Biodiversity Series

Background document on three initial spatial tests used for assessing the ecological coherence of the OSPAR MPA network

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/*Récapitulatif*

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 adopting this recommendation OSPAR recognised the need to define common theoretical and practical aspects of what would constitute an ecologically coherent network of marine protected areas

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. As a result of further work on the development of such practical criteria during 2006/2007, OSPAR published a background document in 2007 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.

On the basis of this work the three initial spatial tests described in this document have been identified recognising that the current lack of detailed ecological data requires approaches which can be applied in the absence of such data.

- *Test 1*: Is the network spatially well distributed, without more than a few gaps.
- *Test 2*: Does the MPA network cover at least 3% of most (seven of the ten) relevant Dinter biogeographic provinces.
- *Test 3*: Are most (70%) of the OSPAR threatened and/or declining habitats and species (with limited home ranges) represented in the MPA network, such that at least 5% [or at least three sites] of all areas in which they occur within each OSPAR region is protected.

These tests have been used in 2008 as a means of making an initial evaluation of whether the OSPAR network of MPAs may be ecologically coherent or not (see OSPAR publication 2008/359). These tests have the aim of identifying whether an MPA network shows the first signs of ecological coherence and should be seen as the first step in a multiple step assessment. However until the network has passed the three initial tests there is no need to scale up the assessment process.

This background document has been prepared under the leadership of Germany (Task Manager: Jeff Ardron, German Federal Agency for Nature Conservation) taking into account comments made at the 2007 meeting of the Working Group on Marine Protected Areas, Species and Habitats and the 2008 meeting of the OSPAR Biodiversity Committee.

La recommandation OSPAR 2003/3 sur le réseau OSPAR de zones marines protégées (ZMP) a pour objectif d'établir un réseau OSPAR de zones marines protégées et de s'assurer que, en 2010 au plus tard, il s'agisse d'un réseau écologiquement cohérent et bien géré. En adoptant cette recommandation, OSPAR a reconnu la nécessité de définir des caractéristiques théoriques et pratiques communes de ce qui constitue un réseau écologiquement cohérent de zones marines protégées.

En 2006, le Comité Biodiversité d'OSPAR (BDC) a adopté des orientations à l'attention des Parties Contractantes sur l'élaboration d'un réseau écologiquement cohérent de zones marines protégées OSPAR (Accord OSPAR: 2006-3). Au même moment, BDC a noté que des travaux complémentaires étaient nécessaires sur ces orientations et sur les étapes procédurales pour évaluer la contribution des sites à un réseau cohérent de ZMP. L'un des résultats de ces travaux complémentaires durant 2006/2007sur le développement de ces critères pratiques, est la publication en 2007 par OSPAR d'un document de fond résumant la littérature existante sur la cohérence écologique de réseaux de ZMP, et décrivant les possibles critères et lignes directrices pour évaluer si le réseau OSPAR de ZMP est écologiquement cohérent.

Sur la base de ces travaux, les trois tests initiaux spatiaux décrits dans ce document ont été identifiés, reconnaissant que le manque actuel de données écologiques détaillées requiert des approches qui peuvent être appliquées en l'absence de ces données.

- *Test 1 : Est-ce que le réseau est spatialement bien distribué, avec pas plus que quelques vides.*
- *Test 2 : Est-ce que le réseau de ZMP couvre au moins 35% de la plupart (sept sur dix) des principales zones biogéographiques de Dinter.*

- *Test 3 : Est-ce que la plupart (70%) des habitats et espèces menacés et/ou en déclin de la liste OSPAR (pour les espèces, celles dont l'aire de distribution est bornée) sont représentés dans le réseau de ZMP, de telle façon qu'au moins 5% [ou au moins trois sites] de toutes les zones dans lesquelles ils se trouvent dans chaque région OSPAR soient protégés.*

Ces tests ont été utilisés en 2008 comme moyen d'évaluer initialement si le réseau de ZMP d'OSPAR peut être écologiquement cohérent ou non (voir publication OSPAR 2008/359). Ces tests ont pour objectif d'identifier si un réseau de ZMP montre les premiers signes de cohérence écologique et doivent être considérés comme la première étape dans une évaluation multi-stade. Cependant, jusqu'à ce que le réseau ait réussit les trois tests initiaux, il n'y a pas besoin d'intensifier le processus d'évaluation.

Ce document de fond a été préparé sous la conduite de l'Allemagne (gestionnaire de tâche : Jeff Ardron, Agence fédérale allemande pour la Conservation de la Nature) en tenant compte des commentaires émis lors de la réunion de 2007 du groupe de travail sur les ZMP, espèces et habitats, et de la réunion de 2008 du comité Biodiversité.

1. Background: OSPAR work to date

This document outlines three spatial tests which have been used in the initial assessment of the ecological coherence of the OSPAR network of Marine Protected Areas – see 2007 Progress Report on the OSPAR Network of Marine Protected Areas (OSPAR Publication 2008/359). The assessment of ecological coherence (eco-coherence) is a relatively new topic, with nothing known to exist currently on this specific topic in the published scientific literature, though there are now several hundred publications relating to marine protected areas (MPAs).

OSPAR has to date published three documents to be used by Contracting Parties in developing and assessing eco-coherence of the OSPAR marine protected area network. These are listed below:

a. *Guidance on developing an ecologically coherent network of OSPAR marine protected areas* (Guidance): Reference number 2006-3;

b. *Background document to support the Assessment of whether the OSPAR Network of Marine Protected Areas is Ecologically Coherent* (Background): OSPAR publication 2007/320;

c. *Rapid Self-Assessment Checklist for the OSPAR Network of Marine Protected Areas* (Self-Assessment): Reference number 2007-6.

