.

Threats: The threat is present on the natural stock and a number of references indicate the cause as fisheries. There is a debate as to whether or not there is a truly natural UK stock. *O. edulis* has also been introduced in the Red List of Biotopes, Flora and Fauna of the Trilateral Wadden Sea Area.

Vulnerability to future threat: There is an increasing abundance of exotic species (*C. gigas*), which are more adaptable than *O edulis* in the German Wadden Sea. This shift in species could have profound effects on the natural stock of *O. edulis*. Furthermore, residential and industrial waste effluents could have consequences on oyster beds.

e) ICES overall evaluation

OSPAR (2001) considered this habitat to be a threatened and/or declining habitat for OSPAR Region II. The Leiden Workshop concluded that evidence was "strong", for both the decline and the threat. ICES finds that there is good evidence of declines and threat in OSPAR Region II.

References

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2.2.6 *Sabellaria spinulosa* reefs

a) Description

Threatened and/or declining habitat across the whole OSPAR area.

"*Dense subtidal aggregations of this small, tube-building polychaete worm can form reefs at least several centimetres thick, raised above the surrounding seabed, and persisting for many years. They provide a biogenic habitat that allows many other associated species to become established and can act to stabilize cobble, pebble and gravel habitats. They are of particular nature conservation significance when they occur on sediment or mixed sediment areas where they enable a range of species that would not otherwise be found in the area to become established.*

Threats The greatest impact on this biogenic habitat is considered to be physical disturbance from fisheries activities. Dredging, trawling, net fishing and potting can all cause physical damage to erect reef communities. Aggregate dredging often takes place in areas of mixed sediment where S. spinulosa *reefs may occur. Apart from direct removal, the impact of this activity on their long-term survival is unknown, but suspension of fine material during adjacent dredging activity is not considered likely to have detrimental effect. Pollution has been listed as one of the major threats to* S. spinulosa *in the Wadden Sea and may have partly contributed to their replacement by* Mytilus edulis *beds.*

Status Research has attributed the loss of the large S. spinulosa *reefs in the Wadden Sea to the long-term effects of fishing activity. A similar detrimental effect was reported for reefs in Morecambe Bay (UK) during the 1950s.*"

b) Literature used (*below)

The literature used (Holt *et al.*, 1988; Hughes, 1998; Vorberg, 2000; UKBAP, 2000; and OSPAR QSR for Region II, 2000) was not sufficient to support the classification that this habitat is under threat or in decline throughout the entire OSPAR area. The evidence for threat from fishing activities where they occur is, however, sufficient.

c) **Literature interpretation**

The literature has not been interpreted fully correctly. The evidence on habitat status does apply to OSPAR Regions II and III, but not to the whole OSPAR area. The evidence presented on threat, however, does appear to be interpreted correctly.

d) **ICES assessment**

The classification of the Leiden Workshop for "strong evidence presented on habitat status" (i.e., geographical location and classification across the entire OSPAR area) does not appear to be supported by solid references, as only one reference reports that reefs of *S. spinulosa* are known from all European coasts, except in the Baltic. A more robust classification might be to confine the classification to OSPAR Regions II and III. The Leiden classification as to "strong evidence presented on threat", as to the fragility of *S. spinulosa* in areas of trawl fishing, does however appear to be supported by the scientific literature cited.

Location: Information shows that *S. spinulosa* reefs are known from all European coasts, except in the Baltic. In the UK, *S. spinulosa* colonies are reported to occur in discreet areas at a number of locations all round the English coast (OSPAR Regions II and III), mostly northwards of a line between the Bristol Channel and the Thames Estuary, as well as at one or two locations on the south coast, although not all of them are at sufficient density to be described as "reefs". On the German coast, intertidal reefs have been reported from the Wadden Sea (OSPAR Region II), where their absence is considered a good indicator of fishing intensity (Berghahn and Vorberg, 1993). The literature provided reports the occurrence of *S. spinulosa* on the French coast, but without precise locations.

