Gutachten „Erarbeitung einer Zusammenstellung und Bewertung internationaler Konzepte zur integrierten Gesamtbewertung mariner Ökosysteme“

FKZ 363 01 331

Forschungsvorhaben des Umweltbundesamts

Referenznummer: 2348

Datum: 30.05.2011

Susanne Altvater, Katriona McGlade, Franziska Stuke, Elena von Sperber, Max Grünig
## List of Acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Full Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>BQE</td>
<td>Biological Quality Indicator</td>
</tr>
<tr>
<td>COP</td>
<td>Conference of the Parties</td>
</tr>
<tr>
<td>EcoQOs</td>
<td>Ecological Quality Objectives</td>
</tr>
<tr>
<td>EFARO</td>
<td>European Fisheries and Aquaculture Research Organisation</td>
</tr>
<tr>
<td>EMMA</td>
<td>European Marine Monitoring and Assessment</td>
</tr>
<tr>
<td>ESF</td>
<td>European Science Foundation</td>
</tr>
<tr>
<td>EU</td>
<td>European Union</td>
</tr>
<tr>
<td>GES</td>
<td>Good Ecologic Status / Good Environmental Status</td>
</tr>
<tr>
<td>GRAMED</td>
<td>Global and Regional Assessments of the Marine Environment Database</td>
</tr>
<tr>
<td>HELCOM</td>
<td>The Helsinki Commission (Baltic Marine Environment Protection)</td>
</tr>
<tr>
<td>ICES</td>
<td>International Council for the Exploration of the Sea</td>
</tr>
<tr>
<td>IOC-UNESCO</td>
<td>International Oceanographic Commission UNESCO</td>
</tr>
<tr>
<td>IEA</td>
<td>Integrated Ecosystem Assessment</td>
</tr>
<tr>
<td>MS</td>
<td>Member State of the European Union</td>
</tr>
<tr>
<td>OSPAR</td>
<td>The Oslo and Paris Commissions (North-East Atlantic Marine Environment Protection)</td>
</tr>
<tr>
<td>QE</td>
<td>Quality Element</td>
</tr>
<tr>
<td>RBMP</td>
<td>River Basin Management Plan</td>
</tr>
<tr>
<td>SEAMBOR</td>
<td>Science Dimensions of Ecosystem Approach to Management of Biotic Oceans Resources</td>
</tr>
<tr>
<td>WFD</td>
<td>Water Framework Directive</td>
</tr>
<tr>
<td>WGECO</td>
<td>Working Group on Ecosystem Effects of Fishing Activities</td>
</tr>
</tbody>
</table>
Table of Contents

1 EXECUTIVE SUMMARY ........................................................................................................5
2 ZUSAMMENFASSUNG ...........................................................................................................6
3 INTRODUCTION ...................................................................................................................7
4 AIMS OF THE STUDY ..........................................................................................................8
5 METHODOLOGY ..................................................................................................................9
  5.1 CENTRAL QUESTIONS .....................................................................................................9
  5.2 ASSESSMENT OF SCIENTIFIC LITERATURE .................................................................10
  5.3 FACTSHEETS SEE ANNEX I ........................................................................................10
  5.4 EXPERT INTERVIEWS SEE ANNEX II AND III .............................................................11
6 BACKGROUND ....................................................................................................................12
  6.1 ECOSYSTEM APPROACH ............................................................................................12
  6.2 INTEGRATED ECOSYSTEM ASSESSMENT ..................................................................13
  6.3 INDICATOR OBJECTIVES ..............................................................................................17
  6.4 CUMULATIVE EFFECTS .................................................................................................19
  6.5 SUPPORTING APPROACHES FOR IEAS ......................................................................21
    • 6.5.1 HELCOM approach ..............................................................................................21
    • 6.5.2 DPSIR (Driver-Pressure-State-Impact Response) approach ..................................21
    • 6.5.3 Anthropogenic impacts approach .......................................................................23
    • 6.5.4 Water Framework Directive approach ..................................................................23
  6.6 MARINE STRATEGY FRAMEWORK DIRECTIVE .........................................................26
  6.7 WATER FRAMEWORK DIRECTIVE .............................................................................29
7 ANALYSIS ............................................................................................................................34
  7.1 ASSESSMENT OF SCIENTIFIC LITERATURE ...............................................................34
  7.2 APPROACHES OF WORKING GROUPS .......................................................................34
    • 7.2.1 WGECO, ICES (2010) ..........................................................................................34
    • 7.2.2 Assessment of Assessments (UNEP) ....................................................................39
    • 7.2.3 EMMA ..................................................................................................................41
    • 7.2.4 MSFD Management Group ...............................................................................46
    • 7.2.5 SEAMBOR .........................................................................................................48
  7.3 DECISION-TREES, RISK-ANALYSIS, ECOLOGICAL NETWORK-ANALYSIS ..........53
    • 7.3.1 Decision-Trees .....................................................................................................53
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.3.2</td>
<td>Risk-Analysis</td>
<td>56</td>
</tr>
<tr>
<td>7.3.3</td>
<td>Evaluation of Ecological Network Analysis for Ecosystem-Based Management</td>
<td>57</td>
</tr>
<tr>
<td>8</td>
<td>Compilation and Evaluation of Case Studies</td>
<td>58</td>
</tr>
<tr>
<td>8.1</td>
<td>Compilation of Case Studies</td>
<td>59</td>
</tr>
<tr>
<td>8.1.1</td>
<td>Selection of approaches</td>
<td>59</td>
</tr>
<tr>
<td>8.1.2</td>
<td>Key elements of an IEA</td>
<td>61</td>
</tr>
<tr>
<td>8.2</td>
<td>Expert Interviews</td>
<td>66</td>
</tr>
<tr>
<td>8.3</td>
<td>Evaluation of Case Studies see Annex I and IV</td>
<td>76</td>
</tr>
<tr>
<td>8.3.1</td>
<td>Summary of findings</td>
<td>76</td>
</tr>
<tr>
<td>8.3.2</td>
<td>Best practice</td>
<td>82</td>
</tr>
<tr>
<td>8.4</td>
<td>Requirements for Integrated Assessment Concepts</td>
<td>95</td>
</tr>
<tr>
<td>9</td>
<td>Applicability of the WFD to the MSD</td>
<td>98</td>
</tr>
<tr>
<td>10</td>
<td>Conclusions</td>
<td>108</td>
</tr>
<tr>
<td>11</td>
<td>List of Figures</td>
<td>110</td>
</tr>
<tr>
<td>12</td>
<td>References</td>
<td>111</td>
</tr>
<tr>
<td>Annex I</td>
<td>Factsheets</td>
<td>117</td>
</tr>
<tr>
<td>Annex II</td>
<td>Guiding Questions for Interviews</td>
<td>117</td>
</tr>
<tr>
<td>Annex III</td>
<td>Interviews</td>
<td>117</td>
</tr>
<tr>
<td>Annex IV</td>
<td>Overview Table of Factsheets (Excel Sheet)</td>
<td>117</td>
</tr>
<tr>
<td>Annex V</td>
<td>Recommended Criteria and Associated Indicators for GES</td>
<td>117</td>
</tr>
</tbody>
</table>
# Executive Summary

The Marine Strategy Framework Directive (MSFD) establishes a consistent regulation framework for an ecosystem based approach to the management of human activities in the European marine waters, i.e. the Baltic Sea, North-East-Atlantic, Mediterranean Sea and Black Sea. At the same time, the MSFD constitutes the environmental column of the European maritime policy (blue book of the integrated maritime policy). Under the MSFD, EU Member States are required to achieve or maintain Good Environmental Status (GES) in their territorial marine waters by 2020. To achieve GES, the EU has proposed criteria for which Member States must now develop associated indicators to produce an initial assessment of the environmental status of the marine ecosystem. It is aimed to get an initial assessment, the description of GES and the determination of environmental goals and indicators until latest 15 July 2012.

In order to determine GES as a first step, this report presents existing Integrated Ecosystem Assessments (IEAs). It further examines whether and which aspects of the assessments are applicable for fulfilling the requirements of the MSFD.

The overview and aims of the report are set out in chapters 3 and 4. Chapter 5 details the guiding questions as well as the methodology used in assembling this report. Chapter 6 is based on a literature review and provides background to IEAs, looking at their basis in the ecosystem approach as well as some of their key building blocks. It highlights different theoretical approaches such as the Driver-Pressure-State-Impact (DPSIR) approach and concludes with descriptions of the Water-Framework-Directive (WFD) and the MSFD. Chapter 7 leads the analysis section with the approaches of different working groups for creating an IEA. It also evaluates the applicability of decision-trees, risk-analysis and ecological network analysis to IEAs. Chapter 8 forms the main part of the work carried out. It describes how the case studies were compiled and analysed and is followed by a summary of the main findings from the interviews and the IEA approaches selected for case study. The chapter concludes with an overview of what were found to be the key requirements for carrying out an IEA. Chapter 9 compares the WFD to the MSFD and analyses to what extent the WFDs experience and approach can feed into the requirements of the MSFD. The main conclusions are presented in chapter 10.
2 Zusammenfassung


Um den guten Umweltzustand vorher festlegen zu können, stellt der vorliegende Bericht bestehende integrierte Bewertungsansätze vor. Auch untersucht er, inwieweit und welche Bereiche dieser Bewertungen für die Erfüllung der Vorgaben durch die MSRL genutzt werden können.

3 Introduction

The Marine Strategy Framework Directive (MSFD) sets up an extensive list of ecological descriptors and characteristics, pressures and impacts that are to be used to assess the environmental status of European marine waters. Furthermore the intention was to elaborate marine strategies, including programmes of measures to achieve Good Environmental Status (GES) to those waters by 2020.

For both purposes these descriptors, pressures and impacts need to be integrated into one or several types of Integrated Ecosystem Assessments.

The German Federal Environmental Agency (UBA) already developed a first concept including 11 descriptors. Moreover several Working Groups like EMMA, WGECO or UNEP’s assessment have suggested approaches which include (i) multidisciplinarity; (ii) integration of biotic and abiotic factors; (iii) accurate and validated methods for determining ecological integrity; (iv) methods for determining the effect of human uses and impacts; and (v) adequate indicators to follow the evolution of the monitored ecosystems.

Following the ecosystem-based approach, attention has been paid to the development of tools for different physical-chemical or biological elements of the ecosystems. However, very few methodologies seem to integrate all the elements into a unique evaluation of status and performance of an aquatic system.

Furthermore, the European Union context requires a sufficient degree of “consistency … between marine regions or sub-regions of the extent to which good environmental status is being achieved.” (Paragraph 25, MSFD). But alone around the European waters, the ecosystems themselves vary in their physics, chemistry, and biodiversity as well as in the types of present uses. In trying to consistently evaluate GES across regions have therefore several important implications.

There is a strong need for robust, pragmatic, but scientifically sound methodologies from the scientific and stakeholder point of view. Politicians and managers need information in order to show to society the evolution of a zone, taking into account human pressures or recovery processes.

The UBA therefore seeks to get a comprehensive survey of the existing knowledge about integrated approaches of ecosystem assessments and its implementation.
Here, the report started to review the current situation of integrative ecological assessments by analysing proofed and “grey” literature and evaluating whether they are appropriate for an assessment approach with regard to the MSFD. The surveys and conceptual proposals forwarded by different Working Groups were flowing into the report as well as statements on GES. This is followed by an investigation of the possible useful role of decision trees and risk analysis. For a sound result several central questions provided guidance as well as conceptual frameworks and “philosophies” like the DPSIR approach.

As a result all identified approaches in theory and practice were collected in a data base.

The focus of the report was on integrative ecological assessments used and designed in practice worldwide. Interviews with experts, managers and stakeholders have been conducted to get the upmost information about consolidated assessments on marine ecosystems and also about existing gaps. The practice examples have been assembled and the best practice evaluated. Again central questions provided guidance to find out which examples are most applicable for an assessment approach concerning the MSFD and the special tasks of the German Federal Environmental Agency. The analysis ends with a comprehensive description of the requirements of integrative assessment concepts for a successful implementation in practice.

Finally the transferability of the WFD to the MSFD was analysed to meet the need of coherence and comparability between Member States and different sea (sub-) regions, and to use the existing experiences of the WFD approach.

4 Aims of the Study

The EU Member States have to fulfil three requirements within the MSFD until the deadline of 15 July 2012:

(a) They have to complete initial assessments of the current status of their marine waters and the environmental impact of human activities thereon, in respect of each marine region or sub-region, taking account of existing data where available and other relevant assessments such as those carried out jointly in the context of Regional Seas Conventions (Article 8(1)).

(b) Further they have to determine for the marine water a set of characteristics for GES, in respect of each marine region or sub-region concerned, on the basis of the qualitative descriptors in Annex I and taking into account the indicative lists of Annex III (Article 9(1)).
Lastly, they have to establish a comprehensive set of environmental targets and associated indicators for their marine waters, in respect of each marine region or sub-region, so as to guide progress towards achieving GES, taking into account the indicative lists of Annex III, table 2 and of Annex IV (Article 10(1)).

Before these actions, the Member States have to develop criteria and methodological standards for the determination of GES in Regulatory Committees so as to ensure consistency and to allow for comparison between marine regions or sub-regions of the extent to which GES is being achieved.

To meet these objectives, the German Federal Environmental Agency (UBA) is interested to obtain a comprehensive survey of the existing knowledge about integrated approaches to ecosystem assessments and their implementation. It is the aim of this study to provide the UBA a comprehensive overview of the up to date knowledge regarding Integrated Ecosystem Assessments. Further, it has to be compiled and evaluated what can be useful for the integrated approach by the MSFD.

5 Methodology

The basis for the analysis of this study is an assessment of three different groups of sources: scientific literature, integrated assessment reports and expert interviews. All three are assessed with the aim of creating an overview on integrated ecosystem assessment approaches, used or developed approaches in methodology on the one hand and forms of implementation on the other. Special focus was put on the applicability for the initial assessment under the MSFD.

As yet, the fully integrated assessments that place substantial emphasis on human ecosystem use are reduced in number. Most ‘integrated’ assessments refer to the integration of different biological, chemical and hydrological criteria. They do not take socioeconomic concerns into account. For this reason a further category has been added in this analysis. The term ‘Integrated assessment’ is used to differentiate from ‘Fully integrated assessments’. Integrated assessments attempt to bring together an evaluation of individual states and pressures usually leading to an assessment of the overall status of the ecosystem. These assessments do not take socio-economic factors into consideration to any large extent.

5.1 Central Questions

The identified approaches for integrated ecosystem assessment have been analysed based on the following central questions:

1) What is the management approach taken for the assessment?

2) Which (biological quality) components are addressed in the assessment?
3) Which anthropogenic pressures are included?
4) What are the indicators that have been identified to measure state and pressure?
5) How are the biological characteristics and human pressures integrated into one overall status assessment?
6) Are cumulative effects taken into consideration and if so, how?
7) Is the assessment based on state indicators or pressure indicators, or both?
8) Does weighting takes place and if so, how?
9) Which MSFD Descriptors are covered by the assessment?
10) What about data provision? What is the quantity and quality of data used in the assessment?
11) What groups are using the results?
12) How is it decided if management measures are needed and which measures are needed?

5.2 Assessement of Scientific Literature

Scientific literature has been analysed in relation to the background chapter and literature on specific integrated ecosystem assessment approaches. Additional literature has been examined, which has been regarded being especially relevant for the topic of integrated ecosystem assessments.

5.3 Factsheets see Annex I

The information on the various integrated ecosystem assessments showed high variation in format and extent of reports or scientific articles. Based on this variation, it was decided to produce factsheets for each approach and a summary overview.

The factsheets are aimed to give an overview of each approach and an evaluation according to previously identified criteria. Each factsheet is therefore structured into three elements:

1. Summary
2. Assessment overview
   o Management
   o Details of Assessment
3. Evaluation

In the Evaluation each approach was assessed according to four key criteria. Firstly, approaches were examined for their (i) **relevance** to the study’s focus. This analysis also included defining the extent to which the assessment was truly integrated (i.e. taking anthropogenic as well as biological, physical and chemical features into consideration). Secondly, assessments were analysed for (ii) **transparency**. This involved examining whether full and open reporting took place such as regarding the process of choosing indicators. The involvement of stakeholders in these processes was also considered a key component of transparency. With regards to (iii) **accessibility**, focus was laid on the presentation of information (is it clear and accessible?) and whether the results of the assessment were made openly available. Finally, assessments were examined for their (iv) **transferability** and the extent to which the assessment had elements that could be considered relevant for the MSFD and its implementation.

5.4 Expert Interviews see Annex II and III

In addition to the literature survey, a number of key experts were interviewed to provide additional input on the background and implementation of IEA approaches worldwide.

Overall, twelve experts were consulted in the time period from mid March to mid May 2011. Eleven individuals were interviewed while one returned a questionnaire in written form. Speaking with the experts proved extremely helpful in better understanding of the different IEA approaches that are implemented internationally and the challenges connected to them in practice. For an overview of the experts that were consulted for this report, please see table 8.

Based on the assessment of the scientific literature and the advice from the various experts along the way, a number of IEA practice examples were chosen that were then examined in greater detail. In some cases, several experts were consulted in order to fully understand and evaluate the respective approach. The information from these specific interviews fed into the development of the case study factsheets (see chapter 8.1 and Annex I).

Interview questions focused on the overall process, framework and indicators used in the assessment as well as stakeholder involvement, management measures and communication of the results. A set of guiding questions was developed for the interviews. These were based on the outline of the factsheet and were intended to help gain a complete understanding of specific assessments selected for case study. For a list of guiding questions used in the interviews, which were adapted depending on the respective interviewee, please see Annex II.
6 Background

6.1 Ecosystem Approach

“An ecosystem approach is a conceptual work to build the knowledge framework in which management will be developed and applied. As soon as policy and management of a single sector is started, Ecosystem Approach (EA) will turn into Ecosystem Approach to Management (EAM)” (Rice 2010). This approach is a widely accepted concept in the field of marine management. However, numerous definitions and interpretations of this concept exist, causing confusion and some resistance against the introduction of the EA, e.g. in the fisheries sector (Morishita 2008). For example, the approach is mentioned once in the 1982 United Nations convention on the law of the sea (UNCLOS), in Article 5 of the 1995 United Nations fish stock agreement (UNFSA) or several times in the 1995 FAO code of conduct for responsible fisheries. The best known description comes from the year 2000, established by the COP 5 of the Convention of Biological Diversity1.

The European Union has adopted several environmental directives, strategies, recommendations, and agreements that require a shift from local- or regional-based regulations to more ecosystem-based, holistic environmental management, i.e. the EU Biodiversity Strategy, the Habitats Directive or the EU Maritime Policy. Ecosystem health is increasingly at the center of regulation and management decision-making in the EU. Over the next decade, therefore, environmental management in Europe is likely to focus more on biological and ecological conditions rather than purely physical and chemical conditions. For instance, the WFD which promotes the protection of continental, estuarine and marine waters was adopted in 2000 and the MSFD in 2008. Worldwide legislative instruments like the US Oceans Act, the Oceans Policy of Australia (Commonwealth of Australia 1999, 2006), the Canadian Oceans Strategy from 2002 (Parsons 2005) or the Integrated Coastal Management Bill of South Africa (www.deat.gov.za) address the need to assess the ecological status of the marine environment. This will require strong efforts to adapt current systems of environmental assessment and management to the basin and ecosystem level, across media and habitats, and considering a much broader set of impacts on ecosystem status than is currently accounted for by most risk assessments. An EA is therefore only as good as the understanding, integration, and communication of economic, ecological, hydrological, and other processes across many spatial and temporal scales (Apitz et al. 2006). This concept brings together natural physical, chemical,

\[1\] COP 5, Dec. V/6: “The ecosystem approach is a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way. Thus, the application of the ecosystem approach will help to reach a balance of the three objectives of the Convention: conservation; sustainable use; and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources.” The decision further outlines 12 principles of an EA.
physiographic, geographic and climatic factors, and integrates these conditions with the anthropogenic impacts and human activities in the area concerned (Borja 2005). It considers the cumulative impacts of different sectors, although work in this area is still emerging. Further it establishes target levels and thresholds for important ecosystem components and evaluates the impacts of management options and risks of not attaining target ecosystem states (Murawski 2007). Other authors add ecosystem attributes such as food web dynamics, species, diversity, and the distribution of life histories to the structural components mentioned. Since they are not direct biological properties but functions of the entire ecosystem, they provide important additional information about the functioning and status and have been perceived as potentially useful indicators of environmental status (Rogers 2007).

Current confusion about the EA is caused by pure misunderstandings and mistrust between those involved in the issue. Also human aspects have a role to play as management measures based on the EA, which are not feasible or sustainable from an anthropocentric point of view, are likely to be met with strong resistance. To overcome these problems, Morishita (2008) recommends good science data, identification of management goals, integration of human factors and stakeholder involvement.

### 6.2 Integrated Ecosystem Assessment

Integrated Ecosystem Assessments (IEAs) are a key component of ecosystem-based management (EBM) approaches and as such are an important part of meeting the Marine Strategy Framework Directive (MSFD) requirements for initial assessment and determining good environmental status (GES) (see chapter 6.6). This section provides an overview of IEAs. Approaches that may support the development of IEAs are described in chapter 6.5.

IEAs seek to incorporate and synergise information regarding the interactions and impacts of a variety of elements (biological, chemical, human) with and on the ecosystem. They should not only provide information on ecosystem status, but should also aim to show trends in dominant pressures and impacts.

ICES (2010a) notes that it is generally agreed that IEA approaches should include the following elements (not in any specific order):

**Assessment of:**

- status and trends of ecosystem components (species & habitats);
- status and trends of human activities (pressures);
- ecosystem component interactions (functions);
- impacts and risk to the marine ecosystem; and
- socio-economic aspects.
To carry out the assessment, criteria such as population size or nutrient level are selected and a set of indicators such as biomass and nutrient concentrations are developed to assess these components. These various components are then brought together through a system of weighting to determine the overall status of the ecosystem. IEAs can vary considerably in their components, their analysis of interactions between states and pressures as well as the extent to which socio-economic factors are taken into account. As a result, IEAs can be divided into three types (see Rice et al 2010):

- **Fully integrative assessments**: include all ecosystem components, including environmental state variables, human activities and socio-economic factors that may drive or change the ecosystem. (MSFD requirements call for a fully integrated assessment).
- **Sectoral assessments of specific human activities**, which assess the impact of a particular activity on all relevant ecosystem components
- **Thematic assessments of specific ecosystem components** which consider a particular component’s status in relation to all the other components it interacts with

The temporal and spatial scale can vary, leading to differences in results depending on the baselines and boundaries used. According to ICES (2010a), IEAs are a place-based approach, and it is therefore necessary to define spatial management units. The hierarchical nature of spatial scales also needs to be taken into consideration e.g. if estuarine processes are important, then coastal habitats need to be included in the IEA.

The complex and interrelated nature of ecosystems, has led to a number of models such as food-web and risk analyses being used in IEAs. However, as IEAs are still relatively new few methodologies have so far produced fully integrated assessments that take a comprehensive range of ecosystem elements as well as human pressures or recovery processes into account.²

It is important to note that an IEA is both a process and a product. The IEA is able to organise scientific information in a way that provides an integrated overview of the health of the entire ecosystem rather than data that is specific to one sector or species. In this way, IEAs provide assistance and support to managers and policy-makers carrying out EBM to make decisions that take social, economic and environmental factors into account.

The IEA forms the basis for evaluation of the effectiveness of existing measures and considerations of whether changes to policies and measures are required. Integrated management processes should be iterative and adaptive, feeding changes in the ecosystem into future management decisions. Additionally, where aspects such as socioeconomic concerns cannot be integrated in the initial stages, this iterative function allows for their integration in later iterations.

---

**Box 1: Key elements of an IEA (Levin et al. 2008)**

An IEA should explicitly consider all components of the ecosystem and include:

- The identification of key issues of concern and stressors that management and policy should address
- Assessment of status, indicators, and trends in the condition of the ecosystem relative to established management targets or thresholds
- Assessment of the environmental, social, and economic causes and consequences of these trends
- Forecast of ecosystem condition under a range of policy or management actions or both
- Periodic reevaluation of management effectiveness in the context of emerging ecosystem issues
- Identification of crucial knowledge and data gaps that will guide future research and data acquisition efforts

*Source: Levin et al. Integrated ecosystem assessments (2008)*

Levin et al. (2009) have developed an IEA process that contains five key steps which they suggest are necessary for IEAs and will enhance their success (see figure 1). It is broken down into a) scoping; b) indicator development c) risk analysis; d) management strategy evaluation; and e) monitoring and evaluation. Steps a) scoping and b) indicator development are in line with the MSFD requirements to carry out an initial assessment and to determine GES respectively. Both scoping and indicator development are therefore crucial elements of IEAs that are compatible with the MSFD.³

---

However, although the approach of Levin et al. is a valuable methodology, as ICES note, there are multiple approaches, frameworks and methods available for conducting IEAs (ICES 2010b). An adaptive management cycle that iteratively accounts for more and more elements of the definition is therefore considered to be of most importance.

A number of regions have already made considerable efforts to begin using integrated approaches to the management of ecological resources (e.g. HELCOM, OSPAR and the EU’s Water Framework Directive). Existing regional and ecosystem-based approaches are of particular relevance due to MSFD requirements that activities (such as IEAs) should be
coordinated and fully integrated with action under other EU legislation and international agreements.\(^4\)

### 6.3 Indicator Objectives

Indicator development is being driven forward by the push for sustainable ecosystem use and management (Mee et al. 2008) and is widely used by the EEA and regional conventions such as HELCOM and OSPAR for their regular reporting on the assessment of the environment. Due to the range in area and scale that the MSFD covers, it is not feasible to create a single set of indicators relevant to all marine regions and sub-regions. EU Member States must therefore develop indicators and targets specific to their marine waters. These indicators will provide information about whether MS are meeting the criteria for attaining GES. In order to ensure that indicators provide the correct information, MS must be clear about how they aim to reach GES and that these aims are SMART (Specific, Measureable, Attainable, Realistic and Time Bound) (ICES 2005).

Nevertheless, as Bundy (2010) has noted, ecosystem-based objectives and reference points are difficult to set due to a lack of theory, limitations in the understanding of ecological complexity, uncertainties in data quality and model behaviour, and difficulties in balancing multiple and conflicting stakeholder interests (Cury et al. 2005). These difficulties may be overcome through the use of historical or theoretical patterns to define reference points for indicators (e.g. Jennings and Blanchard, 2004) (Bundy 2010). However, time-series data sufficient for establishing historical patterns may not always be easily available and there is a danger of focusing on only using indicators for which such patterns can be established. Jennings and Dulvy (2005) and Trenkel et al. (2007) argue that knowledge of the direction of trends in ecological indicators (specifically in size-based indicators) can be sufficient to support management decision-making meaning that action can be taken to reverse negative trends without the need for identifying absolute reference points (Jennings and Dulvy 2005), (Bundy 2010).

