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Report of the Working Group on the Ecosystem Effects of Fishing Activities (WGECO)

1–8 May 2013

Copenhagen, Denmark

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International Council for the Exploration of the Sea

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Contents

Executive Summary

The 2013 meeting of WGECO was held at the ICES HQ in Copenhagen, Denmark from the 1–8 May 2013. The meeting was attended by 14 delegates from nine countries, and was chaired by Dave Reid (Ireland). The WG addressed seven terms of reference.

a) MSFD indicator and target evaluation;
b) Support to the technical specification and application of OSPAR common indicators under D1, 2, 4, and 6;
c) Provide advice on maximizing the use of available sources of data for monitoring of biodiversity;
d) Good Environmental Status for the system impacted by European Pelagic Fisheries;
e) Indicators of foodweb condition in reference to MSFD Indicator 4;
f) LFI development.

Evaluation criteria for MSFD indicators were developed by WGECO in 2012, greatly improved by WGBIODIV, and finalized in this report. The evaluation criteria were then used in the context of the OPSAR request, to examine the work done on this ToR by WGBIODIV. Eleven evaluation criteria for targets were developed covering: the approach to define targets; Framework consistency; Regional consistency; Preference for established targets; Integrity; Adaptability of targets; Uncertainty in target estimates; Derivation of targets; Scale; Cross-sectoral integration and trade-offs; and Ease of understanding. Guidance on their scoring and application was provided. Potential users of these are invited to critically examine these and provide WGECO with feedback. This work is reported in Chapters 3 and 4.

In Chapter 5, we focused on the use of research vessel surveys in the context of biodiversity, and more general MSFD monitoring. This was presented as a review and a compilation of the work done by WGISUR, and its component workshops WKCATDAT and WKECES, as well as responses to WGISUR from a number of survey Expert Groups, for bottom-trawl, acoustic, icthyoplankton and TV surveys. The report also drew on work done for this ToR carried out by WGBIODIV. In particular, the report noted what was already collected and could be used in this context, as well as a range of potential future monitoring applications.

Chapter 6 focused on potential indicators of GES for pelagic fisheries and ecosystems, in response to a request from the FP7 project MYFISH. A range of candidate indicators from MYFISH were evaluated using the criteria developed under ToR a). This allowed both evaluation of the indicators and evaluation of the application of the criteria. The highest scoring indicators were:

- Proportion of total catch discarded;
- Number of individual mammals and seabirds bycaught;
- % contaminants in landed fish;
- Proportion of stocks above a threshold biomass point;
- Aggregated pelagic fish biomass;
- Biomass of piscivores and planktiores;
- Predator condition or weight anomaly;
- Biomass by stock component;

- Condition or weight anomaly of pelagic fish;
- Proportion of spawning habitat impacted by gravel extraction;
- Proportion of migration routes impacted;
- F relative to F_{MSY}.

Foodwebs (Descriptor 4 in the MSFD) are one of the most difficult areas to develop indicators as acknowledged by the EC Decision document. The work focused on possible new structural indicators of the foodweb, and this is reported in Chapter 7. Existing indicators largely focus on key species, but we sought indicators that could integrate more widely. The work concentrated on:

- The distribution of species over body size ranges and hence trophic levels. This was based on the observation that there are many more small-bodied species;
- Responses of the marine size spectra to pressures.

The large fish indicator (LFI) has been one of the key work areas for WGECO in recent years. In this report we highlight developments in LFI in the western Baltic Sea, where the ecosystem is cod dominated, but also looking at a pelagic LFI for the whole of the Baltic. The other area examined was the southern Bay of Biscay, where the LFI has been recovering in recent years, largely due to the increased abundance of large benthivorous fish. This work is reported in Chapter 8.

1 Opening of the meeting

The meeting was opened at 10.00 am on 1 May and adjourned on 8 May 2013. The meeting was chaired by David Reid, Ireland, and attended by 14 participants from nine different countries. A full participants list is found at Annex 1.

2 Adoption of the agenda

The agenda was considered. The draft agenda is found below.

1000 Wednesday 1 May

Plenary

Introductions

Presentation on using ICES SharePoint/Printer and other services

Overview of meeting work plan. **Dave Reid**

Presentation on WGECO approach to **ToR a**: MSFD indicator and target evaluation. **Simon Greenstreet and Isabelle Rombouts**

Presentation on WGECO approach to **ToR b**: Support to the technical specification and application of OSPAR common indicators under D1, 2, 4, and 6 **Mark Tasker??**

Presentation on WGECO approach to **ToR c**: Provide advice on maximizing the use of available sources of data for monitoring of biodiversity **Heino Fock and Ellen Kenchington**

Presentation on WGECO approach to **ToR d**: Review and Comment on the Objectives and Indicators developed for Good Environmental Status for the system impacted by European Pelagic Fisheries (developed by the EU FP7 project MYFISH). **Anna Rindorf and Sam Shephard**

Presentation on WGECO approach to **ToR e**: Indicators of foodweb condition in reference to MSFD Indicator 4. **Axel Rossberg and Fatima Borges**

Presentation on WGECO approach to **ToR f**: LFI development. **Daniel Oesterwind and Elena Guijarro.**

Getting the show on the road

Allocation of people to ToR

Discussion groups for ToRs a–f;

Uploading material to SharePoint, etc. etc.

0900–1000 Thursday 2 May

Meeting of ToR leaders to inform each other of direction each group is taking

1100–1200 Plenary for any emerging issues

0900 Friday 3 May

Discussion groups for all ToRs

***** Meeting to follow a format of break-out group and plenary discussion as required with times to be posted daily based on progress *****

Weekend: WGECO works through both Saturday and Sunday with a later start on Saturday and a late day plenary on Sunday.

Tuesday 7 May

The last plenary session will be scheduled for the afternoon. Remaining time will be spent tidying up the report, finalizing references, etc. Each ToR group should identify at least one member who will be present Tuesday afternoon to do this. There will be no formal meeting on the Wednesday as I anticipate a lot of early leavers!!!!!

3 ToR a) MSFD indicator and target evaluation

ToR text: To continue to develop, test and report on (a) criteria and a process for evaluating the scientific soundness and feasibility of national proposals for indicators and targets used to support the achievement of Good Environmental Status and (b) approaches for combining information provided by indicators and targets into an assessment of status. The focus should be on descriptors 1, 3, 4 and 6, but to the extent possible the criteria and process should be general for all the Descriptors and their associated indicators and targets. Request from ACOM.

3.1 Introduction

This TOR represents an ongoing request from ACOM to develop, test and report on (a) criteria and a process for evaluating the scientific soundness and feasibility of national proposals for indicators and targets used to support the achievement of Good Environmental Status and (b) approaches for combining information provided by indicators and targets into an assessment of status. In 2012, WGECO developed guidelines for criteria to evaluate MSFD indicators (ICES 2012). These were not fully concluded by WGECO at that time, and were then taken up by WGBIODIV at their meeting in 2013. WGBIODIV then developed the guidelines further, constructed a table of the criteria and used the method to evaluate the common indicators developed by ICG-COBAM for OSPAR. This work was reviewed by WGECO, and a small number of changes made to the text in the criteria table. This is reported in more detail in Chapter 4, where the new version of the criteria table is reported.

The second part of ToR a, part a, refers to criteria and a process for evaluating the scientific soundness and feasibility of national proposals for targets. Again, the first steps on this were started at the 2012 WGECO meeting, and continued at the 2013 meeting. The results of this are reported in this chapter (below).

ToR a, part b refers to "approaches for combining information provided by indicators and targets into an assessment of status". WGECO proposes to focus on this part of the ToR in 2014 within the following context.

A number of different approaches to the combination of indicators have been proposed and are available. These are often considered as Integrated Ecosystem Assessments (IEA). Each of these has different approaches to the problem.

Conceptually, IEA is a mechanism for taking a holistic view of the marine ecosystem in specific ocean areas. This should encompass the full range of ecosystem characteristics (foodwebs, biodiversity, habitats, endangered species, etc.), the full range of sectors (fishing, renewable, shipping, oil and gas, gravel extraction, tourism, etc.), the full range of pressures exerted by those sectors (species removals, habitat damage, contaminants, eutrophication, etc.). It should also integrate the three pillars of sustainability; ecological, economic and social. MSFD and GES would also be expected to aim at this objective, with a regional sea attaining GES across a range of descriptors and indicators.

No single technical approach has been developed that can do this, although there are a number of methods that make considerable steps towards this. One key area of development that is needed is the understanding of interactions between different pressures. These can be additive, and are often treated as such, but can also clearly be synergistic or antagonistic.

Levin *et al*. (2009) proposed a framework within which IEA could be carried out. The framework is broader than an analytic IEA and includes; scoping, indicators, risk analysis, assessment of ecosystem status (probably where most people see IEA methods), Management Strategy Evaluations, and finally monitoring.

There are a number of candidate methodologies for IEA:

- Robinson *et al*. (2009) as used for the OSPAR QSR 2010;
- Knights *et al*. 2012); Developed from Robinson *et al*. (2009) and delivered as part of the EU funded ODEMM project;
- Kenny *et al*. (2009) developed for the ICES Regional Ecosystem Group for the North Sea (REGNS);
- Halpern *et al*. (2012), the Ocean Health Index;
- Stelzenmuller *et al*. (2011) using Bayesian Belief Networks BBN;
- ICES (2013) The approach developed by ICES Workshop on Ecosystem overviews (WKECOVER).

The approaches can conceptually be divided into two grouping; quantitative numerical approaches (REGNS & BBN) and expert judgement based (OSPAR QSR, ODEMM and OHI). The REGNS approach is largely data driven, but is also data hungry and requires good time-series of data to work well; it can also miss addressing ecosystem aspects for which such data do not exist. BBN are less data hungry, in that they can be used on quite sparse data support, but the choices and linkages may be more subjective. The expert judgement approaches have the value of being able to address any or all ecosystem components and DPSIR linkages, but in many cases this expert judgement component will be backed by little or no empirical or model data to support conclusions. Evaluation of ecosystem component status is generally categorical in the QSR and ODEMM approaches, though it is more continuous in the OHI approach. Finally, the OHI has the advantage of including the human, social and economic dimension and can illustrate conflicts and trade-offs well. BBN can also be used to evaluate trade-offs. Arguably, the only method that potentially allows for non-additive pressure effects is the BBN, where the linkages between elements can take any linear or non-linear form.

These approaches have often been seen as competing, however, the ICES Workshop on Benchmarking Integrated Ecosystem Assessments- WKBEMIA (ICES 2012) felt that they are in fact more complementary than competing. Each can bring useful elements to the aim of an Integrated Ecosystem Assessment, using quantitative numerical approaches where data allows, moving possibly to BBN where data are sparse, and then to expert judgement for those sector/pressure/component interactions where little or no empirical data exist.

3.2 Criteria for target evaluation

The following text and table on evaluation criteria represent the suggestions of WGECO for an approach to target evaluation. They should NOT be regarded as completed. WGECO invites further comments from ACOM and other interested parties including OSPAR, HELCOM, and STECF. These guidelines will be completed at the WGECO meeting in 2014.

Just as there is a need to evaluate the performance of different indicators being proposed to support implementation of the MSFD, there is an equivalent requirement to assess the adequacy of the targets being proposed for these indicators. While, there is a long history of developing and applying criteria to evaluate indicator performance, culminating in the work reported by WGBIODIV (ICES 2013) and here in Section 4 of this report, taking a similar approach to assess the validity of proposed targets for these indicators represents a new process. Here WGECO take only the initial steps in this process. What we report here is unfinished and this is a task to which WGECO will return.

ToR b, to evaluate the indicators being proposed by OSPAR as "common indicators" to support implementation of the MSFD in marine regions "shared" by several Member States, specifically relates to MSFD indicators. WGECO therefore took the initial stance of developing criteria to evaluate the targets that might be applied to these "common" indicators when monitoring progress towards "good environmental status" to meet MSFD obligations. WGECO, however, recognizes that other management frameworks exist, for example the OSPAR EcoQO approach to implementing an ecosystem approach to management, and equivalent frameworks underpinning traditional fisheries management. At a later data WGECO will consider differences between these various management frameworks, their approaches to defining and setting targets, and assess the extent to which the criteria that we propose to evaluate the OSPAR "common" indicators are generic and applicable within these alternative frameworks.

3.2.1 Text in the MSFD relating to targets

Text in italics in the following section is lifted straight from MSFD documentation. Other text in normal font is WGECO interpretation, thereby providing the basis for our target evaluation criteria.

Chapter 1 Article 3 Part 5 of the MSFD defines 'good environmental status' (GES) as:

'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.:

> *(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 human-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;*

And goes on to state:

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.

The over-arching goal of the MSFD is to achieve GES for marine seas under its jurisdiction. The text above suggests that GES is a holistic concept, relating to whole ecosystems across large-scale spatial regions. The MSFD requires marine regions to be productive. Marine resources should be exploited, but only at sustainable rates: i.e. exploited at a level that can be maintained indefinitely and which conserves ecosystem structure and function. Achieve this and the ecosystem can be considered to be at GES. Given this imperative to make productive use of marine resources, albeit at sustainable rates, and considering that any human disturbance of marine ecosystems inevitably has an impact, it is clear that the state at which the ecosystem is considered at GES cannot be the same as the pristine state of the ecosystem prior to human intervention. Thus GES must represent a permissible degree of deterioration in the state of the marine ecosystem within a region, away from the pristine state, to a state that still maintains full ecosystem functionality and resilience, but which permits sustainable exploitation of the marine natural resources contained within the ecosystem.

Chapter 1 Article 3 Part 7 of the MSFD defines "environmental targets" as:

'environmental target' means 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;

Where Article 10 states:

On the basis of the initial assessment made pursuant to Article 8(1), Member States shall, in respect of each marine region or subregion, establish a comprehensive set of environmental targets and associated indicators for their marine waters so as to guide progress towards achieving good environmental status in the marine environment, taking into account the indicative lists of pressures and impacts set out in Table 2 of Annex III, and of characteristics set out in Annex IV. When devising those targets and indicators, Member States shall take into account the continuing application of relevant existing environmental targets laid down at national, Community or international level in respect of the same waters, ensuring that these targets are mutually compatible and that relevant transboundary impacts and transboundary features are also taken into account, to the extent possible.

Whilst GES is a holistic concept, this text clearly implies that 'environmental targets' are not. 'Environmental targets' relate to individual ecosystem components and the specific 'associated indicators' used to monitor change in the ecosystem component in question. This text infers that it is the integration of the information obtained from assessing the state of all ecosystem components, based on 'environmental targets' for each component and prevailing values of their 'associated indicators' relative to these 'environmental targets', which provides the holistic overview and establishes whether or not the marine ecosystem in a particular region is at GES. Thus for any specific 'associated indicator' for a given ecosystem component, the 'environmental target' is the value of this indicator that would be expected if the ecosystem of which the component is a part was at GES.

Chapter 1 Article 5 of the MSFD establishes the timing for setting "environmental targets" as:

establishment, by 15 July 2012, of a series of environmental targets and associated indicators, in accordance with Article 10(1);

and

establishment and implementation, by 15 July 2014 except where otherwise specified in the relevant Community legislation, of a monitoring programme for ongoing assessment and regular updating of targets, in accordance with Article 11(1);

and Chapter 4 Article 17 of the MSFD states:

1. Member States shall ensure that, in respect of each marine region or subregion concerned, marine strategies are kept up to date.

2. For the purposes of paragraph 1, Member States shall review, in a coordinated manner as referred to in Article 5, the following elements of their marine strategies every six years after their initial establishment:

(a) the initial assessment and the determination of good environmental status, as provided for in Articles 8(1) and 9(1) respectively;

(b) the environmental targets established pursuant to Article 10(1);

(c) the monitoring programmes established pursuant to Article 11(1);

(d) the programmes of measures established pursuant to Article 13(2).

This text simple gives a timetable for deriving 'environmental targets' and their 'associated indicators' and ensuring that these are updated as new science comes on stream and our understanding of what an ecosystem, and its component parts.

Finally Annex IV of the MSFD provides what are essential a set of criteria for guiding the selection of "environmental targets"

Indicative list of characteristics to be taken into account for setting environmental targets (referred to in Articles 10(1) and 24)

(1) Adequate coverage of the elements characterising marine waters under the sovereignty or jurisdiction of Member States within a marine region or subregion.

(2) Need to set (a) targets establishing desired conditions based on the definition of good environmental status; (b) measurable targets and associated indicators that allow for monitoring and assessment; and (c) operational targets relating to concrete implementation measures to support their achievement.

(3) Specification of environmental status to be achieved or maintained and formulation of that status in terms of measurable properties of the elements characterising the marine waters of a Member State within a marine region or subregion.

(4) Consistency of the set of targets; absence of conflicts between them.

(5) Specification of the resources needed for the achievement of targets.

(6) Formulation of targets, including possible interim targets, with a time-scale for their achievement.

(7) Specification of indicators intended to monitor progress and guide management decisions with a view to achieving targets.

(8) Where appropriate, specification of reference points (target and limit reference points).

(9) Due consideration of social and economic concerns in the setting of targets.

(10) Examination of the set of environmental targets, associated indicators and limit and target reference points developed in light of the environmental objectives laid down in Article 1, in order to assess whether the achievement of the targets would lead the marine waters falling

under the sovereignty or jurisdiction of Member States within a marine region to a status matching them.

(11) Compatibility of targets with objectives to which the Community and its Member States have committed themselves under relevant international and regional agreements, making use of those that are most relevant for the marine region or subregion concerned with a view to achieving the environmental objectives laid down in Article 1.

(12) When the set of targets and indicators has been assembled, they should be examined together relative to the environmental objectives laid down in Article 1 to assess whether the achievement of the targets would lead the marine environment to a status matching them.

Any table of criteria the WGECO might propose should ensure that these characteristics of 'environmental targets' are incorporated. The main additional objective should be to ensure that, now that progress is being made in defining the indicators and considering how these might be used within management frameworks, any gaps in this list of characteristics should be covered.

3.2.2 Target evaluation

WGECO found it relevant to distinguish between indicator and target evaluation, i.e. indicator evaluation comprises inter alia operational aspects, standards and protocols to be carried out and in case of state indicators proof of evidence of link between ecosystem component and impact, whereas the target refers to the threshold value or range values of the indicator that encompass the desired environmental state. The precise definition of an "environmental target" in the MSFD (Art 3(7)) is: *"environmental target' means 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"* Aspects like commonality, practicality, data availability, scientific support, etc. therefore clearly address issues of indicator evaluation. Evidently, target and indicator evaluations are often intermingled in existing literature (OSPAR 2011, Borja, Dauer *et al*. 2012), and the establishment of targets might be critical or even speculative, unless formal procedures are applied (e.g. fish stock related reference limits).

The following section comprises work on target evaluation undertaken by WGECO in 2012 and further elaborations carried out during the 2013 meeting. It will be shown, that the suggested list of criteria is fully compliant to MSFD and regional sea conventions (OSPAR, HELCOM).

3.2.2.1 OSPAR target evaluation

In a series of workshops, OSPAR developed a framework to develop targets (2011, 2012a, 2012b).

The basic procedure is to set ***baseline*** or ***reference conditions***, against which ***targets*** are defined. As such, a target defines the lower limit of conditions referring to GES, i.e. lower limits of a state that is desired. Two criteria referring to targets provided during the OSPAR workshop in 2010 were developed (OSPAR 2011), i.e.

- Targets may have to evolve in the context of changing climatic variables. Two key issues, namely ecosystem dynamics and climate changes, could make it inappropriate to reference to a specific state in the past. In such a case, GES needs to be re-assessed on the basis of prevailing conditions (OSPAR 2012);

- That with regards to using trend directions as targets, the specified direction of change in indicator value must represent movement towards a "better" state. WGECO point out that the starting point of the assessment must also be taken into account. If, for example, the population is currently experiencing optimum environmental and climatic conditions, it is possible that it may already have reached its optimum indicator level, thereby precluding further increase.

3.2.2.2 MSFD criteria to evaluate environmental targets and thresholds

In the framework of the MSFD the term "target" is used in a wider context as in this report where it is just referring to thresholds. According to the MSFD directive (Art. 3(7)), "an environmental target means a qualitative or quantitative statement on the desired condition of the different components of, and pressures and impacts on, marine waters." Therefore different types of environmental targets are being established to capture collectively the state of ecosystem components (reflecting good environmental status of ecosystem components), impacts (reflecting the need to avoid or improve an undesirable state not equivalent to GES) and pressures (reflecting the need to reduce or stabilize them). Each target might be associated with a threshold value between an acceptable and an unacceptable condition. Deriving environmental targets is further specified in MSFD Annex IV, where under points 4 to 8 specification of environmental targets in terms of target and limit reference points, consideration of relationships between targets and possible specification of interim targets is required. Annex IV (9) requires to also consider socio-economic effects of environmental target setting.

3.2.2.3 Relationship between environmental target and GES

Annex IV (2) prescribes that **environmental targets** implicitly refer to desired states of the ecosystem based on the definition to GES. This may only be by-passed when interim targets are defined which in do not necessarily define GES. Where **threshold values** cannot be defined, the setting of **trends-based targets** can provide a pragmatic and operational alternative. In essence this means that where scientific evidence suggests that current values of the indicator in question reflect a sub-GES situation, an a priori directional change can be proposed as an alternative to setting an absolute **target indicator value**. When such an approach is adopted, it is important to realize that meeting such trends-based targets does not mean that GES has been achieved. At best it implies that the appropriate measures have been put in place to move the ecosystem attribute reflected by variation in the indicator towards GES.

3.3 Guidelines for criteria to evaluate targets

Criterion 1: Approach to define targets given

Without a justification for proposing a target in its indicator context it is not meaningful to evaluate the target using the presented evaluation tool. The methodological approach and rationale for setting a target must be given, either directly in or with reference to, the technical specification of the indicator. Evaluation of targets lacking essential documentation would be at higher risk of being biased by the experience of the evaluator. This criterion does not evaluate the content of the scientific justification, but only its presence. A "STOP" means that supplementary information is needed before the evaluation of the target can be done.

Criterion 2: Framework consistency

Targets should not conflict across indicators within MSFD and with international policy frameworks. Potential inconsistency between Water Framework Directive (WFD) and MSFD have been analysed by Borja *et al*. (2010). The WFD ecological status classification of Good Ecological Status (GES) is based on biological and physicochemical monitoring results. The normative definitions of the WFD (Annex 5) set the descriptive definitions for the high, good, and moderate status for different water categories and quality elements. According to Borja *et al*. (2010), normative definitions describing the desirable status for GES of biological quality elements as in WFD are not included in the MSFD. Instead, the MSFD 11 applies qualitative descriptors to determine the GES, which at some extent can be related to some of the elements within the WFD. Proper alignment of WFD and MSFD is in particular important if both directives apply to the same area, e.g. overlap in the coastal zone between baseline and 1 nm.

OSPAR (2012) and HELCOM considered three characteristics for GES for biodiversity to be equivalent to assessment of Good Ecological Status for the WFD and Favourable Conservation Status (FCS) for the Habitats Directive which accommodate a defined deviation from reference state (i.e. the absence or negligible level of impact from anthropogenic pressures).

GES can therefore be expected to (OSPAR 2012):

- Have a quality and proportion aspect (whether expressed as GES only or as GES and state/impact targets);
- Accommodate some level of impact, such that quality is not even across an entire region or subregion;
- Represent a defined deviation from a reference state, accommodating sustainable use of the marine environment, provided that there is no further deterioration from present state (at an appropriate scale of assessment).

In particular where GES comprises only qualitative characteristics, compromising indicators with quantitative characteristics could become an issue.

Criterion 3: Regional consistency

To assess GES within regions or shared subregions, regional consistency of targets is required. This is addressed in MSFD Annex II (5) as task defined for the responsible authorities, but also mentioned here since it is considered indispensable requisite for target setting. The management of trans-boundary habitats under the HD has provided evidence that coordination between MS is essential (Fock, 2011).

Targets may differ between subregions, based on corresponding differences in the dynamics of indicators chosen. OSPAR (2011) pointed out the underlying dilemma, saying that whilst GES is to be determined at a regional or subregional level, MSFD responsibilities and obligations lie at MS level. It was concluded then, that effort is required with regard to the possibility of applying a combination of jurisdictional and ecological assessment scales and thus to strengthen trans-boundary coordination.

Criterion 4: Preference for established targets

Targets that are already established and used in a relevant policy framework are favoured over novel targets, because social acceptance is can be assumed. This is also the case if a new defined target meets better the objective of the MSFD, which is sustainable use within an ecosystem approach, because this will be evaluated by other target evaluation criteria (e.g. integrity).

Criterion 5: Integrity

Targets should correspond to the overall aim of the MSFD of "promoting sustainable use of the seas and conserving marine ecosystems" (preamble, paragraph 4, MSFD). This objective refers to Decision Document No 1600/2002/EC (Sixth Community Environment Action Program), which provides the following interpretation of a sustainable development: "Prudent use of natural resources and protection of the global ecosystem together with economic prosperity and a balanced social development" (preamble, paragraph 6, 1600/2002/EC). Against this background the MSFD has to be understood as a legislative aiming for sustainable usage of the European marine waters. As a consequence management should focus on achieving convergence between the three pillars of sustainability, by bringing social and economic aspects in line with conservation needs in the long term. This means that targets should not just aim at achieving pristine states of the ecosystem; instead they should allow a sustainable usage in accordance with the MSFD. Setting targets based on a historical background for which the anthropogenic pressure level is unknown but expected to be minimal, will be evaluated as an intermediate but still not favoured approach.

Criterion 6: Adaptability of targets

The criterion for the adaptability refers to the advantage of targets, which have a framework for incorporating new knowledge and changes in ecosystem information (e.g. improved knowledge of biological functions) in future evaluations of environmental status. The criterion therefore scores targets high if these are assigned/allowed to change with (a) refined analyses and models of the indicator time-series, and/or (b) new ecosystem information higher than fixed targets. The targets need to be revised at least once every reporting period (six year cycle in MSFD), and this revision should be documented.

Criterion 7: Uncertainty in target estimates

Because a target estimate is subjected to the uncertainty associated with its statistical derivation, it is important to know this uncertainty. This uncertainty has to be taken into account when setting the target, and therefore a measure like the coefficient of variation of the estimated target is required. It is also important that the technical specification defines the operational target and its confidence limits in relation to the threshold between GES and sub-GES condition.

Criterion 8: Derivation of targets

It is preferable that ecological targets for GES are based on models founded in ecological theory and validated by data using historical time-series. The presence of empirical evidence with strong supporting theory is also a valid option for the highest score (1). Thresholds could also be set quantitatively without a state-of-the-art statistical framework to relate them to GES (e.g. a precautionary approach). This approach is evaluated to be less stringent than a statistical approach but more valuable than an approach based on expert judgement only.

Criterion 9: Scale

Targets for many indicators should be developed separately for each region, and it should not be assumed that targets established for one region will be applicable in another. Therefore a target been developed for a certain region as for example the southern North Sea should ideally be evaluated for this region only. It might also be applied for overlapping areas either on a smaller more local scale within the same region, e.g. Helgoland Bight, or on a larger spatial scale within which the region is part of, e.g. the whole North Sea. Nevertheless problems might arise from ecological variances on different spatial scales even in such overlapping regions. It may however be entirely inappropriate to expand the usage of the target to a different ecological region as for example the Black Sea. A good understanding of these aspects is provided by the example of the LFI which will have different species composition in different regions and therefore will require different targets.

Criterion 10: Cross-sectoral integration and trade-offs

According to the MSFD (Art.19) *inter alia* targets, as part of monitoring programmes or programmes of measure at latest, should be subject to cross-sectoral public consultation. This criterion reflects the importance of considering the wider implications of setting a certain target by considering social, economic and ecological considerations for society through a public consultation process. This criterion only evaluates if there has been a cross-sectoral public consultation and not to which extent information from the consultation process has been incorporated into the target.

Criterion 11: Ease of understanding

Rationale for the target should be easily understandable by policy-makers and other non-scientists alike, and clear to communicate. This criterion is based on the assumption that a greater public understanding of the target and how it relates to GES will increase its general acceptance and compliance with any management measures taken to reach the target. The target is closely linked to its indicator and how comprehensible it is will depend on the complexity and logic of the indicator. This criterion therefore mainly focuses on the rationale for the chosen target, to the extent that it can be evaluated separately from the indicator and the analytical derivation of its target.

Table 3.1. Criteria used to evaluate the performance of targets for indicators proposed by OSPAR to support implementation of the MSFD at subregional and regional scale. The first criterion determines if the rationale and documentation at hand are sufficient to perform the evaluation at all. The following ten criteria are grouped into three main categories (scientific, management and societal evaluation), and the principle characteristic of each criterion is given. Criterion levels provide the guidelines for assessing the level of *compliance* of each target against each criterion.

CRITERION NO.	CATEGORY	CHARACTERISTIC	EVALUATION CRITERION	CRITERION SPECIFICATION	CRITERION LEVELS
1	Overall evaluation	Method of derivation	Approach to define target given.	Rationale and methodological approach to define target should be given.	(1): Rationale for setting target fully documented (STOP): No scientific justification provided for the target chosen, and evaluation therefore not possible
2	Management evaluation	Framework consistency	Target consistency	Targets should not conflict across indicators within MSFD and with international policy frameworks	(1): No conflicts within MSFD and international legislation; (0.5): No conflicts within MSFD; (0): Conflicts within MSFD
3	Management evaluation	Regional consistency	Level of regional coordination	Target should be coordinated on relevant regional scale for shared regions and subregions (?)	(1) : Full coordination (0.5): Partial coordination (0): No coordination
4	Management evaluation	Framework consistency	Preference for established targets	Targets already accepted and used by wider society as reliable and meaningful, should be preferred over novel targets that perform the same role.	(1) :Yes. The target is already established and used in a relevant policy framework (0): The target has not previously been used in a management framework

CRITERION NO.	CATEGORY	CHARACTERISTIC	EVALUATION CRITERION	CRITERION SPECIFICATION	CRITERION LEVELS
5	Scientific evaluation	State of ecosystem	Integrity	To what level of integrity does the target refer (e.g. sustainable use, pristine state)?	*(1): the target allows a sustainable use of marine resources;* *(0.5): the target allows human activities without reference to the concept of sustainability;* *(0): the target allows no use at all (aims at achieving pristine states)*
6	Scientific evaluation	State of ecosystem	Adaptability of target	The target should be assigned/allowed to change with (a) refined analyses and models of the indicator time-series, and/or (b) change in ecosystem information	(1) Documentation of methods to change targets provided (0) Documentation of adaptability not provided
7	Scientific evaluation	Data quality	Uncertainty in target estimates	The statistical method used for targets setting should provide upper and lower confidence limits.	(1): Statistically sound estimate of confidence limits (0.5): Limits set without statistical certainty (0): No estimate of uncertainty
8	Scientific evaluation	Data quality	Derivation of target	Target should be based on analytical models and ecological theory. .Empirical derivation based on time-series or baseline data are preferred over expert judgement.	(1): Analytical and theoretical derivation based on data, and/or empirical setting with strong supporting theory; (0.5): Empirical derivation based on historical time-series/baseline data only (0): Expert judgement

CRITERION NO.	CATEGORY	CHARACTERISTIC	EVALUATION CRITERION	CRITERION SPECIFICATION	CRITERION LEVELS
9	Scientific evaluation	Data quality	Scale	Target should be based on data for the region for which is being applied and for the same spatial scale	(1): Target set at the same spatial scale as the evaluation spatial scale; (0.5): Target set based on a larger or smaller overlapping area. (0): Target set based on out of area.
10	Societal evaluation	Societal acceptance	Cross-sectoral integration and trade-offs	Targets should be subject to cross-sectoral public consultation to include social economic and ecological implications of targets for society	*(1) Target documentation has been subject to cross-sectoral public consultation;* *(0): Cross-sectoral issues not addressed*
11	Societal evaluation	Societal acceptance	Ease of understanding	Rationale for the target should be easily understandable by policy-makers and other non-scientists alike, and clear to communicate.	(1): Rationale behind the target easy to understand and clear to communicate (0): The rationale behind the target is neither easy to understand nor to communicate

3.3.1 References

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OSPAR. 2012a. MSFD Advice Manual and Background Document on Biodiversity. Biodiversity Series, OSPAR**:** 141.

OSPAR. 2012b. Report of the OSPAR workshop on MSFD biodiversity descriptors: comparison of targets and associated indicators. Biodiversity Series**:** 56.

3.4 Potential wider issues in indicator evaluation

WGECO points here to a potential gap in the approach to indicator evaluation as described in Chapter 4. This relates to the relevant time-scales of ecosystem dynamics.

WGECO have worked for several years on frameworks to identify relationships between pressures, ecosystem states and indicators in relation to sustainable use (ICES 2005; 2006; 2007; 2008; 2010). In 2010, WGECO worked on the problem to:

> Assess the development of integrated ecosystem assessments, in particular focusing on how assessments will be used for the MSFD [...]. This assessment would include a gap analysis in terms of the availability of suitable state and pressure indicators.

