Biodiversity Series

Background document to support the assessment of whether the OSPAR Network of Marine Protected Areas is ecologically coherent

OSPAR Commission
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The Convention for the Protection of the Marine Environment of the North-East Atlantic (the "OSPAR Convention") was opened for signature at the Ministerial Meeting of the former Oslo and Paris Commissions in Paris on 22 September 1992. The Convention entered into force on 25 March 1998. It has been ratified by Belgium, Denmark, Finland, France, Germany, Iceland, Ireland, Luxembourg, Netherlands, Norway, Portugal, Sweden, Switzerland and the United Kingdom and approved by the European Community and Spain.

La Convention pour la protection du milieu marin de l'Atlantique du Nord-Est, dite Convention OSPAR, a été ouverte à la signature à la réunion ministérielle des anciennes Commissions d'Oslo et de Paris, à Paris le 22 septembre 1992. La Convention est entrée en vigueur le 25 mars 1998. La Convention a été ratifiée par l'Allemagne, la Belgique, le Danemark, la Finlande, la France, l'Irlande, l'Islande, le Luxembourg, la Norvège, les Pays-Bas, le Portugal, le Royaume-Uni de Grande Bretagne et d'Irlande du Nord, la Suède et la Suisse et approuvée par la Communauté européenne et l'Espagne.

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Executive Summary

Background

OSPAR recommendation 2003/3 on the OSPAR Network of Marine Protected Areas (MPAs) has the purpose to establish an OSPAR network of marine protected areas and to ensure that by 2010 it is ecologically coherent network and well-managed. In 2006 the OSPAR Biodiversity Committee (BDC) adopted a guidance document for use by Contracting Parties in developing an ecologically coherent network of OSPAR marine protected areas (OSPAR agreement: 2006-3). At the same time BDC noted further work was necessary on guidance and the procedural steps for assessing the contribution of sites to an ecologically coherent network of MPAs. Following further work on the devlopment of such practical criteria during 2006/2007, BDC 2007 has agreed to publish this background document summarising existing literature on ecological coherence of MPA networks, and describing possible criteria and guidelines for assessing whether the OSPAR network of MPAs is ecologically coherent.

Purpose of the background document

The goal of achieving ecological coherence within the OSPAR network of MPAs is broad and ambitious. Yet, there is a pressing need to be able to assess it with a minimum of time and expense. Addressing this difficult question will likely involve a process of staged assessments, beginning with a preliminary assessment that is straight-forward and achievable. However, before such a preliminary assessment procedure can be designed, it is necessary to look broadly at the question of ecological coherence and what practical assessments are likely possible, given the current state of knowledge. The purpose of this document, which has been developed under the lead of Germany, is to provide the scientific background from which methods might be selected where appropriate and initial OSPAR assessment procedure(s) agreed upon. This paper is also intended to provide guidance to Contracting Parties in their own assessments of ecological coherence.

Recommendations & Conclusions

The following recommendations and conclusions have been drawn during the preparation of this document:

a. assessment of ecological coherence should support, rather than delay the identification and implementation of MPAs.

b. the assessment of ecological coherence should be carried out in a stepwise fashion, beginning with initial basic assessments, and then later following up with subsequently more detailed assessments. Some of the guidelines suggested in this document would be appropriate for the latter more sophisticated analyses, while others would be better suited for an initial basic assessment.

c. the occasional use of rudimentary mathematical formulae in this document should be considered, as with all the other guidelines herein, as optional guidance only.

d. the assessment of ecological coherence should be two-fold: national self-assessment and OSPAR-wide analysis. The OSPAR-wide review of ecological coherence will be carried out at the OSPAR area or regional level.

e. that OSPAR immediately begin developing procedures for both self-assessments (e.g. a rapid self-assessment check-list) and an initial assessment of the ecological coherence of the whole OSPAR MPA network.

f. in any assessment of ecological coherence, each one of the four Assessment Criteria (adequacy/viability, representativity, replication, and connectivity) should be addressed. However, for initial assessments, these will not involve complex or detailed analyses. The Assessment Guidelines in this document have been provided as possible examples.

g. as new data become available through the process of MPA identification, these data should be made available for the assessment of ecological coherence. Likewise, as the process of assessing ecological coherence uncovers a greater understanding of the OSPAR network as a whole, these findings should be shared back to inform the selection of additional sites.

h. early assessments of ecological coherence should make the most of the limited data available, including the OSPAR MPA electronic database, in order to provide guidance to Contracting Parties as to where the major gaps and deficiencies likely lie. However, as the OSPAR network of MPAs develops and becomes more sophisticated, so will the need to assess it. This will require a greater depth of information and expertise.

i. the need to coordinate the acquisition and compilation of data sets is urgent. Many of the current assessment guidelines, rudimentary though they may be, cannot be answered because of the current lack of data coordination amongst OSPAR Contracting Parties.

Summary of Possible Ecological Assessment Criteria and Guidelines

The following assessment guidelines have been identified in the document; these are grouped according to four ecological assessment criteria: adequacy/viability, representativity, replication, and connectivity. It is not expected that all of these guidelines will necessarily be applied in any given assessment. They are designed as approachable ways of casting light on the four assessment criteria, particularly when detailed ecological data are unavailable. (Note: for most guidelines, the text below has been abbreviated. The purpose of this executive summary is to provide an overview only. Please refer to the main body of the document for full text, explanations and elaborations.)

Assessment Criterion 1: Adequacy / Viability

Assessment Guideline 1.1: It should be expected that the sizes of network sites (for a given feature) should be distributed throughout, or exceed, the estimated range of sizes necessary to sustain a viable population or community.

Assessment Guideline 1.2: Sites that are heavily impacted and/or surrounded by heavily impacted areas should be larger than those in less impacted areas.

Assessment Guideline 1.3: Features of ecological significance should receive greater protection than normal.

Assessment Guideline 1.4: Location and geography can be used to indicate adequate protection such that:

a. protection of pelagic features should generally be achieved through the implementation of larger sites than those for benthic features;

b. in regions constrained by coastal physical geography (e.g. fjords, bays, bights, passages, straits), the adequate sizes of individual sites will generally be smaller than areas without such physical constraints (e.g. regional seas, open ocean);

c. offshore and/or deeper sites will generally require larger areas than for nearshore and/or shallow sites. (However, the exceptions of certain deep sea benthic features, such as hydrothermal vents and cold seeps, are noted.)

Assessment Guideline 1.5: in a given region, the adequate spatial protection of most OSPAR features, and the overall network, can be expected to conform to the scientific literature, and fall within the range commonly found within that literature. It is recognized that this is an evolving field of study.

Assessment Guideline 1.6: Owing to the multiplicity of its objectives, the OSPAR network can be expected to contain a variety of reserve sizes and corresponding spacing between sites.

Assessment Guideline 1.7: If a site is at the small end of the expected viability range for a given feature, then compact sites are preferable. If, on the other hand, a given site is at the large end of the estimated viability range, then a less compact shape would allow for greater spill-over and benefits outside of the reserve.

Assessment Guideline 1.8: A broad MPA network, such as the OSPAR network, with a wide variety of features, can be expected to have a wide variety of reserve shapes and sizes.

Assessment Guideline 1.9: The OSPAR MPA electronic database lists the aims and ecological criteria on a site by site basis. Thus, as a preliminary assessment, these attributes can be compiled to get an indication of how well they are being met across the network.

Assessment Guideline 1.10: A list / inventory of features within a region that (are known or believed to) meet the OSPAR aims and ecological criteria is required in order to fully assess if the existing MPA sites are likely adequate.

Assessment Guideline 1.11: Features that are common and widely distributed will generally require less proportional (percentage) protection than those features that are rare and/or sparsely distributed.

Assessment Criterion 2: Representativity

Assessment Guideline 2.1: OSPAR MPAs should be checked to ensure that they are broadly distributed across biogeographic regions. In such an assessment, there is no need to restrict the assessment to just one biogeographic classification system. So long as they appear to be rigorous (e.g. peer-reviewed), the use of a variety of systems is encouraged.

Assessment Guideline 2.2: Each of the Dinter bioregions should be adequately protected.

Assessment Guideline 2.3: National classifications that may be linked to EUNIS, such as *The Marine Habitat Classification for Britain and Ireland*, can be very helpful in assessing representativity at a national level, based on national categories, and should be used where they exist.

Assessment Guideline 2.4: In the absence of full biological surveys or full classification systems (such as EUNIS), simple surrogates should be used to check that representativity is possibly being achieved. Benthic and pelagic realms should be considered.

Assessment Guideline 2.5: Representative features that are very common and widely distributed will be likely to require less proportional (percentage) protection than those features that are just somewhat common.

Assessment Guideline 2.6: The OSPAR MPA nomination database should be checked to ensure that the idea of the “best” features was taken into account, across feature types and regions.

Assessment Guideline 2.7: Features that best represent their type can be expected to be characterized by most or all of these indicators:

a. typical morphology;

b. high density / abundance;

c. high degree of health / naturalness;

d. persistence (temporal and spatial); and

e. strong functional linkages.

Assessment Criterion 3: Replication

Assessment Guideline 3.1: In a given biogeographic area, more than one example of each feature should be protected.

Assessment Guideline 3.2: In a given biogeographic area, features protected in areas susceptible to catastrophic events require greater replication than those in low-risk areas.

Assessment Guideline 3.3: In a given biogeographic area, where no better data exist, natural variation can be assumed to be greatest between sites that are furthest apart.

Assessment Guideline 3.4: Features that are very specifically defined will exhibit less variation, and hence require less replication than features which are very general or "catch-all" categories.

Assessment Guideline 3.5: In a given biogeographic area, scientific requirements may require replicate sites for differing purposes. If these requirements are not known, it can be assumed that replicate sites that are a moderate distance apart (neither immediate neighbours, nor at extreme ends of the biogeographic area) will satisfy most scientific requirements.

Assessment Guideline 3.6: In a given biogeographic area, features for which there are weak, incomplete or modelled data require greater replication than those features for which better data are available

Assessment Criterion 4: Connectivity

Assessment Guideline 4.1: If an area is known or suspected to be important to connectivity, then it should be represented in the MPA network.

Assessment Guideline 4.2: Reserves in areas where there are known currents (e.g. many coastal areas) should be more closely spaced than otherwise. In order to maintain connectivity for most short to moderate larval dispersing species, when specific data are lacking, such nearshore sites should be spaced not further than 50 km apart.

Assessment Guideline 4.3: Connectivity between seabird sites can be measured in straight lines.

Assessment Guideline 4.4: Connectivity for marine species can be assumed to be greater along lines of similar habitat than across them.

Assessment Guideline 4.5: The density of marine reserves can be used as a way to group areas of likely connectivity. Likewise, it can also define gaps where connectivity has probably not been achieved.

Assessment Guideline 4.6: In the absence of dispersal data, connectivity may be approximated by ensuring the MPA network is well distributed in space, reflecting the scale of its surroundings.

Récapitulatif

Contexte

La Recommandation OSPAR 2003/3 concernant un réseau de zones marines protégées (MPA) a pour objet de créer un réseau OSPAR de zones marines protégées et de s'assurer que, d'ici 2010, il s'agisse d'un réseau écologiquement cohérent et bien géré. Le Comité biodiversité (BDC) OSPAR a adopté, en 2006, un document d'orientation sur l'élaboration d'un réseau écologiquement cohérent de zones marines protégées OSPAR (accord OSPAR: 2006-3). En même temps, le BDC a noté qu'il est nécessaire d'entreprendre des travaux supplémentaires sur les orientations et les étapes procédurales pour l'évaluation de la contribution des sites à un réseau écologiquement cohérent de MPA. A la suite de nouveaux travaux sur le développement de ces critères pratiques en 2006/2007, le BDC 2007 est convenu de publier ce document de fond qui résume la bibliographie existante sur la cohérence écologique des réseaux de MPA et qui décrit des critères et des lignes directrices éventuelles permettant d'évaluer si le réseau OSPAR de MPA est écologiquement cohérent.

Intention du document de fond

Parvenir à une cohérence écologique au sein du réseau OSPAR de MPA est un objectif vaste et ambitieux. Il y a pourtant un besoin urgent de pouvoir l'évaluer le plus rapidement et économiquement possible. Il faudra probablement envisager un processus d'évaluation à phases, pour traiter cette question difficile, en commençant avec une évaluation préliminaire simple et réalisable. Avant de concevoir une telle évaluation préliminaire, il sera cependant nécessaire d'étudier, de manière générale, la question de la cohérence écologique. Il s'agira également de se demander quelles évaluations pratiques risquent d'être possible étant donné l'état actuel des connaissances. L'intention de ce document, qui a été élaboré sous le pilotage de l'Allemagne, est d'assurer le contexte scientifique à partir duquel des méthodes peuvent être sélectionnées, le cas échéant, et une (des) procédure(s) convenue(s) pour l'évaluation préliminaire OSPAR. Le présent document a également pour intention de fournir aux Parties contractantes des orientations pour leurs propres évaluations de la cohérence écologique.