### Indicator properties

Indicators should enable the monitoring of key interactions within the ecosystem and should reveal information on both status and trends. In some cases, indicators of pressures, activities and state variables are required, but in others a pressure indicator may suffice (ICES 2010). It is also important to recognise that some indicators may overlap or be relevant for more than one criterion. A combination of quantitative and qualitative indicators can be used to provide a best possible understanding of the ecosystem.

Most indicators are assembled into sets of physical, biological or chemical indicators within a systems analysis, such as the DPSIR framework (see chapter 6.5.2). Whilst this may be necessary to summarise complexity for policy purposes, the indicators chosen should make it possible to measure a number of different aspects of the ecosystem and its dynamics. In a regulatory context, an indicator must relay information about the environment in a manner that will determine the necessity for corrective management action (Rees et al. 2008). Indeed, as Bundy (2010) summarises, a suite of indicators that captures a range of impacts on the various attributes of the ecosystem and their response is required. Management systems should be adaptive in order to incorporate new indicators into this suite as and when they are developed so as to ensure that the best possible information is available at all times.

Results from indicators can be synthesised or integrated through means such as traffic-light analysis, multivariate methods, or a decision-tree approach (see chapter 7.3.1). However, as Rochet et al. (2010) have noted, although current indicators and methods of integration such as traffic-light analysis may present a general idea of sustainability or ecological integrity, they do not always provide sufficient information on what is happening and why. Additional methods must therefore be developed for integrating signals (e.g. on directions and dynamics of change) from indicators (Rochet et al. 2010). Management systems that are able to adapt to integrate these smaller signals from within indicators would also be important within this context.

**Box 2: Properties of an ideal indicator (Rees et al. 2008)**

(i) capable of conveying information that is responsive and meaningful to decision-making (directly tied to management questions and linked to thresholds for appropriate action relative to designated ecosystem goals);
(ii) linked to a conceptual stressor–response framework (with the ability to communicate potential cause–effect relationships);
(iii) capable of measuring change or its absence with confidence (robust to influences of confounding environmental factors);
(iv) highly sensitive and anticipatory (early warning of potential problems);
(v) applicable over a variety of spatial scales and conditions (to support global as well as local comparisons);
(vi) desirable operationally (easy to measure, reproducible with minimum measurement error, cost-effective);
(vii) integrative (serves multiple indicator purposes);
(viii) non-destructive (measurement does not cause ecosystem damage);
(ix) easy to understand and communicate (non-specialists need to act on findings);
(x) scientifically and legally defensible (robust to peer review and wider challenge).

**Weighting of indicators**

Central to the construction of a composite index is the need to combine in a meaningful way different dimensions measured on different scales. For instance, anthropogenic pressures are not directly comparable to each other and therefore a weighting score is required. Weights usually have an important impact on the outcome of a composite indicator and on the resulting
ranking. This is why weighting models need to be made explicit and transparent. However, until now no agreed methodology exists to weight individual indicators (Mascherini 2007). Three approaches exist:

- Reward more influential components
- Pay attention to correlations
- Use expert opinions

All these approaches of weighting do in fact imply a subjective evaluation, which is particularly delicate in case of complex, interrelated and multidimensional phenomena. Within IEAs weighting scores are produced mainly by experts. To minimize errors, the weighting should be done by as many experts as possible and be supported through questionnaires and workshops. Ideally, a median of all the expert scores over components for each indicator obtains the weighting score of an index (see e.g. HELCOM 2010b).

### Selection of indicators

The viability of indicators can be tested based on criteria including quality of data in relation to cost, availability and reliability. For the Eastern Scotian Shelf IEA in Canada for example, 270 indicators were identified. These were then designated as a Level 1 (adequate and no significant cost), Level 2 (feasible but investment needed), Level 3 (no current data nor immediate intention to collect data). In order to prioritise monitoring and management, a risk analysis could be the basis for the selection of indicators. Any component highlighted as at risk should be considered in the selection of indicators.

Involving stakeholders in the development of indicators can also be beneficial. Rice and Rochet (2005) have developed an evaluation framework for selecting an appropriate suite of indicators to support an ecosystem approach to fisheries management. The evaluation framework is structured as a sequence of eight steps aimed at separating the numerous issues to be addressed in the selection process, and aims to enhance efficiency and transparency in indicator selection. Burger (2009) notes that the greater inclusion of stakeholders in indicator development and selection is advantageous for monitoring contentious situations, as well as assessments that are ongoing and require frequent evaluation and updating (such as fish consumption advisories and indicator species for contaminant analysis).

### 6.4 Cumulative Effects

A lot of research has been done to document the individual effects of various stressors on species and ecosystems. However natural systems are almost always simultaneously subjected to multiple human-derived stressors. The combined effect of multiple stressors is called...
cumulative effect. Research into these cumulative and interactive impacts of multiple stressors is not common.

The simplest assumption would be that the effect of multiple stressors is simply the **additive** accumulation of the single effects. However, numerous studies have documented that this is often not the case in natural systems where cumulative impacts mostly act synergistically or antagonistically.

**Synergy**, also called synergism in general, is defined as two or more stressors working together to produce a result greater than the sum of their individual effects. Environmental systems may react in a non-linear way to perturbations, so that the outcome may be greater than the sum of the individual component alterations.

**Antagonism**: is defined as two or more stressor having an opposite effect. Antagonism in the ecological context means, if two stressors working together mutually opposed to produce a result which is less than the sum of their individual effects.

The need to better understand the cumulative effects of multiple stressors was already highlighted a decade ago (Breitburg et al. 1999) and is still regarded as one of the most pressing questions in ecology and conservation, as it has implications for management and policies (Crain 2008).

In a comprehensive meta-analysis on cumulative effects of multiple human stressors in marine systems by Crain (2008) a significant overall synergistic interaction effect was found by multiple stressors in marine systems, indicating that multiple stressors result in an effect worse than expected from the single stressor impacts. It is nonetheless concluded that the understanding of mechanisms by which each stressor individually affects the system is necessary to interpret or predict when and where cumulative stressors interact, as the response is dependent on the mechanism. Stressors acting through similar mechanisms showed an additive effect, while those acting through alternative but dependent mechanism showed a synergistic response. Cumulative effects also depend on the response level, such as species, community or ecosystem level. Variation in cumulative effects suggests that context matters. In two-thirds of the studies analysed, differences in context changed the size of cumulative effects significantly, and then mostly in a negative way, resulting in more synergistic interactions.

Based on these results, ocean management should no longer focus on single stressor impacts but should include cumulative effects (Crain 2008). Understanding and increased knowledge of cumulative effects helps to inform management strategies and leads expectations for outcomes of various conservation and management efforts. The study of cumulative human impacts on the marine environment is developing rapidly (Ban 2010, Stelzenmüller 2010), especially through the need to apply ecosystem-based approaches to marine resource management, which was adopted by several major marine policies. Ecosystem-based management (EBM) acknowledges linkages between land and sea, and aims to develop management plans that take into account the cumulative effects of human activities on ecosystems. The Marine Strategy Framework Directive (MSFD) requires taking the main cumulative effects into account in the initial assessment, and analysing the predominant pressures and impacts on the marine regions (MSFD 2008/56/EC Art. 8).
6.5 Supporting approaches for IEAs

A number of approaches have already been developed that provide useful input to developing an IEA. Approaches that were found to be particularly useful are described below.

- 6.5.1 HELCOM approach

The HELCOM integrated assessments have followed closely the development of assessment methods in Europe and globally. The assessment tools have been made flexible to include methodological adjustments and obligations to develop new kinds of indicators and improve the confidence of the existing ones. The environmental status assessments have integrated indicators on the level of thematic groups (representing HELCOM ecological objectives or EU Water Framework Directive Quality Elements). Final classification is done by the “one-out-all-out”-principle (OOAO), where the lowest status classification of the thematic groups is the final status classification.

The current methods, which employ the best parts of the OOAO-principle, but with indicator weighting and thematic grouping of indicators, can be however improved to take account of ecological thinking, i.e. the pressure-impact relationships of indicators.

The weighting of indicators and especially weighting of the thematic groups is a transparent method which would improve the final classification. In addition, it can also be used to bring ecological and geographical thinking to the classification, by e.g. using different weightings in different sub-regions (HELCOM 2010b).

- 6.5.2 DPSIR (Driver-Pressure-State-Impact Response) approach

The framework was originally proposed in 1979 as the Pressure-State-Response model (Rapport and Friend 1979), and has since been modified and officially adopted for use by the European Environment Agency (EEA 2005), the environmental agency of Canada and the US National Oceanic and Atmospheric Administration (NOAA). The DPSIR model is now a broadly applied approach in environmental assessments. It is a causal framework for organising information about the state of the environment and describing interactions between the environmental system and the human system. According to the framework “anthropogenic uses that cause pressure on natural systems are a result of individual drivers constellations. These pressures can change the state of natural systems which again can impact human-environmental systems (Burkhardt and Daschkeit, 2006).” The natural system is much more complex. Decision makers, however, do need clear information on the individual components.
The framework therefore assists in classifying ecosystem indicators for all of the framework components in the context of the chain that links them, as visualized in figure 2. The components are described in detail below.

**Drivers** are factors that result in pressures on the ecosystem. For the purpose of an IEA both human and natural drivers have to be considered. Economic and social policies of governments, and economic and social goals of those involved in industry can be relevant human drivers (Borja et al 2006). Compared to natural drivers, human drivers can be assessed and controlled (Levin et al 2008). Natural drivers, such as environmental changes cannot be controlled but are important to be taken into account in management.

**Pressures** on the environment exerted by drivers can for instance be excessive use of environmental resources and emissions (of chemicals, waste, radiation, noise) to air, water and soil but also habitat loss and degradation.

**State** variables are indicators of the ecosystem condition (biotic, abiotic, chemical and physical). As a result of pressures, the state variables are affected, determining the quality of the ecosystem.

**Impact** variables are indicators of the effects due to changes in the state of environmental system. They are measured with respect to management objectives. Levin et al (2008) places special emphasis on a risk assessment that measures impacts. Within this assessment the risk is analysed and found to be exceeding or returning to below the targets.

**Responses** are the management actions that are taken in response to the impacts. They are triggered when target values are not met as indicated by the risk assessment.

Hence the DPSIR framework provides a basis for analysing the interrelated factors that can affect the environment, including social driving forces, their pressures on the environment, the resulting changes in the state of the environment, its impacts on ecosystems and health, and the role and effectiveness of laws and regulations (EEA, 2005). It can be applied to a wide range of topics, and encourages and supports decision-making by pointing to clear steps in the causal chain where the chain can be broken by policy action. In the marine setting it might be very helpful to determine existing interplays between certain sea uses and coastal uses, as well as between human activities and these ecosystems (Licht-Eggert, 2007).
• 6.5.3 Anthropogenic impacts approach

Humans depend on ocean ecosystems for important and valuable goods and services, but human have also altered the oceans through direct and indirect uses. Based on the ecosystem-based approach that promotes conservation and sustainable use in an equitable way these human influences, also called pressures are getting more and more attention rather than only indicators assessing the state of the ecosystems. Due to ecosystem-based management, assessments of marine ecosystems are increasingly needed to inform management decisions and regulate human pressures to meet the objectives of environmental policies. The ‘Good environmental status’ as defined in the MSFD also refers to a status of sustainable use of the marine environment. Member States shall therefore take into account the pressures or impacts of human activities in each marine region defining the ‘good status’ and developing the measurement programmes ensuring that the collective pressure of such activities is kept within levels compatible with the achievement of good environmental status.

• 6.5.4 Water Framework Directive approach

The Water Framework Directive (WFD) was adopted in 2000 by the EU and marked a change in environmental management of the seas. In contrast to pre-existing water management policy focusing almost exclusively on pollution, the WFD seeks to protect the ecosystem as a whole. The WFD requires Member States to carry out measures at the river basin level, rather than at national or regional levels, and necessitates greater interregional cooperation. It outlines a planning and management philosophy that is centred on the idea that water bodies should move towards ‘good’ or ‘high’ status and that Member States should not undertake actions that lead to a deterioration in water quality. Water status is assessed for coastal waters (as other water bodies require only chemical status to be assessed)\(^5\), and is carried out by combining the ecological and the chemical status of the water body in question. This methodology also highlights the acknowledgement by the WFD that a range of elements (biological, physico-chemical and hydro-morphological) contribute to the overall health and function of coastal waters and must therefore be integrated in any comprehensive assessment of water status.

---

\(^5\) For the remaining territorial waters (referring to all marine waters on the seaward side from the one nautical mile-line up to the territorial border), only ‘good chemical status’ is required.
Figure 3: Assessment scheme for the water status including the assessment of the ecological quality ratio
Chave (2001) (Adapted from the Landesamt für Umwelt, Naturschutz und Geologie Mecklenburg-Vorpommern (2009))
The results of the ecological and chemical status assessment must be expressed in ‘ecological quality ratios’ (EQR), which show the deviation of the current status from the water body’s undisturbed or ‘reference’ condition. The ratio results in a value between one and zero, relating to ‘high status’ (no deviation from the reference condition) and ‘bad status’ (high level of deviation). The poorest EQR is then used to determine the overall water status. \(^6\) Water status is classified as one of five categories: ‘high’, ‘good’, ‘moderate’, ‘poor’ or ‘bad’ (see figure 3). The lowest status is used to determine overall water status (see figure 4) and is known as the ‘one-out-all-out principle’. \(^7\) This approach is in line with the precautionary principle as laid out in the preamble of the WFD. However, it has attracted some criticism as it may lead to an overly negative picture of an otherwise healthy water body.

\(^6\) See Annex V, 1.4.2 (i)
\(^7\) EC (2003) CIS-guidance document Nr.13, Overall Approach to the Classification of Ecological Status and Ecological Potential
6.6 Marine Strategy Framework Directive

The Marine Strategy Framework Directive (MSFD) was adopted in 2008 and is the latest piece of EU regulation on the marine environment. The MSFD applies to all marine waters, with the coastal waters also regulated by the Water Framework Directive (WFD).

The overall objective of the Marine Strategy Framework Directive (MSFD) is to create a coherent EU Marine Strategy to “protect and restore Europe’s oceans and seas and ensure that human activities are carried out in a sustainable manner so that current and future generations enjoy and benefit from biologically diverse and dynamic oceans and seas that are safe, clean, healthy and productive”\(^8\).

The MSFD establishes a framework in which the Member States are required to take the necessary measures to achieve ‘good environmental status’ for the marine environment by 2020 at the latest.\(^9\)

To this end, the Member States are obligated to develop national marine strategies that:

Protect and preserve the marine environment, prevent deterioration or where possible restore areas that have been negatively affected

Prevent and reduce inputs in the marine environment with the aim to reduce pollution as to ensure that there are no significant impacts on or risks to the marine biodiversity, ecosystems, human health or uses of the sea.\(^10\)

---

\(^8\) Ibid., Art.4
An increase in coordination and coherence between different national and international regulations and policies which have an impact on the marine environment are further key objectives of the MSFD. Coherence is especially desired between countries that share a marine region, the Baltic Sea being one of these eco-regions.

For the implementation of the MSFD by the Member States, an ambitious plan of action was set up. The development of a national marine strategy has to follow this plan. The required deadlines are presented in table 1.

After transposition into national law, all Member States are currently developing the initial assessment of the environmental status and determining what ‘good environmental status’ should be.

Below, the requirements for assessment according to the MSFD and for the development of methods to determine ‘good environmental status’ are presented.

**Initial Assessment**

The initial assessment in accordance with the MSFD is required by 2012. Regarding the methodologies used for these assessments, the Member States should take every effort to ensure that the methodologies are consistent across the marine region and that transborder effects are taken into account.\(^{11}\)

For the initial assessment the Member States have to make an assessment of their marine waters containing the following:

- analysis of the essential characteristics and current environmental status of those waters (physical, chemical and biological features)
- analysis of the predominant pressures and impacts, including human activity, on the environmental status of those waters, covering the main cumulative effects
- economic and social analysis of the use of those waters and of the cost of degradation of the marine environment

Indicative lists of elements for this assessment of characteristics, pressures and impacts are set out in Annex III of the directive. With regard to the classification of ‘environmental status’, the status can either be classified as being ‘good environmental status’ or not. No further classification in status exists.

**Good environmental status**

On the basis of the initial assessment, Member States shall establish a comprehensive set of a set of characteristics for ‘good environmental status’ in respect to each Marine Region or Sub-Region.

In general, ‘environmental status’ refers to “the overall state of the environment in marine waters, taking into account the structure, function and processes of the constituent marine

\(^{11}\) Ibid., Art. 8, par. 3
ecosystems together with natural physiographic, geographic, biological, geological and climatic factors, as well as physical, acoustic and chemical conditions, including those resulting from human activities inside or outside the area concerned."

Accordingly, ‘good environmental status’ is an ‘environmental status’ of marine waters that provides ecologically diverse and dynamic oceans and seas. The marine waters should be clean, healthy and productive. Hydro-morphological, physical and chemical conditions support a fully-functioning ecosystem. In regard to the marine biodiversity, species and habitats are protected, human-induced decline is prevented and the use of marine resources is at a sustainable level, thereby safeguarding the potential future uses and activities by current and future generations. Impacts of human activities, such as pollution or noise, do not significantly adversely affect the ecosystem. In general, the natural resilience of the ecosystem against human-induced changes is enhanced. A detailed definition of good environmental status will be made at the level of the marine region, and will be based on the eleven qualitative descriptors defined in the directive (see box 3).


1. **Biological diversity** is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions.
2. **Non-indigenous species** introduced by human activities are at levels that do not adversely alter the ecosystems.
3. Populations of all commercially exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock.
4. All elements of the marine food webs, to the extent that they are known, occur at normal abundance and diversity and levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity.
5. Human-induced eutrophication is minimized, and especially the adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algae blooms and oxygen deficiency in bottom waters.
6. **Sea-floor integrity** is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected.
7. Permanent alteration of hydrographical conditions does not adversely affect marine ecosystems.
8. Concentrations of contaminants are at levels not giving rise to pollution effects.
9. **Contaminants in fish and other seafood for human consumption** do not exceed levels established by Community legislation or other relevant standards.
10. Properties and quantities of **marine litter** do not cause harm to the coastal and marine environment.
11. **Introduction of energy, including underwater noise** is at levels that do not adversely affect the marine environment.

---

13 Ibid., Art. 3, par. 5
The determination of ‘good environmental status’ is needed in connection with the desired coherence. The aim is to be consistent across marine regions. On 1 September 2010, the European Commission published the ‘Commission decision on criteria and methodological standards on good environmental status of marine waters’ \(^{14}\). The Commission Decision acknowledged that the determination of the criteria for achieving good environmental status is the starting point for the development of coherent approaches to national marine strategies. The criteria and associated indicators (see Annex III) required to make the criteria operational (as defined in the decision) are based on scientific and technical advice provided by independent experts and have to be used by Member States to determine the environmental status of the marine ecosystem. They build on existing obligations and developments in EU legislation, covering elements of the marine environment not yet addressed in existing policies. While some criteria are fully developed and operational, others require further refinement. For example, for the descriptors relating to noise and litter, it was problematic to establish criteria based on the current state of knowledge. A major finding therefore is that there is a substantial need to develop additional scientific understanding for assessing good environmental status in a coherent and holistic manner in order to support the ecosystem-based approach of the MSFD.

A ‘good environmental status’ is required for all marine waters, except for the coastal waters as defined in the WFD. In these waters the WFD has precedence over the MSFD.

It is generally stated that the objectives of the MSFD were based on the WFD. However, the MSFD adopted a different status objective – the ‘environmental status’ – than that used in the WFD, which uses the ‘ecological status’. The key difference between the two status objectives is the integration of human activities into the definition of the ‘environmental status’, in accordance with the MSFD. The ‘ecological status’ is based on different quality elements, while the ‘environmental status’ is based on several descriptors which include human activities. Some of the descriptors are consistent with the WFD quality elements. Nevertheless, some descriptors are included in the MSFD that are not consistent with any WFD quality element, such as maritime activities. Consequently, the use of marine resources and, moreover, noise as a result of human activities, is included in the definition of the ‘environmental status’.

6.7 Water Framework Directive

The EU Water Framework Directive (WFD) has over a decade worth of planning and implementation experience. This knowledge, as well as the WFDs scale, ambition and geographical scope make the Directive relevant for further examination in the context of the MSFD. This chapter lays out the overall approach of the WFD, its assessment process and the strengths and weaknesses of the WFD approach to assessment.

\(^{14}\) Decision 2010/477/EU
As mentioned in chapter 6.5.4, the adoption of the WFD in 2000 marked a departure from previous water policy and signaled one of the most ambitious environmental policies of the EU thus far. The WFDs purpose is to establish a framework for the protection of inland surface waters, transitional waters, coastal waters and groundwater, protecting and enhancing their status and preventing their further deterioration. Within this, the WFDs key objective is to protect, enhance or restore all water bodies in order to achieve a good status by 2015.

**Assessing ecological and chemical status**

The WFD applies to all surface and ground waters. Most water bodies require an assessment of ecological and chemical status including coastal waters.\(^\text{15}\) Ecological status is defined as the quality of the structure and functioning of aquatic ecosystems.\(^\text{16}\) It is defined in terms of biological quality elements. Hydro-morphological and physico-chemical elements supporting the biological elements contribute to the ecological status. For each of the water categories covered by the WFD, (river, lake, transitional water, coastal water), different quality elements apply. Table 2 presents the elements for coastal waters divided in terms of biological, hydro-morphological and chemico-physical parameters. For each water type/area, reference conditions must be identified for each quality element. As described in chapter 6.5.4, the results of the ecological assessment must be expressed in ‘ecological quality ratios’ (EQR) which show the deviation of the current status from the water body’s undisturbed or ‘reference’ condition. Based on the deviation from the reference conditions, one of five classifications is assigned: ‘high’, ‘good’, ‘moderate’, ‘poor’ or ‘bad’.\(^\text{17}\)

“**High**” status refers to a situation where the biological elements represent an undisturbed situation in abundance and composition and no or only very minor changes are present in the physico-chemical and hydromorphological conditions.

‘**Good ecological status**’ is defined as the situation where there are only slight changes in the composition and abundance of flora and fauna communities compared to the type-specific communities under undisturbed conditions.

“**Moderate**” status would be waters which deviate moderately from the conditions under undisturbed conditions.

“**Poor**” waters have major alterations but still species from an undisturbed state are still present.

“**Bad**” waters have large deviations and large proportions of the type-specific communities are missing.

\(^{15}\) For the remaining territorial waters (referring to all marine waters on the seaward side from the one nautical mile-line up to the territorial border of 12 nautical miles), only ‘good chemical status’ is required.

\(^{16}\) Water Framework Directive 2000/60/EC, Art. 2

\(^{12}\) 2000:0001–0073.

\(^{17}\) Ibid., Annex V 1.2.4
‘The process of defining ‘good ecological status’ does not take account of socio-economic factors. These are covered by the exemptions to the general objectives.’

**Table 2 Quality elements for coastal waters**

<table>
<thead>
<tr>
<th>Biological</th>
<th>Hydro-Morphological</th>
<th>Chemico-physical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phytoplankton (flora)</td>
<td>Depth variation</td>
<td>Transparency</td>
</tr>
<tr>
<td>Other aquatic flora</td>
<td>Coastal bed conditions</td>
<td>Thermal conditions</td>
</tr>
<tr>
<td>Benthic invertebrates (fauna)</td>
<td>Inter-tidal zone</td>
<td>Oxygen level</td>
</tr>
<tr>
<td></td>
<td>Current direction</td>
<td>Salinity</td>
</tr>
<tr>
<td></td>
<td>Wave exposure</td>
<td>Nutrients</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pollutants in discharges</td>
</tr>
</tbody>
</table>

The chemical status is defined in terms of the presence of polluting substances. One of the aims of the WFD is “to achieve the elimination of priority hazardous substances and contribute to achieving concentrations in the marine environment near background values for naturally occurring substances.” In 2008 the Directive on Priority Substances was adopted, in which the polluting substances were defined with a list of 33 priority substances and 8 other pollutants. The limits of concentrations of these substances in surface waters were also settled in that directive. For the ‘chemical status’ no five-step categorization exists. If the pollutants exceed the agreed limit values, the ‘chemical status’ is not good. ‘Good chemical status’ is defined as a situation where the pollutants do not exceed the agreed limit values and quality values established within the Directive on Priority Substances and other relevant Community legislation.

**Assessment of water status**

---

19 Water Framework Directive 2000/60/EC, ANNEX V
20 WFD 27, p3
22 Water Framework Directive 2000/60/EC, Art. 2. par 24 and Annex IX;and Annex IV
For the purpose of determining the water status, the WFD requires an assessment of both ecological and chemical status. Like the ‘ecological status’ the ‘water status’ can be assigned to one of five classifications, ‘high’, ‘good’, ‘moderate’, ‘poor’ and ‘bad’. The classification is again determined by the level of deviation from the water’s reference conditions.\(^\text{23}\)

These changes or deviations from undisturbed condition can result from any direct impact on the biological quality elements, but also indirectly through changes in the hydromorphological and chemical quality elements. For this reason, these elements are forbidden from reaching levels that compromise the functioning of the ecosystem and the achievement of values below set reference values. In other words, the underlying ecological assumption is that the hydromorphological and physico-chemical status cannot be worse than the biological status, which integrates all impacting pressures on the ecosystem. Figure 5 provides an overview of the assessment of the ecological status of water bodies.

**Figure 5**: Overview of the relative roles of biological, hydromorphological and physico-chemical quality elements in ecological status classification according to the normative definitions in WFD Annex: 1.2. EC (2005)

The WFD itself does not provide guidance how the classification of the ecological status should be made. The Common Implementation Strategy process of the WFD (CIS 2003) provides for

\(^{23}\) Annex V 1.2.4 Definitions for high, good and moderate status in coastal waters
status classification through the so-called one-out-all-out principle (OOAO).\textsuperscript{24} The principle means that the final classification is first determined by the lowest status on the quality element level and finally by the poorer status of the biological or chemical quality element in each water body. In other words, ‘good water status’ is only assigned if both ‘ecological and chemical status’ show at least ‘good’ status. This approach follows the precautionary principle of the European Treaty (Article 174). In some more stringent variances of the OOAO, it has been interpreted that the principle expects 100% compliance of all variables falling into a status class (Korpinen 2011).

Moss et al. (2003) tested misclassifications of the WFD assessments. This shows that the expectations of the 100% compliance or 50% compliance at the variable level were unreliable, but that 75% compliance was seen as the most reliable classification. The 66% compliance approach was used in the classification of Estonian rivers and a 80% compliance was tested in Finnish lakes (Korpinen 2011).

**Strength and weakness of the OOAO**

The strength of the OOAO is its early warning function. In an interlinked ecosystem, degradation of one component leads to cascading consequences in other components. In this way, smaller changes act as alarm bells for further weaknesses within the ecosystem and its management.