For the purpose of indicator construction, WGECO suggested a general framework to identify key pressures, and components at risk due to the effects of single or multiple pressures. After establishing an inventory of links between pressures and ecosystem components (using a matrix marking causal links), key interactions are identified within this framework using criteria related to (i) spatial extent of interaction, (ii) degree of impact, and (iii) recovery potential of components. Detailing the last point, WGECO explain:

> The recovery potential of components should also be taken into account whereby those components with longer periods of recovery, should be given higher priority than those with rapid periods of recovery (taking into account the spatial extent of impact). Ecosystem components with no capacity to recover are of particularly high priority. Any components that would not recover within two assessment cycles would be deemed to have a long recovery period.

As final steps for indicator selection, WGECO recommended that:

1) For any pressure where there is at least one key interaction with a component, suitable indicators will need to be selected as described [...] below.

2) For any component where there is at least one key interaction with a pressure, suitable indicators will need to be selected as described [...] below.

3) For any component not identified in 4, but where there are interactions with several pressures, aggregate effects must be considered (see [...] below). Where the aggregate effects of pressures may themselves lead to acute impacts on a component, suitable indicators will need to be selected as described in 3.5.4 below.

This recommendation follows conceptually the established practice of assessing fish populations in terms of both pressure- and state indices (e.g., fishing mortality and spawning–stock biomass).

The importance of recovery time for the concept of sustainable use and corresponding indicators was also highlighted in later reports by WGECO (ICES, 2011, 2012). Indicator values will have slow recovery times if they describe ecosystem components that recover slowly from pressures. Indeed, some indicators, such as the Large Fish Indicator (LFI, Greenstreet *et al*., 2011), are likely to have long recovery times. Theory (Rossberg, 2012), models (ICES 2011; Shephard *et al*., 2013), and data (Fung *et* *al.*, 2012; Shephard *et al.*, 2013) suggest that recovery of the LFI from pressures can last several decades, implying good responsiveness to unsustainable exploitation.

The approach to indicator evaluation taken in Chapter 4 does not contain criteria that would give indicators a good score when they represent states of ecosystem components that potentially have long recovery times, or pressures on such components. Indeed, the context for the indicator evaluation is the development of an operational use of indicators within the MSFD, which is intended to be in full operation by 2020, and implicitly indicators with a fast response time might be preferred over those with slower response times. However, as detailed above, WGECO has highlighted the importance of ecosystem components that respond slowly to management. Additional evaluation criteria might therefore be required to cover this important aspect of indicators for GES. Such criteria were purposely omitted in Table 4.1 to avoid the risk of biasing indicator suites in such a way that early, positive outcomes of management measures become underrepresented in assessments of GES. A trade-off of this decision is that changes in vulnerable ecosystem components, which accumulate effects of pressures over time and would take long to recover from these pressures, might not receive sufficient attention in assessments ("shifting baseline syndrome", Pauly, 1995).

Indicator evaluation criteria to address this issue could be considered along the following lines:

1) Reflecting potential long-term lack of sustainability. A favoured indicator would represent the state of an ecosystem component that is vulnerable to unsustainable use. It would integrate cumulated effects of pressure(s) over time and only recover slowly when pressures are relaxed.

  1.1) Fully met (score of 1): indicator recovery time is of an order of magnitude of decades;

  1.2) Partially met (score of 0.5): indicator recovery time is of the order of magnitude of years;

  1.3) Not met (score of 0): indicator recovers typically within a year.

2) Also reflecting potential long-term lack of sustainability but in the context of evaluation with a PRESSURE indicator. A favoured indicator would represent potentially unsustainable pressure on one or several ecosystem components. The ecosystem effect of the pressure(s) would accumulate over time, and recovery would be slow when the pressure is removed.

  2.1) Fully met (score of 1): ecosystem recovery time after pressure is (hypothetically) removed is of the order of magnitude of decades;

  2.2) Partially met (score of 0.5): ecosystem recovery time is of the order of magnitude of years;

  2.3) Not met (score of 0): indicator recovers typically within a year.

3) Representation of causal chains in indicator suites. Ecosystem components vulnerable to unsustainable use should ideally be represented in terms of both state and pressure indicators.

  3.1) Fully met (score of 1): Both pressure on, and state of, a vulnerable ecosystem component are characterized by an indicator;

  3.2) Partially met (score of 0.5): either pressure on, or state of, a vulnerable ecosystem component are characterized;

3.3) Not met (score of 0): neither state of nor pressure on a vulnerable ecosystem component are characterized.

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4 ToR b) Support to the technical specification and application of OSPAR common indicators under D1, 2, 4, and 6

ToR text: Support to the technical specification and application of OSPAR common indicators under D1, 2, 4, and 6.

Request for the quality assurance/response to specific questions to support the work of the identification and prioritization of common indicators to support the regional implementation of the biodiversity aspects of MSFD in the Northeast Atlantic. BDC 2012 have requested the submission of first set of common indicators to be presented to BDC 2013 (noting that the relevant ICES groups will meet late February early March 2013). At this time (i.e. first quarter 2013), ICES would be requested to undertake an independent peer review of the technical specifications and proposed operational implementation of the indicators that will be presented. The review should consider, from the perspective of producing a set of common indicators for the OSPAR Region: 1) whether the indicators put forwards are appropriate to implement at a regional scale; 2) whether the set of indicators is sufficient as a set to understand GES; 3) identify any gaps; 4) identify where there are difficulties in the operationalization of the indicators, with proposals for how to overcome these. Based on the outcomes of OSPAR request 2013-4 (below) (regarding maximizing efficiencies for monitoring of biodiversity), 5) identify where there are opportunities to cluster indicators that can benefit from shared monitoring/ data collection. OSPAR request 2013-2.

4.1 Criteria for evaluation of the OSPAR common indicators

This term of reference was addressed to both WGECO and WGBIODIV. In 2012, WGECO prepared an initial series of criteria with which to evaluate indicators. This was in response to a request from ACOM. This initial set of criteria were not fully agreed at the 2012 WGECO meeting, but were passed on for comment and proposals to other Expert Groups. In particular, WGBIODIV at its meeting in February 2013 revisited the criteria, redrafted them, and set them out into a table of 16 criteria, for the evaluation of ecosystem indicators. This was particularly aimed at the MSFD, but should have a broader utility. The criteria were provided with explanations of the approach, weightings, and scoring guidance. WGBIODIV then set out to use these criteria to answer this ToR form OSPAR. Their report is contained in Annex 1of the WGBIODIV report.

WGECO carried out an extensive review of the updated version of the criteria proposed by WGBIODIV, based on those produced at WGECO 2012. Broadly, the WG agreed that the criteria proposed matched what WGECO set out to achieve in 2012, and proposed some minor amendments to the criteria table produced by WGBIODIV. The amended table is presented below as Table 4.1. Mostly the amendments were clarifications and minor improvements. The main substantive change was in criterion 8, where the original version was felt to compound pressure-state relationships with activity-pressure relationships. As pressure-state relationships were covered in criterion 6, criterion 8 was changed to address response-activity and activity-pressure relationships.

4.2 Evaluation of the OSPAR common indicators

WGBIODIV then went on to use the criteria to evaluate the list of OSPAR common indicators based on the technical specifications provided by OSPAR ICG-COBAM. This is described in detail in Annex 1, Part 2 of the WGBIODIV 2013 report. WGECO reviewed this report carefully, and concluded that the analysis and approach were entirely appropriate to the request, and concluded also that the WGECO changes in the criterion table were not substantial, so that we have no reasons to question the conclusions by WGBIODIV overall. It was not, therefore, felt necessary to repeat the analysis or add additional components, and WGECO recommends that this material be used in the advice to OSPAR.

Table 4.1. Revised WGECO (ICES 2012) criteria used by WGBIODIV (ICES 2013) to evaluate the performance of "common indicators" proposed by OSPAR to support implementation of the MSFD at subregional and regional scale. The 16 criteria are grouped into five main categories, and the principle characteristic of each indicator's performance examined by each criterion is given. The *importance* weightings, and their associated scores, assigned by WGBIODIV to each criterion are shown, as are the guidelines for assessing the level of *compliance* of each indicator against each criterion. Pale blue cells indicate criteria not contributing to WGBIODIV's analytical assessment of the performance of the OSPAR "common indicators". In the *compliance* guidelines column, criteria automatically given a zero *compliance* score if the indicator was deemed to be a "pressure" indicator (criterion 1) are highlighted.

Criterion No.	**Category**	**Characteristic**	**Criterion**	***Importance* Weighting**	***Importance* Score A**	**Guidelines for *Compliance* Assessment. Score B**
1	Type of Indicator	State or pressure	Is indicator a "pressure" indicator being used for want of an appropriate "state" indicator?			Fully met (1): indicator is a "state" indicator; Not met (0): indicator is actually a "pressure" indicator.
2	Quality of underlying data	Existing and ongoing data	Indicators must be supported by current or planned monitoring programmes that provide the data necessary to derive the indicator. Ideal monitoring programmes should have a time-series capable of supporting baselines and reference point setting. Data should be collected on multiple sequential occasions using consistent protocols, which account for spatial and temporal heterogeneity.	Core	3	Fully met (1): long-term and ongoing data from which historic reference levels can be derived and past and future trends determined; Partially met (0.5): no baseline information, but ongoing monitoring or historic data available, but monitoring programme discontinued, however potential to re-establish the programme exists; Not met (0): data sources are fragmented, no planned monitoring programme in the future.
3	Quality of underlying data	Indicators should be concrete	Indicators should ideally be easily and accurately determined using technically feasible and quality assured methods, and have high signal to noise ratio.	Core	3	Fully met (1): data and methods are technically feasible, widely adopted and quality assured in all aspects, signal to noise ratio is high; Partially met (0.5): potential issues with quality assurance, or methods not widely adopted, poor signal to noise ratio;

Criterion No.	**Category**	**Characteristic**	**Criterion**	***Importance* Weighting**	***Importance* Score A**	**Guidelines for *Compliance* Assessment. Score B**
						Not met (0): indicator is not concrete or doubtful; noise excessively high due either to poor data quality or the indicator is unduly sensitive to environmental drivers
4	Quality of underlying data	Quantitative vs. qualitative	Quantitative measurements are preferred over qualitative, categorical measurements, which in turn are preferred over expert opinions and professional judgments.	Desirable	2	Fully met (1): all data for the indicator are quantitative; Partially met (0.5): data for the indicator are semi-quantitative or largely qualitative; Not met (0): the indicator is largely based on expert judgement.
5	Quality of underlying data	Relevant spatial coverage	Data should be derived from a large proportion of the MSFD subregion, at appropriate spatial resolution and sampling design, to which the indicator will apply.	Core	3	Fully met (1): spatially extensive monitoring is undertaken across the subregion; Partially met (0.5): monitoring does not cover the full subregion, but is considered adequate to assess status at subregional scale; Not met (0): monitoring is undertaken across a limited fraction of the subregion and considered inadequate to assess status at subregional scale.

Criterion No.	**Category**	**Characteristic**	**Criterion**	***Importance* Weighting**	***Importance* Score A**	**Guidelines for *Compliance* Assessment. Score B**
6	Quality of underlying data	Reflects changes in ecosystem component that are caused by variation in any specified manageable pressures	The indicator reflects change in the state of an ecological component that is caused by specific significant manageable pressures (e.g. fishing mortality, habitat destruction). The indicator should therefore respond sensitively to particular changes in pressure. The response should be unambiguous and in a predictable direction, based on theoretical or empirical knowledge, thus reflecting the effect of change in pressure on the ecosystem component in question. Ideally the pressure-state relationship should be defined under both the disturbance and recovery phases.	Core	3	**IF CRITERION 1 IS SCORED 0 THEN THE SCORE MUST BE 0**. Otherwise: Fully met (1): the indicator is primarily responsive to a single or multiple pressures and all the pressure-state[1] relationships are fully understood and defined, both under the disturbance and recovery phases of the relationship; Partially met (0.5): the indicator's response to one or more pressures are understood, but the indicator is also likely to be significantly influenced by other non-anthropogenic (e.g. environmental) drivers, and perhaps additional pressures, in a way that is not clearly defined. Response under recovery conditions may not be well understood; Not met (0): no clear pressure-state relationship is evident.
7	Management	Relevant to MSFD management targets	Clear targets that meet appropriate target criteria (absolute values or trend directions) for the indicator can be specified that reflect management objectives, such as achieving GES.	Desirable	2	Fully met (1): an absolute target value for the indicator is set; Partially met (0.5): no absolute target set for the indicator, but a target trend direction for the indicator is established; Not met (0): targets or trends unknown.

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[1] Here the term pressure-state relationship is used in the sense described by Piet *et al*. (2007): e.g. fishing ***pressure*** (fishing mortality rate [*F*]) – ***state*** of the stock (stock biomass [*B*]).

Criterion No.	**Category**	**Characteristic**	**Criterion**	***Importance* Weighting**	***Importance* Score A**	**Guidelines for *Compliance* Assessment. Score B**
8	Management	Relevant to management measures	Indicator links directly to management response. The relationship between human activity and resulting pressure on the ecological component is clearly understood.	Desirable	2	**IF CRITERION 1 IS SCORED 0 THEN THE SCORE MUST BE 0**. Otherwise: Fully met (1): both response-activity and activity-pressure relationships[2] are well defined - advise can provided on both the direction AND extent of any change in human activity required and the precise management measures required to achieve this; Partially met (0.5): response-activity and activity pressure relationships are not well understood, or only one of the relationships is defined, but not the other, so that the precise changes in pressure resulting from particular management actions cannot be predicted with certainty; Not met (0): no clear understanding of either relationship, so that the link between management response and pressure is completely obscure.
9	Management	Comprehensible	Indicators should be interpretable in a way that is easily understandable by policy-makers and other non-scientists (e.g. stakeholders) alike, and the consequences of variation in the indicator should be easy to communicate.	Desirable	2	Fully met (1): the indicator is easy to understand and communicate; Partially met (0.5): a more complex and difficult to understand indicator, but one for which the meaning of change in the indicator value is easy to communicate; Not met (0): the indicator is

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[2] Here the terms response-activity relationship and activity-pressure relationship are used in the sense described by Piet *et al*. (2007) and Greenstreet *et al*. (2009); e.g. management ***response*** (total allowable catch) – fishing ***activity*** (days-at-sea), and fishing ***activity*** (days-at-sea) – fishing ***pressure*** (fishing mortality rate [*F*]).

Criterion No.	Category	Characteristic	Criterion	*Importance* Weighting	*Importance* Score A	Guidelines for *Compliance* Assessment. Score B
						neither easy to understand or communicable.
10	Management	Established indicator	Indicators used in established management frameworks (e.g. EcoQO indicators) are preferred over novel indicators that perform the same role. Internationally used indicators should have preference over indicators used only at a national level.	Desirable	2	Fully met (1): the indicator is established and used in international policy frameworks; Partially met (0.5): the indicator is established as a national indicator; Not met (0): the indicator has not previously been used in a management framework.
11	Management	Cost-effectiveness	Sampling, measuring, processing, analysing indicator data, and reporting assessment outcomes, should make effective use of limited financial resources.	Desirable	2	Fully met (1): little additional costs (no additional sampling is needed); Partially met (0.5): new sampling on already existing programmes is required; Not met (0): new sampling on new monitoring programs is necessary.
12	Management	Early warning	Indicators that signal potential future change in an ecosystem attribute before actual harm is indicated are advantageous. These could facilitate preventive management, which could be less costly than restorative management.	Informative	1	**IF CRITERION 1 IS SCORED 0 THEN THE SCORE MUST BE 0**. Otherwise: Fully met (1): indicator provides early warning because of its high sensitivity to a pressure or environmental driver with short response time; Not met (0): relatively insensitive indicator that is slow to respond.

Criterion No.	**Category**	**Characteristic**	**Criterion**	***Importance* Weighting**	***Importance* Score A**	**Guidelines for *Compliance* Assessment. Score B**
13	Conceptual	Scientific credibility	Scientific, peer-reviewed findings should underpin the assertion that the indicator provides a true representation of variation in the ecosystem attribute in question.	Desirable	2	**IF CRITERION 1 IS SCORED 0 THEN THE SCORE MUST BE 0**. Otherwise: Fully met (1): peer-reviewed literature; Partially met (0.5): documented but not peer-reviewed; Not met (0): not documented or peer-reviewed literature is contradictory.
14	Conceptual	Metrics relevance to MSFD indicator	For D1 and D6, metrics should fit the indicator function stated in the 2010 MSFD Decision document. This requirement can be relaxed for D4 indicators because the Decision document stipulates the need for indicator development in respect of this Descriptor (but any newly proposed D4 indicators must still fulfil the overall goals stated for D4).	Core	3	Fully met (1): the metric complies with indicator function; Not met (0): the metric does not comply with indicator function.
15	Conceptual	Cross-application	Metrics that are applicable to more than one MSFD indicator are preferable.	Desirable	2	Fully met (1): metric is applicable across several MSFD indicators; Not met (0): no cross-application.
16	Indicator suites	Indicator correlation	Different indicators making up a suite of indicators should each reflect variation in different attributes of the ecosystem component and thus be complementary. Potential correlation between indicators should be avoided.	Desirable	2	Fully met (1): the indicators are uncorrelated; Partially met (0.5): correlation between some indicators; Not met (0): all indicators are correlated.

5 Provide advice on maximizing the use of available sources of data for monitoring of biodiversity; addressing ToR c

g) Provide advice on maximizing the use of available sources of data for monitoring of biodiversity.

The purpose of this request is to seek ICES advice on the potential sources of data and information that may be available to support the monitoring and assessment of biodiversity in relation to commitments under MSFD so as to maximize efficiencies in the use of available resources, for example where efficiencies could be made to identify where there are monitoring programmes or data sources that can deliver multiple indicators, which may relate to different Descriptors, (e.g. The Data Collection Framework could be used to implement D3 and D1 indicators), or where with a small additional effort existing monitoring could be amplified to deliver a broader set of data. Advice would be sought as to 1) the quality of these potential data sources and how they could be used, including but not limited to the relevance of outcomes identified in chapter 8 of the ICES MSFD D3+ report to Descriptors 1, 4 and 6. **OSPAR request 2013-4**.

5.1 Introduction

In its response to this request WGECO has focused on research vessel surveys as potential sources of data. A range of other potential data sources are recognized, these include:

- Commercial landings data-logbooks;
- Commercial discard data;
- Shore-based sampling, particularly for benthos, contaminants, hydrographic parameters and biological oceanography;
- Remote sensing i.e. satellites for e.g. SST, ocean colour, sea surface elevation, waves (SAR), etc.;
- Other seagoing sampling systems e.g. Continuous plankton recorders on ships of opportunity, underwater cameras;
- Aerial surveys (marine mammals, sea turtles, seabirds, sharks).

A first approach to the potential of research vessel surveys has been carried out by the ICES WG on Integrating Surveys into the ecosystem approach; WGISUR (ICES 2010, 2012), and its associated Workshops WKCADAT (Workshop on Cataloguing Data Requirements from Surveys for the EAFM; ICES 2010), and WKECES (Workshop on Evaluation of Current Ecosystem Surveys; ICES 2012).

5.1.1 WKCATDAT

5.1.1.1 Potential data products

In line with this request, WKCATDAT set out to describe all potential additional data collection that could be carried out on a range of different survey types; trawl surveys, acoustic surveys, icthyoplankton surveys and TV surveys. The first approach was to describe the scope of possible data collection potentials. These fell into the following categories:

- **Fish and organisms** – biological material from the trawls, including *inter alia*; stomachs, organs, disease and parasite registration, etc., but also including acoustic data and tagging;
- **Physical and chemical oceanography** – e.g. CTD, chlorophyll, oxygen, nutrients, turbidity, etc. This was subdivided by collection platform and approach:
    - Continuous underway measurements;
    - Station measurements;
    - Autonomic devices;
    - Water movement (ADCP);
    - Nutrient sampling – Using water bottles, etc.
- **Biological oceanography** – principally collection of plankton and other passive biological material, using; water samplers, continuous plankton recorders, towed profiling samplers, dipped samplers and echosounders;
- **Invertebrates –** collection of invertebrate biological samples such as; infauna, epifauna, and pelagic invertebrates, each of which would require different sampling approaches;
- **Megafauna** – collection of data on mammals, seabirds, large elasmobranchs, etc. usually by sight survey but including towed hydrophone systems to track cetaceans underwater;
- **Habitats** – collection of data on seabed substrate, structure and relief, using acoustic seabed discrimination systems and direct camera observation. For example;
    - Towed/dropped camera systems;
    - Side-scan sonar;
    - Multi-beam echosounder;
    - Single beam echosounder seabed discrimination systems;
    - Sampling for ground-truthing of such systems is also addressed.
- **Pollution –** This would include a range of pollutants, each of which would require a different sampling approach:
    - Floating litter;
    - Sinking litter;
    - Pollution in the water column;
    - Pollution in the sediment;
    - Pollution in organisms.
- **Environmental conditions** – principally weather conditions and sea state.

5.1.1.2 Cross tabulation against MSFD Descriptors

These were then cross tabulated against survey type, principally trawl, acoustic and icthyoplankton, and then further cross tabulated against the eleven descriptors of the MSFD. One broad conclusion was that the existing surveys had at least the potential to collect appropriate data cross nine of the eleven descriptors. Data collection in the context of Human-induced eutrophication (Descriptor 5) was considered as very limited, and largely non-existent for Descriptor 11: Introduction of energy, including underwater noise.

5.1.1.3 Additional considerations

The table also included information on:

- Additional equipment need during survey preparation;
- Additional skills, personnel, ship time, and facilities needed during the survey;
- Additional personnel, facilities, lab facilities, sample and data storage, analytical instruments and software needed for post-processing.

The table is presented as an Excel table attached to this report.

5.1.1.4 Data collection potential on specific vessels and survey types

In a second step, this table was passed to a range of survey based expert groups for further elaboration. It was recognized that the ability to collect these additional data were contingent on the particular vessel, and on the primary purpose of the survey, and so responses were sought across a range of survey types and national research vessels.

Six surveys were evaluated:

- Norwegian Barents Sea Survey – trawl, acoustic and ecosystem survey;
- Belgian North Sea Beam Trawl Survey;
- English North Sea IBTS;
- French Biscay Pelagic ecosystem survey – Acoustic;
- German Mackerel egg survey – icthyoplankton;
- Scottish *Nephrops* TV survey.

Information collected was cross tabulated across the following headings within the data categories and subcategories described above.

- Additional data already being collected during the survey
  - Is it used now?
  - Does it entail additional resources? E.g. Equipment, Expertise, People, Time, or Facilities
- If not already collected
  - Effort required to collect data
  - Does it entail additional resources? E.g. Equipment, Expertise, People, Time, or Facilities
- If collected but not already processed
  - Effort required to process
  - Does it entail additional resources? E.g. Equipment, Expertise, People, Time, or Facilities

The results of the evaluations are presented in the attached Excel worksheets.

5.1.2 Complementary information from IBTSWG, WGBEAM and WGBIODIV

In a complementary approach, IBTSWG and WGBEAM (responsible for the standard trawl and beam trawl surveys) and WGBIODIV were asked to respond to the same ToR. It was considered useful to include some of their responses here to allow a complete response to the Tor in one package. The IBTSWG and WGBEAM responses used identical tables and cross tabulated the EU-COM 477/2010 and corresponding OSPAR indicator ID along with whether the data were currently collected, and what could be added with additional effort. The response was more focused on the OSPAR indicators than the WGISUR approach, which was focused on the MSFD Descriptors. WGECO have used the OSPAR indicator ID here to identify particular indicators in common with the WGBIODIV approach. The conclusions were broadly similar to those seen in the individual survey versions of the WKCATDAT table.

For the IBTS, the main areas where data were available already were understandably the Fish and Cephalopod indicators FC1–8, with the exception of 4 (on bycatch). Additional data products would be available contingent on a number of procedural developments including the development of swept-area estimation procedures and appropriate maturity estimation keys. Data support could be provided for Foodweb indicators (FW4 and 7). FW8 could be supported in terms of stomach sampling. For Bird indicators, the surveys could provide seabird data under B1 and 6, but suggested that this was more appropriate to other survey types (e.g. acoustic and icthyoplankton). The IBTSWG response table is presented in Table 5.1.

For WGBEAM, the conclusions in terms of the FC indicators were broadly similar, although swept-area estimates are much more straightforward with this gear, and could be improved with use of covariates. . No data for FC 6 was obtainable due to survey timing, but improvements could be made with new maturity keys and at sea histological sampling. Biomass and abundance estimates from the survey could support FW 4, 7, and 8. Again, the surveys could provide seabird data under B1 and 6, but suggested that this was more appropriate to other survey types (e.g. acoustic and icthyoplankton). The IBTSWG response table is presented in Table 2.

In their evaluation, WGBIODIV drafted a table cross referencing the OSPAR indicator ID with survey métier, largely derived from the WGISUR work, and it might be suggested that the WGISUR/WKCATDAT report should be used first in this case. For the trawl based surveys, this table should probably be superseded by those offered by WGBEAM, and IBTSWG. For acoustic surveys WGBIODIV indicates data collection possibilities under FC1, and possibilities under M2 and 4, B1 and 6 (in line with the suggestions of WGBEAM and IBTSWG), as well as FW1, and 6–9. Acoustic surveys probably also represent our best option for collecting the Pelagic Habitat (PH) indicators, and also the Benthic Habitat (BH) indicators via Acoustic Sea Bed classification methodologies including multibeam technology. TV surveys are proposed as supporting BH 1, 3 and 4, which seems reasonable, as well as FW9. Finally, Icthyoplankton surveys clearly provide potential in both pelagic habitat and foodweb indicators. They are also ideal platforms for the collection of data on seabirds and mammals at sea, and indeed have been used widely in this way.

5.1.3 DCF Indicators

The request also refers to the DCF indicators of ecosystem impacts of fishing. Four of these in particular are relevant to surveys:

- Conservation status of fish species (FC5);
- Proportion of large fish (FC2);
- Mean maximum length of fishes (FC3);
- Size at maturation of exploited fish species (FC6).

The formulation of these was predicated on the trawl surveys and generally is already being delivered from the IBTS and potentially the beam trawl surveys.

5.1.4 Factors to consider in extending sampling on routine surveys WKCATDAT

WKCATDAT went on to address a number of important implications for survey planning and conduct of any move towards EAFM surveys. In essence, while the potentiality for any particular type of data collection might exist on a survey, there were a number of issues that would need to be resolved before this could be done in practice. These considerations included:

- Seasonality – The impact of changes across the year and the use of a single period survey to characterize the ecosystem.
- Unfishable habitats – Most surveys and particularly trawl surveys will include large areas where bottom-trawl fishing is not possible. This would have implications for EAFM surveys and indeed for stock estimation surveys.
- Spatial resolution – This is a combination of the spatial and temporal scale of our sampling tools and of changes across the ecosystem we wish to sample. The existing sampling protocol e.g. station location or transect design and spacing may not be appropriate to the additional ecosystem sampling.
- Wide spread vs. detailed local surveys – There is value in both wide area synoptic surveys, which allow broad scale perceptions of the ecosystem, but also in small-scale, local and detailed surveys that can provide much more information, particularly about process and linkage.
- Monitoring vs. Process surveying – As with wide spread vs. local, we can learn different things from surveys targeted on monitoring e.g. resources surveys, as well as the more detailed but local process based surveys. Both should form components of a fully integrated ecosystem survey approach.
- Stratification by habitats – Currently many resource surveys are stratified by target species abundance, although some include fish community and ICES depth strata. In an ecosystem approach, it will be important to representatively sample the full range of habitats.
- Use of ecosystem models to identify data or structural weakness – There should be a feedback between the surveys and the models we use to explore the ecosystem based on survey data. As well as illuminating ecosystem functioning, the models can also show us where our sampling is weaker, or where the models themselves require more data support.
- Data stream integration – Full EAFM surveys will develop a vast amount of data, collected on many different approaches, e.g. station based, transect based or integrated sampling across different ranges. Data volume will also vary, from species presence/absence binary data through to multibeam acoustic data, and will require careful consideration of how to bring these all together clearly and coherently.
- Fully Synoptic Surveys – Arguably the best advantage from EAFM surveys will be gained where the data are collected in a synoptic fashion, coherent sampling in time and space. This represents a challenge to surveys and suggests the possible need for multivessel surveys operating either on different parts of the area or on different types of data collection. This in turn raises implications for calibration and management.

- Unused current data potential and samples – Before even addressing future elaboration of EAFM surveys, we should make better use of data that we collect already, and rarely use. For example, plankton samples taken on icthyoplankton surveys.
- Data purpose and conflicts – As we move towards more sampling and analysis on surveys we will likely encounter more and more conflicts between sampling approaches, e.g. different acoustic instruments. We will also need to be clear on the purpose of the data collection and its quality requirements.
- Year of the EAFM survey – Rather than moving in an *ad hoc* and incremental path towards full EAFM surveying, it may well be advised to consider dedicating one year of survey effort to a comprehensive integrated survey. This might provide the substrate for analyses into what level of sampling (in time and space) is needed, and would provide a strong baseline for future work.

5.1.5 Ecosystem and Fisheries Surveys WKECES

Numbers of surveys already exist which are designed or adapted as ecosystem surveys rather than just fisheries surveys which can collect ecosystem data. The aim with the second WGISUR workshop, WKECES, was to carry out a SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis for a shortlist of such surveys. The surveys examined were:

- The UK Western Channel Beam Trawl Survey;
- The Joint Barents Sea ecosystem survey;
- The German Small-scale Bottom Trawl Survey;
- The French and Spanish Pelagic Ecosystem survey in Biscay.

Two key themes emerged as the causes of the strengths and weaknesses for all the surveys:

- Setting and prioritizing objectives;
- Survey design and the need to be able to elucidate process by explicitly linking dynamics in different ecosystem components.

It also became clear that some of the strengths were mutually exclusive, either operationally or conceptually, and therefore an ‘ideal ecosystem survey’ on a single vessel, is unlikely to exist. An ecosystem monitoring programme that has at the heart of it one or more ecosystem surveys is required and these should go beyond strict status observations and link different ecosystem components with each other or the physical environment. The prioritization of these surveys might be based on three factors:

- the characteristics of the ecosystem particularly with respect to the spatial and temporal scales of variability;
- the available resources in ships time, but also expertise and financial considerations. International pooling of resources will aid to increase efficiency and improve regional ecosystem assessments across national boundaries;
- the management and legal requirements and prioritizations for reporting. This is not a scientific criterion, but an ability to address the former will almost certainly have an impact on the availability of resources.

Policy-makers and funding bodies should make themselves more aware of the benefits of integrated monitoring vs. the current discipline-specific monitoring programmes. The former provide advice based on an understanding of ecosystem process identifying how to act rather than merely identifying critical situations. Therefore both the surveys and the advice can provide significant advances in efficiency.

The detailed SWOT analyses are available in the WKECES report (ICES 2012).

5.2 A way forward

While a fully integrated, designed for purpose ecosystem survey would be the ideal, we recognize that this may be difficult to achieve in the current fiscal climate. However, the potential for expanding the data collection procedures on the routine fishery surveys in support of MSFD and other policy drivers remains, albeit in a more limited scope. This additional data collection could be aimed at further populating existing indicators, but may also entail data collection to better understand new proposed indictors.

What then is needed is a route to prioritizing any additional data collection tasks for the surveys, as they certainly cannot support all these new data collection requirements. The indicator evaluation task undertaken by WGECO and WGBIODIV and reported under ToRs a) and b) could provide such a prioritization, by identifying where the data weaknesses in a particular descriptor, indicator or subregion were most critical.

The next step would be to identify the appropriate group of experts who could define the ecosystem monitoring needs in the particular context of the highest priority indicators. This could be the Benthic Ecology Working Group (BEWG) in the context of the example on benthos sampling given above. Their task would be to define what was needed in terms of sample collection (gear, operational protocols, sample handling and so on) and in terms of spatial coverage, spatial resolution, accuracy and precision, etc. to provide a robust data support for the indicator in question. This would then be passed back to the survey experts to see if this could feasibly enacted with existing resources. This is likely to be an iterative process. The initial sampling requirements proposed may not be possible in the context of the survey or perhaps in the context of the survey AND other high priority monitoring requests, and would entail a recourse to the ecology group and so on. One possible outcome might even be that there is no possibility of an adequate monitoring programme being carried out on that survey, but even then, sampling levels may prove possible that would help move towards an appropriate and operational monitoring strategy, say, by establishing stratification criteria. Experience in other areas has shown that the performance of these new indicators will need to be analysed with at least five datapoints and until that time-series is collected it may be impossible to evaluate performance and sensitivity.