Recommandations et conclusions

Les recommandations et conclusions suivantes ont été tirées lors de la préparation du présent document:

a. l'évaluation de la cohérence écologique devra soutenir, plutôt que retarder, la détermination et la mise en oeuvre des MPA.

b. l'évaluation de la cohérence écologique sera effectuée de manière ordonnée, en commençant par des évaluations préliminaires de base et en effectuant ensuite d'autres évaluations plus détaillées. Certaines lignes directrices suggérées dans le présent document conviendraient aux analyses ultérieures plus sophistiquées, alors que d'autres conviendraient mieux à une évaluation préliminaire de base.

c. l'utilisation occasionnelle de formules mathématiques rudimentaires dans ce document sera considérée, comme dans toutes les autres lignes directrices qui y figurent, comme des orientations facultatives.

d. l'évaluation de la cohérence écologique s'effectuera en deux étapes: une autoévaluation nationale et une analyse à l'échelle de la Convention. L'examen de la cohérence écologique, à l'échelle d'OSPAR, sera effectué au niveau de la zone OSPAR ou au niveau régional.

e. OSPAR devra mettre au point immédiatement des procédures pour les autoévaluations (par exemple une check-liste rapide d'autoévaluation) ainsi que pour l'évaluation initiale de la cohérence écologique de l'ensemble du réseau OSPAR de MPA.

f. il faudra traiter chacun des quatre critères d'évaluation (bien-fondé/viabilité, représentativité, réplication et connectivité) dans toute évaluation de la cohérence écologique. Il ne s'agira cependant pas d'effectuer des analyses complexes ou détaillées pour les évaluations préliminaires. Les lignes directrices pour l'évaluation représentent, dans le présent document, des exemples possibles.

g. les nouvelles données disponibles, grâce au processus de détermination des MPA, seront mises à la disposition de l'évaluation de la cohérence écologique. De même, les conclusions du processus d'évaluation de la cohérence écologique, qui permet de mieux comprendre le réseau OSPAR dans son ensemble, pourront servir d'information pour la sélection de sites supplémentaires.

h. des évaluations précoces de la cohérence écologique devront exploiter au mieux les données limitées disponibles, notamment la base de données sur les MPA OSPAR, afin d'orienter les Parties contractantes dans la direction des lacunes et des insuffisances majeures. Cependant, en même temps que le réseau de MPA OSPAR se développe et devient plus sophistiqué, la nécessité de l'évaluer en fera de même, ce qui nécessitera des informations et des expertises plus approfondies.

i. il est nécessaire de coordonner d'urgence le recueil et la compilation des séries de données. De nombreuses lignes directrices pour l'évaluation actuelles, aussi rudimentaires qu'elles soient, ne peuvent pas être suivies car les données ne sont pas actuellement coordonnées entre les Parties contractantes OSPAR.

Récapitulatif des critères d'évaluation écologique et des lignes directrices possibles

Le document détermine les lignes directrices pour l'évaluation suivantes, regroupées en fonction de quatre critères d'évaluation écologique: bien-fondé/viabilité, représentativité, réplication et connectivité. On ne s'attend pas à ce que ces lignes directrices soient suivies dans chaque évaluation. Elles sont conçues pour donner des éclaircissements accessibles sur les quatre critères d'évaluation, en particulier lorsque des données écologiques détaillées ne sont pas disponibles. (Note: le texte ci-dessous a été abrégé pour la plupart des lignes directrices. L'objectif de ce récapitulatif est seulement de présenter une synthèse. Veuillez vous reporter à la partie principale du document pour consulter le texte intégral, les explications et les développements.)

Critère d'évaluation 1: Bien-fondé / Viabilité

Ligne directrice pour l'évaluation 1.1: On devrait s'attendre à ce que la distribution de la taille des sites d'un réseau (pour une caractéristique donnée) corresponde à, ou dépasse, la gamme estimée des tailles nécessaires pour maintenir une population ou une communauté viable.

Ligne directrice pour l'évaluation 1.2: Les sites qui subissent un impact important et/ou qui sont entourés de zones subissant un impact important, devront être plus étendus que ceux situés dans des zones qui subissent un impact moins important.

Ligne directrice pour l'évaluation 1.3: Les caractéristiques importantes du point de vue écologique seront plus protégées que les autres.

Ligne directrice pour l'évaluation 1.4: On peut utiliser des emplacements ou la géographie pour déterminer une protection adéquate, par exemple:

a. on assurera la protection des caractéristiques pélagiques en mettant en oeuvre des sites plus grands que ceux réservés aux caractéristiques benthiques;

b. dans les régions limitées par une géographie physique côtière (par exemple fjords, baies, golfes, couloirs, détroits), la taille adéquate des sites individuels sera généralement inférieure à celle des zones qui ne comportent pas de telles caractéristiques (par exemple, mers régionales, haute mer);

c. les sites offshore et/ou plus profonds seront en général plus étendus que ceux près du rivage et/ou peu profonds. (Il faut cependant noter que certaines caractéristiques benthiques de mer profonde font exception, telles que bouches hydrothermales et sources froides).

Ligne directrice pour l'évaluation 1.5: on peut s'attendre à ce que la protection spatiale adéquate de la plupart des caractéristiques OSPAR dans une région donnée et le réseau dans son ensemble se conforment à la bibliographie scientifique et se situe dans la gamme habituelle qui se retrouve dans cette bibliographie. On reconnaît qu'il s'agit là d'un domaine d'étude en cours d'évolution.

Ligne directrice pour l'évaluation 1.6: On peut s'attendre à ce que le réseau OSPAR contienne diverses tailles de réserve et d'espace correspondant entre les sites car il possède un grand nombre d'objectifs.

Ligne directrice pour l'évaluation 1.7: Si un site se trouve dans la partie inférieure de la gamme de viabilité à laquelle on s'attend pour une caractéristique donnée, il est alors préférable d'avoir des sites compacts. Si, d'un autre côté, un site donné se trouve dans la partie supérieure de la gamme de viabilité estimée, une forme moins compacte permettrait de plus grands débordements et bénéfices en dehors de la réserve.

Ligne directrice pour l'évaluation 1.8: On peut s'attendre à ce qu'un réseau étendu de MPA, tel que celui d'OSPAR, qui comporte une grande variété de caractéristiques, présente une grande variété de formes et de tailles de réserve.

Ligne directrice pour l'évaluation 1.9: La base de données électronique des MPA OSPAR énumère les objectifs et les critères écologiques pour chaque site. On peut donc, au titre d'une évaluation préliminaire, effectuer une synthèse de ces objectifs et critères qui indiquera comment ils sont satisfaits dans l'ensemble du réseau.

Ligne directrice pour l'évaluation 1.10: Il est nécessaire de dresser une liste / un inventaire des caractéristiques au sein d'une région qui sont connues ou sensées satisfaire les objectifs et les critères écologiques d'OSPAR afin d'évaluer pleinement si les sites existants de MPA sont probablement adéquats.

Ligne directrice pour l'évaluation 1.11: Les caractéristiques courantes et à distribution répandue exigeront en général proportionnellement moins (pourcentage) de protection que celles qui sont rares et/ou à distribution éparpillée.

Critère d'évaluation 2: Représentativité

Ligne directrice pour l'évaluation 2.1: Il faudra vérifier les MPA OSPAR afin de s'assurer qu'elles sont généralement distribuées à travers les régions biogéographiques. Dans le cas d'une telle évaluation, il n'est pas nécessaire de la limiter à un système de classification biogéographique. On encourage l'usage d'une variété de systèmes à condition qu'ils semblent être rigoureux (par exemple, revus par des pairs).

Ligne directrice pour l'évaluation 2.2: Chacune des biorégions de Dinter devra être protégée de manière adéquate.

Ligne directrice pour l'évaluation 2.3: Les classifications nationales qui peuvent être liées à l'EUNIS, telles que *la Classification des habitats marins pour la Grande-Bretagne et l'Irlande*, peuvent être très utiles quand il s'agit d'évaluer la représentativité à un niveau national, à partir des catégories nationales, et devront être utilisées lorsqu'elles existent.

Ligne directrice pour l'évaluation 2.4: En l'absence d'études biologiques complètes ou de systèmes de classification complets (tels que l'EUNIS), on devra utiliser des substituts simples pour vérifier que la représentativité peut être réalisée. On pourra envisager les royaumes benthiques et pélagiques.

Ligne directrice pour l'évaluation 2.5: Les caractéristiques représentatives qui sont très courantes et dont la distribution est répandue risquent d'exiger proportionnellement moins (pourcentage) de protection que celles qui sont courantes.

Ligne directrice pour l'évaluation 2.6: On vérifiera la base de données des nominations de MPA OSPAR afin de s'assurer qu'elle tient compte de l'idée des "meilleures" caractéristiques pour tous les types de caractéristiques et régions.

Ligne directrice pour l'évaluation 2.7: Les caractéristiques les plus représentatives de leur type seront définies par la plupart ou tous les indicateurs suivants:

a. morphologie typique;

b. haute densité / abondance;

c. niveau élevé de santé / état naturel;

d. persistance (temporelle et spatiale); et

e. liens fonctionnels forts.

Critère d'évaluation 3: Réplication

Ligne directrice pour l'évaluation 3.1: Il faudra protéger plus d'un exemple de chaque caractéristique dans une zone biogéographique donnée.

Ligne directrice pour l'évaluation 3.2: Les caractéristiques protégées des zones sujettes à des catastrophes devront faire l'objet d'une réplication plus importante que celle des zones à faible risque, dans une zone biogéographique donnée.

Ligne directrice pour l'évaluation 3.3: Lorsqu'il n'existe pas de meilleures données, on présumera que la variation naturelle est plus importante entre les sites qui sont les plus éloignés les uns des autres, dans une zone biogéographique donnée.

Ligne directrice pour l'évaluation 3.4: Les caractéristiques qui sont définies avec précision présenteront moins de variations et nécessiteront donc moins de réplication que celles qui appartiennent à des catégories générales ou collectrices.

Ligne directrice pour l'évaluation 3.5: Les exigences scientifiques peuvent demander des sites répliqués à des fins diverses, dans une zone biogéographique donnée. Si l'on ne connaît pas ces exigences, on peut présumer que les sites répliqués qui sont modérément éloignés les uns des autres (ni voisins, ni situés aux extrémités opposées de la zone biogéographique) satisferont la plupart des exigences scientifiques.

Ligne directrice pour l'évaluation 3.6: Les caractéristiques pour lesquelles l'on possède des données faibles, incomplètes ou modelées exigeront une réplication plus importante que celles pour lesquelles on dispose de meilleures données, dans une zone biogéographique donnée.

Critère d'évaluation 4: Connectivité

Ligne directrice pour l'évaluation 4.1: Si l'on sait ou l'on pense qu'une zone est importante pour la connectivité, elle devra être représentée dans le réseau de MPA.

Ligne directrice pour l'évaluation 4.2: Les réserves situées dans des zones connues pour leurs courants (par exemples de nombreuses zones côtières) seront moins espacées. Afin de maintenir une connectivité pour la plupart des espèces à dispersion larvaire courte à modérée, lorsque l'on de dispose pas de données spécifiques, ces sites proches du rivage ne seront pas éloignés de plus de 50km les uns des autres.

Ligne directrice pour l'évaluation 4.3: On peut mesurer en lignes droites la connectivité entre les sites d'oiseaux de mer.

Ligne directrice pour l'évaluation 4.4: On pourra présumer que la connectivité pour les espèces marines est plus importante lorsqu'il s'agit d'habitats similaires que lorsqu'il s'agit d'habitats différents.

Ligne directrice pour l'évaluation 4.5: On peut utiliser la densité des réserves marines pour regrouper des zones à connectivité probable. Cette densité peut de même déterminer où l'on n'est probablement pas parvenu à la connectivité.

Ligne directrice pour l'évaluation 4.6: En l'absence de données sur la dispersion, on peut obtenir une approximation de la connectivité en s'assurant que le réseau de MPA a une bonne distribution spatiale qui représente l'échelle des zones avoisinantes.

Introduction

The goal of achieving ecological coherence within the OSPAR network of MPAs is broad and ambitious. Yet, there is a pressing need to be able to assess it with a minimum of time and expense. Addressing this difficult question will be likely to involve a process of staged assessments, beginning with a preliminary assessment that is straight-forward and achievable. However, before such a preliminary assessment procedure can be designed, it is necessary to look broadly at the question of ecological coherence and what practical assessments are likely possible, given the current state of knowledge. The purpose of this document is to provide the scientific background from which methods might be selected where appropriate and initial OSPAR assessment procedure(s) agreed upon. This paper is also to provide guidance to Contracting Parties in their own assessments of ecological coherence.

In this document, the assessment of ecological coherence has been grouped under four general criteria. Each of these criteria is then broken down into several aspects, for which plausible assessment guidelines have been suggested. It is not expected that all of these guidelines will necessarily be applied in any given assessment. It is helpful to bear in mind that ultimately these various guidelines are designed to be approachable ways of casting light on the four assessment criteria, particularly when detailed ecological data are unavailable. In certain places, there may be better data and better understanding of ecological processes, which could lead to the development of more locally appropriate and sophisticated assessment techniques. However, in many places data for even the most rudimentary assessments may be missing, and simple guidelines may be the only way forward.

Because ecological coherence is a holistic concept reliant on many constituent parts, it is much easier to develop tests that indicate when it has *not* been achieved (i.e. some of the parts are missing) than it is to test when it has been achieved (i.e. when all the parts are present *and* interacting as expected). Thus, achieving the goal of ecological coherence is one that ultimately cannot be measured exactly, but must rather be stated as a likelihood, based on looking at a broad suite of indicators.

Principles: This document builds upon guidance document on developing an ecologically coherent network of OSPAR marine protected areas adopted by BDC 2006 (OSPAR agreement 2006-3) in which thirteen *Principles* were described. In this present document each Principle (except #13 –management) has been taken verbatim from these earlier documents, discussed, and linked with practical guidelines that can indicate whether that principle has been achieved. All thirteen principles are listed in Annex 3.

It has been found that while some of the Principles (1-4) do not directly address the question of network coherence, they are nevertheless very pertinent to the development of an effective and achievable OSPAR MPA network, and are discussed in Annex 1.

Assessment Criteria: The other Principles (5-12) have been grouped under four *Assessment Criteria*, which when taken together are necessary and sufficient[1] to assess the issue of MPA network ecological coherence: **Adequacy / Viability, Representativity, Replication, and Connectivity.**

Assessment Guidelines: Field data should always be used in preference to general "rules of thumb." Nonetheless, recognizing that sufficient field data will in most cases be unavailable, several *Assessment Guidelines* have been developed throughout this document with the following considerations:

a. the assessment guidelines are intended as an achievable means of casting light on the four Assessment Criteria, particularly when detailed ecological data are unavailable;

[1] As discussed above, being absolutely certain that ecological coherence has been met is extremely difficult. Nonetheless, these widely recognized four criteria can go a long way in providing such assurance.

b. in certain instances, there may be better data and better understanding of ecological processes, which could lead to the development of more locally appropriate and sophisticated assessment techniques;

c. it is not expected that all of these guidelines will necessarily be applied in any given assessment;

d. however, it is suggested that taken together, these guidelines can create a helpful overall picture;

e. therefore, these guidelines are provided as a series of practical checks that can indicate the likelihood that the above-noted Assessment Criteria and/or Principles have been achieved;

f. therefore, the assessment of ecological coherence should not be thought to rest on any one of these guidelines; but rather, that they be considered in their totality.

