Methods for assessing ecological coherence of MPA networks: A review

Marija Sciberras, David Rodríguez-Rodríguez

Coherence

PANACHE
Protected Area Network Across the Channel Ecosystem

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Methods for assessing ecological coherence of MPA networks: A review

Méthodes d'évaluation de la cohérence écologique des réseaux d'AMP : une synthèse

ABSTRACT

Identifying and protecting marine features through the establishment of marine protected areas (MPAs) is an important step towards conserving biodiversity, yet it is insufficient from an ecological perspective. An ecologically coherent network of well-managed MPAs is now a requirement of a number of international, regional and national directives to effectively protect biodiversity. This means having a network of well-conserved MPAs representing the full variety of a region's ecosystems, with sites close enough together to allow movement of individuals among them.

A number of criteria are used to assess the ecological coherence of MPA networks via a variety of methods. Here, the approaches, techniques and data collection methods that may be used to assess the ecological coherence of MPA networks are examined. Expert knowledge-based methods, matrix reporting and GIS-based spatial analyses are discussed.

KEYWORDS: protection, network, coherence, spatial analysis, GAP

RÉSUMÉ

Identifier et protéger les caractéristiques marines d'intérêt à travers la création d'aires marines protégées (AMPs) est une étape importante dans la conservation de la biodiversité, mais pourtant insuffisante du point de vue écologique. Un réseau écologiquement cohérent d'AMPs bien gérées est désormais une nécessité de plusieurs directives internationales, régionales ou nationales, afin de gérer effectivement la biodiversité. Cela signifie avoir un réseau d'AMPs bien conservées représentant tout l'éventail des écosystèmes d'une région, avec des sites suffisamment proches les uns des autres afin de permettre le mouvement des individus entre eux.

Un certain nombre de critères sont utilisés pour évaluer la cohérence écologique de réseaux d'AMPs via plusieurs méthodes. Les approches, techniques et méthodes de collecte de données utilisées pour analyser la cohérence écologique d'un réseau d'AMPs sont examinées dans ce rapport.

MOTS-CLÉS : protection, réseau, cohérence, analyse spatiale, GAP

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Contents

I. Objective of the review

The assessment of ecological coherence can be grouped under a number of criteria generally accepted in the literature surrounding Marine Protected Area (MPA) selection. Among other criteria, these include adequacy, viability, representativity, replication, and connectivity. Each of these criteria is usually broken down into several aspects, for which plausible assessment guidelines can be developed. It is not expected that all these guidelines will necessarily be applied in any given assessment, rather data quality and availability will necessitate the development of locally appropriate and sophisticated assessment techniques.

Despite the fact that representativity is stated as the main objective for the majority of MPA networks world-wide, there have been few attempts to assess the level of representativeness, and even less of ecological coherence (Ardron 2008a; Johnson et al. 2008; HELCOM 2009). This is probably due to the scarcity of detailed and reliable data and maps of marine habitats and the lack of suitable evaluation methods (Ardron 2008a).

The objective of this review was neither to critically analyse the adequacy and appropriateness of each method nor to review the nature and utility of results of each method. Such a review would not have been possible, in most instances, because the only documentation available was a description of the methodology, without any results from pilot studies or applications. Instead, this review examined the approaches, techniques and the data collection methods that may be used in the assessment of MPA networks.

II. Methods of assessment

Achieving full ecological coherence requires that a multitude of ecological processes are functioning interactively to shape a healthy ecosystem. It must be recognized that the assessment of ecological coherence, or interaction of different ecosystem components over wider spaces will necessarily remain theoretical, as not only areas set aside within MPA boundaries are part of the wider ecosystem, but all the marine environment. Many important ecological processes are neither fixed nor predictable but are dynamic and change over time. For example, species may forage away from their breeding areas and do not respect arbitrary boundaries imposed by managers. Similarly, planktonic larvae and propagules may disperse long distances away from parental populations, ending in unprotected areas at the end of their planktonic phase. The assessment of ecological coherence may be further complicated by the fact that some MPAs have been established with single species or habitat conservation in mind, rather than ecosystem-based conservation. Furthermore, the assessment of ecological coherence is very much influenced by the geographical scale of assessment; what may appear as a well-connected and coherent network at a national scale, might be less so as the regional scale. Realistically, therefore, an MPA network will reside somewhere between the two extremes of a completely incoherent network and a fully coherent one, characterized by a mixture of both positive and negative attributes.

Currently, three approaches for assessing and measuring ecological coherence of MPA networks are discussed in the literature:

a) Expert knowledge based method
b) Matrix/spreadsheet reporting
c) Spatial assessment / Spatial analysis

2.1. Expert knowledge based method

2.1.1. Self-assessment method proposed by OSPAR

In early 2007, three different initial approaches to assessing ecological coherence were considered by the OSPAR Biodiversity Committee, each focusing on different sources of information. The self-assessment proposed by OSPAR (OSPAR, 2007) is made up of a checklist and a scoring system, and builds on a checklist developed by Day and Laffoley (2006) for the Marine Programme of the IUCN World Commission on Protected Areas. The higher the overall score from the self-assessment, the more effective the network is towards achieving ecological coherence.

The checklist addresses four main ecological criteria that are generally widely accepted in the literature surrounding MPA selection: **adequacy/viability, representativity, replication, and connectivity**. Consideration is also given to factors that influence the assessment of ecological coherence such as whether clearly defined objectives are in place for the network, whether precautionary design was applied, scientific and socio-economic information has been used to support the planning and management of the network and whether a monitoring system that regularly assesses the efficacy of the network is in place. The likelihood of the long-term success of the MPA network is also considered by assessing factors such as governance, permanence of legal support, sustainable financing and adaptive management. The latter implies a degree of flexibility in the MPA design process whereby for example changes in the MPA boundaries and level of protection may occur so that the network may be made more responsive to changing conditions (ecologically, socially and economically) (IUCN-WCDPA, 2008). The OSPAR MPA self-assessment form lacks however questions for additional enabling factors like political will/support, and compliance and enforcement, mentioned by Day and Laffoley (2006) (refer to Table 1 in Gubbay et al., 2007).

