BACKGROUND PAPER

Establishing criteria for the identification of ecologically and biologically significant areas on the high seas

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Preface

Efforts to protect, maintain, and restore marine ecosystems have focused primarily on inshore environments within national jurisdictions, where a majority of harmful human impacts occur. In contrast, very little consideration has been given to the protection of open-ocean ecosystems beyond the 200 nautical mile limit of the Exclusive Economic Zones (EEZs) of coastal states, where pressures from fishing and fishing-related activities, and commercial exploitation of resources are rising rapidly. The high seas[1] cover an estimated 50 percent of the earth's surface or 64 percent of the world's oceans (Baker *et al.,* 2001), yet few areas have been protected to conserve pelagic or benthic species, habitats, or ecological processes. Conservation of marine ecosystems on the high seas is inhibited by our limited knowledge of open ocean and deep sea environments, the open and dynamic nature of the high seas, the scale involved, and the absence of an appropriate legal framework. Despite these challenges, there are compelling reasons to identify areas of the high seas that would benefit from enhanced protection:

- The high seas and deep oceans are under increasing threat from human activities such as overfishing, bycatch, habitat degradation, shipping, deep seabed mining, scientific research, ocean dumping and bioprospecting (Gjerde & Breide, 2003; Mills & Carlton, 1998).
- The deep oceans contain a vast diversity of life forms, many of which are still being discovered. Some scientists estimate that over 100 million species may inhabit the high seas.
- The open oceans are a critical link for a number of species (e.g., sea turtles, eels) that live alternately between continental waters and open-ocean waters (Mills & Carlton, 1998).
- The open ocean plays a critical role in the regulation of global climate (Mills & Carlton, 1998; WWF & IUCN, 2001).

This paper provides an overview of ecological and biological criteria that can be used for identifying areas of ecological and biological significance (EBSAs) on the high seas. *All* areas have *some* biological and ecological significance; the term is a relative one that refers to the role that a species, habitat feature, community attribute or area may play in the ecosystem.

The paper is divided into two parts: Part I reviews the ecological and biological criteria developed by research groups and governmental and non-governmental agencies to help identify marine areas of ecological and biological significance. Part 2 reviews ecosystems, habitats, and communities of the high seas that have been identified as areas of ecological and biological importance. Many of the papers/frameworks reviewed in Part 1 include a description of the criteria as well as their associated integer scoring scheme. Although a discussion of scoring methods for selection of EBSAs on the high seas is beyond the scope of this Workshop, and although the literature on relative scoring methods has not yet matured, the methods are included here for completeness.

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[1] UNCLOS provides that the areas beyond the limits of national jurisdiction include i) the water column beyond the EEZ, or beyond the territorial sea where no EEZ has been declared, called the "high seas" (article 86); and ii) the seabed which lies beyond the limits of the continental shelf, established in conformity with article 76 of the Convention, designated as "the Area" (article 1 para. 1). It is important to note that where a coastal State's continental shelf (defined by the Convention to include the physical continental shelf, slope and rise together comprising the continental margin) extends beyond the 200 nautical mile, the coastal State has sovereign and exclusive rights to explore and exploit the natural resources in these portions of the shelf, including living organisms belonging to sedentary species. Sovereign rights to conserve these resources are not expressly included. In these cases, the seabed beyond national jurisdiction (i.e., the Area) begins at the outer limit of the shelf, sometimes well beyond 200 nautical miles. The water column above this extended shelf is high seas, since the high seas normally begin at the edge of the 200-nautical-mile EEZ. Thus, the water column beyond national jurisdiction may commence at a different distance from shore than the Area. Where the coastal State has not claimed a 200-nautical-mile EEZ, the high sea may begin closer to shore, at the edge of the 12-nautical-mile territorial sea, as is the case, for example, in many parts of the Mediterranean. Source: UNEP, 2005

List of Abbreviations

ANZECC	Australian and New Zealand Environment and Conservation Council
CBD	Convention on Biological Diversity
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
EBSAs	Ecologically and Biologically Significant Areas
EEZ	Exclusive Economic Zone
HSMPA	High Seas Marine Protected Area
IMO	International Maritime Organization
IUCN	World Conservation Union
MPA	Marine Protected Area
NMCA	National Marine Conservation Area
NRSMPA	National Representative System of Marine Protected Areas
NSW	New South Wales
OSPAR	Convention for the Protection of the Marine Environment of the North-East Atlantic
PSSA	Particularly Sensitive Sea Areas
SAC	Special Areas of Conservation
SPAMI	Specially Protected Areas of Mediterranean Interest
SPA	Special Protected Areas
SPAW	Specially Protected Areas and Wildlife in the Wider Caribbean Region
UNEP	United Nations Environment Programme
WCPA	World Commission on Protected Areas
WWF	World Wildlife Fund

