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International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

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Conseil International pour l'Exploration de la Mer

H. C. Andersens Boulevard 44–46
DK-1553 Copenhagen V
Denmark
Telephone (+45) 33 38 67 00
Telefax (+45) 33 93 42 15
www.ices.dk
info@ices.dk

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Executive summary

The Data Collection Regulations (EC No 199/2008) make it clear that, in order to progressively implement the ecosystem approach to fishery management, it is necessary to collect data to assess the effects of fisheries on the marine ecosystem. In 2008 a Commission Staff working paper described nine indicators that might be necessary to support management, and DGMARE asked ICES to construct time-series for those indicators related to the spatial footprint of fishing fleets. WGECO describe a data request to all Member States for catch per trip logbook data for >10 m vessels, and VMS data from 2000, to derive métier distributions at a range of spatial scales.

In ToR a, the WGECO members reviewed the use of ecosystem terminology in high-level marine policy and management applications and commented on the best definitions for operationalizing those terms. Documents considered included the UN Convention on Biological Diversity, the European Union's Marine Strategy Framework Directive, OSPAR and HELCOM documents, and the FAO Code of Conduct for Responsible Fisheries.

Under ToR b the aim of the WG was to develop the methodology to carry out an assessment of Significant Adverse Impacts (SAI) of particular gears, and to carry out such an assessment on two chosen gears. The tow gear specifications chosen were beam trawls for flat fish in the North Sea and bottom-set gillnets in the Baltic Sea. The beam trawls were known to have major impacts and are well documented. The gillnets were believed to have fewer impacts but are less well documented.

The assessment was carried out on four ecosystem component categories:

- Commercial fish species-representing any fish landed by commercial fishing;
- Listed species including fish, cephalopods and benthos-representing any species previously listed as vulnerable or at risk;
- Marine mammals, marine reptiles and seabirds;
- Pelagic and benthic habitats and assemblages-representing the habitats and their associated species assemblages including fish, invertebrates and flora.

The assessment demonstrated that beam trawls had Significant Adverse Impacts for Commercial fish species and for Pelagic and benthic habitats and assemblages. Listed species including fish, cephalopods and benthos was not evaluated because of lack of an authoritative list. Beam trawls were evaluated as having no Significant Adverse Impacts on Marine mammals, marine reptiles and seabirds. Gillnets had Significant Adverse Impacts for Commercial fish species and for Marine mammals, marine reptiles and seabirds. Listed species including fish, cephalopods and benthos was not evaluated because of lack of an authoritative list. Gillnets were evaluated as having no Significant Adverse Impacts on Pelagic and benthic habitats and assemblages.

A number of unresolved issues were identified:

> What is the minimum level of proportional impact that would constitute an important pressure?
>
> Is there a need for a time-scale factor in an SAI assessment, e.g., "has been below Bpa for 4 out of the last 5 years"?
>
> For fish species with reference points there is an incompatibility in response between being below Bpa and SAI;

What are the appropriate "natural" reference conditions?

What geographic extent constitutes an important impact?

Should there be a nested approach to evaluations? For example, whole species are not SAI, but some stocks are, but not all gears contribute significantly to that.

For several years now WGECO have been involved in the work of developing a framework and the tools required to undertake integrated ecosystem assessments. Working on experience from the earlier WGECO and OSPAR approaches, Robinson *et al*. (REA) have continued to develop methodology with the rationale of using a limited number of state indicators per component, all with thresholds set that represent an *acceptable* (or *unacceptable*) level of deviation, against which the potential impact of any pressure can be assessed. The latest version of the REA methodology was trialled on eight broad ecosystem components in the five OSPAR Regions in February 2009. The outcomes of this exercise were reviewed by WGECO in Section 6 of this report, using the attributes defined by IOC (in press). In general, the assessment performed well in terms of legitimacy, reasonably well in terms of relevance and less well in terms of credibility. Some aspects of the REA methodology were well received; particularly the framework, which provided a transparent means for experts to engage in and work through the assessment. Other aspects require more development as they have led to inconsistencies in the assessments of some ecosystem components and pressures by different expert groups. Improvements in the detail of the methodology, particularly the use of indicators and thresholds and the scale on which the assessment units are undertaken, is critical in ensuring that the assessment process becomes fully credible. WGECO recommend that the lessons learned from this exercise are taken on board in terms of the further development of integrated assessments for commitments such as those made to the MSFD.

Updating of the proportion of large fish indicator trend revealed that the recovery, started in 2001, was ongoing with a current indicator value of 0.22 set against the target of 0.30. Recent developments in size-resolved multispecies modelling were described, but the questions posed by WGECO in 2009 relating to specific advice needs have yet to be addressed. This aspect of the work therefore remains outstanding and should return to the group in 2010. Key North Sea results from a substantial analysis of univariate community metrics undertaken for the OSPAR QSR 2010 were summarized. Strong spatial variation in the proportion of large fish indicator was apparent, and this was persistent in the face of major changes in exploitation levels and considerable variation in the overall North Sea indicator value. The proportion of large fish indicator was found to convey relatively unique information regarding the composition, structure and function of the demersal fish community. Changes in other aspects that are of policy and management relevance, such as species diversity, would require the application of a suite of "surveillance" metrics. Such a suite should always include the proportion of large fish indicator.

New analysis of North Sea survey data examined the extent to which the proportion of large fish indicator responded independently to changes in both the large and small fish components. Between1983 and 1992 the indicator declined through a combination of both decreasing large fish biomass and increasing small fish biomass. Between 1992 and 2000 the indicator varied around relatively low levels, driven primarily by changes in the biomass of small fish. The strong indicator recovery since 2001 was initially driven by a reduction in the biomass of small fish, but in recent years has been sustained by an increase in the biomass of large fish. Over this whole period, species richness of the large fish component of the North Sea demersal fish community has increased steadily, while species evenness has increased then decreased, varying inversely to changes in the proportion of large fish indicator. Current species richness metric values still exceed those prevalent in the early 1980s. These analyses in combination, all suggest an overall increase in the general health of the North Sea demersal fish community since 2001.

Lastly, WGECO was requested by the Working Group on Quantifying all Fishing Mortalities (WGQAF) to develop a rational and a list for non-assessed species to be considered with priority by WGQAF for research on fishing mortality. We discuss rationales for prioritizing non-assess high-biomass species and rationales for prioritizing species that are vulnerable by various criteria, and provide several species lists deriving from these rationales. Different policy preferences and different scientific considerations rank the rationales differently. A shot list of seven species is offered that are priority by multiple rationales and for which research on fishing mortality would therefore be of interest largely independent of overarching considerations.

1 Opening of the meeting

The Working Group on Ecosystem Effects of Fishing Activities (WGECO) met at ICES HQ, Copenhagen, from 10.00 Wednesday 15 April–17.00 Tuesday 21 April 2009. The list of participants and contact details are given in Annex 1.

1.1 Acknowledgements

WGECO would particularly like to thank Helle Gjeding Jørgensen, Cristina Morgado and other members of the ICES Secretariat for their support in enabling the meeting to run smoothly and in ensuring that the final Report was completed to schedule. We would like to further thank Cristina Morgado and Carlos Pinto for their help with the DGMare special request.

2 Adoption of the Agenda

The Agenda (Annex 2) was adopted on April 15th and the meeting proceeded according to the Workplan presented in Plenary Session by the Subgroup Leaders. Throughout the meeting, subgroup meetings were scheduled to allow for member participation in a number of subgroups to the degree possible. Daily updates were provided by the Subgroup Leaders in plenary session and as text was finalized it was presented in plenary. Therefore, all of the content of this report pertaining to the ToRs was fully reviewed in plenary sessions of the WGECO.

3 DG MARE Special Request; Fisheries Indicators

3.1 Introduction

In 2008, the European Commission adopted a Communication on the role of the Common Fisheries Policy (CFP) in implementing an ecosystem approach to marine management (COM, 2008/187 final). This was accompanied by a Commission Staff working paper that was the final report of a Working Group on Research Needs (SGRN) established under the Scientific, Technical and Economic Committee for Fisheries (STECF) that met in 2003 and 2007 (EC, 2003; 2007). This working paper included nine indicators selected to monitor impact of fisheries on the ecosystem.

The Data Collection Regulations (EC, No 199/2008) describe a framework for the collection, management and use of data required to support scientific analyses of fisheries and to support provision of sound scientific advice for the implementation of the Common Fisheries Policy. The Regulations make it clear that, in order to progressively implement the ecosystem approach to fishery management, it is necessary to collect data to assess the effects of fisheries on the marine ecosystem. Indicators that might be necessary to support management are identified in Appendix XIII of the Regulations.

DGMARE asked ICES to construct time-series for those indicators within ICES knowledge and competence, in two phases:

a) The first phase relates to indicators for which relevant data are already available.

b) The second phase aims to build time-series for those indicators where ICES does not yet have data.

This ToR deals with indicators related to the spatial footprint of fishing fleets and falls under the second phase.

3.2 Background to the fisheries indicators

Three of the nine indicators proposed to monitor the impact of fisheries on the ecosystem describe the spatial extent of fishing activities. These are (as defined in EC, 2007):

Indicator 5: **Distribution of fishing activities**

Indicator of the spatial extent of fishing activity. It would be reported in conjunction with indicator 6. It would be based on the total area of grids (3 km x 3 km) within which VMS records were obtained, each month.

Indicator 6: **Aggregation of fishing activities**

Indicator of the extent to which fishing activity is aggregated. It would be reported in conjunction with the indicator for 'Distribution of fishing activities'. It would be based on the total area of grids (3 km x 3 km) within which 90% of VMS records were obtained, each month.

Indicator 7: **Areas not impacted by mobile bottom gears**

Indicator of the area of seabed that has not been impacted by mobile bottom fishing gears in the last year. It responds to changes in the distribution of bottom fishing activity resulting from catch controls, effort controls or technical measures (including MPA established in support of conservation legislation) and to the development of any other human activities that displace fishing activity (e.g., wind farms). This indicator could be reported annually and would state the total proportion of the area by depth strata (0–20 m, 20–50 m, 50–80 m, 80–130 m, 130–200 m, >200 m) in each marine region that has not been fished with bottom gear in the preceding one year period.

3.3 Approach to data collection

The logbook and VMS data currently available to Member States can be used in a number of different ways to provide data for these indicators. This section describes options for collecting and using these data, based on logbook and VMS data, with the use of some algorithms for further interpretation.

3.3.1 Logbook data

There are several different levels of information recorded in logbooks; the most detailed information is also the most difficult to obtain, and in some cases is not yet widely recorded or available to Member States.

These data are important for describing historical patterns of fleet distribution, using catch and effort distribution at the scale of the ICES rectangle. Although improved spatial resolution will be achieved in future for those parts of the fleet that are covered by VMS (Section 3.3.2); the logbook data will be essential to describing the distribution of the 10–15 m vessels (that do not have to carry VMS) over the past decade, and for the foreseeable future.

The most basic logbook data consists of a vessel ID and information on the gear used. This allows the identification of the vessel to métier level 4.

Logbook information usually includes retained catches of the main commercial species on a trip-by-trip basis and at the scale of an ICES rectangle. This information allows the identification of the vessel to métier level 5 or 6. Vessels may change the targeted fish during a trip so that the catches may not necessarily represent the correct métier(s) at level 6.

Logbook data containing catches on a haul-by-haul basis, with exact positions, are preferred. Such data allow the distinction of fishing from other activities (e.g., steaming) with more precision than using VMS records and provide a métier for each position registration. Catch per haul data are not widely available, but will become easier to access once electronic logbooks are introduced.

3.3.2 VMS data

The collection and supply of VMS data is stipulated by Regulation EC 2244/2003, which itself is based on the Council Regulation EC 2371/2002, describing the principles of the European Common Fisheries Policy (CFP). By 2005, all vessels over 15 m were obliged to carry VMS (before that this limit was 18 m and 21 m, respectively), so that, particularly for coastal fisheries carried out with small boats, VMS coverage of all fishing activities is incomplete. Costs for VMS transmission and equipment are paid by the fishing industry. The access by Member States to these VMS data is generally through the national fishery authorities, and is used primarily for enforcement purposes (ICES, 2008).

VMS data are transmitted with information on vessel ID, position (latitude and longitude), speed, and direction. Generally, VMS data are provided at intervals of approximately two hours (Bertrand *et al.*, 2005; Kourti *et al.*, 2005; Mills *et al.*, 2007).

Since 2006, the complete suite of information is available to national authorities inside their national waters both for foreign and national vessels. Before 2006, for foreign vessels only position data were transmitted to national authorities, making it very difficult to know whether or not a vessel was fishing using the raw data.

If measured speed at each position registration is not available, speed can be calculated between successive registrations and used as a proxy. Note that at shorter time intervals the accuracy of the calculated speed increases.

The VMS direction of the vessel at each position may be used to plot the precise track of each fishing vessel and thereby more precisely describe the spatial extent of fishing. The method is most useful when applied to towed gears, and for accurately mapping the spatial extent of this fishing activity at a fine scale (Section 3.3.3). If measured direction at each position registration is not available, direction can be calculated between successive registrations and used as a proxy. Note that at shorter time intervals the accuracy of the calculated direction increases.

Although frequency of position returns of 2 hrs is the lowest usually available, an increase in the frequency of position registrations would improve the accuracy of estimates of fishing activity location. Shorter time intervals between the position registrations would also improve the accuracy of calculated speed and direction. Such precision is necessary if fleet distribution is needed at a fine scale. Should cost be an issue, there can be a trade-off between shorter interval that would allow tracks to be reconstructed with less sophisticated methods or additional information on speed and direction, possibly together with a small subset of data with shorter interval that would allow the most sophisticated algorithm to be used to reconstruct the track.

3.3.3 Analytical methods

VMS and logbook information needs to be processed in order to better describe fishing activity for use in the three pressure indicators. Different methods are used to:

- Identify fishing activity;
- Create fishing tracks;
- Define métiers.

3.3.3.1 Fishing activity

It is necessary to distinguish fishing activity from other activities (e.g., steaming). Methods have been developed that use VMS information:

- Information on speed at each position registration can be partitioned, based on the assumption that specific activities occur only within certain speed ranges. Rijnsdorp *et al.*, 1998 analysed the Dutch beam trawl fleet and identified steaming (approx. 12 knots), fishing (approx. 6 knots), and hauling the gear (0–4 knots). In a similar way, ICES, 2008a illustrates behaviour patterns of gillnets, crabbers, longliners and trawlers. If information on seabed contours is available, it is possible to distinguish between likely bottom trawl vessels and pelagic trawl vessels as the former usually follow the contours although the latter may not.
- At low frequencies of VMS transmissions (e.g., 1–2 hour position registration intervals) spatial information on fishing activity is relatively poor. The precision of the partitioning between fishing vessel activities, particularly for the area potentially affected by fishing, can be improved statistically. Mills *et al.*, 2007 describe a method that uses an ellipsoidal probability

space around sequential pairs of VMS registrations, whereas Fock (2008) redistributed effort into a discrete subset around each registration based on statistical properties of individual vessel behaviour.

3.3.3.2 Fishing tracks

The 2 hourly frequency of typical VMS position returns may be too coarse to estimate the impact of fishing on some ecosystem components (Piet *et al*., in press), and a considerable part of vessel activity is not accounted for with VMS position returns every 2 hours. In particular, it cannot be assumed that vessels only trawl along the straight lines connecting subsequent VMS points, but move to either side and this way covers a greater area. At very short intervals (< 0.5 h), it is likely that many fewer unaccounted movements have been undertaken so that joining points by straight lines is reasonable. At intermediate intervals, this assumption is less likely, so further movements must be accounted for by statistical treatment to model the likely spatial coverage using vessel direction. For each métier there will be an optimal VMS frequency that best describes vessel track, without requiring the additional work involved in applying vessel direction and fishing track algorithms.

A possible solution for this problem is to reconstruct the fishing track by interpolating between the position registrations, resulting in high resolution estimates of spatial fishing patterns and thus more accurate pressure indicators.

Most research on interpolating trajectories has been carried out in animal tracking studies (Jonsen, 2003; Ryan, 2004; Jonsen, 2005; Tremblay, 2006; Hedger *et al*., 2008). Several different techniques, such as state-space modelling, random walk approaches and spline interpolations, have been used to either describe animal behaviour or to reconstruct their movement patterns. Most of these studies use GPS positioning data as their main source of information. Some studies have attempted to describe fishing vessel behaviour using tracking data such as VMS transmissions (Rijnsdorp *et al*., 1998; Dinmore, 2003; Hiddink, 2006; Piet *et al*., 2007). In these studies, fishing impact was mostly represented by the VMS data points themselves. Some recent studies have interpolated trawl tracks from GPS positioning data. Eastwood, 2007 and Stelzenmuller *et al*., 2008, used linear interpolation (connecting sequential data points with a straight line) and the width of the gear to reconstruct a trawled surface. However, Deng, 2005 found that straight line interpolation is still likely to underestimate the length of the trawl track, especially when the interval between position registrations is large. Fock, 2008 demonstrated differences in behaviour between métiers and that beam trawlers and midwater trawlers often do not tow in straight lines.

A promising method was developed recently by Hintzen *et al*. (submitted) using a technique based on cubic Hermite spline interpolation. This technique interpolates trajectories as curves and has been successfully applied to reconstruct animal tracks (Tremblay, 2006). In addition to the position information provided within VMS data, the method can also incorporate speed and heading at VMS data points, thereby ensuring more accurate estimations of the real vessel trajectory. The method has so far only been applied to the Dutch beam trawl fishery so its performance for other fisheries or métiers needs to be assessed.

It would be useful to be able to validate these with occasional and specific rapid polling exercises for specific vessels or fleet segments. The main concern with more rapid polling is the cost of the satellite communication, as 30 minute polling is four times more costly than 2 hourly polling. However, it should be relatively easy to have a VMS system that records vessel position at a chosen frequency and transmits the record to the satellite once a day or even less frequently.

3.3.3.3 Métiers

Métier level 4 describes gear types. Level 5 describes trawl with species (i.e., otter trawl and plaice), while métier level 6 is a specific description based on the catch. The DGMARE request indicates that activity information is required disaggregated to métier level 6. This level is based on the catch composition. In terms of the three activity indicators proposed the WG considers that catch composition will not provide any additional useful information. The key information would be about the vessels and its gear, so down to métier level 5. If this is agreed, it should significantly reduce the data volume needed to address the request and have no impact on the conclusions.

ICES 2003 found that two approaches to defining métiers prevail in the literature and were used in fishery institutes. The first one is a quantitative analysis of logbook data, using multivariate procedures. The other approach is an *ad hoc* trial and error process, based on qualitative *a priori* knowledge of the fisheries in order to identify suitable allocation threshold.

For a quantitative analysis of logbook data, a number of published works exist using various multivariate techniques for fishery métier identification.

- Biseau and Gondeaux, 1988 described the use of a Principle Component Analysis (PCA) on two types of variables: gear used or time spent during each month in each area, and target species or proportion of each of the major species observed in each month in the landings of each vessel. The combinations of species composition and gear used, defined the métiers.
- Lewy and Vinther, 1994 used a hierarchical agglomerative cluster analysis to identify métiers in Danish North Sea trawl fisheries.
- Pelletier and Ferraris, 2000 used a multivariate approach involving PCA, HAC, Multiple Correspondence Analysis (MCA) and Two Way Correspondence Analysis (TWCA) for two métier allocation case studies: one in Senegal the other in the Celtic Sea.
- The fishery observatory (SIH) of IFREMER used also a similar approach combining PCA and HAC at the vessel level to arrange vessels in métiers (Berthou *et al.*, 2003).
- The main objective of IBERMIX (FISH/2004/03–33), titled "Identification and segmentation of mixed-species fisheries operating in the Atlantic Iberian Peninsula waters" was the identification of fleets/fisheries/métiers in the Atlantic off Iberia (ICES Divisions VIIIc and IXa). Spanish fleets were using logbooks from 2003–2005 and Portuguese fleets were segmented by value of daily commercial landings for 2003–2005. The matrices were analysed separately by year, using a non-hierarchical cluster analysis to classify catch/landings profiles.

The qualitative approach is based on *a priori* knowledge of the fisheries. A trial and error process is conducted in order to derive suitable discriminating thresholds allocating each fishing trip to one and only one métier (based either on landing weights, landing values or mesh size; e.g., Biseau and Gondeaux, 1998. Often these approaches are not published, but might be used extensively within the institutes, for example, for designing sampling programmes (ICES, 2003).

Berthou *et al.*, 2003 combined both approaches using quantitative multivariate analyses (described in the previous section) and expert *a priori* knowledge to develop algorithms (decisions rules) to classify vessels to fleets. The Atlantic French fleet has thus been split into 13 fleets and 33 Sub-fleets (e.g., "Trawlers-non exclusive" then "Trawlers-Dredgers"). The main assumption underlying this approach is that the technical characteristics of a vessel limit the numbers of different types of fishing that a vessel can undertake. Some vessels might be used for several fisheries, whereas other vessels might only be used for one type of fishery. For example, vessels that are equipped for trawling might also be used for seining with only slight modifications, whereas vessels equipped for seining would need large modifications (larger engine, other equipment) in order to be able to go trawling.

Finally, ICES 2003 proposed a three-step framework generally applicable to the identification of fisheries: (1) identification of the different landings profiles using landings data, (2) analysis of the relationships between the features of each trip (effort data) and their outcome in terms of landings profile, and (3) aggregation of the results of step 2 to define fisheries that are considered sensible in relation to field knowledge and qualitative expertise.

Such a framework was used in a number of subsequent EU-funded projects dealing with fleets and métiers. In particular, the FP6 project TECTAC made significant progress towards international consistency in identifying fisheries and métiers. All institutes involved, representing several North Sea and Celtic Sea countries, agreed on a common database format for logbook data (the EFLALO format) as well as for other types of data (e.g., TACENQ format for data from on-board observers). This common data format made it possible to apply consistent methods across nations without requiring actual exchange of national logbook data, as only generic SAS codes were written and exchanged. Although a number of generic methods were proposed and tested, a unique multivariate method for métier definition could not be agreed on (see below).

The TECTAC procedure of common data format and code exchange has proven to be very useful and efficient, and subsequent FP6 projects such as CAFÉ and AFRAME have adopted the EFLALO format.

3.4 Determining fishery indicators

There are different combinations of logbook (catch and effort) and VMS data that can be used as indicators of the spatial impact of fishing. These apply to vessels >10 m, describe métiers from levels 4 to 6, and allocate activity to spatial scales between an ICES rectangle to much finer than 3 km x 3 km.

Five levels of indicator are distinguished, based on availability of data and method of analysis (Table 3.4.1). These levels increase in their spatial resolution and precision:

> At the lowest level the indicators can be based only on the gear and effort data obtained from logbooks. This will provide a description of location of fleets, at métier level 4, and at the scale of the ICES rectangle. This method will provide important descriptions of distribution for the 10–15 m fleet, which subsequent methods will not.
>
> If VMS position registrations collected at a 2 hr interval are available, these can be used to describe the presence of the vessel (i.e., not just fishing). These vessels can be classified at métier level 4 using gear descriptions from logbooks. The appropriate spatial scale (3 km grid) corresponds to the use of 2 hr interval position registrations, and with the specification of the indicators described in the DCR.
>
> At the next level, the distinction of fishing from non-fishing activity can be achieved by using an analysis of vessel speed (Section 3.3.1) with 2

hourly position registrations. The métier level of these vessels can be allocated to level 5 or 6 by linking VMS records to logbook catch per trip data. The appropriate spatial scale (3 km grid) corresponds to the use of 2 hr interval position registrations, and with the specification of the indicators described in the DCR.

Two further methods are available that will generate fleet distributions with finer resolution. The data required to generate these are not yet widely available.

The location of fishing activity may additionally be determined by linking 2 hourly VMS position registrations with catch per haul data. This will identify métier level 6 fleet activity at the scale of the required 3 km grid.

At this métier level a higher, and possibly more appropriate, spatial resolution can be considered. This is less relevant if the indicators are used as a relative measure (e.g., trends over time). However, if the absolute spatial extent is of relevance (e.g., when a specific proportion of a habitat should not be affected by fishing), then this has consequences for the data requirements. Higher spatial resolutions can only be achieved if the actual fishing tracks are determined. For this a straight-line interpolation between vessel registrations can be used if the time interval is shortened. More accurate tracks can be obtained by applying interpolation algorithms. The best, however, also require the direction of the vessel in the VMS data. The accuracy increases when the direction is recorded together with an increasingly shorter interval (<<2 hrs) of VMS position returns.

Table 3.4.1. The use of VMS and logbook data for describing the location of fishing vessels, the location of fishing activity, and the location of fishing tracks of towed gears. The use of different combinations of VMS and logbook data provide data at different métier and different spatial scales. Indicator accuracy increases down the table, and to the right hand side. Detailed interpretation of the table should be undertaken with the numbered paragraphs in Section 3.4.

	VMS	Logbook	Method	Relevant vessel length	Vessel Location		Vessel Fishing Location		Vessel Fishing Track	
					Metier	**Scale**	**Metier**	**Scale**	**Metier**	**Scale**
1	None	Gear Effort	None	>10m	4	ICES rectangle				
2	2 hr positions	Gear	None	>15m	4	3km				
3	2 hr positions VMS Speed	Catch per trip	Fishing Algorithm	>15m			5/6	3km		
4	2 hr positions	Catch per haul	None Metier Algorithm	>15m			6	3km		
5	<2 hr positions VMS Speed VMS Direction	Catch per haul	Track Algorithm	>15m					6	<<3km

3.5 Data needs for determining fishery indicators

A call for data will need to be issued (by ICES) in order to compile these three indicators.

The technical specification for the data collected is as follows:

3.5.1 VMS data

Mandatory data: Unique vessel identifier; Latitude; Longitude; Date/Time; Direction; Speed;

Please take into consideration that we are requesting all the raw VMS data points, ship by ship for all the national fleet and for other vessels (preferably only non-EU vessels) that have entered your national waters.

If an extraction query was used to extract the data from a database, please also send this to ICES.

This request is for data from 2000 onwards.

3.5.2 Logbook data for >15 m vessels

Logbook Data:

Mandatory data: Unique vessel identifier; Date/Time; FAO Species Code; Fish quantity; Gear; Mesh;

Haul by Haul data:

Mandatory data: Unique vessel identifier; Date/Time; FAO Species Code; Fish quantity; Gear; Mesh; Start and end latitude and longitude of fishing operation; Start and end Date/Time of fishing operation.

To deliver the required time-series indicator it would be valuable if these data could be submitted for all years for which they are available.

3.5.3 Landings data

Mandatory data: Unique vessel identifier; Date/Time of sale; FAO Species Code; Fish Quantity;

Additional data: Size/Class; Harbour

Information by each species with the FAO Code for each vessel per day would fulfil the minimum requirement.

3.5.4 Extraction format

- dBase (dbf) or Comma separated values (CSV) are acceptable.
- The highest level of accuracy of all fields is requested.
- Please define speed as a decimal value and if using CSV format, do not use a comma as the decimal separator.
- Vessel identifiers can be anonymised by Member States as long as identifiers are the same in the VMS, logbook and landings data, but privacy of all data will be respected.

3.5.5 Delivery

- Member States should either upload the data to the ICES website or ftp, or send data on CD/DVD.
- Assuming that DRC indicators are recalculated on an annual basis, Member States are requested to submit data 2 months before the assessment date.
- Any further questions of VMS of logbook data submission should be directed to ICES.

3.6 Other issues relating to existing protocols for each indicator in data collection regulations described in Appendix XIII

3.6.1 <15 m fleet

Using the protocols outlined earlier in this section will generate indicators for only part of the fleet and will not represent the entire impact of this sector. To illustrate the scale of the missing elements of the fleet <15 m in length, in Ireland there are approximately 2000 vessels in the registry of which 88% are less than 15 m. Of these vessels roughly 23% have some form of dredge as their main gear, 42% are potters and 10% gillnetters, the remainder include lines and midwater gears.

An additional concern is that vessels less than 10 m do not need to provide logbook returns. Again for the Irish fleet, approximately 70% of the vessels are less than 10 m. There may be approaches that allow these vessels to be included. In Ireland a Sentinel Vessel Programme has been in operation since 2008. This programme encourages inshore fishers to record their fishing activity and costs, and is crucial to supplying the information required under the Data Collection Regulation 199/2008. Individual vessels <10 m are supplied with simple logbooks to record daily fishing activity by position and effort level in terms number of pots or nets fished for static gear vessels or hauls in respect of inshore trawlers or dredgers. These data are then aggregated at fleet level to give indications of effort by fisheries.

In some cases vessels less than 15 m may possibly be members of fleet segments that include larger vessels. For instance, for the Irish dredge vessels, there are 409 vessels under 15 m, and a further 45 over 15 m for which VMS is available. In many cases these are from the same home ports as the smaller vessels, and could be used to allocate effort in time and space to these smaller vessels. Validation of such an approach could be provided by temporary installation of GPS loggers on a sample of these smaller vessels. An additional validation could be to use half of the over 15 m vessels in a segment to develop activity data, and compare that with the recorded activity of the remainder, possibly by region or port. Potentially, a bootstrap approach could be used to determine variance in this.

If such approaches do not work, it should still be possible to identify geographical areas where some of the missing vessels might contribute an important proportion of the fishing activity. Logbooks should be able provide activity data at the ICES rectangle level. Some rectangles, particularly in the more offshore areas, will probably include little activity from 10–15 m vessels, although this will tend to be greater in inshore and coastal rectangles. This could be considered as a quality check for any conclusions about fishing activity in these rectangles.

This is particularly relevant when interpreting indicator 7 (Areas not impacted by mobile bottom gears), as this measure will not include the activity of the many inshore vessels using towed gears. Further measures to reduce the minimum length of vessels obliged to use VMS should be encouraged in order to address this concern.

3.6.2 Availability of catch per haul data

Current regulations require catch data to be submitted per day, or when a new ICES rectangle is entered. In many Member States, logbooks that report on a haul-by-haul basis are not available. Recent activity in ICES (ICES, 2008) reviewed the range of methods by which detailed information on catch, effort and location could be generated, including on-board observation, aerial monitoring, and through inspections. The introduction of electronic logbooks in the near future will provide high resolution data for individual trawl hauls, if linked to a fishing location. More highly resolved logbook data on a haul by haul basis is already provided in Denmark for a small reference fleet comprising vessels both above and below 15 m length (ICES, 2008). This information is collected in terms of private logbooks on a haul-by-haul basis. In Sweden and Norway, haul-by-haul information is mandatory.

3.6.3 Spatial scale for reporting VMS activity

The specification of the Indicators in Appendix XIII of the DCR identifies a 3 km x 3 km grid size as optimal for representing fleet distributions. This, however, was determined by the availability of VMS data at a mostly 2 hr interval as opposed to what was needed to achieve the optimal spatial scale necessary to identify the fishing impact on the relevant ecosystem components.

A study by Piet *et al*. (in press) on the effect of spatial scale on our perception of fishing impact on the ecosystem demonstrated for the Dutch beam trawl fleet that in a suite of relatively heavily fished (500–1000 days-at-sea per year) ICES rectangles, less than 5% of the area would be considered unfished on a scale of 3 km x 3 km whereas on a scale of approximately 100 m x 100 m, which better reflects how a typical fishing operation impacts most sessile benthic organisms, this would be more than 70%. This demonstrates that if the absolute value of the indicator is of concern (e.g., because it is linked to conservation objectives of specific benthic organisms) it should be reflected in the value of the indicators. It is therefore recommended that the most appropriate spatial scale is selected, and that the most suitable resolution VMS data are collected in order to calculate the indicators at the appropriate scales.

3.7 Case studies to highlight diverse range of current approaches

With reference to Indicator 6 'Aggregation'

Fock, 2008 has defined areas of aggregation within the German EEZ for level 4 métiers, applying a 75% rule instead of the 90% effort-threshold defined by the proposed EcoQO. Pedersen *et al*., 2009a resolved this level 4 pattern into level 6 métiers although *a posteriori* including information on catch and mesh sizes. The proposed EcoQO prescribes an *a priori* inclusion of métier information which is preferable over the inclusion of information *a posteriori*.

With reference to Indicator 7 'Unimpacted areas'

Pedersen *et al*., 2009b applied a simple mapping approach plotting all métier-specific VMS fishing positions of the international fleet under the basic assumption that the composite behaviour of the entire fleet adequately represents the behaviour of a single vessel during a single trip and thus substitutes the missing spatial information because of VMS recording intervals at an hourly scale on the vessel level. By this procedure, small-scale areas were identified where no VMS recordings were encountered.

3.8 Resources

Converting raw logbook and VMS data to useable management indicators will require significant effort. As no dataset is perfect, it will be necessary to check and clean the dataset to ensure that errors and duplicates are removed. Both Member States and ICES will each be required to undertake some of this work. This will be a substantial task and until the responsibility for this task is allocated between Member States and/or ICES, it is not possible to provide precise estimates of resource needs.

As the data request will generate large volumes of raw data, regardless of how the preparatory work is distributed, it is likely that ICES will require specific additional resources to process and interpret data, and generate the necessary indicators.

3.9 Conclusions

The approach presented here was intended to be comprehensive; encapsulating all possible combinations of logbook and/or VMS data that exist among member states over the last decade and that are relevant to describe the spatial extent of fishing activities. This therefore includes the period prior to 2000 when no VMS data were available. It also includes the period 2000–2005 when the part of the fleet for which VMS needed to be recorded was expanded including first vessels >21 m, later >18 m until finally >15 m, as well as differences among member states in terms of the fields that are collected as part of the logbook and VMS data.

At present most member states collect VMS position registrations for all vessels >15 m at a 2 hr interval including speed and direction, while logbook data consists of gear information, catch per trip and effort for all vessels >10 m. With this information it is possible to calculate the indicators at métier level 5 based on fishing activities only and based on a more appropriate spatial scale than 3 km x3 km (e.g., 100 m x 100 m) providing the best available methodology is applied that distinguishes fishing and reconstructs the trawl track by interpolating between the fishing registrations. The fact that it is not yet possible to distinguish métier at level 6 is not considered a problem as the fishing impact on the ecosystem and its components depends on the type of gear used and the spatial extent and intensity of the fishing operations. These are thought to be sufficiently covered by métier level 5 in combination with the suggested indicators.

In addition to receiving the raw VMS and logbook data from Member States, it might also be possible to receive their extraction queries to classify VMS data into métiers to be used with their databases. These are likely to vary between countries, and with the increasing use of these data for evaluation of management measures and conservation, Member states will have an increasing ability to analyse their own VMS datasets.

Increasing the monitoring frequency to more than once every two hours would result in an improved accuracy of the indicators. How much improvement can be achieved through this; however, still needs to be assessed. Alternatively some improvement could also be achieved if small sets of VMS or logbook data became available for each level 5 métier that would allow the tuning of the available algorithms that distinguish fishing and reconstruct the trawl tracks. These could be high-frequency VMS data and/or logbook data containing haul-by-haul information for a subset of vessels belonging to each métier, or all vessels in each métier over a limited time period. The current observer programmes can already provide this type of logbook information.

Two important omissions were identified that were not covered by these indicators:

- The fishing fleet < 15 m for which no VMS data are collected but are known to have considerable impact in specific areas.
- The period prior to 2000 when no VMS data were collected. This may be of relevance to interpret the indicator values over the longer time-scale.

Both of these can be addressed by using the effort information per ICES rectangle in the logbooks. Even though this only provides information at a very crude spatial scale, it does expand the part of the fleet for which some information on their spatial extent to all vessels > 10 m as well as the time period to before 2000. Both of these allow a somewhat wider perspective on the observed indicator values.

Finally, when the VMS and logbook data become available according to the above specifications for all EU waters, fishing métiers and member states it would be advisable to evaluate if the suggested indicators are the best way to describe the spatial extent of fishing activity or that other indicators are more suitable.

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4 ToR a Sense and sensibility: Bringing consistency to the use of ecological terms and concepts in marine ecosystem management

4.1 Term of reference

a) *define and demonstrate with selected case studies / examples the practical interpretation of the high level terminology used in the international agreements on managing marine ecosystems. Specifically these should include the broad ecosystem management concepts 'significant adverse impacts', 'vulnerable marine ecosystems', and 'good environmental status'. This should include explicit consideration of reference conditions, thresholds and recovery rates, in relation to both ecosystem structure and function;*

4.2 Introduction

Recent years have seen ICES, and WGECO, asked to provide advice to a number of different policy customers on ecosystem impacts and the ecosystem approach to management. In many cases different policy customers have used the same or very similar terminology in different ways while WGECO also recognizes the increasing occurrence of ecological terminology in policy documents. In 2008 WGECO recommended a systematic review of the use of ecosystem terminology in marine policy and management applications (ICES, 2008) and this ToR provides the opportunity to undertake that work.

Clearly this is a task almost without boundaries, each definition will contain terms that can then become the focus of a further definition. We have restricted ourselves to terms that are ecological in derivation as this reflects the core expertise and work of the Working Group and made the task tractable within the resources of time and expertise available. The boundaries are therefore, somewhat, subjective and may not always match the reader's expectations.

4.3 Adopted approach

A systematic review of the major policy drivers and high level international agreements was carried out. Documents considered included the UN Convention on Biological Diversity, the European Union's Marine Strategy Framework Directive, OSPAR and HELCOM documents, and the FAO Code of Conduct for Responsible Fisheries (Table 4.3.1). The review identified 185 ecological terms which were used in the high level policy documents and their supporting texts. For each of these we considered whether a formal definition was given, and if so the original source. This initial list was reduced slightly following a peer review process focusing on the ecological basis of the terminology and the context of their use as high level policy terms (Appendix 1). We also carried out a second phase search of all the high level policy documents and their supporting texts for nine key terms (Table 4.3.2) which appeared repeatedly in several of the documents. This was to ensure that all occurrences of these important terms had been captured.

The remaining terms were further categorized by their use into terms relating to:

1) ecological concepts;
2) descriptors of the environment and its status (including reference states, thresholds);
3) environmental management strategies;
4) impacts or pressures on the system (including limits to impacts);

5) ecological scales, i.e., stock, population, geographical units and

6) 'other'.

The terms in each category were then considered by a group of technical experts who considered the degree of congruence in definitions, ability to underpin practical management and their scientific basis.

We next undertook a more in-depth investigation of the implications for practice and implementation, of the differences among agencies in their definitions (or implicit meanings) of two sets of terms: 'ecosystem health/status/condition' and 'adverse impacts' (Section 4.9). Finally, for one national jurisdiction, a series of short case histories are summarized, reporting successes and challenges that have been encountered in making policy and management decisions using these concepts (Section 4.10).

For many terms, following the analysis of definitions and usage, WGECO selected a definition or otherwise proposes an interpretation or usage that is considered ecologically sound and practical to implement. This is not intended as encouraging ICES to ignore an agency's stated definition when responding to a request for advice from a particular agency. Rather, in cases where the intended interpretation of the term is not explicit in a request, the recommended definition or interpretation would be a reasonable basis for ICES work.

Table 4.3.1 High level sources reviewed for their use of terminology. Documents marked * indicate secondary sources which were reviewed subsequent to the key documents.

Source	Abbreviation used	Document and Reference
Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas.	ASCOBANS	ASCOBANS-Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas (2008).
UN Convention on Biological Diversity	CBD	Convention on Biological Diversity (1992)
EU Common Fisheries Policy	CFP	*Green paper - The future of the Common Fisheries Policy, Brussels 2001 (CEC, 2001) COUNCIL REGULATION (EC) No 2371/2002 on the conservation and sustainable exploitation of fisheries resources under the Common Fisheries Policy CR (EC) No 2371/2002 *COUNCIL REGULATION (EC) No 1967/2006 concerning management measures for the sustainable exploitation of fishery resources in the Mediterranean Sea CR (EC) No 1967/2006 * Reflections on further reform of the Common Fisheries Policy, 2008 CEC (2008a) *The role of the CFP in implementing an ecosystem approach to marine management, Brussels 2008COM (2008) 187 CEC (2008b)

SOURCE	ABBREVIATION USED	DOCUMENT AND REFERENCE
Food and Agriculture Organisation of the United Nations	FAO	FAO Code of Conduct for Responsible Fishing FAO (1995) The ecosystem approach to fisheries. Issues, terminology, principles, institutional foundations, implementation and outlook', and the experts consultation FAO (2003) *The report of the Technical Consultation on International Guidelines for the Management of Deep-sea Fisheries in the High Seas FAO (2008a, 2008b) *FAO Glossary http://www.fao.org/fi/glossary/default.asp *FAO Glossary http://www.fao.org/docrep/005/y4470e/y4470e0h.htm
EU Habitats Directive	HD	COUNCIL DIRECTIVE (EC) 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora.
Helsinki Commission	HELCOM	Helsinki Convention (2004). http://www.helcom.fi/Convention/en_GB/text/ *HELCOM. 2007. Baltic Sea action plan. Helsinki Commission, 2007. http://www.helcom.fi/BSAP/ActionPlan/en_GB/ActionPlan/ *OSPAR-HELCOM. 2003. Statement on the ecosystem approach to the management of human activities. First joint ministerial meeting of the Helsinki and OSPAR Commissions (JMM). Bremen, Germany, 25–26 June 2003. http://www.helcom.fi/stc/files/BremenDocs/JointEcosystemApproach.pdf *Baltic Sea Action Plan http://www.helcom.fi/BSAP/ActionPlan/en_GB/ActionPlan/
ICES	ICES	ICES WGECO reports (2003; 2004; 2005a; 2006; *2008) ICES CRR reports (*1992; *2005b; *2005c)
EU Marine Strategy Framework Directive	MSFD	EC (2008) Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (Council Directive, 2008)
Oslo-Paris Commission	OSPAR	Annex V in: the OSPAR Convention: On the Protection and Conservation of the Ecosystems and Biologically diversity of the maritime area 56. OSPAR Convention 2003/3 *OSPAR (2006) Guidance on developing an ecologically coherent network of OSPAR marine protected areas (Reference number 2006-3) *OSPAR list of threatened and/or declining species and habitats (Reference Number: 2008-07) http://www.ospar.org/v_measures/get_page.asp?v0=08-06e_OSPAR%20List%20species%20and%20habitats.doc&v1=5
EU Water Framework Directive	WFD	COUNCIL DIRECTIVE 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy.
Convention on the Conservation of Antarctic Marine Living Resources	CCALMR	CCALMR (1980) *Fabra and Cabron (2008)

SOURCE	ABBREVIATION USED	DOCUMENT AND REFERENCE
United Nations Convention on the Law of the Seas	UNCLOS and UNFSA	United Nations Convention on the Law of the Seas (UN, 1983). *UN Agreement for the Implementation of the Provisions relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks (UN, 1995) http://www.un.org/Depts/los/convention_agreements/convention_overview_fish_stocks.htm (UN, 2005) *UN Resolution A/61/105. Sustainable fisheries, including through the 1995 Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks, and related instruments *UNECE (2003). Protocol on strategic environmental assessment to the Convention on environmental impact assessment in a transboundary context. http://www.unece.org/env/eia/sea_protocol.htm

Table 4.3.2. The 9 terms used in the second phase of analysis of policy documents (Section 4.7).

MAJOR SEARCH TERM	ADDITIONAL SEARCH TERMS
Resilience	Recovery/Recover/Resistance
Habitat	-
Integrity	-
Functioning	Ecosystem functions / Ecological functions / Function
Sensitivity	Vulnerability
Ecosystem approach	Ecosystem based approach to (fishery) management
Precautionary	Precautionary Principle/Precautionary Approach
Sustainable	Sustainability/Sustainable use
Protected Areas	Marine Protected Areas

4.4 Ecological terminology used in policy documents

Of the 185 terms identified in the twelve high level policy documents and supporting documents reviewed, there were more terms referring to ecological concepts than the other categories (Figure 4.3.1). Details of the use of terminology in each document are presented below and in some cases no further consideration given. In those cases the description below is more extensive than in cases featuring subsequent analysis and commentary.

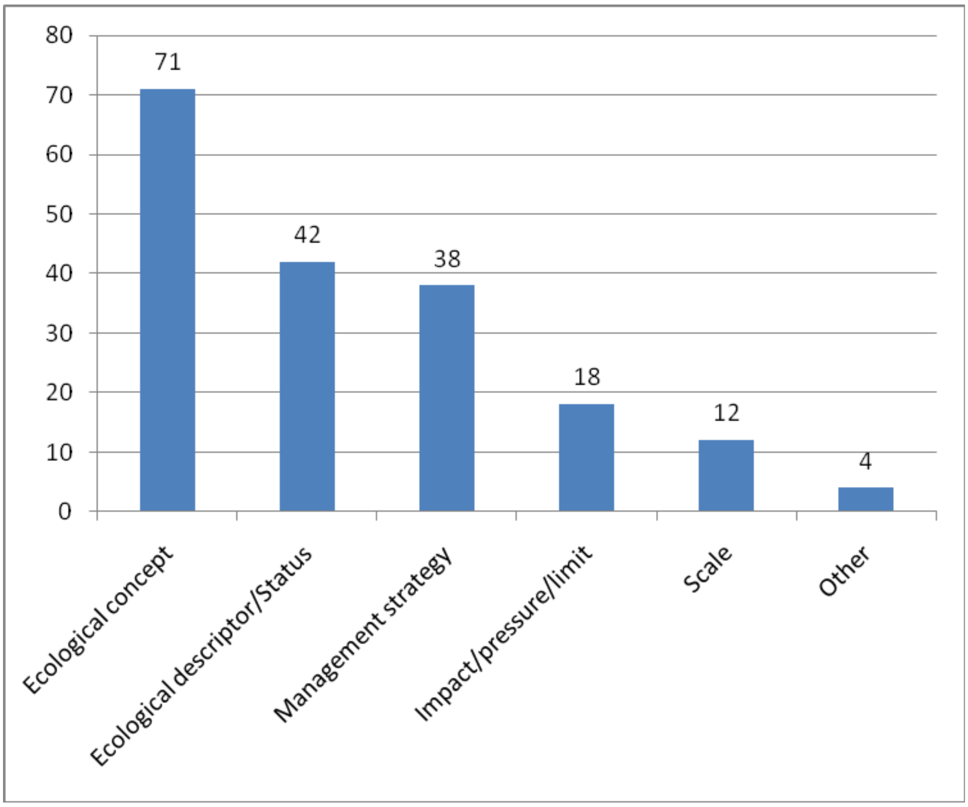

Figure 4.4.1 Occurence (count) of ecological terms (185 in total) per category identified in 12 high level international policy documents and supporting material. Some of these documents were placed into two or more categories.

4.5 Summary of high level policy documents examined

4.5.1 EU Marine Strategy Framework Directive

The EU Marine Strategy Framework Directive aims to apply '*an ecosystem-based approach to the management of human activities while enabling a sustainable use of marine goods and services*'. It aims to put in place measures to achieve '*good environmental status*' in the Community's marine environment.

The Directive identifies a list of environmental characteristics (divided into physical, chemical, biological and 'other' features and habitat types) and pressures and impacts related to human activities. It provides guidance on determining good environmental status using qualitative descriptors which include biological diversity, foodwebs and seabed integrity.