The self-assessment exercise is normally undertaken by those involved in the design and management of the particular MPAs and therefore relies on the subjective perceptions of the person allocating the scoring. Although there may be considerable guidance on how various scores should be allocated, the knowledge base on which respondents allocate their scores may vary considerably. Consequently, evaluations can vary across experts resulting in conflicting views about the efficacy of the MPA network. Given that it draws upon expert knowledge and intuition, this method lacks objective rigour and is limited in the questions that can be reasonably answered (Ardron 2008a). Thus, this rapid self-assessment should complement rather than replace a more in-depth and objective assessment of ecological coherence within a MPA network (OSPAR, 2007a).

Albeit several drawbacks the benefits of this method include the rapidity and simplicity with which one can draw an initial assessment of network performance (Ardron, 2008a). This method takes advantage of expert knowledge on individual MPA sites and the respective governance surroundings, which is a key source of information in very data-poor scenarios. Additionally, it offers a quick and easy method to identify gaps in our knowledge-base to adapt and improve MPA networks accordingly.

2.1.2. Rapid Assessment and Prioritization of Protected Areas Management (RAPPAM)

The Rapid Assessment and Prioritization of Protected Areas Management (RAPPAM) methodology was originally developed by the World Wide Fund for Nature (WWF) International between 1999 and 2002 for assessing **management effectiveness** of protected areas in forests (Ervin, 2003a, b). The primary data collection tool of the RAPPAM method is the rapid assessment questionnaire that covers all aspects of the international evaluation framework developed by the World Commission on Protected Area (WCPA). This method has also been used by Abdulla et al. (2008) to evaluate the management effectiveness of Marine Protected Areas in the Mediterranean Sea.

As with the self-assessment method proposed by OSPAR (OSPAR, 2007), the questionnaire is designed to survey managers' perceptions of MPAs on the basis of the scientific data available or on the basis of their experience (Ervin, 2003a, b). In the absence of an official management body, focal points of the competent MPA authority or scientists working in the MPAs may be asked to fill the questionnaire (see Abdulla et al., 2008). Questions may include:

(i) general questions regarding the features and regulation of MPAs (e.g. contact details, legal status, international recognition, government publication in which the legal MPA designation was published, designation status, administration, management body, consultative committee, surface area, IUCN category, geographical and spatial data (GIS), type of zoning and its regulation, and objectives of the MPA);
(ii) threats affecting MPAs (e.g. intensity, frequency and probability of a number of threats related to overfishing, alien species, pollution, habitat destruction, and climate change)
(iii) information relating to the ecological characteristics of MPAs (e.g. species and habitats)

Feedback from the questionnaire may be analysed utilising different statistical methods. For example, in their work Abdulla et al. (2008) analysed the responses using a descriptive approach based on the frequency of replies (in percentage). The limitations for the RAPPAM method are similar to those of the self-assessment method proposed by OSPAR, because the data in the RAPPAM rely on perception-based, qualitative scoring without direct field verification (Ervin, 2003a, b).

2.2. Matrix/spreadsheet reporting

2.2.1. Matrix method proposed by OSPAR

The matrix or spreadsheet reporting approach is another method proposed by OSPAR to assess ecological coherence. This method is a species-habitat assessment method that considers the spatial distribution of protected features in the MPA network and the spatial characteristics of the network itself (Ardron, 2008a). In this approach, the species and habitats reported to be contained within the MPAs are cross-tabulated against several criteria.

The matrices proposed by OSPAR (2008a) allow examination of five ecological criteria commonly used in the assessment of ecological coherence. **Representativity**, **replication** and **resilience** are assessed by determining the number of MPAs in which the features of interest occur within each OSPAR bioregion. **Adequacy/Viability** is assessed by determining the percentage of species or proportion of habitat in the OSPAR maritime area that occurs within the OSPAR MPA network. The principle of **connectivity** is addressed by referring to the existence of areas of functional importance, such as feeding areas, breeding areas, resting areas, nursery and spawning grounds, for OSPAR threatened and/or declining (T&D) species within the network.

An advantage of this method is that it makes use of data that are already being reported (Ardron, 2008a), for example data reported in OSPAR pro formas and European Marine Sites standard data forms. Since the assessment is carried out for individual species and habitats, this method provides an overview of whether certain agreed-upon (or legislated) species and habitats are being protected, and it can also give some indication if different functional groups and sites are being protected (Ardron, 2008a). An additional benefit of this method is that it is not reliant on subjective opinions as the self-assessment method. A major challenge with this method, however, is the lack of spatial information on the distribution and abundance of protected species and habitats inside and outside the MPA network. Hence, the level of analysis that is possible using the matrix method is limited by the extent of available data and scientific understanding (OSPAR, 2013). Additionally, reporting accuracy by different contracting parties might be a drawback of this method (OSPAR, 2013).

A trial of the matrix methodology was recently undertaken for the OSPAR MPA network in the English Channel (OSPAR, 2013). The study area followed the western limit of OSPAR Regions II and III and the limits of the French territorial waters on the east (OSPAR, 2013). Several important lessons with direct relevance to PANACHE were highlighted in this report, and are listed here in the hope that these will help guide future assessment carried out by PANACHE.

Lesson 1

In order to determine which EUNIS level 3 habitats were present in the study area, predictive modelled data from EU SeaMap[1] were used. A current limitation of EU SeaMap data is that it does not provide coverage of the intertidal area (EUNIS A1 and A2). As a result this trial did not include an evaluation of the extent to which these habitats are protected within MPAs. The question is whether there are alternative sources of data that can be compiled for intertidal areas in the English Channel so that an evaluation can be made regarding the extent to which these habitats are protected.

Lesson 2

The trial application of the matrix highlighted that there was no equivalent information on features protected in OSPAR MPAs available for French and UK MPAs.

a) The UK has yet to determine which non-Natura 2000 species on the OSPAR T&D list may be protected in OSPAR MPAs. As a result it was not possible to provide information for UK MPAs in the matrix for non-Natura 2000 species during the trial matrix assessment (OSPAR, 2013);
b) Similarly, it is yet to be determined which EUNIS Level 3 habitats are protected in French OSPAR MPAs; as a result only UK MPAs were included in the matrix for EUNIS level 3 habitats. This means that in a Channel-wide assessment of ecological coherence using the EUNIS habitat classification it would not be possible to include French OSPAR MPAs in the matrix approach described by OSPAR.