Decline: The literature provided cites evidence for a decline of *S. spinulosa* reefs in areas where trawl fishing occurs. *S. spinulosa* has been placed on the Red List of Macrofaunal Benthic Invertebrates of the Wadden Sea, according to the UK Biodiversity Action Plan, primarily due to beam trawling.

Threats: The literature provided cites a number of references indicating the threat to *S. spinulosa* reefs from fishing, and cites the practice by fishermen of destroying such reefs (as potential obstacles to trawls) with heavy gear prior to shrimp fishing, or to target such reefs as areas where shrimp might congregate. Also, the literature provided cites a number of references considering the risk from benthic trawling to be "high".

Vulnerability to future threat: Information indicates that *S. spinulosa* is very tolerant of water quality variation, but is potentially vulnerable to the short-term and localized effects of mineral extraction (although recovery from other, less-affected areas was predicted) and the effects of oil dispersants on the larvae. Overall, however, it has been concluded that *S. spinulosa* seemed unlikely to show any special sensitivity to chemical contaminants.

e) **ICES overall evaluation**

OSPAR (2001) considered this habitat to be threatened and/or declining across the whole OSPAR area. The Leiden Workshop concluded that evidence for both the decline of and threat to *Sabellaria spinulosa* reefs was strong across the whole OSPAR area. ICES agrees that evidence for both decline and threat to this habitat is sufficient, but only in OSPAR Regions II and III. The status of *Sabellaria alveolata* reefs should also be considered.

References

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2.2.7 Sublittoral mud with seapens and burrowing megafauna

a) **Description**

Threatened and/or declining habitat across the whole OSPAR area.

"*The megafaunal burrowing activity creates a complex habitat, providing for surface enlargement and deep oxygenation. It is assumed that this type of habitat* *supports a much richer and/or higher biomass community of infauna.*

<u>Threats</u> *The deep muds are not easily affected but the extent of physical impact changes the habitat itself Trawl tracks persist for prolonged periods in areas which are not tide or current swept. The main threats are therefore likely to be from demersal fisheries such as those which use beam trawls and scallop dredges.*

<u>Status</u> *The degree of decline is unknown but there is evidence that trawling does decrease and change the benthic communities living in this habitat.*"

b) Literature used (*below)

The supporting literature (see below) contains sufficient information to support the classification that this habitat is declining/under threat in OSPAR Regions II and III.

c) Literature interpretation

The literature is correctly interpreted in terms of the geographic extent of the habitat (OSPAR Regions II and III). There is insufficient evidence on the extent of the threat to this habitat, however, but trawling activity in deeper waters is suspected.

d) ICES assessment

ICES would support the assessment regarding the status of the habitat and the "unclear" classification as to the quality of evidence presented on the threat, as well as the finding that "the degree of decline is unknown".

Decline: In spite of additional material researched by ICES (Linnane *et al.*, 2000), evidence that this habitat is undergoing decline remains unclear, certainly for deeper water, simply because of gaps in our knowledge (although Roberts *et al.* (2000) reports evidence of deep-sea trawling physically impacting the seabed at depths of over 1000 m). Evidence from shallower waters (including Jennings and Kaiser, 1998) shows the damage that communities of burrowing megafauna in muddy sediments endure as a result of trawling activities, that the diversity of species is reduced, and that such communities can take several years to recover.

Threats: There is, however, robust evidence in the literature to support the classification that this habitat is under potential threat from trawling activities. Linnane *et al.* (2000) listed work giving estimates of penetration depth of up to 300 mm in mud for otter board trawl doors and beam trawls. Jennings and Kaiser (1998) also describe the detrimental effects of trawling on infauna in muddy habitats, as well as the effects of hydraulic dredges. They also point out that, in intensively fished zones (many of which occur in OSPAR Regions II and III), areas can be impacted several times (over eight in the case of the southern North Sea) a year. It is noted in the literature provided that fisheries for *Nephrops*, which themselves burrow in muddy habitats, can be intense and localized, which will increase the regularity of disturbance by trawl activity and therefore impact on the habitat itself.