There are also three main shortcomings that can be identified:

1. Each quality element is assessed independently of others. Therefore, a high level of statistical confidence is needed for each quality element before the final classification can be reliable. In practice, high levels of statistical confidence may be difficult to achieve for many individual measures of biological quality. Different biological quality elements are not independent and the interdependency should be acknowledged in the final classification (Moss et al. 2003, Sondergaard et al. 2005). When using several indicators the correlation of indicators is problematic.

2. The OOAO presents only a narrow overview of the ecological quality. The general condition of the ecosystem is not taken into account. For example, the benthic zone may present conditions that are very different to surface water elements (Korpinen 2011).

3. The OOAO aims to minimise the statistical type II errors (i.e reducing the likelihood that a water body is classified as good status when in reality it is below). At the same time it tends to increase the statistical type I error, i.e. claiming that a water body is in bad status when it is in good status (Hering et al. 2010). This could lead to unnecessary management measures being taken. Practical methods to avoid the Type I error in the OOAO could the adjustment of confidence levels (Carstensen 2007). Or to improve monitoring and select only best indicators for the assessment (Hering et al. 2010).

\textsuperscript{24} European Communities. (2003) CIS-guidance document Nr.13 ‘Overall Approach to the Classification of Ecological Status and Ecological Potential’
Overall, the WFD has made an important contribution to environmental management in the EU. Hering et al. (2010) maintain that one of the key benefits of the WFD has been the process itself which has improved overall understanding of applied aquatic ecology and cooperation in Europe. It provides an initial suggestion for an assessment method which is able to take multiple and complex factors into account. With hindsight, there are certainly weak points to the approach. Ten years ago, it may have appeared unproblematic to separate an ecosystem into its constituent (or most important) parts (BQEs), to assess their individual quality and put these back together using a combining rule, assuming that the subsequent outcome would summarise and protect the whole ecosystem. It is now clear that there are dynamics at work within an ecosystem that are lost through such reductionism. Nevertheless, the WFD is very explicit about the elements to be assessed and MS were therefore restricted in the assessment methods available. In this way, the use of the OOAO approach at least allows a precautionary approach to be taken. Thus protecting the ecosystem, even if its full complexity is not described or understood. Additionally, the process of developing implementation procedures for carrying out assessments was a resource- and time-consuming process. There is therefore much to be said for examining the WFD approach in the context of transferability to the MSFD. On the other hand, the MSFD takes a deeper, more fully integrated approach to ecosystem assessment than the WFD. Therefore, whilst there is something to be learned from previous approaches, this must be done with caution and with the knowledge that the WFD approach to ecosystem assessment does not provide the holism necessary for the MSFD (see chapter 9).

7 Analysis

7.1 Assessment of Scientific Literature

Scientific literature was analysed for the background of this study (chapter 6) and was directly fed into the compilation of case studies and factsheets (chapter 8).

7.2 Approaches of Working Groups

- 7.2.1 WGECO, ICES (2010)

Background

The Working Group on Ecosystem Effects of Fishing Activities (WGECO) is an expert group under the auspices of the International Council for the Exploration of the Sea (ICES).

Supported by its 20 member countries, ICES coordinates and promotes marine research in the North Atlantic. The research results are then used to fill knowledge gaps and to develop unbiased, non-political advice.
ICES’s WGECO group consists of roughly 70 international experts who prepare scientific analysis relating to the ecosystem effects of fishing activities for the Advisory Committee (ACOM). As ICES’s advisory body, ACOM is responsible for providing scientific advice to governments and international regulatory bodies that manage coastal and ocean resources and ecosystems in the North Atlantic Ocean and adjacent seas. The analysis developed by the expert group needs to go through a peer review process before the ACOM uses it as a basis for their advice.

Once a year the members of WGECO meet for a week in Copenhagen to discuss a range of issues relating to their focus area of ecosystem effects of fishing activities. The large variety of issues that are discussed in the group, referred to as Terms of Reference (ToR), vary from year to year and are decided upon a year in advance at the previous WGECO meeting, in response to various requests. Each meeting's results are then compiled in a report that is published on the ICES’s website. Looking at the reports from the past three years’ meetings, it seems that they cover a broad range of different topics and that their focus area is concentrated on, but not limited to, fishing activities. Discussions include other impacts such as wave and tidal energy generation devices, as discussed in 2010, or climate change, as discussed in 2008.

**Guidance on carrying out IEAs**

In 2010, a major task for WGECO was ‘helping to build a sound scientific basis for the implementation of the Marine Strategy Framework Directive (MSFD)’. The WGECO report provides practical guidance on conducting sound IEAs in conformance with the MSFD, including detailed guidance on how to choose indicators, establish reference levels and carry out the analysis of the interaction between indicators and between pressures and states required to establish Good Environmental Status (GES). It provides guidance on carrying out assessments that are appropriate to the ecosystems in the regions where they are done as well as ecologically consistent across regions, even though different indicators and/or reference levels are used. Further, it establishes tangential points in the MSFD with existing directives relating to environmental standards in order to make the implementation of the MSFD as efficient as possible with regard to the demands for assessment and monitoring.

It establishes six necessary steps for a framework for assessing ‘good environmental status’ (GES), and provides detailed guidance as to how each might be carried out:

- Evaluate the list of ecosystem components for each regional ecosystem
  
  In particular with regard to its ‘structure, function and processes’, taking into account ‘natural physiographic, geographic, biological, geological and climatic factors’ – this in order to identify the parts of the ecosystem that are most crucial to its ecological integrity, structure and function. In doing so, indicators that represent key components should also be considered.

- Evaluate the list of pressures and drivers
Evaluate the major human activities that are likely to result in pressures in each regional ecosystem (including physical, acoustic, chemical and biological pressures). This allows the identification of the pressure(s) likely to cause the greatest perturbations in the system, and the scales on which they operate. The WGECO includes pressures due to climate change here, as the overwhelming consensus is that climate change is anthropogenic.

- Identify the key interactions between ecosystem components and pressures

Use a scientifically peer-reviewed framework of the interactions between ecosystem components and pressures that reflects which types of ecosystem components are likely to be most impacted, or otherwise most sensitive to the pressures identified in (ii) and the pressures most likely to detrimentally impact the ecosystem components identified in (i).

- Select indicators for those key interactions identified in (iii)

These indicators should be robust and sensitive, paying particular attention to the interactions from (i) and the more severe pressures from (i).

- Set reference levels for these indicators

Select reference levels that reflect for that ecosystem:

- For state indicators: the value of the indicator at a time when pressures were considered sustainable.
- For pressure indicators: the value of the indicator from a time when the ecosystem components most sensitive to the pressure were considered to be in an unimpaired state.
- If there are insufficient data for the above two options, the value of either type of indicator when scientific analyses of historical data shows that there was a low likelihood that the structure, function or process represented by the indicator was impaired.
- If there are insufficient data for the above three options, the value of either type of indicator at which theoretical or generic modeling results suggest that there is a low likelihood that the structure, function or process represented by the indicator would be impaired.

- Combine information across indicators at various levels of integration for an overall assessment of 'good environmental status'

There are three levels of integration required to move from evaluation of the individual indicators to an assessment of GES, these include the assessment of:

a) Indicators within individual attributes of a descriptor (for complex descriptors),

b) Status across all the attributes within a descriptor, and

c) Status across all descriptors.
Practical methodology for each of these stages has not yet been developed, which poses a major challenge to the effective implementation of the Directive by the Commission and Member States.

Consistency between various ecosystems’ IEAs

Besides integrated ecosystem assessments and the selection of indicators, the WGECO report also discusses the integration of information across indicators in assessing GES. Due to the differences between the various European marine regions, WGECO cannot provide guidance relative to a specific indicator suite and assessment method appropriate for all the various marine regions. Rather, it develops a common framework for developing methods and indicator suites that allows for the development of IEAs in a consistent manner through functional equivalence of the indicators and reference levels between the various regional ecosystems. The report states that in order to ensure consistency of the assessment across regions, it is essential that scientifically sound guidance be provided in the process of defining threshold values (see Section 6.3). Moreover, the report cites Article 10 of the MSFD in stating that Member States are also to ensure that monitoring methods are consistent across the marine region in order to allow results to be compared and for the relevant transboundary impacts and features to be taken into account.

Integrated Ecosystem Management Plans

The report conducts a detailed quantitative evaluation of two large-scale integrated ecosystem management plans (IEMPs) in order to assess to what extent these plans actually reflect the scientific foundation that is laid in the initial stages of their development (Section 7). This is because concern has been raised that during subsequent stages of extended stakeholder engagement and other social processes, the links with the scientific foundation might be weakened or distorted. WGECO therefore looks at two IEMPs: the Norwegian national Barents Sea Ecosystem-Based Management Plan and the HELCOM Baltic Sea Action Plan. The plans show significant differences in many respects, which is not surprising given that they were developed in very different political, social and cultural contexts. It is therefore difficult to prescribe a single ‘right’ level of science input to an IEMP, or even a single ‘right’ degree of linkage between the plans and the science behind their development.

However, the authors’ review ‘revealed other pathways to explore and provide constructive guidance for the relationship between science and the development of the IEMPs’ based on some of the positive conclusions that came from their examination of IEMPs. These positive conclusions included the finding that, regardless of the way in which social processes interacted with the science, they certainly contributed to greater stakeholder buy-in to the final products, providing a more solid basis for any future efforts at improving management strategies.

The management plans have also resulted in greater cooperation among various government departments and levels of government, which has positive implications for likelihood of success.
with more integrated management strategies in future. To build upon this analysis, several follow-up questions were suggested for review at upcoming WGECO meetings.

**OSPAR QSR assessment**

Finally, the WGECO assesses the marine assessment and monitoring framework used in chapter 10 of the OSPAR Quality Status Report, an integrated assessment of the North-East Atlantic, and examines the ways in which this framework can be improved, in particular with regard to the thresholds between different assessment classes, extending the methodology to support the assessment of plankton communities and improving the methodology for working at different scales (in this case from the OSPAR region to sub regions like the Irish Sea, to an estuary or MPA) (see Section 8).

---

**Box 4: Guidance on how to choose suites indicators from the candidate set (WGECO 2010)**

The MSFD descriptor Task Groups (see 7.2.4), requested to suggest indicator for each descriptor, proposed many possible indicators for some of the descriptors. WGECO developed a guidance on how choices can be made about which classes of indicators and specific indicators within the classes should be chosen or use in evaluating GES. For the assessment of indicators it is suggested to follow a three-step process. Since the MSFD aims at the sustainable use of the marine environment while safeguarding its processes, functions and structure, this process is based on the recommendation of WGECO to check the attributes of ecosystem structure, function and process against the candidate set of indicators by the Task groups.

1) Take the candidate set of indicators produced by the Task groups as a baseline for the development of indicators.

2) Produce a commonly accepted list of ecosystem properties from key studies on ecosystem structures, processes and functions.

3) Match the available list of candidate indicators with the ecosystem properties. Expert judgment can be used to undertake this assessment. All indicators of the candidate set of indicators are evaluated on their relevance informing the ecosystem property.

The result of the assessment is the identification of ecosystem properties that are captured best by the candidate list of indicators and the indicators that inform most ecosystem properties. WGECO recommends that only indicators that are inform at least one ecosystem property should be taken forward by the Member States in choosing a set of indicators relevant for their marine region.
• **7.2.2 Assessment of Assessments (UNEP)**

The Assessment of Assessments (UNEP and IOC-UNESCO 2009) summarises the findings of a common expert group of the United Nations Environment Programme of the UN and of the Intergovernmental Oceanographic Commission of the UNESCO.

The data resulting from the assessment of marine assessments is available on the Global and Regional Assessments of the Marine Environment Database (GRAMED).²⁵

Assessing the assessment is very challenging: firstly because the assessment methodologies vary considerably depending on the geographical location of the study, and secondly because only very few methodologies are fully documented.

**Data**

In general, it seems that the assessment of biological marine resources is by far the most developed. This is then followed by methods to assess the water quality. While almost all regions have at least developed some method to assess fisheries, full scale assessments are still rare. Similarly, the assessment of non-fished species is rather unusual. Finally, an assessment of lower trophic levels can usually only be found for sea regions bordering the most developed countries.

The description of habitats is much less developed on average. Moreover, there is only very limited data on the socio-economic conditions. Even in regions for which such data is available in sufficient quantity, these are only integrated in a simplified manner.

Additionally, current assessments focus mostly on territorial waters or at most waters in the zone of exclusive economic activity, but go only seldom extend beyond these bounds.

The integration of environmental pressures across diverse economic sectors is fairly usual. However, a further integration of the assessment, such as on the basis of ecosystem services, is very rare. Furthermore, the expert group concluded that, to date, methods for integrated assessment are not sufficiently available.

**Recommendations**

The expert group assessed both ‘products’, i.e. the actual assessment reports, and ‘processes’, i.e. the institutional framework within which the assessment took place.

The group identified three characteristics as being decisive for the assessment, noting that these can also be conflicting and thus result in trade-offs:

---

²⁵ See http://www.unep-wcmc.org/GRAMED/
Relevance. The methodology and the results should be as close as possible to the political process. This also includes the link to stakeholder processes and consultation.

Legitimacy. All relevant stakeholders should perceive the result as being justified. This calls for a fair and transparent methodology.

Credibility. The assessment should use data of high quality and implement a scientifically backed methodology, using peer reviews and consultation of experts.

Overall, there seems to be insufficient understanding of the fact that the design of the assessment process has a fundamental impact both on the result and on the acceptance and the uptake of the results.

Furthermore, the expert group recommends that assessment data be openly accessible in order to make them available for other assessments.

Also, in order to increase the comparability of results, indicators and reference points should be applied systematically and consistently.

In addition, the assessment should follow an integrated approach such that it reports on the status of the entire system and not just on individual sectors.

Best practice experiences from the assessment of assessments show that the best assessments are in line with the following principles:

- The view that the oceans are part of the system that is Earth.
- Both the assessments as well as the assessment process are regularly updated.
- They employ scientific methods and foster scientific excellence.
- They support capacity-building for integrated assessments.
- They are transparent and comprehensible.

In particular, the methodology should follow these rules:

Objectives and scope: clear objectives and definitions.

Science-policy relationship: recurrent dialogue, guidance for priorities as well as clear rules for the role of decision makers in the process.

Stakeholder participation: clear and transparent rules on stakeholder involvement.

Selection and appointment of experts: transparent criteria and processes for the selection of study authors, authors, peer reviewers as well as other experts; balanced composition in order to avoid bias; avoiding conflicts of interest.

Data basis: rules and guidance on the selection and quality of the permissible data; quality assurance, access to meta data, reporting obligations, guidelines on the treatment of data gaps, rules for up- and down-scaling of data, rules for finding conclusions.
Treatment of conflicts between experts: clear and transparent rules for handling dissent between the selected experts.

Handling of uncertainties: clear and transparent rules for the treatment of uncertainties.

Peer reviewing: coordinated and transparent criteria and processes for the use of peer reviewers, selection of external peer-reviewers.

Effective communication: development of a strategy for communication and information, including associated products.

Capacity and network building: as a contribution to long-term improvement of assessment processes.

Evaluation of the assessment: ex-post evaluation of the assessment products and process.

Institutional framework: clear rules on responsibilities and competencies.

Finally, the expert group recommended finalising the entire methodology prior to commencing the assessment, and documenting all aspects of the process thoroughly.

- 7.2.3 EMMA

The European Marine Monitoring and Assessment (EMMA) Working Group was set up by the EEA in 2003. During the time in which the MSFD was under development, EMMA began a process of advancing a common pan-European set of marine indicators. This was in light of the pan-European assessment of the marine environment due in 2017-19 under the first review of the MSFD. However, it was also intended to assist individual Member States with the MSFD implementation process as well as to increase coherence and efficiency in the assessments to be carried out between 2010 and 2012.
Establishing this set of pan-European indicators began with a scoping process in 2006-2007 to identify what was already in existence. This brought together indicators and data sets from regional sea conventions such as OSPAR, and from the EEA, which identified that it had 14 marine indicators\(^{26}\) in use or under development. Those already in existence were then examined in a process of 'indicator convergence'. This process analysed whether there were sufficient indicators and data sets available to measure the MSFD Annex III determinants as required by the 'initial assessment' under the Directive. This process allowed the identification of commonalities between as well as gaps where the requirements were not covered by existing indicators. It was found that of the 44 determinants in Annex III, 23 were 'common' indicators in existence and 21 for which there were not enough indicators.

In the next stage, the 'common' indicators identified underwent an 'indicator comparison'. This involved an examination of certain aspects (e.g. purpose, sampling frequency, etc.) to establish to what extent these indicators were truly equivalent or could be harmonised at the pan-European level. This process of 'indicator comparison' began by a prioritisation of 8

\(^{26}\) Focussing on: (a) Eutrophication, (b) Hazardous substance and oil pollution, (c) Fisheries and aquaculture, (d) Climate change impacts, (e) Biodiversity, and (f) Bathing water quality.
determinants from the MSFD for which indicators would be examined. These 8 determinants were then reduced to 4 determinants for which finding indicators was of high priority. These were: Nutrient concentrations Chlorophyll-a, Fish abundance and Hazardous substances in biota.

Box 5: Criteria for the development of a pan-European indicator specifications

(EEA, 2009) (from Rice and Rochet (2005))

Data collection should:

- Be based on series of stations having:
  - Long time series of data
  - High contrast between ‘impacted’ (high concentrations of hazardous substances, chlorophyll-a, nutrients, etc) and ‘reference’ (background concentrations of hazardous substances, chlorophyll-a, nutrients, etc)
  - A broad geographical range and being representative of regions, water bodies and types
  - Be carried out regularly (e.g. annually)
  - Use methods that facilitate direct comparison or comparison following a certain degree of compilation/analysis (including quality assurance and processing), such that results can be either compared at the pan-European level, or provide regional or sub-regional summaries that contribute to reflect the current pan-European situation

Data analysis should:

- Use well defined, clear methods such that results are comparable at the pan-European level
- Be based on data with known quality assurance and were archiving is known to be good

The indicator should be:

- Updated regularly (at an appropriate time period to show system changes)
- Be able to assess environmental state, temporal trends and spatial distribution of a given marine issue across Europe and, where possible, identify and quantify relationships between cause and effect
- Answer questions at the pan-European level, in particular of policy effectiveness of relevant EU legislation such as implementation of the MSFD, the WFD (for ‘coastal’ waters), etc.
- Where possible include assessment criteria and/or target levels. These could be based on ‘distance to’ the MSFD ‘Good Environmental Status’ or other relevant legislation
- Present the information in a clear precise manner (including assessment criteria) at a level appropriate for policy and management decision-making
- Be cost effective
- Be accepted by regional sea Conventions, Members States and other stakeholders

A framework developed by Rice and Rochet (2005) for selecting fisheries management indicators (see box 5) was used to inform the EMMA process of developing criteria for pan-

---

27 Temperature, Chlorophyll-a, Fish abundance, Nutrient concentrations, Hazardous substances in biota, Oil slicks, Inputs of nutrients (riverine and direct discharges), and Atmospheric deposition of non-toxic contaminants.
European indicator specifications. The tables used for indicator comparison can be seen in table 3, and are grouped in themes as follows:

- **Data supporting the indicator** - Dealing with issues such as: What is the purpose and coverage of the monitoring programme?
- **Analysis of the data supporting the indicator** - Dealing with issues such as: How are data analysed in order to develop the indicator?
- **Assessment provided by the indicator** - Dealing with issues such as: What type of assessment is derived from the data (e.g. trend and targets)?
- **Presentation** - Dealing with issues such as: How is the data/information shown (e.g. map, graph)?

**Table 3: Overview of EMMA indicators**

<table>
<thead>
<tr>
<th>Determinand</th>
<th>Hazardous substances in biota</th>
<th>Chlorophyll-a</th>
<th>Nutrients in seawater</th>
<th>Selective extraction of commercial fish</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Data supporting the indicator</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Be based on monitoring programmes that measure the state, temporal trend and spatial distribution</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Require use of accredited international methods, preferably, QUASIMEME as QA scheme for monitoring and sampling analysis</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Make sampling and analysis methodologies available via web link</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Require annual data submission</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Require a common time period for the submission of data</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Require use of the latest data submitted (i.e. most recent data should not be older than year N-1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Minimising the time lag between collection and submission</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Require annual frequency of sampling</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Data analysis</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Require having and making available the methodologies used to develop and update the indicator via web link</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Require annual indicator update</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>NOTE:</em> As regards the context of legal drivers WFD and MSFD, the frequency of updating should be considered from a principal and a practical (WISE) point of view in the relevant fora</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Establish a common deadline for annual updating</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Include a web link to indicator specification or fact sheet</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Assessment provided by the indicator</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Include reference to main relevant instruments of the EU acquis</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Include reference to main relevant elements of the regional policy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Require assessment of state, temporal trend and spatial distribution</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Include a short environmental assessment or at least ‘Key messages’ within annual indicator updates</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Require that each contaminant is treated separately by the indicators</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Presentation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Require, as a minimum, maps with temporal trends</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Require presentation of target levels or assessment criteria relating to policy targets, existing ones may be acceptable until a specific one relating MSFD distance to GES are available at a regional level</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consider presenting levels and trends on a specific area, regional and sub-region level</td>
<td></td>
<td></td>
<td></td>
<td>-</td>
</tr>
</tbody>
</table>
Once the indicators had been summarised as in table 3, they were assessed for commonalities along the following lines:

a. Really common (‘commonalities’) across indicator components => This is taken as meaning equal = No ‘harmonisation’ needed
b. Comparable across indicator components => This is taken as requiring some ‘harmonisation’ as it has the possibility to become equal
c. ‘Different’ across indicator components

In the case that the indicator met criteria a) and b), the indicator was determined to have ‘clear possibilities for harmonisation’. Overall, the EEA notes that the indicator comparison and harmonisation is a lengthy and bottom-up process compared to the alternative, which would simply be to define a new set of indicators based on the information desired. However, the EEA sees that this is an unrealistic and potentially inefficient approach given the volume of data already being collected by Member States and regionally. In general, EMMA and the EEA have concluded that there is scope for ‘harmonisation’ across the ‘common’ regional seas and EEA indicators included in the indicator comparison for the selected 4 MSFD determinants. The level of harmonisation varies nonetheless and is summarised as follows:

• Indicators on hazardous substances in biota are the most well developed across the regions and have the greatest scope for ‘harmonisation’
• Chlorophyll-a and nutrients in seawater are extremely variable regionally and sub-regionally, in particular seasonally, and comparability is highly correlated with standardisation.
• Indicators on the selective extraction of commercial fish are the least well developed across the 4 regional seas, less comparable and offer few possibilities for ‘harmonisation’.

However, additional information is needed on all the above indicators and EMMA is continuing work to develop these. The process of developing a common set of pan-European indicators also foresees the development of new indicators to address those aspects of the MSFD Annex III for which sufficient indicators do not already exist. These will include the 4 determinants not prioritised during the indicator comparison process. The EEA has identified 3 different types of indicators necessary for the implementation of the MSFD:

\[\text{\footnotesize EEA (2009)}\]
• For Article 8 and Annex III: ‘Factual’ indicators for the 2012 ‘Initial assessment’, regional application possible (‘How it is’=> Invented example: Indicator on levels and trends of TBT in sediments and biota).

• For Article 9 and Annex I: Indicators reflecting the normative definition of GES, regional application possible (‘How it should be’=> Invented example: Ecological quality objective on the degree of biological effects of TBT on gastropod populations (e.g. imposex).

• For Article 10 and Annex IV: Indicators reflecting progress in achieving GES, national application required (‘Are we going in the right direction?’ => Invented example: Indicator showing annual degree of compliance of ships with IMO AFS Convention, and whether TBT still enters the marine environment).


The EEA is also collaborating with international organisations such as regional sea conventions to ensure that gaps are filled with regards to the needs of the MSFD and that these new indicators are pan-European from the outset. It is hoped that these indicators may then provide possible guidance for Member States when determining indicators related to targets for achieving Good Environmental Status (GES).

• 7.2.4 MSFD Management Group

Background

The MSFD required that the European Commission to lay down criteria and methodological standards by 15 July 2010 that allow consistency in the approach by which EU Member States assess the extent to which Good Environmental Status is being achieved. Under coordination of ICES and JRC, Task groups of experts were established for each of the MSFD Descriptors with the aim of developing criteria and methodological standards for each Descriptor. The Management Group consisted of the Task Group chairs and members of a small Steering Group consisting of JRC and ICES representatives. In their report information on a number of issues that are common to all Descriptor is provided. The group moreover provided some comments on what it believes are important next steps as they relate to scientific support of the MSFD. This overview is based on the Management Group Report of 2010.

Indicators and monitoring:

The Management Group recognises the diversity of environmental conditions that exists across and among European seas with respect to physical and biological conditions and human activities and needs. This diversity is the reason therefore that no single set of criteria and indicator can be applied to all marine regions. Additional there is variety of overlap among the
descriptors and indicators, which requires consistency. When selecting the parameters that needs to be monitored the relations between the descriptors have to be taken into account. Moreover the different descriptors are expressed on inherently different scales, from small scale, such as sea floor integrity to larger scale, such as fisheries.

As a consequence the elements of the monitoring programmes need to be tailored to the specific needs of each of the marine regions, regarding the monitoring sites and the precise suite of indicators. The Management group recommends identifying indicators that support multiple criteria to ensure synergy and increase monitoring efficiency. Moreover the maximum use of ongoing monitoring programmes is recommended. For ‘large scale’ descriptors the attributes that integrate across the entire region should be chosen, that can be measured locally.

The management group recommends the use of a risk-based approach for prioritisation in monitoring. Therefore an analysis of spatial overlap of pressures with the vulnerable properties of the marine systems has to be conducted. Based on that areas and indicators can be determined, that are prioritised to assess the environmental status. The assessment of GES is recommended to start in these areas with greatest vulnerability and highest pressures, based on the assumption that if the status is in these areas is ‘good’, the status over the larger area is ‘good’ too. If that is not the case, the assessment has to be conducted stepwise along the gradients of pressure or vulnerability. This pragmatic prioritisation can result in a manageable monitoring programme.

**Integration:**

The management group acknowledges the problem of having a methodology that makes best usage of the available information or having a methodology which is consistent across all regions. The evaluation of GES has to balance this issue. The individual Task Group reports provide guidance to select a suite of classes of indicators and for more local scales, specific indicators within these classes.

Integration has to occur on three different levels, described below.

1) Indicators within attributes of a descriptor

2) Status across all attributes within a descriptor

The Task Groups have outlined the best approach to be taken for each descriptor. Two different approaches are recommended by the Task groups 1) an integrative assessment combining the indicators 2) assessment by worst-case, which means the status will be set at the status of the indicator assessed at the poorest. Table 4 summarises the recommended approaches for the various descriptors.
Table 4: Summary of Task group approaches to integrate within descriptors

3) Status across all descriptors

This last level was not part of the work of the Task Groups. One Task group however pointed out that integration through a specified algorithm is only possible on a local scale. Such an algorithm has to be developed on the scale the indicators and reference levels are used, no universal algorithm exist. On a larger scale there would be too many compromises between the methodology and the scientific rigour. In that case expert knowledge is required.