4.5.2 UN Convention on Biological Diversity (CBD)

The Convention on Biological Diversity is itself a convention in international law (as well as a Secretariat, binding on signatory States (which includes all but a few countries globally). The Convention addresses conservation and sustainable use of biodiversity in all terrestrial and aquatic ecosystems, and the equitable sharing of benefits from those uses. Provisions of the Articles of the Convention and CBD Resolutions are implemented by States within the areas under their jurisdiction. For marine areas beyond national jurisdiction the CBD mandate is to provide scientific and technical information and advice to the UN General Assembly, which under UNCLOS has authority on the High Seas. In addition to the Convention, a number of resolutions are negotiated at the biannual Conference of Parties (COP). One of these resolutions is consistently entitled the "Marine And Coastal Resolution COP [N1/N2] (where N1 is the roman numeral for which COP produced the resolution, and N2 is the number of resolution). For the analyses reported here, two documents were used: The convention itself (http://www.cbd.int/convention/convention.shtml) and the 2008 COP Marine and Coastal Resolution COP-IX/20.

4.5.3 Oslo-Paris Commission (OSPAR)

The OSPAR Network of Marine Protected Areas (MPAs) and to ensure that by 2010 it is an ecologically coherent network of well-managed marine protected areas.

The OSPAR Network of marine protected areas is established to support the sustainable use, protection, and conservation of marine biological diversity and ecosystems in partnership with other measures under Annex V of the Convention. The OSPAR Guidelines for the Identification and Selection of MPAs in the OSPAR Maritime Area (Reference number: 2003–17) set out that components of the network "will, individually and collectively, aim to:

a) protect, conserve and restore species, habitats and ecological processes which are adversely affected as a result of human activities;

b) prevent degradation of and damage to species, habitats and ecological processes, following the precautionary principle;

c) protect and conserve areas that best represent the range of species, habitats and ecological processes in the OSPAR area."

The review of prominent terminology was done by looking through the OSPAR Guidance on developing an ecologically coherent network of OSPAR marine protected areas (Reference number: 2006–3), as well as the Annex V of the OSPAR convention (On the Protection and Conservation of the Ecosystems and Biologically diversity of the maritime Area 5 6).

The review of the OSPAR documents identified a total of nine ecological terms. Of these none defined by Ospar. However, in four cases the OSPAR cite definitions given by CBD and IUCN and provide one term with a description. One term was not found defined in any of the other documents reviewed by WGECO.

HELCOM/OSPAR 2003. Declaration of the first joint ministerial meeting of the Heslinki and OSPAR commissions. First Joint Ministerial Meeting of the Helsinki and OSPAR Commissions (JMM) Bremen: 25–26 June 2003 (Agenda item 6, Annex 8). Convention on the Protection of the Marine Environment of the Baltic Sea Area (Helsinki Convention) and OSPAR Convention for the Protection of the Marine Environment of the North-East Atlantic.

4.5.4 Helsinki Commission (HELCOM)

The new 'Convention on the Protection of the Marine Environment of the Baltic Sea' entered into force 2000 and is governed by the Helsinki Commission-Baltic Marine Environment Protection Commission (HELCOM). The Convention focuses to prevent and eliminate pollution in order to promote the ecological restoration of the Baltic Sea Area; only one Article, No. 15, is concerned with 'nature conservation and biodiversity', on which this analysis concentrated. In 2007, the HELCOM Contracting Parties adopted the 'Baltic Sea Action Plan' (BSAP), to 'achieve a Baltic in good environmental status'. Of this document, only the segment dealing with 'Biodiversity and nature conservation' was analysed. The long list in the BSAP of related Targets and

Indicators which should facilitate the implementation of the proposed management actions was not included in this analysis.

It should be noted that all measures in the BSAP related to fishery management, are in fact calls to the competent fisheries authorities by the environment ministers, as the latter do not have the competency on fishery management that lies with the EU and its Common Fisheries Policy, instead.

Of the 25 terms used in the two documents, only two have been partly defined or are referenced to existent definitions in other international agreements. Instead of definitions of terms given in the BSAP, there is a general statement that the BSAP contributes to the implementation of several global agreements. However, some of the terms used are defined in an earlier document (HELCOM/OSPAR Joint Statement 2003).

4.5.5 Food and Agriculture Organisation of the United Nations (FAO)

The mission of the FAO is to facilitate and secure the long-term sustainable development and utilization of the world's fisheries and aquaculture. Implicitly or explicitly, most of the recently adopted instruments of relevance to fisheries call for an approach to fisheries giving more attention to the ecosystem.

These instruments span from the 1982 UN Convention on the Law of the Sea (hereafter called the 1982 Convention) to the 1995 FAO Code of Conduct for Responsible Fisheries (hereafter called the Code) and its International Plans of Action (IPOAs), and from the 1971 Ramsar Convention to the 1992 Convention on Biological Diversity (CBD), including the 1995 Jakarta Mandate on Marine and Coastal Biological Diversity.

The Code offers a synthesis of the requirements of all the above instruments and provides the conceptual basis and institutional requirement for, inter alia, ecosystem and habitat protection; accounting for environmental factors and natural variability; reducing impacts of fishing and other activities; biodiversity conservation; multispecies management; protection of endangered species; accounting for relations between populations; reducing land-based impacts and pollution; integration in coastal area management; elimination of ghost-fishing; reduction of waste and discards; precautionary approach; delimitation of ecosystem boundaries and jurisdictions, as well as adapted institutions and governance.

The following four FAO documents were thoroughly studied for terminology of ecological terminology by WGECO 2009; the Code, 'The ecosystem approach to fisheries. Issues, terminology, principles, institutional foundations, implementation and outlook', and the experts consultation and 'The report of the Technical Consultation on International Guidelines for the Management of Deep-sea Fisheries in the High Seas' (FAO 1995; Garcia, *et al*., 2003; FAO 2008a. and FAO 2008b).

4.5.6 EU Habitats Directive (HD)

HD (92/43/EEC) is intended to be a contribution to the preservation of biodiversity both for terrestrial and aquatic and marine habitats in order to achieve a favourable conservation status for the species and habitat types under consideration. In Article 1, HD provides a list of definitions referring either to management units ('habitat', 'site', 'specimen', etc.) as well as to quality objectives defining the policy goals ('reaching favourable conservation status', etc.).

4.5.7 EU Water Framework Directive (WFD)

WFD (2000/60/EC) aims at a sustainable use of water resources and at protecting inland, transitional and coastal waters and groundwater from pollution with hazardous substances, with an explicit reference to the marine environment. In Article 2, WFD provides a suite of definitions either for the different physical management units ('rivers', lakes, etc.), but also for policy targets referring to the quality of the different water bodies to be achieved ('ecological status', etc.)

4.5.8 EU Common Fisheries Policy (CFP)

The analysis was mainly focused on two official EU documents, namely: i) the COUNCIL REGULATION (EC) No 2371/2002 on the conservation and sustainable exploitation of fisheries resources under the Common Fisheries Policy, and ii) COUNCIL REGULATION (EC) No 1967/2006 concerning management measures for the sustainable exploitation of fishery resources in the Mediterranean Sea. Moreover three documents presented by the Commission and related to the Common Fisheries Policy (Green paper on the future of the Common Fisheries Policy, 2001; Reflections on further reform of the Common Fisheries Policy, 2008) and its role in implementing an ecosystem approach (The role of the CFP in implementing an ecosystem approach to marine management, COM, 2008 187) were also reviewed.

In total 24 different terms, that were mainly referred to management, impact and scale concepts, were identified. It is worth noting that in most cases detailed definitions of the "ecological" terms were lacking. For instance, in the 2371/2002 Council Regulation only terms referred to the management/biological level of stocks were defined whereas other ecological concepts related to the impact of fishing at ecosystem level were mentioned but not defined (e.g., impact -or threat- to marine-ecosystem is referred to as "negligible", "sustainable", "serious" but no detailed definition/thresholds are given for these concepts).

4.5.9 Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR)

CCAMLR describe their high level objectives in the following terms:

> 1. The objective of this Convention is the conservation of Antarctic marine living resources.
>
> 2. For the purposes of this Convention, the term 'conservation' includes rational use.
>
> 3. Any harvesting and associated activities in the area to which this Convention applies shall be conducted in accordance with the provisions of this Convention and with the following principles of conservation:
>
> a) prevention of decrease in the size of any harvested population to levels below those which ensure its stable recruitment. For this purpose its size should not be allowed to fall below a level close to that which ensures the greatest net annual increment;
>
> b) maintenance of the ecological relationships between harvested, dependent and related populations of Antarctic marine living resources and the restoration of depleted populations to the levels defined in sub-paragraph a) above; and
>
> c) prevention of changes or minimization of the risk of changes in the marine ecosystem which are not potentially reversible over two or three decades, taking into account the state of available

> knowledge of the direct and indirect impact of harvesting, the effect of the introduction of alien species, the effects of associated activities on the marine ecosystem and of the effects of environmental changes, with the aim of making possible the sustained conservation of Antarctic marine living resources.

The terms used are generally not specifically defined, however, the CCAMLR Performance Review Report, states that:

"These CCAMLR requirements are complemented by more recent guidance on the conduct of responsible and sustainably managed fisheries; specifically the FAO Code of Conduct for Responsible Fisheries (United Nations, 1998), the FAO Ecosystem Approach to Fisheries (FAO, 2003) and best practices for RFMOs (Lodge et al., 2007)."

These are described in this report under Section 4.4.4 FAO, and have not been repeated here specifically for CCAMLR.

4.5.10 Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS)

ASCOBANS has been a major driver of the development of initiatives such as the requirement for pingers on bottom-set gillnets.

Its main aim is to achieve and maintain a favourable conservation status for small cetaceans.

4.5.11 United Nations Convention on the Law of the Seas (UNCLOS) and UN Fish Stocks Agreement (UNFSA)

The definitions used in UNCLOS are geographic and physical for example, relative to the definition of the outer edge of the continental margin, wherever the margin extends beyond the 200 nautical miles, from the baselines from which the breath of the territorial sea is measured. The convention does not use ecological terms. In the UN Agreement relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks (UN, 1995), adopted in 1995, an article and an annex are describing in detail the application of the 'precautionary approach' and 'precautionary reference points' into fishery management, although the term 'precautionary' itself is not defined explicitly.

4.6 Terms defined in only one document

A total of 55 terms were prominent in only one of the twelve documents examined (Table 4.6.1). These terms are listed in Appendix 1 (Section 4.14). These terms were considered no further because of time constraints.

Table 4.6.1. The number of terms with a single usage in high level documents.

Category of term	Number of terms
Ecological concepts	26
Descriptors of the environment and its status (including reference state, thresholds)	16
Environmental management strategies	0
Impacts or pressures on the system (including limits to impacts)	4
Ecological scales i.e., stock, population, geographical units	
Other	0

4.7 Undefined terminology

The 7 terms used which are undefined in the 12 documents examined are sorted into their categories in Table 4.7.1 and listed in Appendix 1 (Section 4.14).

Table 4.7.1. Number of terms that are undefined in the high level documents.

Category of term	Number of terms
Ecological concepts	1
Descriptors of the environment and its status (including reference state, thresholds)	2
Environmental management strategies	0
Impacts or pressures on the system (including limits to impacts)	4
Ecological scales i.e., stock, population, geographical units	3
Other	0

4.7.1 Ecological concepts

Only the term 'ecosystem services' was undefined in the source documents.

4.7.1.1 Ecosystem services

Ecosystem services have been defined by the Millenium Ecosystem Assessment (UN, 2005) as 'the benefits people obtain from ecosystems. These include provisioning services such as food and water; regulating services such as flood and disease control; cultural services such as spiritual, recreational, and cultural benefits; and supporting services, such as nutrient cycling, that maintain the conditions for life on Earth'.

The term services is widely used in environmental economics (Costanza *et al*., 1997). Unless specified in more detail, marine ecological service may mean any service such as food and water provided to humans from the marine environment. **WGECO recommends the definition defined by the Millennium Assessment.**

Some of the service types are used interchangeably with ecosystems functions (Section 4.8.1.3).

4.8 Terms with multiple meanings

96 terms were defined differently in more than two of the twelve source documents examined. Some of these terms were used but not defined in other source documents. The categories of terms are shown in Table 4.8.1 and listed in Appendix 2 (Section 4.15). Three of these terms (were selected for a more detailed analysis as case studies (Section 4.9).

Table 4.8.1. Numbers of terms which are undefined in high level documents.

Category of term	Number of terms
Ecological concepts	42
Descriptors of the environment and its status (including reference state, thresholds)	6
Environmental management strategies	37
Impacts or pressures on the system (including limits to impacts)	4
Ecological scales, i.e., stock, population, geographical units	3

Other	4

4.8.1 Ecological concepts

Of the 42 listings covering ecological concepts, seven terms were defined differently in two or more documents (Table 4.8.1.1).

Table 4.8.1.1 Terms that were used in several documents and not defined in some, and defined differently between other documents.

Terms	Source	Section
Biodiversity	CBD, FAO, OSPAR, MSFD	4.8.1.1
Ecosystem	CBD, FAO, OSPAR	4.8.1.2
Functioning	CFP, FAO, HELCOM, ICES, MSFD, WFD	4.8.1.3
Habitat	ASCOBAN, CBD, CCAMLR, FAO, HELCOM, ICES, OSPAR, MSFD, WFD,	4.8.1.4
Integrity	CBD, FAO, HELCOM, MFSD	4.8.1.5
Resilience/Recovery	FAO, ICES, MSFD, OSPAR	4.8.1.6
Persistence	UNCLOS, OSPAR	4.8.1.7

We recognize that some of these terms are actually interrelated. Hereafter, each of these groups of considered in turn.

4.8.1.1 Biodiversity

Biodiversity is a contraction of the term **biological diversity**. The term first appears in the ecological literature in the 1980s but gained policy relevancy following adoption of the 1992 UN Convention on Biological Diversity. Most policy usage follows the definition given in the CBD.

The practical difference between the definitions of diversity between CBD and OSPAR is that CBD defines biological diversity in a global conceptual sense, while OSPARs definition of diversity refers to a given area. Definitions thus vary but those that are defined are scientifically clear.

WGECO considers the CBD definition: '*The variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems*' to be sufficiently comprehensive and robust as to be used as a working definition for biodiversity.

4.8.1.2 Ecosystem

The term **ecosystem** is notoriously diverse in its use, with the term being applied to units as small as a tidal pool (i.e., 'a rockpool ecosystem') up to the planetary system. The key element is that it is a functional unit of the physical environment and the biological components (including humans).

The term ecosystem is frequently used in essentially all international agreements. Four different definitions were found and 6 further were listed at the FAO fishery glossary website (http://www.fao.org/fi/glossary/default.asp). There is, from a scientific point of view no difference between the 4 definitions listed by CBD, OSPAR and the two by FAO and they are all scientifically clear. However, one FAO definition is more explicit in that it emphasizes the importance of space and time in specifying and shaping ecosystems. The second FAO definition specifically notes that humans and human fishing technology and institutions are parts of the ecosystem.

WGECO strongly supports that humans and human activities are considered as components of ecosystem. As such it considers the CBD definition to be adequate.

Therefore an ecosystem may be defined as: '***A dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit***'.

WGECO further notes that operationally for management or science there is the need for additional scale information, e.g., the North Sea ecosystem, or the benthic ecosystem. In all cases humans and human activity should be included unless explicitly excluded by the definition, e.g., 'an unimpacted rock pool ecosystem'.

4.8.1.3 Functioning

The concept of the ecosystem as a **functioning** unit developed in the early 20th century and was formally included in the first formal definition of an ecosystem (Tansley, 1935). A far ranging conceptual framework for the understanding and study of these interacting systems was produced by Lindeman, 1942.

The term ecosystem 'function' was used in eight of the twelve sources investigated, but only the FAO tried to describe or provide a definition for it:

'*The functioning of an ecosystem results from the organization of its species communities, consisting of species populations having their own dynamics in terms of abundance, survival, growth, production, reproductive and other strategies*' (Garcia *et al*., 2003).

In the scientific literature, ecosystem functioning has been defined as '*…the activities, processes or properties of ecosystems that are influenced by its biota.*' (Naeem *et al*., 2004) or the '*process rates in ecosystems, properties of ecosystems, and goods and services derived from ecosystems*' (Gamfeldt *et al*., 2008). The FAO description is broadly in accordance with the peer-reviewed definitions as it considers the effects of biological processes within the ecosystem.

A list of ecosystem functions was developed by two international expert workshops (Frid *et al*., 2008). These included energy and elemental cycling (carbon, nitrogen, phosphorus, sulphur), silicon cycling, calcium carbonate cycling, food supply/export, productivity, habitat/refugia provision, temporal patterns (population variability, community resistance and resilience), propagule supply/export, adult immigration/emigration and modification of physical processes.

Some types of ecosystem function were often used interchangeably in the literature with types of 'ecosystem services' (e.g., nutrient recycling, productivity and food; Frid *et al*., 2008; UN, 2005). The Millennium Assessment states that '*ecosystem services are the benefits people obtain from ecosystems*' (UN, 2005). WGECO consider that there is no problem in using the same terms to describe the ecosystem function and service types as they have the same meaning (also see Section 4.6.1).

Various techniques have been developed to measure ecosystem functioning. They range from a direct estimate of specific functions such as productivity and nutrient release (Hiddink *et al*., 2006), to investigating how individual species or assemblages deliver the functions based on the biological traits of organisms (Bremner *et al*., 2003, 2006a, b; Frid *et al*., 2008). WGECO considers that considerable scientific effort is required to further develop the methodology to measure ecosystem functioning at regional levels.

WGECO considers that there is a distinction between ecosystem functioning, an inherent ecological property, and ecosystem goods and services; those resources used by humans. **WGECO feels that the Naeem *et al.*, 2004 definition to be the most robust in capturing the sense of the concept and having the advantage of being clear and simple to apply. Thus ecosystem functions are; *'…the activities, processes or properties of ecosystems that are influenced by its biota.'***

4.8.1.4 Habitat

The term 'habitat' is widely used in high level policy documents. The definitions can refer to an environment e.g., a sandbank habitat or its use by species/populations, e.g., 'cod habitat'. The definitions are scientifically clear and similar between CBD, ICES, HD and OSPAR.

In the OSPAR Annex V lists of threatened and declining species and habitats, OSPAR restrict habitats to be above a certain size (25 m^2) and the habitats listed do not refer the species occupying the habitats but only the physical characteristics of the environment.

ICES WGECO 2006 described the habitat component as, *'the physical and chemical environment and hence includes water quality and the physical (substratum) aspects of the environment.'* With biotic components listed separately.

While many scientific definitions of habitat exist, in a policy context the CBD defines habitat as *'the place or type of site where an organism or population naturally occurs',*

The full expression of the definition that was partly extracted by CBD from the Australian Natural Heritage Charter 2002 and is as follows:

'Habitat means the structural environments where an organism lives for all or part of its life, including environments once occupied (continuously, periodically or occasionally) by an organism or group of organisms, and into which organisms of that kind have the potential to be reinstated.'

WGECO are content that the definition by Australian Natural Heritage Charter, adopted by the CBD, encapsulates many of the essential aspects of the habitat concept and can form the basis of operational advice relating to the habitats requirements of marine species but is less useful in support of habitats as components of ecological systems.

Thus we support specific references to the physical and chemical environment, including water quality and the physical (substrata) aspects of the environment, and also inclusion of those features of the biotic environment that are relatively stable in space, such as macroalgae and sessile (or near sessile) invertebrates, to be included in the definition.

WGECO further notes that the FAO concept of a 'vulnerable marine ecosystem' and the CBD's 'ecological and biologically significant areas' are consistent with such a physical/chemical definition of the habitat. However, both the VME and EBSA concepts go further, and include areas characterized by life-history aspects of the biotic communities (especially fish and macro-invertebrates) that are present in an area.

4.8.1.5 Integrity

The term ecological integrity is widely used in the high level terminology, e.g., in MFSD, HELCOM, CBD and FAO, but there is apparently no agreed definition of integrity. CBD, however, describes the term:

> *Ecosystem integrity reflects the capability of a system to support services of value to humans. Indicators under the focal area on ecosystem integrity and ecosystem goods and services provide information on the quality and health of ecosystems and their productive capacity. This information complements the information on the area coverage of ecosystems addressed through the indicator on trends in extent of selected biomes, ecosystems and habitats. The two indicators mentioned are marine trophic index and water quality in aquatic systems* (CBD, UNEP/CBD/BS/WG-L&R/1/INF/2 14 April 2005).

FAO (http://www.fao.org/fi/glossary/default.asp) concludes that the application of the principle of ecosystem integrity is taken, in the CBD, as implying or requiring: (i) maintenance of biodiversity at biological community, habitat, species and genetic levels and (ii) maintenance of the ecological processes that support both biodiversity and resource productivity.

Other terms that seem to be used in a similar way as integrity, sometimes parallel, e.g., in the MSFD, are ecosystem functioning and ecosystem health.

From a scientific point of view, the term integrity appears too wide and needs to be specified. Only once this is done will it be possible to develop indicators for ecosystem integrity, e.g., those mentioned above. **WGECO considers that an operational use of the term ecological integrity can be made from the (CBD) requirement to ensure: (i) maintenance of biodiversity at biological community, habitat, species and genetic levels and (ii) maintenance of the ecological processes that support both biodiversity and resource productivity.**

4.8.1.6 Resilience and recovery

Two types of resilience were defined in the twelve sources examined. These were based on either the 'resistance' of an ecosystem to stress (e.g., the ability of an ecosystem to '*maintain its structure and pattern of behaviour in the presence of stress*' (FAO, http://www.fao.org/docrep/005/y4470e/y4470e0h.htm), or on an ecosystem's 'response' to disturbance (e.g., the IUCN 2003 definition used by OSPAR 2006 which was, '*the ability of an ecosystem to recover from disturbances within a reasonable time frame*').

The first definition has a particular role in application of a precautionary approach. Models could be used to estimate how far a system could be stressed before changing its behaviour, and those bounds could inform precautionary reference points for stressors when the dynamics of the system have not been observed under a wide enough range of conditions to estimate precautionary reference points directly. Models might also suggest appropriate indicators to track whether the system was not being stressed to a degree that rapid changes in behaviour were likely. However indicators derived solely from field observations can only be used to evaluate across the range of conditions that have been historically observed. If those conditions include periods when the system had been stressed sufficiently to change its structure or patterns of behaviour, then the indicator may provide information about resistance. Otherwise the indicators must rely on modelling to be interpretable in this context.

The second definition is based on the concept of recovery. It accepts that human activities will cause changes in the ecosystem, and that there is a need to consider how much disturbance/change may be permitted. Indicators could be used to monitor and measure the status of the system. However, in selecting reference points, issues will arise as a consequence of the non-linear responses of systems to perturbations. Moreover, in evaluating "recovery", further issues will arise because ecosystems are not expected to follow the same pathway back when a pressure is released as was taken when the pressure was being applied.

WGECO consider that while both terms are scientifically correct, the 'recovery' definition is more broadly usable in an operational context. WGECO further notes that in much of its fishery advice, ICES has included the phrase that recovery should be expected to be "rapid and secure". ("Rapid" is applied taking account of the normal dynamics of the properties being monitored. "Rapid" for herring is not the same as "rapid" for beluga). WGECO agrees that the condition of "rapid and secure" is an important aspect of recovery.

The FAO has defined time-scales at which recovery should occur and states that '*temporary impacts are those that ... allow the particular ecosystem to recover over an acceptable time frame. Such time frames should be decided on a case-by-case basis and should be in the order of 5–20 years, taking into account the specific features of the populations and ecosystems*'. Robinson *et al*., 2008 have also categorized resilience according to the time-scales at which recovery should occur (Table 4.8.1.6.1).

Table 4.8.1.6.1. The resilience categories used by Robinson *et al.*, 2008.

CATEGORY	DEFINITION
None	No recovery >100 years
Low	Recovery 10–100 years
Medium	Recovery 2–10 years
High	Recovery <2 years

However, there are fundamental issues related to deciding how and when an ecosystem has been deemed to have recovered, or what to do in situations where the recovery occurs at different time-scales, e.g., if 75% of the ecosystem recovers very quickly, but the final 25% takes decades.

There are currently debates on whether simply the presence of the key species is an acceptable indicator of a restored system, or whether the populations of key species need to be present at the same density, and with the same age structures, as before the disturbance. **WGECO consider that provided the majority of the functions are present at a level similar to before disturbance, and that the key species are present, a system may be considered to have recovered.**

4.8.1.7 Persistence

Persistence and persistency is defined by the FAO 'the Ecosystem Approach to Fisheries', using the definition given by Pimm, 1984 and Pimm and Hyman, 1987 which states that they are: '*Characteristic of a group of stable populations that conserve the same number of species in time.'*

The terms are used by several bodies (CCAMLR, ICES, and OSPAR), and although not defined, are used in the same way as the FAO definition.

The expression 'persistent' is used in a series of high level documents (HELCOM, ICES, OSPAR and WDF), in the common English meaning denoting something enduring, e.g., toxicity of pollutive substances, physical qualities of the environment, human actions etc.

WGECO considers that an operational use of the term 'persistence' can be made from the FAO definition, focusing on the quantitative measurable quantity of population size.

4.8.2 Ecosystem descriptors/status

The list examined by WGECO comprises terms that, though being defined in the context of the source documents to some extent (Section 6.3.1), in practice are very often applied with a broader meaning. Thus, during the 2009 International Wadden Sea Symposium (Wilhemshaven, Germany) the status descriptors referring to 'good' conditions from WFD, HD and MSFD attracted a lively discussion and their practical implications remained partly contentious. This demonstrates that definitory work across EU directives is needed and WGECO endorses such an exercise to clarify the course of policy in this field.

The terms with multiple meanings under the category of ecosystem descriptors and statuses are considered in more detail in Section 4.9. The terms considered are 'ecological health, status and quality', 'vulnerable and sensitive species'.

4.8.3 Environmental management strategies

The terms related to environmental management strategies concepts which were defined differently in two or more documents are shown in Table 4.8.3.1. Some of these terms were used but not defined at all in some of the documents.

Table 4.8.3.1. Terms used in several documents and not defined in some, and defined differently between other documents.

TERMS	SOURCE	SECTION
Precautionary	FAO, HELCOM, OSPAR, UNFSA, CBD, CFP, MSFD, ICES,	4.8.3.1
Ecosystem approach	FAO, CBD, ICES, HELCOM, OSPAR, CFP,	4.8.3.2
Sustainable use	FAO, ICES, HELCOM, OSPAR, CFP, CBD, MSFD,	4.8.3.3
Marine Protected Areas	CBD, FAO, MSFD, HELCOM,	4.8.3.4

4.8.3.1 Precautionary approach

The CBD defines this term in the Principle 15 of the Rio Declaration of Environment and Development, 1992 as follows: '*In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation*.'

Whereas the UN Fish Stock Agreement does not have a definition of the term 'precautionary' itself it has an article and an annex describing in detail the application of the Precautionary Approach to Fisheries Management (UN, 1995).

Similarly, the FAO Code of Conduct for Responsible Fisheries dedicates a paragraph (Article 7.5) to provide some guidelines for the application of the Precautionary Approach in the context of Fisheries Management, 1995. In the technical papers that support the Guideline on Application of the Precautionary Approach in Fisheries and Aquaculture, there is a detailed discussion of the difference in how Precautionary Approach and Precautionary Principle are applied in fisheries (Garcia, 1996).

In the HELCOM/OSPAR Joint Statement, 2003 the terms precautionary principles and approach are not defined but it states that "It is understood that, in the context of the management of fisheries, the application of the precautionary principle has the same result as the application of the precautionary approach as referred to in, for example Article 6 of the 1995 UN Fish Stocks Agreement".

The ICES (ICES, 2005) gives an explanatory text focusing mainly on the "precaution" term and suggests the distinction between "Precautionary Principle" and "Precautionary approach".

The MSFD does not have a definition and refers to the Precautionary Principle as mentioned in Article 174 of the EU Treaty.

The CFP (CR (EC) n. 2371/2002 (Article 3)), although leaving out the word 'threat' compared with the CBD definition, gives a quite similar definition, that is well suited for a concrete implementation of the Precautionary Approach:

> " 'precautionary approach to fishery management' means that the absence of adequate scientific information should not be used as a reason for postponing or failing to take management measures to conserve target species, associated or dependent species and non-target species and their environment. "

Therefore, WGECO recommends using the definition as given in the CFP (CR (EC) No 2371/2002). WGECO further notes that the phrase "cost-effective" does not appear in any of the definitions that have been reviewed. This is in marked contrast to the phrasing in the Convention on Biological Diversity, 1992, which is the basis for address precaution in many of the agreements and policies that followed Rio.

4.8.3.2 Ecosystem approach

The term "Ecosystem" is defined in the CBD (Article 2, Convention on Biological Diversity, 1992) as a '*dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit*.'

In the CBD (COP 2, 1995, Decision II/8, defined in Decision V/6, Annex A) the Ecosystem Approach (EA) is defined generally as *'a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way.'*

In the FAO Code of Conduct there is no concrete definition of this term., However, there is a technical paper (Garcia *et al.*, 2003) that is dedicated to "Issues, terminology, principles, institutional foundations, implementation and outlook of the Ecosystem Approach to Fisheries". The FAO technical guidelines highlight four central aspects of applying an ecosystem approach in fisheries:

- Taking account of environmental forcing on stock dynamics;
- Making the fishery accountable for the full range of impacts of the fishery;
- Integrating management of the fishery with management of other human activities in the same area;
- Making decision-making and management inclusive.

Versions of the first three points occur in many of the other definitions, but the issue of inclusive governance is not generally noted by other agencies.

In the CFP ((CR (EC) n. 2371/2002 (Art. 2)) 2002), although stating that '*it shall aim at the implementation of an ecosystem-based approach to fisheries management* there is no definition of the term.'

ICES in a more recent document (ICES, 2005) refers to the above mentioned definition of EA. In fact, there are indications that the definition given by HELCOM/OSPAR is based on an ICES working definition that appeared in an earlier document, the Bergen Declaration of the International North Sea Conference, 2002.

The MSFD referring to the EA defines this term in a more practical way, giving more emphasis to ensure that '*collective pressure of such activities is kept within levels, compatible with the achievement of good environmental status and that the capacity of marine ecosystems to respond to human-induced changes is not compromised, while enabling the sustainable use of marine goods and services by present and future generations.*'

In the recent documents by HELCOM (BSAP 2007) and OSPAR (Annex V) concerned with the protection of the ecosystems or sustainable management neither a definition nor a reference to another definition of the EA could be found. However, both conventions produced a document in 2003, the "HELCOM/OSPAR Joint Statement on the Ecosystem Approach to the Management of Human Activities. Here, the EA is defined as:

> "*the comprehensive integrated management of human activities based on the best available scientific knowledge about the ecosystem and its dynamics, in order to iden-*

tify and take action on influences which are critical to the health of marine ecosystems, thereby achieving sustainable use of ecosystem goods and services and maintenance of ecosystem integrity."

WGECO recommends to use this definition, as it refers to scientific knowledge and is operationally worded.

4.8.3.3 Sustainable use

No analysis of the term "Sustainable Development" will be given in this section as this would be beyond the scope of this Working Group. Instead, the term "Sustainable Use" was analysed assuming that it includes the term "Sustainable Exploitation". In the documents analysed the term "sustainable use" was found together with different extensions, like "of fisheries", "of biological diversity", "of goods and services". However, in all UN agencies it is stressed that sustainability has at least three dimensions: environmental, economic, and social, and that all are necessary dimensions of assessing sustainability. It is sometimes noted that institutional sustainability is a fourth dimension of sustainability, although in the ICES region, the sustainability of the institutions managing industries and protecting the environment is often taken as a given.

MSFD use the terms mentioned above as well but no definition is given in these documents. The FAO Code of Conduct for Responsible Fishery, 1995 does not provide a definition of Sustainable Use of marine resources although it recognizes that '*the long-term sustainable use of fisheries resources is the overriding objective of conservation and management*' (Article 7.2.1) while the FAO Fisheries Technical Paper 443 (Garcia *et al*., 2003), provides several insights regarding the use of this concept in different international agreements.

In the Joint Statement by HELCOM/OSPAR (2003) the term Sustainable Use is not defined although it recalls a whole set of global principles including the CBD (1992 Convention on Biological Diversity and Decisions II/10-conservation and sustainable use of marine and coastal biological diversity and V/6 ecosystem approach) and the World Summit on Sustainable Development.

Of the six documents using this term, only two are defining it, being the CBD and ICES. In the CBD (Article 2, Convention on Biological Diversity, 1992) this term is defined as

> '*use of components of biological diversity in a way and at a rate that does not lead to the long-term decline of biological diversity, thereby maintaining its potential to meet the needs and aspirations of present and future generations*.'

ICES 2005 focus more in the resources giving the definition of the sustainable exploitation as

> *'the exploitation of a resource in such a way that the future exploitation will not be prejudiced and that it does not have a negative impact on the marine ecosystems.'*

WGECO recommends to use the definition given by ICES, as this is more operationable and applied to the use of marine resources.

4.8.3.4 Marine Protected Areas (MPAs)

There is a general definition of "Protected Area" in the CBD (Article 2, Convention on Biological Diversity, 1992) as a '*geographically defined area which is designated or regulate and managed to achieve specific conservation objectives.*'

The term "Marine protected areas" has been found in several documents, but there are only two definitions stated in international agreements. According to Garcia *et al.*, 2003, these two definitions are the most commonly used ones, but there is no single internationally accepted definition for the term. The older definition found is the one given by the IUCN in 1988:

> '*Any area of intertidal or subtidal terrain, together with its overlaying waters, and associated flora, fauna, historical and cultural features, which has been reserved by law or other effective means to protect part or all of the enclosed environment*.'(IUCN, Resolution 17.38 of the IUCN General Assembly, 1988, reaffirmed in Resolution 19.46, 1994)

Moreover in 1994, the IUCN adopted a classification of protected areas management categories according to their primary management objective:

I Strict protection [Ia) Strict Nature Reserve and Ib) Wilderness Area];

II Ecosystem conservation and protection (i.e., National Park);

III Conservation of natural features (i.e., Natural Monument);

IV Conservation through active management (i.e., Habitat/Species Management Area);

V Landscape/seascape conservation and recreation (i.e., Protected Landscape/ Seascape);

VI Sustainable use of natural resources (i.e., Managed Resource Protected Area).

These categories follow a gradation of human intervention with different management objectives. Therefore spatial management adopted to achieve a sustainable use of natural resources (e.g., fishery resources) might be included in the Category VI.

More recently the IUCN 2008 proposed new guidelines for applying protected area management categories, where a protected area is defined as:

> *'A clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values.'* (IUCN, Guidelines for applying protected area management categories. Third draft of revised guidelines, May 2008 http://groups.google.com/group/wcpamarine-summit/web/consultation-on-marine-guidance-for-the-iucn-protected-area-categories-system?version=6).

In this document, a detailed explanation of each phrase/term of the above definition is given while referring to the IUCN 1994 Protected Areas categories system.

Another widely accepted definition comes from the CBD:

> '*Marine and Coastal Protected Area' means any confined area within or adjacent to the marine environment, together with its overlying waters and associated flora, fauna, and historical and cultural features, which has been reserved by legislation or other effective means, including custom, with the effect that its marine and/or coastal biodiversity enjoys a higher level of protection than its surroundings.*' (CBD, COP 7, Decision VII/5 (note 11))

It is worth noting the MSFD refers to the need of enforcing spatial protection measures that should contribute:

> *'to coherent and representative networks of marine protected areas, adequately covering the diversity of the constituent ecosystems, such as special areas of conservation pursuant to the Habitats Directive, special protection areas pursuant to the Birds Directive, and marine protected areas as agreed by the Community or Member States concerned in the framework of international or regional agreements to which they are parties.* (MSFD, Art 13.4)

The same document defines as 'Spatial and temporal distribution controls' those:

> *'management measures that influence where and when an activity is allowed to occur* (MSFD, Annex VI, 3).

WGECO considers that the IUCN 1994 'Protected Areas' definition may be misleading, because the set of management objectives and tools it encompasses is too wide although they are differentiated in several categories. The CBD definition of 'Marine and Coastal Protected Areas' might be considered to be too broad for similar reasons as well. **Therefore WGECO recommends that ICES, when dealing with the issue of Marine Protected Areas, should pay special attention to define the different conservation/management objectives and the actual management tool enforced or to be enforced to meet those objectives, thus preventing any misunderstanding.**

4.8.4 Human impacts/pressures

4.8.4.1 Overfishing

The term *overfishing* is used, defined and undefined, in a large number of sources not included among the sources examined by WGECO. For instance, The US Magnuson-Stevens Fishery Conservation and Management Act defines overfishing as: *...a rate or level of fishing mortality that jeopardizes the capacity of a fishery to produce the maximum sustainable yield on a continuing basis.*

The corresponding guidelines further describes and defines the terms overfishing/overfished: *...fishery stock status is assessed with respect to two status determination criteria, one of which is used to determine whether a stock is ''overfished,'' and the second of which is used to determine if the stock is subject to ''overfishing.'' A stock is considered to be overfished if its biomass falls below the minimum stock size threshold (MSST). Overfishing means that fishing is occurring at a rate or level that jeopardizes the capacity of a stock or stock complex to produce maximum sustainable yield (MSY) on a continuing basis. When a stock is not in an overfished condition, the maximum fishing mortality threshold (MFMT) is equal to the fishing mortality associated with MSY (FMSY).*

WGECO finds that the definition of overfishing used in the Magnuson-Stevens Act corresponds well with the definition used by ICES.

4.9 Case studies on the use of key terms in various fora

In this section, we have a closer look at the terms mentioned explicitly in the ToR description, namely 'significant adverse impacts', 'vulnerable marine ecosystems', and 'good environmental status. These are addressed by looking for the specific usage of this term in the different international conventions described in Section 4.4.

4.9.1 Ecological health, status, and quality

All environmental policies as driven by the different EU directives WFD, MSFD, CFP and HD aim at achieving a good status of the total environment or specified parts of it. However, despite their apparent overlap they differ in terminology, in assessment resolution in terms of qualitative levels and in their focus in terms of (ecosystem) complexity (see Table 4.9.1.1) and objectives.

The terms health and quality were only used in four and three of the conventions respectively and we do not provide an exhaustive discussion of these terms (Table 4.9.1.1). Rather we briefly discuss these related terms in relation to "status". FAO provides a definition of "health" (although it uses "well-being") in terms of *"..in which the ecosystem maintains its diversity and quality.."*. MSFD uses "healthy" as part of the definition of "*Good environmental status*" along with "*clean*" and "*productive*". These usages of the term are therefore rather general although pointing to the core of the meaning. OSPAR on the other hand provides a stricter definition of the term through the use of ecosystem quality objectives and state that "*The sea is healthy when all objectives are met*". Health is thereby used to encompass all elements of the ecosystem and "Healthy" is meant to represent a high level of health in the ecosystem. The MSFD draws on "good environmental status" as describing the overall condition of ecosystems and uses "healthy" as part of the definition. We interpret "Healthy" and "Good environmental status" to be synonymous statements although "Healthy" is more strictly defined by OSPAR than "Good environmental status" is by MSFD. The usage of "Status" in different conventions is discussed in more detail below.

OSPAR uses "quality" quite broadly and states "*In the context of the ecosystem approach, marine ecological quality is an expression of the structure and functioning of a marine ecosystem.*". This definition implies that there is a scale of quality from high to low, but does not define what corresponds to high and low quality. "Quality" is also used by ICES (WGECO) and WFD for more specific purposes in relation to habitat and "Environmental quality standard", and this usage is therefore not discussed in more detail here. The usage of "quality" in these conventions is thus for the most part consistent with the conventional usage of the word.

Table 4.9.1.1. Definitions of ecological health, status and quality used in different international conventions and directives.

Source	Ecological health	Ecological status	Ecological quality
ASCOBANS	-	Conservation status of a migratory species means the sum of the influences acting on the migratory species that may affect its long-term distribution and abundance;	
CCMLAR	CCAMLR therefore seeks to preserve the 'health' of the ecosystem by setting conservative (i.e., precautionary) krill catch limits to take account of the needs of associated species in a manner which preserves the ecological sustainability of all the species concerned.	-	-
CFP	-	Conservation status of marine eco-systems = Recovery plans may include targets relating to other living aquatic resources and the maintenance or improvement of the conservation status of marine eco-systems. (…) in order to conserve and manage living aquatic resources or maintain or improve the conservation status of marine ecosystems.	-
FAO	Note that the terms "health" or "integrity" have a different meaning than in general dictionaries and do not have an agreed operational meaning. Ecosystem well-being: A condition in which the ecosystem maintains its diversity and quality — and thus its capacity to support people and the rest of life — and its potential to adapt to change and provide a viable range of choices and opportunities for the future.	A desired state of the ecosystem (health, integrity)	-

Source	Ecological health	Ecological status	Ecological quality
HABITAT DIRECTIVE	-	Consevrvation staus means the sum of the influences acting on a natural habitat and its typical species that may affect its long-term natural distribution, structure and functions as well as the long-term survival of its typical species within theterritory referred to in Article 2 Conservation status of a migratory species means the sum of the influences acting on the species concerned that may affect the long-term distribution and abundance of its populations within the territory referred to in Article 2;	-
HELCOM	-	The specific strategic goal for the protection of biodiversity is to reach a "favourable conservation status of Baltic Sea biodiversity". This means that biodiversity is restored and maintained and all elements of the marine foodwebs, to the extent that they are known, occur at normal abundance and diversity.	-
ICES(WGECO)	-	Ecological status is an expression of the quality of ecosystem structure and function. Ecological status varies naturally in response to drivers like climate, but human impacts also affect the ecological status of ecosystems, sometimes profoundly. Ecological status is good when human activities are sustainable, as defined above. Good ecological status does not imply that human impacts are not detectable, because some degree of effect is unavoidable whenever humans take benefits from the range of goods and services that ecosystems provide. However, when ecological status is good, the human impacts are still reversible, so any other mix of ecological goods and services could also be taken, should societal needs or values change. In the context of the European Marine Strategy, ecological status would be good when the targets for all indicators that underpin the Strategy have been met, moderate when all precautionary limits were avoided, and poor if any precautionary limits were not avoided.	The most logical way of assessing the suitability of an area for a particular species, or life stage, is to measure the density of that species or life stage. Thus the quality of the habitat is a direct reflection of the abundance of the species/stage there, and the concept of habitat quality in thereby reduced to species abundance. It thus provides no additional scientific information or ecological insight beyond that related to the species concerned. Habitat quality is a multivariate phenomenon and the axes will vary depending on the habitat type, i.e., we would need to define different relationships for each habitat type, and based on common classification systems

Source	Ecological health	Ecological status	Ecological quality
MSFD	'Good environmental status' means the environmental status of marine waters where these provide ecologically diverse and dynamic oceans and seas which are clean, healthy and productive within their intrinsic conditions, and the use of the marine environment is at a level that is sustainable, thus safeguarding the potential for uses and activities by current and future generations, i.e.:	Environmental status = the overall state of the environment in marine waters, taking into account the structure, function and processes of the constituent marine ecosystems together with natural physiographic, geographic, biological, geological and climatic factors, as well as physical, acoustic and chemical conditions, including those resulting from human activities inside or outside the area concerned;	-
OSPAR	To measure the 'health of the sea' several ecological quality issues are chosen (such as status of marine mammals, of seabirds, of oxygen concentrations, etc.). For each issue one or more objectives can be chosen. These objectives each have an indicator that is used to assess whether the agreed Ecological Quality Objective is being met. The sea is healthy when all objectives are met.	-	In the context of the ecosystem approach, marine ecological quality is an expression of the structure and functioning of a marine ecosystem, taking into account its biological community and its natural physiography, geography and climate, as well as physical and chemical conditions, including those resulting from human activities.

Source	Ecological health	Ecological status	Ecological quality
WFD	-	Common definitions of the status of water in terms of quality and, where relevant to the purpose of the environmental protection, quantity should be established. 'Ecological status' is an expression of the quality of the structure and functioning of aquatic ecosystems associated with surface waters, classified in accordance with Annex V. Surface water status is an expression of the quality of the structure and functioning of aquatic ecosystems associated with surface waters, classified in accordance with Annex V. Good ecological status values of the biological quality elements for the surface water body type demonstrate low levels of distortion resulting from the human activity, but deviate only slightly from those normally associated with the surface water body type under undisturbed conditions.	'Environmental quality standard' means the concentration of a particular pollutant or group of pollutants in water, sediment or biota which should not be exceeded in order to protect human health and the environment.

4.9.1.1 Referring to environmental status *sensu* MSFD

With a focus on structure and functioning of the entire ecosystem, MSFD has the broadest scope among EUs directives. Based on the Principle of Sustainable Development in the Charter of Fundamental Rights of the European Union Art. 37, MSFD aims at a good environmental status, defined as ecologically diverse oceans and seas which are healthy, clean and productive to maintain themselves as well as human uses now and in future (MSFD Art. 3(5)). CFP refers to this principle in that it claims that sustainable fisheries, the proper CFP target, and healthy marine ecosystems are interdependent and thus irrevocably linked. As in MSFD, human uses are explicitly part of the dynamics of the whole system and a pristine environmental status is not required to obtain a 'good environmental status' for a system. For a 'good status', the human impacts should be sustainable and reversible. This is slightly different from the MFSD definition of a good environmental status where the cornerstones are safeguarding the future use of the marine goods together with preventing any subsequent deterioration. This is further reflected in the MSFD principle of halting the loss of biodiversity in the EU maritime environment (Preamble 18).

4.9.1.2 Referring to Ecological status *sensu* WFD

Although, WFD refers to the status of aquatic ecosystems in general as a prerequisite for safeguarding aquatic resources, it particularly focuses on the water component itself. Thus, biological and physical-chemical features are treated as indicators of water quality rather than of ecosystem structure and functioning. As a corollary, productivity aspects as for MSFD and CFP are not included. As in MSFD and CFP, it allows separating between human and natural impacts driving the biological and physical-chemical indicators. Human impacts are allowed to cause only little deviation from the conditions of a water body under natural conditions to achieve a 'good ecological status' (WFD ANNEX V). With emphasis on biological and physical-chemical status, the overall status of the water body is defined as the sum of ecological status and chemical status. It is not evident to which extent the overall 'good status of a water body' is linked to the principle of sustainable development, which is one of the key parameters for MSFD good environmental status.

4.9.1.3 Referring to conservation status

HD addresses the lowest level of system complexity in that it focuses on predefined suite of species and natural habitats. Ecosystem functions are merely included to maintain the livelihoods of the targeted species and habitats, a *sine qua non* between ecosystem functions and targets as for CFP is not considered. The aim is to arrive at a good conservation status of species and natural habitats considered. The definition for 'favourable conservation status' is rooted in the respective sections of the Convention on Migratory Species (CMS, 1979). The cornerstones for achieving a favourable conservations status are: maintaining the natural range; (ecosystem) structures and functions exist to safeguard (foreseeable) future existence; and (for species) natural habitat space and (for habitats) typical species persist in quantities required to maintain species' and habitats' long-term existence. With regard to the management of human impacts, the pivotal term is 'natural habitat', which is defined as being either 'natural' or 'semi-natural'. It is not defined to which extent the 'good conservation status' is linked to the principle of sustainable development, which is one of the key parameters for MSFD good environmental status. However, MSFD and HD are congruent in the aim of maintaining biodiversity as such. A summary is shown in Table 4.9.1.3.1.