The process described above is essentially one of “bolting on” new monitoring requirements to existing surveys. It is very important in this process that we do not compromise the core of the original survey work, usually fish abundance estimates. At the same time we would want to be sure that the “bolt on” components were done with sufficient care that they would be useful in the monitoring context. This will be a fine balance to strike, and will need careful evaluation.

5.2.1 Issues to consider when planning changes to data collection protocols

5.2.1.1 Additional data collection

Research vessel fish trawl surveys typically record the total weight and number of individuals caught. For some species data on the length–frequency distribution, sex (including sexual maturity stage), stomach contents and total weight and number are collected also. Additional data collections can extend to other species caught in the trawl catch or to tissue samples of those same species (i.e. for genetic work). These can include non-target fish and a suite of invertebrates as well as marine debris (litter). For example, on the west coast of North America the composition and abundance of benthic marine debris was investigated during the 2008 West Coast Groundfish Trawl Survey from the US-Canada to the US-Mexico borders. Debris items from ~750 randomly selected tow sites (55–1280 m) were classified into eight categories (plastic, metal, clothing, glass, toxic, derelict fishing gear, military debris and other) and counted and weighed. Similar benthic marine debris surveys based on litter collected during benthic trawls are reported for the Mediterranean Sea, Bering Sea, Gulf of Alaska, Oregon coast and the Bay of Biscay. These surveys can also be used to document floating marine litter, waterbirds, sea turtles, sharks and marine mammals by counting these items/species using standard protocols. Similarly aerial surveys for marine mammals can be extended to collect data on floating marine debris, sea turtles, sharks and waterbirds and *vice versa*. Such integrated surveys have been conducted by NOAA in the US.

It is important to recognize that each additional new sampling requirement placed on a survey will have some implications in terms of that surveys core programme, the personnel and equipment needed on board, and ultimately on the vessel time allocated. For example, we might need additional people to monitor cetaceans or seabirds, take plankton tows, run CTD dips, etc. Clearly the resource implications of the post cruise analysis of any material also needs to be considered as this also takes time, manpower and other resources.

5.2.1.2 Additional gear

Modifications to the trawlnets which change the fishing of the gear would compromise the primary objectives of research vessel survey, which are to obtain accurate estimates of the target species. However some gear modifications can easily be accommodated. For example, during a series of North Sea demersal fish surveys, a headline camera was used to photograph the seabed at intervals of 1 min, throughout the duration of 60 min trawls. A successful series of underwater photographs were obtained at 119 stations throughout the North Sea. In addition, the benthos caught at 317 stations was recorded. A total of *ca*. 30 species could be identified on the underwater photographs, and of these ten species were sufficiently common or locally abundant for estimates of local population densities to be made. Distributions throughout the North Sea based on specimens trawled and specimens photographed were compared (Dyer *et al*., 1982). Kenchington *et al*. (2009) used an aquarium on the codend of a midwater trawl to obtain good specimens of mesopelagic fish which assisted in the identification of the species in the net.

Additional gear types can be deployed during the survey. Examples include CTD and water samplers, castnets, acoustics, etc. As an example, it has been suggested that one possibility for enhancing data collection on IBTS surveys would be to collect benthos material using a beam trawl during the night when routine trawling operations are not carried out. This has been tried on an occasional basis on several North Sea

IBTS surveys. While this makes use of time when the vessel is not trawling, it still requires deck crew and scientists to carry out the work, collect, collate and archive the samples and so on. So the vessel would need to carry at least one, and probably more, additional personnel to do this. Most vessels have limited cabin space or indeed a maximum complement, so this may be a limiting factor. The important point is that while there may be space to include data collection for this one aspect, every additional data collection task will likely carry the same constraints.

5.2.1.3 At-sea identification

Research vessel trawl surveys can capture large numbers of invertebrate species. In the Flemish Cap and southwestern Grand Banks area of the Northwest Atlantic over 500 invertebrate taxa have been identified from trawl survey bycatch and dredge surveys (Murillo *et al.*, 2011). Such identifications require specialized taxonomic knowledge and likely require that the trawl catch is sorted at sea by an invertebrate expert but returned to the lab for full processing. This may raise space and formalin storage issues on the vessel in addition to the time delays and personnel required for sorting the catch discussed above. NAFO has produced coral and sponge identification guides (Kenchington *et al.*, 2009; Best *et al.*, 2010) which can help improve the at-sea identification of species of interest.

5.2.1.4 Catchability

Catchability of non-target species in research vessel trawl surveys is a *critical* issue when considering extension of the data collection protocols to other ecosystem components, in particular benthic invertebrate species. Some of those taxa are fragile and are mainly represented in the catch as broken fragments. This is particularly true of the large gorgonian corals and some of the sponge species. The degree of fragmentation may depend on many variables (bottom type, catch weight, gear type) other than species, making it difficult to make generalized adjustments to the data to correct for this problem. Further, some bycatch may pass entirely through the nets. Consequently null catches may not be indicative of zero coral or sponge in an area. The Canadian Northern Shrimp Research Foundation (NSRF) and DFO joint industry/government shrimp surveys in NAFO areas 2G and 0B provide additional insight into the scope of this problem (Kenchington *et al.*, 2012). On these surveys there are essentially two nets, the main trawl codend and a Linney bag attached to the belly of the trawl. Linney bags collect what goes through the trawl mesh and are there to get a signal of small shrimp, however they also provide information on coral bycatch that passes through the meshes. These data show that data recorded as null data using the data from the main trawl codend has a 32.6% error, that is 32.6% (range 20.6 to 42.6%) of the Linney bags (N=482) contained coral when no coral were found in the main trawl codend. Although these results are specific to this area and this gear type it reinforces the importance of not interpreting null data to mean coral absence on the bottom. Further, many of the cold-water corals and sponges are long-lived species with slow growth rates and low recruitment. Consequently even if the above-mentioned problems could be resolved, data on their abundance and biomass collected from research trawl survey bycatch is unlikely to be sensitive to change over short time-scales unless mass mortality events occur. Despite these drawbacks, trawl survey data have been very useful in identifying general distributions of benthos, and could be used to develop geospatial indices in future (Kenchington *et al.*, 2012, ICES 2012).

5.2.1.5 Survey design

Research vessel fish trawl surveys generally follow a stratified random design that implies different sampling probabilities over strata. This increases the precision around the estimates of the target species. It is important to use the sampling design to calculate different probabilities for the estimates of mean and variance and to create confidence intervals by bootstrapping. Such design-based variances produce correct results for the population variance even when the distribution is skewed and/or autocorrelated (and the mean is unbiased). However, surveys design can be very problematic for data collection of non-target species. In particular, many species will have their core distribution in strata other than those occupied by the core distribution of the target species; those strata are not allocated a large number of stations and so additional sampling may be required to compensate for this. For example, coral and sponges typically fall into the deep-water strata that are not well sampled. Consequently bycatch data are typically highly right-skewed, in addition to having many zero hauls (Kenchington *et al.*, 2012). Zero-inflated data can be difficult to analyse and may prove to have too high a variance to be useful for the development of indicators.

5.2.1.5.1 Survey area

The survey area may also not cover the distribution of the non-target species adequately. Deep-water and inshore species, as well as species that live on untrawlable bottom, are clear examples of where research vessel trawl surveys may not meet the requirements for sampling of non-target species.

5.2.1.5.2 Spatial scale

Research vessel trawl surveys cover a broad geographic area but integrate data over spatial scales of 1 km or more depending on the vessel speed and trawl duration. Therefore data that require collection precision at scales of less than 1 km (certain benthic habitats for example) will likely require additional sample once the general distribution is identified.

5.2.1.5.3 Temporal scale

Research vessel trawl surveys are consistently run at the same time of the year in order to reduce seasonal effects in the time-series. Some countries run spring, fall and winter surveys for key fish stocks (e.g. Canada), while other surveys may be restricted to a single time frame conducted annually. The timing of the survey can be very important for some species (e.g. migratory species) or for some data collection types (e.g. genetic data should be collected from spawning aggregations).

5.2.2 Changes in survey protocols over time

Research vessel fish trawl surveys cover a broad area and are a good platform for extending data collection protocols to address the suite of indicators under the MSFD, OSPAR and DCF. However the survey time period may not apply to the collection of data on non-target species which may have a much shorter reporting period than the survey for the target species. Where appropriate data may have been collected but not used for ecosystem reporting it will be important to consider whether any changes to the survey protocols have occurred and to analyse the conversion factors separately for those taxa. For example, when vessels are replaced fish assessment scientists typically conduct comparative fishing trials to create conversion factors to reconcile the change to the time-series. These are done for the target species and would have to be considered for non-target species as they could have a different response to the change.

Case Study

In 2006, the United Nations General Assembly Resolution 61/105 called upon "States to take action immediately, individually and through regional fisheries management organizations and arrangements, and consistent with the precautionary approach and ecosystem approaches, to sustainably manage fish stocks and protect vulnerable marine ecosystems [VMEs], including seamounts, hydrothermal vents and cold-water corals, from destructive fishing practices, recognizing the immense importance and value of deep-sea ecosystems and the biodiversity they contain". To provide States and Regional Fisheries Management Organizations with guidance for implementing Resolution 61/105, FAO sponsored an Expert Consultation in Bangkok, Thailand in September 2007 which resulted in a set of "International Guidelines for the Management of Deep-Sea Fisheries in the High Seas" (FAO 2009). In this context, vulnerability is assessed with respect to species and habitats that come into contact with bottom-contact fishing gears. NAFO contracting parties conducting research vessel trawl surveys for fish stock assessments in the area (notably the EU (Spain, Portugal), Canada and Russia) introduced changes to their data collection protocols to collect data on corals and sponges (VME indicator taxa). NAFO has closed areas to protect VMEs of large gorgonian corals, sea pens and sponge grounds in accordance with the FAO Guidelines based on this enhanced data collection. They have further used that data to produce scientifically based advice on research and commercial encounter thresholds to identify VMEs. The resulting data available for the regulatory area is impressive. For example, the sea pen dataset currently consists of 3063 records from Canadian (N=1051) and EU (N=2012) research vessel trawls from 2002 to 2010. Of these, 2245 records represent null datapoints where no seapen bycatch was observed. Further, of the 818 research trawls recording sea pens, ~92% were found in water depths greater than or equal to 300 m. That data show a seapen distribution that is easily discernible as a horseshoe around Flemish Cap (Figure 5.1).

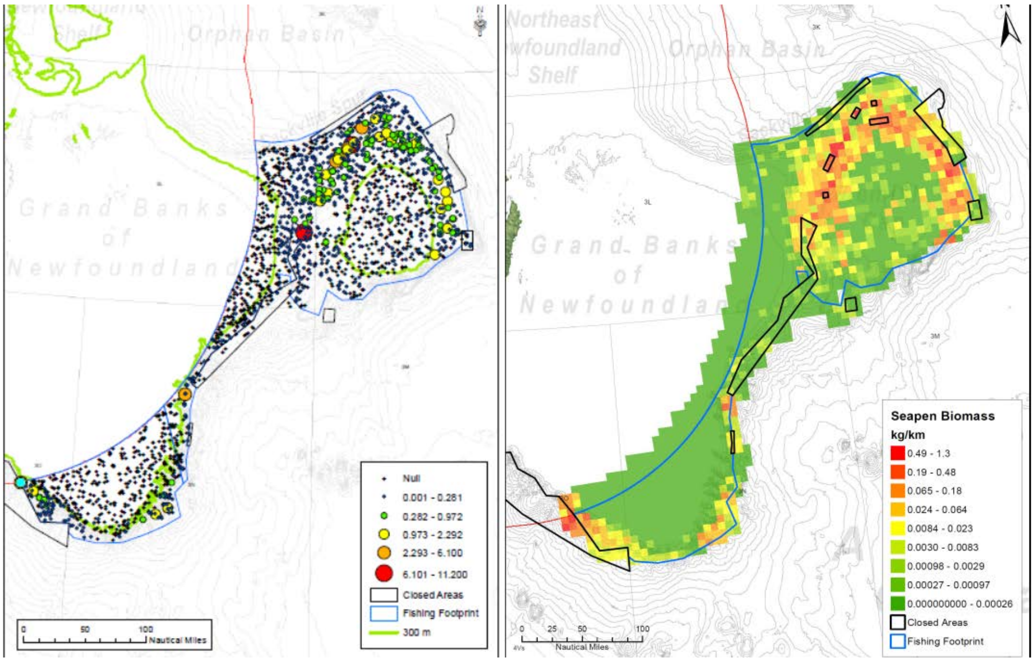


Figure 5.1. The distribution of Canadian and EU research vessel trawl seapen bycatch data (2002 to 2010) for the NAFO regulatory area (Flemish Cap and SE Grand Bank, Northwest Atlantic). Catches are depicted as kg/km and shown as individual trawl sets (left panel) and as a grided surface using 5 x 5 km grid cells (right panel) in relation to the fishing footprint perimeter, the 300 m depth contour and closed areas (symbols obscure some of those areas, see NAFO CEM 2013 for details of closed area positions).

Table 5.1. Possible contributions of the ICES International Bottom Trawl Surveys to reporting under the MSFD, specifically with regard to biodiversity-related indicators. Indicators selected, based on nomenclature in EU-COM 477/2010 (left-hand column); matching OPSAR indicator ID (2nd column); distinction of core and candidate indicators as identified by OSPAR; IBTS data availability from surveys in the North Sea and in the Northeastern Atlantic, respectively; possible improvement of data availability in each of the survey areas if extra effort was allocated to these surveys.

MSFD (EU-COM 477/2010)		OSPAR terminology		IBTS data availability		Possible improvement with extra effort			
Indicator ID	Indicator ID	Indicator name	Core/ Candidate	North Sea	Northeastern Atlantic	North Sea		Northeastern Atlantic	
1.2.1	FC-1	Population abundance/ biomass of a suite of selected species	Core	No population estimates (see assessments for those). But abundance estimates per hour fished for various fish species. Accuracy is species-dependent.	No population estimates (see assessments for those). But abundance estimates per hour fished for various fish species. Accuracy is species-dependent.	Abundance per swept-area will be possible when cpue data from IBTS are additionally given per swept-area (presently per hour fished).	For some species, presently not always reported to species level (e.g. squids, gobies), species could be collected for taxonomic ID on shore.	Abundance per swept-area will be possible when cpue data from IBTS are additionally given per swept-area (presently per hour fished).	For some species, presently not always reported to species level (e.g. squids, gobies), species could be collected for taxonomic ID on shore.
4.2.1	FC-2; FW-3	OSPAR EcoQO for proportion of large fish (LFI)	Core	Yes	Yes				
3.3.2	FC-3	Mean maximum length of demersal fish and elasmobranchs	Core	Yes	Yes				
N.A. (related to 4.3.1)	FC-4	Bycatch rates of Chondrichthyes	Candidate	Not relevant for research surveys	Not relevant for research surveys				

MSFD (EU-COM 477/2010)	OSPAR terminology			IBTS data availability		Possible improvement with extra effort	
Indicator ID	Indicator ID	Indicator name	Core/ Candidate	North Sea	Northeastern Atlantic	North Sea	Northeastern Atlantic
N.A. (related to 4.3.1)	FC-5	Conservation status of elasmobranch and demersal bony-fish species (IUCN)	Candidate	No population estimates (see assessments for those). But abundance estimates per hour fished for various fish species. Accuracy is species-dependent.	No population estimates (see assessments for those). But abundance estimates per hour fished for various fish species. Accuracy is species-dependent.		
1.3.1; 3.3.1	FC-6	Proportion of mature fish in the populations of all species sampled adequately in international and national fish surveys	Candidate	Yes, for IBTS target species, but depending on species-specific maturation process and hence sampling time (quarter).	Yes, for IBTS target species, but depending on species-specific maturation process and hence sampling time (quarter).	For additional species theoretically possible, but requires extra resources for acquisition of maturity data. Guidelines needed for maturity keys/ spawning times.	For additional species theoretically possible, but requires extra resources for acquisition of maturity data. Guidelines needed for maturity keys/ spawning times.
1.1.1	FC-7	Distributional range of a suite of selected species	Candidate	Yes	Yes		
1.1.2	FC-8	Distributional pattern within range of a suite of selected species	Candidate	Yes, according to spatial resolution of the survey	Yes, according to spatial resolution of the survey		

MSFD (EU-COM 477/2010)	OSPAR terminology			IBTS data availability		Possible improvement with extra effort	
Indicator ID	**Indicator ID**	**Indicator name**	**Core/ Candidate**	**North Sea**	**Northeastern Atlantic**	**North Sea**	**Northeastern Atlantic**
possibly related to 1.7.1 or 4.3.1	FW-4	Changes in average trophic level of marine predators (cf MTI)	Core			Samples for fish predators can be provided (for stomach analyses or tissue samples for stable isotope analysis); sample processing requires extra analytical effort.	Samples for fish predators can be provided (for stomach analyses or tissue samples for stable isotope analysis); sample processing requires extra analytical effort.
1.7.1; 4.3.1	FW-7	Fish biomass and abundance of dietary functional groups	Candidate	Biomass and abundance estimates per hour or distance fished of various fish species dependent on definition of dietary functional groups.	Biomass and abundance estimates per hour or distance fished of various fish species dependent on definition of dietary functional groups.	Extra effort if individual fish weights of non-target species are needed.	Extra effort if individual fish weights of non-target species are needed.
could be realted to 4.2.1; 4.3.1	FW-8	Changes in average faunal biomass per trophic level (Biomass Trophic Spectrum)	Candidate	Data on biomass per haul for all fish species			

MSFD (EU-COM 477/2010)		OSPAR terminology		IBTS data availability		Possible improvement with extra effort		
Indicator ID	**Indicator ID**	**Indicator name**	**Core/ Candidate**	**North Sea**	**Northeastern Atlantic**	**North Sea**		**Northeastern Atlantic**
1.2.1	B-1	Species-specific trends in relative abundance of non-breeding and breeding marine bird species	Core			Yes, some vessels in IBTS may be able to take bird observers aboard (however, acoustic surveys or ichthyoplankon surveys may be advantageous for seabird observations).	Yes, some vessels in IBTS may be able to take bird observers aboard (however, acoustic surveys or ichthyoplankon surveys may be advantageous for seabird observations).	
1.1.2	B-6	Distributional pattern of breeding and non-breeding marine birds	Core			Yes, some vessels in IBTS may be able to take bird observers aboard (however, acoustic surveys or ichthyoplankton surveys may be advantageous for seabird observations).	Yes, some vessels in IBTS may be able to take bird observers aboard (however, acoustic surveys or ichthyoplankon surveys may be advantageous for seabird observations).	

Comment for all entries: Limited (like all survey data) by the catch ability of the gear for the species in question.

Table 2. Possible contributions of the ICES Beam Trawl Surveys to reporting under the MSFD, specifically with regard to biodiversity-related indicators. Indicators selected, based on nomenclature in EU-COM 477/2010 (left-hand column); matching OPSAR indicator ID (2nd column); distinction of core and candidate indicators as identified by OSPAR; WGBEAM data availability from surveys in the North Sea, Western Waters of the UK, Bay of Biscay, Adriatic Sea and inshore waters of the North Sea respectively; possible improvement of data availability in each of the survey areas if extra effort was allocated to these surveys. Were 'NO' is recorded this means that without extensive redesigning of the survey, no improvement to the data availability is possible.

MSFD (EU-COM 477/2010)	OSPAR terminology			WGBEAM data availability				
Indicator ID	Indicator ID	Indicator name	Core/ Candidate	North Sea	Western UK Waters	France/Biscay	Adriatic	Inshore
1.2.1	FC-1	Population abundance/ biomass of a suite of selected species	Core	No population estimates (see assessments for those). Abundance (per square km) estimates for various fish species can be supplied.	No population estimates (see assessments for those). Abundance (per square km) estimates for various fish species can be supplied.	No population estimates (see assessments for those). Abundance (per square km) estimates for various fish species can be supplied.	No population estimates (see assessments for those). Abundance (per square km) estimates for various fish species can be supplied.	The area covered is spatially restricted but will give addtional information not available from other survey sources. Abundance (per square km) estimates for various fish species can be supplied.
				Accuracy is species-dependent.	Accuracy is species-dependent.	Accuracy is species-dependent.	Accuracy is species-dependent.	Accuracy is species-dependent.
4.2.1	FC-2; FW-3	OSPAR EcoQO for proportion of large fish (LFI)	Core	Yes - cut-off point and reference limit needs to be defined by survey	Yes - cut-off point and reference limit needs to be defined by survey	Yes - cut-off point and reference limit needs to be defined by survey	Yes	Yes - cut-off point and reference limit needs to be defined by survey

MSFD (EU-COM 477/2010)	OSPAR terminology			WGBEAM data availability				
Indicator ID	**Indicator ID**	**Indicator name**	**Core/ Candidate**	**North Sea**	**Western UK Waters**	**France/Biscay**	**Adriatic**	**Inshore**
3.3.2	FC-3	Mean maximum length of demersal fish and elasmobranchs	Core	Yes	Yes	Yes	Yes	Yes
N.A. (related to 4.3.1)	FC-4	Bycatch rates of Chondrichthyes	Candidate	Not relevant for research surveys	Not relevant for research surveys	Not relevant for research surveys	Not relevant for research surveys	Not relevant for research surveys
N.A. (related to 4.3.1)	FC-5	Conservation status of elasmobranch and demersal bony-fish species (IUCN)	Candidate	No population estimates (see assessments for those). Abundance (per square km) estimates for various fish species can be supplied.	No population estimates (see assessments for those). Abundance (per square km) estimates for various fish species can be supplied.	No population estimates (see assessments for those). Abundance (per square km) estimates for various fish species can be supplied.	No population estimates (see assessments for those). Abundance (per square km) estimates for various fish species can be supplied.	The area covered is spatially restricted but will give addtional information not available from other survey sources. Abundance (per square km) estimates for various fish species can be supplied.
				Accuracy is species-dependent.	Accuracy is species-dependent.	Accuracy is species-dependent.	Accuracy is species-dependent.	Accuracy is species-dependent.

MSFD (EU-COM 477/2010)	OSPAR terminology			WGBEAM data availability				
Indicator ID	Indicator ID	Indicator name	Core/ Candidate	North Sea	Western UK Waters	France/Biscay	Adriatic	Inshore
1.3.1; 3.3.1	FC-6	Proportion of mature fish in the populations of all species sampled adequately in international and national fish surveys	Candidate	No - surveys outside of the spawning period and gear selectivity issues	No - surveys outside of the spawning period and gear selectivity issues	Relative proportion for target species (sole) data is collected	Relative proportion for target species data is collected	No - surveys outside of the spawning period and gear selectivity issues
1.1.1	FC-7	Distributional range of a suite of selected species	Candidate	Yes	Yes	Yes	Yes	Yes
1.1.2	FC-8	Distributional pattern within range of a suite of selected species	Candidate	Yes, according to spatial resolution and extent of the survey	Yes, according to spatial resolution and extent of the survey	Yes, according to spatial resolution and extent of the survey	Yes, according to spatial resolution and extent of the survey	Yes, according to spatial resolution of the survey
possibly related to 1.7.1 or 4.3.1	FW-4	Changes in average trophic level of marine predators (cf MTI)	Core	calculation of relative abundance is possible	calculation of relative abundance is possible	calculation of relative abundance is possible	calculation of relative abundance is possible	calculation of relative abundance is possible
1.7.1; 4.3.1	FW-7	Fish biomass and abundance of dietary functional groups	Candidate	Biomass and abundance estimates per square km of various fish species dependent on definition of dietary functional groups.	Biomass and abundance estimates per square km of various fish species dependent on definition of dietary functional groups.	Biomass and abundance estimates per square km of various fish species dependent on definition of dietary functional groups.	Biomass and abundance estimates per square km of various fish species dependent on definition of dietary functional groups.	Biomass and abundance estimates per square km of various fish species dependent on definition of dietary functional groups.

MSFD (EU-COM 477/2010)	OSPAR terminology			WGBEAM data availability				
Indicator ID	Indicator ID	Indicator name	Core/ Candidate	North Sea	Western UK Waters	France/Biscay	Adriatic	Inshore
could be realted to 4.2.1; 4.3.1	FW-8	Changes in average faunal biomass per trophic level (Biomass Trophic Spectrum)	Candidate	Data on biomass per haul for fish species and benthic organisms available for some surveys and some years	Data on biomass per haul for fish species and benthic organisms available for some surveys and some years		Data on biomass per haul for fish species and mega-benthic organisms available for some surveys and some years	Data on biomass per haul for fish species available. Epi-benthic biomass avialable for some surveys
1.2.1	B-1	Species-specific trends in relative abundance of non-breeding and breeding marine bird species	Core					
1.1.2	B-6	Distributional pattern of breeding and non-breeding marine birds	Core					

MSFD (EU-COM 477/2010)	OSPAR TERMINOLOGY			POSSIBLE IMPROVEMENT WITH EXTRA EFFORT				
INDICATOR ID	INDICATOR ID	INDICATOR NAME	CORE/ CANDIDATE	NORTH SEA	WESTERN UK WATERS	FRANCE/BISCAY	ADRIATIC	INSHORE
1.2.1	FC-1	Population abundance/ biomass of a suite of selected species	Core	improve precision of relative abundance estimate by use of covariates	improve precision of relative abundance estimate by use of covariates	improve precision of relative abundance estimate by use of covariates	improve precision of relative abundance estimate by use of covariates	improve precision of relative abundance estimate by use of covariates
4.2.1	FC-2; FW-3	OSPAR EcoQO for proportion of large fish (LFI)	Core	No	No	No	No	No
3.3.2	FC-3	Mean maximum length of demersal fish and elasmobranchs	Core	No	No	No		No
N.A. (related to 4.3.1)	FC-4	Bycatch rates of Chondrichthyes	Candidate	No	No	No	No	No
N.A. (related to 4.3.1)	FC-5	Conservation status of elasmobranch and demersal bony-fish species (IUCN)	Candidate	No	No	No	No	No

MSFD (EU-COM 477/2010)	OSPAR terminology			Possible improvement with extra effort				
Indicator ID	Indicator ID	Indicator name	Core/ Candidate	North Sea	Western UK Waters	France/Biscay	Adriatic	Inshore
1.3.1; 3.3.1	FC-6	Proportion of mature fish in the populations of all species sampled adequately in international and national fish surveys	Candidate	histological analysis at sea (ICES 2012;1 and 2012;2) during sampling of macro-scopic maturity sampling. And/or back calculating size at maturity from data collected during spawning season. For summer spawning species a validated maturity key	histological analysis at sea (ICES 2012;1 and 2012;2) during sampling of macro-scopic maturity sampling. And/or back calculating size at maturity from data collected during spawning season. For summer spawning species a validated maturity key	histological analysis at sea (ICES 2012;1 and 2012;2) during sampling of macro-scopic maturity sampling. And/or back calculating size at maturity from data collected during spawning season. For summer spawning species a validated maturity key	histological analysis at sea (ICES 2012;1 and 2012;2) during sampling of macro-scopic maturity sampling. And/or back calculating size at maturity from data collected during spawning season. For summer spawning species a validated maturity key.	
1.1.1	FC-7	Distributional range of a suite of selected species	Candidate	No	No	No	No	No
1.1.2	FC-8	Distributional pattern within range of a suite of selected species	Candidate	No	No	No	No	No

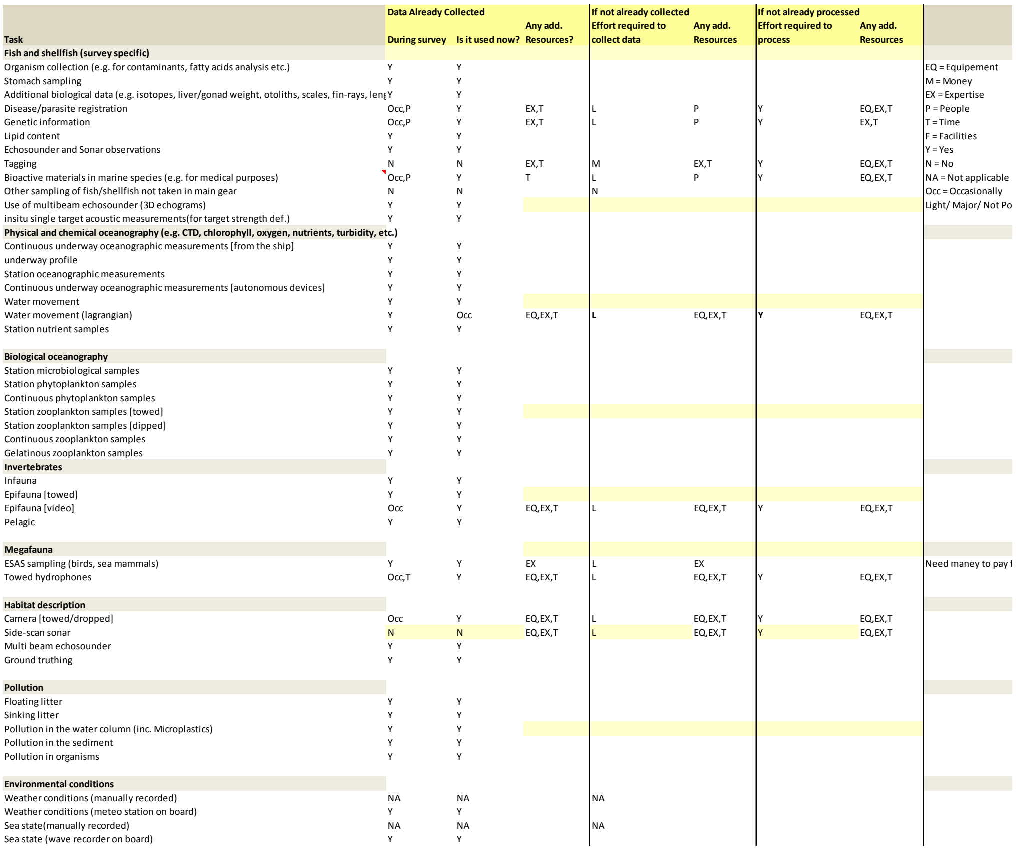
MSFD (EU-COM 477/2010)	OSPAR terminology			Possible improvement with extra effort				
Indicator ID	**Indicator ID**	**Indicator name**	**Core/ Candidate**	**North Sea**	**Western UK Waters**	**France/Biscay**	**Adriatic**	**Inshore**
possibly related to 1.7.1 or 4.3.1	FW-4	Changes in average trophic level of marine predators (cf MTI)	Core	Samples for fish predators can be provided (for stomach analyses or tissue samples for stable isotope analysis); sample processing requires extra analytical effort.	Samples for fish predators can be provided (for stomach analyses or tissue samples for stable isotope analysis); sample processing requires extra analytical effort.	Samples for fish predators can be provided (for stomach analyses or tissue samples for stable isotope analysis); sample processing requires extra analytical effort.	Samples for fish predators can be provided (for stomach analyses or tissue samples for stable isotope analysis); sample processing requires extra analytical effort.	Samples for fish predators can be provided (for stomach analyses or tissue samples for stable isotope analysis); sample processing requires extra analytical effort.
1.7.1; 4.3.1	FW-7	Fish biomass and abundance of dietary functional groups	Candidate	Extra effort if individual fish weights of non-target species are needed.	Extra effort if individual fish weights of non-target species are needed.	Extra effort if individual fish weights of non-target species are needed.	Extra effort if individual fish weights of non-target species are needed.	Extra effort if individual fish weights of non-target species are needed.
could be realted to 4.2.1; 4.3.1	FW-8	Changes in average faunal biomass per trophic level (Biomass Trophic Spectrum)	Candidate	full benthic sort and sampling possible with extra resource	full benthic sort and sampling possible with extra resource	full benthic sort and sampling possible with extra resource	full benthic sort and sampling possible with extra resource	full benthic sort and sampling possible with extra resource

MSFD (EU-COM 477/2010)	OSPAR terminology			Possible improvement with extra effort				
Indicator ID	**Indicator ID**	**Indicator name**	**Core/ Candidate**	**North Sea**	**Western UK Waters**	**France/Biscay**	**Adriatic**	**Inshore**
1.2.1	B-1	Species-specific trends in relative abundance of non-breeding and breeding marine bird species	Core	Yes, some surveys in WGBEAM may be able to take bird observers aboard (however, acoustic surveys or ichthyoplankon surveys may be advantageous for seabird observations).	No	No	No	No
1.1.2	B-6	Distributional pattern of breeding and non-breeding marine birds	Core					

Comment for all entries: Limited (all survey data) by the catchability of the gear for the species in question.