It is anticipated that as experience is gained, this document will be updated with revisions and additional methods included as guidelines.

The Assessment Criteria and Assessment Guidelines are summarized in the Executive Summary, above.

Case studies: Although case studies were originally envisioned as being part of this document, constraints surrounding the drafting group's capacity have made this impractical. Instead, Contracting Parties are encouraged to refer to the references provided in this document. It should also be recalled that BDC 2007 adopted a self assessment checklist as guidance on the design of the OSPAR network of MPAs. BDC 2007 agreed to urge Contracting Parties to make use of this self-assessment checklist in future assessments of ecological coherence and other factors influencing the effectiveness of the MPA network. This checklist is attached at Annex 4.

A systematic approach: In the past, protected areas in general have been created in an ad hoc manner, in a large part stimulated by the requirements of species-based legislation, or other singularly focussed planning (Noss, O'Connell, & Murphy, 1997). However, there is a growing body of MPA literature to suggest that this approach is far from ideal, and in some cases can lead to decisions that would later be regretted (Allison, Lubchenko, & Carr, 1998; Margules & Pressey, 2000; Stewart, Noyce, & Possingham, 2003). A non-systematic approach gives little assurance that initially selected areas will in the end represent an optimal distribution of sites required for an effective network of protected areas. Furthermore, in terrestrial planning it has been demonstrated that poor decisions can lead to sub-optimal solutions that do not efficiently meet the needs of either terrestrial ecology or the resource industry (Gonzales et al 2003). A similar risk exists in balancing the needs of the marine environment and various user groups. Nevertheless, striking such a balance is clearly necessary, as highlighted in the recent EC green paper on maritime policy (EC 2006). Thus, in order to best achieve such a fulsome balance, a systematic approach to OSPAR MPA selection and evaluation is recommended.

Scale: Ecology is intrinsically dependant on many scales of activities (Levin 1992). Thus, ecological coherence should be assessed at several scales, from that of a single site protecting a single small feature, to ultimately a global network. However, because the purpose of this particular document is to provide advice to Contracting Parties and to OSPAR, it focuses on scales appropriate to that of national seas and EEZs, and that of the whole OSPAR Maritime Area. These scales are quite broad, and several important details can be lost in an assessment. Thus, while it is outside the scope of this paper to discuss the finer scales, it is acknowledged that finer scale site-level assessments are also very important, and ultimately contribute to the health of the greater network. Likewise, it is recognized that the efforts of regional management organizations such as OSPAR need to be considered from a global perspective in order to be fully effective. Again, this scale is outside the scope of the current paper. Fortunately, attention is being turned to the global marine issues (e.g. UN Ad Hoc Open-ended Informal Working Group to study issues relating to the conservation and sustainable use of marine biological diversity beyond areas of national jurisdiction; and, the Convention on Biological Diversity). There is also a large and growing literature devoted to single site design considerations (e.g. Roberts et al 2003; NRC 2000), with several good examples to consider (e.g. von Nordheim et al 2006, Sala 2000). On the other hand, the literature devoted to broader ecological scales and applications of protected area *network* design is still rather small in comparison (e.g. Ardron in press). Finally, the assessment of ecological coherence appears to be in its nascent stages, with no comprehensive examples yet found in the literature.

Terms used in this paper

Aims: In this document, the term *aims* shall be used in the context of the OSPAR MPA network. I this respect the OSPAR guidelines on identification and selection of MPAs (*OSPAR agreement 2003-17*) sets out that that the components of the network will, individually and collectively, aim to:

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

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

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

Ecological Coherence: Neither OSPAR nor HELCOM has a formal definition for *ecological coherence,* though HELCOM has begun preliminary work on the topic (e.g. HABITAT 2005 5.2/7), and OSPAR likewise (OSPAR agreement 2006/3). Though “coherent,” “coherence” (and one instance of “ecological coherence” in Art. 10) are used throughout the EC Habitats (1992) and Birds (1979) Directives, these terms are not explicitly defined either. Ecological coherence is not often applied as a term in the scientific literature, and its occasional usage is usually fairly different from what is intended here (e.g. genetic relatedness). The term does show up in the “grey literature” reports often in the context of Natura 2000, but is also not clearly defined. It is generally used to imply some sort of connective structure (e.g. corridors –Good 1998) existing amongst, and binding together, ecological processes and functions (Bull et al 2003; STRA-REP (18) 1998).

The purpose of this paper is not to propose an OSPAR definition for ecological coherence. However, so that there is a general understanding of what is meant by this term, as applied in this paper, the following working definition is put forward based on work begun in OSPAR agreement 2006/3 and also by Laffoley et al (2006):

a. An ecologically coherent network of MPAs:

   i. interacts with and supports the wider environment (§5.3 & §6 OSPAR agreement 2006/3);

   ii. maintains the processes, functions, and structures of the intended protected features across their natural range (Laffoley et al 2006); and

   iii. functions synergistically as a whole, such that the individual protected sites benefit from each other in order to achieve the above two objectives (based on § 5.2, OSPAR agreement 2006/3).[2]

b. Additionally, an ecologically coherent network of MPAs *may*:

   i. be designed to be resilient to changing conditions (§5, OSPAR agreement 2006/3).

[2] That is, if a particular site would be equally effective on its own, then it cannot be said to be part of an ecologically coherent network.

Feature: In this document, the term *features* shall be used to mean "species, habitats and ecological processes" with the general understanding that these normally occur in the OSPAR area.

MPA: marine protected area, as defined in OSPAR Recommendation 2003/3 i.e. an area within the maritime area for which protective, conservation, restorative or precautionary measures, consistent with international law have been instituted for the purpose of protecting and conserving species, habitats, ecosystems or ecological processes of the marine environment. It is assumed that the MPA will be managed in such a fashion to give protection to the features within it, beyond that of the status quo outside of the reserve. Otherwise, any discussion of ecological coherence is misleading. Principle 13 (see Annex 3) also makes this point. It is recognized that MPAs are just one means by which to achieve the ecological goals of OSPAR. While this paper is concentrating on the question of assessing MPA network coherence, it in no way is meant to preclude other management options as well.

Precautionary Principle: The Precautionary Principle has been consistently supported by OSPAR (e.g. Ministerial Meeting of the Oslo and Paris Conventions 1992; Sintra Ministerial Statement 1998; Bremen Ministerial Statement 2003). It was initially defined in the Convention (1992) in relation to pollution, and later added in Annex V (1998) to reflect the broadened mandate of protection of ecosystems and biodiversity. With regard to fisheries, the Bremen Statement refers to the FAO definition.

a. ...preventive measures are to be taken when there are reasonable grounds for concern that substances or energy introduced, directly or indirectly, into the marine environment may bring about hazards to human health, harm living resources and marine ecosystems, damage amenities or interfere with other legitimate uses of the sea, even when there is no conclusive evidence of a causal relationship between the inputs and the effects (OSPAR Convention 1992, Preamble, Art. 2-2-a);

b. ...to develop means, consistent with international law, for instituting protective, conservation, restorative or precautionary measures related to specific areas or sites or related to particular species or habitats (ibid, Annex V Art. 3-1-b-ii);

c. It is understood that, in the context of the management of fisheries, the "application of the precautionary principle" has the same result as the application of the precautionary approach, as referred to in, for example Article 6 of the 1995 UN Fish Stocks Agreement (Footnote 1, Bremen Ministerial Statement, 2003);

d. States shall be more cautious when information is uncertain, unreliable or inadequate. The absence of adequate scientific information shall not be used as a reason for postponing or failing to take conservation and management measures (UN Fish Stocks Agreement 1995, Art. 6-2).

Ecological Coherence Assessment Criteria

Assessment Criterion 1: Adequacy / Viability

The concept of adequacy can be summarized with the following three quotations:

a. **Adequacy**: the required level of reservation [spatial protection] to ensure the ecological viability and integrity of populations, species and communities (ANZECC TFMPA 1998).

b. **Principle 12**: "The appropriate size of a site should be determined by the purpose of the site and be sufficiently large to maintain the integrity of the feature for which it is selected" (OSPAR agreement 2006-3).

c. **A network's constituent parts** should firstly be identified on the basis of criteria which aim to support the purpose of the network (§5.2, OSPAR agreement 2006-3).

A *set* of sites that individually address the purposes of the network does not yet assure that these form a *coherent network*; but it is a necessary prerequisite. Therefore, as a first step to assess the ecological coherence of an MPA network, its adequacy should be assessed on a site by site basis. This will involve considering two components:

a. **sizes and shapes** of the individual sites and their sum total; and

b. **network aims and ecological criteria**, and if the individual sites are said to address these.

Each of these two components will be further elaborated upon below.

Size & Shape: Ideally, sites should be monitored to ensure that their aims are being met. In cases where this is occurring, the *monitoring results should be used to determine if the individual site size / location / shape is adequate*. Where monitoring is not occurring, or is incomplete, or too recent to determine trends, other measures will have to be used. Size is probably the most commonly discussed measure, and yet it remains also probably the most controversial. Nonetheless, even in an absence of consensus on this issue, by looking at possible ranges of sizes, a sense can still be gained if the sites are, or are not, likely to be meeting their aims. A full assessment of site size, which is outside the scope of this paper, should take into account the species life-history, population structure, quality of the habitat, the quality of the surrounding areas, and connectivity to other sites (Lindeboom & Bäck 2005; Fahig 2001).

a. **Individual site size:** A site's size should be commensurate with the stated purposes (Principle 12). However, in many cases the scientific knowledge about a feature will be insufficient to determine this very exactly. Even if the life history of a species is well know, for example, it is usually not known how much the surrounding area can be expected to play a role in supporting the healthy functioning of that species. Nonetheless, it is generally true that heavily impacted surrounding areas will provide less of a supporting role to protected features than pristine ones. In data-poor situations, often it is still possible to specify a range of sizes which would likely be appropriate for the adequate protection of a given feature.

> ➢ **Assessment Guideline 1.1:** *It should be expected that the sizes of network sites (for a given feature) should be distributed throughout, or exceed, the estimated range of sizes necessary to sustain a viable population or community.*

- this range should be based on best available knowledge, and should reflect the uncertainty of being able to determine an exact size. If sites are consistently clustered at the small end of the estimated viability range, for example, then the likelihood that these can meet their aims is reduced.
- if the size requirements of the feature cannot be estimated at all, then it is still probable that a diversity of sizes throughout the network is an approach that will protect at least some of the features adequately. If possible, assessing this range of sizes should be based on a taxonomically or geomorphically similar feature, for which better data exist.
- in extremely data-poor situations, the range and distribution of sizes in a given MPA network could be assessed against other networks globally. A wide variety of sizes, including some quite large sites,[3] should be expected to at least partially protect the feature.

> ➢ **Assessment Guideline 1.2:** *Sites that are heavily impacted and/or surrounded by heavily impacted areas should be larger than those in less impacted areas.*

[3] Clearly, having *only* very large protected sites is the most precautious approach. That possibility is considered self-evident, but also unlikely from a pragmatic point of view, where there are several human users of the marine environment, such as in the OSPAR Maritime Area, and is not discussed further.

- in the absence of data on the surrounding areas, a precautionary approach should be taken, assuming that the individual site should be largely self-supporting. Thus, bearing in mind the precautionary principle, in data-poor situations adequate protection will require greater site sizes than if better data were available.
- see also Replication; and Annex 1, Principle 4.

Site size requirements can vary considerably depending on feature and location, from just a few hectares to tens of thousands of hectares. Many marine species have a planktonic stage in their life-history, which may not be fully addressed by spatial protection measures alone. On the other hand, many species also have critical life stages that are concentrated in smaller areas (e.g. nursery, or spawning areas – see OSPAR Guidelines on identification and selection of MPAs, Appendix 1 – OSPAR Agreement 2003/17)). These smaller areas can be viewed as "bottlenecks" and should receive greater than normal protection (Rice 2006; Roberts et al 2003a; Roberts et al 2003b).

> ➢ **Assessment Guideline 1.3:** *Features of ecological significance (except representativity) should receive greater protection than normal*[4]*.*

- due to their concentrated and usually homogeneous nature, *at a particular location* the entire feature should be included;
- if a feature straddles national borders, efforts should be made to coordination protection such that the feature is protected in a harmonized fashion;
- overall protection in the network should also be greater than normal.

Generally speaking, smaller sites are often closer to shore and larger ones are further offshore, reflecting the gradient from fine scale nearshore (largely benthic) processes to coarser scale offshore (largely pelagic) processes. However, there can be many exceptions to generalizations such as these; for example, offshore hydrothermal vent sites can be relatively small.

> ➢ **Assessment Guideline 1.4:** *Location and geography can be used to indicate adequate protection such that:*
>
> - *protection of pelagic features should generally be achieved through the implementation of larger sites than those for benthic features;*
> - *in regions constrained by physical coastal geography (e.g. Fjords, bays, bights, passages, straits), the adequate sizes of individual sites will generally be smaller than areas without such physical constraints (e.g. regional seas, open ocean) (Ardron in press);*
> - *offshore and/or deeper sites will generally require larger areas than nearshore and/or shallow sites. (However, the exceptions of certain deep sea benthic features, such as hydrothermal vents and cold seeps, are noted.)*

a. **Overall size:** The overall percentage protection of a feature and the overall percentage area of an MPA network are two related concepts that are often confused. For example, protecting 25% of a feature that is 4000 hectares, would be 1000 ha; and this might equate to 0.1% of a study area, if it happened to be one million hectares in all. In

[4] "Normal" can be quickly estimated from the median representativity targets in a given network.

most cases, including OSPAR, the MPA network is expected to protect a number of features. However, MPA modelling, particularly for fisheries purposes, often looks at just one feature (e.g. Rodwell & Roberts 2004). If a feature completely covers the study area (such as a widely distributed fish), the percentage protection of the feature and the percentage protection of the whole area, work out to being the same numbers. It is perhaps this situation that has led to the misconception that they are always the same. In any assessment, it should be made clear when the size of the network is being compared to a feature's overall distribution, or to the size of the study area.

With regard to meeting the aims of specific features, it is more meaningful to assess a network according to the proportion of each of its features to be protected, than it is to assess it according to the area of its sites (which are probably not populated completely with any given feature). However, the overall area of sites is often used as a "short-cut" to assess a network when data on the distributions of its various features are incomplete or unavailable.

