

Environmental indicators: their utility in meeting the OSPAR Convention's regulatory needs

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The role of marine environmental indicators is clear; selecting indicators to inform management and for the development of accepted frameworks is proving more elusive. The OSPAR Commission, charged with the environmental protection of the Northeast Atlantic, has been applying an ecosystem approach since 1998, applying on a trial basis a system of ecological quality objectives as indicators of ecosystem health for the North Sea. This paper presents a framework for biodiversity monitoring and assessment, and discusses specific issues associated with marine-litter indicators, representing a cell within the matrix of the framework. In the immediate future, European marine legislation will drive the development of environmental indicators in the area, and further harmonization of indicator sets should enhance their utility.

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Introduction

As a general maxim, an increased rate of change in the environment will lead to greater conflict among its users and an increasing need to monitor and manage the environment (Spellerberg, 1981). Assuming that particular metrics tell us much about either rates or extent of change, even if the scale and amount of detail in the monitoring required varies according to circumstances, such environmental indicators have a crucial role to play in the simplification, quantification, standardization, and rational explanation (communication) of environmental conditions to regulators and policy-makers. Therefore, environmental indicators represent important tools for delivering information on environmental values and can help to safeguard biological diversity and manage resources for man's benefit.

“Indicate”, from the Latin *indicatore*, can mean disclose, point out, and make publicly known. Characteristics of efficient environmental indicators have been summarized by many individuals and organizations working in this field, but generally they must be (OSPAR, 2007a):

- (i) scientifically sound;
- (ii) easily understood;
- (iii) variable over time;
- (iv) sensitive to the change that they are intended to measure;
- (v) measurable and capable of being updated regularly;
- (vi) based on readily available data and information.

However, as a scientific community, we continue to struggle to agree, validate, and mobilize marine environmental indicators. At a global level, Cicin-Sain (2007) has noted the following

difficulties in assessing progress against overarching goals for sustainable ocean management:

- (i) lack of consistent indicator–evaluation frameworks;
- (ii) no institution being charged with periodic collection and assessment of data on oceans (especially cross-cutting issues and goals);
- (iii) no regular collection and assessment of data on the socio-economic well-being of coastal communities.

Intangibles discussed at OSPAR Commission meetings include dealing with climate-induced shifts in baselines (moving goal-posts), choosing an appropriate significance (risk level) to determine the probability of detecting target levels, accounting for confidence in data analysis, and maintaining continuity in data collection, if resources are reduced or limited.

Linking environmental indicators to policy performance

A useful analysis of the role of indicators by the World Resources Institute (Hammond *et al.*, 1995) recognized the widely used pressure–state–response framework for environmental indicators that has arisen from a simple set of questions: What is happening to the state of the environment or natural resources? Why is it happening? What are we doing about it? Originally developed by the OECD (1993), based on the work by the Canadian Government and following a cause–effect social response logic, a modification of this framework, which includes the identification of the driving force for any threat and consequential impact (DPSIR), has provided the basis for many national and international initiatives (e.g. EEA, 1999).

More recently, Gubbay (2004) recalled that the Earth Summit's Agenda 21, adopted in 1992, promoted the use of performance indicators, so prompting the widespread development of indicator sets in a European context, e.g. by the European Commission (EC), national governments, and NGOs (often with similarities and overlap). These initiatives emphasized the need for indicators that reflect ecosystem resilience, structure, and vigour, and explain the use of "headline" and "detailed" indicators, as adopted by the England Biodiversity Strategy (Defra, 2003). On this basis, Gubbay (2004) proposed a framework for grouping existing marine environmental indicators under the headings of fisheries, biodiversity, and water quality and pollution, together with a consideration of practical and financial issues.

The EC (2008) has finalized a Framework for Community Action in Marine Environmental Policy—the Marine Strategy Framework Directive (MSFD)—which will establish an overall target-driven goal to achieve or maintain "good environmental status" in all EU marine waters by 2020 at the latest. This legislation will have far-reaching implications for marine monitoring and will drive the need for indicators and their integration across different policy sectors. To this end, the European Environment Agency has developed a set of pan-European indicators (five of which are marine) to preparing State of the Environment Reports. The European Marine Monitoring and Assessment (EMMA) process has undertaken a complementary series of workshops covering operational oceanography, ecological processes, and chemical monitoring to add more indicators, and efforts have been made to ensure that all developments are compatible with the Convention for Biological Diversity (CBD) initiative "Streamlining European Biodiversity Indicators" (SEBI 2010, <http://biodiversity-chm.eea.europa.eu/>).