[1]Cameron, A. and Askew, N. (eds.). 2011. EUSeaMap - Preparatory Action for development and assessment of a European broad-scale seabed habitat map final report. Available at http://jncc.gov.uk/euseamap

Lesson 3

For the purposes of the matrix trial, the assessment of ecological coherence for the network of OSPAR MPAs in the Channel was carried out using broad and general thresholds (see below). However, the report highlights the importance of determining ecologically meaningful targets for ecological criteria. When information is available, it is advised that thresholds should be adapted on a case-by-case basis depending on the occurrence and vulnerability of habitats and species in the relevant biogeographic region (OSPAR, 2013). The ecological criteria and thresholds used in the matrix trial (OSPAR, 2013) were:

Features/Representativity:

The network should represent all EUNIS Level 3 habitats and OSPAR T&D habitats and species for which MPAs are considered appropriate in the study area.

Replication and Resilience:

The network should contain at least two MPAs for each EUNIS Level 3 habitat and at least three examples of OSPAR T&D habitats and species for which MPAs are considered appropriate which occur in the study area.

Connectivity:

No quantitative target is proposed, however it is recommended that sites are selected to support OSPAR T&D species at key stages of their life cycle.

Lesson 4

Generally, there was a lack of spatial data for the distribution and abundance of species populations and habitat areas for OSPAR T&D habitats and species in the Channel. This did not permit an assessment of adequacy/viability through the evaluation of the proportions of OSPAR T&D habitats protected within OSPAR MPAs in the study area. A good understanding of what data is available for which species and habitats in France and the UK is required so as (i) to focus data analysis efforts in PANACHE on data-rich species and habitats, but also (ii) to be able to direct research efforts, in both France and the UK, towards data-poor species and habitats protected by legislation.

Lesson 5

The trial highlighted the importance of expert judgement, reported information on species/habitats, and spatial analysis using Geographic Information Systems (GIS) as complementary approaches to the assessment of ecological coherence (OSPAR, 2013).

2.3. GIS-based spatial analysis

Recent advances in marine habitat mapping techniques and the rapid development of GIS-based tools for predicting habitat and species distributions (Elith and Leathwick, 2009) facilitate more detailed and accurate assessment of the ecological coherence of MPA networks (Ardron, 2008b).

2.3.1. Three (3) initial spatial tests proposed by OSPAR

The spatial assessment approach published as part of the OSPAR Biodiversity Series (OSPAR, 2008b) involves three initial spatial tests which evaluate whether the network is:

- "spatially well distributed, without more than a few gaps;
- covers at least 3% of most (seven of the ten) relevant Dinter biogeographic provinces and;
- represents most (70%) of the OSPAR T&D habitats and species (with limited home ranges), such that at least 5% [or at least three sites] of all areas in which they occur within each OSPAR region is protected".

The advantage of the spatial approach recommended by OSPAR is that it is less reliant on subjective opinions or reporting accuracy than the self-assessment and matrix approaches (Ardron, 2008a, b). The disadvantages include that it requires additional work above the minimum reporting requirements and requires the collection/collation of spatial data (Ardron, 2008a, b).

Rather than providing a definite answer of whether the MPA network is ecologically coherent or not, these three tests give a first indication of whether a network is likely to be ecologically coherent or not. The rules of thumb and thresholds suggested for these three initial OSPAR tests are extremely conservative, in that they over- or under-estimate threshold limits normally recommended in the scientific literature. For example, the "rule of thumb" for shoreline spacing (spatial test 1) is 10 times wider than what is normally cited in the literature (Shanks et al., 2003; Palumbi, 2004; Roberts et al., 2010), and also 10 times wider than that used by BALANCE-HELCOM project for assessing ecological coherence for the MPA network in the Baltic Sea (Piekainen and Korpinen, 2008). Therefore, in this particular example, if MPA spacing is greater than the threshold, then the MPA network is highly unlikely to be ecologically coherent. The use of simplified analyses inevitably raises scientific questions concerning whether these tests or ''rules of thumb'' are ultimately supportable (OSPAR, 2007b).

The ecological criteria assessed and the thresholds recommended by OSPAR for each of the spatial tests are:

Test 1 (spatial distribution threshold): Is the OSPAR MPA network spatially well distributed, without more than a few major gaps?

This test involves a simple visual overview of whether the MPAs are well-distributed in near shore and offshore areas (as well as fairly evenly spaced alongshore) with no, or just a *few*, *major gaps* in each of these areas.

The approximate rules of thumb used by OSPAR (2008b) for defining a "major gap" are:

a) for coastline / near shore spaces, any gap wider than 250 km;
b) for offshore / EEZ, any gap bigger than a 500 km diameter circle (~200 000 km^2);
c) for far offshore and high seas waters, any gap larger than approximately 1 000 000 km^2

The approximate rules of thumb used by OSPAR (2008b) for defining "few gaps" are:

a) for shoreline / near shore areas, up to 10 gaps
b) for offshore / EEZ waters, up to 5 gaps
c) for far offshore / high seas, up to 2 gaps.

Test 2 (biogeographic representation threshold): Does the OSPAR MPA network cover at least 3% of most (seven of the ten) relevant Dinter biogeographic provinces?

This test considers primarily representativity and adequacy, and infers some connectivity and replication within the network. The threshold set by OSPAR in this test to assess representativity is 3%, which is a $1/10^{th}$ of the recommendations commonly found in the scientific literature (i.e. 10% - 50%, commonly 30%; OSPAR, 2007b; Annex 2 of OSPAR, 2008b). Therefore, if the representativity of the MPA network is anything under 3%, the network is certainly not adequate. This test infers replication and connectivity based on the assumption that the 3%-or-greater criteria would constitute several sites (>3) distributed throughout the Dinter province.

Other finer scale biogeographic classifications such as the EUNIS classification are recommended by OSPAR instead of the Dinter biogeographic provinces when the analysis is run for (sub-) regions of the OSPAR Maritime Area.

Test 3 (Threatened and/or declining threshold): Are most (70%) of the OSPAR threatened and/or declining (T&D) habitats and species (with limited home ranges) represented in the MPA network such that at least 5% [or at least 3 sites] of all areas within each OSPAR region in which they occur is protected ?