Several eco-coherence principles, indicators and questions have already been put forward in the above OSPAR documents. The Guidance document outlines thirteen principles; the Background document outlines four criteria and 30 assessment guidelines; and the Self-Assessment lists five questions directly related to the eco-coherence criteria, three other questions regarding factors that influence eco-coherence, and three more questions regarding factors that influence the assessment of eco-coherence. The initial three spatial tests are a starting point to complement these guidelines and principles

The Background document (OSPAR publication 2007/320) noted that eco-coherence is a holistic concept reliant on many constituent parts, and tests can only indicate when it has *not* been perfectly achieved (i.e. some of the parts are missing or not functioning as they should). Thus, the degree to which an MPA network is (or is not) ecologically coherent must be stated as a likelihood, based on a continuum of progressively more detailed tests, until a test (or group of tests) is not met. It should therefore involve a process of staged assessments, beginning with an initial assessment that is straight-forward and achievable.

From the overall set of responses to a data questionnaire sent out to Contracting Parties this year (MASH 07/6/5), it can be inferred that for many Contracting Parties bio-physical spatial data are not readily available and/or assembling them for use by OSPAR is not currently a priority. Due to this lack of available data, these three initial tests were developed and avoid relying on OSPAR-wide bio-geographic data that are unavailable, or not readily available, and likely to remain so in the near future.

2. Caveats

The reasoning behind the three initial tests is provided separately in this document –see: *Reasoning behind the three initial tests*.

The three initial tests in this section are proposed as a first step to determine whether or not the OSPAR MPA network is ecologically coherent at this stage. These initial tests should be seen as part of a multiple-step network assessment and development process.

The numerical limits suggested are not planning targets.[1] These are *threshold limits,* beneath which it may be judged that eco-coherence has not yet been achieved. The differences between a limit and a target have been more fully explained in the context of OSPAR's work on EcoQOs. It is also discussed in §§ 3-5 of Appendix 1.

Eco-coherence as a continuum: the nature and assessment of eco-coherence should be seen as a *continuum*, and is more fully explained in Appendix 1 of this document. If these three simple tests are

[1] Percentage targets have not been agreed to by OSPAR. Commonly, they fall in the range of 10%-40% as summarised in Annex 2.

passed, it does not indicate that the MPA network is already fully coherent (i.e. right of point D, Figure 1, Appendix 1); rather, it simply indicates that it could be; i.e. right of Point B, Figure 1, Appendix 1.

3. Three initial tests looking at the ecological coherence of the OSPAR MPA network

The three initial spatial tests are ordered according to ease of assessment, as well as descriptive power, and therefore should be used in the order given.

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

This is a two-step assessment that should begin with i) a simple visual overview,[2] and ii) a quick visual evaluation of the existing spatial gaps. The first part of this test suggests that when looking at the OSPAR network, the MPAs should be seen to be generally well-distributed in both near shore and offshore areas, as well as fairly evenly spaced alongshore. The second part suggests there should be no, or just a few, *major gaps* in each of these areas.

Determining what a "major gap" is will depend on whether one is looking at shoreline / near shore, offshore / EEZ, or far offshore / high seas waters.

Approximate rules of thumb for determining "major gaps:" alongshore, ~250 km; near shore, ~200 000 km^2 (~500 km diameter circle); offshore ~1 000 000 km^2 (square of ~1000 km sides).

As outlined in the Guidance (OSPAR reference number 2006-3) and Background document (OSPAR publication 2007/320), the scale of many ecological processes, and thus the MPA network, will become finer as one moves inshore. Very approximate "rules of thumb" can be used in the absence of comprehensive GIS analyses to identify the following separation distances based on the map in Annex 1 of the annual MPA status reports (Publications 319/2007; 268/2006).[3]

i. It is suggested that coastline / near shore spaces wider than 250 km are "major."

ii. It is suggested that in the offshore / EEZ gaps bigger than this 500 km diameter circle[4] (~200 000 km^2) are "major."

iii. It is suggested that in far offshore and high seas waters, gaps larger than approximately one million square kilometres (1 000 000 km^2) are "major".

How many major gaps are "more than a few?

There should be no or just a few major gaps. But, how many is "a few?" Because of the different scales, this will again depend on where one is looking. It is suggested here that for shoreline / near shore areas, up to 10 is "a few." For offshore / EEZ waters, up to five is "a few;" and for far offshore / high seas, up to two is "a few." The reasoning is explained in the next section of this document.

The extreme northern and arctic waters, due to their ice cover and remoteness, should not be included in this initial test (see test 2, below, for a description of which areas exactly this would include).

If the MPA network is generally not well-distributed in space, then it is very likely not connected and/or representative, and probably is not replicated and/or adequate. Thus, it is very likely not ecologically coherent and the assessment can stop here. However, since this is to some degree a subjective test, if one is unsure, then go on to the next test.

[2] In place of a visual assessment, a GIS "nearest neighbour" analysis could be applied.
[3] Using the map in Annex 1 of the annual MPA status reports (Publications 319/2007; 268/2006), the width of a pencil is roughly 250 km. The body of a regular (not fine) felt tip marker is about twice that of a pencil, 500 km in diameter on this map. If four such felt markers are held in the hand as a group, their bases will together stamp out squares of approximately one million square kilometres (1 000 000 km^2).
[4] 500 km is about 270 nautical miles. Thus, technically, this could in some cases extend beyond EEZs. However, for a simple "rule of thumb" test, this is not seen to be critical.