Role and achievements of the OSPAR convention

The OSPAR Commission is the mechanism by which the governments of 15 countries bordering the west coasts and catchments of Europe, together with the EC, cooperate to implement the OSPAR Convention and to protect the marine environment of the Northeast Atlantic. The 1972 Oslo Convention against dumping was broadened in 1974 by the Paris Convention to cover land-based sources and offshore industry. These two conventions were unified, updated, and extended by the 1992 OSPAR Convention. A new annex on biodiversity and ecosystems was adopted in 1998 to cover non-polluting human activities that can adversely affect the sea.

Under the OSPAR Convention, perceived threats to the marine environment are countered by public international law, a combination of hard and soft law, and by establishing programmes and measures to ensure effective national action to combat these threats. Nations are required to report on what has been done to implement obligations and to effectuate commitments. The Commission's work has always been based on the best available scientific advice. This advice is obtained both by having national marine science experts participating in Commission meetings, and under a memorandum of understanding with the International Council for the Exploration of the Sea (ICES).

In 2005, the OSPAR Commission completed scientific assessments of the results of its monitoring over the past decade or more (OSPAR, 2005a). For inputs of heavy metals (cadmium, mercury, and lead) to the sea through rivers and from direct discharges between 1990 and 2002, there have been widespread and substantial reductions. Inputs of plant nutrients (nitrogen and

phosphorus) have also been reduced significantly, but these reductions have been less consistent over space and time. The assessment of airborne inputs has demonstrated significant downward trends for all the contaminants monitored. Direct atmospheric inputs of contaminants remain important, because they account for up to half of the inputs of some heavy metals from land and up to one-third of those of nitrogen. Shipping also remains an important source of airborne inputs of nitrogen.

The Commission recognizes that biodiversity of the seas can only be protected by keeping the combined impacts of all human activities at a level that allows our seas to remain healthy and sustainable. The whole suite of strategies developed and actions taken (including associated measures such as OSPAR Decisions and Recommendations) is essential for the protection of marine biodiversity. The Texel/Faial criteria have been laid down to identify marine species and habitats that are threatened and/or declining (the OSPAR List; OSPAR, 2008a), and consideration is being given to what additional international action is needed to protect these species and habitats. The OSPAR Commission, as a joint enterprise with the Helsinki Commission (HELCOM), is also committed to setting up an ecologically coherent network of well-managed marine protected areas (MPAs) by 2010 (Ardron, 2008).

Delivering the ecosystem approach

The sea is a highly dynamic environment, with currents moving inputs over long distances and many marine creatures travelling widely. Effects of pressures may be felt thousands of kilometres away from the sources, and impacts often result from myriad causes. For example, high levels of PCBs in porpoises could be caused indirectly by overexploitation of fish populations through a change in diet to bottom-living animals that have been more heavily affected by pollution (OSPAR, 2005b). To deliver an ecosystem approach to management, it is therefore essential to look at:

- (i) what lives where, what eats what and when, where and how marine creatures breed and reproduce;
- (ii) the interactions between the physical environment and marine biodiversity;
- (iii) the way in which critical processes of marine ecosystems work;
- (iv) how different human activities affect ecosystems.

Consequently, an effective management strategy must address the ecosystem as a whole—from the mid-ocean to the boundary between salt water and fresh water. This approach, originally developed by the CBD in the early 1990s (<http://biodiversity-chm.eea.europa.eu>), has now gained widespread currency. Since 1998, the OSPAR Commission's response has been to develop, and now implement, a suite of five thematic strategies (i.e. Eutrophication Strategy, Hazardous Substances Strategy, Radioactive Substances Strategy, Offshore Industry Strategy, and Biodiversity and Ecosystem Strategy) to address the main threats identified within its competence, together with a strategy for a Joint Assessment and Monitoring Programme (JAMP). The JAMP assesses the status of the marine environment, checks on progress with the implementation of the strategies, and evaluates the resulting benefits to the marine environment. A joint statement in 2003 by the OSPAR and Helsinki Commissions explained that these six strategies fit together to underpin the ecosystem approach.