Setting up a process for conducting the assessment of Good Environmental Status the Management group recommends the steps recommended by the UNEP and the IOC-UNESCO Assessment of Assessment Report.

The Management Groups eventually highlights the further need for scientific to the Member States to decide on the attributes and criteria to develop to define ‘Good Environmental Status’, to support the choice of indicators and advice for methodological standards.

- 7.2.5 SEAMBOR

Background

This working group was established in 2006 by the Marine Board ESF, ICES and EFARO after they identified the need to address the gaps between the natural, social and economic sciences in order to meet the scientific needs to implement the Ecosystem Approach to Management according to the Integrated Maritime Policy in Europe. With participation of ESF, ICES and EFARO, various different pan-European and inter-governmental marine organizations were brought together to form an innovative and multidisciplinary working group. With the aim to identify recommendations aimed at the science community, programme managers and high-level policy makers, the working group considered and described the necessary science for proper implementation of the Ecosystem Approach in the context of Good Environmental Status.
(GES), as required by the Marine Strategy Framework Directive (MSFD). The working group emphasised the importance of giving equal importance to science on the three systems supporting the Ecosystem Approach: the natural system, the social system and the governance system, which implies enlargement of the traditional scope of scientific research by considering the interconnectivity of all three systems. Figure 7 illustrates the implementation of an Ecosystem Approach in European Large marine Ecosystems based on Rice et al 2010.

The working group identified the major science and knowledge gaps for understanding:

- the marine environment;
- the social and economic aspects of human use of the oceans;
- and effective governance of the oceans (see table 5).

Figure 7: Ecosystem Approach to Management in Large Marine Ecosystems

Schematic representation of the implementation of an Ecosystem Approach to Management of Biotic Ocean Resources in European Large Marine Ecosystems/Ecoregions (Source: Rice et al 2010). The Ecosystem Approach to Management (EAM) looks at the entire ecosystem, including humans, in an integrated manner. Its goal is to maintain an ecosystem in a healthy, productive and resilient condition so that it can provide the services humans want and need. EAM essentially requires the high-level integration of governance in the form of expert judgement (e.g. referred to here as the Integrated maritime policy – IMP) and with science in the form of objective science and knowledge (e.g. towards the ‘real’ integration between the social, ecological and economic sciences). BHD: Birds and Habitats Directive; EMMRS: European Marine and Maritime Research Strategy; GES: Good Environmental Status; MSFD: Marine Strategy Framework Directive; WFD: Water Framework Directive.

<table>
<thead>
<tr>
<th>Marine environment</th>
<th>Socio-economic system</th>
<th>Management and governance system</th>
</tr>
</thead>
<tbody>
<tr>
<td>The priorities to understand the dynamics and resilience of populations, biological</td>
<td>The knowledge gaps with regard to understanding the dynamics of human use of</td>
<td>Research on a variety of scales is needed to inform the development of</td>
</tr>
</tbody>
</table>
communities and ecosystems include:
- **Climate change and ecosystem processes.** Research should focus on quantifying the relationships between ecosystem changes and combinations of climate forcing and the level of human activities, thus developing an ‘ecosystem risk indicator’
- **Scales of spatial and temporal variation** of patterns and processes, which need to be identified for policy and management to operate at effective scales
- **The dynamics and productivity of complex systems**, together with processes of ecosystem changes and interconnections between ecosystems that must be taken into account in making management adaptive policies? and must be anticipatory rather than only reactive

marine ecosystems include:
- **Links between the state of ecosystems and human well-being**, regarding the nature and extent of the services provided by marine ecosystems, and consequences of changes in these services for human well-being
- **The dynamics of socio-economic systems**, especially methods to influence individual, institutional, and economic behaviours to improve the likelihood of sustainable choices
- **Placing the socio-economic systems into Integrated Management**, Operational measures of the value of ecosystem services need to be established, that can be taken into account by stakeholders in their choices regarding ecosystem uses. Knowing if and how nonlinearities are expressed in the social and economic dynamics of marine industries and communities is also necessary to develop effective policies and strategies for sustainability.

**Table 5: Major science and knowledge gaps in understanding the natural, socio-economic and management and governance system.**

**Integrated Assessment**

The working group stresses that there is no current example of a fully integrative assessment to support management under an ecosystem approach. The reason for that is considered to be the lack of a unifying framework and a mandate for an agency to call for an IA. The individual parts
are more or less available but need to be brought together. Many groups and initiatives have been or are in the process of developing approaches. As a result, there are several building blocks which could be used for IAs.

- The knowledge and experience of OSPAR on the development of Ecological Quality Objectives (EcoQOs) and the status assessment relative to those should be used within the work on the MSFD. The concepts use different wording but are considered to have the same origin.

- In addition, substantial guidance already exists with regard to best practices for the selection of indicators, and can be used for the development of the necessary assessment.

The main point of criticisms of the working group remains: 'More effort is needed to pull the pieces together.' Only when all existing blocks are combined into complete IAs will there be a complete basis available for EBM.

The SEAMBOR working group highlights the importance of matrices in helping to understand the complexity of interactions between human activities and ecosystem state and to identify appropriate levels of monitoring. They prefer a triangular matrix approach as presented in figure 8. Such a matrix allows thematic assessments, dealing with one aspect of the marine environment (highlighted in blue), a sectoral assessment, dealing with the assessment of a single industry or human activity (highlighted in red), and moreover allows integration of various sectors, ecosystem components and socio-economic factors, allowing a fully IA. The OSPAR Quality status reports follow the sectoral approach of IAs. This has the advantage of informing the selection and implementation of effective management and control measures for that specific sector, but clearly lacks the interconnection with other sectors and their impacts. The best partial models for complete IAs integrating across sectors and ecosystem components are the Transborder Diagnostic

![Figure 8: Example of a matrix approach used to describe the relationship or degree of interconnection between human pressures (sectoral activities such as fishing) and ecosystem components (such as benthos).](image)

The specific interactions between all sectors and ecosystem components can be readily observed. For example, the specific interactions (as impacts) between dredging and all other components of the system can be documented (highlighted in red), this would be an example of a sectoral or sector-specific assessment. In addition the interactions between plankton and all other ecosystem components, including sectoral pressures, can be evaluated and this would be described as a thematic assessment (highlighted in blue)
Assessments under the UNEP Regional Seas programme. However, these are very information-poor assessments compared to the European Seas.

The institutional situation, with its lack of coordination, is also emphasised. There is a need for streamlining the national tasks of monitoring and assessment of environmental status, which could moreover result in increased cost-efficiencies by countries that share a marine region working together. The organization involved in this working group, the Marine Board ESF, ICES and EFARO, see themselves as being able to assume a coordinating function in marine research and in communication, and in delivering a unified message to policy- and decision-makers with regard to the implementation of EBM.

The knowledge gaps that need to be addressed before complete IAs can be conducted were identified as being the following:

- Preparation of best practice guidance on how to undertake Integrated Assessments (IAs) and how to disseminate the results of these assessments to the various different stakeholder groups;
- Objective methods which explore, quantify, describe and weight the connectivity and interactions between ecosystem components and quantify, describe and weight the status and trends of ecosystem components;
- A review of methods most suited to dissemination and communication of results; and
- The development of systems which can predict and forecast changes in the interactions and status of ecosystem components against different scenarios.

**Knowledge transfer**

In addition, the issue of knowledge transfer between all relevant stakeholders was highlighted. The research community in particular must increase the priority it gives to knowledge transfer in order to better inform decision-making and policy developments. This requires research on tools and processes that facilitate effective knowledge transfer.

**Supporting the operational implementation of the MSFD**

Besides the research needs on the natural, social and governance systems, the working group has identified operational science needs regarding the monitoring of the ‘good environmental status’ under the MSFD. The directive specifically calls for ‘a new approach to marine monitoring and assessment and the use of scientific information’. All aspects of this improved monitoring can lead to a better IA as well.

**Impediments to the implementation of the EBM**

The requirement of the MSFD to follow the EBM poses many challenges for implementation. Large demands for knowledge and information alone are enough to make implementation difficult. These difficulties are increased, however, because there are actual structural
impediments to progress. The working group SEAMBOR reviewed these impediments to help identify where the science community can help to overcome or avoid them, and allow those responsible for implementation to plan realistically. The issue of IAs falls under the identified lack of clarity with regard to research priorities. As IAs are conducted by competent experts, they are regarded as being the relevant tool for identifying and prioritizing research tasks. The identified research priorities would be at the scale of the IA and can become the basis for specific research agendas.

**Work plan for an improved scientific basis for the implementation of an Ecosystem-Based Approach**

In conclusion, SEAMBOR developed a work plan that could lead to an improved scientific basis. One activity of high priority that is related to the science dimension is the development and improvement of methodologies and provision of guidelines for integrated assessments. These activities reflect the recommendations the working group finally gave to the European Commission and the national funding agencies to ensure rapid implementation of the MSFD.

The recommendations and suggestions of the SEAMBOR working group could be used to improve the scientific basis for the implementation of the MSFD in Germany. The scientific needs and requirements for an IA have been clearly identified. Related to the methodology for an IA, SEAMBOR recommended using the existing knowledge of previous assessments, for example OSPAR — although no fully integrative assessment has been conducted in Europe yet, which could easily be transferred to the MSFD.

**7.3 Decision-Trees, Risk-Analysis, Ecological Network-Analysis**

- **7.3.1 Decision-Trees**

A decision tree can help to make good choices, especially when faced with decisions that involve high costs and risks. It enables a comparison of competing alternatives and assigns values to those alternatives by combining uncertainties, costs, and payoffs. Decision trees offer advantages over other methods of decision making (Olivas 2007). They are:

Graphic: Decision alternatives, possible outcomes, and chance events can be presented schematically. The visual approach is particularly helpful in understanding sequential decisions and outcome dependencies.

Efficient: Complex alternatives can be expressed clearly. Decision trees can be easily modified to incorporate new information. Setting up a decision tree helps to compare how changing input values affect various decision alternatives.

Revealing: The comparison of competing alternatives is possible in terms of risk and probable value - even without complete information.
Complementary: Decision trees can be used in conjunction with other project management tools. For example, the decision tree method can help evaluate project schedules.

The decision-tree approach has been explored within some studies to find out whether a marine ecosystem may be in danger, Borja (2009) describes the use of decision trees when assessing the ecological status, within the WFD. Bundy et al. (2010) use the decision tree approach to classify ecosystems into different states and finds the approach attractive for its simplicity and the hence more likely acceptance by stakeholders. Also within risk assessments for aquaculture non-probabilistic decision trees have been used in marine biosecurity programmes in New Zealand and Chile (Campbell 2008).

Borja (ibid.) stresses that a decision tree permits the derivation of a more accurate global classification, including physico-chemical and chemical elements. This way supports the weighting of some elements with validated and intercalibrated methodologies when historical data or accurate methodologies for some of the elements are missing, or intercalibration is lacking. To integrate quality at the water body level as required by the WFD, Borja (ibid.) suggests two different way of calculation. (1) Calculating the ecological status at each station and then integrating the status at the water body level or (2) integrating the status of each element at the water body level, and then calculating the ecological status for the whole water body. The result is always a quality class (high, good, etc.) and can be substituted by an equivalent value which allows weighting of the global status.

In Bundy (2010) the ingredients for the decision tree are a definition of the initial state of the ecosystem(s), the selection of a suite of ecosystem indicators for one or more ecosystems, an analysis of the trends of the ecosystem indicators, and the development of a decision tree with decision rules. The information used in the decision tree is the trend of the indicators over the period being considered (figure 9).
Figure 9: Decision tree diagnoses. Bundy (2010)

Decision tree diagnoses for the 19 ecosystems evaluated: (a) improving, (b) not improving, and (c) deteriorating. The first node of the decision tree is fish size. If that is decreasing, Decision Rule 1 is invoked and the decision tree is terminated (c). If it is increasing or there is no trend, then the decision tree moves down to the next node (indicator), and the same process is followed until either Decision Rule 1 terminates the decision tree or the last node, inverse fishing pressure, is reached. The three arrows at each node indicate the three possible directions of the indicator trend, decreasing (red), increasing (green), or no trend (striped); the heavy black arrow indicates the observed trend. In (a), white nodes indicates missing data, where it is assumed that there is no change.

This decision tree approach to classifying ecosystems into three states, improving, stationary (not improving), or deteriorating, is attractive for its simplicity. However, there are several methodological issues involved in this approach that are subjective, including the assessment of initial state, the selection of ecosystem indicators, and the decision model itself, including the order of the indicators and the choice of decision rule.

Overall, decision trees seem to be useful for a first assessment of ecosystem status when spatial and temporal variability of data occurs, information is missing and a simple classification system should be used.
Decision tree software ranges from low-cost spreadsheet plug-ins, to server-mediated application suites. Casual users may find the free trial offerings from Decision Support Services, Visionary Tools, or Lumenaut particularly useful.\(^{29}\)

- **7.3.2 Risk-Analysis**

Ecological risk assessment “evaluates the likelihood that adverse ecological effects may occur or are occurring as a result of exposure to one or more stressors” (US EPA 1992). It is a flexible process for organising and analysing data, information, assumptions, and uncertainties to evaluate the likelihood of adverse ecological effects. Ecological risk assessment provides critical input to environmental decision-making by giving risk managers an approach for considering available scientific information along with social, legal, political or economic factors, when selecting a course of action. The connection between risk assessors, risk managers, and interested parties during planning and the communication of risk at the end of the risk assessment is critical to ensure that the results of the assessment can be used to support a management decision (U.S. EPA 1998). Because complex ecological expertise is needed, risk assessors and managers frequently work in multidisciplinary teams. The analysis includes three primary phases: problem formulation, analysis, and risk characterisation.

Risk-analyses were originally developed for the terrestrial sector. In the meantime, risk assessments have been developed for thematic assessments like fisheries, marine safety, port marine safety, offshore platforms and hazardous substances. The methodology for carrying out risk assessments for special substances has been developed and established through international bodies including the European Union and the Organisation for Economic Co-operation and Development (OECD). It can be used as the basis for assessing risks across a range of scenarios or for specific applications of a chemical substance. The methodology increased in importance as EU authorities in cooperation with the OSPAR Commission stated that the marine environment is particularly sensitive to chemical substances. A well executed risk assessment with case studies exists on offshore platforms (Arnold 2006). Here, risk criteria and risk assessment matrices and levels have been mainly developed by Norway, Australia and the U.S.

For the ecological sector no risk-analysis has been found except the ERAEF approach for the effects of fishing (see box 6). It remains to be seen whether other assessment approaches incorporate this comprehensive approach and to what extent.

---

\(^{29}\) e.g. www.lumenaut.com/, www.salford-systems.com/, www.treeplan.com/, www.visionarytools.com/.
7.3.3 Evaluation of Ecological Network Analysis for Ecosystem-Based Management

Ecological Network Analysis (ENA) is a modelling technique used for understanding the structure and flow of material within ecosystems, and is most commonly used for evaluating food webs (Wulff et al. 1989, Christensen 1993). Until now this technique has mainly been developed for the fisheries sector. It has a solid theoretical foundation (Ulanowicz 1986, 1997; Fath and Patten 1999) and some potential for application to both basic science and management. Its use may increase since the fisheries management community is moving away from single species management towards an ecosystem-based approach. ENA therefore could become a routine approach to incorporating science into fishery management decisions. It is clearly one of the few tools available that examines interactions among multiple species, and in doing so allows managers to evaluate an entire food web instead of a single component. However, only few studies exist about this approach and until now the technique has not been used for real fishery management assessments.

Model uncertainties are frequently neglected in the process of ecosystem assessment, even though they may have a significant impact on the result. Using a sensitivity analysis of the food-
web model ENA, Dame (2005) shows a few relevant sources for uncertainty which are equally relevant in the context of other ecosystem assessment methodologies:

- natural variability of input parameters (i.e. changes in biomass with respect to location and time or changes in diet);
- data collection methods (i.e. selectivity among gear types);
- model construction (i.e. choices in aggregating species into compartments); and
- fundamental assumptions of the approach (i.e. steady-state conditions).

Each of these sources of uncertainty can significantly affect the outcome of the assessment and should therefore be treated with utmost care. Dame (2005) recommends a priori predictions of model output and sensitivity analysis for a better understanding of the effect of variability in model input. Model construction could be improved by incorporating multivariate techniques, and concerns of how well a model depicts the real-world system could be addressed by validating model output with independent techniques. No single index from ENA gives a comprehensive picture of trophic conditions, and uncertainties may cloud predictions. However when model output is considered as a group, ENA provides insight into the structure and functioning of the entire ecosystem.

It therefore can be useful for ecosystem-based fishery management because it provides a tool for quantifying direct and indirect trophic interactions, for comparing food web properties among different systems and/or times, and for incorporating fishery harvest into the analysis. Future studies should acknowledge the limitations of ENA, focus more attention on addressing the potential sources of uncertainty, and utilise methods of model validation where possible.

8 Compilation and Evaluation of case Studies

This chapter goes in detail into the analysis and evaluation of integrated ecosystem assessment. The assessment approaches chosen for case studies are presented and the overall findings gained from the analysis are summarised. Additionally, the information provided in the expert interviews, either involved in some of the case study approaches or general experts are presented. Based on this information the case studies are evaluated and ‘best practice’ examples are identified. All of this leads into the identification of requirements for an integrated ecosystem assessment.

Chapter 8 is structured according to key aspects of an IEA. These 12 key aspects were developed on the basis of literature and case study analysis.
8.1 Compilation of case studies

- 8.1.1 Selection of approaches

The compilation of IEAs began by looking at some of the more well-known assessments currently in existence at a regional scale in Europe: these included the Report of the Regional Ecosystem Study Group of the North Sea (REGNS), the Oslo-Paris Conventions for the protection of the north-east Atlantic (OSPAR) and the Helsinki Commission for the protection of the Baltic marine environment (HELCOM). The UK Charting Process provided an example of a northern European approach to IEA at national level. During these evaluations, international examples of IEAs came to light, such as those in North America: assessments for the Eastern Scotian Shelf in Canada and for Puget Sound and the California Current in the USA. An integrated assessment covering the Great Barrier Reef in Australia was also analysed, as was the Ocean Health Index, an attempt at an integrated assessment on a global scale.

As well as the more fully integrated assessments which took both biological and anthropogenic factors into account, two thematic assessments were also examined: the Ecological Risk Assessment for the Effects of Fishing (ERAEF); focused on fisheries in Australia and Assessment of Estuarine Trophic Status (ASSETS); an approach from the USA on eutrophication. Table 6 provides an overview of the studies selected as case studies.

<table>
<thead>
<tr>
<th>Name of assessment</th>
<th>Type of assessment</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>HELCOM</td>
<td>Integrated (supranational)</td>
<td>Baltic Sea</td>
</tr>
<tr>
<td>OSPAR</td>
<td>Integrated (supranational)</td>
<td>North-East Atlantic</td>
</tr>
<tr>
<td>UK Charting Process</td>
<td>Integrated (national)</td>
<td>UK</td>
</tr>
<tr>
<td>Indonesia</td>
<td>Integrated (national)</td>
<td>Indonesia</td>
</tr>
<tr>
<td>Eastern Scotian Shelf Integrated Management (ESSIM)</td>
<td>Integrated (regional)</td>
<td>Canada</td>
</tr>
<tr>
<td>Puget Sound Partnership</td>
<td>Integrated (regional)</td>
<td>USA</td>
</tr>
<tr>
<td>Chesapeake Bay</td>
<td>Integrated (regional)</td>
<td>USA</td>
</tr>
<tr>
<td>Great Barrier Reef</td>
<td>Fully Integrated (regional)</td>
<td>Australia</td>
</tr>
<tr>
<td>Ocean Health Index</td>
<td>Integrated (international)</td>
<td>Global</td>
</tr>
</tbody>
</table>
During the research phase, a number of other assessments were examined which did not result in case studies. Reasons for not taking these forward included lack of information, lack of relevance to the task and not sufficient evidence of integration of indicators. The assessments not taken forward for case study as well as the rationale for these decisions are listed in Table 7.

<table>
<thead>
<tr>
<th>Name of assessment</th>
<th>Remarks and rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indonesia</td>
<td>Two assessments were of interest in Indonesia: Greater Jakarta Bay Ecosystem and that of Raja Ampat. Although overviews and synthesis information was found, there was not sufficient access in English language to primary sources of information to take either forward as a fully developed case study. A brief overview has nonetheless been completed for these assessments.</td>
</tr>
<tr>
<td>Mediterranean</td>
<td>Rochet et al. (2010) carried out an assessment of pressures (mainly from fishing) on marine species in the Mediterranean. The approach presented focuses on impacts at functional group as well as at community level. It integrates metrics for groundfish populations. The study notes that such integrative methods could be taken forward for integrated ecosystem assessments where multiple pressures are present, though it does not do this itself.</td>
</tr>
<tr>
<td>Portugal</td>
<td>No studies of interest</td>
</tr>
<tr>
<td>Ireland</td>
<td>No studies of interest</td>
</tr>
<tr>
<td>Scotland</td>
<td>Scotland has recently published a Marine Atlas (03/2011) assessing its seas which will back up its national plan. This feeds into overall UK efforts to meet the requirements of the MSFD as laid out in Charting Progress II (see factsheet).</td>
</tr>
<tr>
<td>Black Sea</td>
<td>Only a ‘State of the Environment Report’ available, but there is no attempt to integrate the individual findings to produce an overall summary of the ecosystem status.</td>
</tr>
</tbody>
</table>

A Global Environment Fund (GEF) supported project running for 4 years (2009-2013) to support capacity-building and the development of a transboundary Integrated Assessment and Management of the Gulf of Mexico Large Marine Ecosystem

[http://iwlearn.net/iw-projects/Fsp_112799469621](http://iwlearn.net/iw-projects/Fsp_112799469621)

Not enough information on project results so far.

### Bangladesh
No studies of interest

### Senegal
No studies of interest

### Mauritania
No studies of interest

### Uganda
An example of an IEA was found, but this takes place in an inland area (Lake Kyoga sub-catchment of the Nile basin).

### Chile
No studies of interest

### Costa Rica
No studies of interest

The assessments which were taken forward for case study are presented in factsheet format (see Annex I). The overall findings are summarised in an overview table (see Annex IV)

- **8.1.2 Key elements of an IEA**

In order to carry out the analysis of the approaches, 13 elements were identified as key to IEAs. These elements were selected on the basis of factors highlighted in the literature and expert interviews as being of high relevance to IEAs. This section briefly summarises how the case study approaches dealt with each key element.

- **Indicators**

The use and number of indicators show high variation between the different approaches. Whereas some do not use indicators at all, as in the case of the Australian approach, others use several hundred indicators. Especially interesting are two concepts, the Puget Sound and the Australian. In the Puget Sound assessment dashboard indicators are used, serving as lead
indicators for a family of related indicators (roughly 100). By contrast, the Australian approach refrains from the use of indicators. The assessment builds on expert judgment to analyse existing scientific research and information to reach conclusions on the overall status.

- **Human pressure indicators**

As in the case of indicators, there is also high variation in number of pressures included in the assessment. The thematic assessments clearly focus on relevant pressures such as fisheries or eutrophication. The Chesapeake Bay approach does not include human pressures at all in the assessment. The other integrated approaches include more pressures. The OHI, the UK and the OSPAR approaches include a high diversity of pressures. The European approaches, the UK approach, OSPAR and also HELCOM tried to identify the pressures according to the list of pressures in the Annex of the MSFD.

- **Socio-economic indicators**

Socio-economic indicators are only part of the assessment in a few approaches. Approaches considering only few such indicators did so mostly in the context of fisheries revenues. Of the other approaches using indicators, only the Puget Sound and the OHI show higher diversity in the socio-economic indicators included. The Australian approach does not make use of indicators, but rates each pressure for its impact on societal and economic values.

- **Fishery impacts**

Most assessments do include the impacts of fisheries into their assessments, mostly assessing it under the category of biological disturbance to biodiversity or the food web structure. In most cases the removal of target species is included in the assessments, referring to the fisheries landings. HELCOM differentiates between the different kinds of fisheries, such as bottom-trawling fisheries and surface fisheries. The UK approach does include indicators for the impact of the different kind of gear types to the ecosystem and stock characteristics such as the reproductive capacity of the target species and the percentage of sustainably harvested species. The REGNS approach is based on ICES data and therefore included other fishery statistics like catch per unit of effort and total allowable catch. One particularly interesting indicator is included in the OHI, subsidies relative to landed value. It refers to the sustainability of fisheries.

- **MSFD descriptors**

There is high variation between the different approaches in terms of how many MSFD descriptors are covered by the assessments. The thematic assessments obviously do not cover many descriptors based on their comparatively narrow thematic focus. But also purely in the...
case of integrated assessments, the number of descriptors covered shows high variation, addressing anywhere between 6 and all of the specified descriptors. There is no general consistency or pattern of which descriptors are not included. Only the two descriptors ‘marine litter’ and ‘Introduction of energy,’ including underwater noise, were not covered by several approaches.

- Integration / Overall status

Most of the analysed approaches are integrated approaches, however only a few are fully integrated as defined in chapter 6.2. The OHI and Puget Sound approaches are in the process of becoming fully integrated, but the only assessment already in use and considered fully integrated is the Australian approach.

The methodologies for integration range from relying on expert knowledge to incorporate all scientific data into the assessment, to a quantified methodology for integration of all indicators. Other approaches do not result in an overall integrated status at all and present results at lower scale of indicator categories.

- Cumulative effects

Most of the analysed IEA approaches do not yet take cumulative effects into account in their assessment. Whereas the OSPAR approach tries to aggregate all pressures to assess the cumulative impacts, it does not in fact take the interactions between the ecosystem components and pressures into consideration. Other approaches recognise that it is essential to include recognition of the cumulative effect of all relevant human activities but a relevant methodology is still under development. It was often stated in the assessments that there is still a lack of knowledge relating to the links between human activities and the marine environment and the interactions between these links. In order to improve the assessments, better knowledge on cumulative effects is needed. Only the HELCOM approach includes an estimation of potential anthropogenic cumulative pressures. This approach, however, also requires further development.

- Data and information

The Data used in the assessments draws from a variety of agencies, scientific institutions, environmental organizations and industries. For most of the approaches no detailed information is available on how exactly the data is gathered. HELCOM bases its assessment on a cooperative monitoring programme and annually updated indicator factsheets. The Great Barrier Reef approach does not make use of monitoring indicators, but uses the data from existing studies.