Vulnerability to future threat: There is strong evidence in the literature to support the case that, as fishing effort increases, so will the threat to burrowing megafauna in sublittoral muds. As the activity of trawlers reaches further and further afield (Jennings and Kaiser, 1998), so will the threat increase to this habitat on a broader geographical scale than OSPAR Regions II and III, at which time it will be necessary to revisit the classification.

There is also evidence in the supporting literature to support the case that as human activity in the deep sea (such as deep-sea mining, hydrocarbon exploration) increases, so will the threat increase to deep-sea macrofauna from disturbance, which will be extremely slow (possibly several decades) to recover.

In addition to fishing activity, there is speculation in the literature provided that other threats, from heavy organic pollution and salmon aquaculture, may affect muddy habitats in shallow water.

e) ICES overall evaluation

OSPAR (2001) considered this habitat to be threatened and/or under decline across the whole OSPAR area. The Leiden Workshop concluded that evidence for the decline and threat was "unclear" and "unclear/reasonable", respectively. ICES suggests that, while the evidence of decline is insufficient, the evidence for threat is sufficient across the whole OSPAR area.

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2.2.8 *Zostera* beds (*Z. marina*, *Z. angustifolia*, and *Z. noltii*)

a) Description

Threatened and/or declining in OSPAR Regions II and IV.

"*Seagrass beds develop in intertidal and shallow subtidal areas on sands and muds. They may be found in marine inlets and bays but also in other areas, such as lagoons and channels, which are sheltered from significant wave action. They can survive and reproduce under conditions of occasional inundation or total submergence with the different species found at different shore levels or on different substrata. Seagrass stabilizes the substratum as well as providing shelter and a substrate for many organisms. They are an important source of organic matter and may also be important nursery grounds, providing shelter for young fish.*

Threats *Fisheries, nutrient inputs and turbidity (such as that which is caused by dredging activities) are all factors which threaten* Zostera *beds.*

Status *All the* Zostera *areas are dramatically declining. In the Dutch Wadden Sea the area estimated to be covered by* Zostera *in the 19th century was believed to be between 90–150 km² (intertidal and subtidal). Today this has been reduced to less than 1 km² of intertidal bed.*"

b) Literature used (*below)

The information on the status and decline of *Zostera* beds is sufficient for the UK and the Wadden Sea. However, the statement that "all the *Zostera* areas are dramatically declining" is not supported for the other areas within OSPAR Region II. The literature does not cover Region IV, but it does assess the east coast of the UK, which is part of Region II. The evidence for threat from nutrient inputs and turbidity is sufficient. The impact of fisheries is only documented for cockle fishing.

c) Literature interpretation

The literature is correctly interpreted, except for the spatial extent of *Zostera* decline.

d) ICES assessment

More information is needed on the status and decline of *Zostera* in Region II and especially in Region IV.

Location: Davison and Hughes (1998), citing Stace (1997) and Cleator (1993), state that *Zostera marina* and *Z. noltii* occur throughout the whole Atlantic. *Z. angustifolia* is recorded only around the British Isles, Denmark, and Sweden, which may be a matter of taxonomic disputes. According to the background material, OSPAR focuses on Regions II and IV. However, there is no assessment of the present status that adequately covers this area.

The information on the status of *Zostera* beds is rather biased, with extensive literature on the UK (UKBAP, 2000; Davison and Hughes, 1998; Jones *et al.*, 2000; and www.marlin.ac.uk). The latter also describes a large bed of *Z. marina* in Irish waters, and Jones *et al.* (2000) also cover the Wadden Sea. There is no information available on other areas. Within the short time available, ICES traced two sources of additional information. According to Geoffrey O'Sullivan (Marine Institute, Dublin, pers. comm.), Irish *Zostera* beds are stable, but no recent information is available for the past twenty years.

Hendriksen *et al.* (2001) concluded that there are no clear trends in the development of *Z. marina* beds in Denmark (Region II) over the past twelve years.