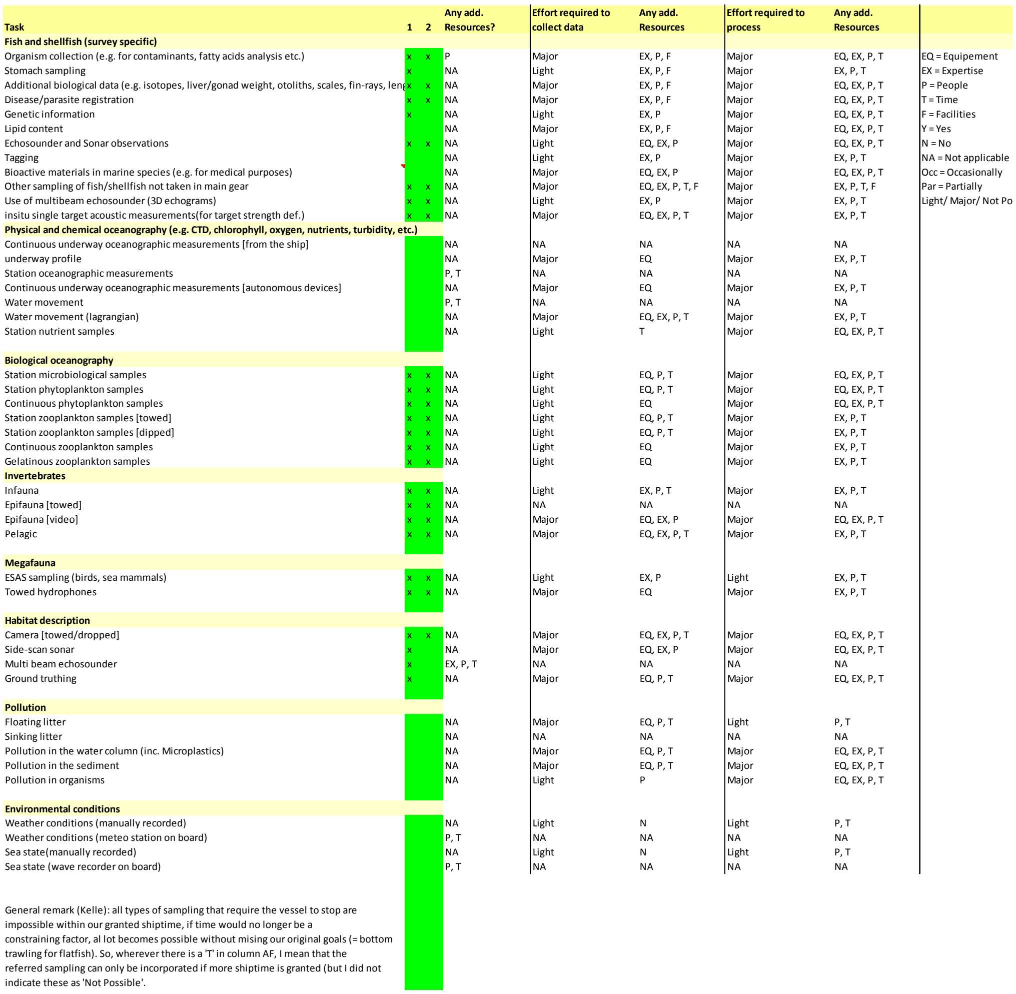
5.3 WKCATDAT table

	MSFD descriptor related to												Preparation	During survey				After survey												
Task	1	2	3	4	5	6	7	8	9	10	11	Fisheries survey for data collection	Additional equipment	Additional skills	Extra personnel	Extra shiptime	Facilities	Additional personnel	Facilities	Lab facilities	Sample storage	Data storage	Analytical instruments	Analysis software	Data Already Collected	Comments: Is it used now, could it be done better etc.	Data could be collected easily	Comments: Any add. Resources	Data could be collected with major additional work	Comments: Estimate of scale of extra: time, people, tools
Fish																														
Organism collection (e.g. for contaminants, fatty acids analysis etc.)	x	x	x	x				x	x			trawl, acoustic and ichthyoplankon	no	no	no	no	sample storage	yes	yes		x	x	x							
Stomach sampling	x		x	x								trawl, acoustic and ichthyoplankon	no	no	yes	no	preservation facilities	yes	yes	x	x	x								
Additional biological data (e.g. liver/gonad weight, otoliths, scales, fin-rays, length-weigh	x	x	x	x				x				trawl, acoustic and ichthyoplankon	no	no	dependent on t	no	no	no	no											
Disease/parasite registration	x							x	x			trawl, acoustic and ichthyoplankon	no	knowledge of fish diseases	dependent on t	no	no	no	no											
Genetic information	x		x									trawl, acoustic and ichthyoplankon	no	no	dependent on t	no	no	yes	yes		x	x	x							
Lipid content				x								trawl, acoustic and ichthyoplankon	Fat meter; Calibation series for t	skills for operation of the de	no	no	no	no	no											
Sonar observations pelagic fish			x									all	scientific sonar	skills for operation of the de	dependent on v	yes	data storage	yes	yes			x		x						
Tagging			x									trawl, acoustic and ichthyoplankon	Tags and fish handling	tagging skills	dependent on t	yes	fish handling facilities	yes	yes			x								
Bioactive materials in marine species												trawl, acoustic and ichthyoplankon	no	no	dependent on t	no	preservation facilities	yes	yes	x	x		x							
Physical and chemical oceanography [CTD, chlorophyll, oxygen, nutrients, turbidity, etc.]																														
Continuous underway measurements							x					all	dependent on variables being cc	skills for operation of the de	dependent on v	no	dependent on the device used	yes	yes			x								
Station measurements							x					all	dependent on variables being cc	skills for operation of the de	dependent on v	yes (deploy/recover)	dependent on the device used	dependent on variables being collected	no											
Autonomic devices							x					all	dependent on variables being cc	skills for operation of the de	operation of the	yes (deploy/recover)	no	dependent on variables being collected	yes			x								
Water movement							x					all	ADCP	skills for operation and analy	no	no	no	yes	yes			x		x						
Nutrient samples							x					all	Water sampler	skills for operation of the de	no	yes (deploy/recover)	no	yes	yes		x		x							
					x																									
Biological oceanography																														
Microbiological samples	x	x	x					x				all	Water sampler	skills for operation of the de	yes	yes (deploy/recover)	lab facilities, preservation facilities	yes	yes		x		x							
Phytoplankton samples	x	x	x					x				all	Water sampler	skills for operation of the de	no	yes (deploy/recover)	preservation facilities	yes	yes		x		x							
Phytoplankton samples	x	x	x					x				all	CPR	skills for operation of the de	yes	yes (deploy/recover)	preservation facilities	yes	yes		x		x							
Zooplankton samples	x	x	x					x				all	Towed samplers	skills for operation of the de	no	yes (deploy/recover)	preservation facilities	yes	yes		x		x							
Zooplankton samples	x	x	x					x				all	Dipped samplers	skills for operation of the de	no	yes (deploy/recover)	preservation facilities	yes	yes		x		x							
Zooplankton samples	x	x	x					x				all	Echosounder at proper frequenc	no	no	no	data storage	yes	yes		x		x							
Invertebrates																														
Infauna	x	x		x		x						all	Grab/corer, sieve	sorting	yes	yes	preservation facilities	yes	yes	x	x									
Epifauna	x	x		x		x						all	Beam trawl/dredge/sledge	identification	dependent on t	yes, except for beam trawl surveys	no	no	no											
Epifauna	x	x		x		x						all	Video	skills for operation of the de	no	yes	no	yes	yes			x		x						
Pelagic	x	x		x								all	Trawl net	identification	dependent on t	yes, except for pelagic trawl (acoustic)	no	no	no											
Megafauna																														
ESAS sampling (birds, sea mammals)	x	x		x								all	no	identification, knowledge of	yes (expert)	no	observation platform	no												
Towed hydrophones	x	x		x								all	Towed hydrophone	skills for operation of the de	yes (expert)	yes (deploy/recover)	data storage	yes	yes			x		x						
Habitat description																														
Towed/dropped camera						x						all	Towed/dropped camera	skills for operation of the de	no	yes	data storage	yes	yes			x		x						
Side-scan sonar						x						all	Side-scan sonar	skills for operation of the de	yes (expert)	yes (deploy/recover)	data storage	yes	yes			x		x						
Multi beam echosounder						x						all	Multi beam echosounder	skills for operation of the de	yes (expert)	no	data storage	yes	yes			x		x						
Ground truthing						x						all	Grab/corer, sieve	knowledge on positioning of	yes (expert)	yes	no	yes	yes	x	x									
Pollution																														
Floating litter										x		all	no	no	yes	no	observation platform	no	no											
Sinking litter										x		trawl and tv/video	no	no	no	no	no	no	no											
Pollution in the water column								x	x	x		all	dependent on variables being cc	skills for operation of the de	dependent on v	yes (deploy/recover)	dependent on variables being collected	yes	no											
Pollution in the sediment								x	x	x		all	Grab/corer	skills for operation of the de	dependent on v	yes (deploy/recover)	dependent on variables being collected	yes	yes		x		x							
Pollution in organisms								x	x			trawl, acoustic and ichthyoplankon			dependent on v	no	dependent on variables being collected	yes	yes		x		x							
Environmental conditions																														
Weather conditions							x					all	no	no	no	no	no	no	yes			x								
Sea state							x					all	no	no	no	no	no	no	yes			x								



	Data Already Collected			If not already collected		If not already processed		
Task	**During survey**	**Is it used now?**	**Any add. Resources?**	**Effort required to collect data**	**Any add. Resources**	**Effort required to process**	**Any add. Resources**	
Fish and shellfish (survey specific)								
Organism collection (e.g. for contaminants, fatty acids analysis etc.)	Y	Y						EQ = Equipement
Stomach sampling	Y	Y						M = Money
Additional biological data (e.g. isotopes, liver/gonad weight, otoliths, scales, fin-rays, leng	Y	Y						EX = Expertise
Disease/parasite registration	Occ,P	Y	EX,T	L	P	Y	EQ,EX,T	P = People
Genetic information	Occ,P	Y	EX,T	L	P	Y	EX,T	T = Time
Lipid content	Y	Y						F = Facilities
Echosounder and Sonar observations	Y	Y						Y = Yes
Tagging	N	N	EX,T	M	EX,T	Y	EQ,EX,T	N = No
Bioactive materials in marine species (e.g. for medical purposes)	Occ,P	Y	T	L	P	Y	EQ,EX,T	NA = Not applicable
Other sampling of fish/shellfish not taken in main gear	N	N		N				Occ = Occasionally
Use of multibeam echosounder (3D echograms)	Y	Y						Light/ Major/ Not Po
insitu single target acoustic measurements(for target strength def.)	Y	Y						
Physical and chemical oceanography (e.g. CTD, chlorophyll, oxygen, nutrients, turbidity, etc.)								
Continuous underway oceanographic measurements [from the ship]	Y	Y						
underway profile	Y	Y						
Station oceanographic measurements	Y	Y						
Continuous underway oceanographic measurements [autonomous devices]	Y	Y						
Water movement	Y	Y						
Water movement (lagrangian)	Y	Occ	EQ,EX,T	**L**	EQ,EX,T	**Y**	EQ,EX,T	
Station nutrient samples	Y	Y						
Biological oceanography								
Station microbiological samples	Y	Y						
Station phytoplankton samples	Y	Y						
Continuous phytoplankton samples	Y	Y						
Station zooplankton samples [towed]	Y	Y						
Station zooplankton samples [dipped]	Y	Y						
Continuous zooplankton samples	Y	Y						
Gelatinous zooplankton samples	Y	Y						
Invertebrates								
Infauna	Y	Y						
Epifauna [towed]	Y	Y						
Epifauna [video]	Occ	Y	EQ,EX,T	L	EQ,EX,T	Y	EQ,EX,T	
Pelagic	Y	Y						
Megafauna								
ESAS sampling (birds, sea mammals)	Y	Y	EX	L	EX			Need maney to pay f
Towed hydrophones	Occ,T	Y	EQ,EX,T	L	EQ,EX,T	Y	EQ,EX,T	
Habitat description								
Camera [towed/dropped]	Occ	Y	EQ,EX,T	L	EQ,EX,T	Y	EQ,EX,T	
Side-scan sonar	N	N	EQ,EX,T	L	EQ,EX,T	Y	EQ,EX,T	
Multi beam echosounder	Y	Y						
Ground truthing	Y	Y						
Pollution								
Floating litter	Y	Y						
Sinking litter	Y	Y						
Pollution in the water column (inc. Microplastics)	Y	Y						
Pollution in the sediment	Y	Y						
Pollution in organisms	Y	Y						
Environmental conditions								
Weather conditions (manually recorded)	NA	NA		NA				
Weather conditions (meteo station on board)	Y	Y						
Sea state(manually recorded)	NA	NA		NA				
Sea state (wave recorder on board)	Y	Y						

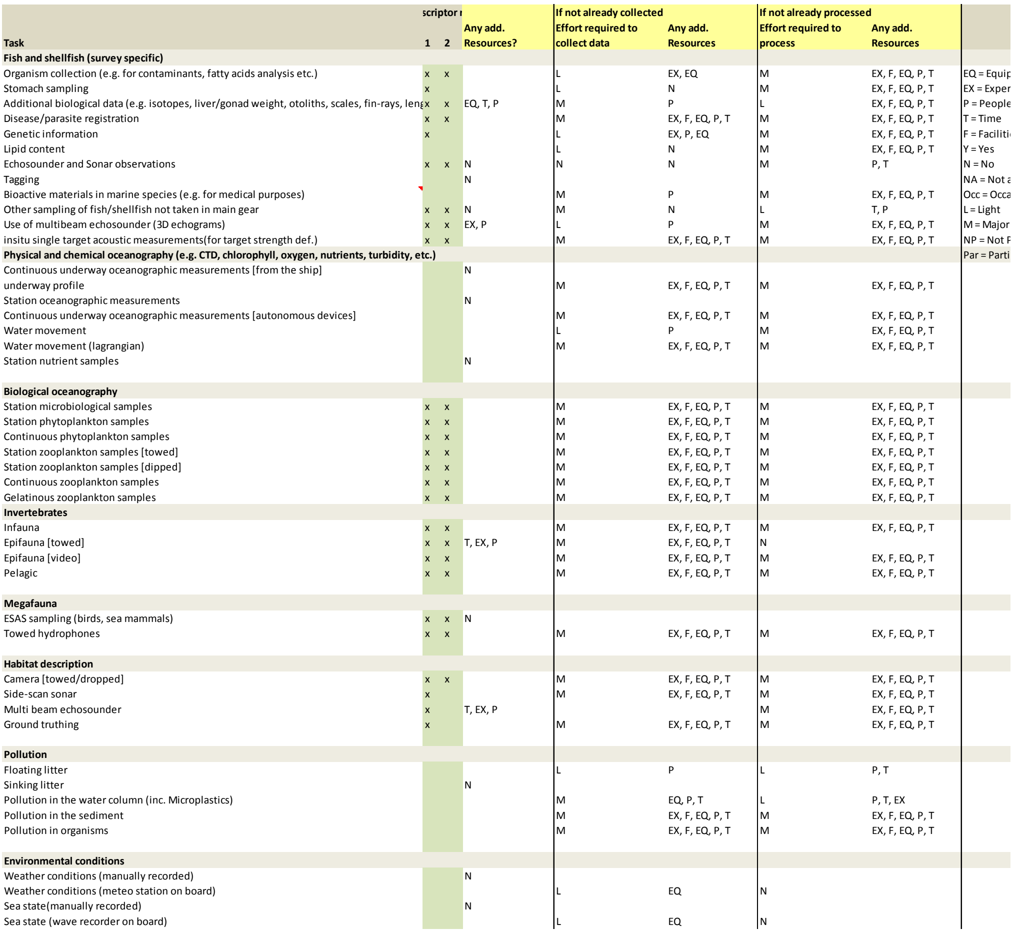
Figure 5.3.1. Additional task table; WGISUR 2012 Barents Sea Norway cut down.



Task	1	2	Any add. Resources?	Effort required to collect data	Any add. Resources	Effort required to process	Any add. Resources	
Fish and shellfish (survey specific)								
Organism collection (e.g. for contaminants, fatty acids analysis etc.)	x	x	P	Major	EX, P, F	Major	EQ, EX, P, T	EQ = Equipement
Stomach sampling	x		NA	Light	EX, P, F	Major	EX, P, T	EX = Expertise
Additional biological data (e.g. isotopes, liver/gonad weight, otoliths, scales, fin-rays, leng	x	x	NA	Major	EX, P, F	Major	EQ, EX, P, T	P = People
Disease/parasite registration	x	x	NA	Major	EX, P, F	Major	EQ, EX, P, T	T = Time
Genetic information	x		NA	Light	EX, P	Major	EQ, EX, P, T	F = Facilities
Lipid content			NA	Major	EX, P, F	Major	EQ, EX, P, T	Y = Yes
Echosounder and Sonar observations	x	x	NA	Light	EQ, EX, P	Major	EQ, EX, P, T	N = No
Tagging			NA	Light	EX, P	Major	EX, P, T	NA = Not applicable
Bioactive materials in marine species (e.g. for medical purposes)			NA	Major	EQ, EX, P	Major	EQ, EX, P, T	Occ = Occasionally
Other sampling of fish/shellfish not taken in main gear	x	x	NA	Major	EQ, EX, P, T, F	Major	EX, P, T, F	Par = Partially
Use of multibeam echosounder (3D echograms)	x	x	NA	Light	EX, P	Major	EX, P, T	Light/ Major/ Not Po
insitu single target acoustic measurements(for target strength def.)	x	x	NA	Major	EQ, EX, P, T	Major	EX, P, T	
Physical and chemical oceanography (e.g. CTD, chlorophyll, oxygen, nutrients, turbidity, etc.)								
Continuous underway oceanographic measurements [from the ship]			NA	NA	NA	NA	NA	
underway profile			NA	Major	EQ	Major	EX, P, T	
Station oceanographic measurements			P, T	NA	NA	NA	NA	
Continuous underway oceanographic measurements [autonomous devices]			NA	Major	EQ	Major	EX, P, T	
Water movement			P, T	NA	NA	NA	NA	
Water movement (lagrangian)			NA	Major	EQ, EX, P, T	Major	EX, P, T	
Station nutrient samples			NA	Light	T	Major	EQ, EX, P, T	
Biological oceanography								
Station microbiological samples	x	x	NA	Light	EQ, P, T	Major	EQ, EX, P, T	
Station phytoplankton samples	x	x	NA	Light	EQ, P, T	Major	EQ, EX, P, T	
Continuous phytoplankton samples	x	x	NA	Light	EQ	Major	EQ, EX, P, T	
Station zooplankton samples [towed]	x	x	NA	Light	EQ, P, T	Major	EX, P, T	
Station zooplankton samples [dipped]	x	x	NA	Light	EQ, P, T	Major	EX, P, T	
Continuous zooplankton samples	x	x	NA	Light	EQ	Major	EX, P, T	
Gelatinous zooplankton samples	x	x	NA	Light	EQ	Major	EX, P, T	
Invertebrates								
Infauna	x	x	NA	Light	EX, P, T	Major	EX, P, T	
Epifauna [towed]	x	x	NA	NA	NA	NA	NA	
Epifauna [video]	x	x	NA	Major	EQ, EX, P	Major	EQ, EX, P, T	
Pelagic	x	x	NA	Major	EQ, EX, P, T	Major	EX, P, T	
Megafauna								
ESAS sampling (birds, sea mammals)	x	x	NA	Light	EX, P	Light	EX, P, T	
Towed hydrophones	x	x	NA	Major	EQ	Major	EX, P, T	
Habitat description								
Camera [towed/dropped]	x	x	NA	Major	EQ, EX, P, T	Major	EQ, EX, P, T	
Side-scan sonar	x		NA	Major	EQ, EX, P	Major	EQ, EX, P, T	
Multi beam echosounder	x		EX, P, T	NA	NA	NA	NA	
Ground truthing	x		NA	Major	EQ, P, T	Major	EQ, EX, P, T	
Pollution								
Floating litter			NA	Major	EQ, P, T	Light	P, T	
Sinking litter			NA	NA	NA	NA	NA	
Pollution in the water column (inc. Microplastics)			NA	Major	EQ, P, T	Major	EQ, EX, P, T	
Pollution in the sediment			NA	Major	EQ, P, T	Major	EQ, EX, P, T	
Pollution in organisms			NA	Light	P	Major	EQ, EX, P, T	
Environmental conditions								
Weather conditions (manually recorded)			NA	Light	N	Light	P, T	
Weather conditions (meteo station on board)			P, T	NA	NA	NA	NA	
Sea state(manually recorded)			NA	Light	N	Light	P, T	
Sea state (wave recorder on board)			P, T	NA	NA	NA	NA	

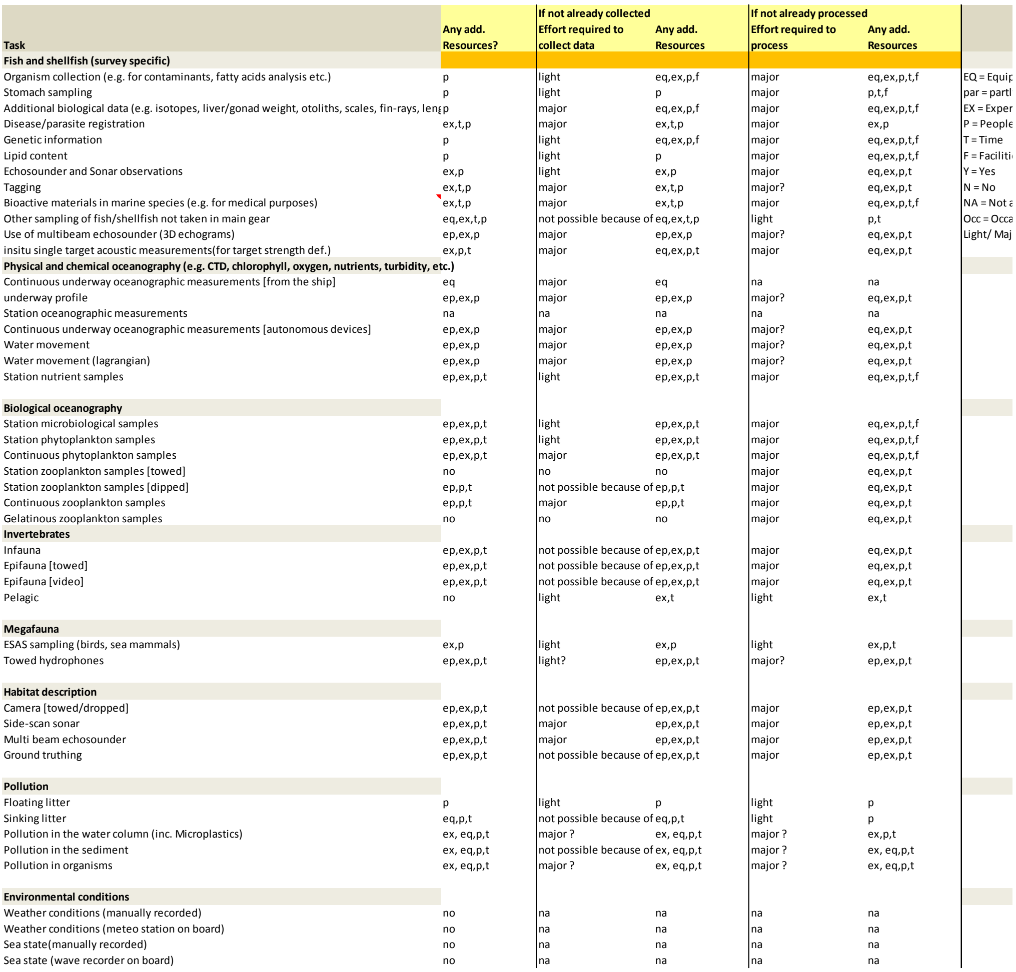
General remark (Kelle): all types of sampling that require the vessel to stop are impossible within our granted shiptime, if time would no longer be a constraining factor, al lot becomes possible without mising our original goals (= bottom trawling for flatfish). So, wherever there is a 'T' in column AF, I mean that the referred sampling can only be incorporated if more shiptime is granted (but I did not indicate these as 'Not Possible'.

Figure 5.3.2. Additional task table; WGISUR 2012 BTS Belgium.



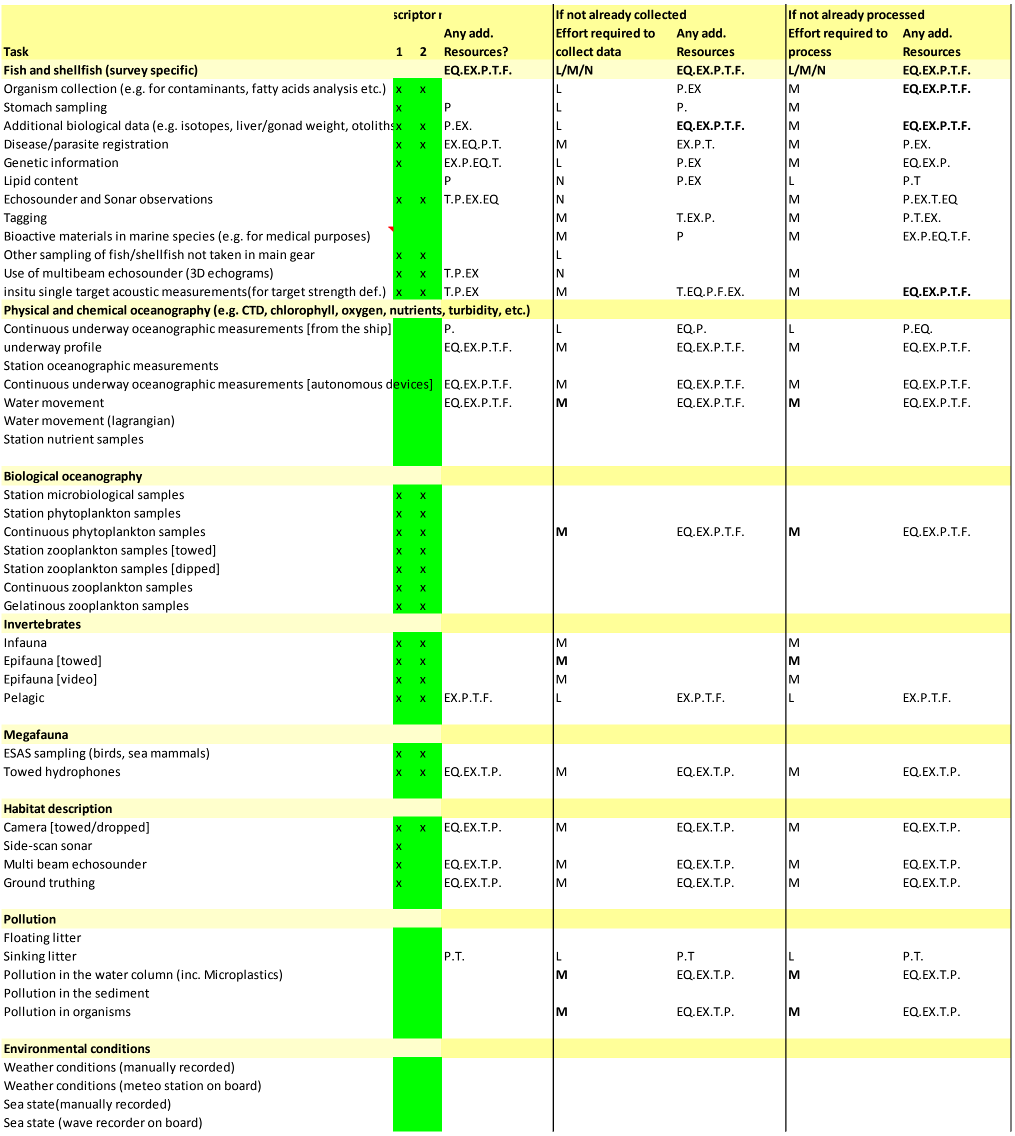
	scriptor			If not already collected		If not already processed		
Task	**1**	**2**	**Any add. Resources?**	**Effort required to collect data**	**Any add. Resources**	**Effort required to process**	**Any add. Resources**	
Fish and shellfish (survey specific)								
Organism collection (e.g. for contaminants, fatty acids analysis etc.)	x	x		L	EX, EQ	M	EX, F, EQ, P, T	EQ = Equip
Stomach sampling	x			L	N	M	EX, F, EQ, P, T	EX = Exper
Additional biological data (e.g. isotopes, liver/gonad weight, otoliths, scales, fin-rays, leng	x	x	EQ, T, P	M	P	L	EX, F, EQ, P, T	P = People
Disease/parasite registration	x	x		M	EX, F, EQ, P, T	M	EX, F, EQ, P, T	T = Time
Genetic information	x			L	EX, P, EQ	M	EX, F, EQ, P, T	F = Faciliti
Lipid content				L	N	M	EX, F, EQ, P, T	Y = Yes
Echosounder and Sonar observations	x	x	N	N	N	M	P, T	N = No
Tagging			N					NA = Not a
Bioactive materials in marine species (e.g. for medical purposes)				M	P	M	EX, F, EQ, P, T	Occ = Occa
Other sampling of fish/shellfish not taken in main gear	x	x	N	M	N	L	T, P	L = Light
Use of multibeam echosounder (3D echograms)	x	x	EX, P	L	P	M	EX, F, EQ, P, T	M = Major
insitu single target acoustic measurements(for target strength def.)	x	x		M	EX, F, EQ, P, T	M	EX, F, EQ, P, T	NP = Not F
Physical and chemical oceanography (e.g. CTD, chlorophyll, oxygen, nutrients, turbidity, etc.)								Par = Parti
Continuous underway oceanographic measurements [from the ship]			N					
underway profile				M	EX, F, EQ, P, T	M	EX, F, EQ, P, T	
Station oceanographic measurements			N					
Continuous underway oceanographic measurements [autonomous devices]				M	EX, F, EQ, P, T	M	EX, F, EQ, P, T	
Water movement				L	P	M	EX, F, EQ, P, T	
Water movement (lagrangian)				M	EX, F, EQ, P, T	M	EX, F, EQ, P, T	
Station nutrient samples			N					
Biological oceanography								
Station microbiological samples	x	x		M	EX, F, EQ, P, T	M	EX, F, EQ, P, T	
Station phytoplankton samples	x	x		M	EX, F, EQ, P, T	M	EX, F, EQ, P, T	
Continuous phytoplankton samples	x	x		M	EX, F, EQ, P, T	M	EX, F, EQ, P, T	
Station zooplankton samples [towed]	x	x		M	EX, F, EQ, P, T	M	EX, F, EQ, P, T	
Station zooplankton samples [dipped]	x	x		M	EX, F, EQ, P, T	M	EX, F, EQ, P, T	
Continuous zooplankton samples	x	x		M	EX, F, EQ, P, T	M	EX, F, EQ, P, T	
Gelatinous zooplankton samples	x	x		M	EX, F, EQ, P, T	M	EX, F, EQ, P, T	
Invertebrates								
Infauna	x	x		M	EX, F, EQ, P, T	M	EX, F, EQ, P, T	
Epifauna [towed]	x	x	T, EX, P	M	EX, F, EQ, P, T	N		
Epifauna [video]	x	x		M	EX, F, EQ, P, T	M	EX, F, EQ, P, T	
Pelagic	x	x		M	EX, F, EQ, P, T	M	EX, F, EQ, P, T	
Megafauna								
ESAS sampling (birds, sea mammals)	x	x	N					
Towed hydrophones	x	x		M	EX, F, EQ, P, T	M	EX, F, EQ, P, T	
Habitat description								
Camera [towed/dropped]	x	x		M	EX, F, EQ, P, T	M	EX, F, EQ, P, T	
Side-scan sonar	x			M	EX, F, EQ, P, T	M	EX, F, EQ, P, T	
Multi beam echosounder	x		T, EX, P			M	EX, F, EQ, P, T	
Ground truthing	x			M	EX, F, EQ, P, T	M	EX, F, EQ, P, T	
Pollution								
Floating litter				L	P	L	P, T	
Sinking litter			N					
Pollution in the water column (inc. Microplastics)				M	EQ, P, T	L	P, T, EX	
Pollution in the sediment				M	EX, F, EQ, P, T	M	EX, F, EQ, P, T	
Pollution in organisms				M	EX, F, EQ, P, T	M	EX, F, EQ, P, T	
Environmental conditions								
Weather conditions (manually recorded)			N					
Weather conditions (meteo station on board)				L	EQ	N		
Sea state(manually recorded)			N					
Sea state (wave recorder on board)				L	EQ	N		

Figure 5.3.3. Additional task table; WGISUR 2012 IBTS England.