Table 4.9.1.3.1. Summary table of sources using the term status in an operational manner.

Source	Overall Goal	Operational tool	Complexity level
MSFD	Good environmental status	Environmental target	Ecosystem level
WFD	Good ecological status	Environmental objectives	Ecosystem level
HD	Favourable conservation status	Conservation objectives (list of species and habitat types)	Species and habitat level
OSPAR	(Good) ecosystem health	Ecological quality objectives (EcoQO; being either a target, limit or indicator)	Ecosystem and species level
CFP	Exploitation of resources under sustainable economic, environmental and social conditions	Management and conservation objectives (including concrete measures)	Ecosystem level and stock level

4.9.1.4 Operational tools to achieve management goals

The directives and conventions typically operate by setting high level goals, such that ecosystems should be healthy, then they use operational lower level objectives to achieve the desired condition. The EU's MSFD provides a list of qualitative descriptors for determining good environmental status and reaching the environmental target (Appendix 2, Section 4.15). The WFD gives an extensive list of quality elements for the classification of ecological status (Annex V, 1.1). Five annexes in the HD provide lists of species, habitats and sites which need the designation of special areas of conservation, while the CFP sets out a set of measures in its scope (Article 1). OSPAR uses ecological quality objectives that involve target values to steer after, or limit, values for when to take action, and also often include specific links to human activities. This allows evaluation of the management actions taken to regulate the activity.

There are some differences in usages between the different conventions/directives. As EU Member States are obliged to implement the MSFD, this document was analysed in more detail. In general, MSFD provides overall goals for ecosystem state through a list of qualitative descriptors, and leaves it to the member states to establish practical operational tools for achieving the goals. This analysis was difficult, as the MSFD on one hand defines some terms, while other terms, although widely used and well defined by other fora, are not described as such in the MSFD. However, these terms, like "objectives", are used in several parts of the documents, but not each time in a clear and consistent way. As an example, statements about how to achieve or maintain good environmental status are listed in Article 1, and although not clearly named as 'objectives' in this article, are referred to as 'objectives' in later Articles. Further, the MSFD is using the term 'target' at a similar level as OSPAR uses the ecological quality objectives (Table 4.9.1.3). OSPAR and HELCOM for example provide more specific operational tools for managing the ecosystems through the use of EcoQO's.

4.9.2 Vulnerable and sensitive species

Only four sources refer to the terms vulnerable and sensitive (see Table 4.9.2.1) and the use of the terms depends strongly on the source. FAO gives very comprehensive and practical definitions of both terms where vulnerable is used when talking about ecosystems, and five criteria are defined to identify vulnerable marine ecosystems (see Table). HELCOM uses the term vulnerable consistent with FAO. For species, FAO uses actually both terms, and a species is sensitive or vulnerable depending on the resilience to disturbances and thus vulnerability is a direct measure of species' resilience. Assessment of sensitivity for a species is based on biological and life cycle characteristics.

In turn, HD treats vulnerability in a different manner and focuses on abundance instead of life-history traits. The HD mentions a vulnerable species as 'likely to move into the endangered category…'. This captures only one element of vulnerability and is not as complete as the FAO definition. ICES WGECO uses sensitivity of a habitat and provides a definition closely related to the FAO definition. For ecosystems, the FAO definition is adequate. Both particular life-history characteristics and low abundance can make a species vulnerable, and definitions should therefore capture both aspects of vulnerability.

Overall, it seems that the terms vulnerable and sensitive can be used interchangeably.

Table 4.9.2.1. Definitions of vulnerability and sensitivity used in different international conventions and directives.

Source	Vulnerability	Sensitivity
FAO	More specifically, the EAF requires an assessment or characterization of the sensitivity or vulnerability of the species of importance to fisheries and ecosystem processes in terms of their resilience to disturbances such as fishing, habitat degradation, pollution, etc. Identifying vulnerable marine ecosystems and assessing significant adverse impacts. A marine ecosystem should be classified as vulnerable based on the characteristics that it possesses. The following list of characteristics should be used as criteria in the identification of vulnerable marine ecosystems: i. Uniqueness or rarity ii. Functional significance of the habitat iii. Fragility – an ecosystem that is highly susceptible to degradation by anthropogenic activities. iv. Life-history traits of component species that make recovery difficult v. Structural complexity.	More specifically, the EAF requires an assessment or characterization of the sensitivity or vulnerability of the species of importance to fisheries and ecosystem processes in terms of their resilience to disturbances such as fishing, habitat degradation, pollution, etc. Sensitivity can be described and assessed based on the biological and life cycle characteristics of the species. The risk of extinction is becoming very relevant considering the levels of overfishing measured on many important resources. This risk can be related to: (i) the life cycle of the species; (ii) its market value related to its availability relative to the demand, and (iii) the effective level of deterrence of protection measures
HABITAT DIRECTIVE	Vulnerable, i.e., believed likely to move into the endangered category in the near future if the causal factors continue operating;	-
HELCOM	Reduced diversity of genes, species and biotopes leads to ecosystems which are more vulnerable to the effects of natural variability and stochastic events.	-
ICES (WGECO)	-	Habitat sensitivity can be defined as the degree and duration of damage caused by a standardized 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 (McDonald *et al.*, 1997). Sensitive – The magnitude of response of any indicator to a change in the system.

4.9.3 Significant adverse impacts

The EC Common Fisheries Policy and CFP Council regulations (e.g., EC/ No 1967/2006 and EC/No 2371) frequently use terms such as ***harmful effects, minimizing of impact, serious threat, impact of fishing activities*** and ***negligible impact***, none of which are further defined. These can usually be considered general statements that might not require or warrant further interpretation. In contrast, however, used terms such as ***significant impact*** come close to requiring further definition and interpretation, although none is usually provided.

In contrast, FAO 2008 is very thorough in describing the utilized term ***significant adverse impact***, including prescription of ways to determine scale, significance, timing and duration of impacts relative to ecosystem functions and the extent to which ecosystem functions may be altered by the impact. A summary of these definitions is shown in Table 4.9.3.1.

The term ***significant adverse impact*** was first introduced in 2007 through UN ***Resolution 61/105: Sustainable fisheries, including through the 1995 Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks, and related instruments.***

Significant adverse impact was subsequently defined by FAO in FAO Fisheries and Aquaculture Report No. 881 of 2008, i.e., prescribing that:

Significant adverse impacts are those that compromise ecosystem integrity (i.e., ecosystem structure or function) in a manner that: (i) impairs the ability of affected populations to replace themselves; (ii) degrades the long-term natural productivity of habitats; or (iii) causes, on more than a temporary basis, significant loss of species richness, habitat or community types. Impacts should be evaluated individually, in combination and cumulatively.

When determining the scale and significance of an impact, the following six factors should be considered:

- i) the intensity or severity of the impact at the specific site being affected;
- ii) the spatial extent of the impact relative to the availability of the habitat type affected;
- iii) the sensitivity/vulnerability of the ecosystem to the impact;
- iv) the ability of an ecosystem to recover from harm, and the rate of such recovery;
- v) the extent to which ecosystem functions may be altered by the impact; and
- vi) the timing and duration of the impact relative to the period in which a species needs the habitat during one or more of its life-history stages.

WGECO recommends that organizations such as the CFP, when describing impacts, adhere to a terminology that leaves less room for interpretation, i.e., such as the one adopted by FAO.

Table 4.9.3.1. A summary of definitions for adverse effects.

	Terms	Definition	Source
ASCOBANS	Adverse Impact	No definition	ASCOBANS
CBD	Adverse Impact	No definition	CBD - Convention on Biological diversity (Rio 5 June 1992)
CCAMLR	Adverse Impact	No definition	CCAMLAR Art. 2
CFP	Adverse Impact	No definition	CFP - COUNCIL REGULATION (EC) No 2371/2002
FAO	Adverse Impact	Adverse impacts caused by fishing gears or other anthropogenic disturbances are impacts on populations, communities, or habitats that are more than minimal and not temporary in nature. If the consequences of an impact spread more widely in space or through ecosystem interactions and are not temporary, the impact is adverse even if the ecosystem feature impacted directly demonstrates rapid recovery. Taking into account Principle 15 of the United Nations Conference on Environment and Development (UNCED) Rio Declaration on Environment and Development, adverse impacts become significant when the harm is serious or irreversible. Impacts that are likely to take several generations or decades (whichever is shorter) to reverse are considered irreversible. Impacts that are likely to reduce the productivity of any population impacted by the fishery (whether intentional or accidental), or the productivity, species richness, or resilience of an impacted community or ecosystem, or the structural complexity of a habitat are considered serious. In this context productivity is intended to mean all aspects of a population's capacity to maintain itself. In circumstances of limited information the assumption should be that impacts will be difficult to reverse or likely to affect productivity or resilience unless there is evidence to the contrary.	FAO - Fisheries Report No. 855

	TERMS	DEFINITION	SOURCE
FAO	Adverse Impact	Significant adverse impacts are those that compromise ecosystem integrity (i.e., ecosystem structure or function) in a manner that: (i) impairs the ability of affected populations to replace themselves; (ii) degrades the long-term natural productivity of habitats; or (iii) causes, on more than a temporary basis, significant loss of species richness, habitat or community types. Impacts should be evaluated individually, in combination and cumulatively. When determining the scale and significance of an impact, the following six factors should be considered: i. the intensity or severity of the impact at the specific site being affected; ii. the spatial extent of the impact relative to the availability of the habitat type affected; iii. the sensitivity/vulnerability of the ecosystem to the impact; iv. the ability of an ecosystem to recover from harm, and the rate of such recovery; v. the extent to which ecosystem functions may be altered by the impact; and vi. the timing and duration of the impact relative to the period in which a species needs the habitat during one or more of its life-history stages	FAO Fisheries and Aquaculture Report No. 881
HABITAT Directive	Adverse Impact	No definition	Habitat Directive (HD)
HELCOM	Adverse Impact	No definition	HELCOM - Overview 2007
ICES	Adverse Impact	No definition	ICES - Cooperative Research Report Rapport des Recherches Collectives No. 273
MSFD	Adverse Impact	No definition	MSFD - DIRECTIVE 2008/56/EC OF THE EUROPEAN PARLIAMENT
OSPA	Adverse Impact	No definition	OSPAR - Annex V
UNCLOS	Adverse Impact	No definition	UNCLOS - Distr. GENERAL A/CONF.164/37

4.10 Case studies of the application of ecological terminology in marine environmental management

This section reports some practical experiences with using the terminology in developing science advice for management and policy. The first case study highlights a successful experience, with a weakly defined term but sound scientific criteria and guidelines for practice. The next three highlight different types of problems that can arise in real-world applications, despite clear definitions supported by scientific guidelines on applications. The final example is a case where a high-level concept can simply be implemented in different ways, both consistent with definition and concept, but not resulting in the same outcomes. This illustrate both the value of sound scientific guidelines for practice, however explicit the definitions, and the likelihood that, when there are likely serious social or economic consequences of science advice on implementing these policies, science will be challenged to explain and defend its advice, however consistent with the definitions and guidance on implementation.

4.10.1 Use of the CBD criteria for ecologically and biologically significant areas

Although worded slightly different, the Science Sector of Fisheries and Oceans Canada adopted criteria for identifying areas as Ecologically and Biologically Significant (EBSA; DFO 2004a, 2006a) that are the same as the CBD criteria in Annex I to CBD COP IX/20. These were used in four of the five Large Ocean Management Areas (LOMAs) that were part of the Ocean Action Plan Part 1 (OAP-1) to identify areas in need of particularly risk averse management. In one of these LOMAs (Beaufort Sea) almost all the information available came from traditional knowledge, so the process of applying the criteria was not readily applicable to ICES practices. However the participants in the process considered the criteria and associated guidelines to be adequately clear and useful in their activities nonetheless. They ended up with maps of the EBSAs within the parts of the Beaufort Sea not covered by ice year-round that comprised approximately a third of those areas.

For the Gulf of St Lawrence (GOSLIM), the Placentia Bay-Grand Bank (PBGB), and the Pacific North Coast (PNCIMA) LOMAs, the regional experts all undertook "layering exercises" using the EBSA criteria. All relevant survey data on ecosystem components (phyto- and zoo- plankton, larger invertebrates, fish, birds, mammals) were geo-referenced, and the maps augmented by meetings with scientists, naturalists, fishers, First Nations, etc. who contributed experiential knowledge of spawning/breeding sites, migration pathways, nursery grounds, etc. Then expert workshops sequentially added each data layer to maps containing information on bathymetry and seabed features, and applied the EBSA criteria to identify areas that met the criteria.

Working independently, initially, each workshop tended to take very liberal interpretations of each criterion, such that essentially all of each LOMA was found to "meet" one or more criteria. As such, the criteria would not have been useful in guiding conservation or management efforts to areas of higher or lower ecological priority. However, the guidelines associated with the criteria (DFO, 2002a, 2004a, 2007a) were found sufficient for each group to refine their initial maps, with areas considered to be of greatest ecological or biological significance readily emerging by the end of the workshop. Although no target was given for what percentage of each LOMA should be identified as EBSAs, in the end the three independent regional groups of experts produced EBSA designations comprising 21, 28, and 34% of the LOMAs.

4.10.2 Use of the FAO criteria for vulnerable marine ecosystems (VMEs)

The Northwest Atlantic Fisheries Organisation (NAFO) began an initiative in its 2007 Annual Meeting to identify areas which met the FAO criteria for VMEs. A Working Group of the NAFO Scientific Council first met in Spring 2008 (NAFO, 2008a). Initially the participants attempted to address the full suite of criteria in the FAO Technical Guidelines, but problems quickly arose from ambiguities about what constituted an "ecosystem" (in the vulnerable marine *ecosystem* phrase) relative to some of the criteria such as features of the fish community. These ambiguities could not be resolved, indicating a problem with operationalising this term. The working group chose to build on the examples of corals and sponges in Annex 1 of the FAO guidelines. The experts began with sites where corals and sponges were found and overlaid information on the distribution of fish species which met the FAO criteria. Experts pooled information from groundfish research surveys, fishery observer records, and directed benthic research to provide maps of the locations of candidate VME areas within the NAFO regulatory area. The meeting of the Scientific Working Group was followed in May by a meeting of a specially created Ad Hoc Working Group of Fisheries Managers and Scientists (WGFMS). At this meeting the maps and data from NAFO, 2008a were reviewed in a management context. A subset of the areas identified by the scientific working group was delineated for further attention (NAFO, 2008b). Issues raised were the relationship between research vessel data (the only data available to the working group) and commercial data, particularly in developing threshold values for encounter protocols. There was also debate about the proper scale to use when going from observed catches of sponges or corals in survey or commercial nets to identifying areas of the seabed with concentrations of these features. The NAFO Fisheries Commission reviewed the information from both working groups and requested its Scientific Council to identify areas with significant concentrations of corals, and of sponges (NAFO, 2008c,d). These results went to the NAFO Scientific Council in October 2008, which considered the report on coral (the report on sponge was deferred to June 2009). This WGFMS met again in March 2009. A report of that meeting is not available, but working papers tabled at the meeting (NAFO, 2009) show that the boundaries of the areas to be proposed as VMEs were refined further, and avoid almost all areas with record of frequent fishing in the past couple of decades.

Despite consideration at several meetings of experts, managers, and policy experts, NAFO has not been able to finalize and adopt the first group of areas it will designate as VMEs according to the FAO criteria. This may happen in the 2009 NAFO Council meeting, depending on the acceptability of the results of the 2009 meetings. Some of the issues have been difficulties in applying the criteria in real-world situations, such as the lack of unambiguous guidance on what constitutes a "concentration" of corals or sponges, and on how to set the size of a candidate area based on observations of these features in research surveys or commercial fisheries. Some of the issues occur with the iterative process between science and management, though, with managers clearly being highly risk adverse to false alarms (designating areas that are larger than necessary), and scientists less risk averse to false alarms but concerned that areas meeting the criteria are not be missed.

4.10.3 Setting targets for "recovery" of species listed in Species At Risk Act (SARA)

Species at risk legislation in the US and Canada requires that recovery targets be set for listed species. In Canada, recovery targets in abundance and range must be specified as part of the mandatory recovery plan for protected species. Several meetings have been held to develop guidelines for the science advice needed as input to consultations and as a central factual basis for provisions to be included in the recovery plans (DFO, 2004b; 2004c; 2005; 2006b; 2007b, c). Many parts of the framework for science advice are working well. However despite discussion at two expert meetings, there still is a lack of consensus on how to operationally interpret the term "recovery" (2005, 2007c). One interpretation is that "recovery" is reached when a population no longer qualifies under any of the criteria used by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). These are the same as the IUCN Red List Criteria (IUCN, 2008). The rationale for this interpretation is based on the logic that if a species is not at risk of extinction, then it must have recovered from the state when it was at risk. The other interpretation is that "recovery" is not reached until a population is at least larger than the limit reference point ("Lower Stock Reference Point" *sensu* DFO, 2002, 2006c). The rationale for this interpretation is that for any stock below its limit reference point for population size, the precautionary approach states than all human induced impacts should be as low as achievable by management, and priority should be given to increase in stock size over any uses. Therefore, although a stock will cease to qualify as at risk of extinction at population sizes well below its limit reference point, it cannot be considered to have "recovered" if the PA framework is still saying that all human impacts should be at the lowest levels achievable by management. It is unclear where guidance to resolve this difference of opinion among experts could be found. However, in practical applications it has large implications, both because the two benchmarks (size or range meeting the IUCN/COSEWIC threatened species criteria and limit reference points for populations size) are quite far apart, and because the Species at Risk Act requires very stringent prohibitions on harm to individuals of listed species or their habitats as long as they are protected under the Act.

4.10.4 Identification of Critical Habitat for aquatic species

Legislation in the US and Canada also requires identification of Critical Habitat (Canada SARA) or Essential Fish Habitat (US-Magnusson Stevens Act). Concepts and challenges of developing consistent guidelines for identifying the portion of a species' habitat that is "essential" are documented (Benaka, 1999; http://www.nmfs.noaa.gov/habitat/habitatprotection/efh/). In Canada, consistent interpretation of what constitutes "critical habitat" is essential, because SARA includes stringent proscriptions against damage to such habitats, and critical habitat must be identified for a wide range of aquatic species (invertebrates, fish, water birds and marine mammals) in freshwater (lacustrine and riparian), coastal, and marine environments. Several expert meetings were held to develop scientific guidance on what constitutes "critical habitat" under SARA (DFO 2003, 2004c, 2006b, 2007b, d). The guidance states that critical habitat is delineated by the physical, chemical, and biotic features of a place that make the place suitable for one or more life-history stages of the species. A species with a complex life history may have several types of critical habitat. Science advisory meetings generally have been able to apply these guidelines, although often progress is limited by lack of knowledge of a species' requirements, or lack of data on the physical, chemical, and/or biotic features of many parts of the sea and many freshwater systems.

Recently two more conceptual problems have emerged in application of the guidelines for critical habitat. One is whether habitat with all the features meeting those specified for a protected species, but where the species does not occur, can be designated as "critical habitat". The practice has been to do so in cases when the recovery target for abundance and range set for species means it must expand its area of occupancy beyond the area used at the time listing. The rationale is that even if the habitat is not being used right now, it will be needed by the time the species reaches its recovery target, and hence it is habitat "critical" to the recovery of the species. This interpretation is being challenged legally by groups that would be prevented legally from conducting activities in such areas. The other problem is that SARA includes food resources as a possible dimension of "critical habitat". When the Act was developed, this provision was included to ensure that plants needed by insects or grazing vertebrates with specialized diets could be protected as "critical habitat". Recently a recovery team for West Coast orcas proposed to include Chinook salmon as a component of "critical habitat" for orcas. This is being challenged in part because of the impact that those designation would have for otherwise sustainable fisheries on Chinook salmon, and in part because highly mobile things like salmon are inherently not "habitat" features. If they are essential to recovery of orcas they should be dealt with under other provisions of SARA, dealing with threats to recovery.

It is unclear if there is a scientific basis to resolve either of these disagreements, or if the resolution will be done through legal process. However, they demonstrate that even when workable science guidelines for the interpretation of the concept of "habitat" can be developed, there remain some fundamental questions like "does habitat have to be being used" and "does habitat have to be associated with a place" that pose challenges to application.

4.10.5 Interpretation of EA as incremental vs. holistic

The final term that is proving problematic to implement under Canadian legislation is what constitutes an "ecosystem approach". The phrase appears in the Preamble to Canada's Ocean Act (http://laws.justice.gc.ca/en/O-2.4/), along with "integrated management" (IM) and the OAP I (see example 1 in this section) LOMA initiative was in part to build the foundation for application of the ecosystem approach in an IM context. After five years of work, two different approaches to this task are emerging. One takes an incremental approach, starting with status quo management, identifying priority ecosystem issues through an inclusive stakeholder-based process, then adding or adapting management measures to address the issues. The other takes a centralist approach, first considering what is known of the ecosystem structure and function, and identifying the suite of conservation objectives that are considered most important for protecting the species, places, and processes most crucial to the characteristic structural and functional properties of the ecosystem. Then a stakeholder-inclusive IM process would be tasked with fitting the human uses of that ecosystem into the area, with the aggregate impacts of the pressures from all uses not moving the system outside the boundaries set by the suite of conservation objectives. These two different interpretations of how to implement an ecosystem approach in IM (or by sector) do not lead to the same priorities necessarily being addressed, or to the same constraints being placed on the various human activities. Definitions and explanations of "ecosystem approach" which stress the adaptive and evolutionary nature of the EA favour the incremental approach, whereas definitions and explanations that stress the protection of ecosystem integrity, resilience, and other higher-order ecosystem features favour the centralist approach. Currently, progress is impaired by the unresolved debate (DFO, 2007a).

4.11 Where to go from here

4.11.1 Press for adoption of common meanings-scientific or practical criteria

There can be few who would argue for multiple definitions of the same term to be used within a field such as marine environmental management. WGECO would therefore support efforts to develop a single consistent set of definitions. The FAO glossary (http://www.fao.org/DOCREP/006/Y4773E/y4773e0g.htm) acts as a good starting point although there are concerns about the robustness of some of the source definitions and the work done here extends that coverage. However WGECO recognizes that there may be the need to have, clearly defined, concepts that are aspirational and related to operational terms. In these cases we plead for the consistent use of different terms.

4.11.2 Science gaps-what science is needed to underpin the application of critical terms

Some terms are well defined in the scientific literature and poorly defined (or undefined) in the policy documents. Some such terms have become central tenants of policy. For example, the FAO definition 'significant adverse impact' makes reference to the recovery of the system taking 5–20 years. However, it does not define recovery, and the academic definitions are not immediately applicable to this operational use. So can science provide managers with advice on what is a recovered habitat and for how many habitats are we confident that we know how long they will take to move from a particular, damaged, configuration to this 'recovered' state? There is therefore both a definitional and science gap to the application of this key concept.

WGECO has previously referred to the challenges presented by differing management units-stocks vs. habitat units vs. 'ecoregions' vs. management areas (e.g., OSPAR Regions). This is not a major issue if one is concerned with only managing fish stocks or conservation zones but, when we move to holisitic, multi-sectoral, ecosystem based management integration across scales will become a major challenge and science is not well placed at present to deal with these issues.

4.12 Recommendations

- ICES informs its policy customers of the key outcomes of this review and works with them in developing the consistent use of terminology in the application and operationalization of ecosystem based management.
- WGECO be tasked with carrying out a detailed, quantitative, evaluation of a limited (2 or 3) management schemes to assess the extent to which they actually reflect the high level definitions and are supported by a scientific evidence base. Possible case studies include the Baltic Sea Action Plan ….
- WGECO recommend that we ask clients to define terms which have multiple definitions in the key policy documents in their requests for advice.

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4.14 Appendix 1. Summary of high level terms and associated categories reviewed in this Report

The terms were placed into six categories:

1) ecological concepts,

2) descriptors of the environment and its status (including reference state, thresholds),

3) environmental management strategies,

4) impacts or pressures on the system (including limits to impacts),

5) ecological scales i.e., stock, population, geographical units and

6) 'other'.

which are shown in the final column. Terms marked with * indicate that they were removed from the final assessment. Definition of these terms can be found in Appendix 2.

Source	Term	Category
OSPAR	adverse effects of human activities	Impact
CBD	Alien or alien species*	Descriptors
FAO	Alien species*	Descriptors
FAO	Associated species*	Descriptors
FAO	Biodiversity	Concept
MSFD	Biodiversity	Concept
CBD	Biological diversity	Concept
OSPAR	Biological diversity	Concept
FAO	Biological potential	Concept
CBD	Biological resources	Concept
CBD	Biotechnology*	Concept
MSFD	catchment area of each marine region or subregion	Scale
MSFD	Characteristics: Biological features*	Descriptors
MSFD	Characteristics: Habitat types*	Descriptors
MSFD	Characteristics: Physical and chemical features*	Descriptors
MSFD	Coastal waters, including their seabed and subsoil	Scale
FAO	Community	Concept
FAO	Competition	Concept
ASCOBANS	Conservation status of a migratory species	Descriptors
HD	conservation status of a natural habitat	Descriptors
HD	conservation status of a species	Descriptors
CFP	conservation status of marine eco-systems	Descriptors
CFP	Coralligenous habitat	Concept
HELCOM	cross-sectoral, marine spatial planning principles based on the Ecosystem Approach	Strategy
FAO	Deep-sea fisheries (DSF)	Scale
FAO	Depended species	Concept
CBD	Domesticated or cultivated species*	Descriptors
FAO	Ecological footprint	Concept

Source	Term	Category
FAO	Ecological niche	Concept
ICES	Ecological objective	Descriptors
WFD	Ecological status	Descriptors
ICES	Ecological status	Descriptors
FAO	Ecological valence	Concept
CBD	Ecosystem	Concept
FAO	Ecosystem	Concept
FAO	Ecosystem	Concept
OSPAR	Ecosystem	Concept
OSPAR	ecosystem	Scale
FAO	Ecosystem approach	Strategy
FAO	Ecosystem approach	Strategy
CBD	Ecosystem approach	Strategy
ICES	Ecosystem Approach	Strategy
HELCOM/OSPAR	Ecosystem approach	Strategy
CFP	Ecosystem approach	Strategy
OSPAR	Ecosystem approach	Strategy
CFP	eco-system based approach to fishery management	Strategy
ICES	ecosystem overfishing	Impact
MSFD	Ecosystem-based approach	Strategy
MSFD	environmental quality in accordance with the principle of sustainable development*	Descriptors
OSPAR	environmental quality objectives	Descriptors
MSFD	environmental status	Descriptors
MSFD	environmental target	Descriptors
CBD	Eradication	Other
CBD	Establishment	Concept
HELCOM	evaluation of the effectiveness of existing technical measures, by 2008, to minimize bycatch of harbour porpoises, and to introduce adequate new technologies and measures*	Impact
ASCOBANS	Exotic species*	Descriptors
ASCOBANS	favourable conservation status	Descriptors
HELCOM	favourable conservation status of marine biodiversity*	Descriptors
FAO	Fish-in-Balance index (FiB)*	Impact
ICES	Function	Concept
WFD	Function	Concept
FAO	Functioning	Concept
HELCOM	Functioning	Concept
CFP	Functioning of aquatic ecosystems	Concept
CBD	Genetic material	Concept
CBD	Genetic resources	Concept
FAO	Ghost fishing	Impact
ICES	Ghost fishing	Impact
HELCOM	good ecological and good environmental status*	Descriptors
WFD	Good ecological potential	Descriptors
WFD	Good ecological status	Descriptors

Source	Term	Category
CFP	good environmental status	Descriptors
MSFD	good environmental status	Descriptors
WFD	Good surface water status	Descriptors
FAO	Guild	Concept
ASCOBAN	Habitat	Concept
CBD	Habitat	Concept
CCAMLR	Habitat	Concept
FAO	Habitat	Concept
HD	Habitat	Concept
HELCOM	Habitat	Concept
ICES	Habitat	Concept
ICES	Habitat	Concept
OSPAR	Habitat	Concept
WDF	Habitat	Concept
OSPAR	habitat	Scale
MSFD	Habitat	Concept
ICES	Habitat of a species	Concept
ICES	Habitat of a species	Scale
ICES	Habitat sensitivity	Descriptors
CFP	harmful effects to marine ecosystem*	Impact
HELCOM	healthy Baltic Sea environment*	Descriptors
CFP	healthy marine ecosystems	Descriptors
OSPAR	Human activities	Impact
CFP	impact of fishing activities on marine eco-systems and non target species*	Impact
ICES	Indicator	Other
CBD	In-situ conditions	Concept
HELCOM	integration of environmental objectives with economic and socio-economic goals	Strategy
MSFD	Integrity, structure and functioning of ecosystems	Concept
CBD	Introduction	Concept
CBD	Invasive alien species*	Descriptors
CFP	Long term ecological sustainability	Concept
CFP	mäerl bed	Scale
MSFD	Marine ecological services	Concept
MSFD	marine environment*	Descriptors
MSFD	Marine regions	Scale
MSFD	Marine subregions	Scale
MSFD	marine waters	Scale
MSFD	Measures to improve the traceability, where feasible, of marine pollution*	Strategy
MSFD	MPAs => coherent and representative networks	Strategy
ICES	Natural habitats	Concept
MSFD	natural marine resources	Descriptors
CFP	no significant impact on the marine environment	Impact
ICES	Operational objective	Other

Source	Term	Category
FAO	Overfishing	Impact
HELCOM	permanent closures of sufficient size for fisheries to prevent capture of non-target species to protect important reproduction and feeding areas and to protect ecosystems, by 2012;	Strategy
UNCLOS	Persistence	Concept
OSPAR	Persistency	Concept
FAO	Population assemblage	Concept
HELCOM	populations of all commercially exploited fish species are within safe biological limits, reach Maximum Sustainable Yield, and are distributed through their natural range, and contain full size/age range*	Descriptors
UN Fish Stock Agreement	Precaution	Strategy
ICES	Precaution	Strategy
CBD	Precautionary approach	Strategy
FAO	Precautionary approach	Strategy
CFP	precautionary approach to fishery management	Strategy
MSFD	Precautionary principle	Strategy
HELCOM/OSPAR	Precautionary principles and approach	Strategy
MSFD	Pressures and impacts	Impact
CBD	Protected Area	Strategy
FAO	Protected areas	Strategy
MSFD	Qualitative descriptors for determining good environmental status	Descriptors
CBD	recovery	Concept
CFP	recovery	Concept
FAO	recovery	Concept
ICES	recovery	Concept
WFD	recovery	Concept
FAO	Regularity	Concept
FAO	resilence	Concept
FAO	resilence	Concept
FAO	resilence	Concept
ICES	resilence	Concept
MSFD	resilence	Concept
FAO	resilience	Concept
FAO	resilience	Concept
OSPAR	resilience	Concept
FAO	Resistance	Concept
CFP	seagrass bed	Scale
ICES	Sensitive	Descriptors
ICES	Sensitive habitat	Descriptors
CFP	serious threat to the conservation of resources, or to the marine eco-system*	Impact
FAO	Significant adverse impact	Impact
UN	Significant adverse impact	Impact
ASCOBANS	Sound ecological principles*	Concept

Source	Term	Category
MSFD	Spatial and temporal distribution controls	Strategy
MSFD	Spatial protection measures such as special areas of conservation, special protection areas or MPAs	Strategy
FAO	Species diversity = Diversity	Concept
FAO	Species richness	Concept
FAO	Stability	Concept
CBD	Strategic environmental assessment	Other
ASCOBANS	substantial threats	Impact
ASCOBANS	suitable habitats *	Descriptors
WFD	Surface water	Scale
WFD	Surface water status	Descriptors
ICES	Sustainable Development	Strategy
CFP	Sustainable exploitation	Strategy
ICES	Sustainable exploitation	Strategy
FAO	Sustainable fisheries	Strategy
FAO	Sustainable fisheries	Strategy
CFP	sustainable level of the impact of fishing activities on marine eco-systems*	Impact
FAO	Sustainable use	Strategy
HELCOM/OSPAR	Sustainable use	Strategy
FAO	Sustainable use	Strategy
CBD	Sustainable use	Strategy
OSPAR	sustainable use of biological diversity	Strategy
MSFD	sustainable use of marine goods and services	Strategy
HELCOM	sustainable use of natural resources	Strategy
MSFD	Sustainable use of the seas	Strategy
HELCOM	the health of the marine ecosystem*	Descriptors
CFP	the negligible impact on living aquatic resources*	Impact
HELCOM	thriving and balanced communities of plants and animals*	Descriptors
FAO	Trophic chain	Concept
FAO	Trophic level	Concept
ICES	Uncertainty	Concept
FAO	Vulnerability	Concept
FAO	Vulnerable marine ecosystem (VME)	Descriptors

4.15 Appendix 2.

4.15.1 Single uses of terms in high level documents

4.15.1.1 Ecological concept terms

High level Source	Term	Definition	Source of definition
FAO	Biological potential	A characteristic capacity of all populations, from bacteria to fish, to expand population size, more or less rapidly up to some naturally variable maximum. The expansion capacity of a population is limited by the biogenic capacity of the ecosystem. In fisheries, the term "potential" of a stock refers to its Maximum Sustainable Yield (MSY).	FAO
FAO	Biological reference points	Not defined in Garcia *et al*., 2003 FAO definitions provided in Caddy and Mahon, 1995: A Target Reference Point indicates to a state of a fishing and/or resource which is considered to be desirable and at which management action, whether during development or stock rebuilding, should aim. A Limit Reference Point indicates a state of a fishery and/or a resource which is considered to be undesirable and which management action should avoid.	Garcia *et al*., 2003
CBD	Biological resources	Includes genetic resources, organisms or parts thereof, populations, or any other biotic component of ecosystems with actual or potential use or value for humanity	CBD Art 2
FAO	Community	An integrated group of species inhabiting a given area; the organisms within a community influence each other's distribution, abundance and evolution. (A Human Community is a social group of any size whose members reside in a specific locality.; WRI Biodiversity glossary of terms).	Garcia *et al*., 2003

High level Source	Term	Definition	Source of definition
FAO	Competition	The interaction among organisms for a necessary resource that is in short supply (Nybakken, 1982). Happens between individuals of a given population or between different populations of the same species which occupy the same ecological niche (intraspecific competition). May happen also between different species with the same or overlapping ecological niches (interspecific competition). It is being argued that, as apical predators, human beings are in competition with marine mammals (Tamura, 2003). Organisms and populations are able to exclude competitors by altering their surroundings through excretion of chemical substances that modify the interactions. In a fished ecosystem, fishers compete for resources with other predators they may exploit (e.g., tunas, sharks) or not (e.g., piscivorous birds and marine mammals).	Garcia *et al*., 2003
FAO	Depended species	A non-target species depending on the target species (e.g., a predator fish depending on prey)	Garcia *et al*., 2003
FAO	Ecological footprint	1) Land (and water) area of the planet or particular area required for the support either of humankind's current lifestyle or the consumption pattern of a particular population. It is the inverse of the carrying capacity of a territory. 2) The area of productive land and aquatic ecosystems required to produce the resources used and to assimilate the wastes produced by a defined population at a specified material standard of living, wherever on Earth that land may be located.	United Nations (1997): Glossary of Environment Statis tics. Studies in Methods, Series F, No. 67Source: Alcamo, J. et al., 2003. Ecosystem and human well-being. A framework for assessment. Millennium Ecosystem Assessment. Island Press, 245 p
FAO	Ecological niche	The function of a species in the ecosystem. For example, the niche of herbivores or the niche of carnivores. The connections between organisms and the ecosystem. Should not be confused with the habitat (Odum, 1975). The ecological niche of an organism depends not only on where it lives (habitat) but also on what it does. By analogy, it may be said that the habitat is the organism's "address", and the niche is its "profession", biologically speaking (Odum, 1959).	Garcia *et al*., 2003

High level Source	Term	Definition	Source of definition
FAO	Ecological valence	Represents the extent of the variations of the environmental factors which a species can survive in the long run. Thus, a species is an indication of a particular ecological situation. Certain species endure great variations (thermal, eurythermic, saltwater, euryhaline) or no variation (stenothermal).	Garcia *et al*., 2003
CBD	Establishment	The process of a species in a new area successfully reproducing at a level sufficient to ensure continued survival without infusion of new genetic material from outside the area	UNEP/CBD/COP/6/18/Add.1 14 February 2002
CBD	Genetic material	Any material of plant, animal, microbial or other origin containing functional units of heredity	CBD Art 2
CBD	Genetic resources	Genetic material of actual or potential value	CBD Art 2
FAO	Guild	Group of organisms that exploit the same resources (share the same food resources) in an ecosystem.	Garcia, *et al*., 2003
CBD	In-situ conditions	Conditions where genetic resources exist within ecosystems and natural habitats, and, for domesticated or cultivated species, in the surroundings where they have developed their distinctive properties	CBD Art 2
CBD	Introduction	Movement of a species, subspecies, or a lower taxon (including any part, gametes, seeds, eggs, or propagule that might survive and subsequently reproduce) into an area where it is not yet present, or present but not widely distributed and being officially controlled resulting in its perpetuation, for the foreseeable future within the area	UNEP/CBD/COP/6/18/Add.1 14 February 2002
CFP	Long term ecological sustainability	The long-term ecological sustainability of fisheries must be the first priority because the past development of the CFP has demonstrated that healthy fish stocks healthy marine ecosystems are a sine qua non for an economically and socially healthy fishery sector.	

High level Source	Term	Definition	Source of definition
FAO	Population assemblage	A group of populations living in a given ecosystem, also called community or species assemblage (Lévêque, 1997; Amanieu and Lasserre, 1982). The term community is sometimes considered as more restrictive, referring to a given taxonomic group taken with a given sampling technique.	Garcia *et al*., 2003
FAO	Regularity	Relationship between the observed diversity and maximum diversity for a given species richness (Odum, 1975). The distribution of the total number of individuals among the species (Nybakken, 1982).	Garcia *et al*., 2003
FAO	Resistance	The degree of modification of the species composition or a species assemblage after a disturbance. The capacity of species assemblages to resist during a disturbance Pearson *et al*., 1992).	Garcia *et al*., 2003
FAO	Species diversity	Diversity is a measure of the complexity of an ecosystem and often an indication of its relative age. It is measured in terms of the number of different plant and animal species (Scialabba, 1998). A numerical measure combining the number of species in an area with their relative abundance (Nybakken, 1982). Often called species richness.	Garcia *et al*., 2003
FAO	Species richness	The number of species (taxons) occurring inside an ecosystem. A simple listing of the total number of species in a community or trophic level (Nybakken, 1982). SR reflect the capacity of the environment to sustain species, because it is a function of the number of ecological niches and of the habitats' diversity. This concept is important in restocking programmes. See also: Species diversity.	Garcia *et al*., 2003
FAO	Stability	An assemblage of species is stable when it conserves the same number of individuals of each species in the course of time (modified from Connell and Sousa, 1983). A population is stable when it conserves the same number of individuals in the course of time.	Garcia *et al*., 2003

High level Source	Term	Definition	Source of definition
FAO	Trophic chain	The complex architecture of living creatures interconnected through feeding (predator-prey relationships) from the lower levels of primary productivity (microscopic algae in the plankton) to top predators.	Garcia *et al*., 2003
FAO	Trophic level	The level of a living creature in the food chain. The phytoplankton is found at the lower levels (bacteria and other micro-organisms are at an even lower level). Top predators occupy the highest levels.	Garcia *et al*., 2003
ICES	Uncertainty	In colloquial meaning, uncertainty relates to how much is unknown about a system. In technical use, particularly for risk management, it is the probability distribution of a variable (ecosystem measure or model parameter) across the range of values which the variable can assume.	ICES, 2005
FAO	Vulnerability	The likelihood that a population, community, or habitat will experience substantial alteration from short-term or chronic disturbance, and the likelihood that it would recover and in what time frame. These are, in turn, related to the characteristics of the ecosystems themselves, especially biological and structural aspects. Long-term sustainable use of deep-sea fisheries.	Garcia *et al*., 2003

4.15.1.2 Descriptor/status terms

High level Source	Term	Definition	Source of definition
ASCOBANS	Conservation status of a migratory species	The sum of the influences acting on the migratory species that may affect its long-term distribution and abundance; in accordance with the definition of Convention on the Conservation of Migratory Species (CMS)	Art 2.1 (1992)
CMS	Favourable conservation status	(1) population dynamics data indicate that the migratory species is maintaining itself on a long-term basis as a viable component of its ecosystems; (2) the range of the migratory species is neither currently being reduced, nor is likely to be reduced, on a long-term basis; (3) there is, and will be in the foreseeable future sufficient habitat to maintain the population of the migratory species on a long-term basis; and (4) the distribution and abundance of the migratory species approach historical coverage and levels to the extent that potentially suitable ecosystems exist and to the extent consistent with wise wildlife management; d) "Conservation status" will be taken as "unfavourable" if any of the conditions set out in sub-paragraph (c) of this paragraph is not met;	Art. 1(e), also applying to ASCOBANS
CFP	Conservation status of marine ecosystems	Contextual definition only : "Recovery plans may include targets relating to other living aquatic resources and the maintenance or improvement of the conservation status of marine eco-systems. (…) in order to conserve and manage living aquatic resources or maintain or improve the conservation status of marine ecosystems."	Art. 5(2)
HD	Conservation status of a natural habitat	The sum of the influences acting on a natural habitat and its typical species that may affect its long-term natural distribution, structure and functions as well as the long-term survival of its typical species within theterritory referred to in Article 2	Art. 1(e)
HD	Favourable conservation status of a natural habitat	The conservation status ◄ of a natural habitat will be taken as 'favourable' when: — its natural range and areas it covers within that range are stable or increasing, and — the specific structure and functions which are necessary for its long-term maintenance exist and are likely to continue to exist for the foreseeable future, and — the conservation status of its typical species is favourable as defined in (i);	Art. 1(e)
HD	Conservation status of a species	The sum of the influences acting on the species concerned that may affect the long-term distribution and abundance of its populations within the territory referred to in Article 2;	Art. 1 (i)
HD	Favourable conservation status of a species	The conservation status will be taken as 'favourable' when: — population dynamics data on the species concerned indicate that it is maintaining itself on a long-term basis as a viable component of its natural habitats, and — the natural range of the species is neither being reduced nor is likely to be reduced for the foreseeable future, and — there is, and will probably continue to be, a sufficiently large habitat to maintain its populations on a long-term basis;	Art. 1 (i)

High level Source	Term	Definition	Source of definition
MSFD	Environmental status	The overall state of the environment in marine waters, taking into account the structure, function and processes of the constituent marine ecosystems together with natural physiographic, geographic, biological, geological and climatic factors, as well as physical, acoustic and chemical conditions, including those resulting from human activities inside or outside the area concerned;	Art. 3(4)
MSFD	Environmental target	A qualitative or quantitative statement on the desired condition of the different components of, and pressures and impacts on, marine waters in respect of each marine region or subregion. Environmental targets are established in accordance with Article 10;	Art. 3 (7)
MSFD	Qualitative descriptors for determining good environmental status	(1) Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions. (2) Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystems. (3) Populations of all commercially exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock. (4) All elements of the marine foodwebs, to the extent that they are known, occur at normal abundance and diversity and levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity. (5) Human-induced eutrophication is minimized, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algae blooms and oxygen deficiency in bottom waters. (6) Sea-floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected. (7) Permanent alteration of hydrographical conditions does not adversely affect marine ecosystems. (8) Concentrations of contaminants are at levels not giving rise to pollution effects. (9) Contaminants in fish and other seafood for human consumption do not exceed levels established by Community legislation or other relevant standards. (10) Properties and quantities of marine litter do not cause harm to the coastal and marine environment. (11) Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment	Annex I
WFD	Surface water status	The general expression of the status of a body of surface water, determined by the poorer of its ecological status and its chemical status.	Art. 2(17)

High level Source	Term	Definition	Source of definition
WFD	Good surface water status	The status achieved by a surface water body when both its ecological status and its chemical status are at least "good". ANNEX V: Good Status - The values of the biological quality elements for the surface water body type demonstrate low levels of distortion resulting from human activity, but deviate only slightly from those normally associated with the surface water body type under undisturbed conditions.	Art. 2(18), ANNEX V
WFD	Good ecological status	Values of the biological quality elements for the surface water body type demonstrate low levels of distortion resulting from the human activity, but deviate only slightly from those normally associated with the surface water body type under undisturbed conditions	Art. 2(22), ANNEX V
WFD	Good ecological potential	The status of a heavily modified or an artificial body of water, so classified in accordance with the relevant provisions of Annex V. Good status : There are slight changes in the values of the relevant biological quality elements as compared with the values found at maximum ecological potential. MAXIMUM EP: The values of the relevant biological quality elements reflect, as far as possible, those associated with the closest comparable surface water body type, given the physical conditions which result from the artificial or heavily modified characteristics of the water body.	Art. 2(23), ANNEX V
CFP	Healthy marine ecosystems	The long-term ecological sustainability of fisheries must be the first priority because the past development of the CFP has demonstrated that healthy fish stocks healthy marine ecosystems are a sine qua non for an economically and socially healthy fishery sector.	EC Commission working document (2008) [http://ec.europa.eu/fisheries/publications/factsheets/legal_texts/reflection_cfp_08_en.pdf]
FAO	Vulnerable marine ecosystem (VME)	The likelihood that a population, community, or habitat will experience substantial alteration from short-term or chronic disturbance, and the likelihood that it would recover and in what time frame. These are, in turn, related to the characteristics of the ecosystems themselves, especially biological and structural aspects. VME features may be physically or functionally fragile. The most vulnerable ecosystems are those that are both easily disturbed and very slow to recover, or may never recover.	FAO FIEP/R881, Art 3.2

4.15.1.3 Environmental management strategy terms

No terms were identified under this category.