Decline: The mass mortality of *Z. marina* owing to wasting disease during the 1920s and mid-1930s has been sufficiently described. More recently, declines have been reported in the Wadden Sea and the UK for both *Z. marina* and *Z. noltii* (Jones *et al.*, 2000; Davison and Hughes, 1998). No information is available on other areas.

Threats: Present threats, both natural and caused by human activities, are adequately compiled by Jones *et al.* (2000) and Davison and Hughes (1998). Actual impacts are recorded locally. The evidence for threat from nutrient inputs and turbidity is sufficiently described in both papers. Other well-documented threats are trampling (*Z. noltii*) and mechanical disturbance by boats (*Z. noltii* and *Z. marina*). The impact of fisheries is only documented for cockle fishing (Davison and Hughes (1998), citing Perkins (1988)).

Vulnerability to future threat: In the available literature, no information is presented on future developments of threats. However, given the long list of threats, the possibility of combined effects, and the long recovery time of affected beds, it seems reasonable to expect a great vulnerability of *Zostera* beds.

e) ICES overall evaluation

OSPAR (2001) considered this habitat to be threatened and/or declining in OSPAR Regions II and IV. The Leiden Workshop concluded that evidence for the decline and threat was “strong”. ICES finds that there is good evidence of declines in and threats to this habitat. However, ICES advises that the available literature only covers parts of Regions II and III; hence, a more robust classification might be to confine the classification to these regions.

References

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ANNEX 2

TITLES OF RECENTLY PUBLISHED ICES COOPERATIVE RESEARCH REPORTS

No.	Title
231	Status of Introductions of Non-Indigenous Marine Species to North Atlantic Waters 1981–1991
232	Diets of Seabirds and Consequences of Changes in Food Supply
233	Report of the ICES Advisory Committee on the Marine Environment, 1998
234	Report of the Workshop on Ocean Climate of the NW Atlantic during the 1960s and 1970s and Consequences for Gadoid Populations
235	Methodology for Target Strength Measurements (with special reference to *in situ* techniques for fish and micronekton)
236	Report of the ICES Advisory Committee on Fishery Management, 1999 (Part 1 and Part 2)
237	Seventh Intercomparison Exercise on Trace Metals in Sea Water
238	Report on Echo Trace Classification
239	Report of the ICES Advisory Committee on the Marine Environment, 1999
240	Report of the Young Scientists Conference on Marine Ecosystem Perspectives
241	Report of the ICES Advisory Committee on the Marine Environment, 2000
242	Report of the ICES Advisory Committee on Fishery Management, 2000 (Part 1)
243	Report of the 12th ICES Dialogue Meeting (First Environmental Dialogue Meeting)
244	Report of the Workshop on Gadoid Stocks in the North Sea during the 1960s and 1970s. The Fourth ICES/GLOBEC Backward-Facing Workshop
245	The Annual ICES Ocean Climate Status Summary 2000/2001
246	Report of the ICES Advisory Committee on Fishery Management, 2001 (Part 1, Part 2 and Part 3)
247	Effects of Extraction of Marine Sediments on the Marine Ecosystem
248	Report of the ICES Advisory Committee on the Marine Environment, 2001
249	Report of the ICES Advisory Committee on Ecosystems, 2001
250	ICES GLOBEC Sea-Going Workshop for Intercalibration of Plankton Samples (report + CD-ROMs)
251	The Annual ICES Ocean Climate Status Summary 2001/2002
252	Report of the ICES/GLOBEC Workshop on the Dynamics of Growth in Cod
253	ICES Science 1979–1999: The View from a Younger Generation