This test looks at non-mobile T&D features for which spatial protection by MPAs would very likely be appropriate. The threshold used to assess representativity and replication is 1/10th of the minimum threshold found in the scientific literature (i.e. 50%) (OSPAR, 2008b). Perhaps a more sophisticated way of determining the cut-off point is that suggested by Pressey et al. (2004), whereby the rarity (R) and vulnerability (V) of the species or habitat in question are taken into account:

$$\text{Cut-off point \%} = 10\% + (10\% \times R) + (20\% \times V)$$

This test is the most data-demanding test out of the three spatial tests suggested by OSPAR. To date, spatial test 3 could not be conducted across the OSPAR Maritime Area as neither comprehensive spatial data regarding the distribution of species populations and habitats is available, nor is the reporting by Contracting Parties complete with regards to the extent to which these features are subject to their respective MPAs (OSPAR Commission, 2012).

2.3.2. GIS-overlay analysis & statistical analysis

Recent assessments on the ecological coherence of the Baltic Sea MPA network (comprising of Baltic Sea Protected Areas and marine Natura 2000 sites) have used a combination of statistical and spatial analyses to assess the **adequacy**, **representativity**, **replication** and **connectivity** within the MPA network in the Baltic Sea (Piekainen and Korpinen, 2008; HELCOM, 2010).

Adequacy was evaluated on a site-by-site basis in relation to size (Piekainen and Korpinen, 2008; HELCOM, 2010) and quality of MPA site (HELCOM, 2010):

a) MPA size
   Whereas, HELCOM (2010) used a minimum MPA size threshold of 3,000 ha, Piekainen and Korpinen (2008) did not use a specific threshold for size. Rather a bias in the size distribution of the MPA sites, a lack of certain size category or bias in size distribution between near shore and offshore waters were used to indicate a possible gap in adequacy (Piekainen and Korpinen, 2008).
b) Quality of MPA
   The quality of a site was analysed on the basis of available geo-information on eutrophication status, ship traffic intensity and fishing intensity (HELCOM, 2010). Maps of ship traffic densities and fish landings/catches were clipped to maps of the MPA network and a relative ship density and landings/catches in tonnes per MPA were calculated in GIS. These values gave an indication of the relative anthropogenic disturbance inside each MPA.

c) Essential habitats

The coverage of essential habitats including Important Bird Areas, Grey Seal haul-out sites, *Zostera* species habitat and Charophyte species habitat was also examined. The data used for the essential habitat analyses consisted of distribution maps and point datasets. For example, to define the coverage of *Zostera* habitats by MPAs the map of *Zostera* distribution was intersected with the MPA network and the total number of *Zostera* sightings located in the MPAs was calculated to determine the number of MPAs exhibiting *Zostera* sightings (HELCOM, 2010).

Representativity of the network of MPAs in the Baltic Sea was examined in terms of benthic marine landscape and geographical representation (Piekainen and Korpinen, 2008; HELCOM, 2010).

a) Marine landscape representativity

Five wide-spread benthic marine landscape types, representing different combinations of substrate, salinity and photic depth were used in the analysis. For the representativity analysis of benthic marine landscapes, GIS intersection methods were used to determine the area percentage of each landscape type in the MPA network. HELCOM (2010) used a three-level classification scheme for the proportionate representation of benthic marine landscapes, whereby, less than 20% protection of each marine landscape was considered inadequate representation, between 20 and 60% protection was considered as questionable and more than 60% was considered adequate representation. In the Balance project, the proportionate representation of landscapes were categorized according to five levels; bad <10%, poor 10-20%, moderate 20-30%, good 30-60 % and high 60-100% (Piekainen and Korpinen, 2008).

b) Geographical representativity

The proportion of each country's marine area designated as MPAs was estimated using an overlay analysis in ArcGIS. The geographical representation of protected areas was assessed with respect to a number of criteria:

- the proportion of each country’s MPA within territorial and exclusive economic zones (HELCOM, 2010);
- the proportion of each country’s MPA in the Baltic Sea basins (Baltic Proper, Bothnian Bay, Bothnian Sea, Gulf of Finland, Kattegat and Skagerrak) (Piekainen and Korpinen, 2008; HELCOM, 2010);
- the proportion of each country’s MPA in inshore and offshore areas (HELCOM, 2010).

In order to assess replication, a replicate should be adequate in size in order to support the communities of species it is intended to protect. HELCOM (2010) set the theoretical minimum of adequate replicates to three, with the minimum size for a landscape patch to be considered a replicate to 24 ha (Piekainen and Korpinen, 2008). The generalized benthic marine landscape dataset was first masked with the layer containing the MPAs in order to select only those landscape patches occurring within MPAs. The number of landscape patches and the mean sizes for patches within MPAs were calculated for each landscape type. Additionally, the total number of patches (unprotected patches also included) was calculated for each marine landscape in order to compare the total number of patches to the number of protected patches. The number of MPAs hosting the replicates of the different benthic marine landscapes was also calculated.

A twofold approach was used to assess connectivity of the MPA network in the Baltic Sea:

a) Theoretical approach

   The map of selected landscapes was then clipped with the maps of the MPA network. A neighbourhood analysis was carried out using a 25km search radius for neighbouring patches of the same landscape. The distance was chosen as a good compromise between short and long-distance dispersers (Piekainen and Korpinen, 2008; HELCOM, 2010)

b) Species specific approach

   Five species that display different dispersal strategies and distances (Macoma balthica, Psetta maxima, Furcellaria lumbricalis, Idotea baltica, Fucus vesiculosus) were chosen for the assessment. Based on information on their preferred habitats, sets of benthic marine landscape types were combined to form clusters of potential habitats for each of the chosen species. The neighbourhood analysis used to assess connectivity among MPAs within the network was carried out using species-specific distances.

This connectivity assessment only takes into account distance between protected landscape patches and does not take into account currents or other water movements aiding dispersal or migration of species between landscape patches (HELCOM, 2010). This is a major disadvantage of the assessment that probably leads to an overestimation of the connectivity.

2.3.3. Spatial predictive modelling and connectivity analysis

Sunblad et al. (2011) present two GIS-based analyses that allow quantitative assessments of the ecological coherence of the Natura 2000 network in the northern Baltic Sea. Two major criteria of ecological coherence were considered in their assessment; **representativity** was measured as the quantity of protected habitats, while the level of **connectivity** was measured as the number of linkages between local populations within the network. The assessment was carried out for four fish species (*Perca fluviatilis*, *Esox lucius*, *Sander lucioperca*, *Rutilus rutilus*) known (i) to utilize near-shore habitats during their early life stages and (ii) to be important for both commercial and recreational fisheries.