4.15.1.4 Humans impacts/pressures

High level Source	Term	Definition	Source of definition
FAO	Significant adverse impact	Significant adverse impacts are those that compromise ecosystem integrity (i.e., ecosystem structure or function) in a manner that: (i) impairs the ability of affected populations to replace themselves; (ii) degrades the long-term natural productivity of habitats; or (iii) causes, on more than a temporary basis, significant loss of species richness, habitat or community types. Impacts should be evaluated individually, in combination and cumulatively. When determining the scale and significance of an impact, the following six factors should be considered: i. the intensity or severity of the impact at the specific site being affected; ii. the spatial extent of the impact relative to the availability of the habitat type affected; iii. the sensitivity/vulnerability of the ecosystem to the impact; iv. the ability of an ecosystem to recover from harm, and the rate of such recovery; v. the extent to which ecosystem functions may be altered by the impact; and vi. the timing and duration of the impact relative to the period in which a species needs the habitat during one or more of its life-history stages. Temporary impacts are those that are limited in duration and that allow the particular ecosystem to recover over an acceptable time frame. Such time frames should be decided on a case-by-case basis and should be in the order of 5–20 years, taking into account the specific features of the populations and ecosystems. In determining whether an impact is temporary, both the duration and the frequency at which an impact is repeated should be considered. If the interval between the expected disturbances of a habitat is shorter than the recovery time, the impact should be considered more than temporary. In circumstances of limited information, States and RFMO/As should apply the precautionary approach in their determinations regarding the nature and duration of impacts.	FAO, 2008

4.15.1.5 Ecological scales

High level Source	Term	Definition	Source of definition
CFP	Mäerl bed	An area where the seabed is characterized by the dominant presence of a specific biological community named "mäerl", or where such community has existed and is in need of restoration action. Mäerl is a collective term for a biogenic structure because of several species of coralline red algae (Corallinaceae), which have hard calcium skeletons and grow as unattached free living branched, twig-like or nodule corallines algae on the seabed, forming accumulations within the ripples of mudflats or sandflats seabed. Maerl beds are usually composed of one or a variable combination of red algae, in particular, Lithothamnion coralloides and Phymatolithon calcareum;	CR (EC) n. 1967/2006 (Art. 2. 13)
CFP	Seagrass bed	An area where the seabed is characterized by the dominant presence of phanerogams, or where such vegetation has existed and is in need of restoration action.Seagrass is a collective terms for the species Posidonia oceanica, Cymodocea nodosa, Zoostera marina and Zoostera noltii	CR (EC) n. 1967/2006 (Art. 2. 11)
MSFD	Marine regions	"Marine region" means a sea region which is identified under Article 4. Marine regions and their subregions are designated for the purpose of facilitating implementation of this Directive and are determined taking into account hydrological, oceanographic and biogeographic features; ....(a) the Baltic Sea; (b) the North-east Atlantic Ocean; (c) the Mediterranean Sea; (d) the Black Sea.	Definition from MSFD Art. 3.2 / Specific regions from Art. 4 of MSFD
MSFD	Marine subregions	Member States may, in order to evaluate the specificities of a particular area, implement this Directive by reference to subdivisions at the appropriate level of the marine waters referred to in paragraph 1, provided that such subdivisions are delimited in a manner compatible with the following marine subregions: (a) in the North-east Atlantic Ocean: (i) the Greater North Sea, including the Kattegat, and the English Channel; (ii) the Celtic Seas; (iii) the Bay of Biscay and the Iberian Coast; (iv) in the Atlantic Ocean, the Macaronesian biogeographic region, being the waters surrounding the Azores, Madeira and the Canary Islands; (b) in the Mediterranean Sea: (i) the Western Mediterranean Sea; (ii) the Adriatic Sea; (iii) the Ionian Sea and the Central Mediterranean Sea; (iv) the Aegean-Levantine Sea. (a) in the North-east Atlantic Ocean: (i) the Greater North Sea, including the Kattegat, and the English Channel; (ii) the Celtic Seas; (iii) the Bay of Biscay and the Iberian Coast; (iv) in the Atlantic Ocean, the Macaronesian biogeographic region, being the waters surrounding the Azores, Madeira and the Canary Islands; (b) in the Mediterranean Sea: (i) the Western Mediterranean Sea; (ii) the Adriatic Sea; (iii) the Ionian Sea and the Central Mediterranean Sea; (iv) the Aegean-Levantine Sea.	MSFD Article 4 and 4.2

HIGH LEVEL SOURCE	TERM	DEFINITION	SOURCE OF DEFINITION
MSFD	Marine waters	a) waters, the seabed and subsoil on the seaward side of the baseline from which the extent of territorial waters is measured extending to the outmost reach of the area where a Member State has and/or exercises jurisdictional rights, (b) coastal waters as defined by Directive 2000/60/EC, their seabed and their subsoil, in so far as particular aspects of the environmental status of the marine environment are not already addressed through that Directive or other Community legislation;	a) in accordance with the UNCLOS, with the exception of waters adjacent to the countries and territories mentioned in Annex II to the Treaty and the French Overseas Departments and Collectivities; b)Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy
WFD	Surface water	Means inland waters, except groundwater; transitional waters and coastal waters, except in respect of chemical status for which it shall also include territorial waters.	Art. 2(1)
MSFD	Coastal waters, including their seabed and subsoil	"Coastal water" means surface water on the landward side of a line, every point of which is at a distance of one nautical mile on the seaward side from the nearest point of the baseline from which the breadth of territorial waters is measured, extending where appropriate up to the outer limit of transitional waters.	Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy

4.15.1.6 Other

No terms were identified under this category.

4.15.2 Terms which are not specifically defined in the high level documents

4.15.2.1 Ecological concepts

HIGH LEVEL SOURCE	TERM	SOURCE
MSFD	Marine ecological services	Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy

4.15.2.2 Descriptors/Status

High level Source	Term	Source
OSPAR	Environmental quality objectives	Treaty Annex V
MSFD	Natural marine resources	2008/56/EC
OSPAR	Adverse effects of human activities	Treaty ANNEX V

4.15.2.3 Descriptors/status

No terms were identified under this category.

4.15.2.4 Impacts and pressures

No terms were identified under this category.

4.15.2.5 Environmental management strategies

No terms were identified under this category.

4.15.2.6 Humans impacts/pressures

High level Source	Term	Source of definition
OSPAR	Adverse effects of human activities	
CFP	Significant impact on the marine environment	13CR (EC) n. 1967/2006 (Art. 13)

4.15.3 Terms with multiple meanings

4.15.3.1 Ecological concepts

High level Source	Term	Definition	Source of definition
CBD	Biological diversity	The variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems	CBD Art 2
FAO	Biodiversity	The variability among living organisms from all sources, including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part (Convention on Biological Diversity, 1992. http://www.biodiv.org/convention/articles.asp). The variety and variability of living organisms. It takes into account intraspecific genetic variability, the variety of species and their way of life, the diversity of species communities and their interactions, as well as the ecological processes that they influence or realize, the diversity of adaptive strategies and the number of interactions between the organisms and the variables of the environment (Lévèque 1997; FAO 1997).	Garcia, *et al*., 2003
MSFD	Biodiversity	Not defined	
OSPAR	Biological diversity	Not defined	

High level Source	Term	Definition	Source of definition
CBD	Ecosystem	A dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit.	CBD Art 2
FAO	Ecosystem	An ecosystem is a very complex entity with many interactive components. It can be defined as "a system of complex interactions of populations between themselves and with their environment" or as "the joint functioning and interaction of these two compartments (populations and environment) in a functional unit of variable size" (Odum, 1975; Ellenberg, 1973; Nybakken, 1982; Scialabba, 1998). In this review, and in EAF, we will consider "populations" as including people, and especially people involved in fisheries, with their technology and institutions.	Garcia, *et al*., 2003
FAO	Ecosystem	Not defined	FAO Code of fisheries
OSPAR	Ecosystem	The marine environment is both an ecosystem and an interlocking network of ecosystems. The Convention on Biological Diversity defines an ecosystem as "a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit". No particular spatial unit of scale is included in this definition. The scale of analysis and action is to be determined by the problem being addressed.	BREMEN: 25–26 June 2003 adopted from CBD
CFP	Functioning	Embeddedness of fisheries resources in their wider ecosystem requires a substantial effort to apprehend better the functioning of aquatic ecosystems and their reaction to different types of fishing pressure and exploitation strategies.	
FAO	Functioning	The functioning of an ecosystem results from the organization of its species communities, consisting of species populations having their own dynamics in terms of abundance, survival, growth, production, reproductive and other strategies.	Garcia, *et al*., 2003
HELCOM	Functioning	Not defined	2002 World Summit on Sustainable Development in Johannesburg
MSFD	Functioning	Not defined	Council Regulation (EC) No 2371/2002 of 20 December 2002 on the conservation and sustainable exploitation of fisheries resources under the Common Fisheries Policy

High level Source	Term	Definition	Source of definition
ICES	Function	Not defined	
WFD	Function	Not defined	
ASCOBAN	Habitat	Not defined	Derived from the Convention on the Conservation of Migratory Species of Wild Animals (CMS, 2003)
CBDBD	Habitat	The place or type of site where an organism or population naturally occurs	CBD Art 2
CBD	Habitat	The structural environments where an organism lives for all or part of his life, including environments once occupied (continuously, periodically, or occasionally) by an organism or group of organisms of that kind have the potential to be reinstated Adopted from the Australian Natural Heritage Charter, 2002: The structural environments where an organism lives for all or part of its life, including environments once occupied (continuously, periodically or occasionally) by an organism or group of organisms, and into which organisms of that kind have the potential to be reinstated.	CBD Art 2
CCAMLR	Habitat	Not defined	The convention on the conservation of Antarctic marine living resources (CCAMLR) and the ecosystem approach 2008
CFP	Coralligenous habitat	An area where the seabed is characterized by the dominant presence of a specific biological community named "coralligenous", or where such community has existed and is in need of restoration action.	EU Common fisheries policy: Council Regulation (EC) No 1967/2006:
FAO	Habitat	The place or type of site where species and communities normally live or grow, usually characterized by relatively uniform physical features or by consistent plant forms (Scialabba, 1998). The biological place or position of a population in an ecosystem (Nybakken, 1982). The place where an organism is found (Odum, 1975). The habitat is the organsim's ”adress”, and the niche is it's ”profession”, biologically speaking (Odum 1959)	Garcia *et al.*, 2003
HD	Habitat	An environment defined by specific abiotic and biotic factors, in which the species lives at any stage of its biological cycle.	Habitat Directive, EU 1992
HELCOM	Habitat	Not defined	HELCOM Ecological Objective

High level Source	Term	Definition	Source of definition
ICES	Habitat of a species	An environment defined by specific abiotic and biotic factors, in which the species lives at any stage of its biological cycle.	ICES. 2005.
ICES	Natural habitats	Terrestrial or aquatic areas distinguished by geographic, abiotic and biotic features, whether entirely natural or semi-natural.	ICES Cooperative Research report NO. 273
ICES	Habitat	The total of all the environmental (i.e., physical/chemical) conditions present in the three-dimensional structural configuration occupied by an organism, population, or community". Therefore it is considered a combination of the physical and chemical ecosystem components in combination with one or more of the biotic components (e.g., macrophytes for seagrass beds, benthic community for coral reefs etc.) which are strongly associated with this physical/chemical environment or may even be the structural habitat agents.	WGECO, definitions
ICES	Habitat	Habitat is taken to refer to the physical and chemical environment and hence includes water quality and the physical (substratum) aspects of the environment.	WGECO 2006
MSFD	Habitat	Not defined	Marine Strategy Framework Directive
OSPAR	Habitat	From the Convention on Biological Diversity of 5 June 1992. It is also stated in the description of habitats on the OSPAR List of threatened and/or declining species and habitats (Reference Number: 2008-07) that: *For a habitat to occur at a site, it should extend over an area of at least 25m², but this threshold may need to be higher in offshore areas because of limitations of surveys and sampling.*	OSPAR Convention Annex 5 and Descriptions of habitats on the OSPAR list of threatened and/or declining species and habitats (Reference Number: 2008–07)
WDF	Habitat	Not defined	The EU water frame directive, 2000/60/EC of October 2000.
CCAMLR	Persistence	Not defined	CCAMLR Criterion 3.3.3
ICES WGECO	Persistence	Not defined	WGECO 2003, WGECO 2004, WGECO 2005 ICES cooperative Research Report No 272
FAOAO	Persistence	Characteristic of a group of stable populations that conserve the same number of species in time (Pimm, 1984; Pimm and Hyman, 1987).	Garcia, *et al.*, 2003

High level Source	Term	Definition	Source of definition
OSPAR	Persistency	Not defined	On the protection and conservation of the ecosystem and biological diversity of the maritime area 5 6. Art. 2
CBD	Recovery	Not defined	
CFP	Recovery	The objective of recovery plans shall be to ensure the recovery of stocks to within safe biological limits. Recovery plans may include targets relating to other living aquatic resources and the maintenance or improvement of the conservation status of marine eco-systems.	
FAO	Resilience	The ability [of an ecosystem] to maintain its structure and pattern of behaviour in the presence of stress	FAO Glossary http://www.fao.org/docrep/005/y4470e/y4470e0h.htm
FAO	Resilience	The community's resilience depends on its capacity to adapt to the physical environment and on its relations with the other communities, e.g., through competition or predation.	Garcia *et al.*, 2003
FAO	Resilience	The capacity of a natural system (fishery community or ecosystem) to recover from heavy disturbance such as intensive fishing.	Glossary http://www.fao.org/fi/glossary/default.asp
FAO	Recovery	Life-history traits of component species that make recovery difficult – ecosystems that are characterized by populations or assemblages of species with one or more of the following characteristics: • slow growth rates; • late age of maturity; • low or unpredictable recruitment; or • long-lived.	
ICES	Resilience	Resilience is the time taken to move from the current status of the component to a point above the threshold level for that component.	WGECO, 2008
ICES	Recovery	Cod recovery plan - rebuild stocks to within safe biological limits - e.g., to allow severely depleted stocks to recover at rates ranging from 5% to 30% per year	WGECO 2008
MSFD	Resilience	Not defined	
OSPAR	Resilience	Resilience is the ability of an ecosystem to recover from disturbances within a reasonable time frame.	OSPAR, 2006 taken from IUCN, 2003.
WFD	Recovery	Not defined	

4.15.3.2 Descriptor/status

High level Source	Term	Definition	Source of definition
ICES	Ecological objective	An objective that relates to ecosystem health, structure, and/or function.	ICES, 2005.
WFD	Ecological status	is an expression of the quality of the structure and functioning of aquatic ecosystems associated with surface waters, classified in accordance with Annex V.	Art. 2(21), ANNEX V
ICES	Ecological status	Ecological status is an expression of the quality of ecosystem structure and function. Ecological status varies naturally in response to drivers like climate, but human impacts also affect the ecological status of ecosystems, sometimes profoundly. Ecological status is good when human activities are sustainable, as defined above. Good ecological status does not imply that human impacts are not detectable, because some degree of effect is unavoidable whenever humans take benefits from the range of goods and services that ecosystems provide. However, when ecological status is good, the human impacts are still reversible, so any other mix of ecological goods and services could also be taken, should societal needs or values change. In the context of the European Marine Strategy, ecological status would be good when the targets for all indicators that underpin the Strategy have been met, moderate when all precautionary limits were avoided, and poor if any precautionary limits were not avoided.	ICES, 2005.
CFP	good environmental status	The entry into force of the Marine Strategy Framework Directive, which obliges Member States to ensure the good environmental status of the seas under their jurisdiction until 2020, provides an important orientation in terms of the long-term goal on which we need to align the reformed CFP in a coherent manner.	MSFD
MSFD	good environmental status	the environmental status of marine waters where these provide ecologically diverse and dynamic oceans and seas which are clean, healthy and productive within their intrinsic conditions, and the use of the marine environment is at a level that is sustainable, thus safeguarding the potential for uses and activities by current and future generations, i.e.: (a) the structure, functions and processes of the constituent marine ecosystems, together with the associated physiographic, geographic, geological and climatic factors, allow those ecosystems to function fully and to maintain their resilience to uman-induced environmental change. Marine species and habitats are protected, human-induced decline of biodiversity is prevented and diverse biological components function in balance; (b) hydro-morphological, physical and chemical properties of the ecosystems, including those properties which result from human activities in the area concerned, support the ecosystems as described above. Anthropogenic inputs of substances and energy, including noise, into the marine environment do not cause pollution effects; Good environmental status shall be determined at the level of the marine region or subregion as referred to in Article 4, on the basis of the qualitative descriptors in Annex I. Adaptive management on the basis of the ecosystem approach shall be applied with the aim of attaining good environmental status;	Art. 3(5) see also : Safeguarding our Seas, Defra, 2002

High level Source	Term	Definition	Source of definition
ICES	Habitat sensitivity	Habitat sensitivity can be defined as the degree and duration of damage caused by a standardized 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 (McDonald *et al*., 1997).	ICES, 2002.
ICES	Sensitive	The magnitude of response of any indicator to a change in the system.	ICES, 2005.
ICES	Sensitive habitat	For the purposes of this TOR, however, the Working Group chose to define a "sensitive habitat" as one which is "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" (OSPAR/Texel-Faial).	ICES, 2003.

4.15.3.3 Management

High level Source	Term	Definition	Source of definition
FAO	Precautionary approach	Not defined*	Code of Conduct for Responsible Fisheries, 1995
HELCOM/ OSPAR	Precautionary principles and approach	It is understood that, in the context of the management of fisheries, the application of the precautionary principle has the same result as the application of the precautionary approach as referred to in, for example Article 6 of the 1995 UN Fish Stocks Agreement	HELCOM/OSPAR Joint Statement, 2003
UN Fish Stock Agreement	Precaution	Not defined*	United Nations Conference On Straddling Fish Stocks And Highly Migratory Fish Stocks, 1995
CBD	Precautionary approach	Principle 15 states that "In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation."	Principle 15 of the Rio Declaration on Environment and Development.
CFP	precautionary approach to fishery management	'precautionary approach to fishery management' means that the absence of adequate scientific information should not be used as a reason for postponing or failing to take management measures to conserve target species, associated or dependent species and non-target species and their environment;	CR (EC) n. 2371/2002 (Art. 3 i)
MSFD	Precautionary principle	Not defined	
ICES	Precaution	Not defined	ICES 2005
FAO	Ecosystem approach	Not defined (Article 7.5)	Code of Conduct for Responsible Fisheries (1995)
FAO	Ecosystem approach	Not defined	Garcia *et al*., 2003

High level Source	Term	Definition	Source of definition
CBD	Ecosystem approach	The ecosystem approach is a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way.	COP 2 Decision II/8, defined in Decision V/6, Annex A
ICES	Ecosystem Approach	To provide the greater specificity for the purposes of the European Marine Strategy the Ecosystem Approach could be described as 'a comprehensive integrated management of human activities based on the best available scientific knowledge of the ecosystem and its dynamics, in order to identify and take action on influences which are critical to the health of the marine ecosystems, thereby achieving sustainable use of ecosystem goods and services and maintenance of ecosystem integrity.'	ICES. 2005.
HELCOM/ OSPAR	Ecosystem approach	The comprehensive integrated management of human activities based on the best available scientific knowledge of the ecosystem and its dynamics, in order to identify and take action on influences which are critical to the health of marine ecosystems, thereby achieving sustainable use of ecosystem goods and services and maintenance of ecosystem integrity	HELCOM/OSPAR Joint Statement, 2003
CFP	Eco-system based approach to fishery management	It shall aim at the implementation of an eco-system-based approach to fishery management.	CR (EC) n. 2371/2002 (Art. 2)
CFP	Ecosystem approach	The ecosystem approach is here defined as one that "strives to balance diverse social objectives, by taking into account knowledge and uncertainty about biotic, abiotic, and human components of ecosystems and their interactions and applying an integrated approach to fisheries within ecologically meaningful boundaries".	COM, 2008 187
HELCOM	cross-sectoral, marine spatial planning principles based on the Ecosystem Approach	Not defined*	Baltic Sea Action Plan
MSFD	Ecosystem-based approach	Marine strategies shall apply an ecosystem-based approach to the management of human activities, ensuring that the collective pressure of such activities is kept within levels compatible with the achievement of good environmental status and that the capacity of marine ecosystems to respond to human-induced changes is not compromised, while allowing the sustainable use of marine goods and services by present and future generations.	
HELCOM	Integration of environmental objectives with economic and socio-economic goals	Not defined	Baltic Sea Action Plan

HIGH LEVEL SOURCE	TERM	DEFINITION	SOURCE OF DEFINITION
OSPAR	Ecosystem approach	Not defined	OSPAR (Annex V)
FAO	Sustainable use	Not defined	Code of Conduct for Responsible Fisheries, 1995
HELCOM/ OSPAR	Sustainable use	Not defined	HELCOM/OSPAR Joint Statement, 2003
FAO	Sustainable use	Not defined	Garcia *et al*., 2003
ICES	Sustainable Development	"…requires that the needs of future generations are not compromised by the actions of people today."	ICES, 2005.
ICES	Sustainable exploitation	The exploitation of a resource in such a way that the future exploitation will not be prejudiced and that it does not have a negative impact on the marine ecosystems.	ICES, 2005.
CFP	Sustainable exploitation	Not defined	COM, 2008 187
CBD	Sustainable use	The use of components of biological diversity in a way and at a rate that does not lead to the long-term decline of biological diversity, thereby maintaining its potential to meet the needs and aspirations of present and future generations.	Art 2. Rio Declaration on Environment and Development
FAO	Sustainable fisheries	Not defined	Garcia *et al*., 2003
FAO	Sustainable fisheries	Not defined	Code of Conduct for Responsible Fisheries, 1995
OSPAR	Sustainable use of biological diversity	Not defined	
MSFD	Sustainable use of marine goods and services	Not defined	
HELCOM	Sustainable use of natural resources	Not defined	Baltic Sea Action Plan
MSFD	Sustainable use of the seas	Not defined	Decision No 1600/2002/EC of the European Parliament and of the Council of 22 July 2002 laying down the Sixth Community Environment Action Programme
CDB	Protected Area	Geographically defined area which is designated or regulated and managed to achieve specific conservation objective	Art.2. Rio Declaration on Environment and Development
CBD	Protected Area	Marine and Coastal Protected Area' means any confined area within or adjacent to the marine environment, together with its overlying waters and associated flora, fauna, and historical and cultural features, which has been reserved by legislation or other effective means, including custom, with the effect that its marine and/or coastal biodiversity enjoys a higher level of protection than its surroundings	COP 7, Decision VII/5

High level Source	Term	Definition	Source of definition
FAO	Protected areas	Designated areas of the ecosystem which are protected by law and regulations with the view to conserving/rehabilitating them and the biodiversity they contain. Protection includes regulation or outright prohibition of human uses.	Garcia *et al*., 2003
MSFD	Spatial and temporal distribution controls	Management measures that influence where and when an activity is allowed to occur.	
MSFD	MPAs => coherent and representative networks	Not defined	1) Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora (5) (hereinafter referred to as the 'Habitats Directive'), 2) Council Directive 79/409/EEC of 2 April 1979 on the conservation of wild birds (hereinafter referred to as the 'Birds Directive'). 3) World Summit on Sustainable Development and in the Convention on Biological Diversity, approved by Council Decision 93/626/EEC
HELCOM	permanent closures of sufficient size for fisheries to prevent capture of non-target species to protect important reproduction and feeding areas and to protect ecosystems, by 2012;	Not defined	Baltic Sea Action Plan
MSFD	Spatial protection measures such as special areas of conservation, special protection areas or MPAs	Not defined	1) Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora (5) (hereinafter referred to as the 'Habitats Directive'), 2) Council Directive 79/409/EEC of 2 April 1979 on the conservation of wild birds (hereinafter referred to as the 'Birds Directive'). 3) World Summit on Sustainable Development and in the Convention on Biological Diversity, approved by Council Decision 93/626/EEC

4.15.3.4 Humans impacts/pressures

High level Source	Term	Definition	Source of definition
FAO	Overfishing	FAO Glossary defintion: the exertion of a fishing pressure (fishing intensity) beyond agreed optimum level. Further description a) The symptoms of ecosystem overfishing include: reduction in diversity, reduction in aggregate production of exploitable resources, decline in mean trophic level, increase in bycatch, greater variability of abundance of species, greater anthropogenic habitat modification (Hall, 1999)*. According to Murawski (2000)*, an ecosystem can be considered to be overfished when cumulative impacts of catches (landings plus discards), non-harvest mortality and habitat degradation result in one or more of the following conditions: (1) Biomasses of one or more of the most important species assemblages fall below minimum biological acceptable levels, such that recruitment is impaired or rebuilding times to MSY are extended; (2) Diversity of communities declines significantly as a result of sequential "fishing down" of stocks; (3) Species selection and harvest rate lead to greater year-to-year variations in populations than would result from lower cumulative harvest rates ; (4) Changes in species composition as a result of fishing significantly decrease the resilience or resistance of the ecosystem to perturbations arising from non-biological factors; (5) The harvest rates result in lower cumulative net economical or social benefits than would result from a less intense overall fishing pattern; (6) Harvest of prey species or direct mortalities resulting from operations impair the long-term viability of ecologically important non-resource species (e.g., marine mammals, turtles, seabirds). b) A generic term used to refer to the state of a stock subject to a level of fishing effort or fishing mortality such that a reduction of effort would, in the medium term, lead to an increase in the total catch. Often equated to biological overfishing, it results from a combination of growth overfishing and recruitment overfishing and occurs often together with ecosystem overfishing and economic overfishing.	(FAO Glossary, 2002; http://www.fao.org/fi/glossary/default.asp). Garcia *et al.*, 2003
FAO	Ghost fishing	The continued killing of fish by a fishing gear, e.g., through gilling or entanglement (by a gillnet) or trapping (by a fish trap or pot) after the gear has been lost or voluntarily dumped in the water body.	Garcia *et al.*, 2003
ICES	Ghost fishing	…gillnets, tanglenets and traps may continue to fish for some time after being lost or discarded…	CRR, Report of the SG ECO 1992. n200

High level Source	Term	Definition	Source of definition
MSFD	Pressures and impacts	Not defined as such but described and exemplified at length: Physical loss — Smothering (e.g., by man-made structures, disposal of dredge spoil), — sealing (e.g., by permanent constructions). Physical damage — Changes in siltation (e.g., by outfalls, increased run-off, dredging/disposal of dredge spoil), — abrasion (e.g., impact on the seabed of commercial fishing, boating, anchoring), — selective extraction (e.g., exploration and exploitation of living and non-living resources on seabed and subsoil). Other physical disturbance — Underwater noise (e.g., from shipping, underwater acoustic equipment), — marine litter. Interference with hydrological processes — Significant changes in thermal regime (e.g., by outfalls from power stations), — significant changes in salinity regime (e.g., by constructions impeding water movements, water abstraction). Contamination by hazardous substances — Introduction of synthetic compounds (e.g., priority substances under Directive 2000/60/EC which are relevant to the marine environment such as pesticides, antifoulants, pharmaceuticals, resulting, for example, from losses from diffuse sources, pollution by ships, atmospheric deposition and biologically active substances), — introduction of non-synthetic substances and compounds (e.g., heavy metals, hydrocarbons, resulting, for example, from pollution by ships and oil, gas and mineral exploration and exploitation, atmospheric deposition, riverine inputs), — introduction of radio-nuclides. Systematic and/or intentional release of substances — Introduction of other substances, whether solid, liquid or gas, in marine waters, resulting from their systematic and/or intentional release into the marine environment, as permitted in accordance with other Community legislation and/or international conventions. Nutrient and organic matter enrichment — Inputs of fertilizers and other nitrogen — and phosphorus-rich substances (e.g., from point and diffuse sources, including agriculture, aquaculture, atmospheric deposition), — inputs of organic matter (e.g., sewers, mariculture, riverine inputs). Biological disturbance — Introduction of microbial pathogens, — introduction of non-indigenous species and translocations, — selective extraction of species, including incidental non-target catches (e.g., by commercial and recreational fishing).	
OSPAR	Human activity	Not defined, but has been described as follows: The criteria to be used, taking into account regional differences, for identifying human activities for the purposes of Annex V are: a. the extent, intensity and duration of the human activity under consideration; b. actual and potential adverse effects of the human activity on specific species, communities and habitats; c. actual and potential adverse effects of the human activity on specific ecological processes; d. irreversibility or durability of these effects.	

4.15.3.5 Ecological scales

HIGH LEVEL SOURCE	TERM	DEFINITION	SOURCE OF DEFINITION
OSPAR	Ecosystem	The marine environment is both an ecosystem and an interlocking network of ecosystems. The Convention on Biological Diversity defines an ecosystem as "a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit at different spatial scales ". No particular spatial unit of scale is included in this definition. The scale of analysis and action is to be determined by the problem being addressed.	Bremen Decl.: 25–26 June 2003 adopted from CBD
CBD	Ecosystem	A dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit	CBD Art 2
FAO	Ecosystem	An ecosystem is a very complex entity with many interactive components. It can be defined as "a system of complex interactions of populations between themselves and with their environment" or as "the joint functioning and interaction of these two compartments (populations and environment) in a functional unit of variable size" (Odum, 1975; Ellenberg, 1973; Nybakken, 1982; Scialabba, 1998). In this review, and in EAF, we will consider "populations" as including people, and especially people involved in fisheries, with their technology and institutions.	Garcia, S.M.; Zerbi, A.; Aliaume, C.; Do Chi, T.; Lasserre, G. 2003. The ecosystem approach to fisheries. Issues, terminology, principles, institutional foundations, implementation and outlook. FAO Fisheries Technical Paper. No. 443. Rome, FAO. 2003. 71 p.
FAO	Ecosystem		FAO Code of fisheries

High level source	Term	Definition	Source of definition
OSPAR	Habitat	For the purposes of this Annex and of Appendix 3 the definitions of "biological diversity", "ecosystem" and "habitat" are those contained in the Convention on Biological Diversity of 5 June 1X2. HOWEVER: It is also stated in the description of habitats on the OSPAR List of threatened and/or declining species and habitats that: For a habitat to occur at a site, it should extend over an area of at least 25m2, but this threshold may need to be higher in offshore areas because of limitations of surveys and sampling. When a habitat type is known to have occurred in the past, but no longer occurs, it should be reported, clearly stating the date of the record and if possible when it disappeared. For some habitat types (e.g., biogenic reefs), the habitat-forming species (e.g., Mytilus, Modiolus, Sabellaria, Zostera) may occur in clumps or patches on the shore or seabed. Guidance has been given in each definition as to the expected minimum density or percentage coverage of such clumps or patches within the overall extent of the habitat. Where accumulations of dead material of the habitat-forming species occur either in association with live material, or indicate that the habitat-forming species was likely to have lived at the site, it can be reported as a record for the habitat type, duly noting its current condition Expert judgment will need to be applied on a site by site basis to determine whether the overall density, coverage and extent of the habitat-forming species is sufficient for the habitat-type to be considered to occur on the site. Practical application of these figures may lead to their adjustment.	OSPAR Convention Annex 5 and Descriptions of habitats on the OSPAR list of threatened and/or declining species and habitats (Reference Number: 2008–07)
Habitats Directive	Habitat	Terrestrial or aquatic areas distinguished by geographic, abiotic and biotic features, whether entirely natural or semi-natural	Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora
ICES	Indicator	A variable, pointer, or index of a phenomenon. Indicators can reflect the status and changes of well-defined parts of an ecosystem, derived from observations, normally from monitoring programmes.	ICES 2005 Fatima checks There must be other definitions. E.g., See also WGECO report 2004 p.21; Cury and Christensen 2005. ICES JMS 62. 307–310.

High level source	Term	Definition	Source of definition
ICES	Indicator	….we routinely used "indicator" and "metric" ... WGECO took note that "indicator" sometimes carries a specific meaning as an "indicator species". Therefore, we decided to use metric in all cases where we mean something that can be measured quantitatively (or, when appropriate, qualitatively) and is at least be considered as being a suitable way to measure the ecological property that the EcoQ is intended to capture. Where we use indicator, we mean for it to be interpreted in the sense of "indicator species".	CES CRR 272, 2005
CBD	Protected area	Geographically defined area which is designated or regulated and managed to achieve specific conservation objectives.	CBD Art 2
CBD	Strategic environmental assessment	A process of evaluating the likely environmental impacts of proposed policies, plans or programmes to ensure that they are fully included and addressed at an early stage of decision-making, together with economic, social and cultural considerations	Definition in the Akwé: Kon guidelines, section II. Use of terms.

4.15.3.6 Other

No terms were identified under this category.

5 ToR b Significant adverse impacts of fishing gears

ToR b) "*Using two existing fishing gear types, describe the significant adverse impacts of those gears for the ICES area, using the methodology developed by WGECO in 2008. Highlight issues that are specific to geographic areas and those that are generic to the gear. Based on this process recommend any modifications to the methodology required to make it operational*".

5.1 Introduction

In 2008 WGECO, in conjunction with WGFTFB, began the process of developing a methodology to assess and quantify the efficacy of Gear Based Technical Measures (GBTMs) introduced to reduce the environmental impact of fishing. An indicative methodology was developed which identified the significant adverse impacts (FAO, 2008) of particular fishing gears that should be considered in experiment planning for developing mitigation measures. Throughout this report "significant adverse impacts" is abbreviated as SAI, and "No significant adverse impacts" is abbreviated as NSAI.

It was, however, identified that in order to develop the methodology further and make it operational it required trialling for existing gears. It was also identified that the terminology used for the criteria that defined significant adverse impact would need further consideration as for some aspects of the ecosystem this terminology is poorly defined (see terminology work in ToR a). In addition, the grouping of ecosystem components within assessment categories was revisited.

The objective of ToR b was to work through an assessment of the significant adverse impacts of two specific fishing gears and using the experience gained to modify the methodology to make it operational. The two case studies selected were flatfish beam trawls in the North Sea and Bottom-set gillnets in the Baltic Sea. These two gears were selected as they represented one gear (beam trawls) that is well studied with an accepted high impact on habitats and benthos, and a second gear (gillnets) that has documented marine mammal and seabird bycatch impacts but is recognized as being environmentally benign in most other respects.

Vulnerability of species to particular fisheries is dependent partly on the likelihood of them suffering any mortality as a consequence of the fishery, and also on their sensitivity to the fishery.

- Mortality should be interpreted as any mortality resulting from the fishery, including both mortality sustained in the catch and in the path of the gear (e.g., in the towpath of the gear on the seabed, or after passing through the gear). This is as defined in 2008.
- Sensitivity is itself a function of the resistance of the species to the fishery (its gear and behaviour), and the resilience of the species to raised levels of mortality (ability to recover; Bax and Williams, 2001; Zacharias and Gregr, 2005).

There is much literature describing life history and ecological characteristics that are associated with high vulnerability to fisheries and these sources should be consulted by experts in this field when applying this methodology.

The assessment was carried out on four ecosystem component categories:

- Commercial fish species-representing any fish landed by commercial fishing;
- Listed species including fish, cephalopods and benthos-representing any species previously listed as vulnerable or at risk;
- Marine mammals, marine reptiles and seabirds;
- Pelagic and benthic habitats and assemblages-representing the habitats and their associated species assemblages including fish, invertebrates and flora.

Species "previously identified" refers to species listed in accepted fora such as IUCN or the OSPAR list. If species included in these lists are impacted then the impact of the fishing gear should be classified as SAI. We have also taken the approach that when a species or habitat is listed as at risk of extirpation or complete loss, ANY mortality or damage would represent SAI. It should be noted that these lists should not be over relied on as they are essentially "works in progress" and merely because a species or group of species does not appear on these lists does not necessarily mean they are not Significantly Adversely Impacted.

5.2 Generic impacts of two fishing gear types

The generic impacts of the selected fishing gear types are highlighted using the categories of ecosystem components from the proposed framework (ICES, 2008b). WGECO have reviewed the generic ecosystem impacts of various fishing gears in a number of previous reports in particular see ICES 2006. However the WG felt it necessary to summarize these here because the request originated from WGFTFB who may not have considered all this information.

5.2.1 Beam trawl fisheries

5.2.1.1 Commercial fish species

Beam trawl fisheries are a mixed species fisheries. Species selectivity is rather low (e.g., Van Marlen, 2003), as is size selectivity for several species, plaice (*Pleuronectes platessa*) in particular (Catchpole *et al.*, 2008). Discarding of commercial fish species can therefore be high for the target species such as plaice, but also for other commercial species (van Helmond and van Overzee, 2008). Another major issue is discarding of over quota species such as cod (*Gadus morhua*). Given the high discard mortality for sole (*Solea solea*) and plaice (Van Beek *et al.*, 1990) discarding of commercial fish is a major issue. No assessments have been found on other sources of mortality. Tow path mortality is expected to be negligible for most fish species, escape mortality can, however, be of concern. Next to direct effects, there are indirect consequences such as improved feedings conditions for flatfish (Rijnsdorp and Vingerhoed, 2001).

5.2.1.2 Listed species including fish, cephalopods and benthos

A proper assessment requires an authoritative collation of all previously listed species within the three species groups. It was not possible to collate such a list during the WG meeting but some indications of potential generic impacts are described below. An approach was made to the construction of a coherent list as part of the work for ToR e (see Section 8.5.5.).

Beam trawl fisheries are known to cause high species mortality for some benthic invertebrates, mostly attributable to mortality in the tow path. Direct mortalities range from about 5 up to 40% of the initial densities for a number of gastropods, starfish, small and medium-sized crustaceans and annelid worms. For bivalve species, mortalities were found from about 20 up to 65%. For the Dutch sector, annual fishing mortality in invertebrate megafaunal populations ranged from 5 up to 39%, with half of the species demonstrating values of more than 20% (Bergman and van Santbrink, 2000).

The catch (numbers) per unit of effort for non-commercial fish species is low (van Helmond and van Overzee, 2008). However, a large number of species are affected and the survival rates are expected to be low, implying a high impact.

Cephalopods can be a bycaught product of flatfish directed beam trawl fisheries (e.g., van Helmond and van Overzee, 2008) and can be discarded at high rates, e.g., Enever *et al.,* 2007. There are also records of cephalopods being the target commercial species in winter. Fishing mortalities indicate a rather stable exploitation pattern for cuttlefish in the English Channel (Royer *et al.,* 2006). Discard issues have not been estimated for this fishery. Other sources and levels of "unaccounted" direct mortality are not anticipated.

According to these known impacts, it is expected that beam trawl fisheries could impact listed species, whether benthic invertebrates, non-commercial fish or cephalopods, to a similar degree. The extent of spatial overlap between the distribution of listed species and fishing effort distribution is, however, an important factor that would be required to allow expert judgement of the impact level.

5.2.1.3 Marine mammals, marine reptiles and seabirds

There are no reported bycatches of marine mammals and marine reptiles. The direct effects of bycaught seabirds in beam trawl fisheries are likely to be negligible (Courtens and Stienen, 2008). Discarding from beam trawl fisheries provides an important food sources for several seabird species and has important implications at the population level, depending on the area (Camphuysen and Garthe, 2000; Tasker *et al.*, 2000).

5.2.1.4 Pelagic and benthic habitats and assemblages

Beam trawl fisheries can change the physical 3D-structure of the seabed, e.g., by flattening sediment structures, removing large physical structures e.g., boulders and oyster beds, sediment compression and penetration (Paschen *et al.*, 1999; Fonteyne, 2000; Lindeboom and de Groot, 1998) and therefore reduce habitat complexity (Rose *et al.*, 2000). Next to their impacts on the physical habitat, beam trawl fisheries are likely to affect macrophytes and biogenic structures as well, depending on the scale of overlap between the fisheries and the habitat distribution. For shrimp beam trawl fisheries, overlap can be quite substantial and its effects have been illustrated in ICES 2007. Rabaut *et al*., 2007 indicate that species, tightly associated with *Lanice conchilega* reefs, will be impacted significantly when beam trawling. In general, different mortality rates for benthic species causes a change in community composition and a reduction in species richness.

There are numerous studies demonstrating that there have been long-term changes in benthic community structure as a result of beam trawling (e.g., Lokkeborg, 2005; Kaiser *et al*., 2006). The results from studies undertaken to consider recent change are less conclusive. For example, when considering effects on productivity of benthic assemblages, findings are mixed. In muddy habitats the production of benthic communities has been demonstrated to be negatively impacted (Hiddink *et al*., 2006; Quiéros *et al*., 2006). Whereas Jennings *et al*., 2002 found negligible effects of beam trawling on infaunal productivity. Beam trawling is also pointed out to have indirect effects on benthic communities, e.g., by changing the food sources (e.g., Ramsay *et al*., 1996; Franco *et al*., 2008).

The effect on fish communities has been described as an increased abundance of small fish (all species) as well as increases in demersal species with a low maximum length (L_{max}) over large parts of the North Sea during the last 30 years (Rogers and Ellis, 2000; Daan *et al*., 2005).

5.2.2 Gillnet fisheries

5.2.2.1 Commercial fish species

Gillnet fisheries are usually more species selective than towed gear fisheries (Gabriel *et al*., 2005); although in some fisheries up to 101 species have been recorded (Perez and Wahrlich, 2005) whereas in others the catch consists largely of 1 species (Huse *et al*., 2000). In general the size selectivity of gillnets is high (Huse *et al*., 1999; STECF, 2006), but there are issues in that these gears tend to target only the large individuals, possibly triggering population/recruitment effects. Discarding by gillnet fisheries is generally low except in fisheries with long soak times for more sedentary species such as anglerfish and turbot (Morizur *et al*., 1996) where discarding can be higher. Rihan *et al*., 2005 report discards of over 70% in nets retrieved that were verified as having been abandoned for more than six months. In general, discards are very much dependent on the fishery (gillnet type and target species) and the fishing grounds. Increased fishing mortality can be invoked by predation of isopods (Sekiguchi *et al*., 1981) or seals.

Gillnet fisheries have also been demonstrated to impact on vulnerable species. For example deep-water gillnet fisheries in the North-East Atlantic principally target anglerfish (mainly *Lophius piscatorius*), but have a bycatch of vulnerable species, such as deep-water sharks, *Centrophorous squamosus* and *Centroscymnus coelolepis* with severe impact on the stocks of deep-water sharks described (to such a degree that EU and NEAFC have closed these fisheries). Similarly gillnet fisheries targeting localized populations of crustacean species such as crawfish or lobster have also been demonstrated to impact severely on such species over a short period of time (Trent *et al*., 1997; He, 2005; Large *et al*., 2009). Gillnets are also widely reported as being an important source of unaccounted mortality through ghost fishing (Brown and Macfadyen, 2007; Tschernij and Larsson, 2003). Levels of unaccounted mortality by ghost nets, however, are reported to be low in inshore waters where nets degrade quickly as a consequence of the effects of tide, weather and biofouling and fishing efficiency is reduced quickly. In deeper water there is evidence that such nets continue to fish over much longer periods of time (Hareide *et al*., 2004).

5.2.2.2 Listed species including fish, cephalopods and benthos

As for non-commercial species in beam trawl fisheries, listed species ought to be known to make this assessment. Moreover, the distribution range of the listed species is crucial. This is an issue of importance beyond the context of this ToR. Therefore generic impact for benthic invertebrates, non-commercial fish and cephalopods are described, indicating the type of mortality caused by gillnet fisheries for species with comparable traits.

Mortality of benthic invertebrates can be caused through a series of mechanisms for bottom-set gillnets. Direct catch mortality can be high for crustaceans (e.g., Sundet, 1999; Large *et al*., 2009), but is generally thought to be negligible (e.g., Santos *et al*., 2002). Again, this is very much area-dependent. Another mechanism through which benthic invertebrates are impacted is by ghost-fishing nets. These can increase food availability for scavengers and/or result in catching, for instance crustaceans, by closing meshes around them (Kaiser *et al.*, 1996; Revill and Dunlin, 2003; Brown and Macfadyen, 2007). For non-commercial fish species, no major assessments have been found, although indications of discards exist in some areas (Santos *et al.*, 2002). Gillnets are not known to have any impact on cephalopods, but again, this is an area-specific issue as for instance in Southern Italy there is an "artisanal" fishery directed to cuttlefish (Colloca *et al.*, 2004).

5.2.2.3 Marine mammals, marine reptiles and seabirds

The bycatch of marine mammals in gillnet fisheries is recognized worldwide as one of the most severe threats (Dayton *et al.*, 1995). The bycatch of small cetacean species and sea otters and the predation of a number of pinniped species, as grey seals, were reported in a number of fisheries (Vinther, 1999; Vinther and Larsen, 2004). However, this impact is very much area- and gear-dependent. For the estimation of its severity, population estimates (abundance, distribution and population health) are needed, but only limited documentation exists. Larger cetacean species can be entangled in buoy lines, e.g., right whale entanglement. Marine reptile bycatch is reported for sea turtles in the Mid-Atlantic monkfish fishery (Chuenpagdee *et al.*, 2003). Seabird species, such as common murres, sea ducks and divers have been bycaught in large numbers (Zydelis *et al.*, in press). Gillnet fisheries can pose a serious threat to marine reptiles and seabirds. Again, the degree of impact is strongly gear and area dependent.

5.2.2.4 Pelagic and benthic habitats and assemblages

The effect of gillnet fisheries on the benthic community is expected to be fairly low, whereas the fish community may suffer strong effects from the removal of large fish.

The direct damage of fixed gears on benthic habitats is thought to be small and caused by individual anchors, weights and groundgear (ICES, 2006). If habitat damage by gillnet fisheries occur, it is most likely to be as a result of abrasion and/or translocation of seabed features by lost nets (Brown and Macfadyen, 2007), breaking or uprooting structures when hauling or setting anchors and buoy ropes (Chuenpagdee *et al.*, 2003).

5.3 Testing of methodology developed by WGECO 2008

The methodology developed by WGECO (ICES, 2008b) for the various ecosystem components was modified at WGECO in 2009. This was then used in a test assessment for two case study fisheries; Flatfish beam trawls in the North Sea and bottom-set gillnets in the Baltic. Applying the methodology *for real* will require a group of experts covering all ecosystem components for which the generic impact assessment identifies there is a high risk of impact, and who also have local knowledge for the area being assessed. Ideally, a group of three or more experts per component should be available, and an audit trail should be completed as the assessment is undertaken.

Any expert judgement based approach should be accompanied by an analysis of uncertainty to account for the level of knowledge available to support the assessments made for each ecosystem component. Uncertainty is usually recorded as confidence and here we have followed the categorization of confidence described by Robinson *et al.*, 2009 where:

- High confidence should be given when data are available, particularly in the form of GIS outputs for the period being assessed, and/or a group of experts (>3) agree that they have high confidence in the assessment.

- Low confidence should be given where detailed information is not available for the period being assessed, or is not available at all, and/or there is no agreement, or the number of experts involved is <4.

5.3.1 Commercial species

In 2008 target species was defined as those species that the fishing gear is directed at in the geographic area of interest. For example, in the North Sea for beam trawls this would be plaice and sole. On further discussion in 2009 it was recommended that this be re-defined as “commercial” rather than “target” species on the basis that this was much easier to define given that many fisheries by their nature are “mixed” making the identification of “target” species problematic. “Commercial species” is taken to mean any species landed. As a result, there will be data available from logbooks and sales slips on abundance by species and time and area of catch. Some of these species will also be advised on by ICES either through a full analytical assessment or using other state of the stock data such as cpue time-series.

For commercial species, the terminology adopted for the significant adverse impact (SAI) categories is essentially unchanged from 2008 and is analogous to the current definition of B_{LIM} as used in fishery management, for those stocks where B_{LIM} is defined. Given that B_{pa} represents a value below which the stock is at risk of going below B_{lim}, then a stock below B_{pa} is ***at risk*** of being SAI. No such “at risk of SAI” category exists and for the purpose of this assessment, stocks assessed as being below B_{pa} were classified in the SAI category. By the same process, stocks that are being fished over F_{pa} should also be included under SAI. We have also adapted and used the broader terminology used in the FAO guidelines, as this is inclusive of all target (commercial) species, some of which do not have defined limit or threshold reference points. We have also applied a precautionary approach (for all impact groups) for situations where a lack of information on population size and/or resilience is recorded. Table 5.3.1 shows the final criteria used.

Table 5.3.1 Criteria for identification of significant adverse impacts for commercial species (shellfish, fish, cephalopods, macrophytes).

CATEGORY	CRITERIA
No significant adverse impact	Long-term projections imply that population size and recruitment potential are not compromised.
Significant adverse impact	Affecting recruitment levels of stocks/or their capacity to increase such that the ability of affected populations to replace themselves is compromised. No information is available on resilience of the populations.