It is unrealistic to expect agreement on any single network percentage; however, it is informative to consider the range of numbers commonly proposed for MPA networks. A variety of network sizes generally ranging from 10% to 50% have been suggested as being effective as a conservation and/or fisheries management tool (GACGC 2006, Rodwell & Roberts 2004, MRWG 2001, NRC 2000, Roberts & Hawkins 2000, Ballantine 1997, Carr & Reed 1993, Ballantine 1991), with an emphasis on larger numbers generally coming from the more recent literature.

➢ **Assessment Guideline 1.5:** *in a given region, the adequate spatial protection of most OSPAR features, and the overall network, can be expected to conform to the scientific literature, and fall within the range commonly found within that literature. It is recognized that this is an evolving field of study.*

b. **Shape**: Various site shapes and configurations have been found to be appropriate for different situations. The venerable *SLOSS* debate (single large or several small; e.g. Diamond 1975; Game 1980) is these days usually side-stepped, by saying, "it depends." For example, metapopulation theory initially appears to suggest that larger reserves may be more effective, but once several assumptions are removed, it may actually be that moderate sizes are better (Rampal & Heesterbeek 2000). Empirical evidence suggests that larger reserves often have beneficial effects disproportionate to their size (Halpern 2003). However, for coastal areas, modelling suggests that a number of smaller "stepping stones" may be more effective than single large reserves separated by greater distances (see also *Connectivity*, below) (Gaines et al 2003). A "banding" approach, with regularly alternating levels of protection, has been applied successfully along the coastline of St. Lucia (Roberts & Hawkins 2000).

➢ **Assessment Guideline 1.6:** *Owing to the multiplicity of its objectives, the OSPAR network can be expected to contain a variety of reserve sizes and corresponding spacing between sites.*

- If a region is dominated by only large widely spaced reserves, or only several small reserves, then it would suggest that the network in this region may not be adequately diverse to meet all of its objectives.
- "Spill-over" effects of reserves are partially dependant on the area to edge ratio. This and other "edge effects" can vary greatly, depending on the compactness of the reserve's shape (as well as oceanographic variables – see Connectivity, below). Compact sites can be expected to have less spill-over and greater internal viability than less compact sites of the same size for a given feature.

> ➢ **Assessment Guideline 1.7:** *If a site is at the small end of the expected viability range for given feature, then compact sites are preferable. If, on the other hand, a given site is at the large end of the estimated viability range, then a less compact shape would allow for greater spill-over and benefits outside of the reserve.*

- The Compactness of a given site can be readily calculated using a GIS and the following formula:

  $C = (4\pi A/p^2)^{0.5}$

  Where C is the Compactness; A is the area of the site; and p is its perimeter. This is based on Selkirk's (1982) circularity ratio,[5] whereby a circle receives a score of 1; i.e. it is the most compact shape, and all others will be less than that.

- Reserves in geographically restricted areas (e.g. fjords) may be necessarily less compact. Such instances should be treated separately, since the walls of a fjord (or similar feature) do not generally allow for spill-over or other common edge-effects.

- Owing to the unique nature of shorelines, the compactness of shoreline sites are most meaningfully compared with other shoreline sites.

- Effective management of a site usually requires simplified boundaries. These tend to increase the area and/or reduce the perimeter, and thus increase compactness.

Compactness and size are two independent variables, best investigated separately, as discussed above. However, they can be combined into a singular score. Like any singular score, it is limited in its descriptiveness, but can at a glance indicate if the network is diverse with regard to shape *and* size.

> ➢ **Assessment Guideline 1.8:** *A broad MPA network, such as the OSPAR network, with a wide variety of features, can be expected to have a wide variety of reserve shapes and sizes.*

- Initially assessing these together, and then plotting the frequency of the results (histogram) can provide a basic indication if the network is indeed diverse in this regard or not.[6] This initial assessment can then be followed up with more in-depth assessments, including characterising the spatial distributions, as required.

- The combined size and compactness of a site be readily calculated using a GIS and the following formula: $SSC = \ln(P/A)$

  Where SSC is here labelled as the site size-compactness; P is the perimeter of the site; and A is the area. (To keep the P/A ratio greater than e, it is convenient to use P in metres and A in hectares.) This is based on a measure of polygon *Precision*, originally derived and used in the context of collecting local knowledge from fishermen. With this measure, large generalized shapes get lower scores than small convoluted ones (Ardron 2005).

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[5] The square root is not in Selkirk's original formula. Its addition allows for the linear comparison of scores between sites. For example, if $C_1/C_2 = 2$, then it can be said that Site 1 is twice as compact as Site 2, in that it has half as much edge per given hectare.

[6] If quasi-normally distributed, these results can be more meaningfully grouped according to standard deviations (z-scores), or a fraction thereof.

Network aims and ecological criteria: This second component of the Adequacy criterion requires that the individual sites be considered to determine if, as a *set*, they fulfil the aims and ecological criteria of the OSPAR MPA network. While this does not yet ensure they are a coherent *network*, it is a necessary prerequisite.

The aims of the OSPAR MPA network are noted above, under *Terms used in this paper*. Ecological criteria / considerations are fully listed in Appendix 1 of OSPAR 2003-17, and are summarized below:

a. Threatened or declining species and habitats / biotopes

b. Important species and habitats / biotopes

c. Ecological significance

d. High natural biodiversity

e. Representativity [discussed in greater detail in the next section]

f. Sensitivity

g. Naturalness

It is not required that all of these considerations be met in a given site, but there is the tacit understanding that the overall network would meet these criteria / considerations. Indeed, some of these are likely spatially exclusive (e.g. criteria (a) and (b) are usually not the same feature, since they represent the two different OSPAR lists) and some ecological criteria conflict with some of the aims (e.g. criterion (g) conflicts with aim (a)). Thus, to meet all the aims and ecological criteria of the OSPAR network requires a set of sites with differing objectives and differing features protected.

> ➢ **Assessment Guideline 1.9:** *The OSPAR MPA electronic database lists the aims and ecological criteria on a site by site basis. Thus, as a preliminary assessment, these can be compiled to get an indication of how well they are being met across the network.*

- Sorting on the relevant database fields, sites can also be stratified according to their biogeographic regions (see Representativity and Principle 6, below) and again according to their OSPAR regions. It should be expected that each stratified region would contain a full suite of sites meeting the aims and ecological criteria.
- Ecological criteria (a) and (b) from the MPA database can be compared with the (initial) OSPAR List of Threatened and/or Declining Species and Habitats, and the "second OSPAR list" (addressing criterion (b)) when it is developed. This should give an initial indication of how well the features on these lists are being protected.

> ➢ **Assessment Guideline 1.10:** *A list / inventory of features within a region that (are known or believed to) meet the OSPAR aims and ecological criteria is required in order to fully assess if the existing MPA sites are likely adequate.*

- Even an incomplete inventory is better than nothing, and can be used to check if the sites are said to protect those features, though the incompleteness of the inventory should be noted.
- Such lists need not be spatial; rather, they need only note that these particular features are known (or believed) to exist. (Spatial assessments are covered by several other Guidelines.)
- Bearing in mind the precautionary principle, if there is not absolute certainty that a particular feature exists, or meets the ecological criteria, this uncertainty should be duly noted; but, the feature should still be included in

the assessment if expert opinion suggests that it likely exists and meets the ecological criteria.

Different features will likely require different levels of spatial protection, depending on their characteristics. While it is difficult to determine exact percentages (see discussion above), the sites of a network can be compared to one another to determine if the levels of relative protection make relative sense. The overall abundance and distribution of a feature will affect what percentage of that feature constitutes adequate protection.[7]

> ➢ **Assessment Guideline 1.11:** *Features that are common and widely distributed will generally require less proportional (percentage) protection than those features that are rare and/or sparsely distributed.*

- See also Representativity, below.

Assessment Criterion 2: Representativity

Representativity, and the closely related concept of comprehensiveness, began in terrestrial conservation planning and were taken up as concepts in marine conservation in the late 1990s. Australia and New Zealand were amongst the first to include them in marine planning. They were defined as:

a. **Comprehensiveness**: [inclusion of] the full range of ecosystems recognised at an appropriate scale within and across each bioregion (ANZECC TFMPA 1998);

b. **Representativity**: [areas that] reasonably reflect the biotic diversity of the marine ecosystems from which they derive (*ibid*).

It is worth noting that in the above two definitions, there is a nesting of scales, whereby comprehensiveness refers to the protection of ecosystems, and representativity refers to protecting the biotic diversity within each of these ecosystems. This separation of the two concepts and scales has generally been lost in subsequent definitions, which tend to group the two together under the one heading of representativity. Note however that in Principle 5, below, the idea of representative features being nested within each biogeographic area is still included, although it is being considered under the single heading of representativity (§15-16 OSPAR agreement 2006-3).

Principle 5: "The network should reflect biogeographic variation across the OSPAR maritime area by selecting the sites for the range of features within each biogeographic area." (OSPAR agreement 2006-3)

The OSPAR definition of representativity also includes the possibility of representativity being nested within comprehensive biogeographic units:

> [an area that] contains a number of habitat/biotope types, habitat complexes, species, ecological processes or other natural characteristics that are typical and representative for the OSPAR-Area as a whole or for its different biogeographic units (OSPAR agreement 2003-17).

The above-quoted Principle and definition are similar to the wording of the OSPAR MPA network aim (c); however there is one difference. In aim (c), the concept of choosing areas that "best" represent features is introduced. (This aim would appear to apply to *all* features, not just representative ones.) This adds an additional constraint, in that representativity must be somehow ranked or quantified, in order to separate out areas that *best* represent features. As discussed under Data Requirements, below, since *best* is a relative measure, absolute quantitative values are not strictly required. This idea that representativity can be ranked to varying degrees is also found in the EC Habitats Directive (1992 Annex III-A-a).

[7] Other considerations, such as a feature's functional role and its required relative abundance to meet ecosystem demands, should ideally be taken into account, but usually are not known.

Thus, considering all the above discussion together, representativity within the OSPAR MPA network can be assessed at three nested levels:

a. **Representative Biogeography:** That each biogeographic region has been protected;

b. **Representative Features:** That within each biogeographic region representative features have been protected;

c. **Best Representative Features:** That the best examples of representativity for each group of representative features have been protected.

Each of these three nested assessments will be elaborated upon below.

Representative Biogeography: To delineate biogeographic regions, a biogeographical classification system is required. An extensive review of existing biogeographic classification systems within the OSPAR Area has been given in Dinter (2001). Out of that work emerged a new classification system that has been applied within OSPAR. Since then, at the request of the EC, ICES also developed a classification system for the NE Atlantic (ICES 2004). Currently, The Nature Conservancy is developing global Marine Ecoregions Of the World (MEOW), which was presented at a side meeting to COP-8 of the Convention on Biological Diversity, and includes shelf regions of the OSPAR Area (Spalding et al 2006). To an outside observer, this plethora of various biogeographic systems can be confusing: Why is there still not universal agreement? This question is treated quite seriously in Dinter (2001), where it is pointed out that there are so many variables to consider, and so many different ways to put them together, that it seems almost inevitable that, "...there are as many methods as biogeographers." (Dunbar 1979, quoted in Dinter 2001). It should be added that data quality and availability can also influence these decisions.

> ➢ **Assessment Guideline 2.1:** *OSPAR MPAs should be checked to ensure that they are broadly distributed across biogeographic regions. In such an assessment, there is no need to restrict the assessment to just one biogeographic classification system. So long as they appear to be rigorous (e.g. peer-reviewed), the use of a variety of systems is encouraged.*

- Different classification systems will emphasize different aspects of the marine ecosystems, and are therefore valuable in highlighting possible gaps in the MPA network that another system might have overlooked.

a. **Principle 6**: "The biogeographic regions proposed by Dinter (2001) should form the initial framework for incorporating biogeographic variation within the network. Finer scale subdivisions may be developed to aid in practical application of OSPAR MPA selection criteria." (OSPAR agreement 2006-3)

> ➢ **Assessment Guideline 2.2:** *Each of the Dinter bioregions should be adequately protected.*

- For an understanding of what might be adequate, see the previous section, Adequacy/Viability. It should be expected that each bioregion would have about the same level of protection as the overall MPA network, though some variation based on bioregion size can be expected.
- It should be noted that the Dinter system uses three overlapping vertically differentiated *biomes:* pelagic waters less than 1000m in depth; the seafloor up to 1000m depth; and waters and the seafloor deeper than 1000m. Altogether, there are 22 biogeographic zones.
- As such, it is currently the most sophisticated of the biogeographic classification systems that completely cover the OSPAR Maritime Area, and should be considered an essential component of any OSPAR-wide assessment.

b. **Principle 7**: "The EUNIS habitat classification scheme should be used to characterise habitats throughout the OSPAR maritime area to assist the implementation of aim (c), particularly through Contracting Parties' assessment of representativity of the range of such features." (OSPAR agreement 2006-3)

Presently the EUNIS data are not publicly available in GIS format. Also, it currently does not cover the whole OSPAR region. Those parts currently completed emphasize nearshore areas. Nonetheless, for those areas that are completed and those that become available, they can be assessed in a limited fashion. However, until the whole of a region (be it politically defined such as national waters, or ecologically defined such as a biogeographic region) becomes fully classified under EUNIS, it will be difficult to draw anything put very preliminary conclusions.