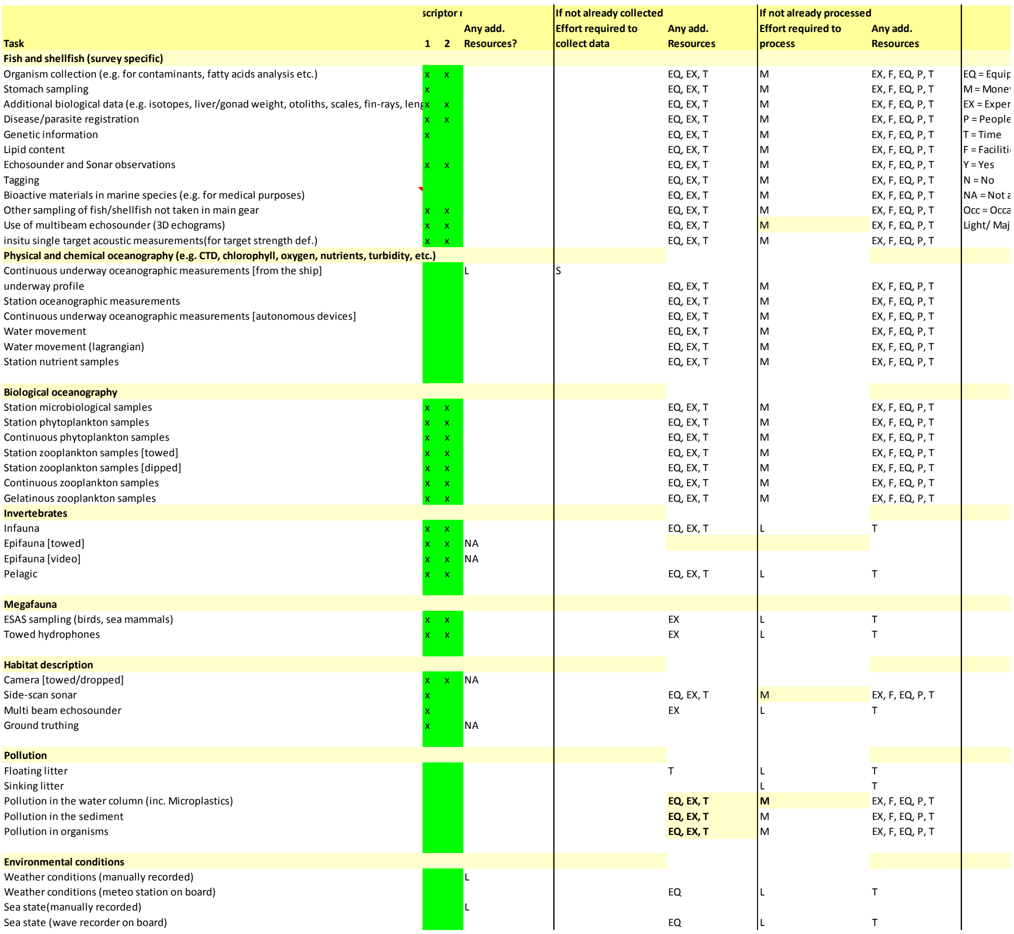
Task		If not already collected		If not already processed		
	Any add. Resources?	Effort required to collect data	Any add. Resources	Effort required to process	Any add. Resources	
Fish and shellfish (survey specific)						
Organism collection (e.g. for contaminants, fatty acids analysis etc.)	p	light	eq,ex,p,f	major	eq,ex,p,t,f	EQ = Equip
Stomach sampling	p	light	p	major	p,t,f	par = partl
Additional biological data (e.g. isotopes, liver/gonad weight, otoliths, scales, fin-rays, leng	p	major	eq,ex,p,f	major	eq,ex,p,t,f	EX = Exper
Disease/parasite registration	ex,t,p	major	ex,t,p	major	ex,p	P = People
Genetic information	p	light	eq,ex,p,f	major	eq,ex,p,t,f	T = Time
Lipid content	p	light	p	major	eq,ex,p,t,f	F = Faciliti
Echosounder and Sonar observations	ex,p	light	ex,p	major	eq,ex,p,t	Y = Yes
Tagging	ex,t,p	major	ex,t,p	major?	eq,ex,p,t	N = No
Bioactive materials in marine species (e.g. for medical purposes)	ex,t,p	major	ex,t,p	major	eq,ex,p,t,f	NA = Not a
Other sampling of fish/shellfish not taken in main gear	eq,ex,t,p	not possible because of	eq,ex,t,p	light	p,t	Occ = Occa
Use of multibeam echosounder (3D echograms)	ep,ex,p	major	ep,ex,p	major?	eq,ex,p,t	Light/ Maj
insitu single target acoustic measurements(for target strength def.)	ex,p,t	major	eq,ex,p,t	major	eq,ex,p,t	
Physical and chemical oceanography (e.g. CTD, chlorophyll, oxygen, nutrients, turbidity, etc.)						
Continuous underway oceanographic measurements [from the ship]	eq	major	eq	na	na	
underway profile	ep,ex,p	major	ep,ex,p	major?	eq,ex,p,t	
Station oceanographic measurements	na	na	na	na	na	
Continuous underway oceanographic measurements [autonomous devices]	ep,ex,p	major	ep,ex,p	major?	eq,ex,p,t	
Water movement	ep,ex,p	major	ep,ex,p	major?	eq,ex,p,t	
Water movement (lagrangian)	ep,ex,p	major	ep,ex,p	major?	eq,ex,p,t	
Station nutrient samples	ep,ex,p,t	light	ep,ex,p,t	major	eq,ex,p,t,f	
Biological oceanography						
Station microbiological samples	ep,ex,p,t	light	ep,ex,p,t	major	eq,ex,p,t,f	
Station phytoplankton samples	ep,ex,p,t	light	ep,ex,p,t	major	eq,ex,p,t,f	
Continuous phytoplankton samples	ep,ex,p,t	major	ep,ex,p,t	major	eq,ex,p,t,f	
Station zooplankton samples [towed]	no	no	no	major	eq,ex,p,t	
Station zooplankton samples [dipped]	ep,p,t	not possible because of	ep,p,t	major	eq,ex,p,t	
Continuous zooplankton samples	ep,p,t	major	ep,p,t	major	eq,ex,p,t	
Gelatinous zooplankton samples	no	no	no	major	eq,ex,p,t	
Invertebrates						
Infauna	ep,ex,p,t	not possible because of	ep,ex,p,t	major	eq,ex,p,t	
Epifauna [towed]	ep,ex,p,t	not possible because of	ep,ex,p,t	major	eq,ex,p,t	
Epifauna [video]	ep,ex,p,t	not possible because of	ep,ex,p,t	major	eq,ex,p,t	
Pelagic	no	light	ex,t	light	ex,t	
Megafauna						
ESAS sampling (birds, sea mammals)	ex,p	light	ex,p	light	ex,p,t	
Towed hydrophones	ep,ex,p,t	light?	ep,ex,p,t	major?	ep,ex,p,t	
Habitat description						
Camera [towed/dropped]	ep,ex,p,t	not possible because of	ep,ex,p,t	major	ep,ex,p,t	
Side-scan sonar	ep,ex,p,t	major	ep,ex,p,t	major	ep,ex,p,t	
Multi beam echosounder	ep,ex,p,t	major	ep,ex,p,t	major	ep,ex,p,t	
Ground truthing	ep,ex,p,t	not possible because of	ep,ex,p,t	major	ep,ex,p,t	
Pollution						
Floating litter	p	light	p	light	p	
Sinking litter	eq,p,t	not possible because of	eq,p,t	light	p	
Pollution in the water column (inc. Microplastics)	ex, eq,p,t	major ?	ex, eq,p,t	major ?	ex,p,t	
Pollution in the sediment	ex, eq,p,t	not possible because of	ex, eq,p,t	major ?	ex, eq,p,t	
Pollution in organisms	ex, eq,p,t	major ?	ex, eq,p,t	major ?	ex, eq,p,t	
Environmental conditions						
Weather conditions (manually recorded)	no	na	na	na	na	
Weather conditions (meteo station on board)	no	na	na	na	na	
Sea state(manually recorded)	no	na	na	na	na	
Sea state (wave recorder on board)	no	na	na	na	na	

Figure 5.3.4. Additional task table; WGISUR 2012 MEGS Germany.



	scriptor r			If not already collected		If not already processed	
Task	**1**	**2**	**Any add. Resources?**	**Effort required to collect data**	**Any add. Resources**	**Effort required to process**	**Any add. Resources**
Fish and shellfish (survey specific)			**EQ.EX.P.T.F.**	**L/M/N**	**EQ.EX.P.T.F.**	**L/M/N**	**EQ.EX.P.T.F.**
Organism collection (e.g. for contaminants, fatty acids analysis etc.)	x	x		L	P.EX	M	**EQ.EX.P.T.F.**
Stomach sampling	x		P	L	P.	M	
Additional biological data (e.g. isotopes, liver/gonad weight, otoliths	x	x	P.EX.	L	**EQ.EX.P.T.F.**	M	**EQ.EX.P.T.F.**
Disease/parasite registration	x	x	EX.EQ.P.T.	M	EX.P.T.	M	P.EX.
Genetic information	x		EX.P.EQ.T.	L	P.EX	M	EQ.EX.P.
Lipid content			P	N	P.EX	L	P.T
Echosounder and Sonar observations	x	x	T.P.EX.EQ	N		M	P.EX.T.EQ
Tagging				M	T.EX.P.	M	P.T.EX.
Bioactive materials in marine species (e.g. for medical purposes)				M	P	M	EX.P.EQ.T.F.
Other sampling of fish/shellfish not taken in main gear	x	x		L			
Use of multibeam echosounder (3D echograms)	x	x	T.P.EX	N		M	
insitu single target acoustic measurements(for target strength def.)	x	x	T.P.EX	M	T.EQ.P.F.EX.	M	**EQ.EX.P.T.F.**
Physical and chemical oceanography (e.g. CTD, chlorophyll, oxygen, nutrients, turbidity, etc.)							
Continuous underway oceanographic measurements [from the ship]			P.	L	EQ.P.	L	P.EQ.
underway profile			EQ.EX.P.T.F.	M	EQ.EX.P.T.F.	M	EQ.EX.P.T.F.
Station oceanographic measurements							
Continuous underway oceanographic measurements [autonomous devices]			EQ.EX.P.T.F.	M	EQ.EX.P.T.F.	M	EQ.EX.P.T.F.
Water movement			EQ.EX.P.T.F.	**M**	EQ.EX.P.T.F.	**M**	EQ.EX.P.T.F.
Water movement (lagrangian)							
Station nutrient samples							
Biological oceanography							
Station microbiological samples	x	x					
Station phytoplankton samples	x	x					
Continuous phytoplankton samples	x	x		**M**	EQ.EX.P.T.F.	**M**	EQ.EX.P.T.F.
Station zooplankton samples [towed]	x	x					
Station zooplankton samples [dipped]	x	x					
Continuous zooplankton samples	x	x					
Gelatinous zooplankton samples	x	x					
Invertebrates							
Infauna	x	x		M		M	
Epifauna [towed]	x	x		**M**		**M**	
Epifauna [video]	x	x		M		M	
Pelagic	x	x	EX.P.T.F.	L	EX.P.T.F.	L	EX.P.T.F.
Megafauna							
ESAS sampling (birds, sea mammals)	x	x					
Towed hydrophones	x	x	EQ.EX.T.P.	M	EQ.EX.T.P.	M	EQ.EX.T.P.
Habitat description							
Camera [towed/dropped]	x	x	EQ.EX.T.P.	M	EQ.EX.T.P.	M	EQ.EX.T.P.
Side-scan sonar	x						
Multi beam echosounder	x		EQ.EX.T.P.	M	EQ.EX.T.P.	M	EQ.EX.T.P.
Ground truthing	x		EQ.EX.T.P.	M	EQ.EX.T.P.	M	EQ.EX.T.P.
Pollution							
Floating litter							
Sinking litter			P.T.	L	P.T	L	P.T.
Pollution in the water column (inc. Microplastics)				**M**	EQ.EX.T.P.	**M**	EQ.EX.T.P.
Pollution in the sediment							
Pollution in organisms				**M**	EQ.EX.T.P.	**M**	EQ.EX.T.P.
Environmental conditions							
Weather conditions (manually recorded)							
Weather conditions (meteo station on board)							
Sea state(manually recorded)							
Sea state (wave recorder on board)							

Figure 5.3.5. Additional task table; WGISUR 2012 Pelgas France.



	scriptor			If not already collected		If not already processed		
Task	**1**	**2**	**Any add. Resources?**	**Effort required to collect data**	**Any add. Resources**	**Effort required to process**	**Any add. Resources**	
Fish and shellfish (survey specific)								
Organism collection (e.g. for contaminants, fatty acids analysis etc.)	x	x			EQ, EX, T	M	EX, F, EQ, P, T	EQ = Equip
Stomach sampling	x				EQ, EX, T	M	EX, F, EQ, P, T	M = Mone
Additional biological data (e.g. isotopes, liver/gonad weight, otoliths, scales, fin-rays, leng	x	x			EQ, EX, T	M	EX, F, EQ, P, T	EX = Exper
Disease/parasite registration	x	x			EQ, EX, T	M	EX, F, EQ, P, T	P = People
Genetic information	x				EQ, EX, T	M	EX, F, EQ, P, T	T = Time
Lipid content					EQ, EX, T	M	EX, F, EQ, P, T	F = Faciliti
Echosounder and Sonar observations	x	x			EQ, EX, T	M	EX, F, EQ, P, T	Y = Yes
Tagging					EQ, EX, T	M	EX, F, EQ, P, T	N = No
Bioactive materials in marine species (e.g. for medical purposes)					EQ, EX, T	M	EX, F, EQ, P, T	NA = Not a
Other sampling of fish/shellfish not taken in main gear	x	x			EQ, EX, T	M	EX, F, EQ, P, T	Occ = Occa
Use of multibeam echosounder (3D echograms)	x	x			EQ, EX, T	M	EX, F, EQ, P, T	Light/ Maj
insitu single target acoustic measurements(for target strength def.)	x	x			EQ, EX, T	M	EX, F, EQ, P, T	
Physical and chemical oceanography (e.g. CTD, chlorophyll, oxygen, nutrients, turbidity, etc.)								
Continuous underway oceanographic measurements [from the ship]			L	S				
underway profile					EQ, EX, T	M	EX, F, EQ, P, T	
Station oceanographic measurements					EQ, EX, T	M	EX, F, EQ, P, T	
Continuous underway oceanographic measurements [autonomous devices]					EQ, EX, T	M	EX, F, EQ, P, T	
Water movement					EQ, EX, T	M	EX, F, EQ, P, T	
Water movement (lagrangian)					EQ, EX, T	M	EX, F, EQ, P, T	
Station nutrient samples					EQ, EX, T	M	EX, F, EQ, P, T	
Biological oceanography								
Station microbiological samples	x	x			EQ, EX, T	M	EX, F, EQ, P, T	
Station phytoplankton samples	x	x			EQ, EX, T	M	EX, F, EQ, P, T	
Continuous phytoplankton samples	x	x			EQ, EX, T	M	EX, F, EQ, P, T	
Station zooplankton samples [towed]	x	x			EQ, EX, T	M	EX, F, EQ, P, T	
Station zooplankton samples [dipped]	x	x			EQ, EX, T	M	EX, F, EQ, P, T	
Continuous zooplankton samples	x	x			EQ, EX, T	M	EX, F, EQ, P, T	
Gelatinous zooplankton samples	x	x			EQ, EX, T	M	EX, F, EQ, P, T	
Invertebrates								
Infauna	x	x			EQ, EX, T	L	T	
Epifauna [towed]	x	x	NA					
Epifauna [video]	x	x	NA					
Pelagic	x	x			EQ, EX, T	L	T	
Megafauna								
ESAS sampling (birds, sea mammals)	x	x			EX	L	T	
Towed hydrophones	x	x			EX	L	T	
Habitat description								
Camera [towed/dropped]	x	x	NA					
Side-scan sonar	x				EQ, EX, T	M	EX, F, EQ, P, T	
Multi beam echosounder	x				EX	L	T	
Ground truthing	x		NA					
Pollution								
Floating litter					T	L	T	
Sinking litter						L	T	
Pollution in the water column (inc. Microplastics)					**EQ, EX, T**	**M**	EX, F, EQ, P, T	
Pollution in the sediment					**EQ, EX, T**	M	EX, F, EQ, P, T	
Pollution in organisms					**EQ, EX, T**	M	EX, F, EQ, P, T	
Environmental conditions								
Weather conditions (manually recorded)			L					
Weather conditions (meteo station on board)					EQ	L	T	
Sea state(manually recorded)			L					
Sea state (wave recorder on board)					EQ	L	T	

Figure 5.3.6. Additional task table; WGISUR 2012 TV Survey Scotland.

5.4 References

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6 ToR d Good Environmental Status for the system impacted by European pelagic fisheries

ToR text: Review and Comment on the Objectives and Indicators developed for Good Environmental Status for the system impacted by European Pelagic Fisheries (developed by the EU FP7 project MYFISH).

Together with industry and NGO stakeholders, the MYFISH project has developed a set of objectives and indicators for GES, with particular relevance for pelagic fisheries and the wider pelagic ecosystem. WGECO is requested to review these and make any additional suggestions as appropriate. Request from ICES Secretariat.

6.1 Indicators of Good Environmental Status in the pelagic ecosystem

Indicators are often defined by analysing which data are available and suggesting indicators based on what can be derived from these data. However, this may lead to an assembly of indicators which are biased towards e.g. bottom-trawl surveys. WGECO and the Myfish project (www.myfishproject.eu) considered that the currently accepted MSFD indicators rarely include indicators specifically for the pelagic system and therefore proceeded to identify such indicators. To ensure that the indicators proposed do not only reflect objectives set be the scientists involved, objectives for Pelagic Ecosystem GES were set in a series of workshops. The objectives and indicators proposed at these workshops were then scored using the criteria suggested by WGECO and WGBIODIV (ToR b).

6.2 Pelagic fisheries characteristics

Most pelagic fisheries are based on single species and, with some exceptions (e.g. de Oliveira *et al*., 1998; Pierce *et al*., 2002; ter Hofstede and Dickey-Collas, 2006), bycatch is not considered a major issue. Many European pelagic fleets will target single species fisheries sequentially throughout the year, e.g. moving from mackerel, to horse mackerel, to boarfish, to herring and back to mackerel. While caution is demanded because of overcompensation at high SSB (Nash *et al*., 2009; Hillary *et al*., 2012), fishing mortality is typically much lower than in demersal fisheries and is often at or below F_{MSY}. However, pelagic stocks in Europe and worldwide are typically subject to substantial natural fluctuations in stock abundance, mainly due to recruitment changes. As a consequence, fishing can interact strongly with environment to affect abundance (e.g. Fréon *et al*., 2005).

For pelagic fisheries (where most species are small and relatively short-lived) size-based indicators are probably quite uninformative. Such fundamental ecological differences mean that many of the paradigms of conventional fishery management are of less relevance to pelagic stocks.

Small pelagics are often seen as key ‘forage fish’ species, in particular herring, sardine, anchovy, blue whiting and sandeel, and to a lesser extent mackerel and horse mackerel, particularly as juveniles (e.g. Cury *et al*., 2011; Smith *et al*., 2011). This means that while pelagic fisheries in addition to a direct impact on the marine community may exert indirect effects that propagate through the foodweb via shifts in prey availability. Finally, pelagic fisheries have little or no direct impact on the seabed. The only likely interaction might be in the slipping of unwanted catches, and their acting as a possible food subsidy to seabed scavenger species.

6.3 Setting objectives for pelagic ecosystem GES

The process of defining objectives took place during two separate workshops, the first comprising scientists and the second having a majority of stakeholders including representatives from the fishing industry, the European Commission (DG MARE, DG ENVIR) and an environmental NGO. In each case, potential objectives were identified. Three scientists from the first meeting attended the second 'stakeholder' meeting, but acted mainly as facilitators. Outcomes (objectives) from the first meeting were not presented at the second meeting except to round of the final general discussion. This meant that the list of objectives suggested by stakeholders was not strongly influenced by the scientists list. Following the meetings, a complete and consensus set of objectives was defined. These were grouped into five different categories of objectives:

1) Maximize societal value (non-use value);
2) Maintain 'normal' structure and flow of the foodweb;
3) Maintain 'normal' structure and flow within fish populations;
4) Maintain habitat quantity and quality to sustainably support pelagic life cycle closure;
5) Optimize fisheries yield.

The first of these was seen as a social sustainability category. The following three were seen as ecosystem sustainability category, pertaining respectively to the integrity of the foodweb, the integrity of individual populations within the fish community, and the integrity of the wider ecosystem in relation to pelagic fishing. The final category was seen as an economic sustainability objective pertaining to the optimal performance of the fishing industry. Potential indicators were then suggested for the objectives in each category, allowing precedence of state indicators over pressure indicators and of pressure indicators over impact indicators. The resulting list of objectives and indicators is seen in Table 6.1.

6.4 Scoring of indicators according to the criteria given by WGECO and WGBIODIV

The proposed indicators were scored using the existing knowledge in the group on Celtic Seas, North Sea and Baltic Sea ecoregions. We did not consider cephalopods or gelatinous zooplankton as the expertise on these areas was limited within the group. As there are most likely issues for which the knowledge in the group was incomplete, the scorings should be seen as preliminary indications identifying where a further effort is needed rather than final scores. The scoring had two purposes:

1) To examine whether the criteria table was useful in a practical example and whether issues came up;
2) To determine which indicators would be most promising to investigate further.

The scoring followed the guidelines set under ToR b, except for three aspects:

- Criteria 7, Relevant to MSFD management targets, was scored by replacing the word MSFD by 'objective';
- Criteria 14, Metrics relevance to MSFD indicator, was not scored as this was an attempt to identify new indicators rather than existing MSFD indicators;
- The scoring was done as a group rather than as individuals, as not all individuals had knowledge of all indicators and because this allowed discussion of the interpretation of the different criteria.

The group included four persons, none of which had participated in the development of the criteria in WGECO and WGBIODIV. It was decided in the group for consistency to score first score all indicators according to criteria 1, then score all indicators according to criteria 2 and so forth. There were some instances where scoring was difficult as the indicator could refer to several datasets, e.g. the proportion of the population caught of bycaught species, which could refer to both bycaught cetaceans and elasmobranchs. In these cases, and average was used as score. In total, 27 indicators were scored according to 15 of the 16 criteria (Table 6.2). The group approach was found to be very useful, possibly due to the absence of technical specifications, which made the scoring highly dependent on the existing knowledge of data, etc. This also meant that a general interpretation could be applied to issues like Criteria 13, Scientific credibility, where there was some differences in the initial interpretation. In general, it is recommended that the Criteria scoring is initially performed for at least one indicator in the group to ensure that the participants in the group have the same interpretation of the criteria and hence avoiding differences in scoring due to differences in perception of the meaning of the criteria. Also, if indicators are scored by individuals and then used to derive average scores, scores should be discussed afterwards to ensure that any differences are not caused by differences in perception of the meaning of the criteria.

Two performance indicators were estimated following the scoring of criteria, the summed score weighted by the importance of the criteria and divided by the maximum score and the summed score weighted by the importance of the criteria and divided by the maximum score in criteria scored for pressure indicators. The latter should allow a comparison of pressure and state indicators, as pressure indicators are not scored for all criteria and hence automatically receive a lower score.

As expected, many indicators scored rather low due to absence of existing indicators and peer reviewed publications. For this reason, we did not find it useful to use the limit levels suggested by WGBIODIV for identifying useful indicators. As almost all indicators referred to a separate objective, we also did not find it useful to rank indicators according to their performance score. Instead, we used the performance to identify promising indicators (performance above 0.5) and to identify indicators which were unlikely to be useful for management (performance below 0.25). This resulted in the following list of promising indicators:

- Proportion of total catch discarded;
- Number of individual mammals and seabirds bycaught;
- % contaminants in landed fish;
- Proportion of stocks above a threshold biomass point;

- Aggregated pelagic fish biomass;
- Biomass of piscivores and planktiores;
- Predator condition or weight anomaly;
- Biomass by stock component;
- Condition or weight anomaly of pelagic fish;
- Proportion of spawning habitat impacted by gravel extraction;
- Proportion of migration routes impacted;
- F relative to F_{MSY}.

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Table 6.1. Objectives and indicators suggested for GES of pelagic ecosystems.

Objective	Suggested indicator	Suggested by Scientists only (1), Stakeholder only (2) or both (3)	Category of objective
limit slippage, discarding	Proportion of total catch discarded	3	1
Limit marine mammal, birds, pelagic sharks, elasmobranchs bycatch	number of individual mammals and seabirds bycaught	3	1
Achieve low level of contaminants from land	% contaminants in landed fish	2	1
Maintain exploited communities	proportion of stocks above a threshold biomass point	1	2
Maintain food supply for higher trophic levels	aggregated pelagic fish biomass	3	2
Maintain functional diversity in the pelagic system	biomass of piscivores and planktiores	3	2
Maintain structural biodiversity	acoustic group diversity, number of species, species dominance	3	2
Limit marine mammal, birds, pelagic sharks, elasmobranchs bycatch	proportion of the population caught (mortality)	3	2
Maintain prey diversity in the diet at *x*	Diversity in diet (empirical estimates)	1	2
Maintain functional plankton community	F and Z on copepods	2	2
Predator of pelagic resource condition and growth rate	Predator condition or weight anomaly	2	2
Maintain the stock component diversity	biomass by stock component	1	3
Maintain a healthy age distribution of the pelagic fish community	number of fish above age at maturity+something	1	3
Maintain a spatial distribution of pelagic fish	95% distribution area (map)	3	3
Maintain body condition / growth rate / age at maturity between *x*and *y*	Condition or weight anomaly of pelagic fish	3	3
Maintain genetic diversity	genetic diversity	3	3
Maintain phenotypic width / breadth	proportion of each type in the spawning population	1	3

Objective	Suggested indicator	Suggested by Scientists only (1), Stakeholder only (2) or both (3)	Category of objective
Maintain spawning habitat	Proportion of spawning habitat impacted by gravel extraction	3	4
Maintain juvenile habitat	extend of potential nursery habitat	3	4
Maintain feeding habitat	extend of potential feeding habitat	3	4
Limit contaminants that effect recruitment success	% contaminants in landed fish	3	4
Maintain migration ways	Proportion of migration routes impacted	1	4
Optimize yield	Yield (or yield stability?)	3	5
Maximize sustainable yield	F relative to FMSY	3	5
limit slippage, discarding	proportion of total catch discarded	3	5
Maintain physical space to fish	Proportion of potential fishing area impacted	2	5

Table 6.2. Rating of indicators using Criteria proposed by WGBIODIV. Indicators receiving an overall performance score of more than 0.5 and 0.25 are green and yellow, respectively.

Indicator	Category	relative to max (all criteria)	relative to max (Pressure criteria only)	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C15	C16
Proportion of total catch discarded	1	0.52	0.70	P	1	1	1	0.5		1		1	0	1			1	0.5
Number of individual mammals and seabirds bycaught	1	0.55	0.78	I	1	1	1	1		0.5		1	1	1			0	0
% contaminants in landed fish	1	0.65	0.87	P	0.5	1	1	1		1		1	1	1			1	1
Proportion of stocks above a threshold biomass point	2	0.68	0.74	S	1	1	1	1	0.5	1	1	1	0	1	0	1	0	0
Aggregated pelagic fish biomass	2	0.61	0.65	S	1	1	1	1	0.5	0	1	1	0	1	0	1	0	0
Biomass of piscivores and planktiores	2	0.61	0.65	S	1	1	1	1	0.5	0	1	1	0	1	0	1	0	0
Acoustic group diversity, number of species, species dominance	2	0.19	0.09	S	0.5	0.5	1	0.5	0.5	0	1	0.5	0	0.5	0	1	0	0
Proportion of the population caught (mortality)	2	0.19	0.30	P	0.5	0.5	1	0.5		0.5		1	1	0.5			0	0
Diversity in diet (empirical estimates)	2	0.16	0.22	S	0.5	1	1	0.5	0.5	0	0	0.5	0	0.5	0	0	0	0.5
F and Z on copepods	2	0.19	0.26	P	0	0	1	0		0		1	0	0			0	1

Indicator	Cate-gory	relative to max (all criteria)	relative to max (Pressure criteria only)	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C15	C16
Predator condition or weight anomaly	2	0.55	0.65	S	1	1	1	1	0.5	0	0	1	0	1	0	1	0	0.5
Biomass by stock component	3	0.52	0.61	S	1	1	1	0.5	0.5	0	0.5	1	0	1	0	1	1	0
Number of fish above age at maturity+something	3	0.39	0.52	S	1	0.5	1	1	0.5	0	0.5	1	0	1	0	0.5	0	0
95% distribution area (map)	3	0.19	0.17	S	0.5	0.5	1	0.5	0	0	0	1	0	0.5	0	1	0	0
Condition or weight anomaly of pelagic fish	3	0.55	0.65	S	1	1	1	1	0	0	0	1	0	1	0	1	0	0.5
Genetic diversity	3	0.06	0.00	S	0	0.5	0.5	0	0.5	0	0.5	0.5	0	0	0	1	0	0.5
Proportion of each type in the spawning population	3	0.13	0.17	S	0	0.5	0.5	0.5	0.5	0	0.5	1	0	0.5	0	0.5	1	0.5
Proportion of spawning habitat impacted by gravel extraction	4	0.55	0.74	P	1	1	1	1		0		1	0.5	1			0	1
Extend of potential nursery habitat	4	0.06	0.09	S	0	0	0.5	0	0	0	0	1	0	0.5	0	0	0	0
Extend of potential feeding habitat	4	0.06	0.09	S	0	0	0.5	0	0	0	0	1	0	0.5	0	0	0	0
% contaminants in landed fish	4	0.65	0.87	P	0.5	1	1	1		1		1	1	1			1	1

Indicator	Cate-gory	relative to max (all criteria)	relative to max (Pressure criteria only)	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C15	C16
Proportion of migration routes impacted	4	0.16	0.22	P	1	0	0.5	0.5		0		1	0	0			0	0.5
Yield (or yield stability)	5	0.48	0.65	I	1	1	1	1		0		1	0	1			0	0
F relative to FMSY	5	0.61	0.83	P	1	1	1	1		1		1	1	1			0	0
Proportion of total catch discarded	5	0.61	0.83	P	1	1	1	1		1		1	0	1			1	0.5
Proportion of potential fishing area impacted	5	0.23	0.30	P	0.5	0	0.5	1		0		1	0	0.5			0	1

7 ToR E (Foodwebs)

e) In 2012 WGECO examined and reported on developing foodweb condition indicators, including those currently envisaged in the MSFD Communication. The next logical step is the identification and, if necessary, the development of indicators addressing each of these aspects; criteria for selecting indicators have been proposed by WGECO 2012, and will be developed further in 2013. This should include a critical examination of the proposed list of attributes presented by WGECO in 2012.

7.1 Introduction

Reporting conclusions from the 2012 meeting of WGECO, ICES (2012) lists the following attributes of marine foodwebs as potentially requiring monitoring through dedicated foodweb indicators: (i) the distribution of species within a foodweb over trophic levels, (ii) specific dynamical responses of marine size spectra to pressures, (iii) the strength of competition among species, (iv) slow dynamics resulting from interactions among functional groups, and (v) characteristic trophic transfer efficiencies.

Indicators for each of these attributes can be developed and tested largely independently. Here we report progress made in indicator development for the first two kinds of attributes.

The trophic level at which a species resides in a foodweb is difficult to determine empirically and can change substantially when the species or its main resources change diets. In view of the general correlation between the logarithmic body mass of species (e.g. adult or maximal body mass) and their trophic level (Jennings, 2002b), the distribution of species over trophic levels is closely related to the distribution of the species forming a community over the logarithmic body mass axis. This is the topic of Sections 7.2.

In preparation of planned work to improve the separation of top–down and bottom–up effects in ecosystem characterizations through indicators [item (ii) above], Section 7.3 reports on a literature study regarding the role of zooplankton in marine foodwebs, in particular its responsiveness to top–down and bottom–up effects. An overview of indicators for foodwebs and communities is provided in Section 7.4.

7.2 The distribution of species over body sizes

7.2.1 Background

Our understanding of the distribution of species over the body size axis has improved substantially over recent years, both empirically and theoretically.

Body size–species richness distributions have been studied by ecologists both empirically and theoretically since Hutchinson and MacArthur (1959). The majority of these studies seem to focus on realizations of this distribution within functional or taxonomic groups.

The form of this distribution for an entire foodweb is less frequently considered. Examples for such a distribution in a small lake ecosystem before and after introduction of a new top predator are given by Jonsson *et al.* (2005). Characteristic is the linear relationship between the logarithmic body masses of species and the logarithms of their ranks in order of falling body mass. This relationship implies a Pareto-distribution of the body masses of species: with M_0 denoting a lower bound on the range of body masses considered and r a positive constant, the probability that a species is larger than M is given by $P[M > xM_0] = x^{-r}$. Jonsson *et al.* (2005) estimated the value of the Pareto exponent as $r = 1/6.16 = 0.16$ before and $r = 1/5.43 = 0.18$ after the introduction of the top predator.