5.3.1.1 Outcomes-beam trawls in the North Sea

Taking the flatfish beam trawl fishery, based on detailed catch information from the Dutch and Belgium fleets, this métier currently catches 14 commercial species of which 4 are assessed by ICES WGNSSK (ICES, 2008c). For these 4 species the following is the current advice:

- Sole ~90% of catches estimated to be from beam trawls. SSB is currently below B_{pa} and fished over F_{pa}.
- Plaice ~75-80% of catches estimated to be from beam trawls. SSB is currently over B_{pa} and fished under F_{pa}. It was under B_{pa} for the previous 4 years.
- Cod ~20–25% of catches estimated to be from beam trawls. SSB is currently below B_{lim} and fished over F_{pa}. Stock is close to its historical low.

- Whiting ~10% of catches estimated to be from beam trawls. No defined reference points, but at historical low.

Based on this 3 of the 4 stocks can be classified in the SAI category with a high degree of confidence. It should be noted that beam trawls are most important for sole and plaice and less so for cod and whiting.

The other 10 commercial species listed, are not currently assessed. In order to judge the status of these species in terms of the SAI criteria, other metrics are required. For instance, cpue time-series from the Dutch fleet are available (van Helmond and van Overzee, 2008) and these could be used as a proxy for the state of these stocks. Where these cpue series demonstrate a consistent decline over time, it is reasonable to assume that these species can be classified in the SAI category. This can be cross-referenced against fishing mortality estimates for some of these species based on the methods developed by Piet *et al*. (in press). This appraisal would require expert judgement from the appropriate community. This will identify the proportion of these species as classified in the SAI or NSAI categories.

5.3.1.2 Outcomes-bottom-set gillnets in the Baltic Sea

Taking the bottom-set gillnet fisheries in the Baltic Sea, based on WGBFAS (ICES, 2008a) the fleets involved in this métier currently catch mainly cod with a small bycatch of flounder and turbot. Of these species only cod is assessed by ICES (ICES, 2008a).

For cod the following is the current advice:

- Cod ~30% of catches estimated to be taken in gillnets. ICES classifies the stock in Subdivision 22–24 as being at risk of reduced reproductive capacity, with the spawning stock just below $\mathbf{B}_{pa}$ in 2008. The cod stock in Subdivision 25–32 is estimated to be around 40% below the long-term average (1966–2007). An increase in spawning-stock biomass has been observed since 2005. Based on the most recent estimates of fishing mortality (for 2007) ICES classifies the stock as being harvested sustainably. In addition, there is evidence that fishing pressure is resulting in lower female size-at-maturity (Andersen *et al*., 2007).

Based on this the cod stock can be classified in the Significant Adverse Impact category with a high degree of confidence.

For the other commercial stocks taken as a bycatch in this fishery there is currently no assessment. ICES reports the following for flounder and turbot:

- Flounder ~10–15% of catches estimated to be taken in gillnets. No biomass reference points to evaluate the state of the stock. SSB in 2008 is estimated to be around 10% above the long-term average. ICES classifies the stock as at risk of being harvested unsustainably.

Based on this flounder could be classified in the SAI category at a low confidence level although the relative impact of gillnets on this stock is low.

- Turbot ~5–10% of catches estimated to be taken in gillnets. The state of the stock is unknown and there is no basis for an advice. Landings have declined in recent years, but this should be further evaluated in relation to effort trends to provide lpue data. Currently there is insufficient information to provide an assessment.

5.3.2 Listed species including fish, cephalopods and benthos

This category applies to all "previously listed" species not already included in commercial species.

Table 5.3.2.1 shows the criteria adopted for this ecosystem component.

Table 5.3.2.1. Criteria for identification of significant adverse impacts for listed species including fish, cephalopods and benthos.

CATEGORY	CRITERIA
No significant adverse impact	For species previously listed as being vulnerable to fishing, mortality[1] is assessed as being sustainable for the population.
Significant adverse impact	For any species previously listed as being vulnerable to fishing, mortality is assessed as being unsustainable for the population. Where any population or species currently assessed to be at risk of extirpation, or otherwise specifically protected by legislation or regulation, suffers any mortality. No information is available on resilience of species, or on mortality rates of the populations in this fishery.

[1]Mortality here includes any mortality in the catch or in the path of the gear (includes on the seabed and unaccounted mortality of animals passing through the gear).

5.3.2.1 Outcomes-beam trawls in the North Sea

A proper assessment requires an authoritative collation of all previously listed species within the three species groups. Without such a list a full assessment was not carried out, but some guidance is provided below.

For listed benthic species, expert judgement would be required to assess whether this specific métier had an adverse impact relative to the SAI criteria. For listed fish species, analyses such as that by Piet *et al*. (in press) could be used to provide mortality estimates and evaluation against the SAI criteria. This information could be supplemented by information from beam trawl surveys in the southern North Sea, in particular declines in cpue and in area occupied. There is little evidence of any impacts on cephalopods.

5.3.2.2 Outcomes-bottom-set gillnets in the Baltic Sea

The same conclusion applies here as for the beam trawl case.

5.3.3 Marine mammals, marine reptiles and seabirds

Suggested acceptable bycatch mortality for marine mammals of 1.7% of the population annually has been proposed by ASCOBANS (Anon, 2000), and would be a suitable candidate for differentiating SAI and NSAI for these species. State indicators for seabirds generally focus on abundance and/or breeding success. Fishery impacts are generally seen in the context of competition for forage fish e.g., sandeels in the North Sea, resulting in potential declines in breeding success and hence abundance. Many seabird species are known to forage on discarded fish and offal from fishing activity. In light of this, a criterion relating to increases in populations above reference levels has also been included as described by ICES 2008b. For seabirds under the proposed EcoQO this is set at 130% above reference levels. A similar criterion may also be applicable to other marine mammals.

Table 5.3.3.1. details the criteria used for this ecosystem component.

Table 5.3.3.1. Criteria for identification of significant adverse impacts for marine mammals, seabirds and marine reptiles.

CATEGORY	CRITERIA
No significant adverse impact	No/negligible impact to any population or species (for example, mortality below the unacceptable level[1] where defined).
Significant adverse impact	Affecting the capacity of populations such that their ability to replace themselves is compromised. This point should be defined by the unacceptable level1 where defined, and where any mortality above the unacceptable level is deemed to cause a significant adverse impact. Where any population or species currently assessed to be at risk of extirpation, or otherwise specifically protected by legislation or regulation, suffers any mortality. No information is available on resilience of species, or on mortality rates of the populations in this fishery.

[1] The unacceptable level will depend on which component you are considering. For example, unacceptable levels have been defined for some species of marine mammals, such that in the OSPAR area the mortality rate cannot be >1.7% of the population in any fishery (Anonymous, 2000). Changes in breeding seabird abundance should be within target levels for 75% of the species monitored in any of the OSPAR regions or their subdivisions OSPAR 2008 (OSPAR, 2008).

5.3.3.1 Outcomes-beam trawls in the North Sea

According to all documentation reviewed and also based on information collated by ICES SGBYC 2009, in prep. there is no known bycatch of marine mammals, seabirds or marine reptiles in the beam trawl fishery in the North Sea.

Some seabird populations are known to utilize discarded fish and/or offal. Adverse impacts could therefore include increases of more than 130% above reference levels. The critical point would then be the chosen reference levels. Until this is settled, an evaluation against this criterion cannot be made.

Based on the above, this group would be classified as having NSAI with a high degree of confidence.

5.3.3.2 Outcomes-bottom-set gillnets in the Baltic Sea

According to HELCOM 2007, bycatch in bottom-set gillnet fisheries represents a major threat to the recovery of the harbour porpoises in the Baltic. This species is listed on the HELCOM list of threatened and/or threatened species. The annual bycatch of harbour porpoise is roughly estimated at 7–10 individuals of which more than 75% is attributed to bottom-set gillnet fisheries. According to ICES 2006 fisheries bycatch historically amounted to 0.5–0.8% of the porpoise population in the southwestern part of the Baltic Marine Area each year, as well as 1.2% of the porpoise population in the Kiel and Mecklenburg Bays and inner Danish waters (Kock and Behnke, 1996). Estimates of the harbour porpoise population are uncertain, however, and the number of porpoises bycaught in fisheries is probably underestimated but given that the population is estimated at only 200–1000 individuals (HELCOM, 2003) this could be classified as a SAI with a low level of confidence, as a result of the level of uncertainty in the population estimate.

For the other three marine mammal species found in the Baltic, namely the Ringed seal, Grey seal and Harbour seal, HELCOM 2007 estimated that at least 300 grey seals, 80 ringed seals and 7–8 harbour seals are captured as bycatch annually in the Baltic Sea, mainly in the salmon driftnet fishery. Further estimates are available for the Swedish Baltic Sea driftnet fisheries where Luneryd *et al*., 2005 reported over 400 grey seals and 50 ringed seals bycaught in 2001. These were mainly attributed to the salmon driftnet fishery although there was also evidence of bycatch in the cod gillnet fishery. Helander and Härkönen, 1997 demonstrated population increases in these species despite these mortality figures suggesting that it is below critical levels (1.7%??). Therefore gillnets could be classified as having No Significant Adverse Impact on these species, at a low level of confidence given the uncertainty surrounding population sizes and actual bycatch levels.

Several studies reported by HELCOM have demonstrated that the gillnet fishery in the Baltic Sea can in certain places cause high seabird mortality (http://www.helcom.fi/environment2/biodiv/fish/en_GB/effects/). The bycatch problem is of special relevance where the gillnetting is carried out in the areas with high concentrations of resting, moulting or wintering seabirds. Bycatches of piscivorous birds (divers, grebes, mergansers, auks, cormorants) and benthophagic ducks are reported although not all this bycatch is attributable to gillnets. Gillnets also cause mortality of long-tailed ducks (*Clangula hyemalis*), velvet scoters (*Melanitta fusca*), eiders (*Somateria mollissima*), and black scoters (*Melanitta nigra*). There are also widescale reports of guillemot and razorbill (*Alca torda*) mortality in the driftnet fishery for salmon (HELCOM, 2003). The majority of these species are listed on the HELCOM list of endangered or threatened species, therefore gillnet fisheries can be classified as having Significant Adverse Impact on seabirds with high confidence.

5.3.4 Pelagic and benthic habitats and assemblages

For habitats, criteria for significant adverse impacts were adapted from the FAO terminology about deterioration of productivity, and risk of permanent local loss and are largely unchanged from 2008. The definition of "damage" as defined by Robinson *et al*., 2009 was as follows:

"Damage can be judged to have occurred where there has been a change in, or loss of, typical or natural elements (e.g., species, physical structures) of the habitat relative to former natural conditions such that structure and/or functioning of the habitat is altered. In terms of a change in biological structure (e.g., species composition), damage is assumed to have occurred where several typical species of the assemblage have been extirpated from the area. This does not include short-term fluctuations in species whereby a species may be present in one year, absent in the next and present the following year. It must be an example where there has been a sustained change in the composition of species."

Terminology on structure and function (see Section 3 in this report for ToR a) is also included in the criteria, in recognition that these are equally important characteristics of a habitat and that long-term degradation of productivity, structure or function should be considered a significant adverse impact (Table 5.3.4.1). The FAO Guidelines 2008 identify serious adverse impacts to habitats as impacts where recovery takes longer than 5–20 years. Priorities for gear technologists to address should be based on impacts that are expected to persist several years or longer, with consideration of natural conditions that affect physical and biological processes. Again presence of features of habitats that are protected and/or currently assessed to be at risk of extirpation were also considered as criteria for significant adverse impacts, and the precautionary approach would be applied where limited information or understanding was encountered (Table 5.3.4.1).

Table 5.3.4.1. Criteria for identification of significant adverse impacts for habitats, including macrophytes and biogenic habitats (horse mussel beds, coral reefs, etc.).

CATEGORY	CRITERIA
No significant adverse impact	Any impact on productivity, structure and function of natural habitats exposed to the gear (e.g., in the towpath or snagged damaged hauling or shooting the gear) would have fully recovered[1] in 5–20 years, dependent on natural background conditions.
Significant adverse impact	Any impact on the long-term productivity, structure and function of natural habitats, such that recovery would not occur in 5–20 years, dependent on natural background conditions. Where any habitat currently assessed to be at risk of permanent local loss, or has features that are otherwise protected by legislation or regulation, suffers any damage or degradation of conservation status. No information is available on habitat types in the area that the fishery operates in.

[1]Here we have adapted the terminology used in the FAO guidelines (FAO, 2008). Some of the terms used (e.g., fully recovered) are not clearly defined yet and it will be essential to complete those definitions before these tables can be made fully operational (see recommendations and ToRs for 2009).

5.3.4.1 Outcomes-beam trawls in the North Sea

The beam trawl fishery in the North Sea is largely carried out in sandy areas. There is evidence of long-term impacts of beam trawling on the physical habitat of the southern North Sea (Lindeboom and de Groot, 1998), in particular, related to the removal of boulder fields and oyster beds. In general this can be seen as irreversible, but historical. Current beam trawling is unlikely to cause further change, assuming no change in fishing activity pattern.

There have been long-term changes in benthos species composition as a result of beam trawling. While this may be capable of recovery this is unlikely that the larger long-lived species would be back to their original proportions in the benthic assemblage within 5–20 years (Collie *et al*., 2000; Kaiser *et al*., 2006). This community is now dominated by highly productive opportunistic species.

The fish assemblages in the southern North Sea (where beam trawling predominates) have demonstrated substantial and long-term changes that have been well documented (Rogers *et al*., 1998; Daan *et al*., 2005).

Assuming natural habitat is defined as former natural conditions; the southern North Sea would be assessed as SAI with high confidence in terms of habitats and associated assemblages.

5.3.4.2 Outcomes-bottom-set gillnets in the Baltic Sea

Based on available documentation (ICES, 2006) the impact from fixed gears on benthic habitats is small, and caused by anchors, weights and groundgear. The largest impacts have been demonstrated to occur when the gear is dragged over the seabed during hauling (Eno *et al*., 2001). In areas of high habitat structure, particularly biogenic features, the consequences of this can be severe; however, such structures are relatively rare in the Baltic Sea.

In terms of the fish communities, there is no evidence of major impacts from gillnet fisheries in the Baltic. Gillnets are generally very selective, and there are relatively few species present or caught. The primary driver for fish community change in the

Baltic is considered as environmental and driven by climate changes (Köster *et al.*, 2005). Therefore gillnets were classified as having NSAI at a high level of confidence.

The assessment outcomes by gear type and ecosystem component group are summarized in Table 5.4.3.2.1.

Table 5.4.3.2.1. Assessment outcomes by gear type and ecosystem component group.

Ecosystem Component Group	Beam Trawls in the North Sea	Bottom-Set Gillnets in the Baltic Sea
Commercial fish species	SAI for sole, cod and whiting NSAI for plaice No evaluation for unassessed species	SAI for cod and flounder No evaluation for turbot
Listed species including fish, cephalopods and benthos	No evaluation as a result of no agreed list	No evaluation as a result of no agreed list
Marine mammals, marine reptiles and seabirds	NSAI	SAI for harbour porpoise and seabirds NSAI for seals
Pelagic and benthic habitats and assemblages	SAI for impact on productivity, structure and function of habitats except pelagic SAI for impact on benthic and fish assemblages	NSAI for any impacts

5.4 Emergent issues

In carrying out the assessment, a number of difficulties arose that may have resonance for other assessments both for gear, and for other pressures.

- What is the minimum level of proportional impact that would constitute an important pressure? For example, if a particular gear, caught less than 5% of a fish stock that was below B_{pa}, would that gear pressure be assessed as a "cause" of that SAI evaluation? Equally, while beam trawling is acknowledged as having a major impact on the North Sea habitats, this will compounded with otter trawl impacts that are also acknowledged as major (Kaiser *et al.*, 2006, Løkkeberg, 2003).
- Standard reference points for assessed fish species are B_{pa} and B_{lim}. We have indicated here that when a stock is over B_{pa} in the current year, it can be considered as NSAI, even when it has been below B_{pa} over a number of previous years. Is there a need for a time-scale factor, e.g., "has been below B_{pa} for 4 out of the last 5 years"?
- Again, we assessed stocks below B_{pa} as SAI. However while B_{pa} requires reduced fishing to allow recovery, SAI requires a complete halt to the responsible activity. The two concepts are not mutually compatible in terms of response.
- What are the appropriate "natural" reference conditions? OSPAR defines these as "pre-industrial". But for instance, beam trawling in the southern North Sea was responsible for permanently modifying the physical habitat many years ago; removal of boulders and oyster beds. This is likely to be irreversible. Is it sensible to permanently assign an SAI category on this basis? Or should we consider more recent impacts and take the reference

as the modified habitat? Similar questions arise for seabirds and other components.

- What geographic extent constitutes an important impact? If one small area is very seriously impacted, but the rest is largely pristine, how does one assign SAI/NSAI? The distributional ranges for vulnerable or endangered species are particularly important in this context; e.g., is the species endangered across its range or locally.
- In many species cases, especially fish, a whole stock for a species may be below B_{pa}, and therefore in an SAI status. At the same time, it may be possible that individual pressures e.g., from different gears do not make an important contribution to that status assessment. Equally, one stock of a species may be SAI, while another may not. There is probably a need for a nested approach to such species evaluations.

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6 ToR c Applying risk-based methodologies to assess degree of impact

ToR c) assess a small number of ecosystem components in one OSPAR region to develop risk based methodology and confirm whether the methodology can be used to consistently assess the degree of impact.

6.1 Background

For several years now (see reports from 2005–2007), WGECO have been involved in the work to develop a framework and the tools required to undertake integrated ecosystem assessments. Most effort in recent years has been focused on developing a methodology to consistently assess degree of impact across components and different human pressures in order to highlight the key pressures. This focuses on the issue of how to equate a similar level of impact across very different ecosystem components (e.g., seabirds and habitats).

Early approaches by WGECO (ICES, 2006) and OSPAR (OSPAR, 2007) classified the degree of impact using criteria that have been suggested to lack transparency, repeatability and consistency (Robinson *et al*., 2008a). In the OSPAR approach each pressure and component interaction was simply classified as the resultant impact being unlikely, low, moderate or high, with little guidance on what these categories signified. In the WGECO approach, impacts were rated separately on their severity (acute or chronic) and extent (widespread or local). A comparative exercise using these approaches by WGECO in 2007 (ICES, 2007) confirmed the difficulty in producing results that would be credible.

The issue of assessing the degree of impact consistently across and within ecosystem components can be tackled in a number of ways. In a review by Robinson *et al*., 2008a it was suggested that consistency could best be achieved by selecting a threshold[1] for an *acceptable* (or *unacceptable*) level of deviation in one or more state indicators for each component (e.g., population size and/or condition; area of degraded habitat and/or area of habitat loss) and to then measure impact against this. Ideally, indicators and thresholds on these would be selected based on a scientifically robust understanding about the relationship between impact to a component and its capacity to replace itself (the relationship described by WGECO in ICES, 2007 Figure 2.4.2.2.1), where the threshold would be set at the point where the recovery potential of the component was compromised (Robinson *et al*., 2008a).

The Robinson *et al*. (REA) methodology has continued to develop with the rationale of using a limited number of state indicators per component, all with thresholds set that represent an *acceptable* (or *unacceptable*) level of deviation, against which the potential impact of any pressure can be assessed. The latest version of the methodology (Robinson *et al*., 2009) was trialled on eight broad ecosystem components in the five OSPAR Regions in February 2009 (and development of this is described in 6.2 here). The outcome of this exercise, is reviewed by WGECO in Section 6.3., using the attributes defined by IOC (in press) in their "Assessment of Assessments" exercise. In general, the assessment performed well in terms of legitimacy, reasonably well in terms of relevance and less well in terms of credibility. We have made suggestions throughout of how the process could be developed to improve overall performance.

[1] Sensu the term 'reference point' as used widely by the ICES community.

WGECO recognize the importance of further developing robust methodologies for broad ecosystem assessments covering status and trends, and identifying key pressures and human drivers of these. This is particularly relevant as a result of the commitments made by member states to a number of key policy drivers (e.g., the Marine Strategy Framework Directive (MSFD), the Habitat's Directive (HD), and the Water Framework Directive (WFD)). In Section 6.4 we make some general recommendations for a way forward.

6.2 Iterative development of the Robinson *et al.* (REA) methodology

The first REA version was described by WGECO in 2008 (ICES, 2008); since then it has been modified twice, and the main developments are described below following a brief summary of the original version. Terminology used in the descriptive text of this section is taken from the defined terms used by the REA approach. It does not necessarily reflect terminology that is widely used or accepted in the ICES community.

6.2.1 REA 2008a

The approach outlined by Robinson *et al.*, 2008a was specifically designed to assess consistently the degree of impact of various pressures on the full range of ecosystem components. The authors state that achieving consistency in assessing degree of impact would be assured by (1) selecting a threshold for a limited number of state indicators for each ecosystem component that defined the point beyond which their recovery potential is threatened and using this to interpret current level of resistance to a pressure (low resistance where the sustainability of a component is currently at risk as a result of a specific pressure), and (2) categorizing current resilience based on a range of recovery times that reflected the full potential across all marine ecosystem components. Key pressures would be those that had caused one or more components to be moved beyond their resistance threshold and among those, highest levels of risk would be associated with pressure/component combinations with the longest recovery times.

6.2.2 REA 2008b

The first version of REA, 2008a was largely a conceptual framework, and further development was required to make the process operational in the context of a large-scale integrated ecosystem assessment. For example, Robinson *et al.*, 2008a state that although scientifically derived resistance thresholds could easily be identified for some elements of the ecosystem (e.g., B_{pa} and B_{Lim} for commercial fish), no such thresholds were agreed for most of the listed ecosystem components. The issue of selecting baseline conditions (= a suitable reference period) also required work as the initial concept was based on a comparison of current conditions with a recent reference period (i.e., relative to a regular reporting cycle of 6-10 years), the objective being to select the *current* key pressures on the ecosystem. Other applications (i.e., the OSPAR Quality Status Report) would require an assessment of the key pressures that had affected the current status of ecosystem components relative to former natural conditions. Finally, further work was required to finalize the level of aggregation of ecosystem components and pressures.

- **Selecting thresholds[2] for ecosystem components**

[2] Threshold is the term used by the REA methodology, but it is considered by WGECO to be analogous to the term reference point which is more commonly used by the ICES community.

In theory, it should be possible to describe any component in terms of the level of degradation that could occur before its recovery potential begins to diminish. In practice it is recognized that for most components, this relationship is not well understood or documented in terms of any quantitative evidence (see discussions in ICES, 2007 Section 2 and Robinson *et al.*, 2008b Section 2.2). Following consultation with experts on habitats and their species, thresholds were selected for broad habitat components (e.g., intertidal sediment habitats; JNCC, 2008). These were based on state indicators related to range, extent and condition of habitats (where condition covered both biological (benthic invertebrates) and physical structure and function). Thresholds based on area were selected for each of the three descriptors (range, extent and condition) using elements from the favourable conservation status (FCS; JNCC, 2007) and OSPAR Annex V Texel-Faial criteria (OSPAR, 2003). It was recognized by the authors that there was no clear scientific rationale behind the thresholds set. Indicators and thresholds for species group components (e.g., Fish, Seabirds) were less well developed at this stage.

- **Baseline conditions and geographic scale**

As the thresholds set for each ecosystem state indicator in REA 2008b related to an amount of decline, it was noted that, dependent on the reference period (the baseline) being used, and the geographic extent of the region being assessed, the acceptable amount of decline could vary. Thus thresholds were set specific to the context of individual assessments (e.g., they varied dependent on when the baseline was set for). Definitions were provided for each baseline.

- **Level of aggregation of ecosystem components**

Ultimately for a broad ecosystem assessment, there will always be a compromise in terms of the level of aggregation of ecosystem components. Having trialled the REA, 2008a methodology on habitat components and taken comments from a number of *fora* on the broader application, it was suggested that all components should be assessed twice; once based on an aggregate response and once a worst-case (see Chapter 3 in Robinson *et al*., 2008b). As an example, if considering the effect of the pressure 'abrasion and other physical damage' (as caused by dredging (fishing)) on the subtidal rock component, the aggregate response would be based on the majority response of all subcomponents in the region being assessed, while the worst-case assessment would be based on the most sensitive subcomponent (here probably *Modiolu*s beds if they were exposed to dredging in the area being assessed). In the aggregate assessment, if, by area, the majority (i.e., >50% of the total area of subtidal reef habitats) of the subcomponents had high resistance to the pressure, the overall component would be assessed to have high resistance. In the worst-case example, if *Modiolus* beds were assessed against the threshold to have low resistance to the abrasion caused by dredging, the overall component would be assessed to have low resistance.

6.2.3 REA 2009

The latest version of the REA methodology was specifically developed for an assessment of the status of, and key pressures on, eight broad ecosystem components in the OSPAR Regions. The WGECO review of the application of the REA, 2009 methodology in the OSPAR regional assessment (Section 6.3 below), focuses on issues related to the suitability of the methodology to assess consistently degree of impact across ecosystem components.

Major developments from the REA (2008b) version included the addition of a second threshold so that further discrimination could be given between pressures that cause a negligible amount of impact, those that cause some impact and those that cause an unacceptable level of impact. Indicators and thresholds for both habitat and species group components were based on guidance from the Habitats Directive Favourable Conservation Status descriptors and the OSPAR Annex V Texel-Faial criteria.

Habitat components

Habitat components were defined to include their physical and biological features. In terms of biological features this referred only to benthic invertebrate species and assemblages, as associated fish and seabirds were covered elsewhere in the assessment. Physical features (and biogenic habitat features) were covered by all three of the indicators (range, extent and condition), while biological features were covered mainly by the 'condition' indicator (Table 6.2.3.1. below).

The condition indicator is based on the area of habitat damaged, where damage was defined as having occurred where "there has been a change in, or loss of, typical or natural elements (e.g., species, physical structures) of the habitat relative to former natural conditions such that structure and/or functioning of the habitat is altered. In terms of a change in biological structure (e.g., species composition), damage is assumed to have occurred where several typical species of the assemblage have been extirpated from the area. This does not include short-term fluctuations in species whereby a species may be present in one year, absent in the next and present the following year. It must be an example where there has been a sustained change in the composition of species." (Robinson *et al*., 2009, Annex 2).

Table 6.2.3.1. Criteria used to assess the degree of impact of pressures on habitat components as taken directly from the REA, 2009 methodology and applied in the Utrecht OSPAR QSR2010 workshop.

	Degree of Impact		
Threshold descriptor	No/Low	Moderate	High
(i) Range	Geographic range of habitat is stable (loss and expansion in balance) AND not smaller than former natural conditions	Geographic range of habitat has decreased <10% relative to former natural conditions AND is not stable	Geographic range of habitat has decreased >10% relative to former natural conditions
(ii) Area within range (extent)	Total area of habitat is stable (decreases and increases in balance) AND negligible (<1%) loss in total surface area relative to former natural conditions.	Some loss (<10% X >1%) in surface area relative to former natural conditions	Large loss in surface area (>10% relative to former natural conditions)
(ii) Condition (damage)	Structures and functions (including typical species) in good condition, with small areas (<10% in total) considered to be damaged.	Between 10-25% of the total area of the habitat is damaged.	Large area of habitat (>25%) is currently damaged[1] relative to former natural conditions

Species components

Species group components included all species represented by the broad ecological components 'Fish', 'Seabirds', 'Cetaceans' and 'Seals'.

Table 6.2.3.2. Criteria used to assess the degree of impact of pressures on species group components as taken directly from the REA, 2009 methodology and applied in the Utrecht OSPAR QSR2010 workshop.

	Degree of Impact		
Threshold descriptor	No/Low	Moderate	High
(ii) Range	<10% of species have range declines >10% compared to former natural conditions.	10-50% of species have range declines >10% compared to former natural conditions	>50% currently have range declines >10% compared to former natural conditions.
(iii) Population size (extent)	<10% of species currently have a large decline in population size (>25% relative to former natural conditions)	10-50% of species currently have a large decline in population size (>25% relative to former natural conditions)	>50% of species currently have a large decline in population size (>25% relative to former natural conditions)
(iv) Population condition	<10% of species have strong deviations in reproduction, mortality or age structure relative to former natural conditions[1]	10-50% of species have strong deviations in reproduction, mortality or age structure relative to former natural conditions[1]	>50% of species have strong deviations in reproduction, mortality or age structure relative to former natural conditions[1]

[1]***Trend information required for clear deviation in reproduction, mortality or age structure showing a significant deviation from former natural conditions.***

6.3 Review by WGECO of the outcomes of the Utrecht workshop

The REA 2009 methodology was applied to an assessment of eight broad ecosystem components across the five OSPAR Regions at a workshop held in Utrecht in February 2009. A description of the major results from the workshop, and the comments made on these by participants and observers is given in OSPAR 2009a.

In the recently completed report by the Group of Experts on the "Assessment of Assessments" it was suggested that the influence of any assessment could be determined based on three attributes: its relevance, credibility and legitimacy (Farrell and Jäger, 2005; Mitchell *et al.*, 2006; NRC, 2007) using the following definitions taken from IOC (in press; Chapter II):

a) *Relevance* (also referred to as salience) denotes the ability of an assessment to address the particular concerns of those using it. An assessment is relevant if the user is aware of it and it informs his/her decisions or behaviour.

The relevance of the *product* is enhanced if its analytical approach and findings are closely related to the needs and timing of decision-making processes and if they provide a means to help decision-makers set priorities. Relevance can be further enhanced if the assessment evaluates alternative options for policies and actions. The assessment is relevant if its geographic and thematic coverage are tailored for the relevant decision-making authorities and for those undertaking or managing the activities covered in the assessment. Such relevance can be enhanced if the *process* identifies key target audiences in the planning stages (e.g., policy-makers, managers, the media and other stakeholders) and ensures effective consultation and communication with them throughout the assessment. Capacity building can also strengthen relevance by making the scientific community more sensitive to the needs and concerns of broader society, by enhancing the ability of decision-makers to act on scientific information and by creating a larger informed audience (NRC, 2007).

b) *Legitimacy* is a measure of the acceptability or perceived fairness of an assessment. A legitimate assessment is one that has been conducted in a manner that allows users to be satisfied that their interests have been taken into account appropriately and that the process has been fair.

The legitimacy of the *product* is enhanced if final reports reflect contributions from interested parties and how their concerns and inputs were judged and used. It also depends on balance in considering the concerns of different groups. This can be ensured through a *process* that provides fairly and adequately for participation. It is the process which establishes the modalities for interested parties to contribute to the design of an assessment and to air their concerns throughout the process. Legitimacy is enhanced if there is clearly articulated agreement on the responsibilities of those who participate and appropriate balance among the experts. Transparent procedures, widespread availability of assessment products and efforts to strengthen the capacity of all interested groups to contribute, also enhance legitimacy.

c) *Credibility* is concerned with whether the knowledge assembled in the assessment is believed to be valid. An assessment gains credibility and authority by virtue of its information, methods and procedures. In cases where science has no clear answer or where competing explanations exist, the credibility of the assessment depends on agreed and transparent procedures for dealing with uncertainty and disagreement and how this is reported.

The credibility of *products* is enhanced by the use of high quality data and established methods and models, available to the wider expert community, and treatment of all contributions without bias. The *process* enhances credibility through appropriate and transparent procedures for dealing with selection of experts, inclusion of the necessary range of expertise and interpretational perspectives, formal procedures for quality assurance, peer review and the treatment of dissenting views and uncertainty. The expert community also judges credibility according to whether issues of particular significance from a scientific perspective have been included, and whether data and information are available to them so that they can verify assessment findings and conclusions. Credibility can further be enhanced if the assessment is conducted under the auspices of, or endorsed by, a reputable institution. Capacity building plays an important role in improving quality, and thus credibility, over time.

WGECO have reviewed the outcomes of the application of the OSPAR Utrecht workshop assessment against the IOC definitions of relevance, legitimacy and credibility. For each of the three attributes, we have separated our review further under the different issues covered by the attribute definitions. WGECO referred to OSPAR (2009a) and the background documents listed therein in reviewing the process.

6.3.1 Relevance

vii) timeliness of the assessment

The Utrecht workshop aimed to prepare assessments of a number of ecosystem components in the OSPAR area to compliment other assessments being prepared for the QSR 2010 under the biodiversity theme. The process completed during the Utrecht workshop was judged to be relevant to the particular concerns that it had been designed for in terms of its timeliness, as the results were generated in time to feed into the overall QSR report. WGECO noted that the process (where the process describes the workshop itself, including its organization, the methodology used and the interpretation and communication of the assessment results generated in the workshop) would have benefited from longer development time and that this may have improved the overall relevance (6.3.1.(vii)), legitimacy (6.3.2.(v)) and credibility (6.3.3.(i) and (viii)) of the assessment as a whole.

Development of the overall assessment process is extremely timely in light of the commitments member states have made to other policy drivers including the MSFD, the WFD and the HD. WGECO support the further development of the overall process and recognize the contribution made to this by OSPAR. WGECO noted that some of the most frequent types of comment made by the contributors related to the need to harmonize assessments for the commitments to other major strategies and directives (OSPAR, 2009a Annex 8).

viii) involvement of the assessment users in the process

It was clear that all member states had been invited to be involved in the assessment workshop, and that the process had been consulted on by the wider OSPAR community a number of times leading up to the workshop, and following it. Representatives from the OSPAR committees, ICES, the EU, and national government bodies were also invited to the workshop as observers and contributed to the development of the process.

ix) match between the needs of the assessment and the methodology used

WGECO noted that OSPAR (2009b) described the key aims (a–d below) of the workshop in relation to the biodiversity assessments for the QSR. Under each aim we have commented on the match between the needs of the assessment (the aim) and the methodology used.

> a) assess the quality status of the marine environment, represented by selected ecosystem components, against former conditions. The results will be presented per OSPAR Region, in 'traffic light' colours (to reflect Good, Moderate and Poor quality levels);

The REA, 2009 methodology had been designed to assess status of the components as described in (a) above and traffic light assessments were produced for each ecosystem component in each OSPAR Region. Concern was raised by contributors about the credibility of some of the assessments made and the reasons for this concern are discussed in Sections 6.3.2 and 6.3.3. WGECO note that if these concerns were satisfied by further development of the methodology and the overall process, the assessment would be highly relevant in terms of addressing aim (a). Given that status assessments for the broad ecosystem components will be required periodically to address the policy drivers described in 6.3.1.(i) above (in addition to the regional seas assessments (see OSPAR QSR)) WGECO welcome the further development of this process.

b) assess trends since the QSR 2000 was published and provide an outlook towards 2020, linking to the objective of the EU Marine Strategy Framework Directive;

WGECO identified that the REA, 2009 methodology did not provide an assessment step specific to aim (b) listed above. There was a step in the methodology where contributors were asked to fill in information on trends in the pressures, but nothing was recorded specifically for trends in the components. Comments by contributors confirmed that the methodology needed to explicitly cover a step to record trends in the status of components. The overall process did record trends in components in the summaries for each Region, but these were generated by the expert groups outside the structured assessment process. WGECO felt that it would be possible to examine recent trends in many of the ecosystem components assessed using state and pressure indicators, for at least some of the OSPAR regions. Previous reports by WGECO have listed indicators that could be used for this purpose.

c) identify and rank the impacts from human activities;

Initially, impacts were ranked based on the overall impact score, which included information on the degree of impact and recovery time for each pressure/ecosystem component combination (Robinson *et al.*, 2009). Although the scoring method used the same range for the individual scores for degree of impact and recovery, the combined score for overall impact still tended to generate lists of key pressures dominated by those pressures that would be associated with long recovery times (e.g., litter; climate change). Contributors expressed much concern in relation to this, and the methodology was revised during the workshop so that impacts could also be ranked based on degree of impact alone (OSPAR, 2009a). WGECO recommend that the numerical scoring method should undergo further consideration in future development of the assessment process, as it would be important to include information on recovery potential to generate advice on future trends and management options. At the same time, WGECO refer to the text in 6.3.3 (ii) below, where we discuss the importance of selecting appropriate thresholds for ecosystem components, as this also has a strong influence on which impacts rank highest in the outcomes.

d) identify priorities for future assessment and monitoring, recognizing the need for indicator development under the MSFD for the 11 GES elements and any limitations in the data available;

The process was very relevant in terms of highlighting the gaps in knowledge, data and the priorities in terms of assessment methodology development. A clear priority that emerged from the assessment was that there is still work required to identify suitable indicators for some ecosystem components, although the components were not necessarily grouped under the 11 GES elements. Several of the assessment contributors highlighted the need to streamline the process with the MSFD, and WGECO recommend that future work on identifying indicators and setting reference points (thresholds) considers the work being undertaken on the GES elements, pending a useful outcome of the task group process.

The assessment was particularly relevant in terms of highlighting data gaps. General areas of low confidence were listed in the regional summaries (Annex 5 OSPAR, 2009a), but low confidence was not always attributable to data gaps; sometimes missing expertise was more important and limitations on time available to use data in the assessment process were described. These issues are explored further in 6.3.3.

x) ability of end users to set priorities and actions based on its outcomes

It was not clear to WGECO how the outcomes of the assessment would be used by the end users, without seeing the final versions of the QSR 2010 report. The latest version of the report from the Utrecht workshop (OSPAR, 2009a) states that "in view of the trial nature of the assessments undertaken" the outcomes would be presented in a "new Chapter 10 of the QSR which would describe approaches to ecosystem assessment which are under development".

WGECO felt that the assessment would at least help end users to prioritize actions in terms of further development of indicators and suitable integrated assessment methodologies. As described in OSPAR, 2009a much greater certainty in the process would be required before the outcomes would be used to set any management actions. It is clear that there is a need for future development of the process to include work on the link between outcomes and the sorts of actions and priorities required by the end users.

xi) relevance of geographic coverage

The assessment was judged to be relevant in terms of its geographic coverage, as it was applied at the OSPAR Region scale and covered the entire QSR area. However, one of the problems encountered in applying the assessment was the effect of using such large units in terms of geographic scale (OSPAR Regions). Several contributors felt this affected the scientific credibility of the assessment and this point is discussed further in Section 6.3.3 (also see effect of geographic resolution on exploration of fish indicators explored in Section 7 of this report).

xii) relevance of thematic coverage

OSPAR does not normally report on all of the pressure sources covered by the framework used in the Utrecht workshop assessment, and the biodiversity elements covered in the QSR have not formally been reported on in such detail. In the responses to some of the comments made by the workshop contributors on this theme, the Chapter 11 authors describe how the thematic coverage has been expanded with the 2012 MSFD assessments in mind (OSPAR, 2009a). Individual thematic assessments have also been undertaken by OSPAR on particular issues like hazardous substances, eutrophication, radioactivity and the agreed EcoQOs. The report from the Utrecht workshop describes the need to pay attention to any potential contradictions from the outcomes of the individual thematic assessments and the overall biodiversity assessment.

xiii) relevance of the planning stages

A number of the major emergent issues described in the lessons learned from the assessment related to the need to improve the planning stages of the process (OSPAR, 2009a). In particular, the collation of information sources on both pressures and ecosystem components could be better completed if this work were suitably resourced (although see comments in 6.3.3 (i) and (viii)). The collation of such data sources should become a less onerous task as more and more broad assessments are completed (as long as archives of data sources are retained). Participants also felt that a number of the steps of the assessment could be completed before the expert workshop (e.g., blanking out those pressure/component interactions that would obviously never occur as a result of a lack of overlap), allowing more time in the expert workshop for the steps that really require an expert consensus. Later we discuss the need for more resourcing (time and people involved) of each of the major parts of the assessment process. The planning stages would benefit from participation of the same group of experts who would later be involved in the assessment workshop to bring together the evidence of the assessment. This could be through correspondence, but would be better coordinated through dedicated meeting time in the planning stages.

6.3.1.1 Summary-relevance

In summary, WGECO felt the main areas where the assessment could be improved in terms of its relevance were in: matching the needs of the assessment to the methodology- this could be achieved in future development of the process; focusing outcomes so that they are relevant to the needs of end users to set priorities and actions-this would be more easily achieved if the needs of the end users were more transparent; improving the relevance of the different thematic assessments to each other; improving the relevance of planning stages so that the expert workshop is better equipped to achieve its objectives.

WGECO also noted that good performance against one attribute (e.g., relevance in terms of geographic coverage), may not equate with good performance against another attribute (e.g., scientific credibility). This is a point picked up by the IOC (in press).

6.3.2 Legitimacy

i) acceptability or perceived fairness of the assessment

A voting system was used at the Utrecht workshop to take feedback on the assessment process. The acceptability of the assessment outcomes in particular, was voted on, and the results are summarized by OSPAR Region in Table 6.3.2.1 below.

The acceptability of the results varied per Region, although in all cases the majority of votes were either in the "Yes provided…" or the "Yes" categories. "Yes provided…" responses were accompanied by comments and WGECO note that the Chapter 11 authors have largely provided suitable solutions for rectifying specific concerns (Annex 8 OSPAR, 2009a). Acceptability was high for between 39–60% of voting participants dependent on the Region being assessed. When including the "Yes provided…" voters, this increased to between 75–100%. WGECO note that acceptability would be interpreted to be lower if participants abstained because they did not accept the results.

Table 6.3.2.1. Percentage of voters (excluding abstainers) that voted that they (i) could not (No), (ii) could provided that (Yes provided…), or (iii) could (Yes) agree with the outcomes of the assessments for each of the five OSPAR Regions. The proportion of the total number of participants that abstained from voting on each Region is also given. Generally participants abstained where they did not feel they had relevant local expertise to comment on the outcomes of the assessment in a particular Region.

OSPAR Region	No	Yes provided…	Yes	Proportion abstained
I	0	45	55	58
II	25	19	56	26
III	7	33	60	64
IV	15	46	39	35
V	14	41	45	46

Lowest levels of acceptability were recorded for the Region II assessment. This was also the Region for which there was the highest representation of expertise (only 26% of participants abstained from voting on this Region's outcomes) and the most information available. In the summary provided for Region II (Annex V, OSPAR 2009a), concerns were raised about the credibility of some of the assessments, as it was identified that some of the expert groups had interpreted terminology central to the assessment in different ways (see discussion in 6.3.3. (i)). Also there were general comments about the scientific credibility of aspects of the REA methodology (most notably the indicators and thresholds used, the aggregation of ecosystem components (particularly not separating fish assemblages and commercial species in the assessment), geographic scale and the reference period used- all discussed further in 6.3.3) and it is clear that these concerns would need to be reduced in the further development of the assessment process to improve acceptability of the overall process.

ii) reflection of contributors concerns and inputs in the final report

WGECO feel that the contributors concerns were well documented in the final report from the workshop (OSPAR, 2009a) and that a sensible forward process has been documented in terms of addressing concerns in the final interpretation of the assessment outcomes.

iii) balance in consideration of the concerns of the different groups

Here WGECO took the "different groups" to be the various groups (e.g., component experts, pressure experts, observers) involved in the assessment process. Based on this interpretation, WGECO could not find any evidence to suggest that there had been any imbalance in consideration of the concerns of these different groups.

iv) adequateness of provision for participation

In terms of general participation in the assessment workshop, WGECO felt there was adequate provision in terms of allowing for participation of a wide range of experts and the wider user community. Some of the OSPAR Regions were not as well represented at the workshop, but the background documents suggest this was as a consequence of the difficulty for some member states to provide representatives, not because they were not invited to.

In terms of adequateness of provision for participation of the participants present at the assessment, the comments on the process suggest that most participants felt that more time and evidence was required to improve the legitimacy of the assessment. While the framework for the assessment process was generally felt to be sound, it was recognized that further time and evidence to complete the assessments would have improved the overall results. During the workshop there was very limited time to consult the background material, even when in some cases (e.g., the information from the OSPAR BA-6 assessments) it was readily available.

The assessment was ambitious in terms of its aim during the time-scale allocated. In future, undertaking the assessments over a longer time period, which would allow the collation of improved datasets and other evidence, was considered desirable (OSPAR, 2009a) and WGECO support this. Participants did, however, comment on the benefits of the different expert groups being present "under one roof"; a sentiment WGECO agree with particularly when trying to achieve consistent assessments. WGECO recommend that further development of the overall process should explicitly build in clear stages for planning, data collation and processing, running the actual assessment workshop, reviewing the results and outcomes, and finalizing the outcomes for the needs of the end users. The experts involved in the assessment workshop should also be involved in (most of) the other stages of process. WGECO recognize that this process requires sufficient time to run through all the stages with appropriate breaks in between stages, where participants may still cooperate by correspondence. Similar scale assessments undertaken in Canada have taken between 18–24 months.

v) ability of participants to contribute to design of assessment

Although some updates to the assessment methodology were made during the workshop to address issues raised by participants early on, there was little other opportunity for the participants to contribute to the design of the assessment. WGECO supports the wide participation of the various user groups in reviewing the further development of such assessments.

vi) ability of participants to air their concerns through the process

The agenda for the workshop and the summary of the process in OSPAR, 2009a suggest that there were plenty of opportunities for participants to air their concerns throughout the workshop. Subsequent to the workshop participants have been given opportunities to comment on the outcomes and reporting.

vii) appropriate balance among the experts and agreement of responsibility

The process seemed well defined in terms of the agreement of responsibilities, with non-specialist process facilitators actively engaged in addition to the methodology experts and organizers. A reasonable balance among experts was achieved but some Regions were underrepresented, as were some ecosystem components. As discussed earlier, this did not appear to be as a consequence of an imbalance in the invitations to attend, but reflected an imbalance in the availability of certain experts to attend.

viii) transparency of the procedures

Overall the procedures appeared transparent although there was variability of auditing of the decisions made by expert groups. The REA, 2009 methodology did clearly describe a process for auditing, and again, participants suggested that better preparation would allow a more thorough audit to be completed.

ix) accessibility of assessment products

WGECO noted that the assessment products had been made widely available to the participants for review. It was not yet clear how accessible they would be made in the final reporting of the QSR 2010, and thus to the wider end users. As OSPAR, 2009a describe, this initial assessment has been viewed as a trial exercise.

6.3.2.1 Summary-legitimacy

In summary, WGECO felt that the assessment performed very well in terms of its legitimacy, and better overall when compared with criteria for the attribute relevance. The only areas where legitimacy could be improved related to: acceptability of the assessment outcomes; an area WGECO felt would improve given further development of the methodology; proper resourcing in terms of time required for the assessment (all stages of the process) and balance of experts to cover some Regions and ecosystem components.

6.3.3 Credibility

i) information used in the assessment.

The organizers of the workshop had obviously invested time in preparing background information for the assessment, particularly GIS maps of human activities (where available) and basic habitat maps. Efforts were made to translate source material on human activities, taken from the other OSPAR thematic assessments, into information that could be readily interpreted into evidence of the distribution of pressures. However, there were clear gaps in evidence on many pressures, even on some of the key pressures (e.g., those related to fishing) in large areas of the geographic Regions being assessed. In some cases, participants were able to provide further evidence, but there was some dissatisfaction expressed with the lack of time available to them to do so. Also, WGECO note that there was risk of misinterpretation of evidence where participants had to translate information on activities into an understanding of the pressure footprint, where they did not have relevant expertise on the pressures.

Although it is unlikely that adequate data will ever exist on some pressures (e.g., litter, noise pollution), WGECO are aware of many good pressure indicators that could be better used in this process. WGECO have worked on pressure indicators for many years; in this year's report we have provided advice specifically related to the provision of pressure indicators on fishing activity and its impacts (Sections 3, 7 and 8). In previous years (e.g., ICES, 2007, 2008) we have described existing and potential indicators specifically related to the types of evidence required by such an integrated ecosystem assessment process. WGECO strongly recommend the formal participation of the ICES community in the planning of any future assessments at this scale. In enabling this participation, organizers would need to be aware of the annual ICES reporting cycle.