> ➢ **Assessment Guideline 2.3:** *National classifications that may be linked to EUNIS, such as The Marine Habitat Classification for Britain and Ireland (Connor et al 2003), can be very helpful in assessing representativity at a national level, based on national categories, and should be used where they exist.*

Representative Features: Nested within the regions of a biogeographic classification will be several representative features. Where the distribution of representative features is not fully known, surrogates (also known as "proxies") can be modelled based on available physical data (CSAS 2005; Day & Roff 2000; Zacharias et al 1998). However, care must be applied in their development, use, and interpretation. It is best to confirm and augment modelled features with *in situ* biological sampling (Rachor 2006). In general, the more spatial attributes that are added to a spatial classification, the greater the spatial generalization (error), and thus it is better to develop separate combinations for specific features than to try to model everything into one comprehensive system (Ardron 2001). It should be appreciated that a representative feature defined in one biogeographic region likely indicates different biological communities than the identical criteria being applied in another biogeographic region. Again, it is stressed that if biological survey data exist, these should be used in preference to surrogates; i.e., the biology should 'speak for itself'.

a. **Surrogates:** Below are listed a few common examples:

- Depth and substrate are often combined to create benthic classifications at different depths for different bottom types (Zacharias et al 1998; Denthier 1990);
- In some seas, the addition of information about oxygen content can be very relevant to a benthic classification. Temperature /salinity and currents are also used (Janekovic 2006);
- Shoreline exposure (either measured or modelled) combined with shoreline composition can give an initial overview of shorelines (Zacharias et al 1998; Denthier 1990);
- In the absence of any data except for bathymetry, broad depth ranges can still be checked. Slope can be used to identify transitional areas. Additionally, topographical complexity can be developed, which can then indicate important habitats such as (depending on the scale) seamount complexes, reefs, and sills (for the GIS methodology, see Ardron 2002);
- The variability of pelagic ecosystems makes it difficult to create comprehensive systems based on any given variable. Nonetheless, there may be particular areas that are characterized by pelagic features with less than usual spatial variability, and these should be seen as opportunities for spatial protection. Example features include down- and upwellings, gyres, areas of high current, mixing zones, retention zones, sea surface highs (or lows), and predictable temperature / salinity fronts;

> ➢ **Assessment Guideline 2.4:** *In the absence of full biological surveys or full classification systems (such as EUNIS), simple surrogates should be used to check that representativity is possibly being achieved. Benthic and pelagic realms should be considered.*

- Simple physical surrogates can be created from singular data sets or combinations usually not exceeding three layers.
- Due to the broad nature of such an assessment, each classification can usually support no more than three to five classes. Class breaks should be determined by a literature review, if possible, or by natural breaks in the data. Equal intervals, while appealing to the human eye, are usually not biologically relevant.
- Areas with high variability should probably not be classified with a crisp boundary; though they can still be noted as “transition zones” with regard to that parameter. (Many such areas of high variability can have important ecological properties.)

b. **Proportion protected**: An assessment of representative features does not necessarily imply that an equal proportion of all features should be included in a network. Indeed, selecting equal proportions is generally not recommended. Differing representative features will likely require differing levels of protection, as suggested in the previous section (Adequacy), as well as by Principle 4 (Annex 1). The reasoning is that if fixed constant proportions are applied uniformly across a network, then that network will become dominated by the protection of vast swaths of what are acknowledged to be very common features, and which are probably not under particularly serious threat. For example, protecting 10% of a 10 000 000 hectare feature is a considerably larger undertaking than protecting 10% of a 10 000 hectare feature.

> ➢ **Assessment Guideline 2.5:** *Representative features that are very common and widely distributed will likely require less proportional (percentage) protection than those features that are just somewhat common.*

- As a rule of thumb taking into consideration the assumptions listed in Annex 2, within a given feature class, representative protection can be expected to be roughly proportional to the square-root of the ratio of representative features’ overall areas.
- Thus, within a given feature class (e.g. seabird species, benthic habitats, or marine biomes), the proportions of any two (x & y) should be such that : $(x_p / y_p) \approx (x_t / y_t)^{0.5}$ where the subscript “$_p$” represents the area protected of a given feature and the subscript “$_t$” represents the total area of a given feature in the network. That is, the rule of thumb is stating that the distribution of protection of multiple representative features of the same general kind should fall within a continuum roughly proportional to the square root of their respective total areas.
- For more details on this Assessment Guideline, please refer to Annex 2.

c. **Distinctive vs. Representative**: Roff and Evans (2002) point out that the difference between representativity, and what they call “distinctive” features, is largely one of scale. Representative features are larger, whereas distinctive features are smaller and nested within larger representative areas. However, when viewed at a different scale, a previously distinctive feature could be representative for that area. Thus, in the multiple-scale considerations of an ecosystem approach, the point at which an area stops being representative and starts becoming distinctive is not always clear.

Rare or unusual "representative" features may not necessarily be representative at a given scale, as that these cannot be said to be typical. In such situations, the following steps can be helpful:

- If the representative feature types are found to cluster around two or more size ranges, these can be separated out into different assessments, at different scales;
- If the area is found to be genuinely unusual, then it should be re-considered if it is better classified as an area of ecological or biological significance meeting a criterion other than representativity (as per 2003-17, Appendix 1);
- Biogeographic classification systems and surrogates (discussed above) can produce *slivers* which are a GIS by-product of attempting to fit several differing polygon boundaries together. If it is determined that an area is likely such a sliver, it is best to try to attach it to a neighbouring class, as that the sliver likely does not represent meaningful information;
- If none of the above points are found to be true, then the area should be treated as representative, with an expected protection proportionate to the other larger areas, based on the formula given in previous Guideline.

Best Representative Features: Aim (c) of the OSPAR network is "...to protect and conserve areas that *best represent* the range of species, habitats and ecological processes in the OSPAR area" (OSPAR agreement 2003-17; emphasis added). As discussed below, under Data Requirements, this superlative requires that not just the distribution of features is known, but also which ones are *more* representative than others. However, because this is a relative measure, absolute values (such as population numbers or health metrics) are not necessarily required, which somewhat eases the burden of this requirement. Nevertheless, the question remains: How can degrees of representativity be determined?

Ideally, a given feature will already have in place a monitoring regime or surveys to indicate under which criteria "best" may be judged, usually reflecting overall heath of the ecosystem (e.g. Laffoley et al 2006). For example, the age distribution of populations is a good monitoring parameter for health, and if it deviates significantly from what was observed in the more distant past (Lindeboom & Bäck 2005).

Furthermore, the identification of best features should have already been part of the MPA site identification process. In that case, one need only to consider the set of sites that were initially identified as possibilities and compare these to those that were finally selected.

However, in the absence of such ideal data, the *post-hoc* assessment may require several steps, beginning with a general survey and ending with site-specific surveys, depending on the capacity to do so. Furthermore, many of these characteristics require data that may not be widely available. Close cooperation with researchers is usually necessary to acquire the level of data required to assess whether a feature best represents its type. Quantifying the quality of a feature is not well addressed using "short-cuts" or "rules of thumb" and is therefore one of the more difficult aims to assess readily.

> ➢ **Assessment Guideline 2.6:** *The OSPAR MPA nomination database should be checked to ensure that the idea of the "best" features was taken into account, across feature types and regions.*

> ➢ **Assessment Guideline 2.7:** *Features that best represent their type can be expected to be characterized by most or all of these indicators:*
> - *Typical morphology;*
> - *High density / abundance;*
> - *High degree of health / naturalness;*
> - *Persistence (temporal and spatial); and*
> - *Strong functional linkages.*

a. **Morphology:** a given feature (usually a habitat structure) has a shape that is considered indicative of that feature. For example, in the context of Natura 2000, Klein (2006) studied bathymetry to initially identify features that had a shape indicative of a possible sandbank. Features were then ranked, with some being more defined than others. In terms of species, one would expect the animals to be "textbook cases," exhibiting the usual morphological characteristics of that species.

b. **Density / Abundance**: a given area exhibits a high number or density of the feature. Note that of the two measures, density is often the more meaningful, as that it is both a relative term, required to rank areas; and, because it has a spatial component required to identify protected area boundaries (i.e., a number of occurrences *per given area*). It is a flexible approach applicable in many different situations. For example, for seagrasses such as *Zostera*, or invertebrates such as *Ostrea*, certain areas might be characterized by greater densities than others. In the case of habitats, such as reefs, or hydrothermal vents, or even seamounts, some areas may be characterized by greater densities of such features (often so named "complexes," "fields," "chains," etc.) than others. For example, seamount complexes in the high seas and EEZs of the west coast of North America were first identified by bathymetric complexity, and then the density of these features was analysed (Morgan et al 2005). Similar work has also been done to identify sponge and coral complexes, based on the density of bottom trawling bycatch (Ardron & Jamieson in press). Seabird colonies of varying sizes can be aggregated by overall density of populations, whereby the clustering distance of colonies should be determined by biological characteristics of a given species (Rumsey et al 2004).

c. **Health / Naturalness**: The population abundance / density, discussed above, is often taken to indicate the health of a species. However, this is an indirect measure that does not consider factors such as toxic loading, population structure, and so forth. Comparing present with past population age structure can be a good indicator of health (Lindeboom & Bäck 2005). The health of a habitat feature can often be equated with its "naturalness" which is one of the OSPAR ecological criteria (OSPAR agreement 2003/17 Annex 1). While this is a rather qualitative term, it can provide some guidance. Ideally the feature in question should have a monitoring programme designed to address the question of health. In such cases, it should be fairly straight-forward to assess if MPAs have been set up in areas where the feature is considered to be most healthy. However, this will not be the usual case. Perhaps the most common indicator used for species health is population growth, whereby a strong growth rate is taken to indicate a robust population, and a negative rate is taken to indicate an unhealthy one (though there can be many circumstances that invalidate this simplistic assumption). For habitats, the degree of (usually human) disturbance can be ranked. For habitats already characterized by high disturbance regimes (e.g. exposed shorelines), the disturbances of interest are the ones *unnatural* to that system, e.g. oil spills, human shoreline development, etc.

d. **Persistence**: High quality sites are ones that are expected to persist over time. To assess this, there are two aspects: a site's past history, and current / future stressors.

i. With regard to species, for example breeding colonies, some sites are considered "core" sites, in that they have been continuously occupied for many years, whereas others are more peripheral. These core sites can be assumed to represent the best examples of that feature. Some feature sites will have less spatial variability than others for the same feature. These areas of greater spatial constancy should be viewed as the ones that best represent the feature, in the context of spatial planning and protection;

ii. Sites that are facing considerably increased amounts of stress might be expected to not persist in the same fashion that they had previously. If these stresses cannot be managed and mitigated (e.g. due to climate change), the site may no longer be considered as best representing the feature.

e. **Functional linkages**: This concept is related to Connectivity, discussed in much greater detail below. In short, better sites are ones that are expected to play an important and integrated role in the ecosystem. Thus, MPA sites that are located off on their own are less likely to be able to play such a role as those that are in the neighbourhood of other sites. Beyond physical isolation, the degree of functional isolation is usually difficult to quickly assess, but with greater research can be quantified to some extent by looking at sophisticated current modelling (Robinson et al 2005) or through genetic markers (Levin 2006).

Assessment Criterion 3: Replication

Principle 11: "Replication of habitats, species and ecological processes in separate OSPAR MPAs in each biogeographic area is desirable where it is possible." (OSPAR agreement 2006/3)

OSPAR agreement 2006/3 notes further that the replication of features is undertaken to:

a. spread risk against damaging events and long term change affecting individual MPAs;

b. ensure that natural variation in the feature is covered (either at a genetic level within species or within habitat types);

c. increase the number of connections between sites and enhance connectivity in the network; and

d. allow the establishment of scientific reference areas.

To this list one more is suggested:

e. allow for uncertainty in the identification of features, such that the greater the uncertainty, the more replication is required to ensure the feature is likely being protected.

The assessment of replication is, unfortunately, not as straight-forward as it would first appear. It is related to the concepts of ecosystem redundancy and resilience, which have been intensively discussed for several years with mixed results (Anderies et al 2006). However, initial assessments are generally tractable, and starting with the obvious is a good place to begin:

> ➢ **Assessment Guideline 3.1:** *In a given biogeographic area, more than one example of each feature should be protected.*

- Recognizing that in the case of very rare features, this may not be possible.

Replication should be assessed based on the five aspects noted above.

Risk Management: Different areas will be under differing levels of risk. Thus, to properly assess if this aspect is being properly addressed, a sense of the risk in a given area is required. Allison et al (2003) noted that in their modelling of risk against oil spills and hurricanes, some areas of the California coast were very low risk, and reserves would be expected to only need to have a 10%

buffer in order to address this low risk; whereas other areas were very high risk areas, and reserves would have to be replicated five to ten times in order to meet the risk!

> ➢ **Assessment Guideline 3.2:** *In a given biogeographic area, features protected in areas susceptible to catastrophic events require greater replication than those in low-risk areas.*

- Risk can be crudely estimated by considering the density of human activities (e.g. shipping, oil and gas extraction) and areas known to be at risk from extreme weather events.
- Features in areas judged to be high-risk are probably better replicated in low-risk areas, if possible, rather than trying to address the risk directly within the high risk zone.

Natural Variation: The assumption is that no one area can capture the full diversity of the feature in question. With regard to a habitat type, somewhat different species communities may be associated with it in different areas. With regard to a species, there may be some genetic variation from place to place. It is common that this variation is correlated with distance between sites (see also Functional Linkages, above; and Connectivity, below). Also, variation is related to the specificity of the feature in question. Thus, very specific features can be expected to exhibit less variation than features that are very broad in their scope.

> ➢ **Assessment Guideline 3.3:** *In a given biogeographic area, where no better data exist, natural variation can be assumed to be greatest between sites that are furthest apart.*

- Therefore, to fulfil this aspect of replication, replicated features should be separated far apart. (However, this will probably not meet the Connectivity criterion, discussed below.)

> ➢ **Assessment Guideline 3.4:** *Features that are very specifically defined will exhibit less variation, and hence require less replication than features which are very general or "catch-all" categories.*

- Thus, many representative features, because of their broad classifications, will require greater replication than distinctive or species-specific features (see also Representativity, above).

Connectivity: This is discussed in detail in the next section.

Scientific reference: In order to understand natural variability, more than one scientific reference site is required. Proximate sites are best to understand temporal variability, whereas more distant sites are better to understand spatial variability. Practical limitations (e.g. ship time) will also limit how far apart replicate sites can be placed. Note that while scientific replication is not directly related to ecological coherence, it is included here because good scientific study is essential for improved assessment of whether ecological coherence has been achieved.

> ➢ **Assessment Guideline 3.5:** *In a given biogeographic area, scientific requirements may require replicate sites for differing purposes. If these requirements are not known, it can be assumed that replicate sites that are a moderate distance apart (neither immediate neighbours, nor at extreme ends of the biogeographic area) will satisfy most scientific requirements.*

Uncertainty: Where data are weak, there can be significant uncertainty in determining if a feature is present, and exactly where. In such cases, replication is required in order to add assurance that the desired feature has indeed been protected. (See also Adequacy, above.)