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

The ten relevant provinces are: *Macaronesia Azores; Lusitanean; Lusitanean-boreal; Boreal- Lusitanean; Boreal; Norwegian Coast; South Iceland; Southeast Greenland - North Iceland shelf*; *Cool-temperate waters; and Warm-temperate waters* (Dinter 2001).

As in the first test, above, due to their ice cover and extreme remoteness, the following Dinter (sub-) provinces are not used in this test: *Cold Arctic Waters; High Arctic Maritime, Northeast Greenland shelf (NEWP), and the White Sea*.

This test does not require usage of the Dinter sub-provinces. Thus, the three Norwegian coastal sub-provinces are treated together as one province, as are the two Lusitanean sub-provinces.

For the purposes of this initial test, the two temperate pelagic provinces (*Cool-temperate waters; and Warm-temperate waters*) shall also be interpreted to include deeper waters and the seafloor. That is, the Dinter pelagic and benthic classes have been collapsed together.

While the Dinter biogeographic provinces are recommended at the scale of OSPAR-wide assessments, if only (sub-) regions of the OSPAR Maritime Area are being examined then other finer scale bio-geographic classifications such as EUNIS should also be used.

This test considers primarily Representativity and Adequacy, and infers some Connectivity and Replication. If this second test is not met the assessment can stop.

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

“Species with limited home ranges” refers to species that in their adult life stage are either fixed in place (sessile), or generally range only over short distances, as would be found in most reserves, on a scale of hundreds of meters.[5] According to the initial list, this would only include the five listed invertebrates.[6]

The square-bracketed text should only be used in Regions where the spatial data are not available. In those cases, counting sites (and noting their area) is the only way forward. However, the OSPAR habitat mapping programme, led by the UK, has been making steady progress in this regard. Because these are listed threatened and/or declining OSPAR species and habitats, it is expected that the collection of these spatial data will remain an OSPAR priority, and eventually the bracketed text from this test can be removed.

The current wording of this test does not consider the protection of threatened and/or declining seabirds. In the future, when ongoing research has produced firmer conclusions, it would be helpful to add this clause to the test:

Are most (70%) of the OSPAR threatened and/or declining seabirds protected through MPAs that include at least 5% of their inter-annually persistent at-sea concentrations; e.g. Important Bird Areas (IBAs)?

Note that “concentrations” is different from normal bird distributions, and suggests a higher than average[7] spatial occurrence. Scientific criteria to better define how inter-annually persistent at-sea seabird concentrations can be delineated are currently under development by a cooperative research venture led by BirdLife International. It is suggested that for the purposes of this possible addition to the test, OSPAR consider these criteria when they are available. However, because criteria have not yet been completed, it is premature to include them in the current version of the test.

[5] Larger MPAs can accommodate species with larger home ranges, which should be taken into consideration when evaluating the representation of such species.

[6] As of 1 Sept 2007, these include: *Arctica islandica* (Ocean quahog), *Megabalanus azoricus* (Azorean barnacle), *Nucella lapillus* (Dog whelk), *Ostrea edulis* (Flat oyster), and *Patella ulyssiponensis aspera* (Azorean limpet).

[7] For example, this could be a density that is calculated as ratio of standard deviations higher than the mean.

4. Reasoning behind the three initial tests

The purpose of this paper is to propose simple tests to determine if the OSPAR MPA network, as a whole, is possibly coherent; i.e. conceptually to the left or right of the minimum point B in the continuum of Figure 1, Appendix 1.

In general, the numeric values of the above tests have been set to 1/10th the value commonly found in the scientific literature. That is, these tests have been designed to consider only bare minimal fundaments, and that these should not be misinterpreted to constitute a fully coherent network. They should be seen as minimum limits and a not aspirations (targets) to aim for.

4.1 Spatial distribution: Is the OSPAR MPA network spatially well-distributed, without more than a few major gaps?

This is the simplest, and yet most holistic of the three initial tests. Although GIS analyses are possible (see footnote 2, above), it is suggested here that the human eye is probably a more powerful tool. The experienced eye of an expert can further note nuances, such as offshore gradients, basin connectivity, and so forth. However, anyone can plainly see the basics, particularly the gaps, where no MPAs currently exist. The simplicity of this test should not be seen to detract from its descriptive power.

The three “rules of thumb” consecutively double the diameter of the areas under consideration for each of the three realms (near shore / shoreline, offshore / EEZ, far offshore / high seas) and as such the areas that are considered “major gaps” are roughly quadrupled each time.[8] Assuming patchiness and protection should be scaled using a near to offshore gradient is a plausible simplification, and is noted in both the Guidance and Background documents (OSPAR publication 2007/320).

While MPAs do not generally protect larvae, they do often protect the species that produce the larvae, and their associated habitats. Thus, MPA spacing can be very pertinent to the genetic connectivity of species that are adversely affected by human activities outside of the MPAs.

The “rule of thumb” for shoreline spacing is 10 times wider than what can be found in the literature, and also 10 times wider than what was agree to at the BALANCE-HELCOM meeting on ecological coherence, Oct. 2006 in Helsinki (25 km). It is five times wider than the assessment suggested in the Background document (OSPAR publication 2007/320) (50 km). Recent connectivity research from the Great Barrier Reef appears to also identify 25 km as an important number, based on the physical arrangement of reefs and their network structures (Kininmonth et al, in review).