The quantity and quality of data gathered shows a variation in all approaches as well as in temporal and spatial availability. For most assessments there is no data available with the same
degree of robustness and reliability for all of the components included. Within HELCOM there is strong effort to prevent variation in temporal and spatial coverage.

All assessments aim to use as much quantitative data as possible. Expert judgment is applied where data availability is limited.

For most of the approaches no detailed information is available on how exactly the data is managed. The UK assessment data is managed via a Marine Environmental Data and Information Network. For the OHI, data will mainly be managed by NCEAS.

- **Forecasting / future trends**

  Most of the analysed approaches present the results in terms of status and trends. The forecast is therefore included in the results of the assessment. Only two of the approaches assess the status without taking the trend into consideration.

- **Risk analysis**

  Only a few of the analysed approaches include a risk analysis in their assessment. It is stated that the OSPAR approach, for example, is entirely premised upon a risk-based approach. The Puget Sound assessment approaches risk analysis by linking threats, drivers, pressures, states, impacts, responses and ERAEF identified areas of assessment. The other approaches do not conduct a risk-analysis as part of the assessment process.

- **Treatment of Uncertainty**

  Due to high variation in the robustness and reliability of data, uncertainty in results is an important aspect. However, only some of the assessments adopted a special methodology to take this uncertainty into consideration. The UK and OSPAR approaches record the level of confidence for each result. Other assessments, such as REGNS and HELCOM, only report the statistical uncertainty.

- **Transparency of methods**

  Most of the analysed approaches are based on a transparent assessment process. They follow clear methodological steps, either predefined or clearly documented in the assessment. In the case of the OSPAR approach, transparency is enhanced through an audit trail and documentation explaining the rationale of decisions made. The only problem is that sometimes the methodology is only transparent within the scientific community and is not easily intelligible to wider audiences. For the Great Barrier Reef and the ESSIM assessments, however, the process is not very transparent.
• **Scientific Rigour**

The level of scientific rigour could only be analysed for the assessments used in practice. All of the approaches aim to build their assessment on a robust and scientifically sound evidence base. Most of them state that the scientific rigour is high and the assessment leads to robust results. Moreover, a scientifically sound assessment process found in many of the analysed assessments increases the level of scientific rigour.

• **Presentation of Results**

The presentation of results shows high variation between the analysed assessments. Most of the assessments try to present the results in a clear and accessible way for the general public and decision makers such as in the UK, the Chesapeake Bay approach, HELCOM, Great Barrier Reef and ASSETS. For the other approaches the results are not very well presented or easy to understand. This results primarily from a very narrow scientific focus of the assessment that does not generally lead to results that audiences outside of the scientific community can easily access.

• **Management measures**

Most of the analysed assessments do not result in a collection of management measures. As it is stated for OSPAR, this would require a further step. In fact, most of the assessments do not even portend or attempt to lead into management measures. Their aim is to inform policy and decision makers and feed into policy strategies or management decisions. For some assessments, however, it is more evident and often clearly stated that they do aim to guide management plans. The OHI additionally states that it wants to raise awareness in the general public and serve as a call for action. Only the Chesapeake Bay approach and the ERAEF approach have directly fed into management strategies for their focus area.

• **Stakeholders involvement**

The involvement of stakeholders seems rather limited in the analysed assessments. In general, only scientific experts were involved in the actual assessment process. Some of the approaches conducted stakeholder consultation at the end of the process to discussing findings. Only a few included stakeholders in the beginning or during the assessment process. Strong emphasis on stakeholder consultation and participation is apparent within the Great Barrier Reef assessment, Puget Sound and ESSIM. ESSIM even made use of a stakeholder advisory council.
8.2 Expert Interviews

In order to learn more about the practical implementation of IEAs, a number of experts involved in these approaches in different countries were interviewed. The information provided in these interviews fed into the compilation of factsheets (see 8.1 and Annex I) and into the evaluation of case studies (8.3).

The experts interviewed for this study can roughly be divided up into two main categories: general experts on IEAs (such as Jeff Ardron of the Marine Conservation Biology Institute in the US, who has been involved in various IEA processes worldwide), and experts working with one specific IEA approach, (such as Paul MacNab of the Bedford Institute of Oceanography in Canada, who holds major responsibilities in assessments and management of the Eastern Scotian Shelf at Canada’s Atlantic coast). A small number of interviewed experts fall into both categories, such as Phil Levin, who was instrumental in the development of NOAA’s IEA approach that is frequently used in the USA today (Levin, 2009), but who also played a crucial role in setting up the system in practice in Puget Sound, Washington. The general experts were helpful in providing a general overview of the current situation of IEAs, while specific experts could provide valuable information on how these approaches are put into practice in different locations around the world. For an overview of the experts interviewed, see table 8 below. For the guiding questions used, see Annex II.

On the whole, there were a number of interesting and often reoccurring issues brought up by the experts that deserve to be highlighted. They mainly concern the different challenges associated with implementing these assessments and lessons learned along the way.
<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>Organization</th>
<th>Country</th>
<th>IEA Background</th>
<th>Date of Interview</th>
</tr>
</thead>
</table>
| Ardron, Jeff    | Director High Seas Program                    | Marine Conservation Biology Institute                                         | USA     | • Directly involved in three IEA processes on the west coast of Canada  
• Indirectly involved in IEAs on the east coast of Canada, the UK, and to a limited extent in OSPAR  
• Has been an expert reviewer on a number of EIA-like documents and processes | 17 March, 2011    |
| Batiuk, Rich    | Associate Director for Science                | U.S. Environmental Protection Agency’s Chesapeake Bay Program (CBP) Office    | USA     | • With Chesapeake Bay Program since 1985,  
• Coordinator of the baywide monitoring program  
• Instrumental role in setting up the Chesapeake Bay IEA and indicator framework  
• Expert on the Chesapeake Bay Program’s Bay Barometer and Bay Health Index | 17 May, 2011      |
| Brennan, Ruth   | Research Associate                            | Centre for Coastal and Oceans Governance, The Scottish Association for Marine Science (SAMS), Scottish Marine Institute | UK      | • Involved in compilation of desk-based study for Marine Scotland: Report on Social and Economic Objectives for a Scottish Marine Plan (March, 2010) | 03 May, 2011      |
| Day, Jon        | Acting General Manager                        | Marine Park Management Branch, Great Barrier Reef Marine Park Authority (GBRMPA) | Australia | • Headed the taskforce for the Great Barrier Reef Outlook Report Assessment in its first years | 11 May, 2011      |
| Gonçalves, Emanuel | Associate Professor                          | ISPA – Instituto Universitario, Lisbon, Portugal                            | Portugal | • Advisor with respect to marine assessments to the National Water Institute in Portugal (INAG), the national authority coordinating the implementation of the Water Framework Directive (WFD) and the Marine Strategy Framework Directive (MSFD) in Portugal | 12 May, 2011      |
| Levin, Phillip  | Program Manager, Ecosystem Science Program    | NOAA Fisheries, Northwest Fisheries Science Center (NWFSC), Conservation Biology Division | USA     | • Developed the 5-step methodology of the NOAA Ecosystem Science Program  
instrumental role in putting IEAs into practice according to the 5-step framework (e.g. Puget Sound, California Current and other regions in the US) | 20 May, 2011      |
<table>
<thead>
<tr>
<th>Name</th>
<th>Title/Position</th>
<th>Organization/Location</th>
<th>Responsibilities</th>
<th>Date</th>
</tr>
</thead>
</table>
| MacNab, Paul          | Biologist, Oceans and Coastal Management Division, Ecosystem Management Branch | Bedford Institute of Oceanography, Department of Fisheries and Oceans, Canada | •Member of the planning office that led ESSIM. MPA Manager of the Gully MPA.  
• Involved in marine planning, environmental assessments, management for marine conservation etc. feeding into the ESSIM process  
•Expert on the IEA approach in the Eastern Scotian Shelf | 3 May, 2011 |
| Oosterbaan, Lex       | Senior Advisor, Directorate of Public Works and Water Management (Rijkswaterstaat North Sea) | Ministry of Infrastructure and the Environment, The Netherlands | •Chairman OSPAR Committee of Environmental Impacts of Human Activities and (co)lead Intersessional correspondence groups on Marine litter and on Cumulative Effects  
•Preparation of the OSPAR Quality Status Report 2010 (involved in defining the different pressures of human activities and their cumulative effects) | 28 March, 2011 |
| Ruckelshaus, Mary     | Director                                                                      | Natural Capital Project, Stanford University | •As lead scientist for the Puget Sound Partnership and head of the Ecosystem Science Program at NOAA, she lead the Puget Sound Partnership’s first iteration of the IEA introduction | 12 April, 2011 |
| Sylvester, Nita       | Indicators Coordinator                                                        | Environmental Protection Agency Chesapeake Bay Program Office, USA | •Expert on the Chesapeake Bay Program’s Bay Barometer and Bay Health Index | 18 May, 2011 |
| van den Hove, Sybille | Director and Partner                                                          | MEDIAN, research, teaching and consulting services on sustainability, environmental governance, ethical business strategies and decision-making. (also: visiting Professor at the Institute for Environmental Science and Technology (ICTA) of the Autonomous University of Barcelona) | •No direct involvement in EIAs but relevant fields: core expertise in science-policy interfaces, participatory approaches to environmental decision-making, integration of natural and social sciences research  
•Involved in several European FP7 research projects including HERMIONE (Hotspot Ecosystem Research and Man’s Impact on European Seas). | 29 March, 2011 |
| Varanasi, Usha        | Director                                                                      | NOAA Northwest Fisheries Science Center (NWFSC), part of the National Marine Fisheries Service (NMFS), USA | •As Director of the NOAA Northwest Fisheries Science Center (NWFSC), highly involved in the Puget Sound Partnership’s IEA introduction | 24 March, 2011 |
Overall, it was repeatedly emphasised that even though IEA is a quickly evolving field (MacNab, 2011), the implementation is still in its beginning (Varanasi, 2011). It is akin to a worldwide experiment in which policy seems to precede the practical aspects of implementation (Macnab, 2011). Moving from science to action has proven to be a complicated process (Varanasi, 2011). This situation can lead to frustration on the side of practitioners facing a range of challenges when trying to make the assessment operational (MacNab, 2011). There is no example of mature integrated assessment in existence that can be turned to for guidance in the form of best practices at this stage (MacNab, 2011). The outcome of the first IEA implementation efforts cannot yet be judged as these projects have had only several years within which to run their course (Ruckelshaus, 2011). Rich Batiuk, Associate Director for Science at the U.S. Environmental Protection Agency's Chesapeake Bay Program (CBP) Office, is not alone when he says that it was a long and difficult process to set up the IEA framework. It took about two years filled with intense discussions until they finally arrived at the framework and the indicators that all partners would agree to. He recommends avoiding becoming engrossed in minute detail in the very beginning (Batiuk, 2011). John Day also emphasises that it took a long time to develop the framework and the criteria for the assessment. But Day goes on that ‘it is worth while taking the time to get the framework right from the beginning so that it can stand as a basis for the following assessments’ (Day, 2011). Having been involved in a number of IEAs, Jeff Ardron, Director of the High Seas Program at the Marine Conservation Biology Institute, calls attention to the danger of producing long reports that are of limited use in practice: As the concept of ‘ecosystem’ includes everything in our biosphere it is a challenge for every IEA to define what the key bounding parameters of the respective ecosystem are and where to stop assessing. Ardron reports that IEAs of the past have tended to be long reports in many volumes that talk about everything that can be found in a particular region (literature reviews, interviews with experts etc). Once they are written, however, often no one knows what to do with these reports and in the worst case they end up on shelves collecting dust’ (Ardron, 2011).

Indicators

Number of indicators: A danger that has been highlighted with respect to the selection of indicators is that oftentimes too many indicators are chosen, requiring intensive time and resources while making it difficult to keep track of the indicators in practice (Ardron, 2011). Paul MacNab, from the Oceans and Coastal Management Division at the Ecosystem Management Branch at Bedford Institute of Oceanography, Department of Fisheries and Oceans gives the example of the Beaufort Sea, where an integrated management initiative was to be implemented for a marine protected area. A total of 87 indicators were defined, but only one of them is reported against today because there is no funding for more (MacNab 2011). Jeff Ardron also expresses concern for the risk of selecting too many indicators as this takes away time or resources from actually responding to the identified threats. He highlights the utility of focusing on a strategic suite of indicators that can tell us when it is appropriate to study certain issues in more detail, comparable to a control panel in a car, which is easy to read quickly and indicates when there is something that needs to be checked as well as what management changes might be required (Ardron, 2011).
This ‘control panel’ approach has been taken in various IEA case studies such as the Puget Sound and the Chesapeake Bay. In the case of Puget Sound, 20 ‘dashboard’ indicators were selected for this purpose from an initial list of over 700 indicators. The ‘dashboard’ indicators are easy to read and understand and will point to changes that need to be looked at in more detail (Varanasi, Ruckelshaus 2011). The scientists involved would have liked to include much more on the dashboard, Usha Varanasi, Director of the NOAA Northwest Fisheries Science Center (NWFSC) points out, but it needs to be easy for the public and managers to understand, and there are roughly 100 underlying indicators which feed into the ‘dashboard’ indicators and provide more information (Varanasi, Ruckelshaus 2011).

Established versus new indicators: Another question that often comes up when developing a set of indicators, as Paul MacNab highlights, is how far to take certain monitoring programs into consideration that are already ongoing: Should these be used in the new IEA framework or should one rather ‘start with a clean slate’ and choose the indicators that are most useful without considering the constraints of resources? Examples have shown that big initial investments were made in selecting and developing new indicators that were widely discussed and agreed upon, and in the end were never taken forward due to a lack of funding (MacNab, 2011). MacNab therefore observes a tendency today to only look at what is already being monitored and how those results can be leveraged for use in the respective assessment. He emphasises that there is no ‘cookie cutter approach’ to this question, and that one must let the site dictate the indicators, selecting the best list possible and including the most important indicators while keeping their feasibility for implementation in mind. In the Eastern Scotian Shelf, it was therefore decided to adopt a hybrid approach working as far as possible with existing information from the monitoring already in existence and at the same time adding new indicators to the list (MacNab, 2011). Also in Puget Sound, it was decided to build upon the history of regional indicator work, extending and adopting it to the current management setting and the stakeholder requests in the region (Levin, 2011).

Criteria for selecting indicators: When selecting appropriate indicators, a number of crucial questions must be addressed, such as: Are they easy to measure? How well do they reflect the larger picture? Can they be explicitly linked to the policy goals (Varanasi, Levin 2011)? A noteworthy and very transparent example of indicator selection is the case of Puget Sound. Here, a list of 18 criteria was elaborated against which all 705 suggested indicators that had been put forward by stakeholders and expert focus groups, were tested. The result of this carefully crafted process (see Puget Sound Science Update for details) was a portfolio of several indicators for each goal that was presented to the managers. In the end, 12 natural indicators were chosen for the ‘dashboard’, which is dynamic and flexible and can be changed at any time. In the final phase of this process, which is currently ongoing, a large survey (phone, internet, live interviews with citizens) is being conducted to look at the social value of the ecological indicators used in the dashboard and how people actually use this information. Based on the survey, the list of indicators will be revisited and changes will be suggested (Levin, 2011).

Working without indicators: In the case of the Great Barrier Reef Outlook assessment, the extensive body of existing information led to the decision not to carry out any
additional research but to build the assessment entirely on existing science (Day, 2011). A conscious decision was made not to use existing indicators or to develop new ones. Jon Day, General Manager of the Marine Park Management Branch at the Great Barrier Reef Marine Park Authority (GBRMPA), explains this choice being on one hand due to the high costs that indicators cause. On the other hand, he emphasises that even if successfully measured in practice, the indicators selected may not fulfill their purpose. ‘Years ago, we wasted a lot of effort on developing indicators’ he says, ‘but they turned out to be rather subjective and broad and we decided to move away from them.’ There are currently no plans to develop indicators in the near future for the Great Barrier Reef Outlook Reports. ‘The risk is that you put a lot of effort into measuring them (e.g. seabirds)’ Jon Day explains, ‘and in the end you might be measuring the wrong thing.’ Taking all existing information into account therefore provides a more holistic view of where efforts have to be made (Day, 2011).

**Human pressures indicators**

Human pressures are an integral part of the majority of the integrated assessments looked at; however the focus varies from one assessment to another. In the case of Puget Sound, it was emphasised that most pressures under consideration originated from land based sources as it is a highly urbanized area with land based toxins as well as nutrient runoffs from agriculture. In the California Current assessment, the focus is set on fishing pressures (Levin, 2011). The Chesapeake Bay Health Index does not include human pressures in the integrated assessment but assesses them in a separate part that focuses exclusively on ‘Factors impacting Bay Health’ (Batiuk, 2011).

**Fisheries** are by far the single largest anthropogenic stressor on marine ecosystems. For historical reasons, they are sometimes treated separately and not included in IEAs. This should not be the case, however, as they clearly affect marine ecosystems and must be considered in the mix like any other marine activity (Ardron, 2011). Sybille van den Hove agrees and highlights that ‘we cannot deal seriously with the oceans without integrating fisheries, which are the single biggest impact on the ecosystem (e.g. trawling). If fisheries are left out of the picture, the assessment does not make sense’ (van den Hove, 2011).

**Socio-economic indicators**

None of the approaches has fully arrived at integrating the socio-economic dimension by using a set of respective indicators, but significant steps have been made in a number of cases. In Canada, for instance, Social Economic Cultural Overview and Assessments (SECOA) are produced as separate documents in addition to the Ecosystem Overview and Assessment Reports (EOAs). The goal is to put these two together and thereby integrate the human and ecological sides. However, there are no examples yet of cases where the two have been successfully integrated (MacNab, 2011). In the Puget Sound work is underway to include indicators of human well-being to the ‘dashboard’ of indicators. Stakeholder discussions are ongoing at the moment, inquiring about their respective priorities (Ruckelshaus, 2011). In the case of the California Current work is currently being carried out in this respect by sociologists/anthropologists, characterizing
fishing communities (economic measures, jobs, effects of the catch-share program) (Levin, 2011) but no indicators have been determined, yet. Sybille van den Hove, Director and Partner at MEDIAN, points out that due to the lack of information on the human dimension, approaches are starting off by just looking at the ecosystem bits. She emphasises at the same time that it is of crucial importance when designing the assessment to keep in mind that it will be part of a larger assessment covering more than just the ecological dimension. With the aim of a fully integrated assessment in mind, it is therefore necessary to choose a framework that can be broadened in order to integrate socio-economics and governance aspects as in the future (van den Hove, 2011).

Integration of indicators / overall status

In some of the approaches it has proven helpful for communication of the assessment results to assign overall status grades for the health of the ecosystem as a whole. In other cases, this step was deliberately avoided. Phillip Levin, Program Manager of the Ecosystem Science Program at NOAA’s NWFSC, has mixed feelings towards this approach, which will also be used in the Ocean Health Index, for example. While recognising its value as an important communications tool on the one hand, he expresses concern that a single index distorts the meaning of the assessment by neglecting the broader suite of indicators on the other (Levin, 2011, see also Goodhart’s law). In the Chesapeake Bay, for instance, top level indices and an overall bay health index are determined by averaging indicators without weighting (Batiuk, 2011). ‘In making the decision to apply equal weight to all component indicators’ Nita Sylvester, Indicators Coordinator at the Environmental Protection Agency CBP Office describes, ‘the CBP looked to other such integrated assessment efforts, such as Yale University’s Ecosystem Sustainability Index and concluded that applying un-weighted averaging is a solid starting point until there is evidence that weighted averaging provides better ability to explain patterns in the results’ (Sylvester, 2011). However, this simple ‘boiling down’ effect has not been received positively by everyone. Program partners were uncomfortable with assigning a single number denoting overall status as it hides the status and trends of individual metrics and might be misleading. In a recent decision it was therefore determined to no longer report on these overall indices in the Bay Barometer publication (Batiuk, Sylvester, 2011).

Cumulative effects

The vast majority of the experts interviewed, while recognising and emphasizing the fundamental importance of cumulative effects, reported that their approach currently does not take these impacts into account. The complexity of measuring these effects was repeatedly highlighted during the interviews. ‘We are not well equipped to deal with this yet’ says Sybille van den Hove, ‘but it needs to be addressed in the assessments’. But even though cumulative impacts are frequently discussed, ‘nobody dared to make a final step in integrating cumulative impacts’ says Lex Oosterbaan, Chairman OSPAR Committee of Environmental Impacts of Human Activities, when reporting about the ongoing work within OSPAR in this respect (Oosterbaan, 2011). Jon Day also recognises that cumulative impacts were not assessed in the Outlook Report, as they are very complex to measure (Day, 2011). Paul MacNab reports from his experience with
assessment efforts in the Eastern Scotian Shelf that ‘a lot of thought has been given to the question of cumulative impacts but it is really tough to figure this one out.’ He goes on to say that ‘they are taken into consideration, but more in an ad-hoc way: the scientists carrying out assessments use their expert judgment to look at the whole picture, but cumulative impacts are difficult to show in monitoring programmes’ (MacNab, 2011). ‘As the science behind cumulative effects is still limited, they are difficult to include in the IEA of the Chesapeake Bay’, tells Rich Batiuk. The approach that has looked furthest into these impacts seems to be the California Current, where they are trying to work with modeling of multiple fisheries, habitat loss, offshore renewable energies and their impacts on natural resources (Levin, 2011).

Data and Information

Oftentimes the lack of data is put forward as a challenge when starting up the assessment process. It was therefore emphasised in a number of interviews that the current approaches often work with a largely qualitative basis where expert opinion is used to a large extent in the beginning because aiming at only quantitative data can unnecessarily stall the process. But as things develop, a more rigorous quantitative approach will be needed (Oosterbaan, Ruckelshaus 2011). From her experience with the IEA in the Puget Sound, Mary Ruckelshaus, Director of the Natural Capital Project at Stanford University and previously manager of the Ecosystem Science program, at NOAA NWFSC puts forward a lesson learned in this context: ‘The perfect can be the enemy of the good’, she says, ‘and it is not possible to bring together all the pieces of the system in the very beginning. But you have to start somewhere and it is important not to grind the process of assessment to a halt just because there is no model already available. Even if we do not have all the data, it is worth going through the whole process to identify and prioritize the important indicators, threats to focus on and priority strategies (Ruckelshaus, 2011).

Forecasting / future trends

An approach that stands out with regards to forecasting is the Great Barrier Reef’s Outlook Report. Jeff Ardron highlights this aspect of the report as a positive feature compared to other assessments out there: ‘The interesting thing with this report is that the assessment approach looks into the future, not into the past, as assessments usually do. This allows them to focus their monitoring efforts on those impacts that are likely to become a problem in the future, which helps narrowing down the discussion.’ In practice, this was carried out through focus groups and expert panels that were gathered to have a look into the future of the reef (Day, 2011).

Transparency of methods

The examples looked at have shown different degrees of transparency with respect to their methodology. The Great Barrier Reef Outlook report, for example, provides a transparent description of the process that took place and the assessment methodology. However, the processes by which the expert task force weighted and made decisions on the final status are not explained (Day, 2011). Other approaches such as Puget Sound, the California Current and Chesapeake Bay provide all information about their indicator
frameworks and methods of integration on the web, even if the user friendliness of the material could be improved (Levin, Batiuk, 2011).

**Scientific rigour**

Although the limited availability of data is regularly pointed out as an obstacle, the importance of using best available scientific underpinnings is crucial (Varanasi, Ruckelshaus, Batiuk). Some cases therefore put a strong emphasis on the use of peer-reviewed evidence in the process (Levin, 2011). Rich Batiuk highlights, for instance, that all the water quality bay health indicators and their target values have undergone independent scientific peer reviews and, have been published in the peer reviewed literature (with the exception of the chlorophyll a indicator for which the manuscript is currently under review) (Batiuk, 2011). In terms of the final selection of indicators for Puget Sound, Levin expresses some concern with regards to the scientific underpinning. Even though they do not reflect the current state of the ecosystem, killer whales were chosen as an indicator. In this case, people’s preconceived notions weighed in the final selection of indicators, and thereby weakened the scientific rigour of the indicator selection (Levin, 2011).

**Presentation of results**

Some of the approaches place a strong focus on presenting their results in a user friendly way. An example is the Great Barrier Reef Outlook Report which was deliberately kept short. It is not a scientific report, although it is supported by a strong scientific basis. The real value of these assessments is to convince decision makers/policy people to make changes. It uses status categories from 1-4. The Outlook report is aimed at the minister and is written in a simple and easy to understand manner with the intent that the minister will actually read it. Following the publication of the report, it has become a very useful document both internally as well as externally by helping to focus the work that the authority carries out and as a basis for requesting funding tailored to its specific goals (Day, 2011). The Puget Sound’s ‘dashboard’ of indicators is another example of clear presentation of information to the public and to decision makers (Varanasi, 2011). The Chesapeake Bay’s assessment stands out by its clear reporting of the 13 main indicators via the website. Background material on the methodology and on each indicator can be accessed on the respective pages (Batiuk, 2011).

**Management measures**

In the Puget Sound, for instance, a discussion on management measures is ongoing at the moment, but the results from the assessment have not yet been fully integrated in policy strategies (Ruckelshaus, 2011). However, the Puget Sound is a unique example in terms of its governance structure (PSP Leadership Council appointed by governor who is behind it, stakeholder groups involved through the Ecosystem Coordination Board), which is engaged and focused on moving ecosystem based management forward and using the results (Levin, 2011). Another approach that stands out is the Chesapeake Bay, where assessment results have been continuously incorporated into the management of the area. Rich Batiuk gives the example of the blue crab fishery, where regulations were changed regarding who is allowed to fish, during which time periods, and which equipment they may use.
As an important prerequisite for this to work, management authorities/decision makers should be engaged in the process from the very beginning, for instance when developing the indicators. They need to be involved in the scientific developments so that they can take decisions more quickly and effectively when necessary (Ruckelshaus, 2011). Policy makers should be asked early in the process what they need to get out of the assessment. They must be given the option to express their needs. This way, the assessment can be adapted accordingly (van den Hove, 2011).

**Stakeholder involvement**

In the majority of the interviews, the early involvement of stakeholders was highlighted as a key factor for the success of an IEA. The various approaches under consideration involved stakeholders to a different degree and in different ways.

In the case of the Great Barrier Reef Outlook, Jon Day states that stakeholders must be involved so that nobody will be confronted with any surprises when the report is published. The results of the assessment are therefore presented to stakeholder groups, such as fishermen, who are encouraged to provide input and additional material in case they object to the results (Day, 2011). In the Eastern Scotian Shelf, stakeholders were actively involved in the development of objectives and indicators, a process that was widely regarded as successful (MacNab, 2011). Phil Levin emphasises the selection of indicators as an important touchstone between science and stakeholders and a good point of contact for them to come together and to get involved at an early stage (Levin, 2011). In the Puget Sound, stakeholder integration was a priority from the first year and throughout the process. The stakeholders were involved in indicator selection and identifying priority strategies for the first few years of ecosystem plan implementation (Ruckelshaus, 2011). But Mary Ruckelshaus also emphasises that it can be useful to start off with a smaller group of stakeholders, particularly if the ecosystem region is large, for the first iteration: ‘Just getting the conservation community and the fisheries representatives to speak to each other is already huge.’ More stakeholders can then be brought in later in the process, she recommends. Ruckelshaus furthermore underlines the importance of holding regular meetings and of finding key representatives from sectors who are open minded. Stakeholder involvement has proven important to build trust and respect among the members and lets personal relationships develop (Ruckelshaus, 2011).