A recent theoretical interpretation of this pattern (Rossberg, 2013) predicts a Pareto exponent of $r = \ln(3)/\ln(\mathrm{PPMR})$, with PPMR (predator–prey mass ratio) denoting the typical ratio between predator and prey body masses. With PPMR = 300 for example, this gives $r = 0.19$, close to the observed values. To the extent that PPMR is constant across communities, the theory predicts that the exponent r is the same for any mature, unperturbed community. Indeed, re-analysis of a dataset published in Jennings *et al.* (2002a) for the benthic community of the central North Sea leads to a similar empirical value for the exponent (Figure 7.2.1.1). Interestingly, the Pareto law can be recovered only when combining species counts from infauna, epifauna, and demersal fish; the pattern is fundamentally a property of the community as a whole.

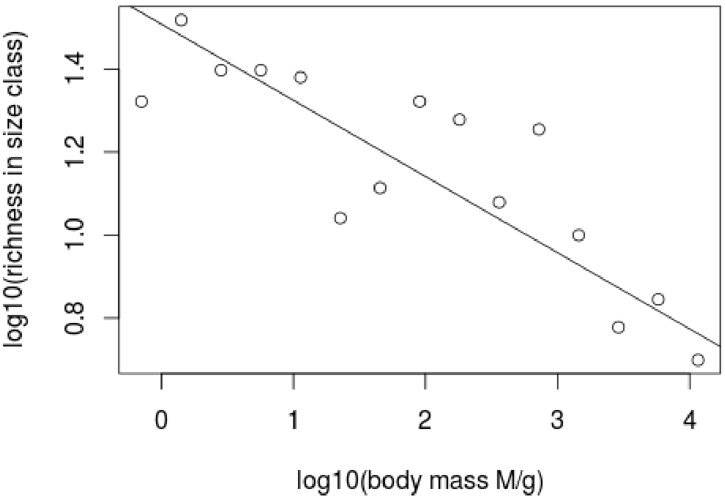


Figure 7.2.1.1. Species richness over body size classes for the benthic community of the central North Sea based on data by Jennings *et al.* (2002a) (electronic data courtesy of Simon Jennings). Points represent species richness as determined for each of 15 body mass octaves. The straight line represents a linear quantile regression using the function `rq` of the R package `quantreg(`Koenker, 2012). The regression slope is 0.183, corresponding to a Pareto exponent of r = 0.183.

The explanation for this pattern proposed by Rossberg (2013) builds on the observation that species richness tends to decline by an approximate factor 3 with each trophic level, a phenomenon demonstrated by WGECO (ICES, 2012) in a simulation study. The factor 3 derives from resource-mediate competition among the consumers at one trophic level in a foodweb, competing for resources at the next lower level, and an analysis of this problem using random-matrix competition theory. This explanation implies that the distribution of species richness over body sizes is bottom–up controlled: a decrease in the richness of smaller species enhances competition among larger species for food, ultimately leading to extinction of larger species until the Pareto law for body masses is re-established. Conversely, an observation of comparatively low richness of large species in a foodweb would suggest that large species might have been extirpated in the past as a result of external perturbations. An indicator characterizing the distribution of species over body sizes, e.g. in terms of a fitted Pareto exponent could therefore help detect and interpret responses of foodwebs to pressures.

Analysing two additional datasets, we verify the pattern demonstrated in Figure 7.2.1.1, and ask how sensitive the fitted exponent r is to sampling effort, and ecosystem perturbations through trawling. We begin with a detailed description of these two datasets, including sampling methods (since these would form part of an indicator protocol), before reporting on statistical analyses of the data.

7.2.2 Small Geographic Scale (Kilometers): Western Bank

A three-year (1997–1999) manipulative experiment on the effects of otter trawling on a gravel bottom was conducted by the Canadian Department of Fisheries and Oceans (Kenchington *et al.*, 2006). The experimental site was located on Western Bank on the continental shelf off Nova Scotia, Canada (approximately 43°5′ N, 61°41′ W). This site is within the 4TVW Haddock Nursery Area which has been closed to otter trawling since 1987. Spatial analyses of observer data indicate that it had been trawled in the early 1980s. The site was selected on the basis of sidescan sonograms, and had a relatively high degree of spatial homogeneity with most sediments classified as pebbles and cobbles, although boulders and sand patches were also present. Depth was relatively uniform, averaging about 70 m.

A 2 km by 2 km box was laid out as the experimental frame over an area of relatively uniform gravel seabed. Eleven north–south lines, 200 m apart, were plotted and labelled A to K. One line was randomly selected to be the experimental (i.e. trawled) line (Line E). Three additional lines were then randomly selected as reference lines (Lines B, G and I). These four lines were the experimental units. Ten sampling stations were randomly selected along Line E and another ten were randomly selected along Lines B, G and I (Kenchington *et al.*, 2006). The intent was to conduct a full sampling program before and after experimental trawling for three successive years to provide an asymmetric BACI.

Experimental trawling was carried out using an Engel 145 otter trawl with 1250 kg polyvalent otter boards which was fitted with a SCANMAR net mensuration system. The trawl had a door spread of 60 ± 5 m while the spread of the footgear and netwings was 20 ± 2 m. The trawl was rigged with 46 cm diameter rock-hopper footgear and had mesh sizes of 180 mm in the wings and belly with 130 mm in the codend. A 30 mm square mesh liner was installed in the final 9 m of the 18.5 m long codend in order to capture organisms which may be damaged but not retained by commercial nets. The rock-hopper footgear does not rotate but drags over the seabed.

Each year, Line E was trawled at least twelve consecutive times in alternating directions. The intent was to concentrate the trawling disturbance within a 100 m wide impact corridor and therefore the research trawlers were requested to steam back and forth between the same two waypoints to keep the sets as close together as possible. Each trawl set began at least 500 m beyond one end of Line E and continued until the gear was at least 500 m beyond the other end of the line. The average distance on bottom of trawl sets was 3.2 km. Trawling speed was approximately 3.5 knots and the average time for each set was 31 min. Fish from the trawl catch were counted and weighed.

Benthic organisms were collected with Videograb at the same twenty randomly selected stations before and after trawling (Kenchington *et al.*, 2006). Area sampled is 0.5 m^2, sampling depth is 10–25 cm and at full penetration the sediment volume collected is about 100 L. Because of the hydraulic closing mechanism, Videograb worked well on the gravel sediment, although several attempts were often needed to get a satisfactory sample because of cobbles jamming the jaws. Benthic species accumulation curves were saturated for this experiment with this gear type.

For this analysis, a species list (N=163) was compiled comprised of the fish species caught in the trawl sets during the experimental trawling and the benthic epifaunal and infaunal species collected in the videograbs. For the fish, maximum biomass for each species was determined from FishBase, with the exception of that for *Gadus morhua* where an average biomass was used and *Myoxocephalus octodecimspinosus* for which individual weight was obtained from the literature. For the invertebrates, biomass per species was determined by dividing the total species biomass by the total number of individuals of that species. A few records of colonial taxa were not included (bryozoans). These should be standardized to a common mass/area but there was insufficient time to do this during the meeting.

A number of species showed statistically significant changes during the course of the experiment. These species were labelled and included or excluded in datasets for some analyses to determine the sensitivity of the indicator to loss of species.

These data were compiled during the WGECO meeting to evaluate a proposed indicator for foodwebs. Consequently they should not be assumed to be error-free. Further, the fish species list was constrained to include only those fish from the experimental trawling. A larger fish community is known to live in the area and those species could be added in future by examining the stock assessment survey data. Equally, whales and seals transit the area and are not included at this time.

7.2.3 Large Geographic Scale (LMA): Barents Sea

7.2.3.1 Area description

In collaboration with Russia (PINRO), the Norwegian Institute of Marine Research (IMR) has conducted annual ecosystem surveys in August–September since 2003. The full survey area covers the Barents Sea from the west, at the Norwegian trench to the east of the Kara Sea and the west coast of Novaja Semlja, south to the Norwegian mainland and north of the Spitsbergen islands close to the polar ice edge. (approximately 70° to 90° N, 10° to 35° W). The surveyed area within the Norwegian jurisdiction area (NEZ) alone is approximately 1.4 million km^2. Other species-specific surveys are performed at other times of the year in this area and the annual report from the Norwegian monitoring group on the state of the ecosystem is based on the results from all of these surveys. However, for the purpose of this analysis, the Ecosystem survey report and datasets derived from the Norwegian vessels taking part of that survey were used as sole source. The Barents Sea is a relatively shallow ocean with an average depth of 230 m. The areas that are under Norwegian jurisdiction include parts of the relatively shallow bank areas Sentralbanken and Storbanken, but also a smaller area north of Svalbard where the water depth reaches 3000–4000 m.

The joint Norwegian-Russian survey analysed here was carried out during the period 7 August to 3 October 2009 (Anon, 2009). A number of vessels contributed to the analysed dataset used herein. The benthic data were derived from benthic sampling of the two survey ships RV "G.O. Sars" (IMR) and "MS. Jan Mayen" (Norwegian Polar Institute) using Campelen trawlnets. Two additional vessels took part in the survey. During the second part of August and the beginning of September, "G.O .Sars" covered the western part, while "Johan Hjort" covered the area along the Norwegian coast. "Jan Mayen" covered the area around Spitsbergen, but difficult ice conditions prevented coverage of some areas in east from Spitsbergen.

Water masses in the Barents Sea have been extraordinary warm since 2000. Temperatures in the Barents Sea reached record high levels in February 2008, but anomalies decreased throughout the year, and by autumn temperatures were colder than during the year before. Considering annual means, temperatures during 2008, however, were slightly cooler than during 2007. This is likely due to strong reductions in the transport of Atlantic Water into the Barents Sea. Still ice cover in the Barents Sea in 2012 was record low. Consequently, if this dataseries proves useful for testing this indicator, there is the possibility of comparing and contrasting performance under widely different environmental conditions.

Other important events that may have influence on the Barents Sea ecosystem is an overhaul in the fisheries management with strict regulations and strong reactions to illegal fishing and ban on discard has led to a significant reduction in fishing mortality since 2003. The annual fluctuations in the various fish stocks have been reduced and the stock of mature, large gadoids was by 2009 in a steep increase to the record levels recorded in 2012 (Johannesen *et al.*, 2012).

Finally, two large sized decapod species, red king crabs (*Paralithodes camtchaticus*) since 1970s and snow crab (*Chionoecetes opilio*) since 2000, have been introduced (*P. camtschaticus*) and migrated in from other polar regions. The *P. camtschaticus* has been found to feed on larger sized benthos, resulting in a significantly reduced average size distribution of native benthic species (Falk Pedersen *et al.*, 2011).

7.2.3.2 Survey methods

Phytoplankton were sampled, but only analysed for chl a biomass in bulk, and therefore not relevant for the WGECO foodweb analyses. Zooplankton sampling on all three Norwegian vessels was carried out by WP-2 plankton nets with a 0.25 m^2 opening and 180 μm mesh size. Usually two hauls were made at each station; one was taken from the bottom to the surface and the other one from 100 m to the surface. The zooplankton data were not included at the WGECO analyses, but could be made available for future work.

The benthos investigation was based on analyses of the bycatch of the Campelen trawl and so dominated by larger epifauna. The benthic invertebrate bycatch from all hauls with bottom trawl (Campelen) was processed to species level on board. Species difficult to identify were photographed and preserved in alcohol for later identification.

The distribution and abundance of 0-group fish were taken from the catches, and measured in number of fish per square nautical mile. Beside the 0-group fish analyses, the numbers and biomasses of fish per length- and age group were calculated from bottom-trawl catches using the "swept-area" method. The trawling procedure consisted of pelagic trawl catches from a midwater trawl with a quadratic mouth opening of 20x20 m. The standard procedure consists of tows covering three depths, each over a distance of 0.5 nautical miles, with the headline of the trawl located at 0, 20 and 40 m and with trawling speed of 3 knots. Additional tows at 60, 80 and 100 m, also of 0.5 nautical miles, were made when the 0-group fish layer was recorded deeper than 40 m depth on the echosounder. The total coverage of the Barents Sea, by a regular and dense grid of bottom-trawl stations, was determined by weather and ice conditions. The survey design that has been used as for the groundfish survey is running east–west courses starting in the south. The main distribution area of target species was surveyed with course lines 30–40 nautical miles apart. Bottom-trawl hauls were executed every 35–40 miles. All participating vessels used a Campelen trawl.

Marine mammal observations (species and numbers observed) were by visual observations made by two observers from the vessel bridges. The marine mammal observers covered approximately the front 90 sector (45 each).

The presented analyses are based on the benthic data material from the RVs "Jan Mayen" and "G.O. Sars", covering the western range of the Barents Sea while the fish and sea mammals are based on data collection from the whole fleet of Norwegian survey vessels.

The list of benthos includes 182 species, or families in some few cases, in a data file with information allowing for analyses of abundance and spatial distribution. Additionally, 82 species of fish are included, as well as eleven sea mammal species. The detailed data on benthic species were provided to the WGECO by Dr Lis Lindal Jørgensen, IMR.

7.2.3.3 Data treatments

The information on benthos total biomass per sampling station was divided by the numbers of specimens registered at the station, to provide an approximate weight per specimen (g). The maximum value of this weight over all stations was used as an approximation for the maximum weight species obtain in the study area. For species not identified by numbers a relative weight was assigned, based on known weight for close relatives within the same size range, based on information and pictures in the Marine Species Identification Portal, Encyclopaedia of Life, or by Google photo search. Because body mass entered the statistical analyses only logarithmically, relatively coarse estimates of body mass were sufficient.

Maximum biomass in kg (M) for each species was determined from maximum length using Fisbase.com, or the Fish Atlas of the Barents Sea (Eriksen *et al.*, 2012) when species length went beyond the registered length given by FishBase.com. For the species not described with maximum weight in any of these sources, M was assigned assuming a fixed condition factor derived from calculations made from the species with known maximum length (either from FishBase.com or the survey samples), weight and body shape: $C=M/L^3$ (Table 7.2.3.3.1).

Snakelike, slender species were assigned lower C than flatfish and fish with compact body shapes, and smaller fish a lower C than larger fish.

Finally, the survey report species list was refined by discarding apparently superfluous lines. When family names were given as "sp.", along with one or two actual species of that family, only the fully named species were kept. In species-rich families with more than two species registered along with the "sp." counts, the family related registration was removed if one of the species accounted for in more than 90% of the total samples.

These data were compiled during the WGECO meeting to evaluate a proposed indicator for foodwebs. Consequently they should not be assumed to be error-free.

Table 7.2.3.3.1. Fixed condition factors for calculations used to assign weight to fish in the Barents Sea survey ($C=M/L^3$). The condition factor (C) is based on measured C from fish of known length (L) and maximum weight (M). No condition factors were calculated for the empty cells in the table.

MAX LENGTH CM	CONDITION FACTOR	
	Snakelike, slender body	Compact body/flatfish
1–4.9	0.001	0.001
5–24.9	0.01	0.01
25–-69.9	0.01	0.1
70–99.9		0.2
100<		0.6

7.2.4 Data analysis

7.2.4.1 Empirical body-size distribution

The empirical distribution functions for the body sizes of species found in the Western Bank and the Barents Sea datasets are shown in Figure 7.2.4.1.1. In both cases, the overall pattern is a Pareto law, i.e. a power law distribution. This distribution is overlaid with modulations along the body mass axis, which are stronger for the Western Bank than for the Barents Sea, possibly caused by a trophic cascade.

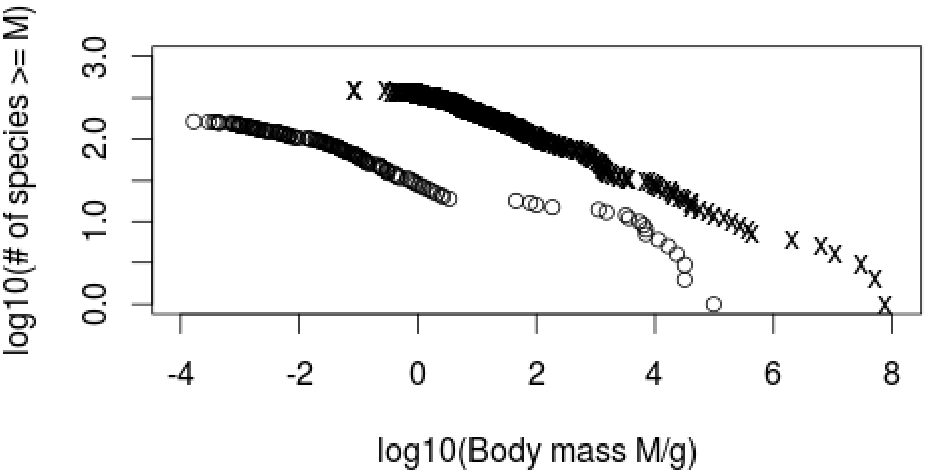


Figure 7.2.4.1.1. Empirical distributions of body size for Western Bank (circles) and Barents Sea (crosses) datasets.

7.2.4.2 Method for determining the Pareto exponent

Methods for determining the Pareto exponent as an index for foodweb status should balance accuracy, robustness, and insensitivity to undersampling of species in an appropriate way. Two approaches are here being considered. The first is the generalized median method described by Bazauskas and Serfling (2000), the second a quantile regression through a histogram of species richness within size classes that are evenly spaced on the logarithmic size axis (usually decades), using the methods known as Chao1 and Chao2 (Chao, 2005) to correct for undersampling of species richness within each size class. Both methods are less sensitive to deviations from perfect power-law distributions than, e.g. maximum likelihood estimation is. Yet, a lower cut-off needs to be introduced for consistent results. This cut-off was here selected by eye, based on the onset of curvature at the lower end of the body mass axis in Figure 7.2.4.1.1.

7.2.4.3 Effect of sampling effort

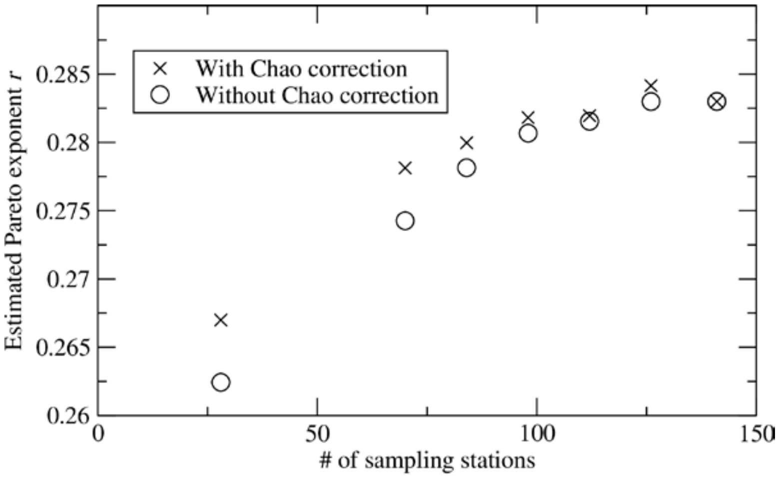


Figure 7.2.4.3.1. Dependence of estimated Pareto exponent in the Barents Sea on sampling effort, with and without Chao correction. Averages over ten random subsamples of stations.

Using the method of richness histograms, the Pareto exponent for the Barents Sea is estimated as $r = 0.283$ which is, compared to other datasets, rather large. However, the corresponding PPMR according to the formula $r = \ln(3)/\ln(\text{PPMR})$ where is PPMR = 48, a value within the empirical range. The generalized median method gives a similar result. As documented in Figure 7.2.4.3.1, Chao correction helps reducing the bias in the exponent when the sampling effort for benthic invertebrates is reduced, but cannot fully compensate it.

7.2.4.4 Indicator response under perturbation and sampling error

Applying the generalized median estimator for the Pareto exponent to the Western Bank data gives an estimate $r = 0.212$. As a crude test for the responsiveness of the exponent to pressures, we repeated this analysis, first excluding all species that significantly increased in abundance as a result of trawling, and then excluding all species that decreased in abundance as a result of trawling, thus comparing hypothetical changes in the community composition, including both hypothetical extirpations and hypothetical invasion, after extensive periods of intensive trawling. The hypothetical exponent for the "before" community is 0.206, for the "after" community is 0.197. Thus, there were comparatively less small species after extensive hypothetical trawling than before. One needs to take into account, however, that this analysis did not account for potential changes in the fish community, which would probably responds much slower to perturbations than the invertebrates.

7.2.4.5 Sampling error

Using 100 iterations of standard bootstrapping from the Western Bank community, the standard error of the Pareto exponent was estimated as 0.016. This small error justifies the conclusion that the value obtained for the Western Bank is close to the theoretically expected value (Section 7.2.1). However, it also implies that the hypothetical changes in the community discussed in the previous section might be too small to be considered statistically significant.

7.2.5 Conclusions

We reported on initial steps for the development of an indicator for the distribution of the body masses of species in marine communities, and so possibly an indicator for the distribution of species richness over trophic levels. Theory and data agree that species body masses essentially follow a Pareto distribution. For the Pareto exponent, numerical values near 0.2 were found in the data by Jonsson *et al*. (2005) (0.16, 0.18), Jennings *et al*. (2002b) (0.18), and for the Western Bank (0.21). The value obtained for the Barents Sea dataset was somewhat larger (0.28). Reasons for this deviation could be the larger spatial coverage of the Barents Sea dataset and differences in protocols for sampling and data processing. However, a contributing factor might also have been an increased diversity of small invertebrates as a result of warming, to which the diversity of larger species could not adapt, yet. We showed that the exponent can be established to high accuracy using conventional sampling designs. A bias due to dependencies on sampling intensity (and also spatial coverage) must be expected, so that potential future monitoring should be mindful to carefully standardize sampling effort.

Changes in the experimental system of the Western Bank may have been too small to translate into statistically significant changes in the Pareto exponent. The Barents Sea community currently undergoes dramatic changes driven by climatic changes and reductions in exploitation. In ongoing studies of the indicator for this system we therefore expect notable changes in the indicator value. The good theoretical basis of the indicator should then allow us to provide an interpretation of such changes in the management context.

7.3 Zooplankton: predator and prey in marine ecosystems

7.3.1 Background

An important question for the characterization of size spectra is whether marine foodwebs are bottom–up controlled. An understanding of how bottom–up and top–down processes influence the dynamics of marine communities is necessary for effective management of marine ecosystems in the face of environmental variability and multiple human impacts. This has been a topic of serious debate over decades.

Crustacean meso- and macrozooplankton are the main food source of pelagic fish and selected life stages of a long list of other species. This section will focus on the lower trophic levels of phytoplankton and zooplankton and investigate if zooplankton is likely to be bottom–up or top–down controlled.

The aim of this exercise is to derive a limited inventory on the extent of the discussion surrounding this question, also in the light of the feasibility and relevance of indicators for the strength of bottom–up effects in foodwebs.

7.3.2 Approach

Firstly, a simple description of the ecology of plankton will be given. Then a selection of case studies is described to assess the prevailing types of control. Finally, thoughts are developed regarding indicators for foodweb functioning. For example, indicators for bottom–up control might be necessary in some systems to assess potential impacts of changes in turbidity, nutrients, or temperature on primary production and higher trophic levels.

7.3.3 Describing plankton

Plankton refers to the set of aquatic organisms that cannot move against the water current. The classification of plankton is not only based on taxonomy; frequently species are grouped according to their size (Table 7.3.3.2). There is a first division between autotrophic (phytoplankton) and heterotrophic plankton (zooplankton). Phytoplankton is photosynthesizing microscopic organisms that inhabit the upper sunlit layer of almost all oceans and bodies of freshwater. They are agents of "primary production," the creation of organic compounds from carbon dioxide dissolved in the water, a process that sustains most aquatic foodwebs. While almost all phytoplankton species are obligate photoautotrophs, there are some that are mixotrophic and other, non-pigmented species that are actually heterotrophic (the latter are often viewed as zooplankton). Phytoplankton can be light limited, nutrient limited or grazing limited.

Zooplankton is a categorization spanning a range of organism sizes including small protozoans and large metazoans. It includes holoplanktonic organisms whose complete life cycle lies within the plankton, as well as meroplanktonic organisms that spend part of their lives in the plankton before graduating to either the nekton or a sessile, benthic existence. Although zooplankton is primarily transported by ambient water currents, many organisms are capable of locomotion, and use this to avoid predators (as in diel vertical migration) or to increase prey encounter rate.

Through their consumption and processing of phytoplankton and other food sources, zooplankton play a key role in aquatic foodwebs, as a resource for consumers on higher trophic levels (including fish), and as a conduit for packaging the organic material in the biological pump. Since they are typically small, zooplankton can respond rapidly to increases in phytoplankton abundance, for instance, during the spring bloom.

Table 7.3.3.2. Grouping of plankton based upon size. Classifications following Omori and Ikeda (1984).

GROUP	SIZE LIMITS	MAJOR ORGANISMS
1. Ultrananoplankton	<2 µm	Free Bacteria
2. Nanoplankton	2–20 µm	Fungi, Small Flagellates, Small Diatoms
3. Microplankton	20–200 µm	Most Phytoplankton Species, Foraminiferans, Ciliates, Rotifers, Copepod Nauplii and Other Crustacean Nauplii
4. Mesoplankton	200 µm–2 mm	Cladocerans, Copepods, Larvaceans, Larval Crustaceans
5. Macroplankton	2–20 mm	Pteropods, Copepods, Euphausids, Chaetognaths, Larval and Post Larval Crustaceans
6. Micronekton	20–200 mm	Cephalopods, Euphausids, Sergestids, Myctophids
7. Megaloplankton	>20 mm	Scyphozoans, Thalacians (Gelatinous plankton)

7.3.4 Foodweb structure as a criterion

In this section the role of zooplankton in the foodweb is described. In addition, a short review addresses the importance of zooplankton in the energy flows.

7.3.4.1 Population dynamics of zooplankton

Zooplankton population dynamics are rather complex. The key questions for zooplankton population dynamics are: (i) to what extent are populations driven by ''bottom–up'' (productivity) or ''top–down'' (predation) forcing; (ii) are observed dynamics initiated by persistent forcing or by episodic events whose effects propagate through the system; and (iii) what proportion of the biological variability is caused directly by physical forcing and what proportion might be caused by the inherent dynamics of the community (e.g. predator–prey oscillations)?

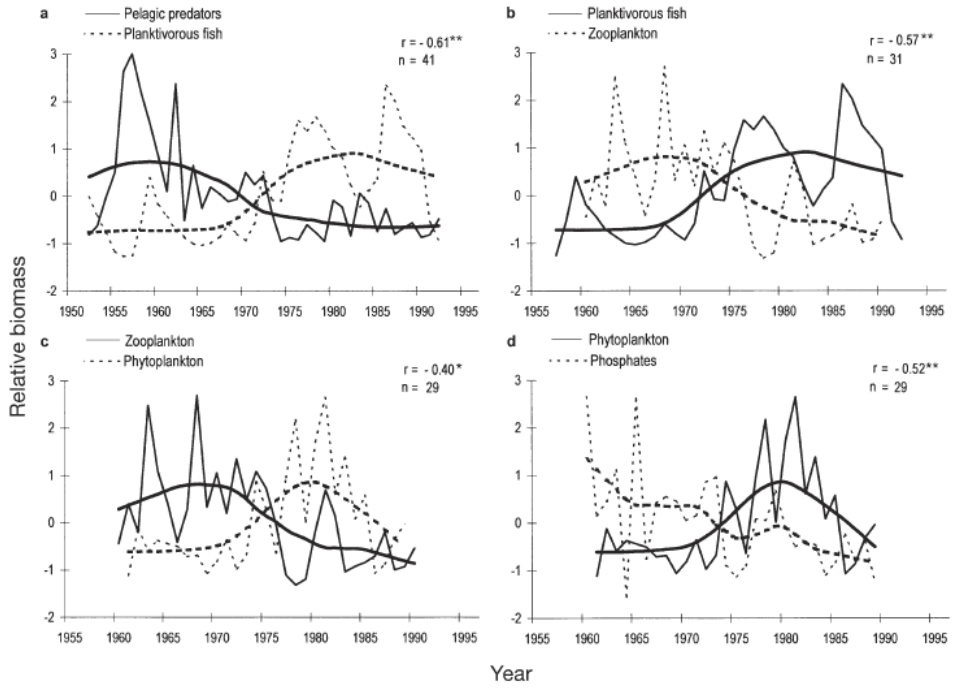


Figure 7.3.4.1.2. Inverse trends across consecutive trophic levels. Light curves give original data (subtracting the mean and dividing by the variance); bold curves give non-linear trends smoothed by locally weighted regression (loess). (a) Pelagic predatory fish (bonito, mackerel, bluefish) catch vs. planktivorous fish (sprat, horse mackerel) biomass, (b) planktivorous fish biomass vs. zooplankton biomass, (c) zooplankton biomass vs. phytoplankton biomass, (d) phytoplankton biomass vs. phosphate content in surface water. Spearman rank correlation is estimated for pairs of logtransformed original series given on each panel. Correlation coefficients (r) are significant at **p < 0.01 and *p < 0.05 From Daskalov (2002).

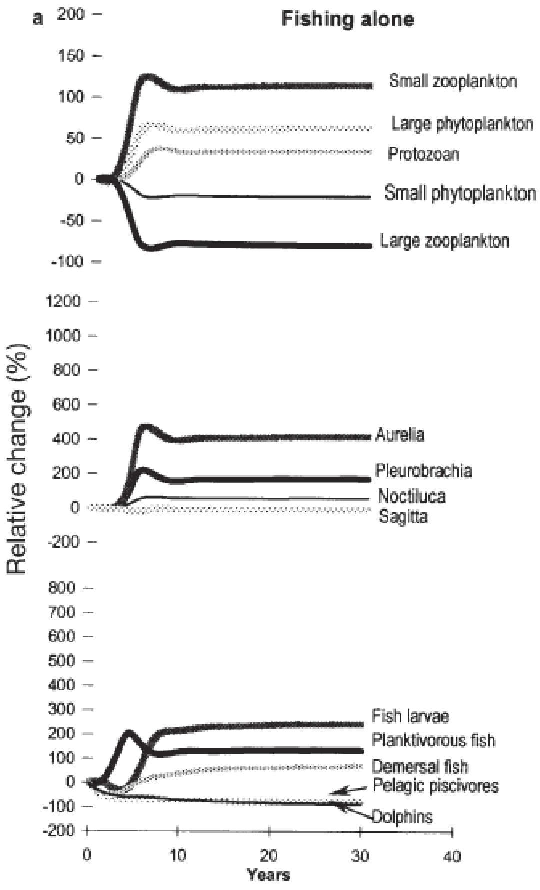
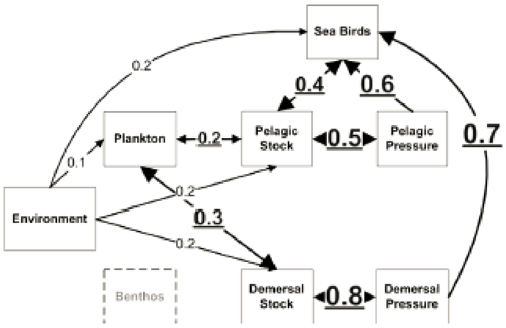


Figure 7.3.4.1.3. Results from the temporal dynamic model Ecosim: (a) Changes due to fishing mortality forcing, 'Fishing alone'; adapted from Daskalov (2002).

Fluctuations in zooplankton populations might be related to predation (top–down forcing). However, the contribution of this effect has been difficult to assess (Reid *et al.*, 2000), except for simple systems with few alternative trophic linkages (e.g. Shiomoto *et al.*, 1997; Daskalov, 2002; Frank *et al.*, 2005). Riegman *et al.* (1993) showed that algal communities start expanding with faster growing pico- and nanoalgae, which is later being eaten and depleted by microzooplankton. This makes nutrients available to micro- and macroalgae that support mesoplankton. Top–down effects generally lead to trophic cascades: Less predatory fish mean more planktivorous fish, less meso- and macrozooplankton; and more large phytoplankton and small zooplankton. There are also strong hints that suggest that, in more complex coastal upwelling systems, top–down control of zooplankton populations may be significant (Cury *et al.*, 2000). Frank *et al.* (2005) demonstrated a trophic cascade in a once cod-dominated Northwest Atlantic ecosystem. On the other hand, Aebischer *et al.* (1990); Micheli (1999) and Ware and Thomson (2005) suggested bottom–up control in different systems such as the Northern North Sea and coastal upwelling systems.