Specific distances specifying connectivity for further offshore waters have not been found in the literature. The rules of thumb for these two other realms were best estimates, based on the geography of the OSPAR area: a) the suggested offshore / EEZ circle is about the same size of the Bay of Biscay and also Iceland; and b) the suggested far offshore / high seas square is very approximately the same length (on a side) as the Azores chain, and also the mainland of Great Britain. It is hard to imagine anyone arguing that these would not constitute “major gaps.”

The rule of thumb delineating “a few” was based on ¼ the total estimated possible number of gaps in each of the respective realms.

Again, it is stressed that these rules of thumb are meant to provide an idea of what might be reasonable to expect, and are not meant to replace subsequently more sophisticated testing, should the three initial tests in this document be met.

[8] The far offshore / high seas example used a square shape instead of a circle, and so is actually five times larger.

4.2 Biogeographic Representation: Does the OSPAR MPA network cover at least 3% of most (seven of the ten) relevant Dinter biogeographic provinces?

The use of the Dinter classification system is contained as Principle 6 in the Guidance document (OSPAR Reference number 2006-3) and is also an Assessment Guideline in the Background document (OSPAR publication 2007/320) (§13, Executive Summary).

As in the first test, above, due to their ice cover and extreme remoteness, the following Dinter (sub-) provinces are not used in this test: *Cold Arctic Waters; High Arctic Maritime, Northeast Greenland shelf (NEWP), and the White Sea*. The assumption is that developing appropriate spatial protection in these regions will require special considerations, and should not be part of an initial assessment procedure.

This test begins to consider representativity by looking at a number which is 1/10th that commonly found in the scientific literature (i.e. 10% - 50%, commonly 30%, as referenced in the Background document (OSPAR publication 2007/320), and also listed in Annex 2 of this document).

The Guidance document (OSPAR Reference number 2006-3) notes some existing commitments, aspirations, and guidance, in the range of 10% to 60%, which also strongly suggests that anything under 3% is certainly not adequate (§11).

The Guidance document (OSPAR Reference number 2006-3) also notes that protection could be done incrementally, which also supports the use of a low initial number, which would then be increased in time (§12).

This test infers replication and connectivity based on the assumption that the 3%-or-greater criteria would constitute several sites (>3) distributed throughout the Dinter province. This assumption is supported by: a) the previous initial test (visually well-distributed); and b) examining patterns in the current (2006) OSPAR MPA network. In the current OSPAR MPA network there are no large MPAs that alone account for 3% of a single province.[9] Furthermore, in provinces where there are currently some MPAs, all but one (Lusitanean Warm North) already have more than three. Therefore it is reasonable to assume that if 3% of a province is protected, it will also include several sites. Having several sites suggests that some replication may be occurring.

It is extremely unlikely that connectivity can be achieved with fewer than three sites and more than 97% of the biome unprotected, simply because there is so much open unprotected space.

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

This test begins to consider the protection of threatened and/or declining features by looking at a number which is 1/10th that found as a minimum in the scientific literature (i.e. 50%).[10]

The Guidance document (OSPAR Reference number 2006-3) supports the idea that threatened and/or declining features should receive greater percentage protection (Principle 4). It also notes that protection could be done incrementally, which also supports the use of a low initial number, which would then be increased in time (§12).

This test only looks at non-mobile threatened and/or declining features for which spatial protection would very likely be appropriate.

The alternate [bracketed] text suggesting the use of three replicate sites is only to be applied in those Regions where spatial data of the feature in question do not exist. The assumption is that the three sites would be of average size for the feature in question, and that about 60 patches of the feature occur in the OSPAR Region. If it can be better estimated how many patches occur in a given Region, then the 5% value of that number could be used.

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[9] The smallest Dinter (sub-)province is the Macronesian Azores (22 576 km^2), where the largest MPA contributes 2.3%. At 6.1% protection overall, distributed in four MPAs, this small biome has also the highest percentage spatial protection.
[10] Pressey et al. (2004) use a more sophisticated variable target which is noteworthy. The target is given by a simple formula which takes into account the scaled rarity (R) and vulnerability (V) of the ecosystem in question: Target % = 10% + (10% x R) + (20% x V).

OSPAR Regions were used as the basis for this test because that is the primary spatial classification used in the OSPAR case reports.

Threatened and/or declining birds are often linked to nesting sites as well as predictable breeding and foraging grounds. However, because the OSPAR Maritime Area does not include land, the nesting sites cannot be included in this test, though clearly their protection should be encouraged. The waters around nesting colonies can of course also be protected, though like the at-sea Important Bird Areas, these criteria are still being developed.

5. General strategies that can be applied filling spatial gaps in data-poor situations

Addressing gaps in the OSPAR MPA network will ideally use good spatial data and follow the principles found in the literature (e.g. Sala 2000; Roberts et al 2003a, b; von Nordheim et al 2006).

In mixed-data situations, various "rules of thumb," such as outlined in the Background document (OSPAR publication 2007/320), can be used.