> ➢ **Assessment Guideline 3.6:** *In a given biogeographic area, features for which there are weak or incomplete or modelled data require greater replication than those features for which better data are available.*

- Thus, bearing in mind the precautionary principle, in data-poor situations adequate protection will require greater numbers of replicate sites than if better data were available.

Assessment Criterion 4: Connectivity

As discussed above (see Terms), the concept of ecological coherence appears to be strongly associated with that of connectivity. It is therefore ironic that of the four Assessment Criteria discussed in this paper, connectivity is likely the most poorly studied and understood. Connectivity can be considered in spatial terms (e.g. physical linkages) as well as functional terms (e.g. persistence, genetic exchange, etc.). MPA site selection modelling has begun to consider these complicated issues of connectivity, but with much more work still to be done (Williams et al 2005). Some results suggest that spatial efficiency (see Annex 1, below) and connectivity may often be trade-offs (Briers 2002). Arguably the most important, and the least studied, aspect of connectivity is larval transport. Gaines *et al* lament: "...despite the clear relationship between larval export/recruitment, and fishery sustainability or species persistence, few existing models consider larval dispersal explicitly. Indeed, most existing models do not even include the larval stage in the life cycle..." (2003; pp s32-s33). From the perspective of assessing ecological coherence, this is clearly unfortunate. However, research of larval dispersal has increased dramatically in the past few years, and this data-poor situation is thus likely to change (Levin 2006). In the meantime, the precautionary principle / approach and Principle 10, below, reminds us that this lack of knowledge should not be used as a reason to not develop an MPA network. Indeed, it is this hard-earned practical experience that can be gained only by doing, which is most needed in this field.

Principle 10: "Lack of knowledge with regard to connectivity in the marine environment should not prevent the development of the OSPAR MPA network." (OSPAR agreement 2006/3)

Principle 9: "Detailed connectivity issues should be considered only for those species where a specific path between identified places is known (e.g. critical areas of a life cycle)." (OSPAR agreement 2006/3)

Principle 8: "The design of a network of marine protected areas needs to recognise aspects of connectivity and, where possible, place protected sites where they may have maximum benefit as measured against the objectives of the network." (OSPAR agreement 2006/3)

> ➢ **Assessment Guideline 4.1:** *If an area is known or suspected to be important to connectivity, then it should be represented in the MPA network.*

- Given the lack of data regarding such issues, this need not be a comprehensive list. It is rather expected that such knowledge will be piecemeal and thus, for the moment, suggests that piecemeal site nomination based on this criterion is the only way forward.

Modelling suggests that in areas with significant advection (currents > 1cm/s (0.02 knots)), such as along a typical shoreline, a series of smaller reserves are more effective than fewer large ones (Gaines et al 2003). Separate modelling based on observed larval characteristics in nearshore temperate environments suggests that a reserve 4–6 km in diameter should be large enough to contain the larvae of short-distance dispersers, and reserves spaced 10–20 km apart should be close enough to capture propagules released from adjacent reserves (Shanks et al 2003). Still other research, based on genetic research, suggests that genetic isolation can typically be noticed at 2 – 5 times the mean larval distance (Palumbi 2003). Taking the mean values from these last two papers (15 km x 3.5 = 52.5 km) suggests that about 50 km spacing could serve as a reasonable rule of thumb for maximum spacing in nearshore environments, in which connectivity for short-moderate distance dispersers is being preserved.

> ➢ **Assessment Guideline 4.2:** *Reserves in areas where there are known currents (e.g. many coastal areas) should be more closely spaced than otherwise. In order to maintain connectivity for most short to moderate larval dispersing species, when specific data are lacking, such nearshore sites should be spaced not further than 50 km apart.*

- There are a numerous assumptions to this general statement. One worth bearing in mind is that this assumes breeding adult species will not be viable outside of reserves. In areas that face few external pressures, this rule of thumb can be relaxed. If pressures are unknown, or suspected, then the precautionary principle demands that we assume the features can only survive within the MPAs, until better data become available (reversal of the onus of proof).
- It should be noted that at the recent BALANCE-HELCOM workshop on ecological coherence (25-27 Oct. 2006, Helsinki), 25 km was suggested as necessary spacing (BALANCE 2006).

The concept of “sources and sinks” is one that has sometimes been successfully used to demonstrate connectivity, with sources viewed as being valuable exporters of larvae and/juveniles to adjacent downstream areas (e.g. Roberts 1997). However, it is generally difficult to know beforehand where these areas might lie. Modelling of known currents can aid in this decision-making (Robinson et al 2005), but is rather sophisticated and therefore outside the scope of initial assessments. However, some simple “short-cuts” can aid in the assessment of connectivity:

> ➢ **Assessment Guideline 4.3:** *connectivity between seabird sites can be measured in straight lines*.

> ➢ **Assessment Guideline 4.4:** *connectivity for marine species can be assumed to be greater along lines of similar habitat than across them.*

- Alongshore connectivity is usually greater than cross-shore;
- Connectivity along seamount chains and ocean ridges is usually greater than across them;
- Connectivity can be assumed to more often follow similar depth / temperature / salinity values than cross them;
- Connectivity can be assumed to follow the general paths of currents, eddies, and gyres.

When all other data are lacking, simply looking at the network can reveal spatial patterns that are likely correlated to connectivity. These can be quantified using basic GIS techniques.

> ➢ **Assessment Guideline 4.5:** *the density of marine reserves can be used as a way to group areas of likely connectivity. Likewise, it can also define gaps where connectivity has probably not been achieved.*

- The “search radius” of the GIS density analysis can be varied to assess likely connectivity for different features with differing connectivity requirements.
- Because density looks at straight-line distances, this is only a very approximate assessment, best done at scales where the localized effects of land (e.g. bays, etc.) are less noticeable.

- More accurate, but more involved, GIS techniques use a "cost surface" whereby barriers (e.g. land) and corridors (e.g. currents) can be incorporated.

Finally, there is the advice of OSPAR agreement 2006/3, §20:

> - **Assessment Guideline 4.6:** *In the absence of dispersal data, connectivity may be approximated by ensuring the MPA network is well distributed in space, reflecting the scale of its surroundings.*

- For example, the nearshore is generally dominated by finer scale processes than the offshore, and therefore MPAs in offshore regions may be larger and further apart than those in nearshore areas.

Data Requirements

Specific circumstances will vary from case to case, with varying amounts of data and expertise being available. This document takes this into account by noting methods that can be applied in moderate through to data-poor situations commonly encountered in the OSPAR maritime area. While these approaches are clearly not as reliable as those taken with better data, they nonetheless can give some indication of how well the criterion or principle is being met. In all cases, the acquisition of the **best available data** combined with **relevant expertise** is recommended.

To address the three network aims and the assessment criteria, as well as good network design (Annex 1), the following base data should be assembled as completely as possible. Clearly, better resolution data will lead to better resolution assessments, and ultimately better decision-making (Richardson et al 2006).

a. **OSPAR MPA data:** Contracting Parties should report MPAs using the agreed OSPAR electronic nomination database and should supply a GIS file of the nominated MPAs (BDC 2006 Summary Record § 3.43a).

b. **Relative distribution and relative health of the relevant features**. Since the objective is to know where the best areas are (see MPA network aim (c), above), and "best" is a relative measure, relative measures will suffice. In moderate data situations, it is unlikely that the health of the feature will be known directly. In this case, abundance and/or density can often be assumed to also represent health, though this is not always so. In data-poor situations, it is unlikely that the overall abundance of the feature is known. Nonetheless, there may still be enough data to model the expected relative abundance. Clearly, modelled or interpolated results are only as good as the model, its methods, and its inputs; and it is probable that some areas will be overlooked. Nonetheless, if the model does identify key areas of abundance, then it can be seen as helpful. Such predicted areas can be subsequently surveyed to aid in boundary delineation (Boedeker et al 2006).

c. **Overlapping distribution of human activities**. This is necessary to address aims (a) and (b). Of interest here is classifying the data as follows:

   i) *Activities that are likely to have already caused irreparable harm to the feature in question.* These areas are expensive or impossible to restore and usually should be ruled out for protection (Earll 2006). However, they should still be accounted for in determining a historic baseline.

   ii) *Activities that are likely to have harmed the feature, but the harm can be reversed.* Protecting these areas may also be expensive to restore, and cause significant economic displacement, but a decision may be made that the ecological values warrant it. This fulfils aim (a) of the OSPAR MPA aims, noted above.

iii) *Activities that have not yet harmed the feature significantly, but pose a future threat.* Protecting these areas may cause some economic displacement, but are less expensive since restoration is not required. Nonetheless, these areas represent a sense of urgency because delay in decision-making may cause future harm and greater associated costs. This fulfils aim (b) of the OSPAR MPA aims, noted above.

iv) *Activities that have not yet harmed the feature, and are unlikely to do so, but which would be affected by protection measures.* This last classification does not directly address the network aims. Nonetheless, it is included to point out that economic displacement, if it is used in the selection process,[8] may not be limited to harmful activities and that these other activities should be taken into account, as that it is becoming widely recognized that economic factors can determine the success or failure of a protected area (Wätzold et al 2006).

Recommendations & Conclusions

The assessment of ecological coherence should not delay, but should rather support the identification and implementation of MPAs.

The assessment of ecological coherence should be carried out in a stepwise fashion, beginning with initial basic assessments, and then later following up with subsequently more detailed assessments. Some of the guidelines suggested in this document would be appropriate for the latter more sophisticated analyses, while others would be better suited for an initial basic assessment.

The occasional use of rudimentary mathematical formulae in this document should be considered, as with all the other guidelines herein, as optional guidance only.

The assessment of ecological coherence should be two-fold: national self-assessment and OSPAR-wide analysis. The OSPAR-wide review of ecological coherence will be carried out at the OSPAR area or regional level.

That OSPAR immediately begin developing procedures for both self-assessments (e.g. a rapid self-assessment check-list) and an initial assessment of the ecological coherence of the whole OSPAR MPA network.

In any assessment of ecological coherence, each one of the four Assessment Criteria (adequacy/viability, representativity, replication, and connectivity) should be addressed. However, for initial assessments, these will not involve complex or detailed analyses. The Assessment Guidelines have been provided as possible examples.

As new data become available through the process of MPA identification, these data should be made available for the assessment of ecological coherence. Likewise, as the process of assessing ecological coherence uncovers a greater understanding of the OSPAR network as a whole, these findings should be shared back to inform the selection of additional sites.

Early assessments of ecological coherence should make the most of the limited data available, including the OSPAR MPA electronic database, in order to provide guidance to Contracting Parties as to where the major gaps and deficiencies likely lie. However, as the OSPAR network of MPAs

[8] OSPAR agreement 2003-17 suggests taking practical considerations (including political acceptance and the potential success of management measures) into account to prioritize the selection of possible sites, as *Stage 2,* after they have been initially screened according to ecological criteria (ref 2003-17, §3.2 & Appendix 2). The EC Habitats Directive (1992), however, states that site identification should be based on scientific criteria (Article 4.1 and Annex III). Subsequently, management of sites ...*shall take account of economic, social and cultural requirements and regional and local characteristics* (Article 2.3) and in the special case of Article 6.4, also consider *...imperative reasons of overriding public interest, including those of a social or economic nature.*

develops and becomes more sophisticated, so will the need to assess it. This will require a greater depth of information and expertise.

The need to coordinate the acquisition and compilation of data sets is urgent. Many of the current assessment guidelines, rudimentary though they may be, cannot be answered because of the current lack of data coordination amongst OSPAR Contracting Parties.

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Annex 1: Additional Considerations

1. It has been found that some of the Principles (developed in OSPAR agreement 2006/3) do not directly address the question of network ecological coherence; nonetheless, they are pertinent to the development of an effective and achievable OSPAR MPA network, and are discussed below.
2. Because these additional considerations are not directly relevant to the assessment of ecological coherence, assessment guidelines have not been developed. Rather, the network design implications of each principle, 1 – 4, from OSPAR agreement 2006/3 are discussed.

Efficiency (Principles 1−4)

3. **Process efficiency**: Efficiency within the MPA identification and selection process should be considered (Principle 2, discussed below). If protection is achieved sooner rather than later, it is better for the features in question, and hence for the overall ecological coherence of the network. The OSPAR goal of 2010 is ambitious and will require a great deal of MPA process efficiency.
4. **Spatial efficiency**: Because MPAs are a spatial management tool, the efficiency of an MPA network is usually measured in spatial terms; that is, the ability of the network to meet its individual conservation targets using a minimum of area. However, it should be pointed out that spatial efficiency may not in itself equate to maximizing coherence or persistence (Pressey et al 2004). With regard to spatial efficiency, it is generally better to select areas that can protect a variety of features at the same time. However, the discussion of spatial efficiency is actually much more complicated than that, and it has been shown that just selecting sites based on the richness of features can lead to sub-optimal solutions overall (Possingham et al 2000). One site with several valuable features on its own may or may not be the best choice overall, depending on distribution and replication of those features in the study area. Also, the question of spatial efficiency can be confounded by connectivity (Biers 2002), and economic considerations whereby some places are more expensive to protect and/or may cause greater economic displacement. Several methods and models have been developed to address this problem of efficiency (Evans et al 2004), with two site-selection programmes, *Marxan* (Ball & Possingham 2000) and *C-Plan*, being widely applied in marine and terrestrial environments (e.g. Cowling et al 2003, Ardron et al 2002, Sala 2002), including within the OSPAR area (Lieberknecht et al 2004). Both of these Australian-based programmes are freely available for download, and are noted in the references section of this document. They require spatial (i.e. GIS) data and require moderate to advanced technical expertise. These programmes also (at least partially) address the Assessment Criteria given in this document; i.e. Adequacy, Representativity, Replication, and Connectivity; though connectivity is, regardless of the model, always very rudimentary (Williams et al 2005). Little guidance is given to addressing the proper vs. improper use of these models.[9] A future version of Marxan is expected to allow for multiple zoning options, which should make it very flexible to real-life applications.[10]
5. The first three *Principles*, developed in OSPAR agreement 2006/3, are ones related to efficiency of site selection, specifically addressing the possibility that sites can be selected to

[9] There is an international Marxan Best Practices Workshop planned for April 2007 in Canada to address this issue and develop a handbook of best practices in the use of MPA selection algorithms (see www.PacMARA.org).