The ecosystem approach requires a method to evaluate whether or not an ecosystem as a whole is healthy and sustainable. Indeed, one of its primary purposes can be seen as facilitating the translation of “ecosystem understanding” into high-level decision-making. Following the 2002 Fifth North Sea Conference, the OSPAR Commission began implementing a system of ecological quality objectives (EcoQOs) for the North Sea, which should in due course be extended to other regions (Heslenfeld and Enserink, 2008). EcoQOs have been selected to reflect five basic ecosystem properties—resilience, stability, productivity, diversity, and trophic structure—and they measure, in quantified terms, progress on a selection of issues. The measurements define an envelope within which the marine environment should be healthy and sustainable. To measure progress against the agreed strategies, periodic assessments of the state of the entire maritime area within the OSPAR Convention are undertaken (Quality Status Reports, QSR). These are largely derived from assessments undertaken as part of the JAMP, and the forthcoming QSR 2010 will include for the first time assessments of the EcoQOs. This type of application of the ecosystem approach endorses the view expressed by Murawski (2007) that ecosystem considerations are being employed despite perceptions to the contrary.

Towards a framework for biodiversity monitoring and assessment

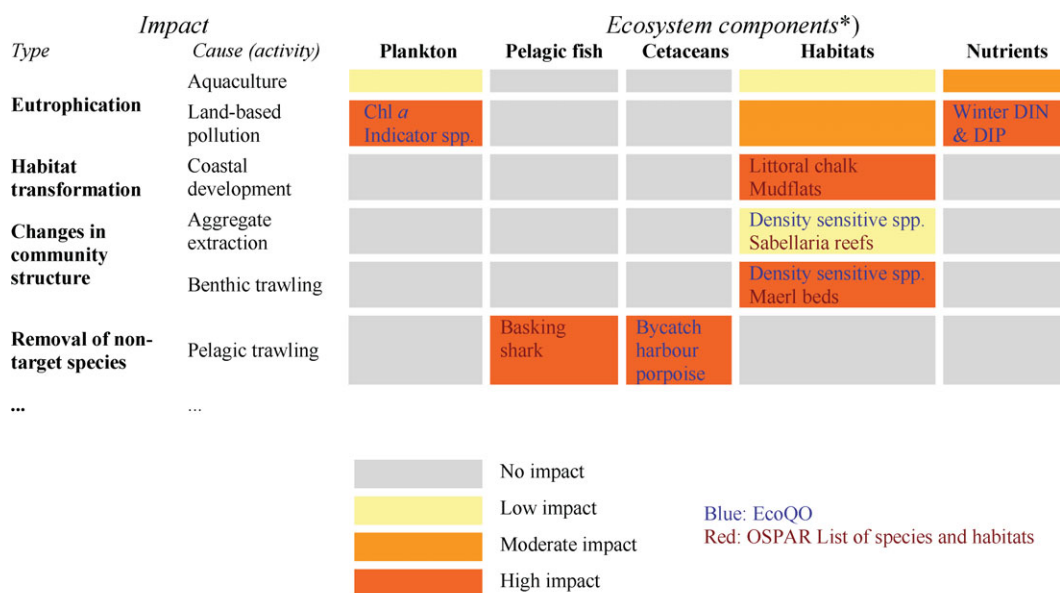
As part of its ecosystem approach, the OSPAR Commission has recognized the need for a strategic approach to biodiversity monitoring and assessment, accepting that these programmes are still in their infancy and biodiversity issues are underrepresented in the JAMP. In this context, it is logical to focus first on those aspects of the ecosystem that are known to be adversely affected by human activities, because these are the ones that can be addressed most readily through regulation. However, focus on known impacts also introduces risks, because cumulative effects might

remain unnoticed or emerging impacts may not be identified in the absence of wider environmental monitoring.

An assessment framework in the form of a matrix has been developed by the UK, the outline of which is presented in Figure 1. Ecosystem components are based on those used in the EcoQO system and correspond to those set out in Annex II of the MSFD. Because some components (fish, habitats, and communities) were considered too broad, suitable subcomponents have been identified for which assessment needs should be evaluated (e.g. habitats and communities have been divided into nearshore, shelf, and deep-water components). Aspects of the chemical and physical status of ocean processes, which are important to characterize the overall functioning of the OSPAR maritime area, are also included. A generic, prioritized set of human activities and their main types of impact on the marine environment has been defined, based on the list given in the Commission’s MPA management guidelines and in Annex II of the MSFD.