When spatial data are very incomplete or non-existent, however, other techniques will have to be applied. Three are suggested below, in descending priority:

a. **Collect expert opinion and local knowledge**. This is always important, even when spatial data exist. This can be done through meetings, or better, through one-on-one interviews. Spatial data produced by stakeholders, when properly collected and processed, has been found to be at least as good quality as typically available scientific data sets (Ardron 2005).

b. **"Pick the best."** If expert / local knowledge is unavailable, and some sites of a feature are already known, then pick what is generally considered to be the best. This is in the spirit of the third aim in OSPAR Reference Number 2003-17, as noted also in the Guidance and Background documents. The Background document (OSPAR publication 2007/320) outlines criteria for what could constitute "best:"

   Assessment Guideline: Features that best represent their type can be expected to be characterized by most or all of these indicators (§29 iii):

   - Typical morphology;
   - High density / abundance;
   - High degree of health / naturalness;
   - Persistence (temporal and spatial); and
   - Strong functional linkages.

   This strategy turns out to be very robust in many situations, across a variety of life situations, and is based on the fact that collective knowledge taken as a whole is fitted to its "environment" and can be surprisingly good in making decisions (Garcia-Retamero & Hoffrage 2006, Todd & Gigerenzer 2007). Thus, if an area is already recognised as "best" this is likely due to reasons that are specific to its characteristics and separate it out from others like it. In this regard, a single measure of "best" can often surpass long lists of general criteria. This belongs to a class of decision making strategies labelled as "fast and frugal heuristics" where it is argued that in data-limited situations, multiple criteria often fare more poorly than simple heuristics that rely on singular measures of "best" (Todd 2007, Gigerenzer et al 1999).

c. **"Pick the best-known"** (the recognition heuristic): If in the above test, the "best" cannot be determined, and then pick the best-known. Picking the best-known assumes that what has already been noticed is probably better than what has not yet been noticed or surveyed. Again, this heuristic can be surprisingly powerful, and is explained in this quotation from Todd & Gigerenzer (2007):

   "...consider the inference task of predicting which of two tennis players will win an upcoming Wimbledon match. This decision can be made on the basis of pieces of information, or cues, that could be looked up about each player, such as whether they are past champions, how many games they have won this season, what their seeding by the Wimbledon experts is, and so on. More simply, one could ignore all of this information and just rely on the recognition heuristic: ''If you recognize one player and not the other, then predict the recognized one will win''

(Gigerenzer, 2007). Tennis novices make predictions in line with this heuristic often (90% of the time). More surprisingly, their collective recognition can be even more accurate (e.g., correct on 72% of men's 2003 matches) than the Wimbledon experts' ratings (69%). But the recognition heuristic will only perform so well in environments that it is suited to—namely, those where the ''biggest'' objects (like the biggest winners in sports) are frequently discussed and hence likely to be recognized. (pp 167-168)"

In the case of ecological features, it is very conceivable that the best known features are so known perhaps because they are (or were) ecological "hotspots" representing areas of productivity, or perhaps known for their beauty / biodiversity, or perhaps for their ecologically rare or unique features. In any case, there is a reasonable chance that their being well-known is in itself a good basis for protection, when other data are not available.

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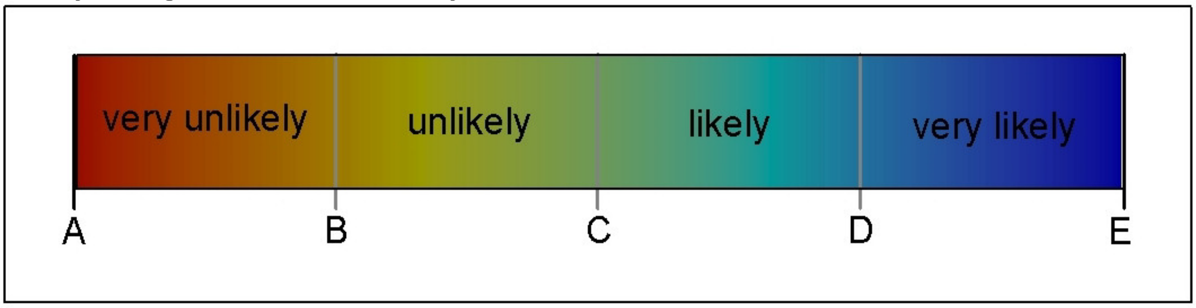
Annex 1: Eco-coherence as a continuum

Achieving full ecological coherence (eco-coherence) requires that a multitude of ecological variables are healthy, functioning and interacting. Thus, a marine protected area (MPA) network will often rest between the two extremes of a completely incoherent network and a fully coherent one, containing a mixture of both positive and negative attributes.

Figure 1, below, illustrates graphically such a continuum. In the case of an MPA network, point A could represent no protection and E could represent full protection. The far left of the graph, between points A & B, could be said to be "not ecologically coherent;" that is, it is very likely so. Similarly, the far right of the graph, between points D & E, would be ecologically coherent, in most likelihood. However, the broad middle zone between points B & D is less clear.

Figure 1: Continuum of certainty, as can be applied in assessing ecological coherence. Defining points B & D is important in understanding the continuum between "threshold" (point B) and "success" (point D). Point C can be seen as representing the "turning point," a compromise of mixed results –some failures and some successes. For simplicity, this illustration is depicted linearly, though the true bounds may be non-linear.



In general, research efforts have been spent on better predicting points C & D and understanding the range of trade-offs between them. For example, scientific modelling has often suggested that 30% - 50% protection would give a high level of assurance that marine ecosystems and stocks would be protected; i.e. aiming to define point D.[11] On the other hand, politically oriented statements usually come up with lower numbers, such as 20% or 10%; i.e. aiming more for the space between C & D, whereby the costs may be lower, but there is still a reasonable likelihood of some success.[12] In this hypothetical example, point C might be seen as the 10% target, since one seldom hears of any declarations to protect less than this amount. (See Appendix 1 for a more examples of MPA percentage targets.)