[10] Tentatively named MarZone, this greatly expanded tool is expected to be publicly available in mid-2007, with beta testing being conducted by the US California State government (that funded this version) in spring 2007.

achieve multiple *spatial* aims, and that the *process* of selection should keep multiple aims in mind. These specific *Principles* are discussed in greater detail below.

Principle 1: "Selection of sites for OSPAR network aims (a) and (b) may include some areas that are selected to best represent the range of species, habitats and ecological processes for aim (c)." (OSPAR agreement 2006/3)

6. This Principle is pointing out two possibilities of spatial efficiency / overlap:[11]

   a. That areas selected because they have been adversely affected by human activities may nonetheless in some cases also be the best remaining examples of certain features. The corollary to this is that if this feature also occurs in more pristine areas, these areas are not very representative of that feature. Thus, it follows that in this case, all or mostly all the important representative areas (in the study area) for this feature have been adversely affected by human activities.[12] This is usually true for once abundant features that are now rare. In these cases, restoration to protect these remaining few features is often given a high public profile, can be costly, and restoration is not often successful (Earll 2006). In cases such as these, it is often questionable whether the few remaining features are "ecologically coherent" anymore, since by definition they have been degraded from their former abundances, often severely so, and are therefore unlikely to be providing the same ecosystem services, or even representing the same genetic diversity. Nonetheless if the restoration measures are successful (see Principle 12, under Adequacy, above), and the features rebound, then ecological coherence can be regained at the site level, which presumably could feed into network level coherence in the future.

   b. That areas selected to prevent the possible degradation of features (i.e. they face a possible human threat) may also best represent certain features. This second possibility is often applied in decision-making when a place recognized as being "special" is faced with increasing pressures or threats from human development, and is therefore protected. It is often an ad hoc and reactive form of decision-making, but is nonetheless effective when acted upon with sufficient haste to avoid harm. In this second case, the ecological coherence of the individual site can probably be immediately achieved if the site is sufficiently large enough (see Principle 12, under Adequacy, above) and protected to address the features in question.

Principle 2: "Identification of OSPAR MPAs for OSPAR network aim (c) should contribute substantially to the requirements for identification of sites to meet aims (a) and (b)." (OSPAR agreement 2006/3)

7. This second Principle suggests process efficiency in site-selection, whereby in the identification of areas that best represent a feature, areas that require restoration and areas that are under possible threat should also be identified (or the work substantially begun).

8. In order to meet OSPAR network aim (c), this second Principle is tacitly assuming a comprehensive and systematic approach to MPA identification will be undertaken. Also implicit in this Principle is that the user has access to data for the feature throughout the study area so that the best areas can be chosen. To determine possible human threat,

[11] A third possibility, that one larger area can contain multiple sub-areas addressing different aims that do *not* overlap, is not discussed here, as that it does not address the criterion of efficiency. It would be simply grouping several smaller single-purpose MPAs under a larger multiple-purpose designation.

[12] While it is possible that certain features are degraded or lost solely due to natural causes (i.e. background extinction rates), these cases are rather unusual and are not treated here. Invariably, most degradation, extirpations, and extinctions of the recent centuries have been associated with human-induced causes (e.g. Leakey & Lewin 1995).

human activity data are also required. The data requirements are the same as for Principle 1, and are outlined in the Data Requirements section of the main document.

9. A method to inventory sites on a post-hoc basis is required to ensure that overall the areas meet all three aims (a) (b) and (c). Many site-selection softwares can do this automatically, allowing for a quick comparison of network scenarios (Evans et al 2004). If site selection software has not been employed, then a GIS analysis can be used, assuming the data are available, to compare what has been protected against what has not. At the very least, Contracting Parties could use the matrix of ecological criteria/considerations and aims of the OSPAR network (OSPAR 2003-17, Appendix 3) alongside the OSPAR MPA database as a basis for examining whether sites have been reported to fulfil criteria which relate to each of the three aims of the network. This latter approach, however, is rather limited in its scope, can only identify reporting gaps, and relies on the veracity of the site reports. Furthermore, it says nothing about what was *not* protected. Thus, although this cross-checking with MPA reporting can in some instances note when the aims were not achieved, it does not contain enough information to report if the aims have been achieved. As such, relying only on MPA reporting, as it currently stands, is insufficient to ensure ecological coherence of the OSPAR network or even of a particular feature or site.

Principle 3: "Meeting OSPAR network aim (a) should be at least in part addressed by identifying OSPAR MPAs for those species and habitats on the (initial) OSPAR list for which MPAs are an appropriate measure." (OSPAR agreement 2006/3)

10. This Principle is pointing out overlap between the (initial) OSPAR List of Threatened and/or Declining Species and Habitats and the aims of the network.

11. Because aim (a) is directed at those features "which are adversely affected as a result of human activities," it is clear that several features listed on the (initial) OSPAR list will fall within this category.

12. Likewise, because aim (b) is directed to "prevent degradation" of features, it is clear that that those features in the (initial) OSPAR list which are *threatened*, are also likely covered.

13. Thus, combining aims (a) and (b) should include all of the features in the (initial) OSPAR list −where MPAs are the appropriate management tool. In other words, the (initial) OSPAR list is a subset of aims (a) and (b) combined. In this light, if aims (a) and (b) are being fully met, then all features of the (initial) OSPAR list (for which MPAs are an appropriate measure) should be covered.

14. The corollary of the above is: If features on the (initial) OSPAR list (for which MPAs are an appropriate measure) are not being protected in the MPA network, then aim (a) and/or aim (b) is also not being fully met.

15. It is understood that meeting any of the aims is an ideal that may never be *fully* achieved. Nevertheless, because the (initial) OSPAR list was created to highlight specific features that require immediate protection, it can be assumed that this list should be a necessary component of meeting aims (a) and (b). Thus, it can be concluded that: *If features on the (initial) OSPAR list (for which MPAs are an appropriate measure) are not being protected, then the OSPAR MPA network is not meeting its aims.*

16. However, if all features on the (initial) OSPAR list are being protected by MPAs, this does not in itself guarantee that the network is ecologically coherent, as that the aims are broader than just the (initial) OSPAR list, and ecological coherence broader than just meeting the aims.

Principle 4: "The OSPAR MPA network must include features meeting aims (a), (b) and (c). For features meeting aims (a) or (b), a larger proportion of the total extent of the habitat/species population or ecological process may be included within the network." (OSPAR agreement 2006/3)

17. This Principle is pointing out that i) all three aims of the OSPAR network must be addressed through the selection of protected areas (see also discussion under Principle 3, above); and ii) that a greater *proportion* of those areas that have been degraded and/or are currently under threat may be required to be protected than the proportion of those areas that are representative (see also Guideline 29-a-ii, under Adequacy, above).

18. Data requirements are the same as for Principle 1, above, and as outlined under the Data Requirements section of the main document. Further evaluation of this Principle is largely the same as that of Principle 2, above. The proportions of features which are included in sites contributing to aims (a) and (b) can be compared against those features in sites which are only contributing to aim (c). These could also be cross-checked to national or regional targets, where applicable. Evaluation of this principle will be dependent on data availability, especially with regard to the total extent of the feature which the Contracting Party chooses to protect. It is expected that for many features, full data will not be available and that selection and evaluation will necessarily involve a measure of expert judgement.

Annex 2: Guideline Assessing Representative Site Sizes, Assumptions

Assessment Guideline (repeated here from Representativity, above)**:** *As a rule of thumb taking into consideration the assumptions listed below, within a given feature class, representative protection can be expected to be roughly proportional to the square-root of the ratio of representative features' overall areas.*[13]

- Thus, within a given feature class (e.g. seabird species, benthic habitats, or marine biomes), the proportions of any two (x & y) should be such that : $(x_p / y_p) \approx (x_t / y_t)^{0.5}$ where the subscript "$_p$" represents the area protected of a given feature and the subscript "$_t$" represents the total area of a given feature in the network. That is, the rule of thumb is stating that the distribution of protection of multiple representative features of the same general kind should fall within a continuum roughly proportional to the square root of their respective total areas.
- Another way to express this identity is to introduce an average ratio, which is labelled here as the "Protection Ratio" (PR): $PR = (\sum((i_p) / (i_t)^{0.5})) / n$ Summed for each protected feature occurrence "i" in a given representative network where "n" is the total number of features. If these feature occurrence data are unavailable, then individual sites that are said to protect a given feature can be used as very approximate proxies for "i." Once PR is calculated, then individual protected areas can be compared to it. To evaluate the representative network overall, a coefficient of variation (CV) for the ratios across the network can be calculated in the standard fashion. High CV values should trigger further investigation, as that it would indicate that protection in a given class varies widely across the network of representative sites, even after varying feature sizes has been accounted for.
- The underlying assumptions that validate this Guideline are:
  a) The features can be reasonably grouped into the given feature class whereby the rationale of why representativity is important is more-or-less the same, no matter which particular feature is being considered within that class;
  b) The delineation of the protected representative areas has not been unduly confounded by other overlapping features or other considerations; and,
  c) That mathematical distribution of the total areas of representative features is skewed, with a long right-hand tail, and that taking the square-root of these area measures helps to normalize the distribution.
- Assumption (a) is pointing out that different representative feature classes could have differing protection requirements. If such information is available, then the representative features should be stratified according to protection requirements, and then assessed using this formula. However in many situations, representativity may be treated as a "catch-all" category, when no other data are available. In these situations, assumption (a) can be seen as holding true across all representative sites.
- In practice, so-called "representative" sites will likely be protected with other considerations also in mind, and thus assumption (b) should be seen as guidance, not a strict criterion, when selecting which sites in a network will be assessed using this rule-of-thumb.
- Assumption (c) is a specific example of the common assumption of normality that is usually not stated but nonetheless widely applied in statistics. Fortunately, standard deviation (and thus CV) is robust to this assumption (Zar 1999). Bimodal or multi-modal distributions, if they exist, should be separated out into separate distributions that can be assessed separately, as per assumption (a), above. This may be facilitated by identifying a determining variable (e.g. territorial vs. EEZ waters; or two different nationalities), which has led to different selection methodologies and/or protection requirements.

[13] Taking the square-root of a two-dimensional measure is a common transformation to render it appropriate for linear comparisons (i.e. in one dimension). Note also the assumptions listed under this guideline.

Annex 3: Thirteen Principles of Ecological Coherence (OSPAR agreement 2006/3)

1. Selection of sites for OSPAR network aims (a) and (b) may include some areas that are selected to best represent the range of species, habitats and ecological processes for aim (c).
2. Identification of OSPAR MPAs for OSPAR network aim (c) should contribute substantially to the requirements for identification of sites to meet aims (a) and (b).
3. Meeting OSPAR network aim (a) should be at least in part addressed by identifying OSPAR MPAs for those species and habitats on the Initial OSPAR list for which MPAs are an appropriate measure.
4. The OSPAR MPA network must include features meeting aims (a), (b) and (c). For features meeting aims (a) or (b), a larger proportion of the total extent of the habitat/species population or ecological process may be included within the network.
5. The network should reflect biogeographic variation across the OSPAR maritime area by selecting the sites for the range of features within each biogeographic area.
6. The biogeographic regions proposed by Dinter (2001) should form the initial framework for incorporating biogeographic variation within the network. Finer scale subdivisions may be developed to aid in practical application of OSPAR MPA selection criteria.
7. The EUNIS habitat classification scheme should be used to characterise habitats throughout the OSPAR maritime area to assist the implementation of aim (c), particularly through Contracting Parties' assessment of representativity of the range of such features.
8. The design of a network of marine protected areas needs to recognise aspects of connectivity and, where possible, place protected sites where they may have maximum benefit as measured against the objectives of the network.
9. Detailed connectivity issues should be considered only for those species where a specific path between identified places is known (e.g. critical areas of a life cycle).
10. Lack of knowledge with regard to connectivity in the marine environment should not prevent the development of the OSPAR MPA network.
11. Replication of habitats, species and ecological processes in separate OSPAR MPAs in each biogeographic area is desirable where it is possible.
12. The appropriate size of a site should be determined by the purpose of the site and be sufficiently large to maintain the integrity of the feature for which it is selected.
13. OSPAR MPAs should be managed to ensure the protection of the features for which they were selected and to support the functioning of an ecologically coherent network.

Annex 4. OSPAR MPA Network Rapid Self-Assessment Checklist

The self-assessment checklist

The attached rapid self-assessment checklist is based on the World Commission on Protected Areas (WCPA) and World Conservation Union (IUCN) self-assessment checklist for building networks of MPAs developed by Day & Laffoley (2006) and has been re-ordered and modified according to OSPAR requirements. It has been used with the kind permission of the authors. The checklist has been adopted by BDC 2007 as guidance on the design of the OSPAR network of MPAs. BDC 2007 agreed to urge Contracting Parties to make use of this self-assessment checklist in future assessments of ecological coherence and other factors influencing the effectiveness of the MPA network.

How to use this checklist

This checklist may be applied at different scales; e.g., employing local, regional, national, or international study areas. It is recommended, however, that the scale of the assessment be made clear at the outset, and that one scale be applied throughout any given assessment. (Many of the questions can also be used to rate individual sites, though clearly a single site cannot be considered a "network.")

To use this checklist, simply review the statements against each of the principles, and choose whichever statement is the best approximation or corresponds most closely with your assessment of the **current** situation**.** The higher the score against the principle, the more effective is the current approach to achieving that principle. If you assess each statement realistically and honestly as either a 0, 1, 2, or 3 then you will be able to determine what might be expected to increase management effectiveness. This will enable a comparison of the current approach against what are considered 'best practices', and to understand where gaps (or weaknesses) may exist, to be addressed as future priorities. Regular use of the checklist can then be used to quickly assess progress towards the overall goal of an effectively established and lasting MPA network. However, given the subjective nature of this assessment, it should be taken only as one initial indication of how well the network is doing, and it is not meant to replace science-based monitoring, and/or more detailed assessments.

This checklist is called a "self-assessment" because it is expected that those directly involved in the design and management of a given network would best be able to judge the relative ratings for many of these questions. Nonetheless, it can be expected that different assessors will have different internalized standards by which they rate their networks, and thus two different assessors would likely produce somewhat different scores for the same network. In this light, making comparisons of scores between networks that have used different assessors should be applied with caution.