As a first step maps of recruitment habitats were produced for each of the fish species by relating species occurrence to environmental variables that influence juvenile fish and egg distribution (e.g. depth, wave exposure, water clarity). Species occurrence data was obtained from fish surveys using point abundance sampling to determine the distribution and abundance of egg, juvenile and adult fish and the length of adult individuals. Generalized additive models and GIS were used to describe species–environment relationships and to produce high resolution habitat maps for the 30 000 km^2 study area in the northern Baltic Sea.

During the second stage of the analyses, the recruitment habitat maps were used to assess how well the recruitment habitats were protected by the MPA network. To assess representativity and connectivity, a habitat map of the species assemblage (i.e. 4 species) was produced by combining the habitat maps of each species and classifying areas where the habitat of at least three species occurred as an 'assemblage' habitat. Representativity analysis was carried out at two scales; (i) 10 x 10 km^2 so as to provide a detailed picture of local representativity and (ii) 20 x 20 km^2 so as to represent the longest typical migration distance of the studied assemblage. Representativity was calculated as the amount of predicted 'assemblage' habitat protected by the Natura 2000 network in each square. The predicted 'assemblage' habitat patches were only included in the analysis if they were larger than 1 ha.

The assessment of connectivity was based on additional information on the dispersal ability of the most mobile species, pike perch (*Sander lucioperca*) and was set to 20 km. The premise here is that species with local populations or short dispersal distances will require more closely spaced protected areas than more migratory species (Johnson et al., 2008), and hence if the network is well-connected for long-distance dispersers than it should also be adequate for short-distance dispersers. The connectivity assessment was done in two steps: (i) the water distance between separate patches in the assemblage habitat map was calculated in GIS using the cost distance procedure, thus simulating fish movement around islands whenever these occurred, and (ii) the water distance between habitat patches within the Natura 2000 areas was also calculated.

The whole process not only examined whether the existing Natura 2000 network in the Baltic Sea was representative and well-connected for fish species but was also beneficial in identifying gaps in the network and target areas for future MPA establishment.

2.4. Other spatial assessment tools

2.4.1. Gap Analysis Program (GAP)

The Gap Analysis Program (GAP) is a nationwide program in the United States that began in the 1980s to assess and support the overall conservation status of wildlife (http://gapanalysis.usgs.gov). The objective of GAP is to identify biotic elements (species or alliances) that are either underrepresented or not represented in the existing network of conservation areas (Jennings, 2000). The basic process of gap analysis is to compare the distributions of species and vegetation types of interest with the distribution of conservation areas (Jennings, 2000) (Figure 1). Areas that are not adequately represented in conservation areas are identified as 'conservation gaps' or vulnerable and these, then become the focus of further conservation work.

Three principal data components are required for the analysis: (a) maps and other spatial information on species distributions, (b) maps and other spatial information of dominant vegetation cover types, and (c) maps of conservation areas (Jennings, 2000). Once these datasets are prepared, the vegetation and species distribution maps are intersected with the conservation area coverage map. The outputs of the statistical analysis include tables showing the number of hectares of each element's distribution that occur within each conservation area and maps detailing the relationship between species distributions and conservation areas (Jennings, 2000).

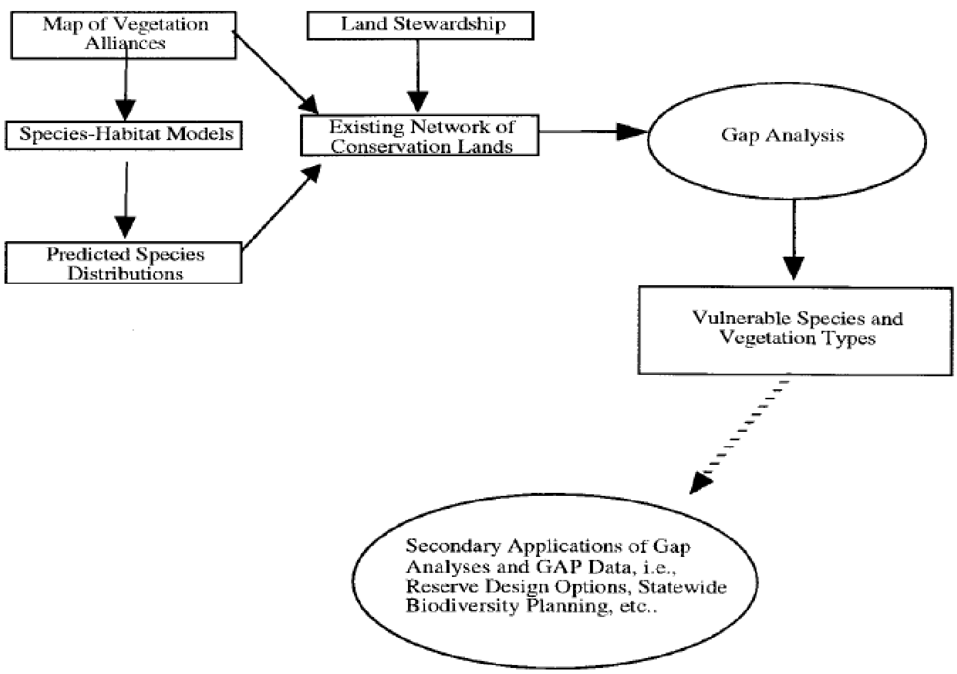

Figure 1. The GAP analysis process (taken from Jennings, 2000).

Weeks et al. (2009) adopted this approach to determine how well existing MPAs in the Philippines represent marine bioregions, conservation priority areas and marine corridors identified by the Philippine Biodiversity Conservation Priority-Setting Program. Polygon feature layers for the bioregions, priority areas, and corridors were overlaid with a point-feature shapefile of the locations of MPAs. To quantify the degree to which each feature was represented by existing MPAs, MPAs occurring within each feature polygon were summed from the MPA attribute table (Weeks et al., 2009). A size–frequency distribution plot was used to identify the proportion of MPAs that meet minimum size requirements set at (a) 10 – 100 km^2 (Halpern and Warner, 2003) and (b) 12.5 – 28.5 km^2 (Shanks et al., 2003) on the basis of recommendations in the literature (Weeks et al. 2009). Connectivity between MPAs was analysed by calculating the Euclidean distance to the nearest MPA for each site. The observed inter-MPA distances were compared with recommendations for MPA network design taken from Shanks (2003) and Jones et al. (2008).