Little time has been spent defining the area between points B & C, in Figure 1. Presumably, this is because no one wants to aim for a target that is unlikely to succeed! However, it is as important to understand point B as it is point D, because these two points delineate the range whereby a mix of results –some success and some failures– can be expected.

Target versus limit: Just as point D can be seen as an ultimate goal, or *target,* to aim for in the long term, so can point B be seen as the lowest minimum starting point, or *threshold limit,* in the short term. The three tests put forward in this paper are identifying the area around point B. That is, they are threshold limits, and should not be confused with planning targets (i.e. point D), even though it may be politically tempting to do so.

Preferably, an MPA network would not start at B, but would instead be established somewhere between C & D. Indeed, there are famous examples, such as the Great Barrier Reef, which appear to have been ultimately successful in doing so.[13] However, because the OSPAR MPA network is not designed under any single authority, but rather through the cooperative efforts of its Contracting Parties (CPs), it is more reasonable to expect it to develop incrementally. Indeed, to date, because some CPs nominated sites before others, the

[11] This is discussed further in the Background document, OSPAR publication 2007/320.
[12] This is discussed in the Guidance document, reference number 2006-3. There have already been several concerted political calls for significant marine protection. For example, in 1998 about 1600 scientists called for 20% protection of the EEZ and high seas by 2020: http://www.mcbi.org/publications/pub_pdfs/TroubledWaters.pdf
[13] Though, it is noted that GBR's initial management plan had much lower protection measures than currently exist, and thus could be conceived to have started left of point C.

network has grown from a point somewhere to the left of B; i.e. the network has started from a place of being *not* eco-coherent (OSPAR Publication 268/2006).

To generally meet the 2010 eco-coherence goal of the Bremen Declaration and OSPAR recommendation 2003/3, it will be necessary to be somewhere in the area to the right of point C. While the area between B & C does not generally meet this eco-coherence goal, it does indicate *ecologically meaningful progress* towards meeting it. Otherwise, to the left of point B, it is very likely that this goal has not been met at all, with little ecologically meaningful progress to report on, at the OSPAR-wide scale.[14] Thus, as the first step in a multiple-step assessment, OSPAR will have to determine if the OSPAR MPA network, as a whole, is to the left or to the right of point B. The purpose of this paper is to put forward three initial tests to determine this.

Once these three initial tests appear to have been met, more sophisticated spatial tests should be performed, such as those suggested in the Background document (OSPAR publication 2007/320), as well as more sophisticated database analyses, such as currently being developed by the UK. These tests would allow better charting progress of achieving eco-coherence along a continuum (as from B to D in Figure 1).

[14] Recognising that at the national scale, significant progress may have been made in some individual cases.

Annex 2: Examples of MPA percentage protection targets

From: Nevill, J. 2006. Marine no-take areas[15]: How large should marine protected area networks be? Accessed 13 Sept. 2007: http://www.ids.org.au/~cnevill/marineNotesOnNTA_targets.doc

Table 1: Examples of No Take Area (NTA) network size targets

Percentages refer generally to coverage within major ecosystem or habitat type, however see footnote below.

AUTHOR	NTA TARGET[i]	COMMENTS
Agardy et al. 2003	not specified	The authors warn against the universal application of a single (20%) target for NTAs[ii].
Airame et al. 2003	30-50%	A recommendation from scientists to a community-based panel of stakeholders[iii].
Allison et al. 2003	not specified	The author's arguments and methods require a planning authority to specify an initial area target, which is then expanded by an insurance factor to meet possible catastrophes.
Ardron 2003	10-50%	Review of earlier studies[iv]
Beger et al. 2003	at least 20%	Examined reserve selection options to protect corals and reef fishes[v].
Bellwood et al. 2004	not specified	Authors describe a USA coral reef protection goal of 20% NTAs by 2012 as "too little too late".
Bohnsack et al. 2000	20-30%	Recommends at least 20-30% NTA.
Botsford et al. 2003	<35%	Not a recommendation: a theoretical (modelled) maximum based on species survival assumptions[vi].
Commonwealth of Australia 2001	30%	Recommends a target of 30% of the pre-1750 ('pre-disturbance') extent of terrestrial ecological communities. Can similar logic be applied to marine systems? See Rodrigues & Gaston 2001 discussion of terrestrial issues[vii], and Pressey et al. 2003, 2004.
Fogarty et al. 2000	35-75%	Not a recommendation. Fogarty et al. review a number of studies which suggest a range of 35% to 75% of an area should be protected to optimise fishery yield outside the reserves. As quoted by AHTEG 2003.
Gell and Roberts 2003	20-40%	Not a recommendation: authors present evidence suggesting these sizes work best for some (mostly local) fisheries enhancements.
Gladstone (2006)	>30%	Modelling of coastal reef fish communities finds that a 30% MPA target will cover 75% of surveyed species[viii].
Halpern 2003	not specified	Author reviews studies on the related issue of reserve size and MPA performance, and finds size is important[ix] (larger is more effective).
Halpern et al. 2006	not specified	Authors review modelling approaches accounting for uncertainty in effective dispersal, within a framework of variable persistence. A 'rule of thumb' for reserve spacing of around 25 km is suggested[x].