Ruth Brennan, research associate at the Centre for Coastal and Oceans Governance, Scottish Association for Marine Science (SAMS), recalls from the Scottish Marine Spatial Planning (MSP) process that it was important not to create any new structure, but use stakeholder forums that already existed. She also highlights the importance of everybody feeling as though they are part of the process and that the right people are involved. In Scotland, groups that felt excluded joined together against the process and it was difficult to bring them back in. She also advises on the importance of bearing in mind that stakeholder processes take time and that it is of great importance to have a good facilitator to maintain focus and to manage the expectations of the people involved (Brennan, 2011). Another related issue that was frequently highlighted during the interviews is expectation management. Since both stakeholder communities and managers enter the process with very high expectations, it is important to avoid unrealistic expectations from the very beginning (Day, Levin, 2011). Sybille van den Hove also underlines the importance of not involving stakeholders at the ‘end-of-pipe’
when the assessment has already been conducted. They must be brought on board early on in the process on the one hand because they have important knowledge to contribute, and on the other hand because stakeholder buy-in into the process is crucial for its credibility and legitimacy (van den Hove, 2011). Finally, the development of a good communication strategy to keep everyone informed was highlighted as a lesson learned from the work with a number of IEAs (Levin, 2011).

8.3 Evaluation of case studies see Annex I and IV

This chapter presents the evaluation of the 12 approaches chosen for case study. It begins with the key strengths and weaknesses of each approach, followed by a compilation of best practice examples.

- 8.3.1 Summary of findings

Below is a summary of the main findings for each of the approaches presented for case study (See Annex I for the factsheets presenting the full analysis and Annex IV with the overview table of the factsheets). Each summary contains a brief description, followed by an overview of the identified key strengths and weaknesses and the transferability of the approach to the MSFD initial assessment.

i) HELCOM

Developed by: The Helsinki Commission, intergovernmental body composed of the Baltic Sea coastal states and the EU to implement the Convention on the Protection of the Marine Environment of the Baltic Sea Area (Helsinki Convention, 1992), supported by the HELCOM CORESET project.

Location: Baltic Sea

Overview: The strength of this assessment is that the visions, goals and objectives for a better protection of the Baltic Sea are embedded in the Baltic Sea Action Plan and the four thematic assessments. It is clearly stated that the aim to achieve the good environmental status by 2021 at the latest can only be reached through implementation of adaptive management. It is also an ecosystem-based assessment in that it deals with complete systems rather than the analysis or treatment of individual parts or issues. The assessment work is based on reliable data such as monitoring activities carried out by Baltic Sea countries. A confidence assessment was produced for each indicator-based assessment by scoring underlying data, reference levels, and threshold levels through experts. The methodology does lead to an integrated status assessment of the Baltic Sea including anthropogenic pressures, as well as temporal and spatial trends across the different variables. One of the key objectives of all four thematic assessments is to produce targeted and timely assessments for the public.

The objective of the new HELCOM CORESET project (2010-2013) is to develop a set of core indicators for the Baltic Sea that can be used for a follow-up examination of the effectiveness of the implementation of the BSAP. Although not all 11 MSFD descriptors are included yet, the thematic assessments can be easily widened to include pressure indicators.
However, because the assessment is built on the WFD, there may be some difficulty in extending and adjusting these existing indicators to fall in line with MSFD requirements. Although early stakeholder involvement has proved to be important, it has not yet started. HELCOM provides a good overview of its work with the help of reports, an updated website and information papers. Nevertheless it is hard to establish the exact number of indicators used, and in some cases it is unclear whether a pressure indicator is employed or not. Because the assessment is partly based on new tools and preliminary targets and indicators, the results should be interpreted with care.

ii) Eastern Scotian Shelf Integrated Management (Ecosystem Status Report and Social Economic and Cultural Overview Assessment Report)

Developed by: Department of Fisheries and Oceans (DFO), Canada

Location: Eastern Scotian Shelf Large Marine Canada

Overview: The ESS LOMA (Eastern Scotian Shelf Large Management Area) is an important and well developed example of integrated management. However, the management structure developed in an ad-hoc and organic way making its progress difficult to follow. This means that although there is a wealth of information within the Canadian DFO, this information is not all published or made publicly available. Nevertheless, the project does provide some important lessons. It is an example of how assessments can progress, even with limited resources, by developing indicators that use monitoring and data collection programmes already in place, rather than devoting resources to developing new indicators. Although there has been some attempt to summarise findings, the ESSIM is still catching up in reporting the practical activities taking place and the institutional knowledge gained over the last 20 years. This has several implications for the implementation of the MSFD: Firstly, and on a basic level, the lack of transparency means that it is difficult to benefit from the lessons learned in Canada. Secondly, the lack of detail in those documents that are made available, especially regarding the choice and integration of indicators, makes the approach difficult to apply in the context of MSFD implementation. Finally, there is no structured attempt to use information from the indicators to come to an overall conclusion on the status of the ecosystem, a key requirement of the MSFD. The SECOA report takes land-based factors into account, which is relevant for the MSFD as it must work in collaboration with the WFD. Additionally, the process by which indicators are chosen and rated is well described and could be used for the process of choosing indicators for the MSFD. However, it has not yet been implemented and as such, conclusions cannot be drawn as to how this will work in practice.

iii) Great Barrier Reef Outlook Report 2009

Developed by: Government of Australia Great Barrier Reef Marine Park Authority

Location: Great Barrier Reef Marine Region and Ecosystem, Australia

Overview: Overall, this assessment is one of the most developed in the world and has some valuable features for the MSFD, pre-eminently in that it draws clear conclusions on the status of various components and makes them easily comparable. Of note with this
approach is the use of existing evidence to draw conclusions on the status of these components. This is a valuable way to start the ball rolling on the assessment process, which can sometimes stagnate due to the necessity of waiting for new data. However, in order to reach overall conclusions on the sub—groups or on the 8 assessment areas, a small task-force takes decisions based on scientific data available. This reliance on human judgement by experts and stakeholders (although supported by a strong scientific basis) is carried out through a non-transparent process. Secondly, it relies upon the fact that in the GBR, a great deal of monitoring and scientific data is already available in comparison to other marine ecosystems. Furthermore, due to the fact that the goal of the report is not to suggest management actions, it does not propose a clear plan for the monitoring of these components, or indeed the indicators to be used in order to facilitate this monitoring. The GBR Outlook Report provides an important basis for the structure of a truly integrated assessment. Nevertheless, it is likely that the use of expert opinion and existing knowledge will be insufficient for the reporting and monitoring needs of EU member states and this would be an element that would need to be adapted for the implementation of the MSFD.

iv) OSPAR Pilot Approach

**Developed by:** OSPAR

**Location:** OSPAR region (the North-East Atlantic)

**Overview:** In the report of the assessment it is stated: “The pilot assessment provides valuable experience but results need to be treated with caution.” It was a qualitative assessment, trying to use the best available data. Improvement of the methodology is still highly needed. Many human pressures having an impact on the marine environment have been included. The assessment is based on the MSFD list of pressures and therefore covers many of the MSFD descriptors. The assessed ecosystem components and habitat types are however very limited, focusing on 4 ecosystem components and 4 habitat components. Future assessment would need more finely divided ecosystem components and smaller-scaled habitat types as well as a finer scale than the entire OSPAR region. The assessment process is based on a predefined sound assessment methodology. Moreover, the use of an audit trail and documentation explaining the rationale of decisions made increase transparency. The assessment is highly dependent on expert judgment. Cumulative effects were considered to a degree, but the interactions between ecosystem components were not taken into account. For a fully integrated assessment socio-economic and governance indicators must be incorporated. Regarding the transferability to the MSFD, the assessment is too broad in the assessed components and in the spatial scale. The assessment of human pressures however might be transferable to the initial assessment, covering all pressures listed in the MSFD.

v) Ocean Health Index (OHI)

**Developed by:** Conservation International

**Location:** Global with regional focus areas
**Overview:** The assessment is not in use yet and is still in development. Aim to present the first result in spring 2012. Obviously due to the global focus, the scale is very broad but the regional focus area assessment might be of relevance for the MSFD. It aims to provide a truly integrated assessment, providing the world with a new standard of measurement using the best available science and scientific expertise. The assessment takes a comprehensive list of human pressures into account, covering most of the MSFD descriptors. Of particular interest might be some of the developed indicators, especially looking at socio-economic indicators. Interesting but also still in development might be the integrating process. The method of different indicators, being part of goals, again contributing to the overall status could be used in the development of the methodology for the initial assessment of the MSFD.

**vi) REGNS**

**Developed by:** Regional Ecosystem Study Group for the North Sea (REGNS)

**Location:** North Sea

**Overview:** The results of this approach are of high relevance for the scientific community increasing knowledge on the North Sea ecosystem. The assessment gives insights into spatial and temporal trends across many variables, found in the North Sea. However, the coverage of ecosystem components however is limited and only the human induced pressures fishing and eutrophic asion are part of the assessed pressures. Moreover, it is a data-driven approach limited to the available and appropriate time-series of data, which makes it impossible to integrate new indicators into the assessment. Cumulative effects are not taken into account in this assessment. As a result, the assessment is not able to present a fully integrated picture of the North Sea and not applicable to the

**vii) Puget Sound Integrated Ecosystem Assessment**

**Developed by:** NOAA’s Ecosystem Science Program based on Phillip S. Levin et al. (2009) Five-Step-Process of Integrated Ecosystem Assessment,

**Location:** Puget Sound, Washington, USA

**Overview:** The Puget Sound Integrated Ecosystem Assessment constitutes an important example of the implementation of the US approach as it serves as a sort of ‘experimental ground’ for IEAs in the US. ‘If something works here, it will be expanded to other areas’ (Levin, 2011). Based on Levin’s 5-step-method, this approach contains all of the steps necessary for MSFD implementation. Strengths of this approach include the high involvement of stakeholders as well as management authorities/decision makers from the very beginning, e.g. in indicator selection and in the identification of strategies. This was a priority throughout the process and has created trust and respect among different groups involved and significant buy-in from different sides. Further strengths of the approach include its structured yet flexible framework to select ecologically and socially meaningful indicators that are explicitly linked to societal goals. Also, the approach shows strengths in clear communication of its methodology (Puget Sound Science Update) and easily understandable presentation of results to the public and policy makers through a ‘dashboard’ of indicators. In terms of anthropogenic pressures, this
approach is noteworthy due its inclusion of land use and its effects on the marine environment to a large degree. With respect to integration, there is no real integration of overall status taking place in this approach, nor are status categories used for the results. Also, not all indicators have been fully developed yet (human well-being indicators still need to be identified), and the results of the assessment have not yet led to changes in management strategies. It is therefore too early to judge the success of the practical application of this IEA approach in Puget Sound but it is definitely an approach worth following with respect to the MSFD.

viii) Chesapeake Bay Program (CBP), the Bay Barometer’s Bay Health Index

Developed by: The Chesapeake Bay Program (CBP)
Location: Chesapeake Bay, US East Coast
Overview: When requested by the US Government Accountability Office (GAO) in 2005, The CBP partners developed and implemented an integrated assessment approach looking at a number of existing national and international approaches. The result was the Bay Barometer’s ‘Bay Health Index’, an integrated ecosystem assessment approach that answers the question of ‘How is the Bay doing?’ with one overall percentage number. The underlying indicator framework is hierarchically structured and integrates indicators by averaging without weighting, first into 3 top level indices (Water Quality, Habitats & Lower Food Web, Fish & Shellfish) and then into one overarching index of Bay Health. This simple methodology provides highly summarized messaging as requested and utilized by managers and policy makers. The ‘Boiling down’ effect to one single overall status of bay health by averaging has been criticized as a weakness. Also, human pressures are assessed in a separate part of the Bay Barometer (‘Factors Impacting Bay and Watershed Health’) and are not integrated into the ecological components from the ‘Bay Health’ assessment. The above mentioned strengths of the approach make several of its elements interesting to look into with respect to the MSFD.

ix) UK – Charting Progress 2010

Developed by: UK Marine Monitoring and Assessment Strategy (UKMMAS)
Location: UK marine waters
Overview: The UK Charting Progress 2010 was developed as a response to the first Charting progress in 2005. The assessment is an integrated assessment, including not only the biological and chemical status of UK waters, but also the socio-economic status of a broad range of human activities having an impact on the marine waters. All MSFD descriptors are covered by this assessment and it builds on a broad evidence base created through extensive monitoring programmes. Some indicators and monitoring programmes still need to be extended and adjusted in order to be in line with the MSFD requirements. The assessment was developed by various scientists, environmental organisations and industries across the UK. Other stakeholders were included in the final phase of the assessment, to discuss the findings. The results are presented in an easy and accessible way, within maps for each regional focus area. An overall integrated status for each of those areas is however missing. The assessment provides the
foundation for the MSFD initial assessment. It will require to produce a more specific and comprehensive set of practical indicators and targets to increase the quantitative assessment and reduce the reliance on expert judgment. Moreover the current monitoring and surveillance programme needs to be adjusted and in some cases even extended. The current gaps in knowledge need to be addressed, driven by the obligations under the MSFD. Some of the indicators used can serve as a good example to assess some of the MSFD descriptors.

x) Assessment of Estuarine Trophic Status (ASSETS)

Developed by: NOAA

Location: US and EU estuaries

Overview: The assessment has a clear thematic focus and it is therefore not relevant aiming at a fully integrated assessment. Interesting for the initial assessment under the MSFD however, is the methodology of combining pressure, state and response indices in order to generate an overall status of the assessed water body. The integration matrix is a tool possible to use integrating different indicators or components aiming to assess the overall status. It is especially relevant for an assessment following the DPSIR framework.

xi) ERAEF (Ecological Risk Assessment for the effects of Fishing), Australia

Developed by: A research program sponsored by CSIRO (Commonwealth Scientific and Industrial Research Organisation), Australia

Location: Australia

Overview: The ERAEF is a risk analysis methodology focused on hazards generated by activities associated with fisheries. It employs a three-tiered approach to risk assessment. It examines combinations of ecological components and fishery-related activities to assess first qualitatively assess risk, (Level 1), then semi-quantitatively (Level 2) and, finally, fully quantitatively (Level 3). This tiered risk assessment structure allows elements that are not at risk to be eliminated early on, and for the risk to all remaining elements to be assessed in more detail at the next stage. This leads to savings in time and resources, and the close involvement by stakeholders in the assessment process (specifically at Level 1) leads to greater support for results. The assessment methodology's cautious approach to risk, building in a mechanism that automatically assigns high risk to ecological components in case of uncertainty, also ensures that at-risk elements are not mistakenly dismissed due to lack of data. It allows new assessment tools to be 'plugged in' at any level in the hierarchy as needed, as levels are not defined as tools in and of themselves, but by the degree of complexity and the data requirements. The entire process is documented, including the rationale for risk scores, allowing for transparency and review in case of disputes. The methodology’s weakness lies in its use of qualitative risk assessments in the initial stages, as a lack of proper training in the methodology can lead to deviations in the risk scores assigned by stakeholders. Further, it was found that up to three training sessions were required before stakeholders were comfortable with the approach due to its scope and complexity, as well as its rather specific terminology.
xii) Indonesia

Developed by: Nature Conservancy (TNC), Conservation International (CI) and World Wildlife Fund (WWF)

Location: Raja Ampat, Indonesia

Overview: The assessment process is led by NGO partners who, in the absence of government action and with strong stakeholder interest, have taken the process forward. Therefore stakeholder involvement appears to be at high level. The assessments appear to take social and biological factors into account, however, there is no information as to whether there is a formalised framework available for analysis. In general, there is not enough evidence of this assessment to establish whether it can be used for the MSFD. However, some of the assessments carried out may well provide interesting information on assessment techniques and there may be lessons to be learned on stakeholder involvement processes.

- 8.3.2 Best practice

During the evaluation of case studies, no single approach was found to be fully satisfactory on all fronts. The following section therefore covers examples of best practices extracted from the case studies. The schema follows the key elements of an IEA (as identified in 8.1.2). For each key element, the approaches seen as exemplifying best practices are outlined. We have not identified best practice examples for the key element ‘data and information’ based on the lack of detailed information available in most approaches.

i) Indicators

Indicators are a key element of an IEA. Those assessments that developed or used indicators in a particularly interesting way, those which incorporated status and pressure indicators (human pressures) as well as those which took socio-economic indicators into account were considered to be examples of best practice.

- ESSIM

The initial process for the Ecosystem Status Report of the Eastern Scotian Shelf of Canada was to arrive at a concise list of strategic indicators that should be measured and reported against. However, it was subsequently decided that monitoring a large suite of indicators was impractical and that resources were not sufficient. The decision was therefore taken to make best use of existing indicators thereby accessing longer time-series data and saving resources. In the SECOA report, the development of indicators is of particular interest. The planning group identified 270 indicators of human use factors along with the indicators, themselves. The viability of indicators was tested based on criteria including quality of data in relation to cost, availability and reliability. The indicators were then designated as a Level 1 (adequate and no significant cost), Level 2
(feasible but investment needed), and Level 3 (no current data nor immediate intention to collect data). A mixture of qualitative and quantitative indicators were analysed for use in the assessment. No information is given as to whether the indicators measure state or pressure and full assessment using these indicators has not yet taken place.

**UK**

The UK approach includes indicators that cover all qualitative descriptors for determining Good Environmental Status under the MSFD. Some indicators and monitoring programmes still need to be extended and adjusted to be fully in line with the MSFD requirements, but the assessment will form the foundation for the initial assessment required under the MSFD.

**HELCOM**

The main basis for the HELCOM monitoring strategy is the Baltic Sea wide adjustment of indicators to ensure suitability for the implementation of regional and European guidelines respectively provisions. At the same time Member States should be enabled to use HELCOM data and information for national purposes and for reporting commitments. HELCOM developed environmental goals and indicators that already cover most of the parameters mentioned in the annexes I and II of the MSFD. In 2003 HELCOM (as well as OSPAR) decided to outline overarching ecological goals and special environmental goals and indicators to define the GES in accordance with activities on the global, European and national levels. First, strategic goals were defined. Following this, ecological objectives, so called EcoOs, and management objectives as well as short-, mid- and long-term environmental goals and indicators were allocated. These indicators have been developed continuously within projects and thematic assessments with constant regard to the GES and MSFD.

**Human pressure indicators**

A key element of an IEA is to include both state and pressure indicators. Assessments were considered to be examples of best practice where the inclusion of human pressures constitutes a core part of the assessment and is well integrated into the overall status. Of special interest was the consideration of land-based or coastal pressures due to the impact on the marine region.

**Examples of best practice:**

**HELCOM**

For the first time in an assessment of a regional sea, HELCOM seeks to identify and rank all of the relevant pressures and their impacts by special indices. The Baltic Sea Pressure Index (BSPI) and the Baltic Sea Impact Index (BSII) are used in the HELCOM Initial Holistic Assessment for estimating the quantity and geographical distribution of anthropogenic pressures (BSPI) and their potential impacts (BSII). The BSII grouped 52 data layers of anthropogenic pressures. The pressures were grouped under pressure categories according to the list in Annex III of the EU MSFD. The selection of the pressures is based on (1) the relevance to the marine environment, (2) data coverage, and (3) data quality. Since the assessments of the status of the Baltic marine ecosystem have been based on classification methods from the EU WFD, HELCOM partly integrates coastal areas and areas covered by the WFD.
The OSPAR Pilot assessment was based on the list of ecosystem components and pressures listed in Annex III of the MSFD. Where the ecosystem components amounted to an unsuitable level, the focus was laid on the pressures. 22 pressures were assessed on their impacts on the ecosystem components. Key pressures of human activities, likely to be responsible for the observed trends could be identified, based on that assessment. Moreover the total impact form each pressure was tried to assess.

The OHI includes a broad range of human pressure indicators in the draft list of indicators. This is especially interesting as it takes into account some more recently identified pressures such as light and noise pollution, species invasion and plastic debris.

A special feature of the assessment in the Puget Sound is that it does not look at the marine area in isolation, but takes the land-sea connection into consideration. Pressures from land use as well as from fresh water sources are included in the suite of indicators. This might lead to the development of more targeted and more effective management measures.

**Socio-economic indicators**

*Socio-economic indicators are part of fully integrated ecosystem assessments. Because not many assessment do take them into consideration yet, all assessments which integrated socio-economic aspects are identified below.*

ESSIM provides a SECOA report covering socio-economic factors. It is intended that at some point these components should be fully integrated and then integrated with the regional ecosystem status assessments. However, this has not yet been put into use and as such the suggested list may not be practicable.

**Great Barrier Reef**

The GBR assessment takes socio-economic factors such as fishing and shipping into account throughout the report and 4 additional pressures are also assessed: Climate change; Coastal development; Catchment runoff; and Direct use (including all commercial and non-commercial activities). Each pressure is rated separately for its impact on environmental, societal and economic values.

**Ocean Health Index**

The OHI aims to include several socio-economic indicators. Especially for the goals ‘Cultures and traditions’ as well as ‘Coastal livelihoods, several socio-economic indicators have been developed. Iconic species, landscapes, and other cultural values are part of the indicators.
Until now HELCOM has had no specific socio-economic indicators, instead providing information on the costs and benefits of taking action to obtain indications of economic profitability and to improve future decision-making. The estimations rely on available data and models, and have been published in two studies. Fishing and hunting have been identified as specific pressures causing biological disturbances within the BSPI. However, only ecological issues are taken into consideration. Within the HELCOM CORESET project it is planned to contain specific sections on the human footprints on the marine ecosystem and socioeconomic aspects in the area.

**MSFD descriptors**

*With regard to the transferability to the MSFD, best practice assessments were identified that covered most of the MSFD descriptors.*

*Examples of best practice:*

- **UK**

  The UK assessment covers all MSFD descriptors, as indicated in the Charting progress report. While some indicators are still in development, many of the already-developed indicators can serve as example of good practices. It is stated that the assessment provides the foundation for the initial assessment of the MSFD that will occur in 2012. Improvements are however required, including the production of a more specific and comprehensive set of practical indicators and targets to increase the quantitative assessment and reduce reliance on expert judgment.

- **HELCOM**

  The HELCOM approach to measure pressures and impacts follows the pressure classification of EU MSFD and serves the HELCOM Contracting Parties to produce the initial assessment of MSFD of the state of their marine areas. Until now, the BSAP ecological objectives have lacked reference to underwater noise, marine litter, hydrographic alterations and most of the pressure-related criteria of the 11 descriptors, but still provided many data layers that serve as example of good practices. Above all, HELCOM provides a great deal of information on the implementation of the MSFD with regard to the GES discussion, specifically: (1) new quantitative evaluation methods for eutrophication, biodiversity, hazardous substances and holistic assessments, and (2) ecological goals, distinct environmental targets, indicators and Indicator Fact Sheets including Red Lists on endangered or threatened species as well as invasive species for the sub-region Baltic Sea.

**ii) Integration/Overall Status**

*This key element refers to the overall integration of all available data and indicators. This may include a summary of the integration as a single overall status. Best practice case studies have been listed where the methodology worked well (i.e. considers and weighs all different element) or is especially interesting.*

*Examples of best practice:*

- **HELCOM**
1. Within HOLAS the Baltic Sea Impact Index (BSII) has a weighting score to transform a pressure to a potential impact on a specific ecosystem component. The score was produced with the help of an expert estimation of the "weights of the anthropogenic pressures". Three categories were used: functional impact of the pressure on an ecosystem component, resistance of that ecosystem component against the pressure, and recovery time of that ecosystem component after the pressure. The criteria were based on the method by Halpern et al. (2007). The first criterion describes the pressure while the latter two criteria describe the ecosystem component. In many cases, the latter two criteria are more useful in determining the final weighting score. Moreover, there may arise several questions when transforming pressures to impacts. Therefore, the criteria should be seen primarily as guidelines for consideration. The experts provided boundaries of the criteria (values).

2. Within the thematic assessment of eutrophication (HEAT) exist four equally weighted groups called quality elements. The HEAT tool used two integration methods: weighted averaging of indicators within thematic groups as well as the one-out-all-out principle for the status among the four thematic groups based on the poorest thematic class. Thus, the integration did not use the OOAO principle in its strictest sense.

3. The HELCOM thematic assessments and the holistic assessment use five distinct statuses in the classification of the thematic groups and in the final classification following the EU WFD and using the so-called traffic light visualization.

- **Chesapeake Bay**

The CBP’s Bay Health Index is an IEA that integrates component indicators stepwise, first into three top-level-indices (Water Quality, Habitats & Lower Food Web, Fish & Shellfish), and then into an overall status, the overarching index on Bay Health. Integration takes place by averaging. To make this possible, quantitative goals have been set for most of these indicators and indicator values are converted to a common score of “percent of goal achieved”. Percent achievement values for each indicator are averaged to create the top-level-indices, which again are averaged to create the overarching index score. The approach gives equal weight to each indicator. This simple methodology provides highly summarized results as requested and utilized by managers, policy makers and the public. It must be mentioned, however, that concern has been voiced about boiling down information in an oversimplified way which might be misleading. Some of the Chesapeake Bay Program’s partners were uncomfortable with publically reporting the ‘averaged’ integrated indices. In a recent decision it was therefore determined to no longer report on these overall indices in the Bay Barometer publication (Batiuk, Sylvester, 2011).

- **Assets**

The assessment is based on the Pressure-State-Response model, deriving an Overall Eutrophic Condition index (OEO), which is associated with a measure of Overall Human influence (OHI), and the Definition of Future Outlook (DFO) for each water body. For the overall evaluation, those indices are combined. There are five possible grades for each index. The individual classifications are then combined to provide an overall grade. A combination matrix is used, showing all possible combinations of the individual
classification for every final category. The overall categories are High, good, moderate, poor or bad eutrophic condition.

- **Great Barrier Reef**

Although the GBR does not use indicators, it comes to conclusions about the overall status of the ecosystem. However, the weighting takes place between experts who use their judgment and understanding of the ecosystem to determine its health according to different sources of evidence. It is therefore less transparent than other methods. On the other hand, it does appear to be able to take many, often unmonitored factors into account, where scientific studies may have been carried out, but no longstanding datasets exist. Therefore, the weighting and integration takes place using a less rigorous but potentially more holistic methodology.