The reliability of the results is influenced by the accuracy of the datasets used as inputs in the analysis. Scale is a pertinent issue to this type of analysis, especially when inferences are made from analyses done at a larger cartographic scale than the scale that the data were collected at (Jennings, 2000). A limitation is that GAP analysis currently does not predict element viability. For most species and plant communities, viability measures (e.g., habitat quality, species abundance, population trends) are unknown. Only information on representation, with the objective of identifying at-risk species and vegetation types, is provided (Jennings, 2000). The issue of how much of any species' distribution needs to be represented in conservation areas remains in many cases unresolved, primarily owing to the daunting task of collecting spatial data for each individual species or habitat (Jennings, 2000).

2.4.2. Marxan

Marxan is a software tool that selects a suite of areas that meet user-specified conservation targets in the most cost-effective way (Game and Grantham, 2008). Marxan has been used during the Irish Sea pilot project to identify important marine areas in the Irish Sea (Lieberknecht et al., 2004). From this project, it was concluded that Marxan is a highly useful tool to aid in the selection of nationally important marine areas. Marxan cannot assess criteria directly, that is, it cannot be used to measure biodiversity and naturalness and on that basis select the most diverse and natural areas (Lieberknecht et al., 2004). Pre-processing of spatial data is necessary by the user and once input files have been developed, the user sets targets to be met for conservation features within the area of study. For example, one scenario examined in the Irish Sea pilot project set targets of between 10 – 40 % of the total area of each marine landscape and for 2 – 5 of each benthic species and habitat on the Irish Sea provisional list to be present in the final output (Lieberknecht et al., 2004). A series of scenarios each incorporating slightly different targets and constraints can be run. There is no limit on the number of data layers that can be incorporated in Marxan, so targets can be set for any species, habitats for which spatial data are available. For example, a target could be set to represent a given percentage of known fish spawning grounds or known pristine areas within the selected areas. Once all data layers and targets are set, Marxan will then identify sets of planning units that meet these targets.

Although Marxan was not set up as a tool specifically to assess the ecological coherence of a MPA network, given the availability of some spatial information related to each criterion (e.g. representativity, replication) and pre-agreed conservation targets, Marxan can identify the ‘best’ MPA system that meets the specified criteria and targets. The Marxan output may then be compared to the existing MPA network and the likelihood of the network being ecologically coherent can be assessed based on how well the two match up.

III. Data requirement for assessment methods

The data requirements for methods reviewed in the literature for assessing ecological coherence of MPA networks are given in Tables 1 – 6. Methods of assessment are summarized by ecological criteria such that each table is specific to different criteria.

METHOD CATEGORY	METHOD NAME	APPROACH	REFERENCE	DATA NEEDS
Expert knowledge based method	OSPAR Self-assessment	Expert knowledge & judgement	OSPAR, 2007a	• none
Matrix/spreadsheet reporting	Matrix method proposed by OSPAR	Cross-tabulation	OSPAR, 2008a	• List of features protected by the MPAs • Distribution maps of features • MPA network map
Spatial analysis	OSPAR Spatial Test 1	Visual overview	OSPAR, 2008b	• MPA network map
Spatial analysis	OSPAR Spatial Test 2	GIS overlay analysis	OSPAR, 2008b	• MPA network map • Biogeographic regions map (Dinter)
Spatial analysis	OSPAR Spatial Test 3	Visual overview / GIS overlay analysis	OSPAR, 2008b	• List of OSPAR T&D species with limited mobility • Distribution maps for T&D habitat & species • MPA network map • biogeographic map
Spatial analysis	Spatial predictive modelling	GIS (cost-distance procedure) @ 2 spatial scales: 10 x 10 km^2 & 20 x 20km^2	Sundblad et al., 2011	• Predicted recruitment habitat maps for each species (relates species occurrence to environmental variables that influence juvenile fish and egg distribution) • MPA network map • Info. on migration/dispersal distance

Spatial analysis	GIS overlay & neighbourhood analysis	GIS intersection & overlay analysis @ 2 spatial scales: Marine landscape representativity & Geographical representativity	Piekainen and Korpinen, 2008; HELCOM, 2010	• MPA network map • Biogeographic regions map • benthic marine landscape map • inshore/offshore territorial waters limits; EEZ
Spatial analysis		MARXAN (Computer algorithm)	Game and Grantham, 2008	• Targets for features in MPAs • MPA network map • Spatial data & distribution of species and habitats

Table 1. Summary of methodological approach and data requirements for the assessment of representativity within an MPA network.

METHOD CATEGORY	METHOD NAME	APPROACH	REFERENCE	DATA NEEDS
Expert knowledge based method	OSPAR Self-assessment	Expert knowledge & judgement	OSPAR, 2007a	• none
Matrix/spreadsheet reporting	Matrix method proposed by OSPAR	Cross-tabulation	OSPAR, 2008a	• List of features protected by the MPAs • Distribution maps of features • MPA network map
Spatial analysis	OSPAR Spatial Test 3	Visual overview / GIS overlay analysis	OSPAR, 2008b	• List of OSPAR T&D species with limited mobility • Distribution maps of T&D habitat & species • MPA network map • biogeographic map
Spatial analysis	GIS overlay & neighbourhood analysis	GIS overlay analysis & descriptive statistics: minimum number of replicates: 3 minimum landscape patch size: 24 ha	Piekainen and Korpinen, 2008; HELCOM, 2010	• MPA network map • Size of MPAs • Benthic marine landscape maps • List of features (species and biotopes) of interest
Spatial analysis		MARXAN (Computer algorithm)	Game and Grantham, 2008	• Targets for features in MPAs • MPA network map • Spatial data & distribution of species and habitats

Table 2. Summary of methodological approach and data requirements for the assessment of replication within an MPA network