A:



B:

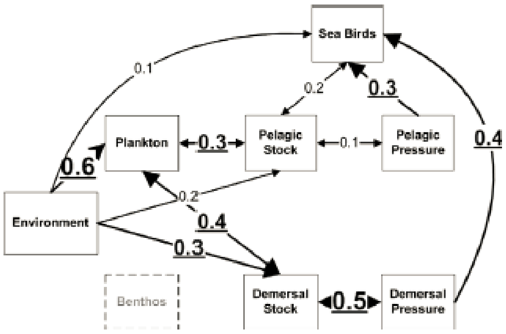


Figure 7.4.3.1.4. A: The relatedness (or degree of connection) between ecosystem components of the North Sea for the period 1983–1993, highlighting a significant possible top–down pressure as a result of fishing. Numbers underlined indicate a significant correlation. B: The relatedness (or degree of connection) between ecosystem components of the North Sea for the period 1993–2003, highlighting a significant bottom–up pressure for the pelagic part of the ecosystem and top–down pressure for the benthic part of the ecosystem. Numbers underlined indicate a significant correlation. (adapted from Kenny *et al.*, 2009).

In practice, zooplankton fluctuations are likely to occur as a result of both bottom–up and top–down forcing. A key question is therefore how much of the observed zooplankton variation is due to each type of forcing, and how this changes in time (e.g. Verheye and Richardson, 1998; Verheye, 2000; Chiba *et al.*, 2004; Kenny *et al.*, 2009). When a key mid-trophic species induces top–down control on species at lower trophic levels and bottom–up control on higher trophic levels, this is sometimes referred to as ''wasp-waist'' control (Rice, 1995). Under ''wasp-waist'' control, meso- and macrozooplankton is highly vulnerable to small pelagic fish and therefore competition for zooplankton prey is reduced when fishing is increased. This allows the ecosystem components to respond more readily to changes in stock sizes of small pelagic fish. Simulations by Shannon *et al.* (2000) indicate that assumptions on the type of control of different trophic components are important in determining the projected effects of fishing on ecosystems.

7.3.4.2 Energy flows

An additional consideration to take into account is that of energy transfer and flow. Can algal concentration and production determine zooplankton biomass and production? This section describes carbon flows for several systems to the extent that literature could be found on exact quantitative trophic flows between marine phytoplankton and zooplankton.

North Sea

Carbon budgets established for the southern North Sea suggest that, in May, south of the Dogger Bank, ca. 15% of phytoplankton production was channelled directly into the larger zooplankton (copepods), while north of the Dogger Bank ca. 30% was ingested by copepods. The production of the phytoplankton fraction >11 µm (i.e. potential copepod prey items) could not alone account for the daily carbon demand of the copepods. The carbon budgets suggest that ciliates could potentially have been of nutritional importance to the copepod population (Nielsen *et al.*, 1993). In February and March, on the other hand, when the spring bloom was under development, <5% of total daily primary production was grazed by the copepod community. The bulk of the primary production occurring in the North Sea at this time of the year was transferred directly to the benthos (Nielsen and Richardson, 1989).

Other systems

In Dabob Bay, a steep- sided fjord with an average depth of 200 m in Puget Sound, Washington, herbivore zooplankton consumed 36% of primary production (Downs and Lorenzen, 1985). In upwelling systems 12–30% of the algae is necessary to sustain the pelagic fish populations (cited in Cury *et al.*, 2000; Shannon *et al.*, 2003). The transfer estimates from phytoplankton to zooplankton in the southern Benguela upwelling ecosystem ranged 27–56% (Shannon *et al.*, 2003).

7.3.5 Concluding on zooplankton

An important question is whether marine systems are bottom–up or top–down controlled and what the role of zooplankton is in this context. This information is necessary for effective management of marine ecosystems, and therefore indicators that capture this information.

Above, examples were cited in which more phytoplankton clearly led to more zooplankton. In other examples, there was evidence of top–down control. Our limited inventory makes it clear that care must be taken when quantifying and interpreting the population dynamics of zooplankton through indicators. The relevant mechanisms might differ from system to system and between seasons. A comprehensive review should address different types of systems such as upwelling systems, open oceans like the Norwegian Sea, shallower seas like the southern North Sea, and closed systems like the Baltic Sea or Black Sea. For each system the feasibility and relevance of corresponding indicators can be discussed. WGECO consider that research on the mechanisms controlling zooplankton should continue, in particular in relation to ecosystem indicators.

7.4 Overview of indicators for food chains and communities

7.4.1 Community and Species Abundances and Biomasses

One of the weaknesses of ecological diversity is that it ignores abundances *per se*, responding only to relative abundances within a community. Thus, McGill (2011) recommended reporting overall abundance (summed across species) alongside species richness and an evenness measure. That is particularly necessary where ecosystems of the open sea are concerned, since one of the strongest signals of anthropogenic pressures that they display is the sharp drop in the abundances and biomasses of fishery resource populations that follows expansion of fishing effort.

Aside from that role as a supplement to measures of ecological diversity, the suite of indicators used in characterizing environmental status should likely include various abundances and biomasses, including those of resource populations, species at risk and perhaps others besides, forage species for example.

Other indices that may be useful take the form of ratios of the abundances of different groups of organisms. The ratio of planktivorous fish to ichthyovores, for example, could serve as a trophodynamic indicator (cf. Cury *et al.*, 2005), while ratios of pelagic to demersal fish have been of research interest. Such ratio measure depends on the availability of estimates from routine, standardized surveys and very rarely will the selectivities of the survey protocols be known for all of the species concerned. Ratios of relative abundances can show temporal change nonetheless, though care is sometimes needed in interpretation of the observed trends. Notably, quantitative surveys of pelagic fish are often challenging and tend to be species-specific. In the Southern Gulf of St Lawrence or on the Scotian Shelf, for example, herring (*Clupea harengus*) biomass might be estimated from catches in groundfish survey trawls or by a separate acoustic survey but neither method could yield useful data on mackerel (*Scomber scombrus*) or saury (*Scomberesox saurus*). It would be tempting to monitor a groundfish: herring ratio however, should that change, it would not be immediately known whether the shift was in the demersal: pelagic ratio or in the fraction of the pelagic biomass that was composed of herring due to the survey design.

7.4.2 Size compositions and size spectra

Changes in the size compositions of individuals within a population are clearly relevant to environmental status, particularly for species with indeterminate growth, such that large size is linked to high ages; as is true of most aquatic animals and macrophyte plants. Since size differences (whether within or among species) are related to variations in trophic level in many marine organisms, size compositions also carry important information about ecosystem structures and functions.

Community size spectra, on the other hand, can be linked to models of ecosystem fluxes and hence to the magnitude of ecosystem services (Dornelas *et al.*, 2011). Furthermore, since size compositions represent variation amongst individuals, they can be regarded as an aspect of biodiversity, in the CBD sense.

In offshore ecosystems, size compositions are among the most sensitive of all aspects of biodiversity to anthropogenic pressure: the direct effect of fishing effort is to increase mortality rates, which decreases life expectancy and hence the time available for the average individual to grow. This effect is commonly exacerbated by targeting practices, which tend to favour the harvesting of larger fish, and by the widespread lower ability of large animals to sustain any given level of fishing mortality. The latter is in itself a consequence of size-related differences in natural mortality rates (cf. Shin *et al.*, 2005; Greenstreet, 2008; Shephard *et al.*, 2013).

More than a dozen indices based on individual sizes (termed "Size-Based Indicators" or "SBIs": Shin *et al.*, 2005) have been suggested, including both simple ones, such as the community-wide mean length of the members of some taxonomic group, and others more complex. The latter include the slopes, intercepts and curvatures of size spectra, drawn in either length or weight units (Shin *et al.*, 2005; Charnov *et al.*, 2012). Most of the measures have been shown to respond to fishing pressure as they are expected to do (e.g. mean size falling as fishing effort increases), though size spectra tend to be rather insensitive and so-called "diversity spectra" even more so. It remains to be seen how sensitive the new indicators proposed above prove to be (see however the model study by Houle *et al.*, 2012). A much greater deficiency is that the time delay between full development of the response of size compositions may be many years behind changes in fishing effort; at least one exploited lifetime of the affected species and sometimes much more if the effect involves ecosystem responses to the depletion of the targeted fish (Shin *et al.*, 2005). In consequence, the signal communicated by an SBI tends to reflect fishery-management choices made long before, rather than those currently in effect.

All SBIs face further challenges. Firstly, in most marine species, recruitment success is highly variable, resulting in great variability of year-class strengths. In consequence, a downward shift in the sizes of individuals in a population can result either from depletion of larger individuals, usually driven by anthropogenic factors (particularly fishing effort), or from a strong recruitment event. An upward shift can be a result of reduced mortality rates on exploited size classes, a decline in recruitment (including a return to normal levels after a strong recruitment event) or simply the progression to higher age, and so sizes, of a strong year class that recruited some time before. Since depletion of larger size classes is usually a negative indicator for conservation purposes, while strong incoming recruitment is generally a positive one, changes in size compositions over short time-scales cannot be readily interpreted. Observed size compositions are also affected by shifts in temperature and food availability (the latter sometimes but not always having anthropogenic causes, including the ecosystem effects of fishing) through their effects on species' growth rates and hence on individual sizes, as well as any genetic change driven by selective fishing (Shin *et al.*, 2005). Moreover, most SBIs yet suggested carry a further weakness in that they compound within-population changes in size compositions with shifts in relative abundances among species that differ in adult sizes. If an SBI could be a meaningful indicator of environmental status, there might be an advantage in summarizing both kinds of change within a single index. Since these measures can only be regarded as illustrative, however, separating the within- and among-species trends would reduce the scope for misunderstanding among users of the scientific advice (Shephard *et al.*, 2011; Rossberg, 2012).

Given full data on the abundances of each size class in a population, it is sometimes possible to disentangle the various drivers and draw conclusions about the state of that population, though that cannot always be done without access to information (e.g. absolute abundances of some size classes) beyond that of a size composition itself. In many situations, however, no SBI could be interpreted to provide any unique explanation for its observed temporal changes, while the further that the data are compressed into simpler indices, with the loss of information inevitable in such compression, the more doubtful the disentangling will become. Indeed, Shin *et al.* (2005) recognized that "diagnosis of population state is not straightforward" when working with SBIs and that the "main problem is to disentangle the different sources of variation". They were reduced to calling for changes in mean lengths to be interpreted alongside information on condition factor and size-at-age, as well as for SBIs to be supplemented with information on the proportions of large and small species in the community and on the abundances of recruits (Shin *et al.*, 2005); which calls into question the value of summarizing size data into a simple index in the first place, unless it is to be used merely as illustration of advice founded in more complex analyses.

7.4.3 Trophodynamics

A wide variety of indices and indicators have been suggested for tracking the trophic structures and functioning of marine ecosystems. Cury *et al.* (2005) were able to list more than two dozen generic classes of such measures relevant to the ecosystem approach to fisheries management, admittedly a rather different focus from biodiversity monitoring. They selected six of those classes for further investigation, though the reasons for their choice were not reported. Of these six classes, quantifying the proportion of primary production which goes to support fish landings (termed "Primary Production Required" or "PPR") requires knowledge of consumption, ecotrophic efficiency and diet composition for each predator species; information that would seem to strain the limitations of existing scientific knowledge of most marine areas. The "Mixed Trophic Impact" measure requires an assumption of stability in trophic structure which has too obviously been violated by too many aquatic ecosystems. The "Fishing-in-Balance" index of Pauly *et al.* (2000) was developed in relation to Pauly *et al.* (1998) observation of "fishing down marine foodwebs" and allows total (pooled species) catch to be scaled for the greater ecological efficiency of harvesting lower in the trophic pyramid. Its relevance to other issues is unclear.

Of the remaining three classes of indices, Cury *et al.* (2005) made some use of ratios of biomasses of different trophic groups, as discussed above, as well as similar ratios of production and consumption of such groups; measures that may be useful as summaries of data, once observed trends have been successfully interpreted and understood. They gave perhaps the greatest prominence to "Mean Trophic Level", an index that has also been called the "Marine Trophic Index" ("MTI"). It was designed as a measure of Pauly *et al.* (1998) "fishing down". It fails, though, in key aspects of that role since it does not distinguish changes in the trophic level of catches that follow from depletion of higher level species from those arising through other mechanisms, such as technological development allowing economically viable seafood production from smaller (and hence lower trophic level) animals (cf. Caddy *et al.*, 1998; Essington *et al.*, 2006). The MTI is simply a weighted average of the trophic levels of the species present. As implemented by Cury *et al.* (2005); Pauly and Watson (2005); Bhathal and Pauly (2008) and others, each species is given a constant value for its trophic level, while the weighing is by the proportions of the species in fishery catches. The constancy sets aside the whole issue of the greater depletion of large individuals of a species within a resource population (as discussed above) that results from fishing mortality: larger fish typically occupy higher trophic levels than others of their species. Thus used, MTI misses much of its point, though it must be said that adequate data to describe size-specific diets are unavailable for most marine ecosystems: Even for such a long-studied case as the Atlantic cod of the western Scotian Shelf, Araújo and Bundy (2011) were only able to distinguish the diets of young-of-the-year and early juveniles (ages 1 to 3), all older and larger fish having to be lumped into a single dietary unit for lack of better data. For few other fish species of that area can subdivision by size or age proceed even that far (Cook and Bundy, 2010; Araújo and Bundy, 2011). Meanwhile, the weighting by catch makes the MTI into a measure of anthropogenic pressure more than one of ecosystem biodiversity, though if it were intended as such weighting by fishing mortality might be more appropriate if appropriate data were available. Where suitable survey estimates are available, however, a version of the MTI weighted by biomasses could be developed and would then become a more useful measure.

Cury *et al.* (2005) applied variants of their six classes of indices to fishery data from the Benguela Current system during the second half of the 20th century, though it remains unclear what they learned from the trends in index values. They did find that the indices tended to be insensitive, despite major changes having occurred in the fisheries. Cury *et al.* (2005) concluded that that insensitivity "emphasizes the potential danger of interpreting a single indicator without analysing the causes of the observed trajectory, or understanding the dynamics" of the system, which observation could be applied more widely than just to the trophodynamic indices. Cury *et al.* (2005) went on to conclude: "Quantifying changes in an ecosystem is not straightforward, and no single trophodynamic indicator can track the complexity of the observed changes in fisheries and ecosystems" and suggested that "it might have been more informative to consider abundance and species composition from research surveys, rather than to compute the indicators used here". While they nevertheless went on to recommend broader application of their chosen indices, a focus on analysis and understanding of the complexities of particular ecosystems would seem a more appropriate response.

A more recent development is the representation of the distributions of some community across tropic levels as "trophic spectra" (Gascuel *et al.*, 2005), rather than their summary as weighted means (e.g. the MTI) or other simple indices. Spectra might be drawn for biomass, abundance, extracted fishery catch or some other property. That approach has great promise as a tool for exploring the structures of ecosystems and the changes in those structures under anthropogenic pressure, while the spectra themselves could be valuable illustrations of conclusions reached through deeper analysis of the condition of the ecosystem of interest. As with graphical methods for examination of species relative abundances, however, trophic spectra are not well suited to summary in simple, numerical terms: no summary statistics have yet been defined, far less fully evaluated (Gascuel *et al.*, 2005).

In short, a trophodynamic index may aid in reporting results and may serve to guide scientists towards issues meriting attention, though it may also guide attention away when either insensitivity or the conflicting consequences of contrasting trends in multiple drivers mask real change. What no simple index seems able to do is to reveal what is happening to an ecosystem. That needs broader and deeper analysis. Some authors have applied trophodynamic indices to dietary information derived directly from field studies (e.g. Bhathal and Pauly (2008)). Others have relied on the outputs from some model of the system, often one prepared using Ecopath software (e.g. Cury *et al.*, 2005). Once such models have been prepared, and supposing that they adequately represent reality, they can be used to examine changes across time, differences across space and the implications of each of those for management (e.g. Bundy, 2005; Bundy and Fanning, 2005; Araújo and Bundy, 2012), reducing the role of any simple trophodynamic index to that of the dependent variable in a graph illustrating conclusions drawn from the models.

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IMR - http://www.IMR.no

Encyclopaedia of Life - http://eol.org/

FishBase.org - http://www.fishbase.org/

Marine Species Identification Centre - http://species-identification.org/

8 ToR f) LFI development

Continue development and analysis of use of the LFI in the North Sea and areas other than the North Sea, and explore methods to develop ensemble LFI for regional seas covered by multiple surveys, and survey types (e.g. gear differences). Examine and report on the possible interactions between LFI and climate change.

8.1 Introduction

The LFI is explicitly required to support implementation of the European Union Marine Strategy Framework Directive (MSFD) to monitor progress towards "good environmental status" (GES) in respect of Descriptor 4 (D4) marine foodwebs. The Decision document (2010/477/EU) proposes that "*Large fish (by weight)*" be used as an indicator (indicator 4.2.1) to monitor change in the "*Proportion of selected species at the top of foodwebs*".

In this section then, we report on three recent case studies that have developed and applied Large Fish Indicators (LFI) for new marine regions; the western Baltic Sea and the southern Bay of Biscay. Work on developing methods to derive regional scale assessments based on the LFI where systematic regional scale datasets are not available, building on the ideas and analyses WGECO reported in 2012, is still in progress, so at this point in time, further comment would be premature. WGECO anticipates that ToRs related to the development and application of the LFI will continue to come their way and by 2014, WGECO should be in a position to report on this aspect of the use of the LFI more completely.

8.2 LFI for the Western Baltic Sea

Compared with other sea areas where the LFI has been applied, the demersal fish community of the Western Baltic Sea is characterized by low species richness and survey bottom-trawl samples are dominated by just the one species: cod. Further LFIs were therefore defined and analysed to assess the role of cod in driving the observed LFI trend in the Western Baltic Sea.

Analyses were based on data obtained from 900 trawl sampled collected by research vessels from Denmark and Germany participating in the Baltic International Trawl Survey (BITS). This survey is carried out in the Western Baltic Sea (Subdivisions 22, 23, 24) twice a year in Quarters 1 (Q1) and 4 (Q4) between 1991 and 2012 (ICES, 2011a). Investigations focused on Q1 data, considering potential effects of the recruitment of fish from the previous year. Analyses focused on the western Baltic, ICES Subdivisions 22–24, to avoid any bias associated with declining salinity from west to east over the Baltic Sea. Major methodological changes occurred over the course of the survey time-series, in particular changes in the fishing gear used. Only data from 2001 onwards, when the smaller gear (TVS) was used, were considered appropriate to analysis. Individual haul data on catch per unit of effort (cpue) at length for each species for the years 2001–2012, held in the ICES database (ICES, 2013), were therefore downloaded on 9 January 2013 and filtered following established procedures.

Based on the available data, eight commercial fish species were chosen. Cpue per length per haul were converted to weight-at-length using weight-at-length relationships determined for each species. Two LFIs were calculated, one using data for all eight species and the second based only on cod. Length thresholds to define "large" fish of >30 cm and >40 cm were tried. Data for all species in the demersal fish community of the Western Baltic were downloaded from ICES DATRAS on 18 February 2013 (ICES, 2013) to assess the extent to which the eight key species were representative of the whole community.

Fishing mortality (F) data and numbers of recruits at age 1, used respectively as indicators anthropogenic pressure on the system and variation in environmental conditions, were available only for cod (except that 2012 data were not yet available). Cross Correlation Functions (CCF), combined with bootstrapping, were used to assess the utility of each of the proposed LFI´s as an ecological indicator.

The eight key demersal fish species selected for analysis represented more than 98% of the total biomass of BITS samples collected between 2001 and 2011 and, depending on the year, cod made up 25–70% of total annual biomass. Across all length classes, cod dominated the combined biomass of the eight key species; and the level of dominance increased with increasing fish length (Figure 8.1). Both the $\text{LFI}_{>30\text{cm}}$ and the $\text{LFI}_{>40\text{cm}}$ exhibited positive long-term trends. In some years, for example 2003 and 2004, the direction of interannual variation differed between the two trends (Figure 8.2). Both the $\text{LFI}_{>30\text{cm}}$ and the $\text{LFI}_{>40\text{cm}}$ correlated negatively with cod fishing mortality with a time-lags of three and one year respectively. No correlation between the $\text{LFI}_{>30\text{cm}}$ and cod recruits was detected, but a negative correlation was observed for the $\text{LFI}_{>40\text{ cm}}$ involving a time-lag of one year.

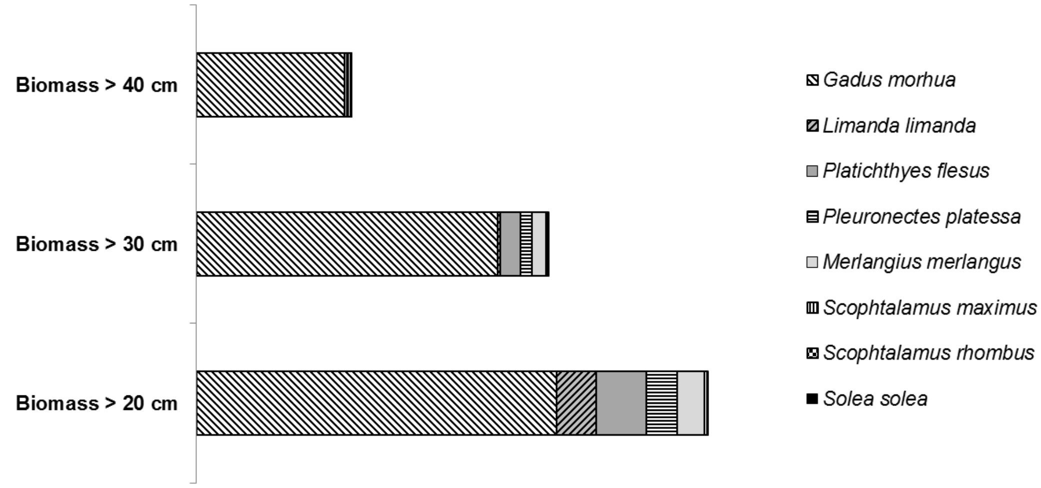

Figure 8.1. Species biomass in percentage of the total biomass of the fish community analysed, concerning the different length classes caught during the Baltic International Trawl Survey in Quarter 1 between 2001 and 2011 (Oesterwind *et al.*, in prep).

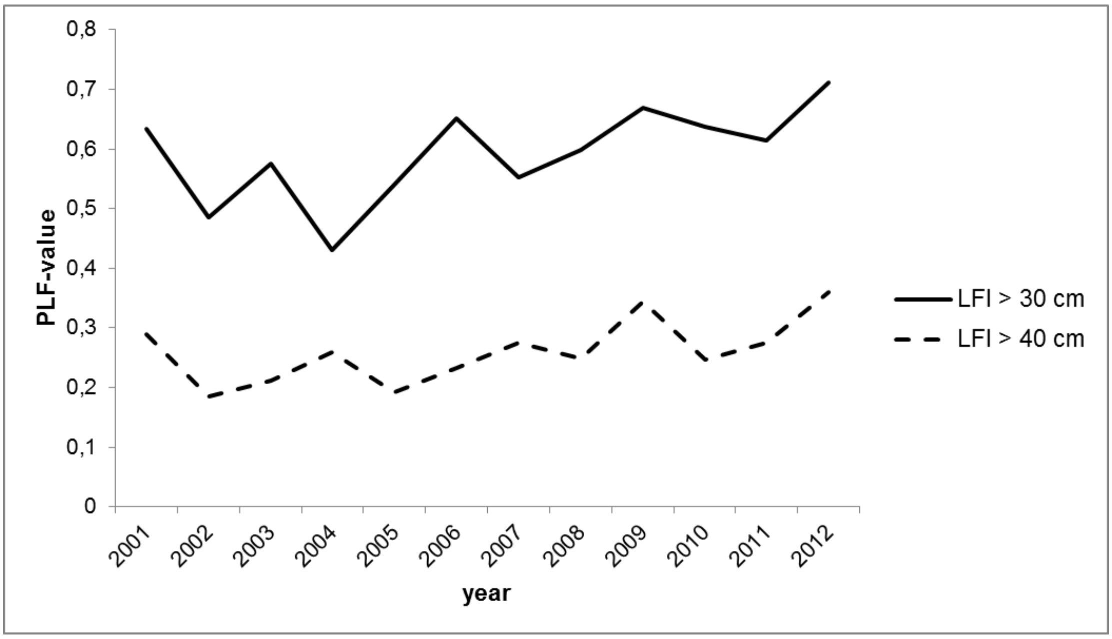

Figure 8.2. Time-series of two different Large Fish Indicators in the Western Baltic between 2001 and 2012 (Oesterwind *et al.*, in prep).

Trends in the $LFI_{>30cm}$, and $LFI_{>40cm}$ determined for all eight key demersal species were similar to equivalent LFIs based only on cod biomass of ($LFI_{>30cm,cod}$, $LFI_{>40cm,cod}$), revealing the predominant influence of a single species, cod, on the more general LFIs. To test whether more subtle impacts of fishing on the rest of the demersal fish community were masked by this dominant effect that variation in cod biomass had on the two general LFIs, two further LFIs ($LFI_{>30cm,excod}$, and $LFI_{>40cm,excod}$) were calculated based on biomass data for the remaining seven key demersal species only (i.e. excluding cod). Trends in the $LFI_{>30cm}$ and the $LFI_{>30cm,excod}$ were not correlated, confirming the predominant influence of varying cod biomass on the general $LFI_{>30cm}$. Variation in the $LFI_{>30cm,excod}$ negatively correlated with changes in cod fishing mortality with a time-lag of two years, suggesting that the cod fishery had a deleterious impact on the wider demersal fish community. The $LFI_{>40cm,excod}$ showed no correlation with cod fishing mortality.

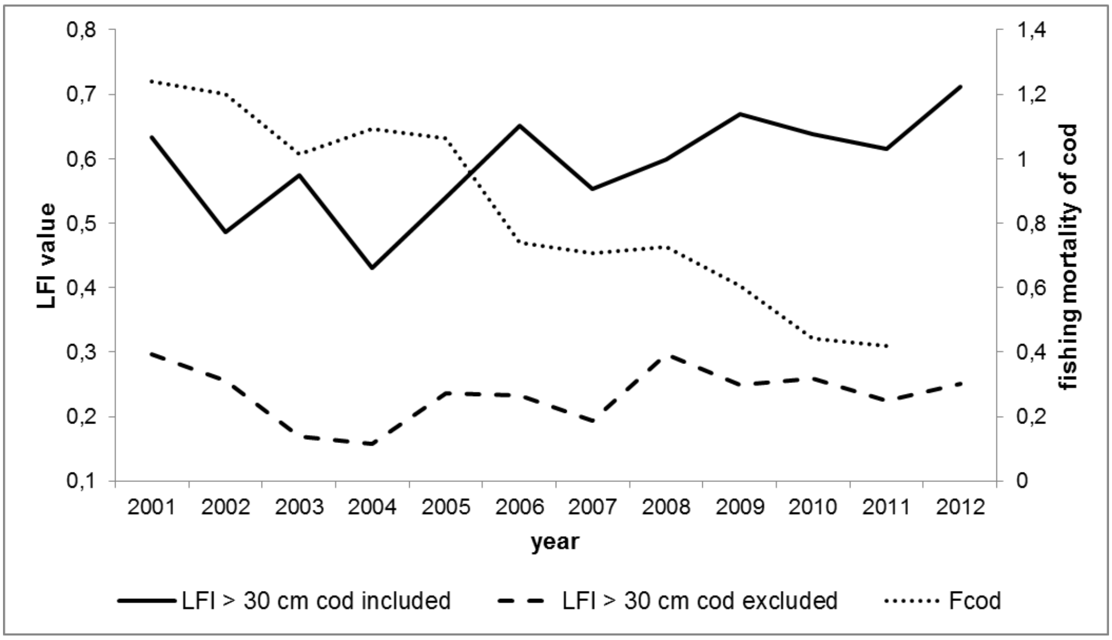

Figure 8.3. Comparison of the trends in cod fishing mortality (dotted line), the LFI>30 cm Proportion of Large Fish (LFI) of 30 cm with (bold solid line) and without cod (bold broken line) (Oesterwind *et al.*, in prep).

Among fish smaller equal than 30 cm, dab in particular increased in biomass from 2001 onwards. Whiting biomass also increased between 2001 and 2007, then subsequently declined to the 2001 level. Plaice biomass increased strongly from 2009 onwards (Figure 8.4). Considering the large fish component >30 cm, cod biomass increased markedly over the entire time-series, dab, plaice and whiting biomass also increased (Figure 8.4).

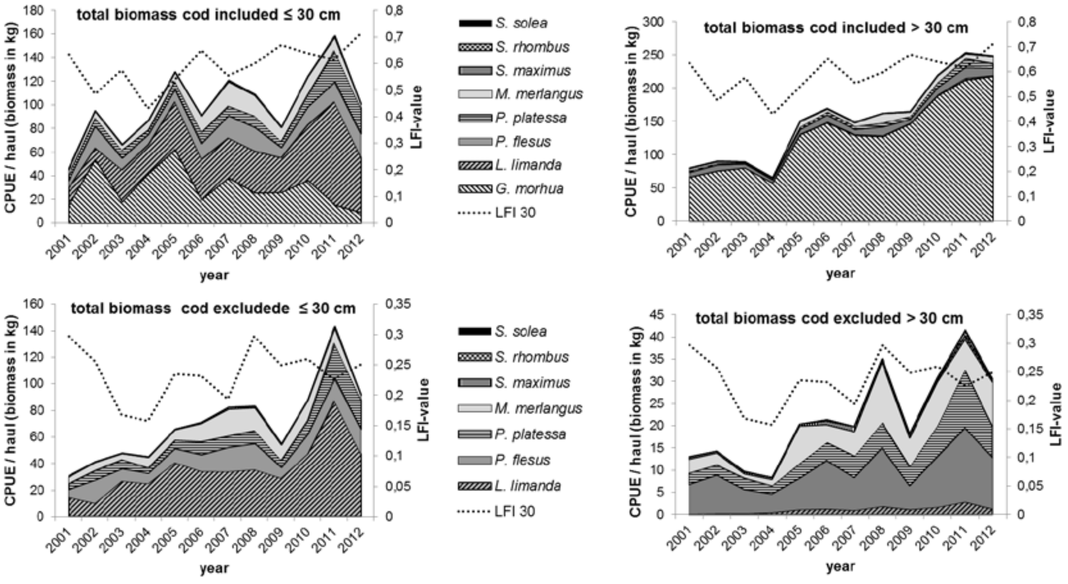

Figure 8.4. Biomass (cpue per length class/number of hauls) of the selected eight species for the analysed time-series depending at the length threshold of 30 cm. First line with and second line without cod (Oesterwind *et al.*, in prep).

As with previous LFI studies, this study again confirms the usefulness of the LFI as an indicator of the impact of fishing pressure on fish community size composition.

8.3 LFI for the southern Bay of Biscay

The approach used to define LFIs, first for the North Sea, and then for the Celtics Sea (Greenstreet *et al.*, 2011; Shephard *et al.*, 2011), was followed to define an LFI for the southern Bay of Biscay (Figure 8.5). The suite of species considered to constitute the community to be monitored was determined and the same polynomial smoother protocol was applied to determine 35 cm as the most appropriate length threshold to define "large" fish (Figure 8.5). Examination of community-averaged "precautionary" plot for the area suggested that in 1990 and 1991, the start of the period for which survey data were available, the state of the community was consistent with "sustainable use". However, taking account of the fact that estimates of small fish biomass at this time were some of the lowest recorded over the course of the time-series, management targets set as high as the LFI values recorded in 1990 and 1991 might not actually be achievable under more normal conditions. Consequently, an LFI value of 0.3 was adopted as the EcoQO for the southern Bay of Biscay (Modica *et al.*, submitted).

With rapidly increasing fishing pressure on the fish community, the LFI quickly declined to a minimum value in 1996. Two phases of recovery subsequently followed, in 2001 and 2002, and then again between 2005 and 2008; both strongly driven by increases in the abundance of large fish. In 2007 and 2008 the LFI actually exceeded the EcoQO target value. Over the whole period, variation in the LFI was equally influenced by changes in biomass of both small and large fish (Modica *et al.*, submitted). Rather than being piscivorous, the species of fish primarily responsible raising large fish abundance were mainly benthivorous, or at best omnivorous (Olaso *et al.*, 2002; Preciado *et al.*, 2002; Sanchez and Olaso, 2004; Olaso *et al.*, 2005). Horse mackerel, included in the suite of species to which the LFI was applied in the southern Bay of Biscay and which rarely grows above "large" fish length threshold of 35 cm, was responsible for driving much of the variation in small fish abundance (Modica *et al.*, submitted). However, at lengths of 25 to 30 cm horse mackerel becomes strongly piscivorous (Olaso *et al.*, 1999; Cabral and Murta, 2002; Jardas *et al.*, 2004; Bayhan and Server, 2009). Consequently, early declines in the LFI, mainly caused by increased horse mackerel abundance, and subsequent recoveries, primarily influenced by the increased abundance of large benthivorous fish, suggest an inverse relationship between the LFI and the proportion of top predators (piscivores) in the community. Modica *et al.* (submitted) therefore conclude that the LFI is best used as a D1 biodiversity indicator in the southern Bay of Biscay, rather than as a D4 foodweb indicator.