- **Ocean health index**

The OHI is structured around 10 goals. The identified indicators are also categorized into these goals. The indicators ought to assess the status relative to reference values, reflect recent trends, near-term vulnerability to stressors and longer-term sustainability. Different weights of the indicators determine its relative importance to each goal, so that the state of each goal is expressed as the composite value of its weighted indicators. The goals again will be weighted for their contribution to the overall index. The 10 goals however are comparable to the MSFD, which then again would need to be integrated into one overall status, comparable to the OHI. The methodology is not yet fully developed, but once it is finished it might be transferable to the MSFD assessment.

### iii) Cumulative effects

A key element of an IEA is to take cumulative effects into account. Because no assessment examined has yet been able to take them into consideration, the assessment that tries to assess and integrate the cumulative effects is given as an example of a first approach.

- **HELCOM**

The impact index is a combination of BSPI and BSII. Within the HOLAS assessment, the combined BSPI and BSII bring together all available data layers relevant to human uses and pressures and rates their impacts on the marine environment for the first time in the Baltic Sea region. The sum of all the potential pressures throughout the Baltic is visualized by the Baltic Sea Pressure Index (BSPI) without taking into account their impacts on the marine environment. The first purpose of the exercise is to produce a cartographic representation of human pressures in the whole sea area. There are two approaches to make the index. First, the presence/absence index of different pressures and second, the quantitative index of different pressures which is more sensitive to spatial differences. The Baltic Sea Impact Index (BSII) is a tool to estimate potential anthropogenic impacts on the marine ecosystem. The purpose of the BSII approach is to assess which areas of the Baltic Sea are sensitive to anthropogenic pressures. This tool is thus based on the spatial distribution of species, biotopes and biotope complexes in addition to the sum of anthropogenic pressures. It should be noted that BSPI and BSII were demonstrated for the first time in this assessment.
iv)  Risk analysis

A risk analysis is one step in an integrated ecosystem assessment. It is a flexible process for analysing data, information, assumptions, and uncertainties to evaluate the likelihood of adverse ecological effects. Best practice case studies have been identified where a risk analysis was part of the assessment.

Examples of best practice:

- ERAEF

The ERAEF methodology is a pure risk assessment approach on fisheries based on a three-tiered scheme with increasing demands for data as one progresses through the hierarchy. This tiered risk assessment structure allows elements that are not at risk to be eliminated early on, and for the risk to all remaining elements to be assessed in more detail at the next stage. This leads to savings in time and resources, and the close involvement by stakeholders in the assessment process (specifically at Level 1) leads to greater support for results. The assessment methodology’s cautious approach to risk, building in a mechanism that automatically assigns high risk to ecological components in case of uncertainty, also ensures that at-risk elements are not mistakenly dismissed due to lack of data. The entire process is documented, including the rationale for risk scores, allowing for transparency and review in case of disputes.

- Puget Sound

In the Puget Sound, status and risks of indicators are evaluated and reported each year. The risk analysis is conducted linking threats, drivers, pressures, states, impacts, and responses (following the DPSIR approach). Susceptibility is assessed via a full inventory of the status and threats of key indicators. A simple spatial analysis of threats is conducted. Resiliency is defined by using ecosystem models.

- OSPAR

Although OSPAR may be an example of best practice as it takes a risk-based approach throughout, it is not clear how it does this.

- GBR

The section on risks touches on cumulative effects, since an individual risk does not happen in isolation but together with all the other risks. It is hoped that more ways of exploring this will be built into the next Outlook Report.

v)  Treatment of uncertainty
The robustness and reliability of data used in the assessment shows high variation. Moreover marine research and monitoring varies hugely in its spatial and temporal coverage. Based on that, a treatment of uncertainty is a key element for an IEA. Best practice examples were identified where a methodology was adopted to take this uncertainty into consideration in the assessment.

Example of best practice:

- **UK**

In the UK assessment a framework for assigning ‘confidence’ to each assessment was adopted, based on that used by the Marine Climate Change Impacts Partnership (MCCIP) and the Intergovernmental Panel on Climate Change (IPCC). The framework brings together an evaluation of the amount of data and information available at the right spatial and temporal scale and an assessment of the ‘degree of consensus’ about what the data mean. The confidence level has been allocated High, Medium or Low and is clearly indicated in the results of the assessments.

- **OSPAR**

For the OSPAR approach the level of confidence was determined for each assessment of impact. The assessed confidence level is presented in the results. The summary of the results even omitted the status assessments with low confidence.

vi) **Forecasting / future trend**

An IEA should result in an assessment of both status and trends. Best practice examples were identified where future trends were taken into account and attempts were made to forecast how the current situation would develop.

Examples of best practice:

- **UK**

Within the UK assessment both status and trend are indicated for each component where sufficient data is available. Trend arrows are used in the summary tables and maps to indicate whether the state of the component over time is improving, deteriorating or remaining stable. In some cases, this is based on trends since the first Charting Progress in 2005, but in others, longer timeframes have been used and this is clearly set out in the individual Feeder Reports.

- **HELCOM**

The assessment provides information about the current status of biodiversity and positive/negative trends for selected species in the different sub-regions of the Baltic Sea. Furthermore, the collected data allow for more in-depth reporting on signs of change and deterioration. A Baltic-wide overview of the conservation status of biodiversity (for the years 2000-2006) in the different sub-regions presents an estimation of favourable (green) or unfavourable (red) conservation statuses among different elements of biodiversity based on the information compiled into the assessment report and on expert judgement. These estimations are related to future trends, as the underlying Indicator Fact Sheets include temporal trend indices based on the series
maps. However, the upcoming new indicator CORESET will consider the possibility for trend analysis in more depth since until now qualitative recommendations for future goals within the BSAP are the main focus of forecasts.

- **OHI**

The OHI aims to incorporate the current status and the likely future status in the overall status. This is the only example where status and future trend are integrated into one status. The MSFD does not aim at this combined status and trend result. It is however worth considering simplifying the assessment of both, status and trend.

**vii) Transparency of methods used:**

This key element refers to the transparency of the assessment process. Best practice examples were chosen where the process was made clear and those who were involved in the process were identified.

Examples of best practice:

- **OSPAR**

A consistent assessment framework was used across ecosystem components and OSPAR Regions, following specified assessment criteria and threshold values and leading to a clear assessment of status. Transparency was increased by the use of an audit trail during the process.

- **Great Barrier Reef**

The GBR assessment is very clear about the persons involved in the development of the report and the use of external reviewers for the chapter on management effectiveness. There is a clear description of the process that took place and the assessment methodology. However, the processes by which the expert task force weighted and made decisions on the final status are not made obvious. Nevertheless, this is somewhat compensated by the fact that there is a concerted effort to involve stakeholders through various consultations.

- **HELCOM**

The assessment process is clearly outlined in the five thematic reports feeding into the HOLAS report (2003-2007). For instance, the reports present information about the grouping of anthropogenic pressures under pressure categories and associated pressure data layers. The standard methods for monitoring are defined in the COMBINE Manual and regularly updated and revised. Guidelines and reporting forms for specific areas like the monitoring of the waterborne pollution load provide clear instructions. The HELCOM website offers access to all meetings and associated documents, as well as manuals and guidelines. Furthermore, notices on the progress in the HELCOM CORESET project are regularly published. Here, for example, information on the classification methods in thematic assessments are outlined.

- **Puget Sound**

In the Puget Sound, a structured yet flexible framework has been employed for the selection of ecologically and socially meaningful indicators. All information regarding the
methodology of selecting and evaluating indicators as well as the definition of reference levels is openly available on the web (Puget Sound Science Update). The user friendliness of the material could however be improved.

- Chesapeake Bay

The Chesapeake Bay Program also provides all information about their indicator frameworks and integration methods as well as detailed information on each indicator including data sources and data files on its website. Also in this case, the material could be presented in a more user friendly way.

viii) Scientific rigour

*Scientific rigour refers to a robust evidence base for the assessment. This evidence base can either be quantitative, building on extensive use of scientific data, or also qualitative, including expert judgment. The criteria for this element are a solid, robust scientific basis.*

Examples of best practice:

- HELCOM

The HELCOM assessment can be deemed scientifically rigorous based on its methodologies, very broad data sets, and expert involvement. Since it is a political instrument of all Baltic States it must regularly publish scientific results via reports and websites. For instance, two integration methods exist: weighted averaging of indicators within thematic groups as well as the one-out-all-out principle for the status among the four thematic groups based on the poorest thematic class. A confidence assessment was produced for each indicator-based assessment and expert questionnaire investigation with the Contracting Parties to make an expert estimation concerning the “weights of the anthropogenic pressures”. Furthermore, measurements are performed over several decades by internationally accepted standard methods (HELCOM’s COMBINE manual), performed in regular intervals and with continuity in the future. The Indicator Fact Sheets must be scientifically sound and written in plain English. They should be based on time series and trends to greatest possible extent, so that changes in pressures and/or states can be evaluated. The reviewing procedure of the Indicator Fact Sheets is organized by the Secretariat and includes the review by national experts appointed by HELCOM MONAS Contacts.

- UK

The UK Charting Progress is based on a broad evidence base building on an extensive monitoring programme. The assessment is based on the evidence of peer-reviewed sector reports that have been agreed upon by the UK Government and the Devolved Administrations after consultation with representatives of the other contributing organisations and stakeholders. Expert judgment was applied in areas where a robust database is missing. Due to variation in robustness and reliability of some indicators, a framework for assigning ‘confidence’ to each assessment was adopted. Gaps in knowledge have been identified and indicated in the assessment.

- Puget Sound
From the very beginning of its implementation, the Puget Sound approach has had a high degree of emphasis on scientific rigour. A structured yet flexible framework was used to select ecologically and socially meaningful indicators which are explicitly linked to societal goals. Thirty leading scientists were involved in the process of selecting indicators. As the science develops, the list of indicators will be reviewed and revised on a yearly basis. A panel of 9 leading scientists is one of the three main bodies of the Puget Sound Partnership providing expertise and advice. NOAA has been leading the introduction of the assessment process and will continue to provide technical support to the Puget Sound Partnership in the future. The first iteration of the IEA was based on a mix of expert information and quantitative analyses (e.g., food web modeling for identifying indicators). Subsequent iterations will include more quantitative assessments and modeling. Also interesting to note is that the scientific basis for each step of the IEA is documented in a live, wiki-based document called the Puget Sound Science Update (PSSU). This web-based state-of-the-science synthesis aims at ensuring that credible science about the lands, waters, biota, and human social systems within the Puget Sound basin is used transparently to guide strategic policy decisions.

- **Great Barrier Reef**

Although it does not solely rely upon the monitoring and measuring of indicators, the GBR is well founded on scientific evidence, as illustrated at the end of each chapter of the report. Indicators are not used as it was determined that these may prove unreliable. Instead, the approach maintains that the assessment of broader components is more successful as it can adapt to use the latest or best indicators available for monitoring a particular component.

**ix) Presentation of results to policy makers and the public**

*Essential for an IEA is the presentation of the results to decision and policy makers. Best practice examples have been identified where this is conveyed in an easily understandable and suitable way and includes graphical presentation of results.*

*Examples of best practice:*

- **Great Barrier Reef**

The GBR presents an excellent example of how results can be presented in an understandable way that is both useful for policy makers and public dissemination, but which is underpinned by a broad scientific basis. The decision was taken to include the scientific reference s used at the end of each chapter, meaning that the evidence is transparent and available to those who wish to use it, but does not occlude the key messages which are presented as an overall status ranging from very poor to very good.

- **Puget sound**

The Puget Sound IEA works with a so-called ‘dashboard’ of 20 indicators to provide a snapshot of the overall health of the Sound. These ‘dashboard’ indicators are easily understandable by the public and by decision makers and provide clear visibility of certain trends. Each of these indicators serves as a lead indicator for a ‘family’ of
underlying indicators. The PSP will likely continue to monitor a larger number of indicators (roughly 100). The ‘dashboard’ provides an early warning of negative trends so that management measures can be adapted quickly.

- **Chesapeake bay**

Similar to the Puget Sound approach, 13 component indicators were chosen as main ‘reporting’ indicators for the CBP's Bay Health (further indicators provide more detailed information but are not included in the presentation). The scores for these indicators and the results for the integrated top-level-indices are presented visually by charts in a very user friendly way on the website. Background material on the methodology and on each indicator can be accessed on the respective pages. The main messages of the assessment are additionally compiled in a brief report, the Bay Barometer Executive Summary, which can be downloaded as a pdf from the website.

- **UK**

The results of the UK assessment are presented in a clear and accessible way, easy to understand. Regional maps have been developed, indicating the habitat types and the status assessment for all components assessed. Three of the individual assessments use a traffic-light system indicating ‘Few or no problems’, ‘Some problems’ and ‘Many problems’. The assessment on the productivity gives the gross value added. Trends are also indicated where possible.

- **HELCOM**

In the case of HELCOM, results are presented in reports for each thematic assessment and the two pressure indices. These are easy to read with a good amount of explaining figures, pictures and tables. Graphs are easily comprehensible with proper scales and legible fonts and understandable without disturbing the text. Authors of the Indicator Fact Sheets are asked to provide temporal trend indices instead of a series of annual maps, and only maps referring to the most recent year should be presented. Several reports offer solutions, cost-benefit analysis, conclusions and outlooks guide policy makers and administrative bodies. Key messages are short and arouse interest.

**x) Stakeholders**

The involvement of and consultation with stakeholders is a key element of an IEA. Especially relevant is at which stage of the process stakeholders have been included and what kind of stakeholders these are.

Examples of best practice:

- **Puget sound**

From the very beginning stakeholders as well as management authorities/decision makers have been highly involved in the assessment process, i.e. in the definition of a healthy Puget Sound ecosystem, the selection of indicators, the development of recovery targets and in the identification of priority strategies. Additionally, a large number of stakeholders are involved with developing technical background material for the target setting and input from the public is encouraged. The NOAA regular decision making
process in the case of Puget Sound includes 12 sectors integrating the different parts of the system. The involvement of stakeholders has created trust and respect among different sectors. Involving policy makers from the very beginning enables them to take quick and effective decisions when needed.

- **Indonesia**

In Indonesia, stakeholders were consulted before the assessment took place and were involved in the assessment to determine issues within the marine areas. However, this assessment occurred under the auspices of the three NGOs leading the process that, due to lack of funding, may have been more reliant upon such informal sources of information. The involvement of stakeholders from the beginning of the process means that they are now motivated and involved in the monitoring and management of the subsequent actions that have been taken to deal with issues raised in the assessments.

- **Chesapeake Bay**

Stakeholders have been involved in the IEA process via the CBP partnership from the beginning. Stakeholders represent organizations ranging between federal and state agencies, local governments, non-profits and academic institutions as well as scientists, the business community and citizens. An example for their participation is in the determination of indicators and target values. Recommendations are provided through their involvement in various committees and subcommittees of the CBP.

- **GBR**

A strong government and community interest in the GBR was an incentive for broad ranging engagement and advice mechanisms. During the initial stages, community workshops were held to learn about changes to the Great Barrier Reef by listening to community members’ stories of the past. In addition, an Outlook Forum attended by 42 participants including scientists, leaders from industry, interest groups and the community and government representatives developed likely ‘outlooks’ for the Great Barrier Reef. Four issues-based Reef Advisory Committees were also engaged in the process. The GBRMPA places a strong emphasis on community engagement, consultation and participation. The Queensland Government also has a range of advisory and engagement mechanisms that include consideration of Great Barrier Reef matters, including fisheries Management Advisory Committees and the State-wide Tourism Industry Forum. These committees were not engaged as part of the development of the Outlook Report but may provide an avenue for input to subsequent reports.

**xi) Management measures**

*A key element of an IEA is adaptive management. Best practice examples were identified where the results of the assessments fed into management measures.*

*Examples of best practice:*

- **Chesapeake Bay**

The results are continuously incorporated into the management of the area. Strategies have evolved in the past based on the assessments. The blue crab fishery regulations
are an example where changes have been made with respect to who is allowed to fish, when and with which equipment. In this case, the management measures seem to have proven successful with healthy levels of blue crab abundance achieved in 2009. Also, the integrated assessment was utilized in gaining Presidential focus on the Chesapeake Bay and was referred to in many documents associated with the Presidential Executive Order 13508.

8.4 Requirements for integrated assessment concepts

Based on the analysis of the scientific literature, working group paper, the cases studies as well as on a number of interviews, we have compiled a collection of requirements with respect to the development on an integrated ecosystem assessment.

Indicators

- Make best use of indicators, monitoring programmes and expertise already in existence.
- Include both state and pressure indicators.
- Take resource restrictions and feasibility into consideration when selecting indicators.
- When developing new indicators, consult integrated approaches from other regions.
- Focus on strategic indicators which can act as a bellwether for underlying changes in the ecosystem.
- An initial assessment should include indicators for each MSFD descriptor.
- Consult with stakeholders when selecting indicators.
- Ensure indicators are relevant to policy goals.
- Avoid working with too many indicators.

Human pressure indicators

- Consider all human pressures having an impact on the ecosystem, both at sea (e.g. fishing) and from land-based sources (e.g. run-off).
- Start a coordinated database on the anthropogenic pressures as soon as possible
- Be aware of the very few databases for single pressures

Socio-economic indicators
- Include indicators that measure the social, cultural and economic use and value of the ecosystem.
- Design a framework that can be broadened in order to cover more than just the ecological dimension (be prepared for to integrate socio-economic and governance aspects)

**Integration / Overall status**
- Indicators should be integrated within each descriptor for descriptor status, and across all descriptors for the overall status.
- Choose an assessment approach that integrates, or can be broadened to integrate socio-economic and governance indicators.
- Consider the possibility of weighting indicators and descriptors according to their significance.
- Both pressure and state indicators must be integrated.

**Cumulative effects**
- Take cumulative effects into consideration.
- Expand scientific understanding with regards to cumulative effects.
- Use expert judgement to increase understanding of cumulative effects where scientific data is not available.

**Data and information**
- Do not let a lack of data hold back the assessment process: start with data that is available.
- Make use of time-series data and other information already available from existing monitoring programmes.
- Use a methodology that allows new data to be incorporated as the assessment process develops.
- Move towards a more quantitative approach, but make use of qualitative data where necessary.
- Use expert judgement to complement other data sources.
- Coordinate with nations that share the marine region, streamlining data collection and monitoring.
Forecasting / future trends

- Include future trend analysis, evaluating past management measures and showing the need for additional management measures.
- Take future trends into account, either integrated with status as part of the overall result, or separated from status, indicating trends.

Risk analysis

- Use risk-based approaches to ensure that the precautionary principle is observed.
- Prioritise indicators and monitoring based on risk analysis.

Treatment of uncertainty

- Carry out confidence assessments indicating the robustness of information sources.
- Make confidence ratings clear in the presentation of assessment results.

Transparency of methods

- Provide transparent and accessible information on the management process and assessment methodology.
- Make data and academic information used in the assessment publicly available.
- Ensure there is a clear audit trail showing decision-making processes

Scientific Rigour

- The assessment process should always make use of best available science:
  - use peer-reviewed information as the basis of the assessment
  - use a methodology that is scientifically sound
- Use qualitative sources such as expert judgment or indigenous knowledge to complete a holistic understanding of the ecosystem.
- Identify knowledge gaps and support scientific development in these areas.

Presentation of Results

- Present results in a format that is accessible to both policy makers and members of the public.
• Include a graphical presentation of results showing status and trends.
• Set up a user-friendly web interface that allows public access to the results, including the assessment methodology and underlying information.

Management measures
• Management systems should be adaptive and allow for new information from assessments to be integrated into management strategies.
• Each status category should imply a clear management strategy.
• Clearly define and structure targets and goals.
• Uncertainty in assessment results should not impede management measures as long as these are in line with the precautionary principle.
• Consider potential impediments to the implementation of the assessment.
• Feed scientific activities and new developments into management systems on a regular basis.

Stakeholder involvement
• Include all relevant stakeholders from the beginning of the assessment process and not after the assessment has been carried out.
• Make use of stakeholder forums that already exist and keep the process open to new stakeholder groups.
• Policy makers and managers should be involved from the outset and should make their assessment needs clear.
• Local stakeholders should share information on their use and value of the ecosystem.
• Establish a communication strategy that is targeted to each stakeholder group.
• Keep channels of communication open and provide regular updates to stakeholders.
• Manage expectations of stakeholder communities, managers and decision makers from the outset.

9 Applicability of the WFD to the MSD

9.1 Comparison and mismatches between WFD and MSFD
Two overlapping directives exist in European coastal and marine waters: the WFD and the MSFD. This brings some confusion in quality status assessment. To ensure coherence and comparability between Member States and the various sea regions, the aim is to make these two directives compatible. Given the experience gained through the implementation of the WFD over the past decade, we will outline below how that experience could benefit the implementation of the MSFD. In this context the data and assessments carried out by the Regional Seas Conventions like OSPAR, HELCOM and Barcelona support a coherent approach when implementing the steps to reach the good environmental status within the MSFD. They are also compatible with the WFD classifications since these assessments of the status of marine ecosystems have been based on classification methods used in the WFD (Korpinen 2010, Wenzel 2009).

However, when comparing the two directives, potential mismatches can be expected and the type and quantity of variables that are assessed (table 9).

Table 9 Main concepts within the Water Framework Directive and the Marine Framework Directive (adapted from Borja et. al 2010)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Spatial application</td>
<td>Estuaries and coasts (baseline – 1nm)</td>
<td>From baseline to 200nm</td>
</tr>
<tr>
<td>Overarching aim</td>
<td>Function and quality of ecosystems</td>
<td>Efficient ecosystems supporting the sustainable use of the sea and conserving marine ecosystems</td>
</tr>
<tr>
<td>Objectives</td>
<td>Good ecological and chemical status – small deviations in reference conditions</td>
<td>Good environmental status – overall state of the marine environment</td>
</tr>
<tr>
<td>Status levels</td>
<td>High, good, moderate, poor, bad</td>
<td>Good, not good</td>
</tr>
<tr>
<td>Good status achieved by</td>
<td>2015</td>
<td>2020</td>
</tr>
</tbody>
</table>
| Elements (WFD) or qualitative descriptors (MSD) to be used in assessing the ecological status | Quality parameter:
- Physico-chemical
- Hydro-morphological
Biological:
- Phytoplankton
- Macroalgae
- Phanerogams
- Macroinvertebrates
- Fishes only in transitional waters | 11 descriptors:
1. Biodiversity
2. Non-indigenous species
3. Exploited fish and shellfish
4. Food webs
5. Eutrophication, human-induced
6. Sea-floor integrity
7. Hydrographical conditions
8. Contaminants
9. Contaminants in fish
10. Marine litter
11. Introduction of energy/noise |
| Ecological differences | Integration of each element | Ecological integrity |
In the following the main differences will be shortly outlined. Hereby we will compare the following issues:

- Comparison between the European Directives’ objectives
- Comparison between the spatial applications
- Comparison between management units
- Comparison between water and environmental status
- Good Water Status
- Assessment obligations

Comparison between the European Directives’ objectives

Similarities

Both directives aim to create harmonization of previous fragmented policies.

In accordance with the waters in question, both directives require maintaining or achieving a target status by reducing impacts that adversely affect the environment.

The measures aiming to achieve that status can be chosen by the Member States.

Both directives give a clear and ambitious time frame within which the target statuses should be achieved.

Differences

Regarding the target status, the WFD aims to achieve ‘good ecological status’, while the MSFD aims to achieve ‘good environmental status’.

The MSFD in particular emphasises the need for coherence across the marine.

The management approach of the Member State espouses the concept of regional cooperation within marine regions. The division of the European marine environment into marine regions is based on their hydrological, oceanographic and biogeographic features. The MSFD identifies four marine regions for the European Community: the Baltic Sea, the Northeast Atlantic Ocean, the Mediterranean Sea and the Black Sea (Box 7).

Box 7: Key approaches of the European directives

<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>River basin management</td>
<td>Marine regions</td>
</tr>
<tr>
<td>A river basin is a natural geographical and hydrological unit of the aquatic environment, consisting of the expanse of land through which all rivers and streams flow, acting as a funnel towards one sea area, and is</td>
<td>Due to the transboundary nature of the marine environment, the European sea region was divided into four marine regions. The division was based on hydrological, oceanographic and biogeographic</td>
</tr>
</tbody>
</table>
called a catchment area or river basin. A river basin therefore reflects a naturally occurring management unit, regardless of national boundaries. A river basin district can be the river basin of one single river or an area that includes the catchment areas of several smaller rivers or streams.\(^\text{30}\)

**The concept of a combined approach**

In the past, there have been two different approaches to pollution control.

- **The Emission Limit Value approach**, focusing on the sources of pollution, tried to exercise control by applying regulatory standards and a permitting regime, thereby limiting the quantity of discharge.

- **The Water Quality Objective approach** focuses on the immission side, reflecting the quality of the receiving water environment.

The WFD adopted a ‘combined approach’, of both emission limitation by means of source control and the quality objectives on the immission side of the water body. It will be applied using emission limits and also numerical standards for pollutants in the receiving water body.\(^\text{32}\)

**Public consultation**

Both directives specify procedures for public consultation in their decision-making process: on the one hand to inform the public, and on the other hand to promote the active participation of all stakeholders. The consultation process therefore includes providing information presenting draft plans and holding hearings before adopting new management plans.

**Ecosystem-based approach**

Both directives base their programme of measures on the ecosystem-based approach. This approach was first defined by the Convention on Biodiversity in 2000 as ‘a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way. The application of the approach will help to reach a balance of the conservation, sustainable use, and the fair and equitable sharing of the benefits arising out of the utilisation of genetic resources’.\(^\text{34}\) Human activities are to remain within levels that are compatible with the achievement of the environmental objective.\(^\text{35}\)

Whereas the Member States are required to develop national marine strategies, the MSFD also requires cooperation between Member States that share a marine region. Cooperation is required for determining regional threats and objectives and ensures that measures in aid of achieving the objectives are coherent and coordinated across the whole marine region.\(^\text{36}\) In addition, the MSFD follows an approach that even extends beyond the European community waters. Transboundary **EU-Regional approach**

The Member States are required to develop national marine strategies while taking the overall perspective of the marine region into account. This regional cooperation and coordination between European Member States sharing the same marine region is aimed at achieving coherence across a marine region. Due to the transboundary character of marine regions, cooperation with third non-EU countries sharing a marine region is furthermore aimed at whenever possible in order to ensure the coordinated development of a regional marine strategy for the whole marine region.\(^\text{33}\)

---

\(^{30}\) Chave P. (2001), The EU Water Framework Directive: An Introduction. IWA Publishing


\(^{32}\) Ibid

\(^{33}\) Ibid


\(^{35}\) Water Framework Directive 2000/60/EC, Art. 1, par 3

effects on the marine environment of third states have to be taken into account. This means that the Member States are required to cooperate not only within the Community, but also with third countries bordering on the EU marine waters; they must also take impacts on other marine waters into consideration within their own strategies.  