METHOD CATEGORY	METHOD NAME	APPROACH	REFERENCE	DATA NEEDS
Expert knowledge based method	OSPAR Self-assessment	Expert knowledge & judgement	OSPAR, 2007a	• none
Matrix/spreadsheet reporting	Matrix method proposed by OSPAR	Cross-tabulation	OSPAR, 2008a	• List of features protected by the MPAs • Distribution maps of features • MPA network map
Spatial analysis	OSPAR Spatial Test 2	GIS overlay analysis	OSPAR, 2008b	• MPA network map • Biogeographic regions map
Spatial analysis	GIS overlay & neighbourhood analysis	Sub-criteria considered: MPA size Descriptive statistics: Graphic representation of size distribution of MPAs	Piekainen and Korpinen, 2008	• Size of MPA
Spatial analysis	GIS overlay & neighbourhood analysis	Sub-criteria considered: • MPA size • Quality of MPA site • Essential habitats Descriptive statistics (graphic representation of size distribution of MPAs) & GIS (mapping, interpolation)	HELCOM, 2010	• Size of MPA • Geo-information on eutrophication status; ship traffic; fish landings/catches data • Distribution maps & point data for Important Bird Areas, Grey seal haul-out; Zostera species, Charophyte species • MPA network map

Spatial analysis		MARXAN (Computer algorithm)	Game and Grantham, 2008	• Targets for features in MPAs • MPA network map • Spatial data & distribution of species and habitats

Table 3. Summary of methodological approach and data requirements for assessment of adequacy/viability within an MPA network

METHOD CATEGORY	METHOD NAME	APPROACH	REFERENCE	DATA NEEDS
Expert knowledge based method	OSPAR Self-assessment	Expert knowledge & judgement	OSPAR, 2007a	• none
Matrix/spreadsheet reporting	Matrix method proposed by OSPAR	Cross-tabulation	OSPAR, 2008a	• Distribution maps of ecologically significant areas (e.g. feeding & breeding areas) • MPA network map
Spatial analysis	OSPAR Spatial Test 1	Visual overview / GIS nearest neighbour analysis	OSPAR, 2008b	• MPA network map
Spatial analysis	GIS overlay & neighbourhood analysis	• Theoretical approach (using 25km search radius) • Species-specific approach (search radius based on species-specific dispersal distance)	Piekainen and Korpinen, 2008; HELCOM, 2010	Theoretical approach: • Benthic marine landscape map • MPA network map Species-specific approach: • Spatial data & distribution maps for species of interest • Info. on dispersal strategies & distances • Info. on species' potential geographical distribution (suitable habitat) • MPA network map

Spatial analysis	Spatial predictive modelling & connectivity analysis	• Generalized additive models (GAMs) • GIS (cost-distance procedure)	Sundblad et al., 2011	• Predicted recruitment habitat maps for each species (relates species occurrence to environmental variables that influence juvenile fish and egg distribution) • MPA network map • Info. on migration/dispersal distance
Spatial analysis		MARXAN (Computer algorithm)	Game and Grantham, 2008	• Targets for features in MPAs • MPA network map • Spatial data & distribution of species and habitats

Table 4. Summary of methodological approach and data requirements for the assessment of connectivity within an MPA network.

METHOD CATEGORY	METHOD NAME	APPROACH	REFERENCE	DATA NEEDS
Expert knowledge based method	OSPAR Self-assessment	Expert knowledge & judgement	OSPAR, 2007a	• none
Matrix/spreadsheet reporting	Matrix method proposed by OSPAR	Cross-tabulation	OSPAR, 2008a	• inferred through analysis for the other criteria (adequacy/viability, representativity, replication, connectivity)
Spatial analysis: inferred through other criteria for ecological coherence (in particular replication)				

Table 5. Summary of methodological approach and data requirements for the assessment of resilience within an MPA network

METHOD CATEGORY	METHOD NAME	APPROACH	REFERENCE	DATA NEEDS
Expert knowledge based method	RAPPAM	Questionnaire method	Ervin, 2003b; Abdulla et al., 2008	• none

Table 6. Summary of methodological approach and data requirements for the assessment of management effectiveness within an MPA network

References

Abdulla, A., Gomei, M., Maison, E. and Piante, C. 2008. *Status of Marine Protected Areas in the Mediterranean Sea*. IUCN, Malaga and WWF, France. 152 pp.

Ardron, J.A. 2008a. The challenge of assessing whether the OSPAR network of marine protected areas is ecologically coherent. *Hydrobiologia*, 606: 45–53

Ardron, J.A. 2008b. Three initial OSPAR tests of ecological coherence: heuristics in a data-limited situation. *ICES Journal of Marine Science*, 65: 1527-1533

Day, J.C. and Laffoley, D. 2006. Self-assessment checklist for building networks of MPAs. WCPA IUCN.

Elith, J. and Leathwick, J.R. 2009. Species distribution models: ecological explanation and prediction across space and time. *Annual Review of Ecology, Evolution, and Systematics*, 40: 677–697

Ervin, J. 2003a. Rapid Assessment and Prioritization of Protected Area Management (RAPPAM), Gland (Switzerland): World Wide Fund for Nature.

Ervin, J. 2003b. Rapid assessment of protected area management effectiveness in four countries. BioScience, 53(9): 833-841.

Game, E. T. and H. S. Grantham. (2008). Marxan User Manual: For Marxan version 1.8.10. University of Queensland, St. Lucia, Queensland, Australia, and Pacific Marine Analysis and Research Association, Vancouver, British Columbia, Canada.

Gubbay, S., Ashworth, J., Bull, K., Earll, R., 2007. Towards a Coherent Network of Marine Protected Areas. Report of a Conference held on the 2-4th October 2007. Natural England Research Report No, 006, Scarborough, UK, p. 53.

Halpern, B.S. and Warner, R.R. 2003. Matching marine reserve design to reserve objectives. *Proceedings of the Royal Society B*, 270: 1871-1878

Helsinki Commission (HELCOM), 2009. Biodiversity in the Baltic Sea – an integrated thematic assessment on biodiversity and nature conservation in the Baltic Sea. Baltic Sea Environmental Proceedings, No 116B, pp. 1–188. Helsinki Commission, Helsinki, Finland.

HELCOM, 2010. *Towards an ecologically coherent network of well-managed Marine Protected Areas – Implementation report on the status and ecological coherence of the HELCOM BSPA network*. Baltic Sea Environment Proceedings No. 124B. Available from: http://www.helcom.fi/stc/files/Publications/Proceedings/bsep124B.pdf

IUCN World Commission on Protected Areas (IUCN-WCPA) (2008). *Establishing Marine Protected Area Networks—Making It Happen.* IUCN-WCPA, National Oceanic and Atmospheric Administration and The Nature Conservancy. Washington, D.C.

Jennings, M.D. 2000. Gap analysis: concepts, methods and recent results. *Landscape Ecology*, 15: 5-20.