List of Tables

PART ONE

1. Ecological criteria for identification of candidate sites of ecological and biological significance

The section that follows reviews ecological and/or biological criteria for evaluating candidate marine areas of ecological or biological significance. The paper addresses the following questions:

- What are the criteria?
- What is the science basis for the criteria (e.g., empirical, modeling, Delphic, etc.)?
- At what scale are the criteria used (e.g., large/small, hemispheric/regional/local)?
- Are the criteria identified for a specific geographic or climatic zone?
- Are the criteria applicable to all climatic zones?
- Is there a weighting system built into the criteria suite, and if so, what is it based on?
- Have the criteria been field tested, and if so, where?
- What are the pros/cons of the criteria, if they were field tested?
- What type of data is required to use the criteria?

If these questions are not addressed in the source document, they are absent from this review. This paper does not compare the criteria, nor conclude on a set of preferred criteria. Much of the work undertaken on identification of EBSAs has been associated with the design of potential marine protected area (MPA) networks. Within their suggested approaches, many authors have included criteria that are not restricted to ecological and biological significance. 'Degree of threat to an area' is an example of such a criterion. To maintain the integrity of the authors' suggested approaches we have not excluded criteria that are not strictly related to EBSAs. We have stayed as faithful as possible to the original source; the information is therefore quoted, not interpreted. Due to the complexity and/or detail of a number of approaches, some material is summarized in table format. Provision of a table in no way suggests that a particular approach is superior or inferior to other approaches where a text summary is provided; decisions were made purely on the basis of improving readability of the document. All of the biological/ecological criteria reviewed below are summarized in a matrix (Table 1) for ease of comparison.

This section follows a general order, but the sources are not in any way prioritized. Criteria relating to the identification of marine areas of ecological and biological significance on the high seas are reviewed first, followed by a review of criteria developed for the selection of marine reserves in nearshore areas. The main purpose of this paper is to outline different authors' perspectives on criteria used to identify ecologically and biologically significant areas, however, publications addressing the general problem of designating areas as ecologically and biologically significant are included, regardless of the intended management measure(s). For example, in the majority of cases the criteria detailed in this report have been developed for identification of candidate sites for marine protected area status. Since marine reserves are typically selected, in part, on the basis of an area's ecological and biological significance, the criteria for marine reserve selection are relevant for inclusion.

1.1 In a scientific background paper prepared for the IUCN, WCPA and WWF High Seas Marine Protected Areas (HSMPAs) Workshop in Malaga, Spain, Gubbay (2003) identified a list of possible preliminary criteria for HSMPAs Site selection is based on an evaluation of a site's ecological, geological and cultural value, as well as practical considerations.

Areas that would benefit from site specific management, such as locations which are:

a. Representative of the range of habitats/ecosystems in a region
b. Functionally critical (e.g., nursery grounds, spawning sites)
c. Support rare species/habitats/ecosystems
d. Support unique species or areas exhibiting high endemism
e. Support a high diversity of species/habitats

Practical considerations:
f. Site integrity
g. Degree and nature of threat(s) to species/habitats/ecosystems in the area
h. Geo-political circumstances
i. Feasibility of management, compliance and enforcement

Using the proposed criteria outlined above as a guide, the following biophysical information needs were identified by Gubbay (2003):

Representativeness - information needs include identification of the main ecosystems and habitats (benthic and pelagic), decisions about scale on which management is to be applied , biogeographic zones and habitat classifications

Functionally critical – information needs include identification of areas such as nursery grounds, migration routes and spawning sites for species, and areas where functionally critical ocean processes operate such as upwellings, frontal systems etc.

Rarity – a better understanding of which habitats, species or ecosystems of the High Seas are truly rare as opposed to being an artifact of the extent and location of sampling programmes.

Unique/high levels of endemism – locations where there are concentrations of endemic species or unique habitats, distinguished from areas highlighted as such because of an artifact of sampling programmes.

Site Integrity – the size and make up of potential spatial units of management and particularly the processes that drive marine systems and therefore which need to be understood if sites are to be kept in favourable condition.

Level of threat – current and future activities that are likely to pose a threat to High Seas species, habitats and ecosystems.