The checklist has been ordered according to the OSPAR requirement to assess ecological coherence, with the most applicable criteria in Table I, secondary criteria in Table II, and tertiary criteria in Table III. Table IV puts forward criteria that while not applicable to the assessment of ecological coherence, are recognized to be of importance to the long-term success of an MPA network.

Scoring

Three different scoring systems can be used, depending on if only ecological coherence is under consideration, or if an overall network assessment is desired, or if only certain sub-groups are of interest.

First of all, mark the corresponding score for each principle/criteria in the column marked *Score* and then add the total of all scores, for each table. Once this is done, there are two ways to calculate the grand total score:

- **Un-weighted Overall Score**: This will give you an indication of how well the network is doing overall. Simply add up the sums for each table. There is a possible grand total score of 60. (To calculate the percentage, multiply your score by 100 and divide by 60.)
- **Weighted Ecological Coherence Score**: This will give you an indication of how likely the network is ecologically coherent. Take the sum for Table I and multiply by 3; take the sum for Table II and multiply by 2; take the sum for Table III and multiply by 1; and *do not use Table IV*. Then, add the three new table sums together. The weighted grand total is out of a possible 93. (Thus, to calculate the percentage, multiply your score by 100 and divide by 93.)
- **Separate Sub-Table Scores**: The questions have been grouped according to a continuum ranging from strictly ecological considerations to ones that look at other external factors such as some management and socio-economic considerations. It can be helpful to look at the sub-table scores to get a better indication of likely areas of strengths or weaknesses in the effectiveness of the network.

Recognizing the subjective nature of the scoring, calculation of all scores can assist in tracking changes to a given network over time, and can also highlight which key area(s) require greater emphasis to achieve 'best practice'. However, making comparisons of scores between networks that have used different assessors should be applied with caution.

Acknowledgements

We would like to thank John Day & Dan Laffoley for the generous use of their draft document, which was used extensively in the development of this checklist:

Day, J., & Laffoley, D.d'A., 2006. Self-assessment checklist for building networks of MPAs. WCPA IUCN. (17Nov. 06 draft)

In developing the original checklist Day and Laffoley drew upon on the principles and approaches of other existing checklists and acknowledged the following:

Staub, F and Hatziolos, ME (2004) Score Card to Assess Progress in Achieving Management Effectiveness Goals for Marine Protected Areas. The World Bank, Washington DC, USA 30 pp

Mangubhai, S (nd) Interim Guidelines for the Assessment of Management Effectiveness of Marine Protected Areas in the western Indian Ocean. Report produced for IUCN supported by NORAD. 37pp.

Corrales, L (2005) Manual for the Rapid Evaluation of Management Effectiveness in Marine Protected Areas of Mesoamerica. PROARCA/The Nature Conservancy, Technical Document No 17, 54 pp

MIC Working Group (2004) Effective Conservation Programs Scorecard. Micronesia, 14 pp.

OSPAR MPA Network Rapid Self-Assessment Checklist

1. Ecological Coherence Criteria			
1.1. Assessment Criterion 1: Adequacy / Viability			
1.1.1. Size & Shape		**Score**	**Comments**
Specific consideration was given to the size and shape of the sites within the MPA network when it was designed and implemented in order to maximize the effectiveness of the network to achieve its ecological objectives.	**3**		
Some consideration was given to the size and/or shape of the sites within the MPA network when it was designed, and some consideration overall to achieving its ecological objectives.	**2**		
Some consideration was given to the size and/or shape of the sites within the MPA network when it was designed, but no consideration overall to achieving its ecological objectives.	**1**		
Little or no consideration was given to the size and/or shape of the sites within the MPA network; nor any consideration of the effectiveness of the network to achieve its ecological objectives.	**0**		
Consideration was given to edge effects of the sites within the MPA network when it was designed.	**Bonus 1**		
1.1.2. Viability		**Score**	**Comments**
The MPA network includes many self-sustaining viable no-take areas, which are all geographically dispersed within the study area ensuring viability at all levels (i.e. at the ecosystem, species and genetic levels) within natural cycles of variation	**3**		
The MPA network includes some no-take areas geographically dispersed within the study area, some of which are designed to be self-sustaining.	**2**		
The MPA network includes a few no-take areas geographically dispersed within the study area.	**1**		
The MPA network includes no or only a single no-take area.	**0**		
1.2. Assessment Criterion 2: Representativity			
The MPA network represents all or almost all (~80-100%) of the range of species and/or habitats and/or ecological processes within the study area.	**3**		
The MPA network represents most (~30-80%) of the range of species and/or habitats and/or ecological processes known in the study area.	**2**		
The MPA network represents some (~10 -30%) of the known range of species and/or habitats and/or ecological processes in the study area.	**1**		
The MPA network comprises only one or two types of marine species and/or habitats known in the study area (e.g. only coral reefs are protected in the network)	**0**		

1.3. Assessment Criterion 3: Replication		**Score**	**Comments**
The MPA network includes highly protected spatially-separated replicates of 80% or more of the features occurring within the study area (i.e. almost all known features within your network are replicated to spread any risk).	**3**		
The MPA network includes spatially-separated replicates of highly protected areas within 25 - 80% of the features occurring within the study area	**2**		
The MPA network includes some spatially-separated replicates of highly protected areas, but they represent less than 25% of the features occurring within the study area	**1**		
The MPA network does not have any spatially-separated replicates of highly protected areas within the study area.	**0**		
Systematic replication is occurring throughout every ecological region in the study area, e.g. cross shelf and long-shore replication	**Bonus 1**		
1.4. Assessment Criterion 4: Connectivity		**Score**	**Comments**
The MPA network has been purposefully designed to maximize all / most key ecological processes (spatial and/or temporal) in the study area	**3**		
The MPA network was purposefully designed and does consider some of the key ecological processes (spatial and/or temporal) in the study area	**2**		
The MPA network was purposefully designed and does consider a few (one or more) of the key ecological processes (spatial and/or temporal) in the study area	**1**		
The design of the MPA network took little or no account of any key ecological processes in the study area	**0**		
The MPA network has been purposefully designed to maximize and enhance most of the physical linkages between individual MPAs in the network.	**Bonus 1**		
Table I Total (out of a possible 18)			
Eco-Coherence Weighted Total (total given above x 3)			

2. Factors Influencing Eco-Coherence			
2.1. Resilience		**Score**	**Comments**
The MPA network has been specifically designed so 30% or more of the study area is free from extractive activities or habitat-altering activities, or other significant human-induced stresses.	**3**		
Between 10-30% or the study area is free from extractive activities, habitat-altering activities, or other significant human-induced stresses.	**2**		
Only a small part the study area (<10%) is free from extractive activities, habitat-altering activities, or other significant human-induced stresses.	**1**		
Virtually none of the study area is free from extractive activities, habitat-altering activities, or other significant human-induced stresses.	**0**		
The MPA network has been specifically designed to maximize the resilience of the network in the face of long-term geophysical and/or biochemical changes;	**Bonus 1**		
2.2. Precautionary design		**Score**	**Comments**
The MPA network is configured to take into consideration all or most of the known threats occurring within the study area.	**3**		
The MPA network considers several of the known threats occurring within the study area	**2**		
The MPA network considers a couple of the known threats occurring within the study area.	**1**		
MPA network does not consider any of the known threats occurring within the study area	**0**		
The MPA network has been effectively designed to cope with a lack of comprehensive data.	**Bonus 1**		
2.3. External spatial & temporal considerations		**Score**	**Comments**
The design of the MPA network considered a wide range of external spatial and temporal considerations including ecological processes, connectivity and other external influences; and managers continue to consider these as part of ongoing implementation.	**3**		
The design of the MPA network did consider some external spatial and temporal issues; and managers continue to consider each of these issues as part of ongoing implementation.	**2**		
The design of the MPA network did consider one or more external spatial or temporal issues; and some of these are still considered by managers in the ongoing implementation of the network.	**1**		

External spatial and temporal issues were not considered in the design or in the ongoing implementation of the MPA network.	**0**		
There is good historical baseline information (or historic data) to determine whether there are 'shifting baselines' for a range of issues.	**Bonus 1**		
Table II Total (out of a possible 12)			
Eco-Coherence Weighted Total (total given above x 2)			

3. Factors Influencing the Assessment of Eco-Coherence			
3.1. Clearly defined objectives		**Score**	**Comments**
There is a range of clear, achievable and measurable objectives (including ecological, social and economic objectives) defined for the MPA network and derived from the legislation;	**3**		
There are various objectives for the MPA network which are clear, achievable and measurable; addressing at least two of the relevant aspects in the necessary range (i.e. ecological, social or economic objectives);	**2**		
There are some objectives for the MPA network; but only one or two can be considered as clear, achievable and measurable; AND the objectives do not address the necessary range (i.e. ecological, social and economic objectives).	**1**		
There are no clear objectives for the MPA network.	**0**		
These objectives were determined through an open, transparent and balanced process involving a wide range of stakeholders.	**Bonus 1**		
3.2. Scientific information		**Score**	**Comments**
All available scientific information is used to support planning and management, and it is regularly updated and used for effective decision-making.	**3**		
There is some scientific information to support planning and management, and whatever is available is used for decision-making.	**2**		
There is limited scientific information to support planning and management, and it is sometimes used for decision-making.	**1**		
There is little or no scientific information base to support planning and management; or, the available information is not used for decision-making.	**0**		
There is an ability to incorporate new scientific information into subsequent planning or for ongoing management tasks.	**Bonus 1**		

3.3. Social & economic information		**Score**	**Comments**
All available social and economic information is used to support planning and management, and it is regularly updated and used for effective decision-making.	**3**		
There is some social and economic information to support planning and management, and whatever is available is used for decision-making.	**2**		
There is limited social or economic information to support planning and management, and it is sometimes used for decision-making.	**1**		
There is little or no social or economic information base to support planning and management; or, the available information is not used for decision-making.	**0**		
There is an ability to incorporate new social or economic information into subsequent planning or for ongoing management tasks.	**Bonus 1**		
3.4. Monitoring & assessment		**Score**	**Comments**
A good monitoring and evaluation system exists, with progress against most if not all the objectives of the MPA network being monitored regularly and objectively, with the results being widely disseminated and used in adaptive management.	**3**		
There is an agreed and implemented monitoring program, and progress against some of the objectives of the MPA network is objectively monitored periodically, with the results publicly available and/or used in adaptive management.	**2**		
There is some ad hoc monitoring and progress against at least one of the objectives of the MPA network has been monitored and/or publicly reported.	**1**		
Progress against the objectives of the MPA network is rarely monitored AND no assessment of MPA effectiveness has ever occurred or been reported.	**0**		
Table **III** Total (out of a possible 15)			
Eco-Coherence Weighted Total (same as total above**)**			

4. Factors Influencing Long-Term Success			
4.1. Adaptive management		**Score**	**Comments**
The MPA network is readily able to incorporate changes such as new information becomes available (e.g. from 'in-the-field' experience, or as a result of changing external circumstances).	**3**		
The MPA network has some ability to incorporate some changes when new information becomes available (e.g. 'in-the-field' experience, or as a result of changing external circumstances).	**2**		
The MPA network is has a limited ability to incorporate occasional changes when new information becomes available (e.g. in the timeframe of several years).	**1**		
The MPA network does not have management systems or any monitoring arrangements to determine system responses and provide a basis for adaptive management; NOR is it likely able to incorporate changes were new information to become available.	**0**		
4.2. Economic & social considerations		**Score**	**Comments**
The design and implementation of the MPA network continues to consider the economic and socio-cultural setting, as well as the real benefits and costs of the network (including both tangible and intangible benefits and costs);	**3**		
The design and implementation of the MPA network initially considered the economic and socio-cultural setting, as well as the real benefits and costs of the network (and may have included tangible and intangible benefits and/or costs).	**2**		
Some consideration was given to the economic and socio-cultural setting, or to the benefits or costs, when the MPA network was initially designed.	**1**		
No consideration was given to the economic or socio-cultural setting, or to the benefits or costs, when the MPA network was initially designed, and little/no consideration occurs during implementation.	**0**		
The MPA network has addressed the need for structural adjustment or compensation for lost benefits from foregone economic opportunities.	**Bonus 1**		
4.3. Institutional & governance considerations		**Score**	**Comments**
The MPA network has well established mechanisms for the horizontal integration among all levels of government, and vertical integration among agencies with different mandates, as well as involving local communities, indigenous people and regional groups.	**3**		

The MPA network has some mechanisms for the horizontal integration among different levels of government, and vertical integration among agencies with different mandates, as well as involving local communities, indigenous peoples and regional groups.	**2**		
The MPA network has some legislative and administrative arrangements, but these do not provide both effective horizontal integration among different levels of government, and vertical integration between agencies.	**1**		
The MPA network has little or no mechanisms for the horizontal integration among different levels of government, nor for any vertical integration among agencies with different mandates.	**0**		
The MPA network has an effective legislative and administrative framework, including a 'nested governance' structure operating simultaneously at multiple scales and levels (integrating local aspirations, national strategies and/or international obligations).	**Bonus 1**		
4.4. Sustainable financing		**Score**	**Comments**
The MPA network has a well-developed and periodically audited program of long-term funding (assessed, and if necessary, increased against a recognised financial index) in order to meet both core costs and emerging issues.	**3**		
The MPA network has an adequate program of long-term funding for core costs and able to seek funding for emerging issues.	**2**		
The MPA network has poor and spasmodic program of long-term funding to meet core costs, and is sometimes able to seek funding for emerging issues.	**1**		
The MPA network doest not have a well-developed or periodically audited program of long-term funding.	**0**		
The budget in the MPA is well managed; and all staff understand the financial situation.	**Bonus 1**		
Table IV Total (out of a possible 15)			
Eco-Coherence Weighted Total (zero: table not used)	**0**		
Grand Total of all Tables (out of a possible 60)			Percentage: Grand Total x 100 / 60 =
Weighted Eco-Coh. Grand Total (out of a possible 93)			Percent: Grand Weighted Total x 100 / 93 =

Location / Extent of Study Area: the area under consideration in this survey. (For example, it may include the jurisdictional waters of a CP, region within a CP's waters, or it could include a particular biogeographic region.)	
Assessor(s) & Date:	