The current set of EcoQOs has been mapped onto the matrix to indicate which components of the ecosystem and which aspects of human impact they primarily address. Likewise, the current set of species and habitats on the OSPAR List has been mapped onto the matrix, indicating the key factors that are thought to cause their decline. Subsequently, indicators have been added, based on the EU Water Framework Directive, EU Habitats Directive, EU Birds Directive, reports of the Scientific Technical and Economic Committee for Fisheries (EC, 2007), and the Global Ocean Observing Systems Action Group (Hardman-Mountford and Huthnance, 2006). Synergies between OSPAR work and these other policy frameworks are needed both to reduce the cost of monitoring and to better understand how the marine ecosystem works (OSPAR, 2006).

For the whole matrix, a “rapid” assessment has been made at the OSPAR maritime-area level as to which types of impact and activity have been determined to affect each component of the ecosystem. The impacts have been graded as follows: none, low, moderate, and high, depending on whether or not the activity



*) linked to EcoQO elements, OSPAR Strategies, and EMSFD Annex II categories.

Figure 1. Outline of an assessment framework for evaluating various types of anthropogenic impact on different ecosystem components.

occurs in the proximity to the ecosystem component, and on the anticipated impact. If the score is high, the component would be included in the strategy and require monitoring and assessment of the associated indicator(s).

Work is currently under way to develop suitably worked examples to demonstrate how the framework could be applied to identify a prioritized set of monitoring requirements and to develop an improved methodology for assessing the degree of impact from human activities on the various components of the marine ecosystem. The intention is then to apply this within the OSPAR maritime area to conform with and address the MSFD requirements.

An example: marine-litter indicators

The subject of marine litter provides a good example of the OSPAR Commission's approach. Comprehensive surveys of marine litter on beaches have been made in the OSPAR maritime area, often for many years and using well-established methods. The QSR 2000 recommended improved and more standardized methodologies, including the establishment of reference areas (OSPAR, 2000). A pilot project (2000–2006) determined reference beaches and beach-survey protocols for 100-m and 1-km stretches. An illustrated, Internet-based, multilingual marine-litter guide has been developed to assist fieldworkers. The pilot project (OSPAR, 2007b) considered 55 beaches in nine countries.

The indicator items identified represent five major sources of marine litter comprising operational waste from fishing (including aquaculture), galley waste (non-operational waste from shipping, fisheries, and offshore activities), sanitary and sewage-related waste, operational waste from shipping and offshore activities, and waste from tourism and recreational activities. To qualify as a relevant marine-litter indicator, an item must be typical of the source represented, relatively common in the survey area (to allow for statistical power in analysing trends), easy to identify, easy to find (not too small or inconspicuous), and easy to count.

Further consideration of these indicators has been prompted by the inclusion of marine litter in the indicative list of characteristics, pressures and impacts within the MSFD. For floating marine litter, the presence of plastic particles in the stomachs of seabirds has already been established as a seabird EcoQO, which states that, over a period of at least 5 years, <2% of the stomachs of 50–100 beach-washed northern fulmars (*Fulmarus glacialis*), collected during winter (November–April) from each of 15 North Sea areas distinguished, should contain ≥ 10 plastic particles (OSPAR, 2008b). Potential generic indicators for marine sediments and beaches are being investigated.

Conclusion

The Contracting Parties to the OSPAR Convention have a general obligation to take all possible steps to prevent and eliminate pollution and to take the necessary measures to protect the maritime area against the adverse effects of human activities so as to safeguard human health and to conserve marine ecosystems and, where practicable, restore marine areas that have been adversely affected in the past.

The Commission has recognized the need to apply the precautionary principle and has determined priorities by establishing strategic targets up to 2020. Monitoring of biodiversity must now address the following series of issues:

- (i) recognition of the spatial (do they occur throughout the OSPAR maritime area or in specific regions, or do types of impact differ by region) and temporal (acute or chronic) characteristics of impacts;
- (ii) evaluation of whether observed changes are related to direct and indirect effects of human activities;
- (iii) review of the suitability of the established indicators (EcoQO and OSPAR List of threatened and/or declining species and habitats) and consideration of whether or not other indicators are needed to cover the various ecosystem components adequately;
- (iv) acknowledgement of cost—whether it is more pragmatic to monitor a human activity itself than monitoring a biotic or abiotic indicator;
- (v) harmonization of data collection with other international obligations: measure once and apply many times.

On this basis, the OSPAR Commission will take forward work on indicators, in particular, to determine the need for monitoring particular species and habitats appearing on the OSPAR List, to enhance the EcoQO system further, and, in concert with other European Regional Seas Conventions, to identify additional, complementary indicators suitable for the MSFD. Further indicator development will seek to develop and apply impact methodology, evaluate indicators, and identify gaps or shortcomings.

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