Evidence was also lacking on the distribution and status of the ecosystem components in many or all of the Regions being assessed (e.g., cetaceans, some habitats). WGECO note that data for status indicators on some of these components are notoriously difficult to collect, and that significant additional resourcing of monitoring efforts would be required to fill in gaps. However, we recommend the further investigation of the use of pressure indicators (e.g., the indicator for the harbour porpoise bycatch EcoQO) to aid the overall assessment of these components. OSPAR, 2009a (Annex 8) comments that the use of specific indicators (such as those that support EcoQOs) should be readily encouraged in providing evidence of the assessment. The overall process should be developed to specifically include the collation of indicators (state, pressure, driver where appropriate) in the planning stages.

WGECO note that it still remains that participants felt they did not have enough time during the workshop to use even the insufficient information available to them. Given appropriate provision for evidence of the assessment, it is clear that sufficient time would need to be built into the process to allow for this to occur.

ii) methods and procedures used in the assessment.

WGECO note that most dissatisfaction expressed by participants and observers of the assessment were related to the scientific credibility of some aspects of the assessment methodology. Overall, participants were happy with the framework used, but expressed unease with some important details of the REA, 2009 methodology applied within the framework. In particular, concern was expressed in relation to: threshold values used for species (less so for habitats); the level of aggregation of ecosystem components; the consistency in use of reference conditions; the effect of working at very low geographic resolution (large regions); the lack of integration in terms of assessing indirect effects on components and cumulative effects across pressures. Each of these issues is briefly commented on below.

Species (and habitat) thresholds

The setting of thresholds between categories of impact is central to the REA methodology. Robinson *et al*., 2008a and b described the difficulty in selecting thresholds for state indicators that are scientifically justified (i.e., based on a robust relationship between the level of perturbation and recovery potential of ecosystem components). As a result, the REA, 2009 methodology used thresholds that were based on acceptable limits set by society, with the rationale that they would at least be legitimate to the users of the assessment. It is clear that, at least the species thresholds were not judged to be scientifically credible. Many participants felt it illogical to use generic thresholds (*e.g.*, 25% decline in population size) across very different ecological units (e.g., components with very different life-history strategies).

WGECO note that several components do now at least have some indicators and components that are scientifically derived with reference points (e.g., B_{Lim} for assessed commercial stocks, harbour porpoise bycatch EcoQO) and that these could be used in any future assessment as a robust threshold. For all the components where such indicators are not currently available a large-scale data analysis exercise is required to define the relationships between levels of perturbation and either recovery potential, or cost in terms of loss of ecosystem function or socio-economic benefits. This would allow us to set scientifically robust thresholds that allow a consistent assessment of degree of impact across components and pressures. These sorts of analyses require a dedicated concerted effort by a wide group of experts with access to robust datasets covering examples from all ecosystem components and different examples of perturbation. WGECO feels it could play an important role in helping to plan such an exercise but it would need to be properly resourced to take this important area of science any further forward.

WGECO recommends that *all* thresholds should be reviewed in further development of the process in order to improve credibility. Further development of indicators and thresholds should consider the work being undertaken by the task groups on development of the 11 GES descriptors.

Aggregation of ecosystem components

Another reason that participants struggled to complete the assessments, was that the coarse level of aggregation of ecosystem components actually led to outcomes that were unsatisfactory. For example, the low level of acceptability of the outcomes for the Region II assessment was partly related to the application of the methodology to the Fish component, where the entire fish assemblage was assessed as one unit. Participants felt uncomfortable that the commercial fish species were not treated separately, as the high degree of impact to these species was not then clearly reflected in the outcomes. The worst-case approach was designed to provide a means for reflecting examples of particularly poor status (Robinson *et al.*, 2009), however, many contributors felt that future assessments should include a finer resolution, and reference was made to the "trade-off between simple, aggregated 'policy' statements and scientific credibility" (OSPAR, 2009a).

The Chapter 11 authors noted that assessments at a very fine scale (e.g., individual species and habitat types) may be scientifically more desirable but are, of course, resource intensive. Such a level of detail would also require aggregation of the results to make broader judgements that are relevant and legitimate (e.g., about GES) and such aggregations can bring their own difficulties. WGECO supports further investigation of an appropriate level of aggregation of ecosystem components, but note that this should be considered in light of the further development of indicators and thresholds (as described above).

Consistent use of reference conditions-the baseline

The Utrecht workshop assessments were undertaken against 'former natural conditions'. Variation in interpretation of 'former natural conditions' adopted by each subgroup led to some inconsistent outcomes. For example, the seabird subgroup concentrated on recent trends, many of which reveal population declines, and led to a "moderate" status assessment. However this ignored long-term increases in population size over most of the 20th century in several Regions, which mean that current population sizes are considerably higher than they were historically. Conversely, the fish subgroup (and other subgroups) used much more historical reference points, when fishing pressure was much lower than it is today. Compared with such a reference period, the current population size of fish is much lower, and this also led to a "moderate" status assessment (e.g., fish; OSPAR, 2009a).

Inconsistency in the interpretation of the baseline used has led to inconsistency in the status outcomes. WGECO also note that in future development of the overall process, the issue of setting a suitable baseline needs to be considered and discussed in relation to the needs of the end users.

Effect of working at very low geographic resolution (large regions)

The geographic units used in the assessment were the OSPAR Regions. Such a large-scale of assessment proved particularly problematic for the habitat assessments, where impact was measured against area-based thresholds, meaning that high levels of impact in smaller areas were initially completely missed in the outcomes (see another example of problems with large-scale assessments in Section 7 of this report). As a consequence of this, the deep-sea habitat component was re-assessed split into two depth bands (OSPAR, 2009a). WGECO recommend that in further developing the methodology, work is undertaken so that the assessment could be undertaken using smaller individual geographic units that could then be aggregated to larger regional scales relevant to the assessment for which they are being undertaken. This sort of approach would fit well to information sources stored in GIS databases and could be coordinated to provide useful inputs to spatial planning exercises. In 2008, a relative ecological risk assessment procedure was developed for defining management priorities in German N2000 sites in relation to fishing activities (Fock *et al.*, 2008). Here, numerical solutions were applied to overcome problems of scaling different impacts in a comparable way.

WGECO emphasize that there must be rules set for the aggregation of data at different spatial scales if this sort of approach were to be taken forward. Without such rules, many more problems will be encountered when trying to aggregate data stored at very different spatial resolutions.

Interactions between ecosystem components and cumulative effects of pressures

WGECO note that there is currently no accounting of the interactions between ecosystem components, nor the cumulative effects of pressures on individual components. A truly integrated ecosystem assessment should be based on an approach that achieves both of these aims (IOC, in press Chapter II). As commented on by various participants in the Utrecht workshop, the complexity of biological interactions is often difficult to separate from direct effects of particular pressures. Where indirect effects can be reliably related to the status of a component, they should be considered in the assessment. However in general, the complexity of indirect effects and ecosystem interactions will require further research to allow them to be incorporated into individual component assessments and into any integrated assessment process.

iii) method for reporting on uncertainty.

Confidence is scored at each step of the assessment. WGECO were encouraged to see the clear communication of the final confidence scores for each assessment in the summarized outcome tables and text (Annex V OSPAR, 2009a). There was some indication, however, that confidence assessments had not always been applied consistently by different groups. WGECO recommend that for future development, the confidence assessment is better automated to assist participants in consistently selecting the correct category.

WGECO also notes that the confidence assessments provided a useful means of cross-checking the impact scores assigned to the individual pressure/components with the overall status assessment for ecosystem components. Where high confidence was assigned for the impact of the key pressures on a component, but lower confidence was assigned for the overall status assessment, this suggested experts should be able to revisit their status assessment. These occurrences highlight situations where the use of a number of specific pressure indicators may be very useful where poor information is available on status indicators (see discussion in 6.3.3. i)–iii) above).

iv) appropriateness and transparency of the selection of experts.

WGECO thought the appropriateness and transparency of the selection of experts was credible. The selection of experts was recorded in a transparent method, with preparations for the assessment including wide circulation and consultation on the invitee list. As discussed earlier, any imbalance in expertise appeared to be as a result of a lack of attendance rather than a lack of invitation.

v) procedures for quality assurance, peer review and the treatment of dissenting views and uncertainty.

As described in 6.3.2 above, there were several opportunities provided to participants and observers both during the workshop and following it, to comment on the process and express any concerns. WGECO found it difficult to find any formal process for quality assurance and peer review outside the OSPAR community, and recommend the inclusion of such measures in the further development of the process.

vi) availability of data and information to contributors so that they might verify their assessment findings and conclusions.

A general comment by participants was that they would prefer more time to examine the results, and data/information underlying these in order to verify the assessment findings and conclusions (see 6.3.2. iv)).

6.3.3.1 Summary-credibility

In summary, WGECO felt that the shortcomings in the performance of the assessment related most to its credibility. However, the diversity of experts engaged in the process and the means by which they were heard had clearly added credibility to the expert opinion assessment. WGECO note that overall credibility could be improved significantly by further developing some of the detailed steps of the methodology, improving the availability and use of information used in the assessment and ensuring that a suitable peer review and quality assurance step is built into the process.

6.4 Conclusions-the way forward

The testing of the REA, 2009 methodology in a broad expert-opinion based assessment process for the OSPAR 2010 QSR has provided some important insights into the requirements of future development of such approaches. Some aspects of the REA methodology were well received; particularly the framework, which provided a transparent means for experts to engage in and work through the assessment. Other aspects require more development as they have led to inconsistencies in the assessments of some ecosystem components and pressures by different expert groups. Improvements in the detail of the methodology, particularly the use of indicators and thresholds and the scale on which the assessment units are undertaken, is critical in ensuring that the assessment process becomes fully credible. These improvements will only be achieved if there is a concerted effort to deal with the data and analytical issues required for selecting scientifically robust thresholds and indicators.

The overall process seemed to have high legitimacy and was relevant to the requirements of end users in many areas. However, it would benefit from more planning, more resourcing in terms of the collation of evidence, provision of experts for the workshop, and an appropriate timetable for the stages necessary to complete the task. Some important lessons were learned, and issues of best practice can be taken forward for future regional assessments and, in particular, should be reviewed in the development for the MSFD assessments. WGECO also recommend that the best practice recommendations from the IOC (in press) be considered in future development of such an assessment process.

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7 ToR d Developing EcoQO on changes in the proportion of large fish in the North Sea

7.1 Introduction

The element of ecological quality for the North Sea fish community was established in 2002 as "Changes in the proportion of large fish and hence the average weight and average maximum length of the fish community" (Heslenfeld and Enserink, 2008). Work by ICES (ICES 2007; ICES 2008) subsequently developed an index of the proportion of large fish in the community (P_{LF}) to perform the state indicator role for this issue. The metric is defined as the proportion by weight of fish greater than 40 cm in length in trawl samples collected by the ICES International Bottom Trawl Survey (IBTS) carried out in the first quarter of each year (Q1),

$$P_{LF} = W_{>40cm} / W_{Total}$$

where $W_{>40cm}$ is the combined weight in the sample of all fish larger than 40 cm and W_{Total} is the total weight of all fish in the sample. Subsequent work has determined that the appropriate management target for this indicator should be 0.3, thus the EcoQO for the North Sea demersal fish assemblage is "the proportion (by weight) of fish greater 40 cm in length should be greater than 0.3 (Heslenfeld and Enserink, 2008). This rationale underpinning the EcoQO indicator value, and the indicator trend from 1983 (the start of consistent Q1 IBTS) up to 2008 is summarized in Figure 7.1.1. At its lowest point in 2001, the indicator fell to a value of 0.05, but it has subsequently recovered in 2008 to a value of 0.22.

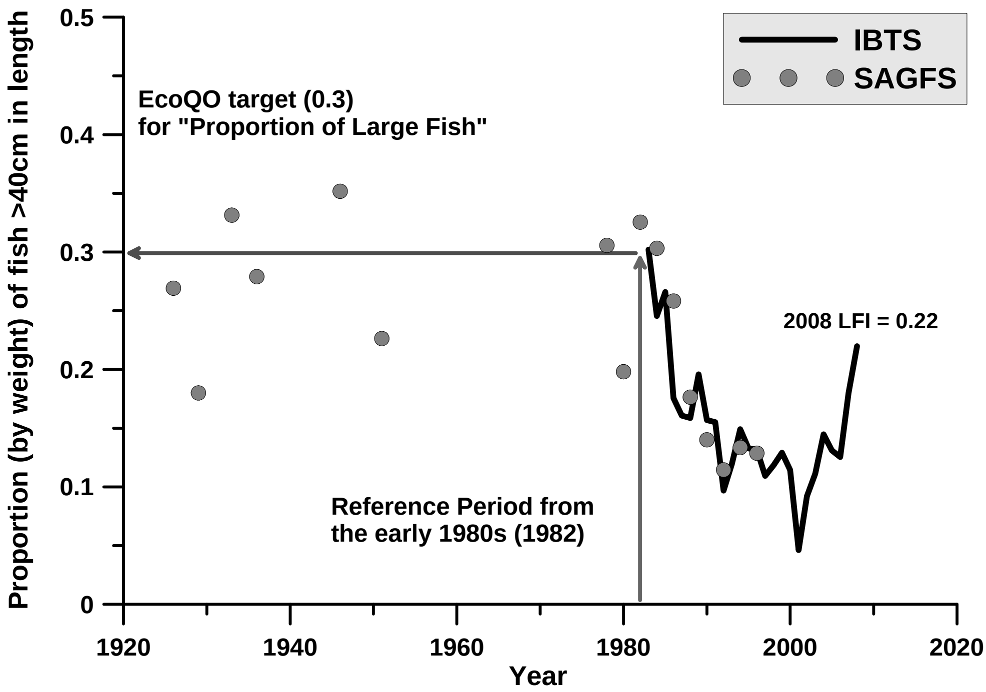

Figure 7.1.1. Variation in the LFI, which is based on the Q1 IBTS. Stock assessments in the early 1980s suggested that stocks were not being overexploited at that time and that therefore fishing was at sustainable levels. The early 1980s were therefore considered to be a "reference" period, and the LFI recorded at that time deemed to be an appropriate level for managers to aspire to. The EcoQO is therefore 0.3; an LFI value consistent with individual stock conservation and preservation of the integrity of the wider demersal fish community, and yet a level that should still allow a viable fishing industry to persist. Analysis of the Scottish August Groundfish Survey (SAGFS), which stopped in 1997, confirms that an LFI value of 0.3 is an appropriate target for management. The SAGFS LFI tracks the IBTS Q1 index remarkably well over the period that the two surveys coincided, while the earlier index values varied around 0.29.

Subsequent work, at both WGFE and WGECO, has focused on the provision of advice related specifically to the exploitation rates that would allow the EcoQO target of 0.3 to be achieved. Such advice relies on the use of size-based, multispecies models and, in 2008, WGECO prepared a table (Table 7.1.1) listing the questions that such models should address in order to provide the most useful advice. The philosophy underlying these questions can be summarized as:

- If fishery management achieves the aims set for individual stocks, would this be sufficient that the EcoQO for the proportion of large fish indicator would be achieved?
- If the answer to this question is yes, then current fishery management plans are adequate with no need to implement additional measures to meet current broader ecosystem goals for the whole North Sea demersal fish community. Modelling simulations would then address the time-scale issue: how long might it take for the EcoQO to be achieved?
- If the answer to the question is no, then what further reductions in fishing mortality below F_{PA} would be required to attain the EcoQO for the proportion of large fish indicator, and over what time-scale might different fishing scenarios achieve the target?

Recent progress in this modelling work is summarized.

Table 7.1.1. Scenarios for theoretical multispecies size-based fish community models to explore the effects of different levels of fishing mortality on the performance (recovery time) of the North Sea demersal fish community proportion of large fish index. Shaded cells indicate "feasibility" scenarios (can the EcoQO be achieved?). Non-shaded cells indicate scenarios with regard to achievement of the EcoQO from status quo conditions, with regard to providing time-scale indications.

Fishing mortality averaged across the seven main demersal species (cod, haddock, whiting, saithe, sole, plaice, Norway pout)	Value of EcoQO at equilibrium	Time to reach Indicator target from Present stock status
F=FPA for all stocks	?	?
ONLY if F=FPA scenario FAILS to achieve EcoQO target, then: F=0 for one stock and F=FPA for all other stocks. Repeat with F=0 for each stock	?	?
F=FSQ for all stocks	?	?
F=0.75[FPA or FSQ , whichever is lower, for each stock]	?	?
F=0.50[FPA or FSQ , whichever is lower, for each stock]	?	?
F=0.25[FPA or FSQ , whichever is lower, for each stock]	?	?
F=0	?	?

Substantial analyses of groundfish survey data to describe trends in the state of the demersal fish community of the North Sea have recently been undertaken as part of the OSPAR Quality Status Report 2010, and as part of the UK's Charting Progress II report. Included among these analyses were subregional scale analyses of the proportion of large fish indicator within the North Sea and an analysis of redundancy among fifteen different univariate community metrics applied to the ICES Q1 IBTS data, including the proportion of large fish indicator. Results from these analyses that are pertinent to the future development and application of the proportion of large fish indicator are summarized.

Finally, some new analyses of ICES Q1 IBTS data are carried out. First, the relative extent to which changes in the proportion of large fish indicator are driven by changes in the biomass of fish >40cm in length, believed to be primarily influenced by variation in fishing pressure, or by changes in the biomass of fish ≤40 cm, which are primarily influenced by recruitment events, is examined. Second, changes in species richness and species evenness among the large fish component of the community are examined to ensure that, by focusing on the size composition of the community, changes in biodiversity aspects are not being missed.

7.2 Multi-species, size-resolved models under development

7.2.1 The Marine Scotland/Strathclyde University model (ICES, 2008; Guirey *et al.*, 2008)

This dynamic, size-resolved model is being designed to allow both disaggregation into status and size composition of individual species, and bottom–up forcing by environmental changes and fluctuations in recruitment (e.g., Heath, 2009). Species comprising 95% of the demersal fish biomass (Fraser *et al.*, 2007) are modelled explicitly. These include several mainly benthivorous species (plaice, common dab, long-rough dab and lemon sole), several primarily piscivorous species (cod, haddock, whiting, saithe, monkfish, grey gurnard, ling and starry ray), and two demersal but primarily planktivorous or hyper-benthivorous species (Norway pout and poor cod). Two key pelagic species (herring and sandeels), which are important as prey of the piscivorous species and as predators on the eggs and larval phases of many of the demersal species, are also explicitly modelled. The goal is to have a model that can be used in testing of hypotheses, including hypotheses regarding the performance of the proportion of large fish indicator under different fishing and environmental regimes. Consequently it is designed to run in a forward projection mode.

Key modelling challenges that are being explored in development of the model include:

- putting density-dependence in the appropriate population processes (e.g., among growth, food uptake, non-fishery mortality, reproduction, etc) and at the right magnitudes. Model parameterization for the density-dependent terms is proving difficult, both because the functional forms of the relationships are poorly known, and because both the key processes that are density-dependent and the magnitude of the dependencies are unlikely to be the same among species.
- quantifying the strength of predator-prey and competitive interactions among species. This is being undertaken incrementally from non-interactive, through weak coupling, to stronger couplings, each species being added sequentially.
- representing recruitment of the individual stocks. Empirical estimates from single species assessments pose difficulties because many assessments do not estimate numbers-at-age zero. Stock-recruit relationships derived from the stock assessments pose other problems because the relationships would not take account of the impacts on recruitment of changing number and sizes of predators in the multispecies community. Both approaches have the additional problem of how to obtain appropriate recruitment estimates for non-assessed species? Currently, the model uses fecundity values and models the egg to larval and larval to post-metamorphosed juvenile stages explicitly.
- obtaining coexistence of all species, particularly with explicit representation of the lower trophic levels as a biomass size spectrum of discrete "pseudo populations". Coexistence of similar predators is being explored with different levels of overlap in food resources, while providing an appropriate amount of energy to propagate from lower trophic levels up to the benthivores and planktivores.
- parameterization with species and multiple trophic levels represented explicitly. Data are very often not available in the literature and often therefore have to be assumed to be constant across the different species. The project is working to establish which parameters define each species, and which might instead be simplified as constants across groups of species. Particular attention is being given to feeding preferences that take account of variation in the availability of different sizes (and species) of prey in the environment (Ursin, 1973; Floeter *et al*., 2003; 2005; Underwood *et al*., 2004). The model currently uses a constant minimum, optimal and maximum prey to predator length ratio of 0.001, 0.03, and 0.1 respectively for each species (Hall *et al*., 2006; Ursin, 1973), but this is almost certainly unrealistic.

- Computational efficiency in dealing with multiple species in variable discrete size classes. The method of Gurney *et al*., 2007 can carry out fast integrations of large multispecies assemblages.

7.2.2 The IMAGE North Sea fish community size-resolved model

This is a dynamic size spectrum model that consists of 12 interacting fish species and a background community. It is developed from the equations of Andersen and Pedersen, 2009 but with an explicit representation of species. It is similar to the size-resolved multispecies model of Hall *et al*., 2006, but with food-dependent as opposed to predetermined growth. This is a feature that has not been represented before in this type of model. Each species is characterized by a set of parameters detailing size at maturation, asymptotic size, maximum consumption rate etc. together with a matrix detailing the interaction with other species. Following the North Sea model (Andersen and Ursin, 1977) the main output of this model is a size spectrum based on the number of individuals $N_i(w)$ of species i per volume in each specific size (w) range. Because the indicator values for the North Sea are specifically based on the IBTS survey, a survey-specific sampling routine is added that mimics the IBTS and delivers the values on which the indicator is based. Some specifics are described below:

- Encounter and selection of food: Food is either fish from the species size spectra Ni(w) or from the background resource community, which is comprised of planktonic and benthic organisms. Food is selected by an individual based on a preference for prey size ϕ and species θij . Selection of prey size is based on the ratio between predator and prey size w/wp and described by the classical lognormal size selection model (Ursin, 1973) (M1). Consumption of encountered food (M2–3) is described by a functional response type II to represent satiation (M4–5). The feeding level $f_i(w)$ (M5) is the amount of consumed food relative to maximum consumption $h_i w^n$.
- Growth: Consumed food $f_i(w)h_i w^n$ is assimilated with an efficiency α. Ingested food is first used for standard metabolism and activity $k_i\ w^p$. A fraction ψ(w)of the remaining energy is used for reproduction and the remainder 1-ψ(w) for somatic growth. The function ψ(w) therefore plays the role of a maturation function (M6). For a constant feeding level this description of growth (M7) leads to a von Bertalanffy like growth curve with asymptotic size W_i and growth constant $K \approx \alpha h_i\ W_i^{n-1}/(1-n)$ (Pedersen *et al*., 2009; Andersen *et al*., 2009).
- Reproduction: Egg production is calculated from the energy routed to reproduction multiplied by a reproductive efficiency (M9). Because this physiological recruitment does not always allow stable coexistence of all the species (Pedersen *et al*., 2009) recruitment is specified by a hockey-stick recruitment function (M10). The rising part of the hockey stick is given by the physiological recruitment and the upper flat part is a species-specific maximum value of recruitment.
- Mortality: Total mortality is composed of a constant background mortality (M11) and predation mortality (M12). The most important part is the predation mortality which is derived to ensure that there is mass balance in the model, i.e., that all consumption by predators results in a corresponding mortality on its prey (Andersen and Ursin, 1977).
- Resource spectrum: The smallest individuals in the model do not eat fish belonging to the fish spectra, but do consume smaller planktonic or ben-

thic organisms. For simplicity, this production is described by a background resource spectrum where each size class has semi-chemostatic growth (M13) with a fixed carrying capacity (M14).

- Sampling routine: an observation–error model mimics the behaviour of the IBTS survey (M15–M18). The chance a species present in the size based community is caught in this virtual survey depends on the species' length (j), abundance (n) and identity (i). The selectivity of the survey gear is tuned to the actual IBTS catches in order to derive realistic values.
- Solution procedure: The model is solved numerically using standard finite-difference techniques for partial differential equations; see Pedersen *et al*., 2009. The size axis is discretized with 100 logarithmically spaced grid points and the time-step is 0.1 year.

Table 7.2.2.1. North Sea Fish Community Size-based model equations.

ENCOUNTER AND CONSUMPTION		
Prey size selection	$\phi\left(\frac{w}{w_p}\right) - \exp\left[-\left(\ln\left(\frac{\beta_i w_p}{w}\right)\right)^2 / (2\sigma_i^2)\right]$	M1
Volumetric search rate	$V(w) = \gamma w^n$	M2
Encountered food	$E_i(w) = V(w) \sum_j \theta_{ij} \int_0^\infty N_j(w_p) w_p \, dw_p$	M3
Maximum consumption rate	$I_{max} = h_i w^n$	M4
Feeding level	$f_i(w) = \frac{E_i(w)}{E_i(w) + I_{max}}$,	M5
GROWTH AND REPRODUCTION		
Maturation function	$\psi(w) = \left[1 + \left(\frac{w}{w_i^*}\right)^{-10}\right]^{-1} \left(\frac{w}{W_i}\right)^{1-n}$	M6
Somatic growth	$g_i(w) = (\alpha f_i(w) h_i w^n - k_i w^p)(1 - \psi(w))$	M7
Gonadal growth	$g_r(w) = (\alpha f_i(w) h_i w^n - k_i w^p)\psi(w)$	M8
RECRUITMENT		
Physiological recruitment	$R_{p,i} = \epsilon / (2 w_0 N_i(w_0) g(w_0)) \int_{w_i^*}^{W_i} N_i(w) g_r(w) dw$	M9
Recruitment	$R_i = \min(R_{p,i}, R_{max,i})$	M10
MORTALITY		
Background mortality	$\mu_0 = Z_0 W^z$	M11
Predation mortality	$\mu_{p,i}(w) = \sum_j \int_{w_0}^{\infty} \phi\left(\frac{w'}{w}\right)\left(1 - f_j(w')\right) V(w') \theta_{ij} N\_j(w') dw'$	M12
RESOURCE SPECTRUM		
Growth rate	$\frac{\partial N_r(w)}{\partial t} = r_0 w^{n-1}(\kappa(w) - N_r(w)) - \mu_{p,r}(w) N_r(w)$	M13
Carrying capacity	$\kappa(w) = \kappa_r^{-\lambda}$	M14
SAMPLING ROUTINE		
Selectivity	$L_{i,j} = \frac{1}{1 + \exp(L_{\alpha,i} - S_{i,j} \cdot L_{\beta,i})}$	M15
Probability to get caught	$P_{i,j} = \frac{S_{n,i,j}}{\max(S_n)} \cdot L_{i,j}$	M16
	$A = Log - N(\mu, \sigma^2)$	M17
Survey catch	$C_{i,j} = BetaBin(n = 10000, p = \frac{1}{10000} \cdot P_{i,j} \cdot A \cdot S_{n,i,j} \cdot \delta, \phi = \varepsilon)$	M18

7.2.3 The population-dynamical matching model (Rossberg *et al.*, 2009)

Mindful of the challenges faced when building and parameterizing marine community models that represent specific species of fish and their interactions in a consistent way, the population-dynamical matching model (Rossberg *et al.*, 2008) implements an approach based on abstract species that evolve to form complex communities (Caldarelli *et al.*, 1998). Each abstract species is assigned a characteristic body mass and derives its life-history traits from allometric scaling relations. Interactions with resources species and predators are determined by an additional set of abstract traits assigned to each species (trait matching, see Rossberg *et al.*, 2009). The model simulates the evolution of body masses and abstract traits, and species additions and extinctions of species until an evolutionary and population-dynamical community steady state is reached. The species richness of the resulting stable communities seems to be limited only by the available computational resources. Model communities in the steady state reproduce empirical size spectra and several other generic macroecological patterns (e.g., trophic level structure and foodweb topology). Fitting the model to the North Sea's pattern of the distribution of species over body sizes would allow it to address the questions posed in Table 7.1.1 in a form that takes foodweb dynamics into account. As a caveat, the current version of the model only describes the dynamics of size spectra across species, but not within species; it is unclear in how far this affects the accuracy of model predictions for the proportion of large fish indicator.

7.3 Summary of OSPAR QSR2010 analysis of univariate community metrics

7.3.1 Spatial variation

Currently the proportion of large fish indicator is determined at a regional scale; all the data collected during each year's Q1 IBTS are analysed to produce a single North Sea indicator value. However, species composition of the fish community varies, markedly across the North Sea (Daan *et al.*, 1990; Fraser *et al.*, 2008). As different species grow to different ultimate body lengths, the proportion of large fish indicator is not homogeneous over the North Sea; distinct spatial patterns emerge with lower metric values prevalent in the northwestern North Sea and higher metric values observed mainly in the eastern and southern North Sea. Furthermore, these patterns are relatively consistent over time (Figure 7.3.1.1), regardless of variation in the regional scale, overall metric value. Taking account of this spatial variation in the indicator could help to identify more effective management strategies. To start this process, the North Sea was subdivided into eight subregions (Figure 7.3.1.2) and temporal trends in the proportion of large fish indicator in each subregion were examined (Figure 7.3.1.3). In most subregions, some sort of recovery in recent years was evident, but the extent of this recovery varied considerably. Furthermore, indicator start points in the early 1980s, and the levels to which indicator values declined in the 1990s, also differed between subregions. In one subregion, the Western Central Basin, the decline in the proportion of large fish in the community was marked with no evidence of any recovery apparent.

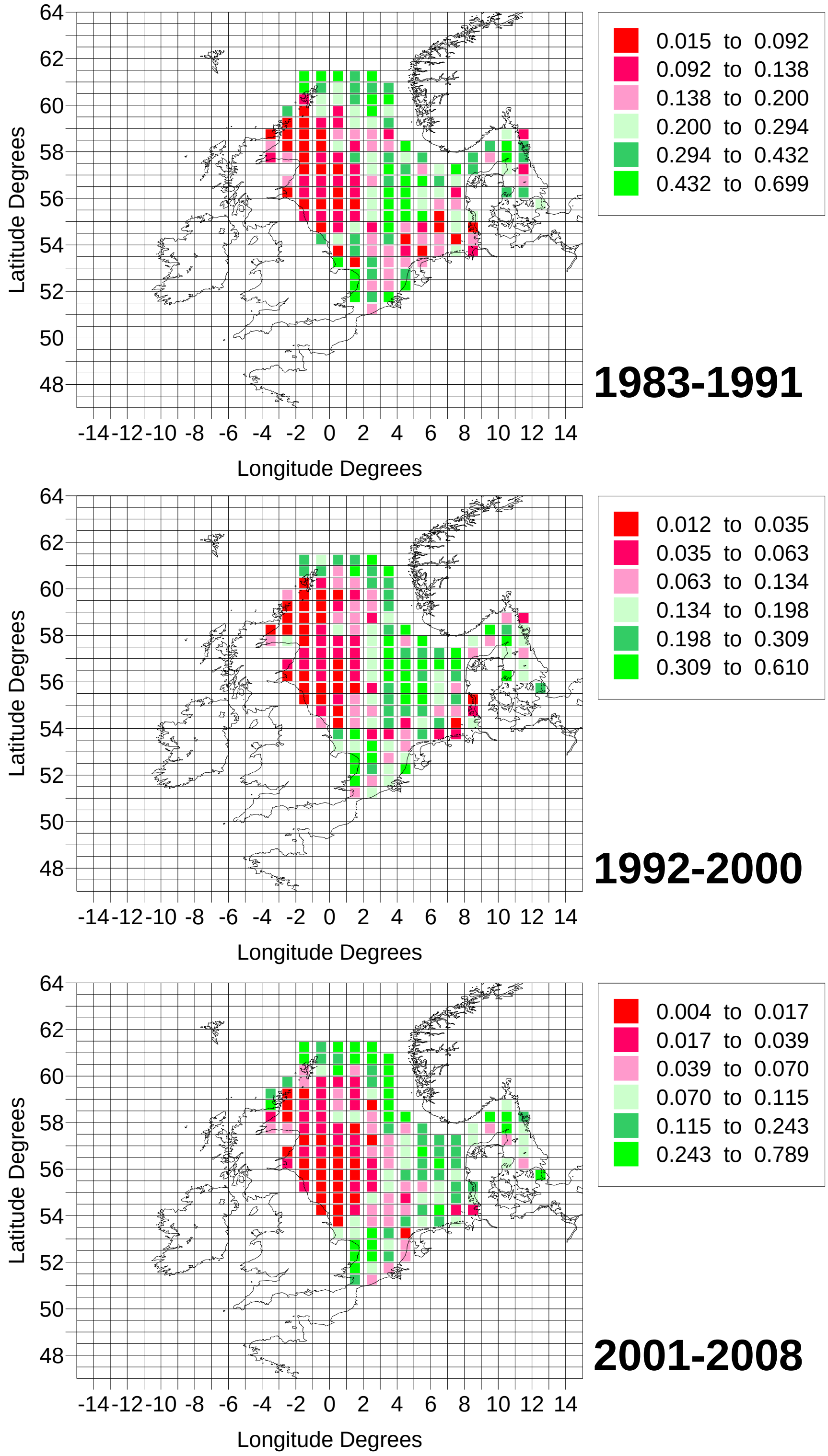

Figure 7.3.1.1. Spatial variation in the Q1 IBTS proportion of large fish indicator calculated for three different time periods; 1983 to 1991, 1992 to 2000, and 2001 to 2008. Bin intervals are set to hold equal numbers of data within each bin, so that the break between red tone and green tone intervals indicates the median indicator value for the North Sea in each period.

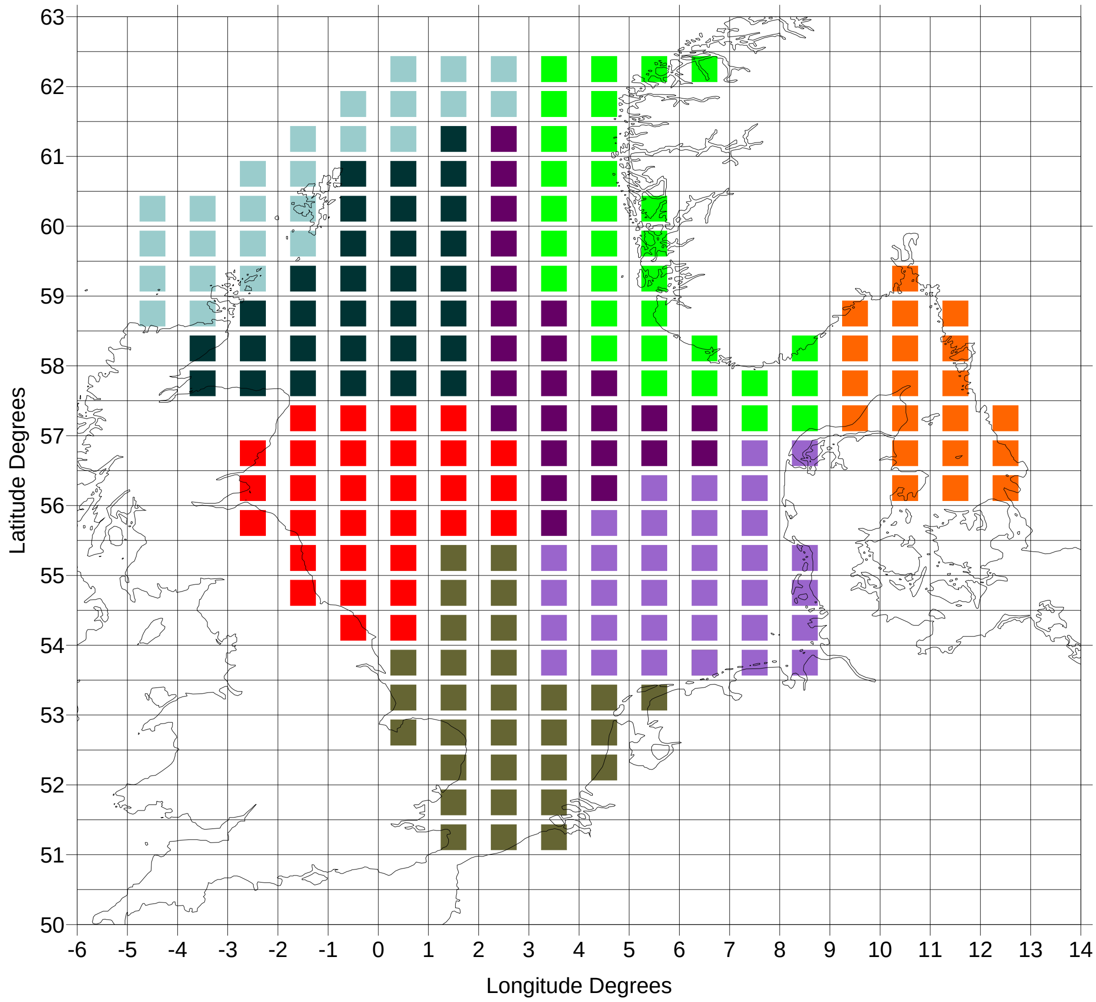

Figure 7.3.1.2. Chart showing subregions in the North Sea for which LFI trends were calculated. (Starting from the top: blue/grey – North-west Scotland Continental Shelf; dark green – North-western North Sea Basin; dark purple – North-eastern North Sea Basin; bright green – Norwegian Deeps; orange – Kattegat and Skagerrak; red – Western Central North Sea Basin; light purple – Eastern Central North Sea Basin; kaki – Southern North Sea Basin.

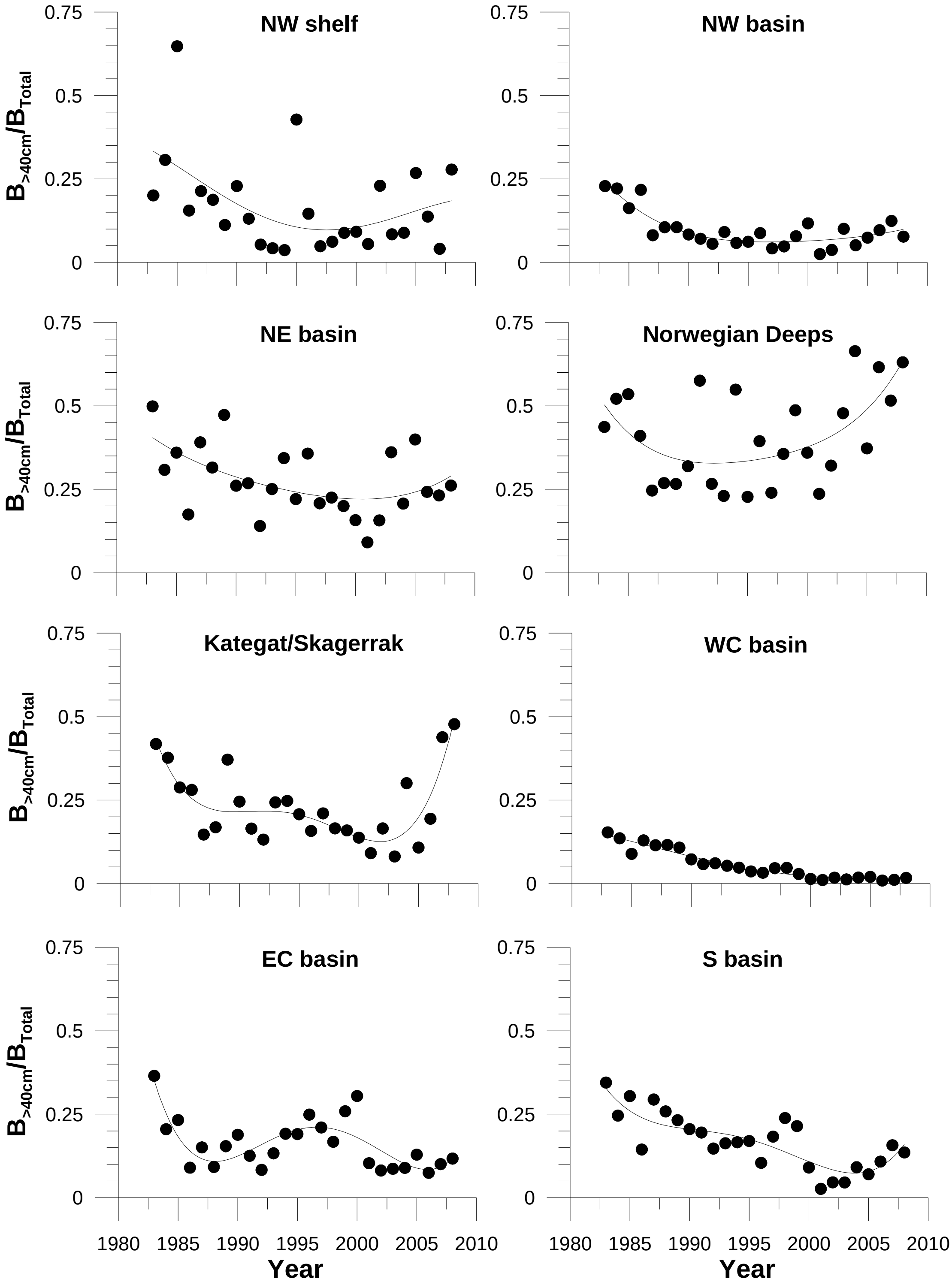

Figure 7.3.1.3. Variation in the LFI calculated for 8 subareas within the North Sea for which Q1 IBTS data were available. See Figure for area key.

7.3.2 Metric redundancy

The need to select an indicator of state that responded primarily to fishing mainly influenced the selection of size structure as the basis of the fish community EcoQO (ICES, 2001). Prior to the 2002 Bergen North Sea Ministerial Conference, other aspects of composition, structure and functioning of communities had received most attention in policy and scientific fora. Earlier work by WGECO concluded that a suite of indices was necessary to capture adequately all changes in the composition, structure and functioning of fish communities (ICES, 1994; 1995; 1996). Consequently, many other metrics describing various aspects of the fish community composition and structure have also been applied to groundfish survey data (Greenstreet and Hall, 1996; Greenstreet *et al*., 1999; Jennings *et al*., 1999; Piet and Jennings, 2005) and related to different fishing activity scenarios (Greenstreet and Rogers, 2006). Many other political commitments, such as OSPAR Annex V and the EC Marine Strategy Framework Directive, place great emphasis on the conservation and/or restoration of biodiversity. This begs the question, if the EcoQO is achieved, and the proportion by weight of demersal fish in the North Sea once again exceeds 30%, will other aspects of fish community composition, structure and function be equally safeguarded? This is essentially a question of metric redundancy; how many metrics are actually required to capture adequately the types of change in the composition, structure and function of the North Sea demersal fish community that might be relevant to policy or management?

To address this issue, fifteen univariate community metrics (Table 7.3.2.1) were applied to the Q1 IBTS data for the whole North Sea (Figure 7.3.2.1) and a principal components analysis (PCA) was carried out (Table 7.3.2.2). This analysis was then repeated, but for each of the eight subregions depicted in Figure 7.3.1.2. Figure 7.3.1.3 provides an example of variation in the proportion of large fish metric in each of the eight subregions, while Figure 7.3.2.2 provides an example of variation in each of the 15 univariate metrics in one subregion, the Kattegat and Skagerrak. Results of the PCA analysis carried out for each subregion are provided in Table 7.3.2.3.

At both the whole North Sea scale (Table 7.3.2.2), and at the subregional scale (Table 7.3.2.3), redundancy was clearly apparent among the fifteen metrics: the biomass and overall productivity metrics (often with the abundance metric) always associated with one factor; the two species richness metrics always associated with a second factor; and the three species evenness metrics always associated with a third factor. These three factors combined accounted for between 52% and 70% of the total variance. At the whole North Sea scale the proportion of large fish indicator was associated with the same factors as the abundance, biomass and overall productivity metrics (Table 7.3.2.2). However, at the subregional scale this same grouping of metrics never occurred. Instead, the proportion of large fish indicator was twice the sole metric linked to a factor; twice it combined with mean weight; on three occasions it was linked to the same factor as the two species richness metrics; and once it combined with the age at maturity life-history trait metric (Table 7.3.2.3). Associative behaviour of the specific productivity, mean individual weight, and four life-history trait metrics was quite variable, although L_∞ and L_{mat} were always linked to the same factor, and only once linked to the same factor as the age at maturity metric. Regional variability of the association between indices may partially be as a result of smaller amount of data available at the subregional scale, compared with the North Sea scale. This could enhance uncertainty in the empirical estimates of the covariance-matrices underlying the PCA. To conclude, the proportion of large fish indicator on its own would be insufficient to monitor the health of the North Sea fish community, but it would perform a key role in any suite of "surveillance" metrics.

Table 7.3.2.1. Descriptions, abbreviations and derivations of the fifteen univariate community metrics applied to the groundfish survey data.

METRIC	ABBREVIATION	METRIC CALCULATION	TERMINOLOGY
Biomass	B	$B=\sum_{s=1}^{S}\sum_{l=\min}^{l=\max}\sum_{n_{s,l}=1}^{N_{s,l}}c_s l^{b_s}$	Where S is the total number of species, l is the length class, Ns,l is the total number of individuals in each length class of each species. The constants cs and bs are the constant and exponent values respectively in the species-specific weight at length relationship.
Abundance	N	$N=\sum_{s=1}^{S}\sum_{l=\min}^{l=\max}n_{s,l}$	Where S is the total number of species, l is the length class, and ns,l is the number of fish in each species and length class.
Daily growth production	P	$P=\sum_{s=1}^{S}\sum_{l=\min}^{l=\max}\sum_{n_{s,l}=1}^{N_{s,l}}c_s b_s l^{b_s-1}\frac{k_s}{365}\left[l_{\infty,s}-l\right]$	Where S is the total number of species, l is the length class, Ns,l is the total number of individuals in each length class of each species. The constants cs and bs are the species-specific weight at length relationship constant and exponent values respectively. The constants ks and l∞,s are the species-specific von Bertalanffy growth function growth and ultimate body length values respectively. ks is divided by 365 to convert and annual parameter to a daily parameter.
Daily production to biomass ratio	P/B	$"P/B"=\frac{P}{B}$	Where P is the total daily growth production and B total biomass of the fish community (see above).
Large fish indicator	LFI	$"LFI"=\frac{\sum_{s=1}^{S}\sum_{l>40cm}^{l=\max}\sum_{n_{s,l}=1}^{N_{s,l}}w_{s,l}}{B}$	For term explanations, see “Biomass” above. Note that in the numerator, the summation is carried out across lengths >40 cm only.
Mean weight of fish	W	$W={}^{B}\!/\!{}_{N}$	Where B is the total biomass and N the total number of fish in the sample (see above).
Species count	S	S	Where S is the count of the number of species in the sample.
Margalef’s species richness	SMarg	$S_{M\arg}=\frac{(S-1)}{LogN}$	Where S is the total number of species and N the total number of individuals in the sample (see above)
Pielou’s evenness	J	$J=\frac{-\sum_{s=1}^{S}{}^{N_s}\!/\!{}_{N}\log{}^{N_s}\!/\!{}_{N}}{LogS}$	Where Ns is the number of individuals belonging to species s, N is the total number of individuals of all species in the sample, and where S is the total number of species recorded in the sample (see above).