[15] It is acknowledged that the definition of a marine protected area need not be limited to a marine no-take area

Hughes et al. 2003	>30%	Not a recommendation: authors present evidence from ecological modelling studies – greater than 30% reef NTAs needed[xi] to protect coral ecosystems.
Leslie et al. 2003	20% +	Not a recommendation: figure selected for illustrative purposes (model demonstration).
Lockwood et al. 2002	not specified	Authors model population persistence inside coastal reserves assuming zero populations outside reserves. To ensure persistence "[the] upper limit for the minimum fraction of coastline held in reserve is about 40%."
Mangel 2000	~5-50%	Modelling analysis of reserves as a fishery enhancement tool depends on selecting a time horizon, fishing pressure and a probability of ecological extinction of the population[xii].
National Research Council 2001	20-50%	Figures from a literature review[xiii] relating to enhancement of fisheries effects.
Palumbi 2004	not specified	Author reviews information on the scale of marine neighbourhoods, and discusses the relevance of MPA size and spacing[xiv].
Pandolfi et al. 2003	not specified	The authors talk about a need for "massive protection" and "protection at large spatial scales" (coral reefs).
Pew Fellows 2005	10-50%	"Place no less than 10% and as much as 50% of each ecosystem in no-take zones, according to identified needs and management options in a particular ecosystem"
Pressey et al. 2003, 2004	variable	See papers: target proportion selected for modelling (2004) depends on natural rarity and vulnerability (10-40%). See text above.
Ray 2004	Implicitly supports (high) targets	Ray's paper is a critique of Agardy et al. suggesting that (a) MPAs in general need much more attention, and (b) to argue about the rights or wrongs of particular views on targets is counter-productive.
RCEP 2004	>30%	Authors call for the urgent creation of massive NTAs to allow marine habitat / ecosystem recovery[xv].
Roberts et al. 2003ab	>20%	Not a recommendation; authors provide a comprehensive review of NTA design methods and parameters.
Shanks et al. 2003	NTA size & spacing	Authors deal only with size and spacing using analysis and modelling of dispersal data[xvi].
Sala et al. 2002	40%	Gulf or California rocky reef habitat[xvii]
Sale et al. 2005	20 – 35%	Not recommendations – paper includes brief review[xviii].
UNEP 2004	>10%	Not a NTA, or even a MPA target. CBD CoP VII/30 annex II (see discussion above): "at least 10% of each of the world's ecological regions effectively conserved".
Walters 2000	NTA size	No recommendations on habitat targets. The paper deals with the relative benefits of a few large vs. many small NTAs. For mobile species, many tiny fragmented NTAs are likely to have negligible benefits[xix].
World Parks Congress 2003	20-30%	WPC recommendation 5.22 to be considered by the UN General Assembly[xxxxi].

[i] The percentages listed below are not recommended on a strictly equivalent basis. Some (e.g. DEH 2001) apply to specify ecological communities, while others apply to a total area under jurisdiction (like the New Zealand target). The former (more common) approach follows a specific rationale concerned with the protection of biodiversity through the protection of representative examples of habitat (see Appendix 1).

[ii] The authors also make the important point that MPA system design should go hand in hand with measures aimed at sympathetic management of the remaining matrix.

[iii] "After consideration of both conservation goals and the risk from human threats and natural catastrophes, scientists recommended reserving an area of 30-50% of all representative habitats in each biogeographic region". Page S170.

[iv] Ardron 2003:18 "A variety of marine reserve sizes ranging from 10% to 50% have been suggested as being efficacious as a conservation and/or fisheries management tool (MRWG 2001, NRC 2000, Roberts & Hawkins 2000, Ballantine 1997, Carr & Reed 1993), with an emphasis on larger reserves coming from the more recent literature. Furthermore, it has been found that larger reserves often have beneficial effects disproportionate to their size (Halpern 2003)".

[v] Beger et al. found that over 80% area protection would be required to protect 100% of both coral and fish species at their Kimbe Bay study site. Their recommendation of 20% coverage was based on protecting just under 80% of all surveyed species.

[vi] The authors present modelling analysis suggesting that, based on larvae dispersal and survival assumptions, together with assumptions about reserve size and distribution, 35% of coastal habitat would need to be reserved if no survival occurred in the remaining areas (the remaining 65%).

[vii] Rodrigues and Gaston 2001 examine the application of complementarity-based network design methods for identifying a minimum reserve network area to contain all species of identified terrestrial taxa. They found that the minimum area depends (in part) on type of taxa, regional endemism, and the size of the selection unit used in the design. At this level of generality their findings are likely to apply to marine ecosystems. Assuming every terrestrial plant needs to be represented at least once within a reserve network, a selection unit size of 12,000 km^2 leads to a reservation requirement of 74% of the global land area, while a selection unit size of 270 km^2 leads to a reservation requirement of 10% of the global land area. As the authors state, it is most unlikely that such small reserves would protect the processes which underpin biodiversity persistence, let along evolution. There is however a major difference between terrestrial conservation and marine conservation. Mankind has succeeded in not only modifying most pristine terrestrial habitats, but in destroying them and replacing them with highly modified and simplified ecosystems, where only highly adaptable organisms continue to survive. The analysis of Rodrigues and Gaston assumes that the greater part of terrestrial biota needs protected areas to survive – a reasonable assumption. While global marine ecosystems have been pushed into ecological crisis, it may be that, if harvesting impacts can be sufficiently reduced, most marine ecosystems can continue to function as 'homes' for resident biodiversity. If this is the case, the need for strictly-protected no-take areas may be somewhat reduced. It is important to note, however, that the processes which underpin marine biodiversity *often* operate at regional and global scales, and the means for their comprehensive protection is at present well outside the scope of current science. Under these circumstances, a precautionary approach to marine protected area network design is appropriate. If we are to adequately protect marine biodiversity, we must now err on the side of creating reserves which are too large rather than too small.