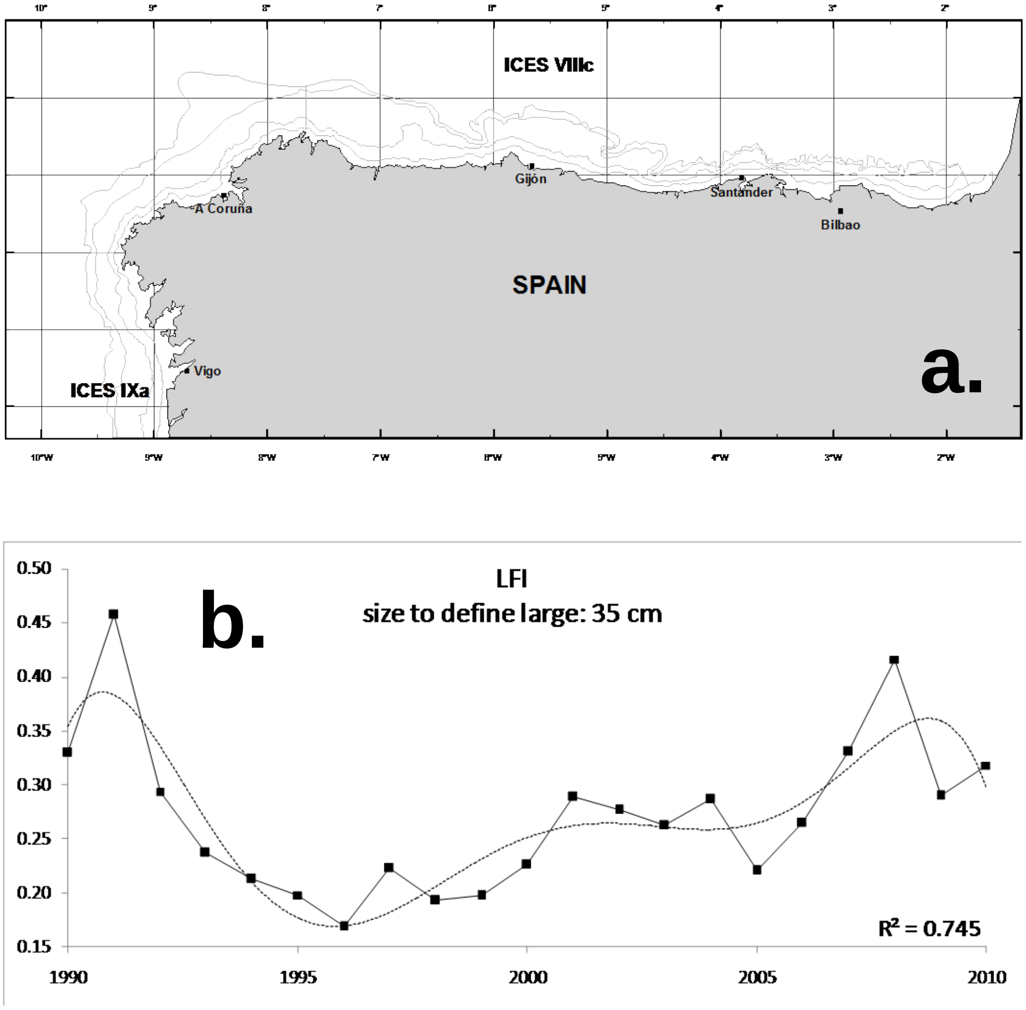

Figure 8.5. Area from which data were collected to derive an LFI for the southern Bay of Biscay (a) and observed variation in the LFI between 1990 and 2010 (b). Dotted line shows the 6th degree polynomial smoother fitted to the time-series based on a "large" fish defining threshold length of 35 cm, giving a fit of r^2=0.745. LFI trends based on "large" fish defining threshold lengths of 30 cm, 40 cm and 45 cm showed similar trends, but the 6th degree polynomial fits, at r^2=0.699, r^2=0.704 and r^2=0.690 respectively, were weaker, suggesting that 35 cm was the most appropriate "large" fish defining threshold length for the fish community in this marine region.

8.4 LFI for the Baltic Sea pelagic fish community

In the Baltic Sea, the derivation of LFIs is currently limited to the area where the Baltic International Trawl Survey (BITS) operates, i.e. the ICES Subdivisions (SDs) 22–28 (western and central Baltic Sea, Figure 8.6), the depths layers shallower than 100 m depth, and the time period after 2000 where a standardized gear type was put in force (see Section 8.2 above).

Validation trawl samples obtained from the Baltic International Acoustic Survey (BIAS) provide an opportunity to develop an LFI for the whole Baltic Sea (up to the Bothnian Sea SDs 30, and Gulf of Finland SD 32; Figure 8.6) and for a longer time period (from 1978). This survey covers the pelagic habitat and primarily samples only four species, herring, sprat, sticklebacks and cod, which represent more than 99% of the whole pelagic community. Cod is frequently encountered in the pelagic habitat of the Baltic Sea because it feeds on pelagic fish and anoxic/hypoxic water layers can also limit its use of the seabed habitat.

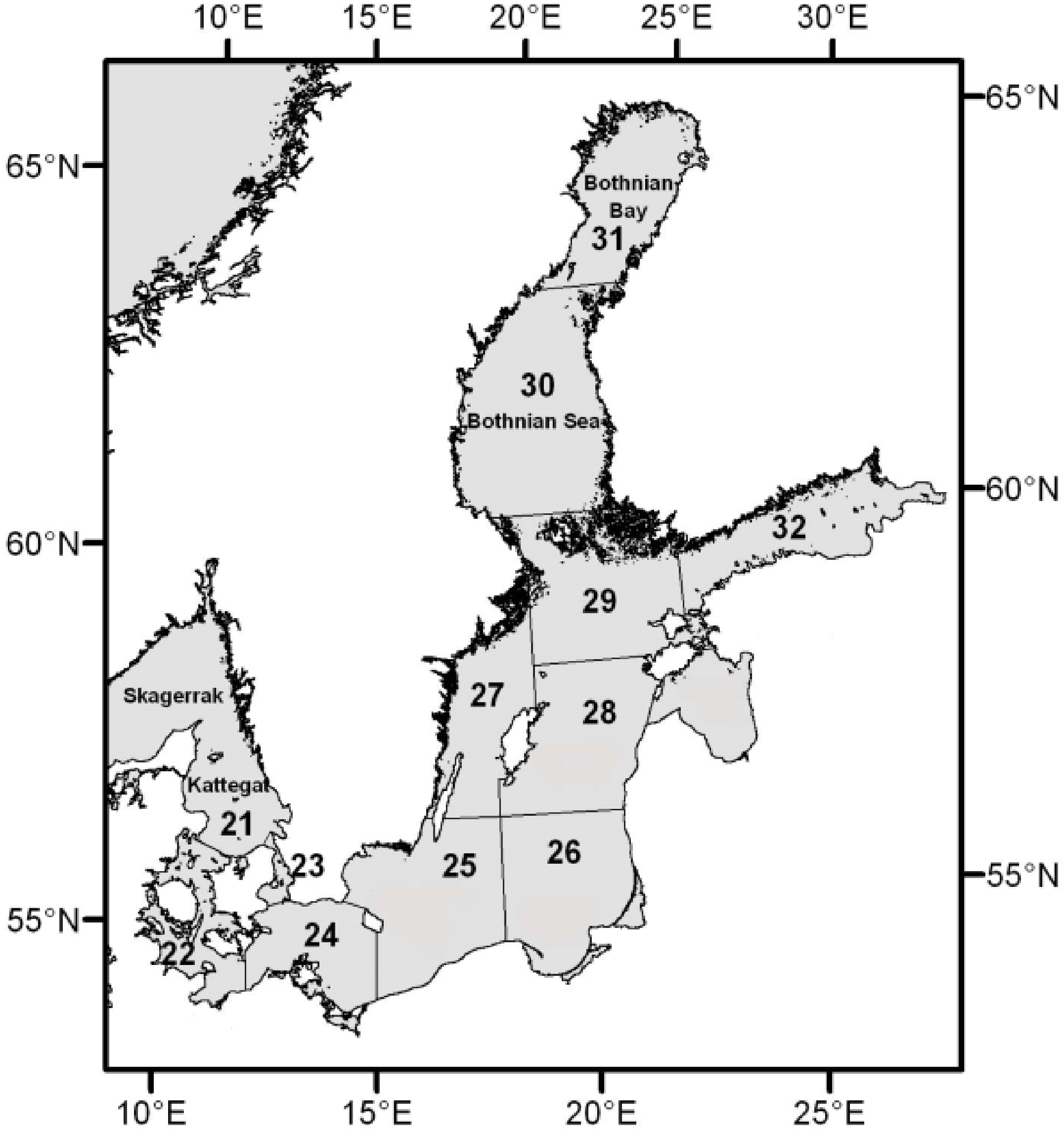

Figure 8.6. Map of the Baltic Sea divided into ICES Subdivisions (SDs).

We estimated separate LFIs (by weight) for the total pelagic community (including cod) and for the "typical" pelagic community (excluding cod), using length thresholds to define "large" fish of 38 cm (i.e. the current minimum landing size of cod) in the first instance, and 16 cm (i.e. the size at maturation of the second larger fish species in the community, herring) in the second case (Casini *et al.*, 2013). Preliminary results show that both Baltic Sea LFIs decreased markedly during the 1980s, but have stabilized since the mid-1990s (Figure 8.7) (Casini *et al.*, 2013). These trends are in line with the reduction in the size of the eastern Baltic cod stock and an increase in the abundance of the small-sized sprat and sticklebacks (Casini *et al.*, 2013).

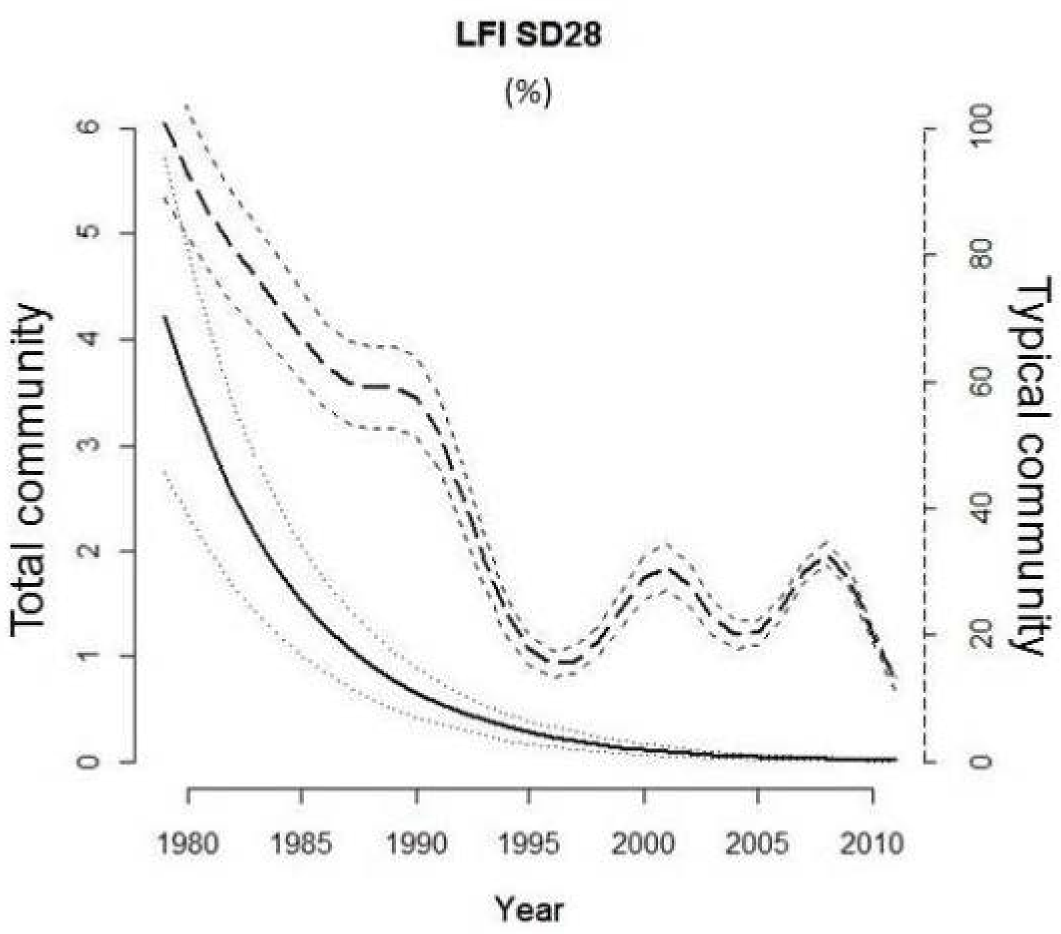

Figure 8.7. Trend in LFI for the total pelagic community (sprat, herring, sticklebacks and cod) and typical pelagic community (excluding cod) in the Baltic Sea Subdivision 28.

This study shows the high potential of pelagic survey data in the estimation of LFI and in the evaluation of the state of the Baltic Sea pelagic foodweb.

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Annex 2: WGECO terms of reference for the next meeting

The **Working Group on the Ecosystem Effects of Fishing Activities** (WGECO), chaired by XX XX, XX, will meet in Copenhagen, Denmark xx–xx May 2014 to:

a) Review and consider recent research into unaccounted mortality in commercial fisheries;

b) Review ongoing work for reducing unintended effects on the seabed and associated communities of fishing operations and gears, including ghost fishing.

WGECO will report by DATE 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	Term of Reference a) Several countries are conducting or have recently completed significant studies in this area and the subject would benefit from a review of progress and an evaluation of the results obtained. The last review of significant studies occurred in 1996 by the ICES Study Group on Unaccounted Mortalities. A review of more recent work will determine the need for revision and update on planning and methodology for studying this subject. Term of Reference b) All fishing activities have influences that extend beyond removing target species. The approach recommended by FAO is that responsible fisheries technology should achieve management objectives with a minimum of side effects and that they should be subject to ongoing review. WGFTFB members and others are currently undertaking a range of research programmes to provide the means to minimize side effects.
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 Fisheries.
Linkages to other organizations	The work of this group is closely aligned with similar work in FAO and in the Census of Marine Life Programme.

Annex 3: Technical minutes from the Review Group for OSPAR MSFD related request

- RGMSFD
- Review deadline 1 June 2013
- Participants: Samuli Kopinen (Chair), Verena Trenkel, Francisco Velasco, Claus Hagebro (ICES Secretariat)
- Working Group: WGECO

Review of ICES WGBIODIV, WGECO, WGMHM, WGMME WGITMO, IBTSWG and WGBEAM, annual reports (2013) as regards the OSPAR Requests 3-4/2013.

Audience to write for: Advice Drafting Group.

General

The Review Group considered how the above-mentioned ICES expert groups addressed the following special requests by OSPAR:

3/2013 Support to the technical specification and application of common indicators under D1, 2, 4, and 6

Request for the quality assurance/ response to specific questions to support the work of the identification and prioritisation of common indicators to support the regional implementation of the biodiversity aspects of MSFD in the Northeast Atlantic. BDC 2012 have requested the submission of first set of common indicators to be presented to BDC 2013 (noting that the relevant ICES groups will meet late February early March 2013). At this time (i.e. first quarter 2013), ICES would be requested to undertake an independent peer review of the technical specifications and proposed operational implementation of the indicators that will be presented. The review should consider, from the perspective of producing a set of common indicators for the OSPAR Region: 1) whether the indicators put forwards are appropriate to implement at a regional scale; 2) whether the set of indicators is sufficient as a set to understand GES; 3) identify any gaps; 4) identify where there are difficulties in the operationalization of the indicators, with proposals for how to overcome these. Based on the outcomes of Request A-5 (regarding maximising efficiencies for monitoring of biodiversity), 5) identify where there are opportunities to cluster indicators that can benefit from shared monitoring/ data collection. Delivery of this request would be desirable by May/June 2013.

4/2013 Maximise the use of available sources of data for monitoring of biodiversity

The purpose of this request is to seek ICES advice on the potential sources of data and information that may be available to support the monitoring and assessment of biodiversity in relation to commitments under MSFD so as to maximise efficiencies in the use of available resources, for example where efficiencies could be made to identify where there are monitoring programmes or data sources that can deliver multiple indicators, which may relate to different Descriptors, (e.g. The Data Collection Framework could be used to implement D3 and D1 indicators), or where with a small additional effort existing monitoring could be amplified to deliver a broader set of data. Advice would be sought as to 1) the quality of these potential data sources and how they could be used, including but not limited to the relevance of outcomes identified in chapter 8 of the ICES MSFD D3+ report to Descriptors 1, 4 and 6.

The Review Group (RG) was given the task to evaluate how the ICES Working Groups (WG) WGBIODIV, WGECO, WGBEAM, WGITMO, WGMME, IBTSWG and WGMHM had addressed the two OSPAR requests and whether they have been sufficiently met.

The RG acknowledges that several WGs have addressed the two requests by OSPAR and scientifically sound methods and considerations have been used to evaluate the OSPAR common set of indicators. The reports of WGBIODIV and WGECO contained most thorough analyses of the two requests but WGITMO, WGMME and WGMHM contributed to specific details of the requests. WGBEAM and IBTSWG were only required to answer to the second request, but their input has been used mainly by WGBIODIV and WGECO to complete their answers to the first request.

More specific review of how the working group reports were meeting the requests is given below.

Review of the OSPAR Request 3/2013 ‘Support to the technical specification and application of common indicators under D1, 2, 4, and 6’

The OSPAR request 3/2013 was divided into five specific questions. This division was partly used also in the reports of the ICES WGs while also some questions were combined. The five sections below evaluate how the WGs have addressed the five questions.

Question 1 ‘whether the indicators put forward are appropriate to implement at a regional scale’

The RG noted that the emphasis of this question most likely refers to the geographical adequacy of the indicators. This can include at least three aspects: (1) Are the indicators appropriate for the OSPAR convention area or the OSPAR Regions? (2) Are the indicators appropriate as regional indicators in general? (3) Can the indicators be operationalized in the region?

WGBIODIV and WGECO

The WGBIODIV and WGECO had developed 16 criteria to evaluate the performance and applicability (or adequacy) of the indicators for a given region and the report of WGBIODIV 2013 contained a thorough analysis of the OSPAR common indicators for the Greater North Sea area based on these criteria. The WGBIODIV approach was to analyze the indicators from three perspectives: (1) spatial data coverage, (2) operationalization and (3) overall performance of the indicators against all the criteria. The results from the first analysis (spatial data coverage) are relevant for question 1). However, RG notes that the evaluation by WGBIODIV and WGECO strictly only applies to the greater North Sea (OSPAR region II) and does not cover Arctic waters (Region I), Celtic Seas (Region III), Bay of Biscay and Iberian Coast (Region IV) and Wider Atlantic (Region V). This point is important as several criteria relate to data availability which is not homogenous across all regions. Also, the existence of certain ecosystem components may vary across the five OSPAR regions.

WGBIODIV applied threshold values for the final evaluation of OSPAR common indicators (Table 2 in WGBIODIV Annex 2). These threshold values were derived in a simulation study (Section 2.2) which assumed that different criteria can completely compensate each other, i.e. a bad score (0) for one criteria can compensate for a good score (1) for another criteria. Further, the underlying logic applied was one of "acceptable" indicators being better than the upper 5% value obtained for random scores. RG believes that this is not the most pertinent approach for determining threshold values. Indeed, it would have been more logical to set thresholds in such a way that the scores for all criteria were at least partially met (0.5 or 1 depending on criterion). Applying this method provides threshold scores of 0.559 for overall assessment of state indicators, 0.456 for pressure indicators, and 0.5 for operationalization. Applying these new threshold values would probably lead to a different result for the final evaluation of the OSPAR common indicators (Section 2.3 in WGBIODIV and Table 3). Unfortunately the raw score matrix was not available so that RG could have redone the final indicator evaluation in response to the question 1) but also question 4).

The analysis by WGBIODIV included a single criterion '#5 Relevant spatial coverage' which evaluated the availability of data from the Greater North Sea region. WGBIODIV had made a sound analysis whether the OSPAR indicators met this criterion in an adequate way and the results were given in Table 3 (green= 'meet the criterion', red = 'does not meet'. However, RG noted that criterion #5 included only an analysis of data availability and not the other aspects of adequacy of the indicators to the OSPAR region. For example, do the indicators reflect relevant and scientifically understood ecosystem components or processes in the OSPAR convention area? Section 4.2 of the WGBIODIV report ('Ecological gaps') may provide some further insight to this OSPAR request for the Greater North Sea region, because the discussion of the gaps also recognizes relevant ecosystem components and processes in the OSPAR area, but that potential linkage was not identified in the WG report.

The criterion #13 of the WGBIODIV analysis says that "Scientific, peer-reviewed findings should underpin the assertion that the metric provides a true representation of variation in the ecosystem attribute in question". RG considers that criterion #13 fits with the above-mentioned need to evaluate the applicability of the indicators 'in general', i.e. within a region. However, the results of this criterion were not shown separately in the report, but included in the 'overall analysis'. So RG was not able to pull out the results for criteria #13 for the greater North Sea to complement the response prepared by WGBIODIV.

WGITMO

The non-indigenous species (MSFD D2) were dealt by the WGITMO, which used the same methodology as WGBIODIV to assess the indicators. The RG considered the assessment relevant for this specific question of the OSPAR request.

WGMHM

WGMHM analyzed the benthic OSPAR indicators in a qualitative way. The approach of the WGMHM was to estimate whether the indicators can be used as regional indicators in general and no other consideration was made. The analysis was narrow but the input complements the analysis by WGBIODIV.

WGMME

WGMME report did not contain a specific analysis of the OSPAR indicators, and the RG got the feeling that the members of the group were also part of the development team of the OSPAR indicators. The report included a short paragraph discussing the appropriateness of the mammal indicators, but no conclusion was given.

IBTSWG and WGBEAM did not address this question of the OSPAR request, but WGECO referred to their reports.

In general, the RG finds an evident bias in all groups answers towards the North Sea that is the recurrent scenario/case study/region considered along the report, this is not in line with the OSPAR request since one of the obvious problems is the applicability of indicators to different regions, and the comparability of results/assessments within and between regions. Probably this fact is due to the scarce participation from other areas, and hence the expertise available, but this should be acknowledged in the advice.

Question 2 'whether the set of indicators is sufficient as a set to understand GES'

WGBIODIV

WGBIODIV 2013 (Section 4 in Annex 2) based on the results of the OSPAR common indicator scoring exercise considered this question for the Greater North Sea region from the point of view whether the OSPAR common indicators cover i) the metrics mentioned in the EC decision 2010 and ii) whether they do it for all relevant ecosystem components. The conclusions drawn are sound and show that the OSPAR common indicators do not cover all MSFD indicators and hence they are not sufficient to understand GES (Section 4.1). However, the group did not have the expertise for all ecosystem components. Therefore the conclusions regarding which ecosystem components might or might not be covered by the OSPAR common indicators which are needed to understand GES might not be completely valid (Section 4.2). However, the biggest drawback is that the evaluation only applies to the Greater North Sea region.

Also in the concluding remarks (Section 4.2.12) it was discussed that there is no need to monitor every marine ecosystem component in order to assess achievement of GES, but the indicators should address the critical ecosystem components. It is also proposed that in certain cases correlations between the healths of different ecosystem components and/or indicators could be used to reduce the number of indicators needed. RG considers that this makes sense but requires further research.

The report further considered whether status assessments could be measured by a single pressure indicator (e.g. fishing pressure) which is behind the reduced status. This consideration remains however slightly contradictory in the report as in previous sections it was clearly stated that GES should be assessed by state indicators (Quotation: "…assessment of the status of different components of marine ecosystems, and monitoring progress towards good environmental status (GES), primarily requires the use of "state" indicators, and that "pressure" indicators should only be used for this purpose if no appropriate "state" indicator is available.").

Finally, the WGBIODIV criterion #7 is relevant for this question but the results were not shown separately. The criterion states that *"Clear targets (absolute values or trend directions) for the indicator can be specified that reflect management objectives, such as achieving GES"*. Showing results of this analysis could provide an additional answer to the OSPAR request question 2).

WGMHM, WGMME and WGITMO

WGMHM and WGMME were rather general and short in their responses and WGITMO did not address this question.

Question 3 'identify any gaps'

This question is closely linked to question 2.

WGBIODIV

The RG is of the opinion that the gap analysis of the OSPAR indicators was performed well in the WGBIODIV report (except that MSFD D2 related indicators were not included in the analysis and WGITMO did not make a gap analysis).

The matrix of MSFD indicators vs. OSPAR indicators (Table 5) showed how the OSPAR indicators can relate to the indicators given in the EC Decision 2010. In the matrix, some mistakes in the relations of OSPAR and MSFD indicators were correctly noted and the lack of some indicators was also highlighted. RG noted however that the matrix seems to treat the OSPAR pressure indicators as non-applicable to meet the MSFD criteria/indicators. This corresponds to the ICG-COBAM Technical Specification document. While WGBIODIV noted disagreement with some links suggested by the technical specification document, it did not point out missing links, which one might argue exist for the pressure indicators. In particular, dropping pressure indicators do not meet the spirit of the directive where pressures are given specific attention. The discussion in the report of the use of state and pressure indicators was partly contradictory (as already explained above).

The discussion of the Section 4.1 of the WGBIODIV report focuses on the redundancy of indicators which is more relevant to the OSPAR request #2 on the sufficiency of the set of indicators to assess GES (see above). Section 4.2 discusses the ecological gaps and makes a good comparison of the OSPAR indicators against the marine ecosystem. The section pinpoints clear gaps but could improve by being more concrete in some findings. For example, what would be the species where an indicator for genetic diversity would best improve the OSPAR set of indicators? Moreover, the finding that rocky habitats are underrepresented in the OSPAR indicators could be widened to note that the OSPAR indicators for benthos lack likely also for sandy habitats and mixed bottoms where grab samples are difficult to take.

The RG noted that the Table 5 of the report (the indicator comparison matrix) considers multimetric indices non-applicable to assess the MSFD indicator 'sensitive/tolerant species'. The RG was of the opinion that this is only partly true as the main parameter in these indices is the abundance of sensitive/tolerant species. However, the interpretation is correct in the sense that in order to use the index one should show these results separately from the index results.

Other WGs

WGECO, WGITMO, and WGMME did not address this question of the request and WGMHM was very general in the response.

Question 4 'identify where there are difficulties in the operationalization of the indicators, with proposals for how to overcome these'

The question lacked a definition of what is meant by "operationalization" which was somewhat of a hindrance to evaluate the replies to the question.

The RG noted that this request was sufficiently covered by the WGBIODIV and WGITMO analyses where six criteria related to operationalization of indicators were used. The WGBIODIV and WGITMO results of the analysis were shown in the reports and it was clearly shown whether the indicators were judged by the expert to meet the threshold value for an operational indicator or not. The comment in question 1 regarding threshold values for scores applies here. More indicators could be considered operational if the threshold score value (0.5 or 50%) proposed by RG was used. This concerns OSPAR common indicators M-6, B-3, BH-1, BH-2, BH-3 and BH-4 which could be considered operational.

The WGBIODIV analysis based on indicator scores for criteria # 2, 3, 4, 5, 10 and 11 showed the potential for operationalization of the indicators. The results are relevant for Question 4 ‘identify where there are difficulties in the operationalization of the indicators, with proposals for how to overcome these’ for the Greater North sea region. According to the RG opinion, this analysis consisted of relevant aspects and the results were clearly shown in Table 3 of the report.

Further, RG wondered why criteria #9 on comprehensibility ("Indicators should ideally be understandable by policy-makers and other non-scientists (e.g. stakeholders) alike, and the consequences of variation in indicator should be easy to communicate") was not used to evaluate the performance of common indicators with respect to operationalization. The RG noted that the criteria used to estimate the potential for operationalization of the indicators did not include coherence of monitoring data from multiple sources (e.g. national monitoring programmes). This may sometimes be a really difficult challenge for regional indicator operationalization. The set of criteria could also include a criterion for a common database (or similar) and/or existence of an expert group to deal with the assessment. Although that is a marginal issue in a review of the applicability of an indicator, it may be a hindrance in operationalization of an indicator.

Other WGs

WGMHM noted that operationalization may be difficult for biotopes which are spatially difficult to distinguish (i.e. require high quality data). The RG noted this as a valid point, but was of the opinion that the seabed indicators would have benefited of a more comprehensive review as they performed rather poorly in the WGBIODIV analysis.

WGMME did not address this OSPAR request.

Question 5 ‘identify where there are opportunities to cluster indicators that can benefit from shared monitoring/data collection’

The RG noted that this part of the OSPAR request was addressed by all the WGs of this review report (see above). The most thorough analysis was given by WGECO and WGBIODIV which also summarized the outcomes of IBTSWG and WGBEAM and referred to WGISUR, WKCATDAT and WKECES. WGMHM analysis was restricted to clustering within benthos monitoring and WGMME did not analyze this request.

WGECO

In its introduction to ToR c hence question 5, WGECO listed various monitoring approaches which could be used to cluster under shared data collection but focused the discussion to fishery surveys only. This focus is understandable due to the great potential in integration of various samplings with the fishery surveys, but it seemed likely that the WG lacked expertise in other fields of environmental monitoring such as remote sensing and bird monitoring. The report, however, contains a paragraph were some possible (other than fish survey) monitoring methods were suggested for a number of indicators.

Despite this gap in the analysis, the RG noted that the discussion of the possible way forward was particularly constructive and included also other monitoring approaches than fishery surveys.

The strongest part of the WGECO report was the table where the potential for integration of monitoring with bottom-trawl and beam-trawl surveys was presented for every MSFD indicator of the EC Decision. Even more specific was the table by WKCATDAT that was reported by WGECO, where each monitored parameter was analyzed separately and it was estimated whether the monitoring would require extra resources (personnel, ship time, skills, facilities, etc.). The RG considered this very useful comparison.

However, the RG noted that the WGECO conclusions were perhaps too optimistic of some possibilities for integration and the analysis would likely benefit from larger group of different expertise on monitoring. For example, as the IBTSWG and WGBEAM tables correctly note, integration of fishery surveys and bird/mammal monitoring may be too optimistic, as the sampling design of trawl surveys is not adequate for seabird and mammal surveys, which use fixed 'zigzag' transects covering a certain region (in a relatively short time), while trawling surveys likely follow different sampling approach and may also focus on specific habitats only. Moreover, bird surveys have largely shifted to aerial surveys and the use of high definition cameras/videos and automatic object identification. With mammal surveys the need to cover large areas over short times is even more important.

WGBIODIV

The response of WGBIODIV focuses on the ground fish surveys presented by WGISUR. The analysis is qualitative and, though including valid points, lacks concrete recommendations (such as an analysis of extra resources needed to perform the integrated monitoring). The WKCATDAT table includes these aspects.

The RG considered the Table 6 of the WGBIODIV report, however, very useful, because it relates the various monitoring opportunities to the OSPAR indicators, which is a very concrete approach and could be widened to include more information.

Review of the OSPAR Request 4/2013 'Maximise the use of available sources of data for monitoring of biodiversity'

Question 1 'quality of potential data sources and how they could be used, including but not limited to the relevance of outcomes identified in chapter 8 of the ICES MSFD D3+ report to Descriptors 1, 4 and 6'

The request was addressed by WGECO, IBTSWG and WGBEAM and the response of WGMHM was rather limited. WGITMO also responded to this request in Section 4.9 of the report, referring to WGITMO 2012 report, and with a quick questionnaire to different countries; nevertheless the response is also limited since it just addresses a list of ongoing programmes in the countries that answered the question, WGMME did not address this request.

The RG noted that those WGs that addressed this request treated it in combination with the previous request and was of the opinion that the request was generally met well. The focus of WGs seemed to be in cost-efficiency issues but the RG did not notice that there would have been any discussion of the 'quality of potential data' as requested by OSPAR. This could, however, be estimated (indirectly) from the WKECES 2012 report where, as brought on and mentioned by WGECO, a SWOT analysis was made for some ecosystem surveys.

The WG reports could have given a clearer input to the OSPAR request if the various potential data sources were be listed under each OSPAR indicator. At present all different surveys have their own table.

Conclusions

The Review Group concludes that in general the two OSPAR Requests have been adequately met by the Working Groups, but there are two major shortcomings: (1) the WG responses applied only to the Greater North Sea, and (2) the quality of the available monitoring data was not specifically addressed. The RG, however, noted that the other questions were analyzed with appropriate methods.

The RG particularly noted that a more thorough evaluation of the OSPAR indicators would need:

- an analysis covering the entire OSPAR convention area;
- an analysis of the quality of the monitoring data more detailed presentation of the analysis results (results of the 16 criteria);
- testing of an alternative way of assessing the indicator performance (see the text above); and
- a result of an analysis whether the set of OSPAR indicators is sufficient to understand GES.

The RG considers that the two 'major issues' should be addressed before giving the advice, but the minor issues are of lesser importance at this point of time.