ACRONYMS

ACE	Advisory Committee on Ecosystems
ACFM	Advisory Committee on Fishery Management
ACME	Advisory Committee on the Marine Environment
AFEN	Atlantic Frontier Environment Network
ASCOBANS	Agreement on Small Cetaceans of the Baltic and North Seas
BDC	OSPAR Biodiversity Committee
BEWG	Benthos Ecology Working Group
BSIM	Beaufort Sea Integrated Management Planning Initiative
BSRP	Baltic Sea Regional Project
CCIM	Central Coast Integrated Management
CFP	Common Fisheries Policy
DEFRA	Department for Environment, Food and Rural Affairs (UK)
DFO	Department of Fisheries and Oceans (Canada)
DG	Directorate General
DIN	dissolved inorganic nitrogen
DIP	dissolved inorganic phosphate
DPSIR	Driving force, Pressure, State, Impact and Response
EC	European Commission
EcoQ	Ecological Quality
EcoQO	Ecological Quality Objective
EEA	European Environment Agency
EPAP	Ecosystems Principles Advisory Panel
ESI	Environmental Sensitivity Index
ESSIM	Eastern Scotian Shelf Integrated Management
EU	European Union
EUNIS	European Nature Information System
FAO	Food and Agriculture Organization
FEPs	Fisheries Ecosystem Plans
GEF	Global Environment Facility
GIS	Geographical Information System
GIWA	Global International Waters Assessment
GLOBEC	Global Ocean Ecosystem Dynamics
GOOS	Global Ocean Observing System
GOSLIM	Gulf of St. Lawrence Integrated Management
HELCOM	Helsinki Commission (Baltic Marine Environment Protection Commission)
IBSFC	International Baltic Sea Fisheries Commission
IBTS	International Bottom Trawl Survey
ICES	International Council for the Exploration of the Sea
ICSU	International Council for Science
IGBP	International Geosphere-Biosphere Programme
IM	Integrated Management
IOC	Intergovernmental Oceanographic Commission
IUCN	The World Conservation Union
IWC	International Whaling Commission
JAMP	OSPAR Joint Assessment and Monitoring Programme
JNCC	Joint Nature Conservation Committee (UK)
LME	Large Marine Ecosystem
LOMAs	Large Oceans Management Areas
LRP	limit reference point
MAFAC	Marine Fisheries Advisory Committee (USA)
MAWG	Multispecies Assessment Working Group
MCWG	Marine Chemistry Working Group
MEQ	Marine Environmental Quality
MONAS	HELCOM Monitoring and Assessment Group
MSVPA	Multispecies Virtual Population Analysis
MPAs	Marine Protected Areas
NASCO	North Atlantic Salmon Conservation Organization
NGOs	non-governmental organizations
NOAA	National Oceanic and Atmospheric Administration (USA)
NSBP	North Sea Benthos Project
NSTF	North Sea Task Force
OA	Oceans Act
OSPAR	OSPAR Commission

SACs	Special Areas of Conservation
SCOR	Scientific Committee on Oceanic Research
SGCOR	Study Group on Mapping the Occurrence of Cold-Water Corals
SGDBI	Study Group on Discard and By-catch Information
SGEAM	Study Group on Ecosystem Assessment and Monitoring
SGEF	Study Group on Elasmobranch Fishes
SGFEN	Subgroup on Fishery and Environment
SGGOOS	ICES-IOC Steering Group on GOOS
SGSEF	Study Group on Effects of Sandeel Fishing
SMRU	Sea Mammal Research Unit (UK)
SSB	spawning stock biomass
STECF	Scientific, Technical and Economic Committee for Fisheries
TBT	tributyltin
TMAP	Trilateral Monitoring and Assessment Programme (Wadden Sea)
UK	United Kingdom
UN	United Nations
UNEP	United Nations Environment Programme
U.S.	United States
USA	United States of America
WGAGFM	Working Group on the Application of Genetics in Fisheries and Mariculture
WGDEEP	Working Group on the Biology and Assessment of Deep-Sea Fisheries Resources
WGECO	Working Group on Ecosystem Effects of Fishing Activities
WGMHM	Working Group on Marine Habitat Mapping
WGMMHA	Working Group on Marine Mammal Habitats
WGMMPH	Working Group on Marine Mammal Population Dynamics and Habitats
WGPE	Working Group on Phytoplankton Ecology
WGSE	Working Group on Seabird Ecology
WMO	World Meteorological Organization