**Spatial application**

The WFD defines coastal waters in the following way: “Coastal water means surface water on the landward side of a line, every point of which is at distance of one nautical mile on the seaward side from the nearest point of the baseline from which the breadth of territorial waters is measured”. The WFD applies to all surface waters inland and up to one nautical mile from the baseline, including coastal waters. The MSFD applies to all marine waters starting at the baseline (Figure 10).

![Figure 10 Spatial range of the WFD and the MSFD (Adapted from Wenzel C., EC-Marine Strategy Framework Directive (MSFD))]({})

This results in spatial overlap between the WFD and the MSFD for the coastal waters. To ensure complementarity and to avoid overlap regarding coastal areas, the MSFD will only address certain aspects of the coastal waters not covered by the WFD, and the WFD has precedence over the MSFD in this area.

However, the overlapping of the two directives can cause great potential for duplication and confusion in the coastal waters (NAVI report 2010). Both use the acronym GES for their objectives, meaning that two very different GES targets will apply in the same water body. Two

---

37 Ibid., Art. 2, par. 1, recital 13 and 20
38 Water Framework Directive 2000/60/EC, Art.2 Par.7
39 Preamble 12 of the Marine Strategy Framework Directive refers to ‘coastal waters’ as defined in the EU Water Framework Directive. It states that these coastal waters, including their seabed and subsoil, are an integral part of the marine environment and as such should also be covered by the MSFD.
40 Water Framework Directive 2000/60/EC, Art.2 Par.7, Recital nr. 12
different strategic plans, which in some Member States will be developed and administered by
different organisations, will set out different programmes of measures which will apply to the same
water body. For several of the MSFD descriptors good environmental status in coastal water
bodies will be brought about largely or entirely through the measures to be taken under the WFD.

**Comparison between management units**

**Similarities**
The river basin management approach as well as the marine region approach aims to manage the waters within their natural boundaries.

**Differences**
The size of the management units, river basin versus marine region, differs remarkably.

For example, German Baltic Sea coastal waters belong to three management units according to the WFD, referring to the river basin districts, whereas they belong to one management unit under the MSFD, namely the Baltic Sea marine region.

The goal of the MSFD is stated to be in line with the objectives of the WFD. However two different approaches were adopted in the directives: ‘good water status’ according to the WFD and ‘good environmental status’ according to the MSFD.

**Comparison between water status and environmental status**

It is generally stated by authors that the objectives of the MSFD are based on the WFD. However, the MSFD adopts a different status objective, namely the ‘environmental status’, unlike the ‘water status’ used in the WFD. A comparison of the two is summarized in table 10.

The key difference between the two status objectives is the integration of human activities into the definition of ‘environmental status’ in the MSFD. ‘Water status’ is based on various different quality elements, while ‘environmental status’ is based on several descriptors, which include human activities. Some of the descriptors are consistent with the WFD quality elements, but some descriptors are included in the MSFD that are not consistent with any WFD quality element, such as maritime activities. As a result, the use of marine resources and, moreover, noise as a result of human activities, is included in the definition of ‘environmental status’.

<table>
<thead>
<tr>
<th>‘Water status’</th>
<th>‘Environmental status’</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>Quality and functioning of the ecosystem</td>
</tr>
<tr>
<td>Definition</td>
<td>- By quality parameters: biological, physico-chemical, hydro-morphological</td>
</tr>
<tr>
<td></td>
<td>- Pollutants do not exceed limit</td>
</tr>
</tbody>
</table>

In the WFD, the parameters that need to be assessed for each quality element are further defined; for the descriptors of the MSFD, the identification of criteria and indicators started after the directive was adopted and were presented in 2010.

The target status stipulated in the WFD is at least ‘good ecological status’, defined by slight deviation from reference conditions. These reference conditions are therefore used as calibration values, and refer to conditions as they would be without human pressures. However, the prefix ‘at least’ creates the impression that it is possible to achieve these conditions of an environment without impacts.

The MSFD, in contrast, acknowledges human activities and their impact on the environment. These impacts is taken into account when defining the target status. The goal status is a healthy ecosystem that supports economic and social activities, and consequently not an environment with no human activities or impacts.

The definition of ‘good environmental status’ should link to the WFD ‘good water status’ defined for coastal waters, since the directives overlap in these coastal waters. The same indicators, methodologies and tools might potentially be used.

**Good Water Status**

According to the ‘one-out-all-out principle’

42, ‘good water status’ is only assigned if both ‘ecological and chemical status’ are classified as being ‘good’. Like ‘ecological status’, ‘water status’ can be assigned one of five classifications, ‘high’, ‘good’, ‘moderate’, ‘poor’ or ‘bad’ (Figure 11). The classifications are determined by the amount of deviation from undisturbed conditions

43. However, ‘good water status’ only applies to coastal waters, whereas for the remaining territorial waters (referring to all marine waters on the seaward side from the one nautical mile-line up to the territorial border) only ‘good chemical status’ is required.

---

42 European Communities. (2003) CIS-guidance document Nr.13, *Overall Approach to the Classification of Ecological Status and Ecological Potential*

43 Annex V 1.2.4 Definitions for high, good and moderate status in coastal waters
Assessment obligations

Different interpretations based on the results of assessment of water status would have led to different classification of the status. The assessment of ‘ecological status’ is especially susceptible to disparities in status due to differences in interpretation, since no limit values exist for ‘chemical status’. To overcome this problem, standard methods of analysis that have to be used in the assessment were first identified by experts.

9.2 Aspects of the WFD that can be carried over to the MSFD

As described above, the WFD and MSFD have differing approaches to dealing with human pressures, the former aiming at natural conditions and the latter allowing for sustainable use of the marine ecosystem. Moreover, there can be no doubt that the re-assessment of coastal waters with the inclusion of an assessment of biodiversity, marine mammals, underwater noise, marine litter and commercial fishing will lead to different results for MSFD assessment than WFD assessments would in those areas. In order to ensure coherence between the two directives, the same indicators with same targets in coastal waters should be used for both directives (Korpinen 2010).

The WFD separates an ecosystem into its constituent parts, or at least those parts considered important – the so-called BQE (biological quality elements) – and assessing the individual quality of each BQE. Afterwards a combining rule is used to put these back together under the assumption that the result reflects the status of the whole ecosystem. Although the WFD assesses several BQE independently, when combining the BQE the final status is based upon the OOAO ('one-out-all-out') principle. With this approach, the status of the worst element used in the assessment determines the final status. This has raised discussion on the biological rationale and communication value of the principle. The most serious shortcomings have been that single...
indicators have been given too high a significance and that groups of indicators which are in a causal relationship with one another are given equal significance (for more shortcomings, please see Chapter 6.7).

However, the strength of the OOAO principle lies in the information it provides in order to guide conservation and restoration measures, and the use of a precautionary approach. It therefore appears to be a good starting point for the MSFD’s assessment suggestion. A possible way to proceed could be to provide HELCOM as an example. Here, the current methods are based on the OOAO principle, but with indicator weighting and thematic grouping of indicators. The weighting of indicators is a transparent method which could improve the final classification, and it can add ecological and geographical thinking to the classification. However, the weighted averaging has been criticized for hiding alarming status indicators behind the averages. Here, a separate assessment of indicators and the presentation of the final status assigned to single indicators, along with all underlying data, would address those weaknesses.

Although the text of the WFD does not mention the EBA (ecosystem-based approach), its programme of measures follows this approach and requires a planning process that ensures sustainable use of aquatic resources (Borja, 2010). Like the MSFD, the WFD requires an economic and social assessment of the costs and benefits, and allows for exemptions when targets are not reached if it can be economically and socially justified.

Further, both directives require a definition of restoration targets, defined as ‘good environmental status’ and ‘good ecological status’ respectively. Member States are obliged to also compare these targets for their sub-regions and regional seas in order to ensure consistency of environmental objectives and approaches throughout Europe. As the objectives of the directives are parallel and spatially overlap in coastal waters, experience from the implementation of the WFD will need to be applied to the implementation of the MSFD (Borja 2006).

Unlike with the WFD, reference conditions do not exist in the MSFD. However, its 11 descriptors could implicitly be considered to be an indication of conditions where the aspect in question is not adversely affected (Borja 2010). Those indicators/BQE that are common to both the WFD and the MSFD could be used in order to achieve the MSFD targets that are compatible with the GES set.

The WFD approach of normative definitions (Annex 5) that provide a general description of how the critical biological components (like species composition, diversity, biomass) change in response to environmental pressures and thus describe a GES, could be used for the MSFD. The next step for the descriptors could be to translate them into specific quantitative metrics (e.g. various diversity indices or biomass metrics) in order to enable monitoring for their compliance (Gray and Elliott 2009). This approach was also recommended by the European Commission (2008).

Some of the parameters and assessment tools used in the WFD seem to be applicable in the MSFD. Borja (2010) mentions that tools that are designed to assess the status of eutrophication (e.g. indices for phytoplankton) are potentially applicable for use in larger oceanic regions. However, the possible use of the current intercalibrated WFD classification tools has to be evaluated for the MSFD monitoring and assessment.

Overall, as some WFD methods to assess status already exist for many of these descriptors, they can be used together with new ones specifically developed for the MSFD. The normative descriptors in the WFD could be linked to the practical management of environmental status, as the targets, like reference conditions and Environmental Quality Status, rely on observed true
changes in BQE. This can be linked to pressure proxies that allow a link to drivers (Borja and Rodriguez 2010). Recently, the eutrophication assessment of the Baltic Sea HEAT (HELCOM 2009) tested the applicability of the WFD approach and eutrophication assessment tools across the entire Baltic Sea for coastal monitoring sites as well as other monitoring sites in off-shore waters. It uses available monitoring data and reference levels determined in the course of the national WFD implementation, and calculates ecological quality ratios for each individual BQE. A confidence rating of the regional assessment was carried out and the rules for combining different BQEs were agreed upon. In the end, a comparable assessment of eutrophication status of the Baltic Sea was developed (Andersen et al. 2010). In the assessment of the biodiversity status of the Baltic Sea, BEAT, a similar approach was carried out (HELCOM 2010).

The Member States have spent considerable time developing tools for data collection, and have funded a large number of research projects. Sharing indicators with the WFD can therefore represent considerable savings.

Also, large amounts of raw data already exist for the WFD, which might be used to inform knowledge of species distribution, for instance, in order to help to determine which indicators are relevant to which marine ecosystem.

One key success of the WFD was to bring in standardised procedures for sampling and analysis (Hering). Any implementation of the MSFD is therefore naturally reliant on the foundation which has been laid by the WFD. It would furthermore be inefficient not to take these standardised procedures into account. In addition, the work of groups such as EMMA and WGECO has been important for developing pan-European standardised indicators.

There is still scope within the MSFD to explore the development of metrics that deal with ecosystem function rather than simply with taxonomic indices, as is the case in the WFD. However, despite the fact that the MSFD may be more comprehensive, there is no avoiding the fact that the WFD already exists and as such, work on the MSFD should complement rather than override the WFD.

What is needed, therefore, is not a fully-specified and well-structured analytical method for assessing GES, but a fully specified and well-structured process for conducting assessments of GES. The specific method used should be adaptable from one periodic assessment to another, and learning from experience with regard to indicators selected, weightings and benchmarks applied, and approaches to integrating local scale evaluations into regional conclusions. With MSFD, uniformity therefore lies in the process followed, and not the method used to assess a particular sea region – and this needs to be developed by the Member State(s) involved in the assessment of a particular sea region.
10 Conclusions

The present analysis has shown that many interesting approaches for the assessment of the environmental status of marine ecosystems exist worldwide.

None of the approaches looked at fulfils the requirements of the MSFD fully, however certain aspects and the experience gained during their development and implementation could serve as useful input in developing an assessment approach in the MSFD context.

Regional Sea Conventions like OSPAR and HELCOM have outlined already holistic approaches of assessments. These regional or sub-regional rules cover most of the requirements of the MSRL and are important for a consistent procedure. For instance, HELCOM has introduced two interesting assessment tools, HEAT and BEAT, for the entire Baltic Sea area that combine biotic and abiotic indicators to assess environmental status. BEAT is an innovative assessment system in that it considers all ecosystem components in a quantitative manner.

The UK approach should be highlighted as it covers all MSFD descriptors and builds on a broad evidence base created through extensive monitoring programmes. Some indicators and monitoring programmes still need to be extended and adjusted in order to be in line with requirements of the MSFD.

Currently, the EMMA working group is developing an indicator set for the MSFD and has analysed coherence between the different assessments.

The Australian approach for the Great Barrier Reef comes closest to a fully integrated assessment. However, the case of Australia provides an entirely contrary picture in that rather than attempting to generate possibly imperfect results, the nation has decided to continue gathering data. It has acknowledged that not enough is known in general, but has taken the information that exists in the scientific literature and has perhaps saved itself time by summarising what is already out there.

The Australia example outlines a potential first step for MS in the EU, however would require quick follow-up by a planned strategy outlining steps to develop specific indicators to be used in monitoring and evaluation. This approach is a somewhat similar to the example of the Puget Sound. Even where not enough data was available, they proceeded with the assessment in order to ensure the process did not remain stagnant. It is the process, which was the most important aspect of carrying out the assessment in Puget Sound and in the Great Barrier Reef Marine Protected Area (GBRMPA). It is possible that once key individuals have agreed to take part, it is then possible to create
more specific and accurate data sets but this could be done in the second iteration of an assessment. The approaches of Canada and the US began with the development of indicators rather than investing time developing indicators as the process, itself, was regarded as most important. Meanwhile REGNS invested a huge amount of time into methodology and did not reach analysis and interpretation of the results.

Nearly all assessments stress the inclusion of scientific experts from the very beginning as essential. This ensures qualitative assessments in addition to quantitative groundwork. Data are serviceable even after several time intervals when the selection of criteria and the evaluation by experts is documented sufficiently. The mere quantitative data of REGNS, for instance, are not functional anymore due to a missing qualitative weighting.

Furthermore, the engagement of stakeholders when starting the procedure is very important, such as during the process of developing indicators. Management authorities and/or decision makers should have the opportunity to express what it is they need from the assessment. Ideally they are also involved in the scientific developments so that they can take decisions more quickly and effectively when necessary. This procedure ensures the expression of stakeholder needs. The engagement can start with special groups and enlarge within a transparent process afterwards. The Australian as well as the Puget Sound approach are two examples of successful stakeholder integration.

Taking into account the experience gained through the implementation of the WFD over the past decade, some procedures should be used for the implementation of the MSFD. The comparison of these two directives shows important similarities as well as differences.

Many methods have been developed through the WFD for analysing and evaluating single quality components, calibrated on European level.

The WFD and the MSFD have different approaches to human pressures, the former reaching near natural conditions and the latter allowing for sustainable use of the marine ecosystem. The re-assessment of coastal waters with the inclusion of an assessment of biodiversity, marine mammals, underwater noise, marine litter and commercial fish will cause different results for MSFD assessments than WFD assessments in those areas. In order to ensure any coherence between the two directives, one should use the same indicators with the same targets in coastal waters for both directives. Hence, the use of different integration method for the two Directives will not be an overly large concern when compared to the other changes.

The MS have spent considerable time developing tools for data collection and have funded a large number of research projects. Sharing indicators with the WFD can therefore be highly effective and economically efficient.
II List of figures

Box 1: Key elements of an IEA (Levin et al. 2008) ................................................................. 15
Box 2: Properties of an ideal indicator (Rees et al. 2008) ......................................................... 18
Box 4: Guidance on how to choose suites indicators from the candidate set .......................... 38
Box 5: Criteria for the development of a pan-European indicator specifications .................. 43
Box 6: The ERAEF - Ecological Risk Assessment for the Effects of Fishing ......................... 57
Box 7: Key approaches of the European directives

Table 1: Timeline for implementation of the MSFD ...................................................................... 26
Table 2: Quality elements for coastal waters ............................................................................ 31
Table 3: Overview of EMMA indicators ................................................................................... 44
Table 4: Summary of Task group approaches to integrate within descriptors ......................... 48
Table 5: Major science and knowledge gaps in understanding the natural, socio-economic and management and governance system. ........................................................................... 50
Table 6: assessments selected for case study .......................................................................... 59
Table 7: assessments not taken forward for case study ............................................................. 60
Table 8: IEA Expert Interviews Conducted ............................................................................. 67
Table 9: Main concepts within the Water Framework Directive and the Marine Framework Directive (adapted from Borja et. al 2010)
Table 10: Comparison between water status environmental status

Figure 1: The 5-step approach to IEAs Levin et al. (2009) ...................................................... 16
Figure 2: The Driver-Pressure-State-Impact-Response framework ........................................ 22
Figure 3: Assessment scheme for the water status including the assessment of the ecological quality ratio Chave (2001) ............................................................................ 24
Figure 4: Representation of the WFDs classification scheme for water status. EC (2005) ........ 25
Figure 5: Overview of the relative roles of biological, hydromorphological and physico-chemical quality elements in ecological status classification according to the normative definitions in WFD Annex : 1.2. EC (2005) ......................................................................................... 32
Figure 6: Overview of the process to define a pan European set of marine indicators. EEA (2009) ........................................................................................................................................ 42

110
Figure 7: Ecosystem Approach to Management in Large Marine Ecosystems .......................... 49

Figure 8: Example of a matrix approach used to describe the relationship or degree of interconnection between human pressures (sectoral activities such as fishing) and ecosystem components (such as benthos). .......................... 51

Figure 9: Decision tree diagnoses. Bundy (2010) .......................................................... 55

Figure 10: Spatial range of the WFD and the MSFD (Adapted from Wenzel C., EC-Marine Strategy Framework Directive (MSFD))

Figure 11: Assessment scheme for ecological status (adapted from Ministry for the Environment, Nature Conservation and Agriculture of state Schleswig-Holstein’, 2009)

12 References

LITERATURE


Conservation International (2011): Annual Report to the Advisory and Steering Committees Ocean Health Index February 2011


DEFRA (Department for Environment Food and Rural Affairs) (2005): Charting Progress An Integrated Assessment of the State of UK Seas

DEFRA (Department for Environment Food and Rural Affairs) (2010): Charting Progress 2

DFO Fisheries and Oceans Canada, ESSIM initiative website: http://www.mar.dfo-mpo.gc.ca/e0010285


DFO Fisheries and Oceans Canada, State of the Eastern Scotian Shelf Ecosystem, August 2003.


Earth Tech Canada Inc. for Fisheries and Oceans Canada, Assessment of Quantitative and Qualitative Data and Information for the Social, Economic and Cultural Overview and Assessment of the Scotian Shelf, March 2008.


Ecosystem Overview and Assessment (EOA) Reports (Draft) April 2005.


ICES Advice 2010a, Book 1


WEBSITES

Figure DPSIR: http://ia2dec.ew.eea.europa.eu/knowledge_base/Frameworks/doc101182


www.deat.gov.za
### Annex I: Factsheets

### Annex II: Guiding questions for interviews

### Annex III: Interviews

### Annex IV: Overview table of Factsheets (excel sheet)

### Annex V: Recommended Criteria and associated Indicators for GES

Criteria and indicators for good environmental status relevant to the descriptors of the MSFD (based on Decision 2010/477/EU)

<table>
<thead>
<tr>
<th>Descriptor</th>
<th>Criteria</th>
<th>Indicator</th>
</tr>
</thead>
<tbody>
<tr>
<td>1: Biological diversity</td>
<td><em>Species level</em></td>
<td>Species distribution</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Distributional range</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Distributional pattern within the distribution range, where appropriate</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Area covered by the species (for sessile/benthic species)</td>
</tr>
<tr>
<td>1: Biological diversity</td>
<td></td>
<td>Population size</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Population abundance and/or biomass, as appropriate</td>
</tr>
<tr>
<td>1: Biological diversity</td>
<td></td>
<td>Population condition</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Population demographic characteristics (e.g. body size or age class structure, sex ratio, fecundity rates, survival/mortality rates)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Population genetic structure, where appropriate</td>
</tr>
<tr>
<td>1: Biological diversity</td>
<td></td>
<td>Habitat level</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Habitat distribution</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Distributional range</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Distributional pattern</td>
</tr>
<tr>
<td>1: Biological diversity</td>
<td></td>
<td>Habitat extent</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Habitat area</td>
</tr>
<tr>
<td>2: Non-indigenous species</td>
<td>3: Fish and Shellfish</td>
<td></td>
</tr>
<tr>
<td>---------------------------</td>
<td>----------------------</td>
<td></td>
</tr>
<tr>
<td><strong>Habitat condition</strong></td>
<td><strong>Level of pressure of the fishing activity</strong></td>
<td></td>
</tr>
<tr>
<td>Habitat volume, where relevant</td>
<td>Primary:</td>
<td></td>
</tr>
<tr>
<td>Condition of the typical species and communities</td>
<td>Fishing mortality</td>
<td></td>
</tr>
<tr>
<td>Relative abundance and/or biomass, as appropriate</td>
<td>Secondary:</td>
<td></td>
</tr>
<tr>
<td>Physical, hydrological and chemical conditions</td>
<td>Ratio between catch and biomass index</td>
<td></td>
</tr>
<tr>
<td><strong>Ecosystem level</strong></td>
<td><strong>Reproductive capacity of the stock</strong></td>
<td></td>
</tr>
<tr>
<td>Ecosystem structure</td>
<td>Primary:</td>
<td></td>
</tr>
<tr>
<td>Composition and relative proportions of ecosystem components (habitats and species)</td>
<td>Spawning Stock Biomass (SSB)</td>
<td></td>
</tr>
<tr>
<td><strong>Environmental impact of invasive non-indigenous species</strong></td>
<td>Secondary:</td>
<td></td>
</tr>
<tr>
<td>Abundance and state characterisation of non-indigenous species, in particular invasive species</td>
<td>Biomass indices</td>
<td></td>
</tr>
<tr>
<td>Trends in abundance, temporal occurrence and spatial distribution in the wild of non-indigenous species, particularly invasive non-indigenous species, notably in risk areas, in relation to the main vectors and pathways of spreading of such species</td>
<td><strong>Population age and size distribution</strong></td>
<td></td>
</tr>
<tr>
<td>Ratio between invasive non-indigenous species and native species in some well studied taxonomic groups (e.g. fish, macroalgae, molluscs) that may provide a measure of change in species composition (e.g. further to the displacement of native species)</td>
<td>Primary:</td>
<td></td>
</tr>
<tr>
<td>Impacts of non-indigenous invasive species at the level of species, habitats and ecosystem, where feasible</td>
<td>Proportion of fish larger than the mean size of first sexual maturation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mean maximum length across all species found in research vessel surveys</td>
<td></td>
</tr>
<tr>
<td></td>
<td>95 % percentile of the fish length distribution observed in research vessel surveys</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Secondary:</td>
<td></td>
</tr>
<tr>
<td>4. Marine food webs</td>
<td>Productivity (production per unit biomass) of key species or trophic groups</td>
<td>Size at first sexual maturation, which may reflect the extent of undesirable genetic effects due to exploitation</td>
</tr>
<tr>
<td>---------------------</td>
<td>------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td></td>
<td>Performance of key predator species using their production per unit biomass (productivity)</td>
<td></td>
</tr>
<tr>
<td>Proportion of selected species at the top of food webs</td>
<td>Large fish (by weight)</td>
<td></td>
</tr>
<tr>
<td>Abundance/distribution of key trophic groups/species</td>
<td>Abundance trends of functionally important selected groups/species</td>
<td>Including where appropriate:</td>
</tr>
<tr>
<td></td>
<td>groups with fast turnover rates (e.g. phytoplankton, zooplankton, jellyfish, bivalve molluscs, short-living pelagic fish) that will respond quickly to ecosystem change and are useful as early warning indicators, groups/species that are targeted by human activities or that are indirectly affected by them (in particular, by-catch and discards), habitat-defining groups/species, groups/species at the top of the food web, long-distance anadromous and catadromous migrating species, groups/species that are tightly linked to specific groups/species at another trophic level</td>
<td></td>
</tr>
<tr>
<td>5: Eutrophication</td>
<td>Nutrients levels</td>
<td>Nutrients concentration in the water column Nutrient ratios (silica, nitrogen and phosphorus), where appropriate</td>
</tr>
<tr>
<td>Direct effects of nutrient enrichment</td>
<td>Chlorophyll concentration in the water column Water transparency related to increase in suspended algae, where relevant Abundance of opportunistic macroalgae Species shift in floristic composition such as diatom to flagellate ratio, benthic to pelagic shifts, as well as bloom events of nuisance/toxic algal blooms (e.g. cyanobacteria) caused by human activities</td>
<td></td>
</tr>
<tr>
<td>Indirect effects of nutrient enrichment</td>
<td>Abundance of perennial seaweeds and seagrasses (e.g. fucoids, eelgrass and Neptune grass) adversely impacted by decrease in water transparency</td>
<td></td>
</tr>
<tr>
<td>6: Sea-floor integrity</td>
<td>Physical damage, with regard to substrate characteristics</td>
<td>Dissolved oxygen, i.e. changes due to increased organic matter decomposition and size of the area concerned</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>----------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>7: Hydrographical conditions</td>
<td>Spatial characterisation of permanent alterations</td>
<td>Extent of area affected by permanent alterations</td>
</tr>
<tr>
<td>8: Contaminants</td>
<td>Concentration of contaminants</td>
<td>Concentration of the contaminants mentioned above, measured in the relevant matrix (such as biota, sediment and water) in a way that ensures comparability with the assessments under Directive 2000/60/EC</td>
</tr>
<tr>
<td>9: Contaminants in fish and other seafood</td>
<td>Levels, number and frequency of occurrence contaminants</td>
<td>Actual levels of contaminants that have been detected and number of contaminants which have exceeded maximum</td>
</tr>
</tbody>
</table>
| 10: Marine litter | Characteristics of litter in the marine and coastal environment | Regulatory levels  
Frequency at which regulatory levels are exceeded  
Trends in the amount of litter washed ashore and/or deposited on coastlines, including analysis of its composition, spatial distribution and, where possible, source  
Trends in the amount of litter in the water column (including floating at the surface) and deposited on the sea-floor, including analysis of its composition, spatial distribution and, where possible, source  
Trends in the amount, distribution and, where possible, composition of micro-particles (in particular micro-plastics)  
Impacts of litter on marine life | Trends in the amount and composition of litter ingested by marine animals (e.g. stomach analysis) |
| 11: Introduction of energy, including underwater noise | Distribution in time and place of loud, low and mid frequency impulsive sounds | Proportion of days and their distribution within a calendar year over areas of a determined surface, as well as their spatial distribution, in which anthropogenic sound sources exceed levels that are likely to entail significant impact on marine animals measured as Sound Exposure Level (in dB re 1μPa 2.s) or as peak sound pressure level (in dB re 1μPa peak) at one metre, measured over the frequency band 10 Hz to 10 kHz  
Continuous low frequency sound | Trends in the ambient noise level within the 1/3 octave bands 63 and 125 Hz (centre frequency) (re 1μPa RMS; average noise level in these octave bands over a year) measured by observation stations and/or with the use of models if appropriate |