Metric	Abbreviation	Metric calculation	Terminology
Hill's N1 diversity	N1	$"N1" = e^{-\sum_{s=1}^{S} \frac{N_s}{N} \log \frac{N_s}{N}}$	Where Ns is the number of individuals belonging to species s, N is the total number of individuals of all species in the sample, and where S is the total number of species recorded in the sample (see above).
Hill's N2 dominance	N2	$"N2" = 1 \Big/ \sum_{s=1}^{S} \frac{N_s}{N}$	Where Ns is the number of individuals belonging to species s, N is the total number of individuals of all species in the sample, and where S is the total number of species recorded in the sample (see above).
Mean ultimate body length	L∞	$L_{\infty} = \frac{\sum_{s=1}^{S} \sum_{n_s=1}^{N_s} l_{\infty,s}}{N}$	Where l∞,s is the von Bertalanffy ultimate body length of each species s. S is the total number of species recorded in the sample and Ns is the total number of individuals of each species caught. N is the total number of individuals recorded in the sample.
Mean growth coefficient	K	$K = \frac{\sum_{s=1}^{S} \sum_{n_s=1}^{N_s} k_s}{N}$	Where k,s is the von Bertalanffy growth parameter for each species s. S is the total number of species recorded in the sample and Ns is the total number of individuals of each species caught. N is the total number of individuals recorded in the sample.
Mean length at maturity	Lmat	$L_{mat} = \frac{\sum_{s=1}^{S} \sum_{n_s=1}^{N_s} l_{mat,s}}{N}$	Where lmat,s is the length at maturity of each species s. S is the total number of species recorded in the sample and Ns is the total number of individuals of each species caught. N is the total number of individuals recorded in the sample.
Mean age at maturity	Amat	$A_{mat} = \frac{\sum_{s=1}^{S} \sum_{n_s=1}^{N_s} a_{mat,s}}{N}$	Where amat,s is the age at maturity of each species s. S is the total number of species recorded in the sample and Ns is the total number of individuals of each species caught. N is the total number of individuals recorded in the sample.

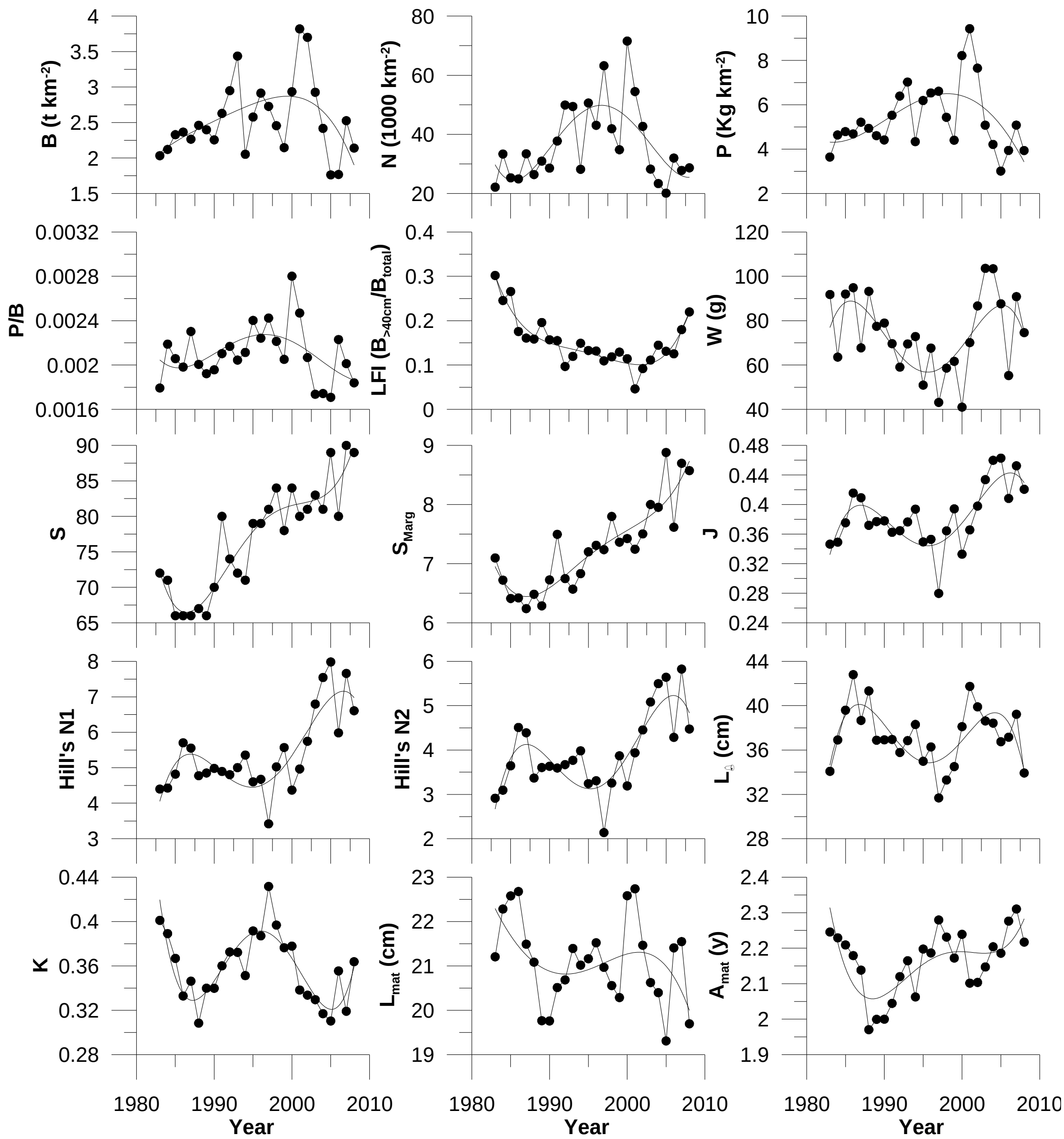

Figure 7.3.2.1. Trends in fifteen indicator metrics applied to the IBTS Q1 groundfish survey data for the whole North Sea. See Table 7.3.2.1 for explanation of metrics (y axis labels).

Table 7.3.2.2. Summary of principal components analysis results for whole North Sea.

	Factors						Total Variance Explained
	1	2	3	4	5	6	
Variance Explained	30.5%	19.2%	15.2%	13.1%	11.2%	9.0%	98.1%
Associated Metrics	N1	B	S	P/B	Lmat	Amat	
	N2	P	SMarg		L∞		
	J	N					
	K	LFI					

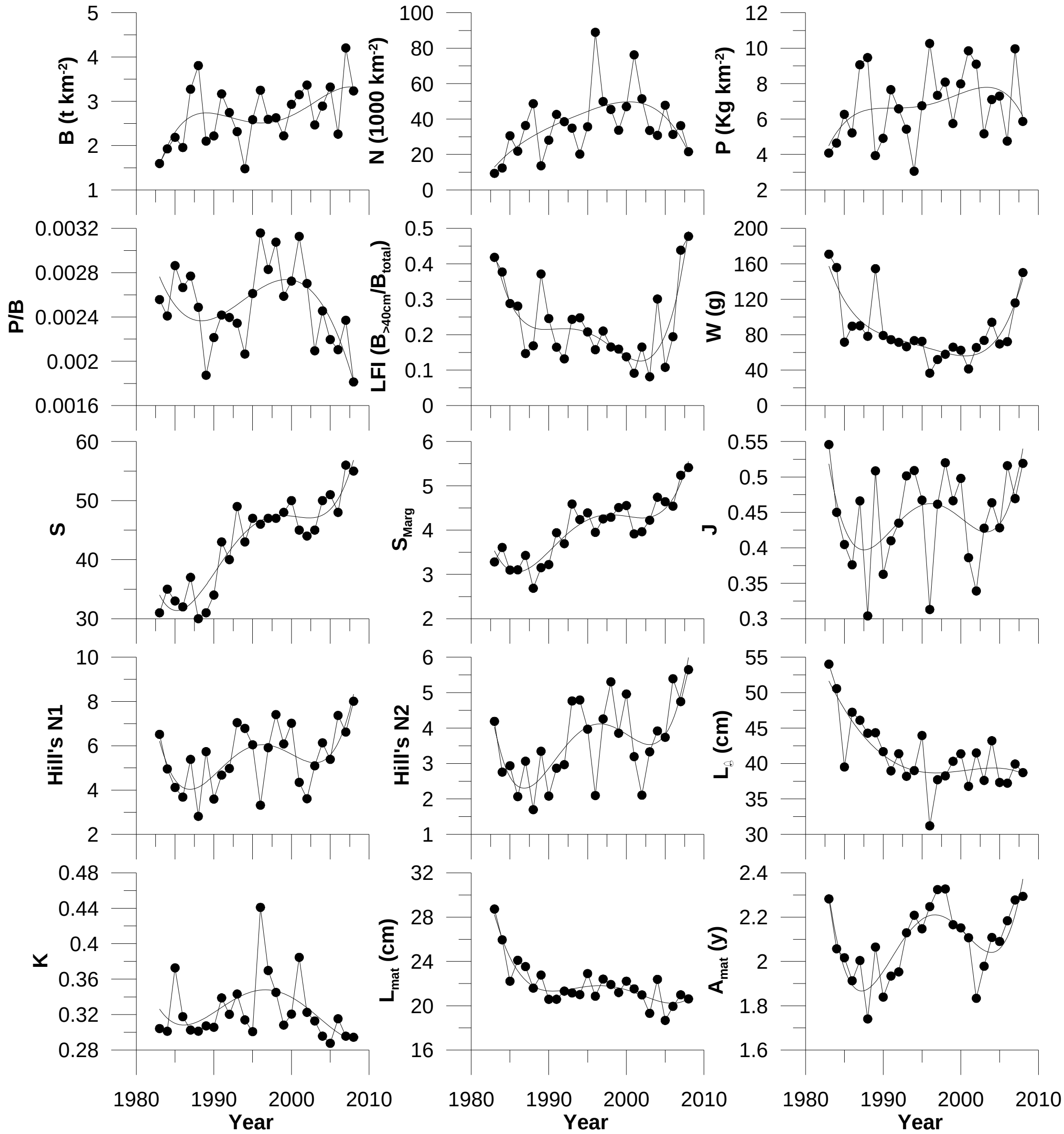

Figure 7.3.2.2. Trends in fifteen indicator metrics applied to the IBTS Q1 groundfish survey data for the Kattegat and Skagerrak. See Table 7.3.2.1 for explanation of metrics (y axis labels).

Table 7.3.2.3. Summary of principal components analysis results for eight subregions of the North Sea.

Sub-region		Factors 1	2	3	4	5	6	Total Variance Explained
North-western shelf	Variance explained	20.2	24.6	16.9	7.3	9.5	19.3	97.9%
	Metrics	B P N	N1 N2 J Amat	S SMarg LFI	K	$\overline{W}$	Lmat L∞ P/B	
North-western basin	Variance explained	18.0	35.9	13.3	14.5	8.1	7.9	97.7%
	Metrics	B P N	N1 N2 J L∞ K Lmat $\overline{W}$	S SMarg	P/B	LFI	Amat	
North-eastern basin	Variance explained	17.9	36.7	15.0	7.4	13.1	6.8	96.8%
	Metrics	B P	N1 N2 J K P/B N $\overline{W}$	S SMarg	Amat	Lmat L∞	LFI	
Norwegian Deeps	Variance explained	13.3	36.2	15.5	15.2	16.0		96.2%
	Metrics	B P	N1 N2 J K L∞ $\overline{W}$ Lmat	S SMarg	Amat LFI	P/B N		
Kattegat/ Skagerrak	Variance explained	16.9	29.5	16.3	16.8	14.0		94.0%
	Metrics	B P	N1 N2 J Amat S SMarg	Lmat L∞	K P/B N	LFI $\overline{W}$		
Western central basin	Variance explained	20.7	19.4	18.5	17.7	8.6	12.3	97.0%
	Metrics	B P N	N1 N2 J	S SMarg LFI	Lmat L∞ K	Amat	$\overline{W}$ P/B	
Eastern	Variance explained	21.2	17.6	13.2	24.8	11.7	13.2	96.0%

SUB-REGION		FACTORS						TOTAL
central basin	Metrics	B P N	N1 N2 J	S SMarg	P/B Lmat L∞ Amat	$\overline{W}$ LFI	K	
Southern basin	Variance explained	20.2	24.6	16.9	19.3	7.3	9.5	97.9%
	Metrics	B P N	N1 N2 J Amat	S SMarg LFI	Lmat L∞ P/B	K	$\overline{W}$	

7.4 New analyses

Trends in the biomass of the key species making up the >40 cm and ≤40 cm components of the North Sea fish community where plotted (Figure 7.4.1). A clear and relatively steady decline in the biomass of large fish was evident from 1983 through to 2001. But between 1983 and 1995, the biomass of small fish doubled, and it was this rapid expansion in the biomass of small fish, combined with the decline in large fish, that was responsible for the initial sharp drop in the proportion of large fish indicator at the start of the time-series (see Figure 7.1). During the 1990s, much of the year-to-year variation in the indicator was driven by variation in the biomass of small fish. Marked peaks in small fish biomass were evident in 1993, 1996 and 2001, coinciding with especially low points in the indicator trend. From 2001, a decline in the biomass of small fish, combined with an increase in the biomass of large fish, particularly since 2006, has been responsible for the recovery in the proportion of large fish indicator.

One point of note is that variation in the biomass of small fish was heavily influenced by changes in the biomass of some species (e.g., whiting) that never (or rarely) grow to a length where they eventually influence variation in the biomass of large fish (Figure 7.4.1). Changes in the abundance of such species will always therefore represent environmentally driven noise in proportion of large fish indicator.

A contoured surface demonstrating variation in the proportion of large fish indicator with varying combinations of biomass of fish both greater than 40cm in length and smaller or equal to 40cm in length was generated. The observed trajectory of the proportion of large fish indicator was then plotted on top of this, revealing three clear phases and allowing the process generating them to be identified (Figure 7.4.2). During the "decline phase", from 1983 to 1992, indicator values were driven down by both a decrease in the biomass of large fish and increasing small fish biomass. Between 1992 and 2000, large fish biomass altered little, and variation in the indicator was influenced primarily by changes in the biomass of small fish. A further decline in the biomass of large fish combined with a substantial increase in small fish biomass drove the indicator down to its lowest point in 2001. The "recovery phase", from 2001 to the current time, was characterized by declining small fish biomass combined, particularly since 2006, with an increase in the abundance of large fish.

Given that the indicator is a ratio metric, it is clear that variation in the indicator value, as illustrated in the discussion above, is influenced by variation in the abundance of fish both larger and smaller than the 40 cm bound. Relating variation in the indicator value directly to variation in the biomass of fish both larger and smaller than 40 cm, however, confirmed its greater sensitivity to the former (Figure 7.4.3). The relationship for the small fish component of the community was heavily reliant on the data collected in years when small fish biomass was high. Excluding the three exceptionally high small fish biomass years reduced the r^2 value by 20%. Variance in the proportion of large fish indicator was considerably higher when the biomass of fish ≤40 cm was low. One management implication of this is that sudden reduction in the indicator value may be caused by environmentally driven influxes of small fish, and not necessarily the result of a fisheries impact on the larger fish in the community.

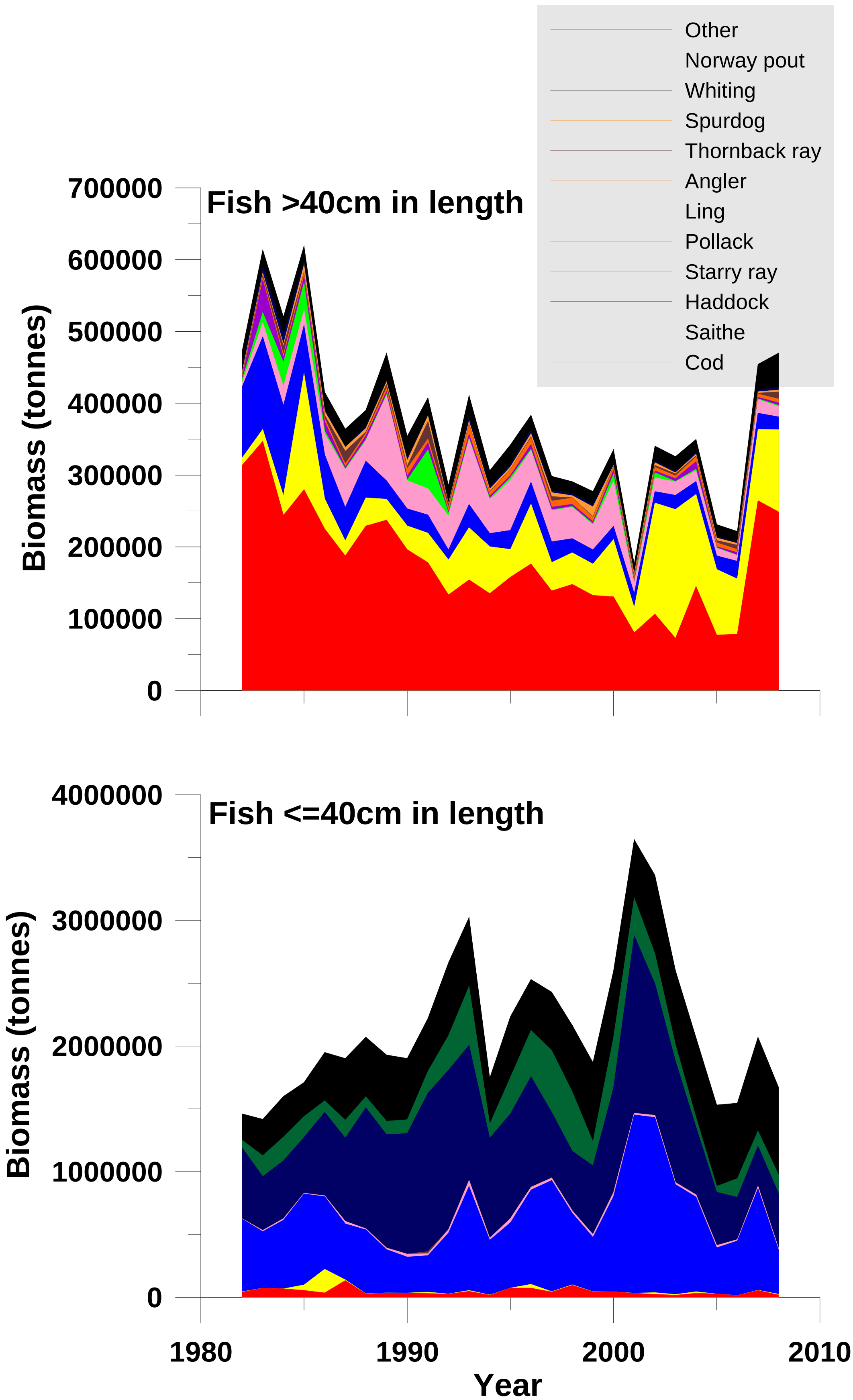

Figure 7.4.1. Trends in the biomass of key species making up the >40 cm in length and ≤40 cm in length components of the North Sea fish community.

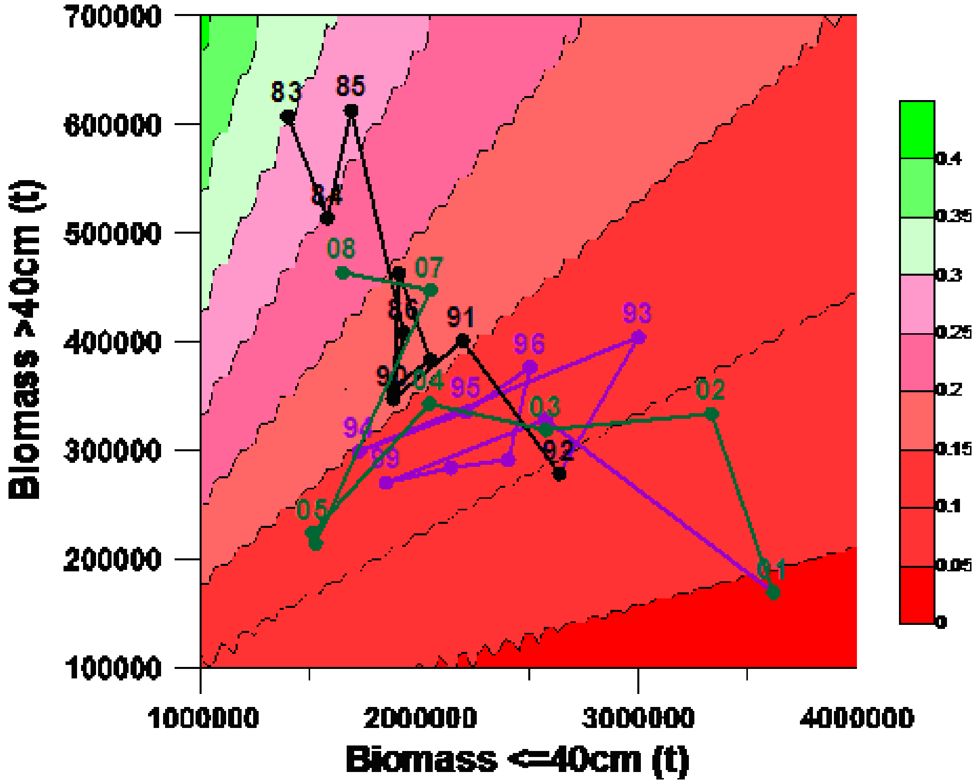

Figure 7.4.2. Contoured surface showing variation in the proportion of large fish indicator for varying biomass of fish >40 cm in length and ≤40 cm in length. The EcoQO value of 0.3 is indicated as the contour between green and red shades. The actual trajectory of the indicator is shown during three phases, the decline phase (black; 1983 to 1992), the "unhealthy" phase (purple; 1992 to 2001) and the recovery phase (green; 2001 to 2008).

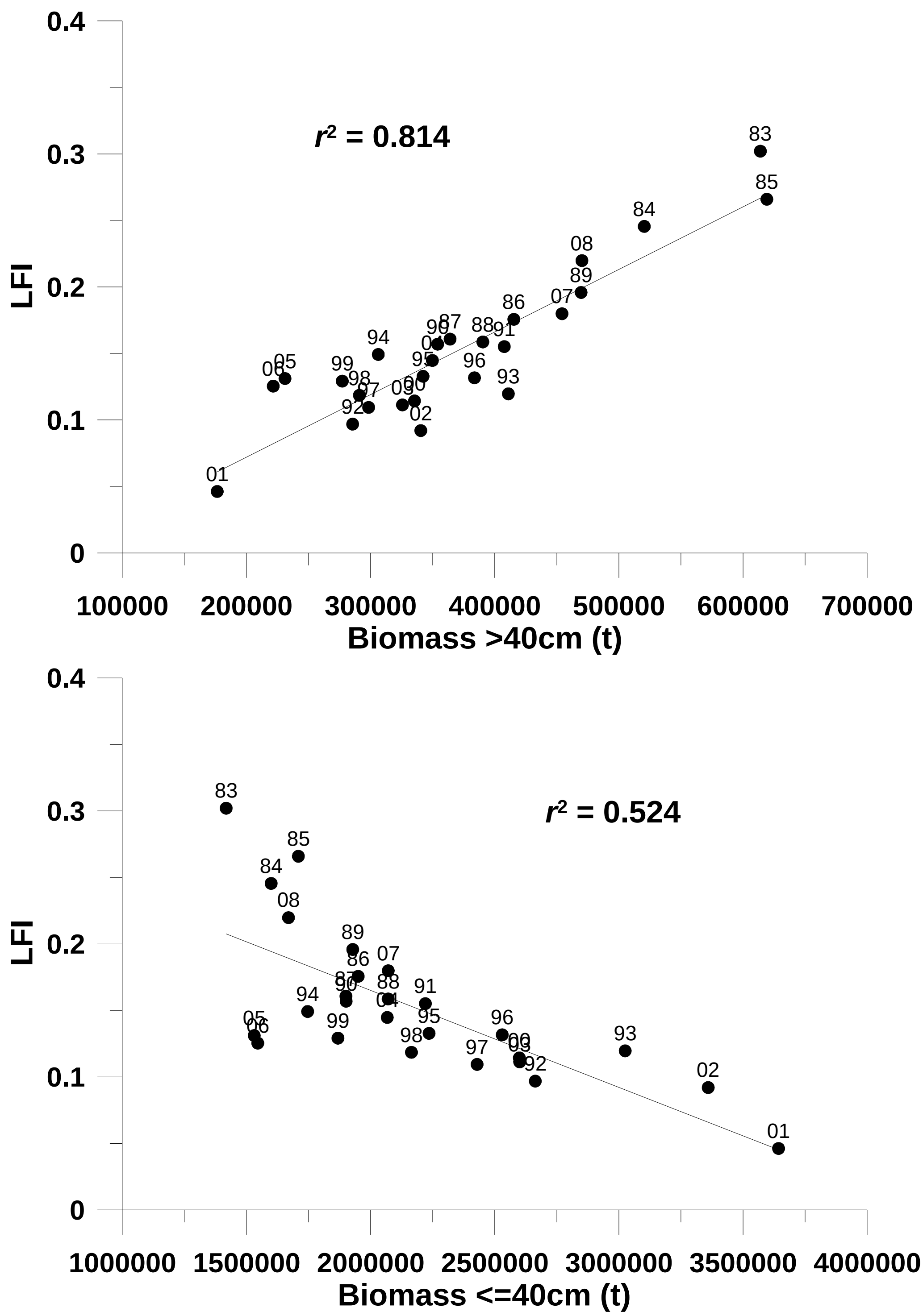

Figure 7.4.3. Relationship between the proportion of large fish indicator and variation in biomass of fish both larger and smaller or equal to the 40 cm bound.

There was some concern that recovery in the large fish indicator might be driven by single strong cohorts of one, or a few species, so that while the indicator might suggest an improving situation, diversity in the large fish component might be deteriorating. The principal components analysis QSR indicated that variation in the proportion of large fish indicator conveyed little information regarding biodiversity changes within the fish community, suggesting that this was an issue that needed to be addressed. Three diversity metrics were applied to the biomass data for fish >40 cm in length (Figure 7.4.4). These suggested that species richness in the large fish component of the community might actually have increased over the period for which data were available. The two dominance metrics suggested an increase in evenness during the "decline phase" in the proportion of large fish indicator and a decrease in evenness during the "recovery phase". However, 2008 values in both evenness metrics still exceeded the values prevalent at the start of the time-series.

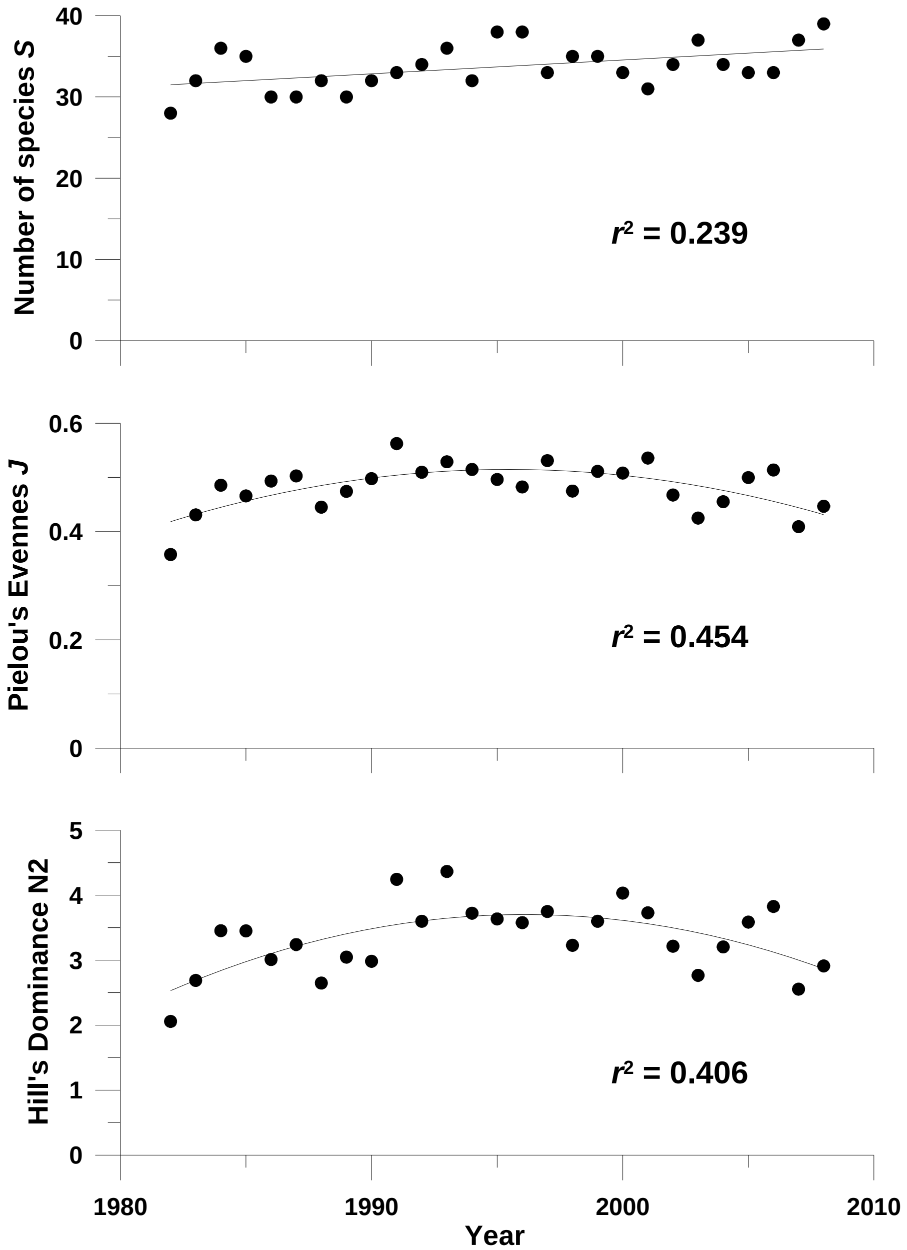

Figure 7.4.4. Trends in the number of species recorded, Pielou's species evenness (J) and Hill's dominance index (N2) calculated on the individual biomass data for species in the >40 cm in length component of the North Sea demersal fish community.

7.5 Concluding comments

Analyses undertaken for the OSPAR QSR raised two interesting issues. First, the proportion of large fish indicator varies spatially across the North Sea, with a pattern that was persistent over time despite major changes in exploitation rates and considerable variation in the overall regional scale North Sea indicator value. The resulting regional scale temporal variation in the indicator may need to be taken into account when formulating management advice, and may require some form of spatial resolution to be applied in the size-resolved multispecies modelling work that is currently in progress. The second issue, in respect of metric redundancy, established that the proportion of large fish indicator provides relatively specific information regarding changes in the overall composition, structure and function of demersal fish communities. To ensure that the range of aspects of change in fish communities likely to be of policy interest is covered, such as biodiversity, additional surveillance metrics will need to be applied.

This second issue was examined formally in a new analysis performed by WGECO. Examination of species richness and species evenness among the larger fish component of the North Sea demersal fish community suggested that biodiversity in the community was also improving, alongside the increase in the proportion of large fish.

Finally, the trajectory, in terms of the biomass of fish of both ≤40 cm and >40 cm in length considered independently, was examined. This helped to elucidate how the community had changed, giving rise to the observed trend in the proportion of large fish indicator. This empirical analysis helps in understanding the behaviour of the indicator and should inform the ongoing modelling work.

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8 ToR e Prioritizing fish species for research on fishing mortality

8.1 Terms of reference

The Working Group on Quantifying all Fishing Mortalities (WGQAF) requested WGECO to address the following ToR:

Provide a prioritized list and rational for inclusion of any non-commercial fish species that should be considered for research into fishing mortality estimates by WGQAF. Priority should be assigned according to use of the information addressing ecosystem objectives. Where possible, métiers and geographic locations should be included.

8.2 Basic considerations

There are a variety of rationales for prioritizing species for the assessment of fishing mortality. Several rationales are described below, followed by specific lists of species that derive from these rationales. A closing section discusses choices on policy and scientific grounds between rationales and the implied lists of prioritized species. The number of species to be considered depends on the resources available to WGQAF for conducting such assessments. The lists of species provided here are meant to be concise and to identify priorities within the large number of possible species to consider, and leave scope for WGQAF to choose from them according to feasibility considerations.

8.3 Methodological considerations

In many situations, it might be reasonable not to restrict the assessment of fishing mortality to non-commercial species, but to take any non-assessed species into account. In fact, there are a number of important commercial species/locations for which fishing mortality is poorly estimated.

For both commercial and non-commercial species, it should be noted that a considerable proportion of fishing mortality takes place underwater (escape mortality, ghost fishing; see ICES, 2005) and is not observable "on deck". This unaccounted mortality has previously been the focus of the ICES SGUFM and now is being considered by WGQAF.

As a reference for future efforts to estimate fishing mortality for large sets of non-commercial species, the work by Piet *et al.*, 2009 may be useful. This study introduces a spatially explicit model that combines abundance data of all the main fish species in the demersal North Sea fish community with international effort data and estimates of gear, species and size-dependent catch efficiency, to determine the mortality of non-commercial fish species caused by bottom-trawl fisheries and its spatial variation. Where necessary information was lacking, assumptions were made and a sensitivity analysis was performed to examine the impact of these on model results. Model outcomes were validated using international landings and discards data for five target species: cod, haddock, whiting, sole and plaice. This demonstrated that, depending on its configuration, the model could reproduce recorded landings and discards of these species reasonably well, confirming that the model could be used to simulate fishing mortality rates for non-commercial fish species. Sensitivity analyses revealed that model outcomes were most strongly influenced by the estimates of gear catch efficiency and the degree to which the distributions of fishing effort and the different species overlapped. Further details are described in Appendix in Section 8.7.

Most considerations below assume that abundance estimates for the species prioritized for mortality assessments are available. This is not a particularly strong assumption, because fishing mortality estimates generally require knowledge of overall abundance (Quinn and DeRiso, 1998). Moreover, many measures for improving the sustainability of fishing mortality in a stock can be based on relative abundance indicators rather than absolute abundance estimates, as long as the relative index reliably reflects trends in stock status.

8.4 Estimating fishing mortality for high-biomass species

Several arguments speak in favour of prioritizing non-assessed species with high biomass for estimating their fishing mortality.

a) Such estimates would provide valuable input for simulation models of marine foodwebs, because the dynamics of these models depend crucially on the species with highest biomass. For example, the ICES Working Group on Multispecies Assessment Methods (WGSAM) might have specific data requirements.

b) High-biomass species naturally play an in important role in top–down (Frank *et al*., 2005; Scheffer *et al*., 2005; Rossberg *et al*., 2008), bottom up (Ware and Thompson, 2005; Morten *et al*., 2007), and "middle-out" (Bakun *et al*., 2009; Cury, 2004; Cury *et al*., 2000) control of energy flows in biotic communities, and their status can characterize the state of the marine community. Fishing mortality estimates would contribute to understanding the degree to which fisheries are having an influence on energy flows and community dynamics. Additional information for identifying ecologically important non-commercial species could be derived from diet data or dynamic or static (Ecopath) foodweb models (Libralato *et al*., 2006). Testing the response of foodweb models to perturbations in the abundances of various species could reveal which species are the ones to which system dynamics is most sensitive.

c) Many system-level characterizations of the state of the marine ecosystem, e.g., the "proportion of large fish" EcoQO discussed in Section 7, are naturally dominated by high-biomass species. This is another reason why knowing the degree to which fisheries influence their population dynamics is important.

Examples for important high-biomass species are provided by the following list of demersal species currently included in the Marine Scotland/Strathclyde University foodweb model described Section 7. Some of these species (in bold) are assessed annually and so for these, a time-series of fishing mortality rates estimates are available. For the remaining eight non-assessed species included in the model, estimates of the rate of fishing mortality that they experience are currently based on the methods developed by Piet *et al*., 2009. It would be useful to explore whether alternative methods used to estimate fishing mortality in non-assessed species provide consistent results, or not, because the estimates of fishing mortality used in the model are likely to have a significant influence on model outcomes.

Benthivorous species
European plaice (*Pleuronectes platessa*)
Common dab (*Limanda limanda*)
Long-rough dab (*Hippoglossoides platessoides limandoides*)
Lemon sole (*Microstomus kitt)*

Piscivorous species
Atlantic cod (*Gadus morhua*)
Haddock (*Melanogrammus aeglefinus*)
Whiting (*Merlangius merlangus*)
Saithe (*Pollachius virens*)
Angler (*Lophius budegassa* and *L. piscatorius*)
Grey gurnard (*Eutrigla gurnardus*)
Common ling (*Molva molva*)
Starry ray (*Raja radiata*)

Planktivorous/Hyperbenthivorous species
Norway pout (*Trisopterus esmarkii*)
Poor cod (*Trisopterus minutus*)

8.5 Estimating fishing mortality for vulnerable species

Conservation considerations provide another set of rationales for prioritizing particular non-commercial and non-assessed commercial species for estimates of fishing mortality rates. For the purpose of this section, we mean by a vulnerable species a species whose populations are, for a given level of fishing effort or mortality, more likely to be adversely affected by fishing. In the following, specific considerations to identify such species are outlined.

8.5.1 Species that are vulnerable because of their life-history characteristics or ecology

Species can be vulnerable because of particular life-history characteristics (Hutchings, 2002; Gislason *et al*., 2009) or ecology. According to Garcia *et al*., 2008, species can be vulnerable to fishing pressure because of life-history characteristics such as are, for example, species with low productivity, i.e., low fecundity, slow growth rates, late sexual maturity and long interbirth interval, are less able to compensate for increased mortality and are therefore more vulnerable to depletion (MacArthur and Wilson, 1967). Long lived late maturing species will be adapted to a low natural mortality and even rather modest levels of fishing mortality can cause population decline. Sharks, rays and chimaeras as a group have life-history traits that make them particularly vulnerable to fishing (see Figure 8.5.1.1).

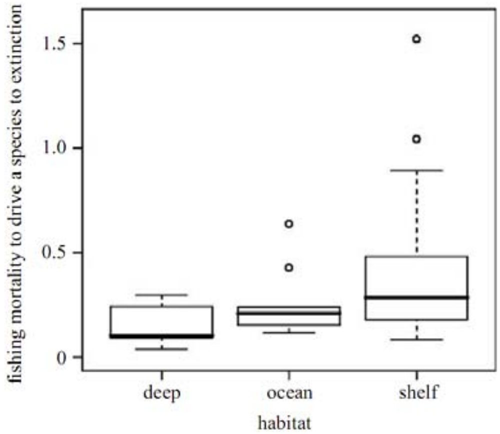

Figure 8.5.1.1. $F_{extinct}$ (the fishing mortality needed to drive a species to extinction) for sharks, rays and chimaeras (class *Chondrichthyes*) of the three main marine habitats. Bold line, median; box, interquartile range; whiskers, range (excluding outliers) and open circles, outliers. From Garcia *et al.*, 2008.

8.5.1.1 Specific approaches for identifying species vulnerable because of particular life history or ecology

Identifying species which are vulnerable because of particular life history or ecology can be difficult because most candidate species are not well studied. However, basic life-history information can contribute to estimating sustainable mortality rates for many marine species. Several approaches to identifying vulnerable species in situations of poor data availability are conceivable. The approaches suggested here use various strategies to derive an estimate for a reference point for fishing mortality from basic life-history information. Depending on the method, the reference point may be a limit for F, a bound on a target for F, or a surrogate for $F_{pa.}$ Species where the estimates are comparatively low are considered vulnerable. Knowing the actual fishing mortality of these species would be of particular interest.

a) An approach previously suggested in the literature is to estimate the natural mortality M for a species, and use that as a maximum bound on an allowable incidental F; the F=M strategy (see Clark, 1991 and references therein). If it is possible to age individuals of a species, then samples from fisheries or surveys can be used to get an estimate of maximum age (MaxAge) for the species in the area. If the fisheries of concern have been operating for many years, historical samples or literature values from a period when the population was not heavily exploited should be strongly preferred.

Two different lines of reasoning have been used to support an F=M strategy as appropriate to relatively long-lives and late-maturing species. The first rationale is just the logic that doubling mortality on a long-lived species (if F=M then Z=2M) might be near the limit of the ability of a low productivity species to compensate for increased mortality through increasing productivity. The other rationale is that many long life species that have been targeted in fisheries have undergone major declines in abundance when F exceeded M (Musick, 1999; Heifetz *et al.*, 2007; Love *et al.*, 2005). For additional discussion and references, including approaches for estimating M, see Clark, 1991 and García *et al.*, 2008.

b) The approach outlined under a) has been extended and implemented by WGECO (Appendix 8.7). Estimates of MaxAge are obtained indirectly form estimates of the von Bertalanffy parameters K and L_{inf} and an estimate for the age of initial capture in fisheries of concern. Assuming the latter age is older than the period of high larval and juvenile mortality, such that M can be assumed to be constant between the age-of-recruitment and MaxAge, the method provides an estimate of M. Estimates of sustainable fishing mortality are derived and compared with estimates of actual fishing mortality. By comparing sustainable fishing mortality with actual fishing mortality, a measure of fishing pressure is derived. This measure is demonstrated to correlate well with the rate of population decline determined from survey time-series. Details are described in Appendix 8.7.

c) In an approach suggested by Myers and Mertz, 1998 and Garcia *et al*., 2008 $F_{extinct}$ is defined as the average fishing mortality needed to drive a species to extinction. For deep-water chondrichthyan species the $F_{extinct}$ was estimated to be 38–58% of that estimated for oceanic and continental shelf species, respectively by Garcia *et al*., 2008. Following Myers and Mertz (1998), $F_{extinct}$ can be calculated iteratively from the following equation:

$$\tilde{\alpha} = \exp(F_{\text{extinct}}(a_{\text{mat}} - a_{\text{sel}} + 1))(1 - \exp(-(M + F_{\text{extinct}}))),$$

where $\tilde{\alpha}$ is the annual reproductive rate corrected by embryonic sex ratio; a_{mat} is the age at maturation; a_{sel} is the age at which fish enter the fishery; and M is natural mortality. When a_{sel} is set equal to 1 F-extinct is equivalent to the maximum intrinsic rate of population increase (r_{max}), which is a standard measurement of population productivity and extinction risk (Dulvy *et al*., 2005). We suggest that WGQAF might use this approach to estimate $F_{extinct}$ for species as this will be useful for assessing the vulnerability of the stocks to present level of fishing mortality.

d) Yet another approach, with similarly low data requirements, derives from the observation that F_{lim} or F_{pa} are often positively correlated with a stock's non-fishing biomass B_0 (the biomass it would have in the absence of fishing pressure), Figure 8.5.2.1. It is currently unclear if this correlation is mainly as a result of allometric scaling relations or mainly because of variations of population growth rates within L_{max} size classes. In the latter case, estimates of F_{lim} or F_{pa} for non-assessed species could be obtained by interpolating established values of F_{lim} for well-studied species. This would imply that species with low biomass are particularly vulnerable to fishing mortality.

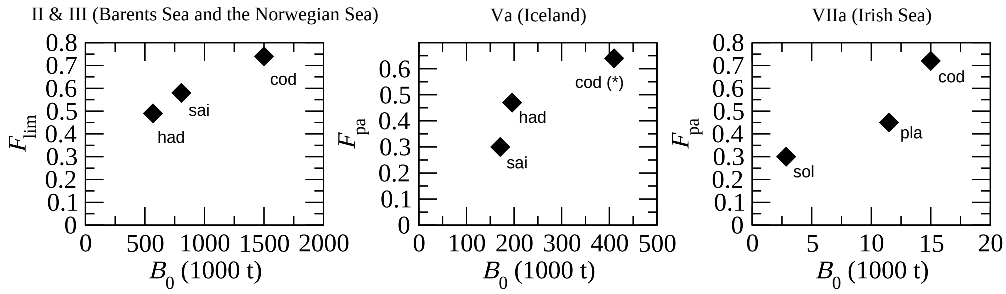

Figure 8.5.2.1. Assessment results for F_{lim} or F_{pa} (annual mortalities) in relation to the zero-catch biomass B_0 for specific ICES regions as reported by ICES 2008. The correlations exhibited in the graphs could help identifying precautionary limits for non-assessed species. (*) F_{pa} for Icelandic Cod estimated as $2F_{msy}$.

8.5.2 Species that are vulnerable as a consequence of high catchability

Here we consider species that are particularly vulnerable, because they are expected to have a high catchability relative to target species with which they co-occur spatially. These species would be a priority because they could be suffering an unsustainable fishing mortality rate even if fishing mortality on the target species was sustainable. Species with particularly high catchabilities (Walsh *et al.*, 2004; Arreguín-Sánchez, 1996) could be taken in the gear at rates higher than the target species, and actually be suffering greater mortality than the target species. Such species can be identified through an analysis of the geometry of the species and their degree of aggregation relative to target species in the same fishery. The ICES-FAO Working Group on Fish Technology and Fish Behaviour (WGFTFB) would be well-placed to conduct such analyses.

8.5.3 Commercially important non-assessed species

Species which are considered to be commercially important but are not assessed at present are a priority because their commercial importance makes it likely that they will attract fishing effort, and without periodic assessments of the sustainability of fishing mortality a key feedback for management of the fishing effort is not available. Such species can be identified simply by reviewing the list of marketed species in various areas, relative to the lists of species in those areas for which assessments are done. For example, the following are Species with EU quota and no ICES 2008 or ICCAT 2009 assessment:

Common dab (*Limanda limanda*)
Lemon sole (*Microstomus kitt*)
Turbot (*Psetta maxima*)
Roundnose grenadier (*Coryphaenoides rupestris*)
Blue ling (*Molva dypterygia*)
Common Ling (*Molva molva*)
Tusk (*Brosme brosme*)
Flounder (*Platichthys flesus*)
Pollack (*Pollachius pollachius*)

In addition to these, the ICES Working Group on Assessment of New MoU Species (WGNEW) covers the following non-assessed commercial species:

Sea bass (*Dicentrarchus labrax*)
Brill (*Scophthalmus rhombus*)
Witch flounder (*Glyptocephalus cynoglossus*)

Red gurnard (*Aspitrigla cuculus* or *Chelidonichthys cuculus*)
Grey gurnard (*Eutrigla gurnardus*)
Tub gurnard (*Trigla lucerna* or *Chelidonichthys lucernus*)
Striped red mullet (*Mullus surmuletus*)
John Dory (*Zeus faber*)

Skates and rays, which may be vulnerable by life-history traits (Musick, 1999), have a generic EU quota and are not assessed by ICES 2008. These groups include:

Thornback ray (*Raja clavata*)
Spotted ray (*Raja montagui*)
Starry ray (*Amblyraja radiata*)
Cuckoo ray (*Leucoraja naevus*)
Common skate (*Dipturus batis*)
Blonde ray (*Raja brachyura*)
Lesser spotted dogfish (*Scyliorhinus canicula*)
Smooth hound and starry smooth hound (*Mustelus mustelus* and *M. asterias*)
Angel shark (*Squatina squatina*)

and

Kitefin shark (*Dalatias licha*)
Basking shark (*Cetorhinus maximus*)
Porbeagle shark (*Lamna nasus*)
Spurdog (*Squalus acanthias*).

For some species ICES 2008 provides advice but no assessment. These are

Red Sea bream (*Pagellus bogareveo*)
Greater Argentine (*Argentina silus*)
Greater Forkbeard (*Phycis blennoides*)
Black scabbard (*Aphanosus carbo*)
Alfonsinos (*Beryx* spp.).