Johnson, M.P., Crowe, T.P., McAllen, R. and Allcock, A.L. 2008. Characterizing the marine Natura 2000 network for the Atlantic region. *Aquatic Conservation: Marine and Freshwater Ecosystems*, 18: 86–97

Jones, G.P., Ablan Lagman M.C., Alcala A.C., Almany G.R., Botsford, L.W., Doherty P.J.,Green A., McCook L.J., Munday P.L., Planes S., Russ, G.R., Sale P.F., Steneck R.S., Thorrold S.R., Treml E.A., van Oppen M.J.H. and Willis B.L. 2008. Connectivity and the design of marine protected area networks in the coral triangle. Coral Triangle Initiative, Townsville, Queensland.

Lieberknecht, L M, Carwardine, J, Connor, D W, Vincent, M A, Atkins, S M and Lumb, C M (2004) *The Irish Sea Pilot - Report on the identification of nationally important marine areas in the Irish Sea*. JNCC report no. 347. Available online at www.jncc.gov.uk/irishseapilot.

OSPAR, 2007a. OSPAR Convention for the protection of the marine environment of the Northeast Atlantic, Meeting of the Intersessional Group on Marine Protected Areas, Secretariat, London, 5–7 Feb. 2007. Rapid Self-assessment Checklist for Ecological Coherence of the OSPAR Network of Marine Protected Areas. ICG-MPA 07/03/02-rev.

OSPAR, 2007b. Convention for the Protection of the Marine Environment of the Northeast Atlantic. 2007. *Background Document to Support the Assessment of Whether the OSPAR Network of Marine Protected Areas is Ecologically Coherent*. OSPAR Biodiversity Series, 320. Available from:
http://www.ospar.org/documents/dbase/publications/p00320_ecological%20coherence.pdf

OSPAR, 2008a. OSPAR Convention for the protection of the marine environment of the Northeast Atlantic. *A Matrix approach to assessing the ecological coherence of the OSPAR MPA Network*. Meeting of the Working Group on Marine Protected Areas, Species and Habitats (MASH), 21-24 October, Baiona (Spain).
Available from:
http://jncc.defra.gov.uk/pdf/0506_UK_OSPARMPAsEcoCoherenceAssessmt.pdf

OSPAR, 2008b. OSPAR Convention for the protection of the marine environment of the Northeast Atlantic. *Background document on three initial spatial tests used for assessing the ecological coherence of the OSPAR MPA network*. OSPAR Biodiversity Series, 360.
Available from:
http://www.ospar.org/documents/dbase/publications/p00360_3_initial_tests_ospar_mpa_network%20.pdf

OSPAR, 2013. OSPAR Convention for the protection of the marine environment of the Northeast Atlantic meeting of the Intersessional correspondence group on Marine Protected Areas (ICG-MPA) Edinburgh, UK: 21-23 January 2013. A matrix approach to assessing the ecological coherence of the OSPAR MPA network: trial of methodology in the Channel. ICG-MPA 13/3/3-E

OSPAR Commission, 2012. 2011 Status report on the OSPAR network of Marine Protected Areas. Biodiversity Series, 2012.

Palumbi, S.R. 2004. Marine reserves and ocean neighbourhoods: The spatial scale of marine populations and their management. *Annual Review of Environment and Resources*, 29:31-68.

Piekainen, H. and Korpinen, S. (eds.) 2008. Towards an assessment on ecological coherence of the Marine Protected Areas network in the Baltic Sea Region. BALANCE Interim Report No. 25, pp. 1–140. Balance, Copenhagen, Denmark. Available at: http://balance-eu.org/publications/index.html, accessed 15 September 2009.

Pressey, R.L., Watts, M.E. and Barrett, T. 2004. Is maximizing protection the same as minimizing loss? Efficiency and retention as alternative measures of the effectiveness of proposed reserves. Ecology Letters, 7: 1035-46

Roberts, C.M., Hawkins, J.P., Fletcher, J., Hands, S., Raab, K. & Ward, S. 2010. *Guidance on the size and spacing of Marine Protected Areas in England*. Natural England Commissioned Report NECR037. Available from: publications.naturalengland.org.uk/file/73037

Shanks, A.L., Grantham, B.A. & Carr, M.H. 2003. Propagule dispersal distance and the size and spacing of marine reserves. *Ecological Applications*, 13: S159-S169.

Sunblad, G., Bergstrom, U. and Sandstrom, A. 2011. Ecological coherence of marine protected area networks: a spatial assessment using species distribution models. *Journal of Applied Ecology*, 48, 112–120

Weeks, R., Russ, G.R., Alcala, A.C. and White, A.T. 2009. Effectiveness of marine protected areas in the Philippines for biodiversity conservation. *Conservation Biology*, 24(2): 531-540

PANACHE

Protected Area Network Across the Channel Ecosystem

PANACHE is a project in collaboration between France and Britain. It aims at a **better protection** of the Channel marine environment through the **networking** of existing marine protected areas.

The project's five objectives:

- **Assess** the existing marine protected areas network for its ecological coherence.
- **Mutualise** knowledge on monitoring techniques, share positive experiences.
- **Build** greater coherence and foster dialogue for a better management of marine protected areas.
- **Increase** general awareness of marine protected areas: build common ownership and stewardship, through engagement in joint citizen science programmes.
- **Develop** a public GIS database.

France and Great Britain are facing similar challenges to protect the marine biodiversity in their shared marine territory: PANACHE aims at providing **a common, coherent and efficient reaction**.

PANACHE est un projet franco-britannique, visant à une **meilleure protection** de l'environnement marin de la Manche par la **mise en réseau** des aires marines protégées existantes.

Les cinq objectifs du projet :

- **Étudier** la cohérence écologique du réseau des aires marines protégées.
- **Mutualiser** les acquis en matière de suivi de ces espaces, partager les expériences positives.
- **Consolider** la cohérence et encourager la concertation pour une meilleure gestion des aires marines protégées.
- **Accroître** la sensibilisation générale aux aires marines protégées : instaurer un sentiment d'appartenance et des attentes communes en développant des programmes de sciences participatives.
- **Instaurer** une base de données SIG publique.

France et Royaume-Uni sont confrontés à des défis analogues pour protéger la biodiversité marine de l'espace marin qu'ils partagent : PANACHE vise à apporter **une réponse commune, cohérente et efficace**.

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