[viii] Gladstone concludes: "…the upper range of currently promoted targets for MPA establishment (i.e. 30%) should be regarded as a minimum for biodiversity conservation."

[ix] Halpern 2003 concludes: "The most important lesson provided by this review is that marine reserves, regardless of their size, and with few exceptions, lead to increases in density, biomass, individual size, and diversity in all functional groups. The diversity of communities and the mean size of the organisms within a reserve are between 20% and 30% higher relative to unprotected areas. The density of organisms is roughly double in reserves, while the biomass of organisms is nearly triple. These results are robust despite the many potential sources of error in the individual studies included in this review. Equally important is that while small reserves show positive effects, we cannot and should not rely solely on small reserves to provide conservation and fishery services. Proportional increases occur at all reserve sizes, but absolute increases in numbers and diversity are often the main concern. To supply fisheries adequately and to sustain viable populations of diverse groups of organisms, it is likely that at least some large reserves will be needed."

[x] Halpern et al. 2006 argue: "unless we are fairly certain about our estimate of dispersal distance, reserves should be spaced around 25 km from each other." They note: "Botsford et al. 2001 developed a similar rule of thumb using a different approach to modelling dispersal distance." Halpern's findings are supported by Cowen et al. 2006, who report: "typical larval dispersal distances of ecologically relevant magnitudes are on the scale of only 10 to 100 kilometres for a variety of reef fish species."

[xi] Pandolfi et al. 2003:933 "Ecological modelling studies indicate that, depending on the level of exploitation outside NTAs, at least 30% of the world's coral reefs should be NTAs to ensure long-term protection and maximum sustainable yield of exploited stocks".

[xii] The upper 50% figure derives from selecting a high fishing pressure outside the NTA network, a planning time horizon of 100 years, and an acceptable probability of population extinction of 1%. Assuming lower fishing pressures, a shorter time horizon, and an increased acceptable risk of extinction will all produce a smaller NTA network size target.

[xiii] "For fisheries, the benefit of a reserve does not increase directly with size. The maximum benefit of no-take reserves for fisheries, in terms of sustainability and yield, occurs when the reserve is large enough to export sufficient larvae and adults, and small enough to minimize the initial economic impact to fisheries (see review in Guenette et al. 1998). Data from harvested populations indicate that species differ greatly in the degree to which they can be reduced below normal carrying capacity before they are not self-sustainable in the long term (e.g., Mace and Sissenwine 1993, Hilborn, personal communication). If reserves are designed for fisheries enhancement and sustainability, the vast majority of studies done to date indicate that protecting 20% to 50% of fishing grounds will minimize the risk of fisheries collapse and maximize long term sustainable catches (NRC 2001, Table 1)".

[xiv] Palumbi concludes: "[Available studies] suggest adult neighbourhood sizes for many demersal fish and invertebrates as small as kilometres and up to 10 to 100 km. Larval dispersal may be shorter than previously suspected: neighbourhood sizes of 10 to 100 km for invertebrates and 50 to 200 km for fish are common in current compilations. How can small reserves protect such species? One conceptual framework is to set reserve size based on adult neighbourhood sizes of highly fished species and determine spacing of a

reserve network based on larval neighbourhoods. The multispecies nature of fisheries demands that network designs accommodate different life histories and take into account the way local human communities use marine resources."

[xv] Recommendation 8.96.

[xvi] "We suggest that reserves be designed large enough to contain the short-distance dispersing propagules and be spaced far enough apart that long-distance dispersing propagules released from one reserve can settle in adjacent reserves. 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."

[xvii] "We describe a means of establishing marine reserve networks by using optimization algorithms and multiple levels of information on biodiversity, ecological processes (spawning, recruitment, and larval connectivity), and socio-economic factors in the Gulf of California. A network covering 40% of rocky reef habitat can fulfil many conservation goals while reducing social conflict."

[xviii] According to Sale et al. (Box 1) "Protecting 20% of the area [available habitat type] has become a commonly cited target. This arbitrary target relies on the assumption that protecting 20% of the area protects 20% of the original spawning stock, and on the argument that protecting 20% of the stock would prevent recruitment overfishing. More recent models suggest that >35% of the total area needs to be in no-take reserves to prevent recruitment overfishing of sedentary species, such as sea urchins or many reef fishes, and area requirements differ among species with differing biology."

[xix] According to Walters: "The message is simple: for relatively mobile species, single large MPAs can be much more effective than many small ones".

xx

[xxi] "Therefore, PARTICIPANTS in the Marine Cross-Cutting Theme at the Vth World Parks Congress, in Durban, South Africa (8-17 September 2003): CALL on the international community as a whole to:

Establish by 2012 a global system of effectively managed, representative networks of marine and coastal protected areas, consistent with international law and based on scientific information, that: (a). greatly increases the marine and coastal area managed in marine protected areas by 2012; these networks should be extensive and include strictly protected areas that amount to at least 20-30% of each habitat, and contribute to a global target for healthy and productive oceans;" The full text of the recommendation is available from www.iucn.org.