Some shellfish species other than *Nephrops* also belong to this category.

8.5.4 Species that have exhibited unexplained population declines

Understanding the causes of declines in fish populations is necessary for appropriate conservation measures to be identified. Even when fisheries are not a primary cause of a decline, it is useful to know the scope that is available to reduce total mortality of such species through measures to reduce capture or increase survivorship in fisheries. Dulvy *et al*., 2005 developed a threat score that identifies such species and applied this to 23 mostly non-commercial North Sea fish species. In this study threat was assessed using IUCN decline criteria (IUCN, 2004). Results reveal that large-bodied species, including wolfish, cod, rays, and spurdog, consistently met one of the threat criteria (Figure 8.5.5.1). Rate-of-decline criteria resulted in previously threatened species becoming less threatened toward the end of the time-series (Figures 8.5.5.1*a* and 8.5.5.1*b*). However, when using extent-of-decline criteria, the number of threatened species and the degree of threat increased over time (Figure 8.5.5.1*c*).

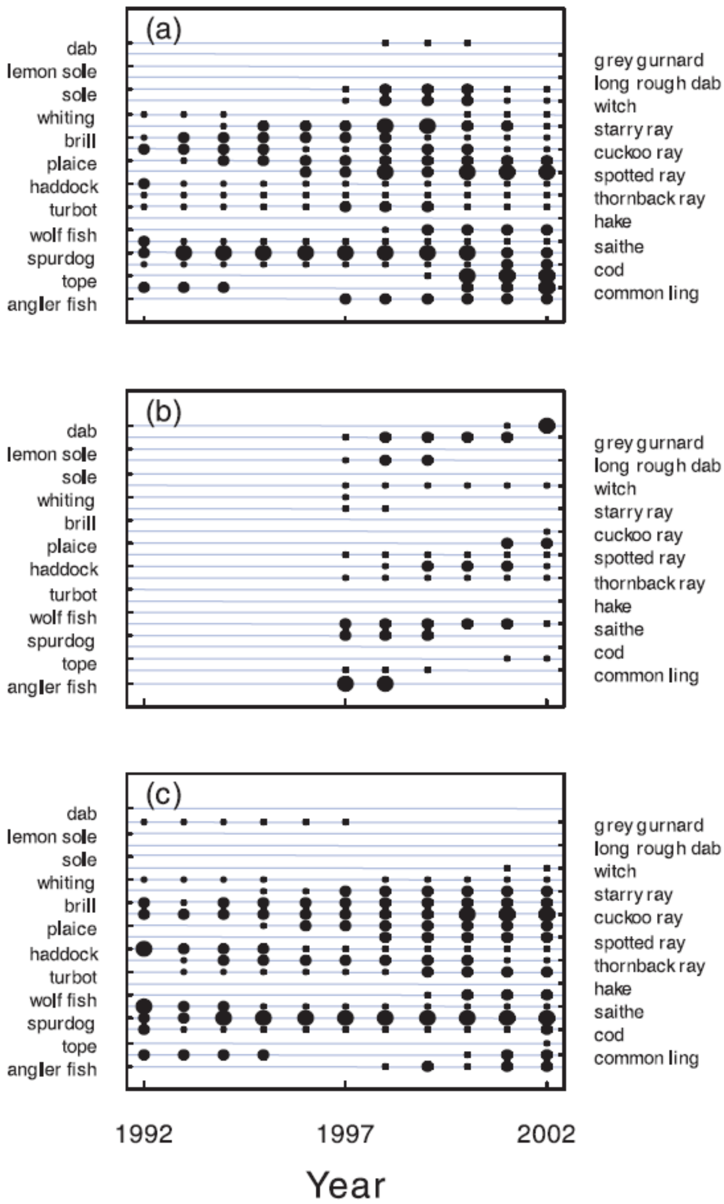

Figure 8.5.5.1. Species threat scores in each year measured as (a) rate of decline with a 10-year window, (b) rate of decline with a 15 year window, and (c) extent of decline. Species are plotted in descending rank order of body size, with smallest species at the top. Point size is proportional to threat scores, with the largest, intermediate, and smallest symbols representing declines over the qualifying time of >= 90%, >= 70%, and >= 50%, respectively. From Dulvy *et al.*, 2005.

8.5.5 Species listed as being of concern by conservation agencies

Several marine species directly affected by fishing are assessed by conservation agencies to be under threat of local or global extinction. These are species which the conservation agencies have flagged as in urgent need of conservation actions. Assessing fishing mortality on these species will contribute to determining both the possible role of fisheries as threats to recovery of these species, and opportunities for promoting recovery through reducing fishing mortality.

In the following we list marine fish and invertebrate species in the ICES area identified by various authorities using their protected-species criteria. (This list does not constitute ICES endorsement of either the criteria used by any of these agencies, or the degree of risk of extinction assigned by the agencies).

<u>OSPAR threatened and declining species</u>
<u>Invertebrates:</u>
Ocean quahog (*Arctica islandica)*
Azorean barnacle (*Megabalanus azoricus)*
Dog whelk (*Nucella lapillus)*
Flat oyster (*Ostrea edulis)*
Azorean limpet (*Patella ulyssiponensis aspera)*
<u>Fish</u>:
Sturgeon (*Acipenser sturio)*
Allis shad (*Alosa alosa)*
European eel (*Anguilla anguilla)*
Portuguese dogfish (*Centroscymnus coelolepis*)
Gulper shark (*Centrophorus granulosus*)
Leafscale gulper shark (*Centrophorus squamosus*)
Basking shark (*Cetorhinus maximus*)
Houting (*Coregonus lavaretus oxyrinchus*)
Common Skate (*Dipturus batis,* synonym: *Raja batis*)
Spotted Ray (*Raja montagui,* synonym: *Dipturus montagui*)
Cod (*Gadus morhua– populations in the OSPAR regions II and III*)
Long-snouted seahorse (*Hippocampus guttulatus,* synonym: *Hippocampus ramulosus*)
Short-snouted seahorse (*Hippocampus hippocampus*)
Orange roughy (*Hoplostethus atlanticus*)
Porbeagle (*Lamna nasus*)
Sea lamprey (*Petromyzon marinus*)
Thornback skate / ray (*Raja clavata*)
White skate (*Rostroraja alba*)
Salmon (*Salmo salar*)
[Northeast Atlantic] Spurdog (*Squalus acanthias*)
Angel shark (*Squatina squatina*)
Bluefin tuna (*Thunnus thynnus*)

<u>Species, populations, and stocks listed as Critically Endangered (CR), Endangered (EN), or Vulnerable (VU) in the 2006 Norwegian Redlist (Kålås *et al*., 2006)</u>:

Species:	
Sand eel (*Ammodytes marinus*)	VU
European eel (*Anguilla anguilla*)	CR
Aspius aspius	VU
Porbeagle (*Lamna nasus*)	VU
Blue ling (*Molva dypterygia*)	VU
Fourhorn sculpin (*Myoxocephalus quadricornis*)	VU
Ocean perch (*Sebastes marinus*)	VU
Deepwater redfish (*Sebastes mentella*)	VU
Spurdog (*Squalus acanthias*)	CR

Populations or stocks:	
Arctic cod (*Boreogadus saida*), Polartorsk,	CR
Atlantic cod (*Gadus morhua*), Kysttorsk north of 62N	EN
Atlantic salmon (*Salmo salar*), Bleke	CR
Atlantic salmon (*Salmo salar*), Namsblank	CR

Endangered or critically endangered fish in the NE Atlantic (including estuaries) from the IUCN redlist (http://www.iucnredlist.org, excluding invertebrates):

Common Sturgeon (*Acipenser sturio*)	CE
European Eel (*Anguilla anguilla*)	CE
Aphanius baeticus	EN
Dusky Grouper (*Epinephelus marginatus*)	EN
Atlantic Halibut (*Hippoglossus hippoglossus*)	EN
Island Grouper (*Mycteroperca fusca*)	EN
Red Porgy (*Pagrus pagrus*)	EN
Acadian or Rose Redfish (*Sebastes fasciatus*)	EN

8.6 Synthesis

8.6.1 Policy prioritization

There are policy rationales for making each of the above selection criteria the major priority for selecting non-commercial species for estimating fishing mortality. It is for clients of ICES advice to choose which policies pose the most urgent needs for science support. However, in each case ICES would be positioned to make some contribution the policy needs.

8.6.1.1 High-biomass species

The Marine Strategy Framework Directive (Directive 2008/56/EC) requires definition of Good Environmental Status (GES) by 2012, and monitoring programmes to support assessment of GES by 2015. Furthermore it lists eleven Descriptors of GES, two of which-Food Webs and Biodiversity-are likely to require ecosystem modelling in order to provide indicators for assessment. High-biomass species play critical roles in the dynamics of ecosystem models. Hence knowledge of the fishing mortality on high-biomass species could contribute important information to the assessment of GES.

8.6.1.2 Species with high vulnerability

Both the Convention on Biological Diversity Resolution COP IX/20 and the FAO Technical Guidelines for Deep-Sea Fisheries on the High Seas include presence of species that are able to support only low rates of fishing mortality as criteria for Ecologically and Biologically Significant Areas (CBD) or Vulnerable Marine Ecosystems (FAO). Fisheries in areas that meet these criteria can only proceed with a number of additional operational constraints, including mitigation measures and encounter protocols, or else are not be authorized. Hence estimates of the fishing mortality on species that are identified as particularly vulnerable would be a key contribution to demonstrating compliance with these international policy commitments.

8.6.1.3 Species listed as at risk of extinction

Many national legislations, and the Species and Habitats Directives and CITES, which are binding on member states, require actions to minimize harm and to promote recovery of listed species. The IUCN Redlist is not binding, but has a strong influence on public debate and policy formation on sustainable use of natural resources. Hence, for species that are listed by these bodies, there is a need to establish both the degree to which fisheries pose threats to current status, and the potential for measures that would reduce mortality in fisheries to contribute to recovery.

8.6.2 Scientific prioritization

Prioritizing on scientific grounds between preferences for research by WGQAF on high-biomass species or on vulnerable species is difficult, because it partially requires value judgements.

Generally it can be said that rationales for prioritizing high-biomass species rather tend to aim at long-terms goals, related to a deeper understanding of marine communities. Generally, and in particular in the context of ecosystem simulations, arguments favouring high-biomass species come to full force only when information for larger sets of species is included, because only then they would contribute significantly to improving the accuracy of predictions-provided the purpose is not just the verification of the mortality estimates currently used.

Investigations of fishing mortality for vulnerable species could provide more immediate guidance to management. Generally, information relating to each individual species could be used independently, especially if the vulnerable species are rare, because rare species tend to have a weak effect on other species and their population dynamics can therefore be more easily described independently.

However, stocks of rare species, by comprising less biomass, tend to have low immediate economic value. The choice between prioritizing high-biomass species or vulnerable rare species therefore partially depends on the valuation of biodiversity.

In choosing between specific locations for estimates of fishing mortality, well-studied areas are preferred by the rationales for the inclusion of high-biomass species, because for these modelling and community characterization is most advanced and information of fishing mortality would complement other information available already. With respect to vulnerable species, no specific recommendation for locations can be made.

In choosing between different métiers, all rationales considered here speak in favour or prioritizing the most commonly used métiers, thereby taking heuristic considerations regarding the catchability of the studied species into account.

8.6.3 Two shortlists of species

Our analysis above identifies five species that have high biomass and, at the same time, can be considered vulnerable because they are commercially relevant (an EU quota exists) but not assessed. These are:

Common dab (*Limanda limanda*)
Lemon sole (*Microstomus kitt*)
Grey gurnard (*Eutrigla gurnardus*)
Common ling (*Molva molva*)
Starry ray (*Amblyraja radiata*)

The analysis in the Appendix (Section 8.7) identifies the following three species as particularly vulnerable by combining information on life-history traits, fishing-mortality estimates, and population trends:

Wolffish (*Anarhichas lupus*)
Common ling (*Molva molva*)
Blond ray (*Raja brachyura*)

Pending specific requests of ICES clients for advice, WGECO recommends choosing from these seven species for research on fishing mortality (common ling is contained in both lists).

The exchange between WGQAF and WGECO on this important question should be continued and intensified.

8.7 Appendix: Identification species vulnerable by their life-history traits

A recent study has developed a simple catchability model to estimate the proportion of individuals of approximately 45 North Sea fish species, which, if in the path of either a commercial otter or beam trawl, would be retained in the net. The model was then "driven" using estimates of otter trawl and beam trawl fishing effort and applied to estimates of the abundance of each species derived from scientific groundfish survey data, corrected to take account of species- and size-specific variation in the catchability of fish in the survey trawl (e.g., Fraser *et al.*, 2007). Both datasets were determined at the ICES 0.5° latitude by 1.0° longitude statistical rectangle spatial resolution. The model produced estimates of the proportion of the population of each of the 45 species present at the start of the year that was removed by the two fisheries; for the first time therefore, producing estimates of fishing mortality for 39 non-assessed species in the North Sea (Piet *et al.*, 2009).

For these 39 species, a critical question is whether these levels of bycatch fishing mortality are sustainable or not? Previous work (Myers and Mertz, 1998; Garcia *et al.*, 2008) has suggested that fishing mortality rates equal to rates of natural mortality are likely in most species to be sustainable over the long term. So, if natural mortality rates can be estimated for the non-assessed species, then these could be used as proxies for the required rates of sustainable fishing mortality (F_{sus}).

For most species, growth follows the von Bertalanffy growth function

$$L_{S,t} = L_{\infty,S}(1 - e^{-K_S(t-t_0)}) \qquad 1.$$

where for any species (S), length at a given time t (in years) is determined by two species-specific parameters, $L_{\infty,S}$ and K_S, the final body length which an individual might be expected to reach under natural conditions (known as length infinity, or ultimate body length) and a growth term describing the speed at which a fish proceeds to this length. Because t is relative to t_0, setting t_0 to zero allows the equation to be easily rearranged to find the solutions for t at various body lengths of any particular species.

$$t = \frac{Ln\left(1 - \frac{L_{S,t}}{L_{\infty,S}}\right)}{-K_S} \qquad 2.$$

This equation can be used to determine the age of individuals of each species at two particular body lengths. First, the length to which we might reasonably expect an individual to grow in the absence of fishing mortality, here defined as $0.95L_{\infty,S}$, can be substituted for $L_{S,t}$ to give $t_{S,0.95L_{\infty,S}}$, the age of the fish when it has reached this length. Second, the length ($L_{F,S}$) at which individuals might start to be taken in the fishery bycatch can be substituted for $L_{S,t}$ to give $t_{S,L_{F,S}}$, the age when the fish effectively recruits to the fished population. The period of time over which individual fish surviving to reach $0.95L_{\infty,S}$ are exposed to the risk of fishing mortality ($t_{S,risk}$) is now easily defined as

$$t_{S,risk} = t_{S,0.95L_{\infty,S}} - t_{S,L_{F,S}} \qquad 3.$$

It is widely assumed that by the time that most species reach the length that they become exposed to fishing mortality, natural mortality rates have settled to a relatively constant rate. The standard mortality rate (*Z*) equation

$$N_t = N_0 e^{-Zt} \qquad 4.$$

can be rearranged to solve for *Z*:

$$Z = \frac{-Ln\left(\frac{N_t}{N_0}\right)}{t} \qquad 5.$$

where N_t is the number of individual surviving at the end of a time period of duration *t* (in years) and N_0 is the number of individuals at the start of the time period. Given that total mortality (*Z*) is the sum of fishing mortality (*F*) and natural mortality (*M*) (*Z*=*F*+*M*), in the absence of fishing *F*=0 so *Z*=*M*, by substituting $t_{S,risk}$ for *t* and setting N_t to 1 and N_0 to 1000, the natural mortality rate that would reduce a cohort of fish of any particular species to 0.1% of their initial abundance over the period that they would be exposed to fishing mortality risk in the presence of fishing (M_S) can now be determined. Given the premise stated above, that the natural mortality rate is equivalent to the sustainable rate of fishing mortality (M_S=$F_{S,sus}$), the estimates of M_S derived using this method provide the proxy estimates of $F_{S,sus}$ required to assess whether the rates of fishing mortality on non-assessed species observed in Piet *et al.*, 2009 study are in fact sustainable or not. The instantaneous rates of mortality, derived using the equations above, however, first have to be converted to annual percentage removals ($Z_{\%ann,S,sus}$) to render the data compatible with the values provided by Piet *et al.*, 2009.

$$Z_{\%ann,S,sus} = 100 - \left(100e^{-Zt}\right) \qquad 6.$$

where *t*=1y.

Table 8.7.1 lists the species for which Piet *et al.*, 2009 provide modelled fishing mortality data and the von Bertalannfy parameters used to estimate sustainable levels of fishing mortality for each of these species. Plotting actual modelled annual removals by fisheries against estimates of sustainable annual removals, and demonstrating the sustainable line of *F*=*M*, clearly identifies those species whose current losses in the bycatch may be unsustainable, and those species for which bycatch mortality may not be an important factor in their population dynamics (Figure 8.7.1). Species with $L_{\infty,S}$ values that suggest that they are unlikely ever to grow large enough to be subjected to fishing mortality (see Table 8.7.1), were arbitrarily assigned an $F_{S,sus,\%ann}$ value of 100% so that they could be represented in the most appropriate position on the plot (Figure 8.7.1). The data suggest that in the North Sea there was a strong tendency for species whose life-history characteristics (ultimate body size and growth rate) render them most vulnerable to fishing mortality (low sustainable F) to be experiencing some of the highest levels of fishing mortality and, in many instances, these mortality rates may well be unsustainable.

Table 8.7.1. List of species for which modelled estimates of the proportion of individual removed annually by fisheries ($F_{\%ann,S}$) were provided by Piet *et al.*, 2009. Von Bertalannfy growth function parameters ($L_{\infty,S}$ and K_S) and assumed lengths-at-entry to the bycatch ($L_{F,S}$) used to estimate final age ($t_{S,0.95L_{\infty,S}}$) and age-at-entry to the bycatch ($t_{S,L_{F,S}}$) for each species are provided, giving the eventual species-specific estimates of the risk period ($t_{S,risk}$), instantaneous rate of sustainable fishing mortality ($F_{S,sus}$) and sustainable annual removal percentages ($F_{S,sus,\%ann}$). Grey shaded cells indicate data for assessed species. Species with blank cells in the four columns on the right of the table have length infinity values that are less than the length at which they might be likely to enter into the fishery, $L_{\infty,S}$<$L_{F,S}$. Such a condition results in an incomputable result when $L_{F,S}$ is substituted for $L_{S,t}$ in equation 2.

Common name	Code	F%ann,S	KS	L∞,S	LF,S	$t_{S,0.95L_{\infty,S}}$	$t_{S,L_{F,S}}$	tS,risk	FS,sus	FS,sus,%ann
Wolffish	CAT	53	0.047	117.4	25	63.7	5.1	58.6	0.118	11.1
European eel	EEL	59	0.076	83.2	27	39.4	5.2	34.3	0.202	18.3
Scaldfish	SCF	8	0.840	15.8	20	3.6				
Solenette	SOL	5	0.540	11.7	20	5.5				
Common dragonet	DRA	2	0.471	22.2	25	6.4				
Spotted dragonet	SDR	5	0.402	12.7	25	7.5				
Tub gurnard	TUB	21	0.148	65.0	25	20.2	3.3	17.0	0.407	33.5
Lesser weever	WEE	0	0.417	11.9	25	7.2				
Four-bearded rockling	FOR	5	0.196	36.0	25	15.3	6.0	9.2	0.748	52.7
Snake pipefish	SPI	44	0.193	46.1	25	15.5	4.1	11.5	0.601	45.2
Grey gurnard	GGU	10	0.156	46.2	25	19.2	5.0	14.2	0.486	38.5
Tope shark	TOP	16	0.168	163.0	25	17.8	1.0	16.8	0.410	33.6
Black mouthed dogfish	BMD	57	0.154	68.6	27	19.5	3.3	16.2	0.426	34.7
Witch	WIT	30	0.165	45.5	20	18.2	3.5	14.6	0.472	37.6
Long-rough dab	LRD	11	0.336	24.6	20	8.9	5.0	3.9	1.760	82.8
Halibut	HAL	37	0.100	204.0	20	30.0	1.0	28.9	0.239	21.2
Megrim	MEG	40	0.073	51.8	20	41.0	6.7	34.4	0.201	18.2
Sandy ray	SAR	36	0.131	90.9	19	22.8	1.8	21.0	0.328	28.0
Cuckoo ray	CRA	29	0.109	91.6	19	27.5	2.1	25.4	0.272	23.9
Dab	CDA	29	0.261	26.7	20	11.5	5.3	6.2	1.118	67.3
Anglerfish	ANG	48	0.176	135.0	25	17.0	1.2	15.9	0.436	35.3
Vahl's eelpout	VEE	12	0.209	40.1	25	14.3	4.7	9.7	0.715	51.1
European hake	HAK	50	0.107	103.6	25	28.0	2.6	25.4	0.272	23.8

Common name	Code	F%ann,S	KS	L∞,S	LF,S	$t_{S,0.95L_{\infty,S}}$	$t_{S,L_{F,S}}$	tS,risk	FS,sus	FS,sus,%ann
Lemon sole	LSO	28	0.415	37.1	20	7.2	1.9	5.4	1.291	72.5
Common ling	LIN	69	0.118	183.0	25	25.4	1.2	24.1	0.286	24.9
Striped red mullet	RMU	5	0.430	33.4	25	7.0	3.2	3.8	1.839	84.1
Smooth hound	SHO	33	0.060	205.0	25	49.9	2.2	47.8	0.145	13.5
Bullrout	BRO	2	0.240	34.0	25	12.5	5.5	6.9	0.995	63.0
Flounder	FLO	84	0.230	47.3	20	13.0	2.4	10.6	0.650	47.8
Pollack	LYT	59	0.186	85.6	25	16.1	1.9	14.2	0.485	38.4
Turbot	TUR	81	0.320	57.0	20	9.4	1.4	8.0	0.862	57.8
Blond ray	BRA	98	0.120	139.0	19	25.0	1.2	23.7	0.291	25.2
Thornback ray	TRA	71	0.220	105.0	19	13.6	0.9	12.7	0.544	41.9
Spotted ray	SPY	58	0.148	97.8	19	20.2	1.5	18.8	0.368	30.8
Brill	BRI	95	0.270	50.0	20	11.1	1.9	9.2	0.751	52.8
Lesser-spotted dogfish	LSD	42	0.200	90.0	25	15.0	1.6	13.4	0.517	40.4
Spurdog	SPU	39	0.150	90.2	25	20.0	2.2	17.8	0.388	32.2
Bib	BIB	2	0.211	38.0	25	14.2	5.1	9.1	0.758	53.1
Poor cod	PCO	1	0.506	20.3	25	5.9				
Cod	COD	45	0.230	123.1	25	13.0	1.0	12.0	0.574	43.7
Haddock	HAD	13	0.190	68.3	25	15.8	2.4	13.4	0.517	40.4
Whiting	WHI	11	0.320	42.4	25	9.4	2.8	6.6	1.050	65.0
Plaice	PLA	75	0.110	54.4	20	27.2	4.2	23.1	0.299	25.9
Saithe	SAI	42	0.070	177.1	25	42.8	2.2	40.6	0.170	15.6
Sole	DSO	51	0.280	39.2	20	10.7	2.5	8.1	0.848	57.2

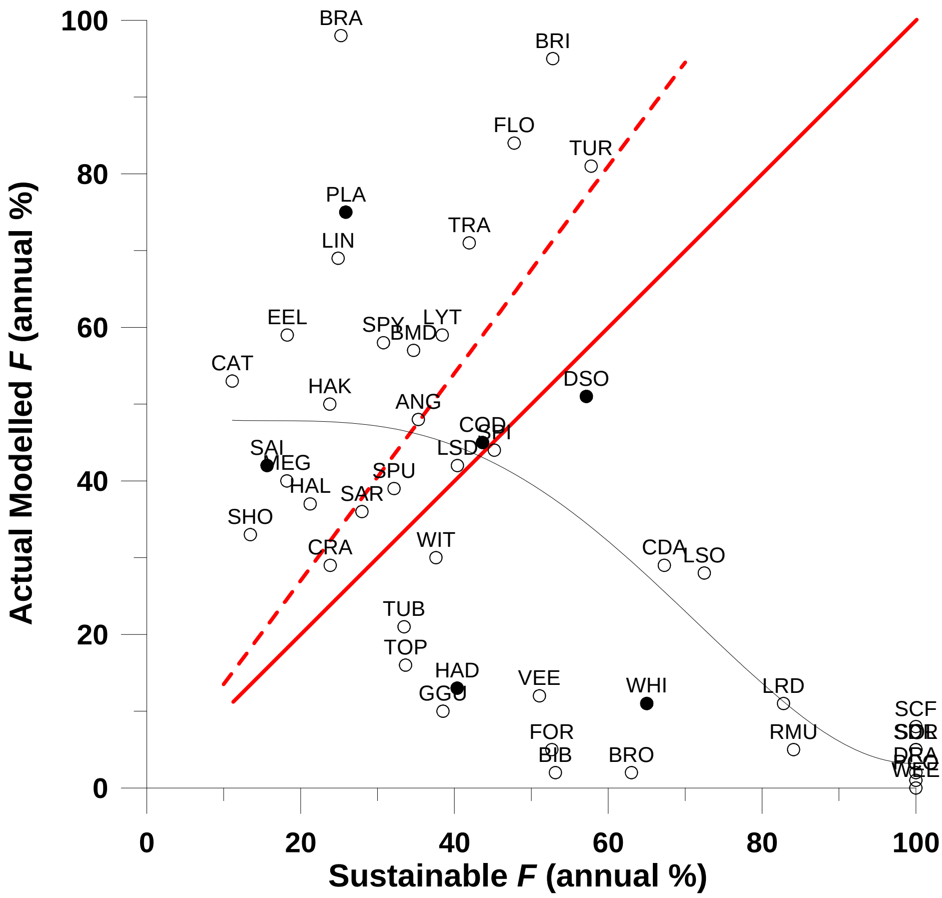

Figure 8.7.1. Modelled estimates of actual annual removals by fishing derived by Piet *et al.*, 2009 plotted against estimates of annual removals that would be sustainable over the long term. A polynomial smoother is fitted to the data to illustrate trends ($r2$=0.336, P<0.01). Red solid line shows the relationship anticipated for species being bycaught at sustainable levels (assuming the $F_{sus}=M$, see text) and red dashed line shows indicates the arbitrary 35% error added to this to identify species (those whose plot lies above the dashed line) whose levels of fishing mortality in the bycatch are likely to be critically high. For explanation of three letter codes, see Table 8.7.1.

Table 8.7.2. Species identified as potentially experiencing critically high levels of fishing mortality.

LATIN NAME	COMMON NAME	3 LETTER CODE
Galeus melastomus	Black mouthed dogfish	BMD
Mustelus mustelus	Smooth hound	SHO
Raja brachyura	Blond ray	BRA
Raja clavata	Thornback ray	TRA
Raja montagui	Spotted ray	SPY
Anarhichas lupus	Wolffish	CAT
Anguilla anguilla	European eel	EEL
Lophius piscatorius	Anglerfish	ANG
Merluccius merluccius	European hake	HAK
Molva molva	Common ling	LIN
Pollachius pollachius	Pollack	LYT
Pollachius virens	Saithe	SAI
Hippoglossus hippoglossus	Halibut	HAL
Lepidorhombus whiffiagonis	Megrim	MEG
Platichthys flesus	Flounder	FLO
Pleuronectes platessa	Plaice	PLA
Psetta maxima	Turbot	TUR
Scophthalmus rhombus	Brill	BRI

To test this idea, an arbitrary "error margin" of 35% was applied to the plot in Figure 8.7.1 and this identified 18 species of immediate concern; species for which fishing mortality rates may be at critically high levels. This included five elasmobranch species, four gadoid species and six flatfish species (Table 8.7.2). For fifteen of these species, catch rates in the ICES Q1 IBTS were sufficient to examine biomass trends. A simple population trend metric (P_S), based on the first five and last five years of the time-series, was derived.

$$P_S = Log\left(\frac{\overline{B_{S,2004-2008}}}{\overline{B_{S,1982-1986}}}\right) \qquad 7.$$

where for species S, $\overline{B_{S,1982-1986}}$ was the average biomass density over the five year period 1982 to 1986 and $\overline{B_{S,2004-2008}}$ was the average biomass density over the five year period 2004 to 2008. This metric was plotted against variation in an overexploitation index determined as

$$E_S = Log\left(\frac{F_{\%ann,S}}{Z_{\%ann,S}}\right) \qquad 8.$$

where $F_{\%ann,S}$ is Piet *et al.*, 2009 modelled annual percentage of the population removed by fishing (Figure 8.7.2).

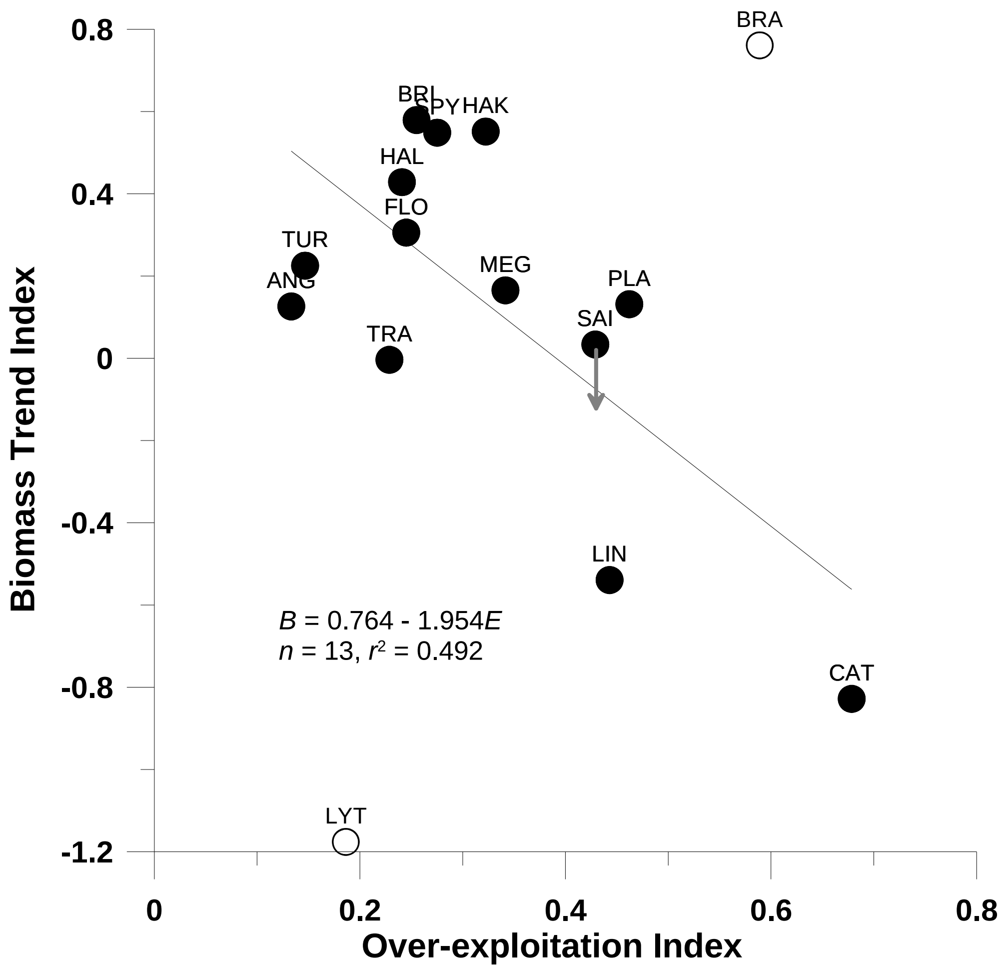

Figure 8.7.2. Relationship between indices of overexploitation in 15 species selected as being at greatest risk. See Table 8.7.1 for 3-letter codes. Two outliers excluded from the correlation analysis are indicated by open circles. Possible adjustment of the saithe (SAI) datum, resulting from the miss-identification of pollack, is indicated by an arrow.

Two outliers were identified. Pollack abundances in the IBTS were relatively high at the start of the time-series, but were considerably scarcer by the end of the time-series. Pollack (LYT) is a species normally associated with reefs and ship-wrecks; habitats that the IBTS generally avoids. The high abundances early in the time-series were therefore considered to be unlikely. This species closely resembles saithe and it is more likely that fish identified as pollack in the early 1980s were in fact saithe. The problem was particularly evident in 1984 and 1985 when "pollack" abundance was about an order of magnitude greater than in the other three years. Pollack was therefore excluded from the analysis. One consequence of this error is that the saithe biomass trend index is to be too high a value. The extent to which this may have been an issue was examined by adjusting the saithe values in 1984 and 1985 by moving 60% of the biomass identified as pollack and reclassifying as saithe. This adjustment is illustrated in Figure 8.7.2 and it increased the r^2 to 0.510. The second species, blond ray, appears to have increased markedly in the Q1 IBTS data, and this contradicts the general declining trends in most elasmobranch species that have been well documented. Again it seems likely that these species was identified as another ray early in the time-series, but was later on recognized as being a different species. When these two outliers were ignored, the relationship between species overexploitation index and the biomass trend index values was highly significant; suggesting that overexploitation in the fisheries was responsible for the observed declines in population biomass.

This analysis makes several key points:

1. Piet *et al*., 2009 present one method for modelling mortality in the fisheries bycatch. For most species in the North Sea, mortality in the bycatch has until this time, been unknown. Without such estimates, it is extremely difficult to assess the impact of fishing on non-assessed species in any direct and quantitative way. Deriving such estimates is clearly therefore a key requirement in ensuring that the impact of fishing on the majority of species in the demersal fish assemblage is not unsustainable.
2. The second aspect to determining whether fishing mortality rates on non-assessed species are sustainable not relies on being able to determine, in the absence of real population dynamics modelling (e.g., equivalent to the VPA modelling undertaken in commercial stock assessments), what sustainable rates of mortality are? Here we have developed a method that utilizes widely available life-history trait data to derive an index of sustainable fishing mortality which can be applied to the majority of demersal species for which groundfish survey data are available.
3. Examination of modelled actual fishing mortality rates and rates of sustainable fishing mortality of species sampled in the Q1 IBTS suggests that fishing mortality rates in the bycatch are actually highest in the species least able to tolerate additional mortality. This suggests that bycatch mortality may be a more serious issue than first imagined.
4. For species where modelled actual rates of fishing mortality were substantially higher than estimates of sustainable fishing mortality, a strong correlation was detected between the level of overexploitation and the degree of change in their population biomass over the last 25 years.
5. This confirms that, for some species at least, bycatch mortality may be responsible for reductions in population size.

8.8 References

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Annex 1: List of participants

Name	Address	Phone/Fax	Email
Eider Andonegi	AZTI-Tecnalia AZTI Sukarrieta Txatxarramendi ugartea z/g E-48395 Sukarrieta (Bizkaia) Spain	Phone +34 94 602 9400 Fax +34 94 687 0006	eandonegi@suk.azti.es
Annelies De Backer	Institute for Agricultural and Fisheries Research Ankerstraat 1 B-8400 Oostende Belgium	Phone +32 59 569847 Fax +32 59 330623	Annelies.debacker@ilvo.vlaanderen.be
Maria de Fátima Borges	IPIMAR-INRB Avenida de Brasilia PT-1449-006 Lisbon Portugal	Phone +351 21 302 7098 Fax +351 21 301 5948	mfborges@ipimar.pt
Jochen Depestele	Institute for Agricultural and Fisheries Research Ankerstraat 1 B-8400 Oostende Belgium	Phone +35 59 569838 Fax +32 53 330623	jochen.depestele@ilvo.vlaanderen.be
Christian von Dorrien	Johann Heinrich von Thünen-Institute Federal Research Institute for Rural Areas Forestry and Fisheries Institute for Baltic Sea Fisheries Alter Hafen Süd 2 D-18069 Rostock Germany	Phone +49 381 8116106 Fax +49 381 8116199	christian.dorrien@vti.bund.de
Heino Fock	Johann Heinrich von Thünen-Institute Institute for Sea Fisheries Palmaille 9 D-22767 Hamburg Germany	Phone +49 40 38905 169 Fax +49 40 389 05 263	heino.fock@vti.bund.de
Alain Fréchet	Fisheries and Oceans Canada Institut Maurice-Lamontagne PO Box 1000 Mont-Joli QC G5H 3Z4 Canada		frecheta@dfo-mpo.gc.ca

Name	Address	Phone/Fax	Email
Chris Frid	University of Liverpool Crown Street L69 7ZB Liverpool UK	Phone 151 7954382	c.l.j.frid@liv.ac.uk
Simon Greenstreet	Marine Scotland Marine Laboratory PO Box 101 AB11 9DB Aberdeen Torry UK	Phone +44 1224 295417 Fax +44 1224 295511	S.Greenstreet@MARLAB.AC.UK
Michele Gristina	Istituto per l'Ambiente Marino e Costiero Via Luigi Vaccara 61-Mazara del Vallo, (Tp) Italy	Phone +39 0923 948966/934116 Fax +39 0923 906634	Michele.gristina@irma.pa.cnr.it
Geir Huse	Institute of Marine Research PO Box 1870 N-5817 Bergen Norway	Phone +47 55236988 Fax +47 55238687	geir.huse@imr.no
Ellen Kenchington Chair	Fisheries and Oceans Canada Bedford Institute of Oceanography PO Box 1006 Dartmouth NS B2Y 4A2 Canada	Phone 1 902 426 2030	kenchingtone@mar.dfo-mpo.gc.ca
Gro I. van der Meeren	Institute of Marine Research PO Box 1870 N-5817 Bergen Norway	Phone +47 56182268 Fax +47 56182222	Gro.van.der.meeren@imr.no
Gerjan Piet	Wageningen IMARES PO Box 68 NL-1970 AB IJmuiden Netherlands	Phone +31 (0)255 564646 Fax +31 (0)255 564644	Gerjan.Piet@wur.nl
Odette Paramor	University of Liverpool Crown Street L69 7ZB Liverpool UK	Phone +44 (0)151 795 4390	o.a.l.paramor@liv.ac.uk
Saša Raicevich	Istituto Superiore per la Protezione e la Ricerca Ambientale Loc. Brondolo 30015 Chioggia Italy	Phone +39 041553933 Fax +39 0415547897	s.raicevich@icram.org
Dave Reid	Marine Institute Rinville Oranmore Co. Galway Ireland	Phone +353 91 387431 Fax +353 91 387201	david.reid@marine.ie

Name	Address	Phone/Fax	Email
Jake Rice	Fisheries and Oceans Canada 200 Kent Street Ottawa ON K1A 0E6 Canada	Phone +1 613 990 0288 Fax +1 613 954 08 07	jake.rice@dfo-mpo.gc.ca
Dominic Rihan	Irish sea Fisheries Board PO Box 1 Dun Laoghaire Co. Dublin Ireland	Phone +353 1 2841544 Fax +353 1 2300564	Rihan@bim.ie
Leonie Robinson	University of Liverpool School of Biological Sciences Crown Street L69 7ZB Liverpool UK	Phone +44 Fax +44	Leonie.Robinson@liverpool.ac.uk
Stuart Rogers	Centre for Environment, Fisheries and Aquaculture Science Lowestoft Laboratory Pakefield Road NR33 0HT Lowestoft Suffolk UK	Phone +44 1502 562244 Fax +44 1502 513865	stuart.rogers@cefas.co.uk
Axel Gerhard Rossberg	Queen's University Belfast Biological Sciences University Road BT7 1NN Belfast UK	Phone + 44 28 9097 5859 Fax +	a.rossberg@qub.ac.uk
Mattias Sköld	Swedish Board of Fisheries Institute of Marine Research Lysekil PO Box 4 SE-453 21 Lysekil Sweden	Phone +46 523 18774 Fax +46 523 13977	mattias.skold@fiskeriverket.se
Thomas Kirk Sørensen	National Institute of Aquatic Resources Charlottenlund Slot Jægersborg Alle 1 DK-2920 Charlottenlund Denmark	Phone +45 33963300	tks@aqua.dtu.dk
Mark Tasker	ICES c/o Joint Nature Conservation Committee Dunnet House 7 Thistle Place AB10 1UZ Aberdeen UK	Phone + 44 1 224 655 701 Fax + 44 1 224 621 488	mark@ices.dk

Annex 2: Agenda

1000 Wednesday 15 April

Plenary

Introductions

Presentation on using ICES Sharepoint/Printer and other services, Helle Gjeding Jørgensen

Comments on EU Special Request, Mark Tasker

Presentation on WGECO approach to EU Special Request, Stuart Rogers

Presentation on WGECO approach to ToR b, Dominic Rihan

Presentation on WGECO approach to ToR d, Simon Greenstreet

Discussion groups for Special Request/ToR b/d; Uploading material to Sharepoint

1500

Plenary

Presentation on WGECO approach to ToR a, Chris Frid

Discussion groups for Special Request/ToR a/b/d

0900 Thursday 16 April

Plenary

Presentation on WGECO approach to ToR c, Leonie Robinson

0900 Friday 17 April (note ICES Secretariat not available on this day)

Plenary

Presentation on WGECO approach to ToR e, Phil MacMullen/Jake Rice

Weekend: WGECO works through both Saturday and Sunday with a later start on Saturday and a late day plenary on Sunday. A group dinner is planned for Saturday night as some members will be leaving Sunday.

Special Presentation: Jake Rice has recently attended the Group of Experts for the Assessment of Assessments meeting dealing with setting up, within the UN a "Regular Process" for global and regional fully integrated assessments (integrated across ecosystem components, industry sectors and ecological, social and economic dimensions of sustainability). He has offered to make a presentation on this meeting during our meeting sometime after Friday.

Tuesday 21 April

The last plenary session will be scheduled for the morning. The afternoon will be spent tidying up the report, finalizing references, etc. Each ToR group, including the SR, should identify at least one member who will be present Tuesday afternoon to do this. Meeting adjourned 1700.

Annex 3: WGECO terms of reference for the next meeting

The **Working Group on the Ecosystem Effects of Fishing Activities** [WGECO] (Chair: Ellen Kenchington, Canada) will meet at ICES in Copenhagen, Denmark from 7–14 April 2010 to:

a) Assess the development of integrated ecosystem assessments, in particular focusing on how assessments will be used for the MSFD and considering the use of the IOC's (in press) best practice recommendations. This assessment would include a gap analysis in terms of the availability of suitable state and pressure indicators;

b) Address the data analyses required to examine the relationships between perturbation and recovery capacity, or some other element of "cost", for ecosystem components where there is still little information available (e.g., habitats, benthos, fish assemblages, communities in general);

c) Continue to work on the proportion of large fish EcoQO indicator for the North Sea;

d) Review methods used to determine "good environmental status" under the WFD, HD and MSFD, including a discussion of reference points and indicators;

e) Conduct a detailed, quantitative, evaluation of a limited number (2 or 3) of management schemes to assess the extent to which they actually reflect the high level definitions and are supported by a scientific evidence base. Possible case studies include the Baltic Sea Action Plan and the Norwegian Integrated Management Plan for the Lofoten-Barents Sea area. This would include the last four years of ecosystem-based management schemes. The plans should be assessed using a common framework.

WGECO anticipates other ToR from ACOM, WGFGTB, WGQAM.

WGECO will report by 3 May 2010 to the attention of the Advisory Committee.

Supporting Information

Priority:	The current activities of this Group will lead ICES into issues related to the ecosystem affects of fisheries, especially with regard to the application of the Precautionary Approach. Consequently, these activities are considered to have a very high priority.
Scientific justification and relation to action plan:	Action Plan No: 1. Term of Reference a) Integrated assessments are still undergoing development and revision. This ToR will assist that process by identifying gaps in knowledge to complete the process specifically as it pertains to the MSFD. Term of Reference b) Assessment of signficant adverse impact of fisheries and other activities requires an ability to determine levels of damage which can be sustained without loss of ecosystem function. This ToR will review the methodology for determining relationships between perturbation and recovery capacity in selected ecosystem components. Term of Reference c) WGECO advanced its work on the proportion of large fish indicator in 2009, however new information arising from modeling efforts give reason to suppose that revisiting this ToR in 2010 will further advance our advice on this issue. Term of Reference d) In their 2009 report, WGECO endorsed a review of how high level policy terms were being implemented and referred to discussion at the 2009 International Wadden Sea Symposium (Wilhemshaven, Germany) where the status descriptors referring to 'good' conditions from WFD, HD and MSFD attracted a lively discussion and their practical implications remained partly contentious. WGECO proposes to begin its review of these terms, following on from its ToR A of 2009, with the "good environmental status" descriptor. Term of Reference e) WGECO has recommended to ACOM that this ToR be conducted and requests confirmation and suggestions of which plans to work on. Norway has been managing the Norwegian section of the Barents Sea as an ecosystem for four years now. This summer a joint Norwegian-Russian report on the status of the Barents Sea will be published in English, which will be an accessible document for all the members of the WGECO. In addition, Norway is preparing an evaluation of the management scheme these four years, for a national evaluation report in the spring next year. Inclusion of the plan came by suggestion of Norwegian members of the WGECO. The Baltic Sea Action Plan was viewed by WGECO as another plan which was similarly well-developed.
Resource requirements:	The research programmes which provide the main input to this group are already underway, and resources are already committed. The additional resource required to undertake additional activities in the framework of this group is negligible.
Participants:	The Group is normally attended by some 20–25 members and guests.
Secretariat facilities:	None.
Financial:	No financial implications.
Linkages to advisory committees:	There are no obvious direct linkages with the Advisory Committees.
Linkages to other committees or groups:	There is a very close working relationship with all the groups of the Fisheries Technology Committee. It is also very relevant to the Working Group on Ecosystem Effects of Fishing Activities.

Linkages to other organizations:	The work of this group is sometimes aligned with similar work in FAO.

Annex 4: Recommendations

We suggest that each Expert Group collate and list their recommendations (if any) in a separate annex to the report. It has not always been clear to whom recommendations are addressed. Most often, we have seen that recommendations are addressed to:

- Another Expert Group under the Advisory or the Science Programme;
- The ICES Data Centre;
- Generally addressed to ICES;
- One or more members of the Expert Group itself.

RECOMMENDATION	FOR FOLLOW UP BY
1. ICES informs its policy customers of the key outcomes of the terminology review presented in ToR A and works with them in developing the consistent use of terminology in the application and operationalisation of ecosystem based management.	ICES
2. WGECO be tasked with carrying out a detailed, quantitative, evaluation of a limited (2 or 3) management schemes to assess the extent to which they actually reflect the high level definitions and are supported by a scientific evidence base. Possible case studies include the Baltic Sea Action Plan and the Norwegian sector of the Barents Sea Action Plan, but these should be selected by ACOM to provide the most relevance.	ACOM
3. WGECO recommend that we ask clients to define high level terms which have multiple definitions in the key policy documents in their requests for advice.	ACOM
4.	
5.	
6.	

After submission of the report, the ICES Secretariat will follow up on the recommendations, which will also include communication of proposed terms of reference to other ICES Expert Group Chairs. The "Action" column is optional, but in some cases, it would be helpful for ICES if you would specify to whom the recommendation is addressed.