Information needs and guidelines for application of the criteria are recognized as fundamental issues. “Since relatively few areas of the High Seas are known in any detail, a systematic and comprehensive application of the criteria may only be possible in a limited number of places. A degree of “expert judgment” or “specialist opinion” may be used to guide the process and suggest where action or more detailed investigations should be focused” (Gubbay, 2003, p. 12). In regards to prioritization of candidate sites, there are different opinions about whether or not highest priority should be given to areas that are already threatened, or to areas where the establishment of spatial management regimes is particularly feasible. The author stresses that since the idea of High Seas MPAs is still being developed, it is important to be flexible and consider potential sites that represent real opportunities for establishing the precedent for HSMPAs, even if they do not qualify as “outstanding” when considered against the proposed criteria.

1.2 In the North East Atlantic, an MPA programme is developing under the Convention on the Protection and Conservation of Ecosystems and Biological Diversity of the North East Atlantic (OSPAR Convention). Contracting Parties to the Convention have developed a set of “*Guidelines for the Identification and Selection of Marine Protected Areas in the OSPAR Maritime Area*”[2] (OSPAR Commission, 2003). Possible sites are identified by applying a set of ecological criteria/considerations (summarized below). If a number of possible sites are identified, the ecological criteria/considerations are reapplied to help prioritize identified sites. For example, an area that holds a higher population of the species concerned, or that meets additional ecological criteria, may warrant a higher priority. A set of practical

[2] The Convention for the Protection of the north-east Atlantic (OSPAR Convention) applies to what is described as the “maritime area” which extends westwards from mainland Europe to sections of the mid-Atlantic Ridge, eastwards to the continental North Sea coast, and from the North Pole to the Straits of Gibraltar. It does not include the Baltic or Mediterranean (Gubbay, 2002).

criteria/considerations are also taken into account to develop a prioritized list of sites. Additionally, guidelines are provided to help determine which criteria should be used to select areas as components of the OSPAR Network in relation to a set of identified aims (Table 2).

Guidelines for the identification and selection of marine protected areas in the OSPAR Maritime area (OSPAR Commission, 2003):

ECOLOGICAL CRITERIA / CONSIDERATIONS

An area qualifies for selection as an MPA if it meets several but not necessarily all of the following criteria. The consideration and assessment of these criteria should be based on best available scientific expertise and knowledge.

1.1 **Threatened or declining species and habitats / biotopes -** The area is important for species, habitats/biotopes and ecological processes that appear to be under immediate threat or subject to rapid decline as identified by the ongoing OSPAR selection process.

2.1 **Important species and habitats / biotopes -** The area is important for other species and habitats/biotopes as identified by the ongoing OSPAR (Texel-Faial) selection process.

3.1 **Ecological significance -** The area has:

- a high proportion of a habitat/biotope type or a biogeographic population of a species at any stage in its life cycle;
- important feeding, breeding, molting, wintering or resting areas;
- important nursery, juvenile or spawning areas; or
- a high natural biological productivity of the species or features being represented.

4.1 **High natural biological diversity -** The area has a naturally high variety of species (in comparison to similar habitat/biotope features elsewhere) or includes a wide variety of habitats/biotopes (in comparison to similar habitat/biotope complexes elsewhere).

5.1 **Representativity -** The area contains a number of habitat/biotope types, habitat/biotope complexes, species, ecological processes or other natural characteristics that are representative for the OSPAR maritime area as a whole or for its different biogeographic regions and sub-regions.

6.1 **Sensitivity** - The area contains a high proportion of very sensitive or sensitive habitats/biotopes or species.

7.1 **Naturalness** - The area has a high degree of naturalness, with species and habitats/biotope types still in a very natural state as a result of the lack of human-induced disturbance or degradation.

PRACTICAL CRITERIA / CONSIDERATIONS

2.1 **Size** - The size of the area should be suitable for the particular aim of designating the area, including maintaining its integrity, and should enable the effective management of that area.

2.2 **Potential for restoration** - The area has a high potential to return to a more natural state under appropriate management.

2.3 **Degree of acceptance** - The establishment of the MPA has a comparatively high potential level of support from stakeholders and political acceptability.

2.4 Potential for success of management measures - There is a high probability that management measures and the ability to implement them (such as legislation, relevant authorities, funding, and scientific knowledge) will meet the aims for designation.

2.5 Potential damage to the area by human activities - It is an area where significant damage by human activity may happen in the short term.

2.6 Scientific value - The area has a high value for scientific research and monitoring.

Two examples of sites which have been discussed informally at workshops developing MPA Guidelines for OSPAR are a long term research reference station (described as a "unique science priority area") that extends from the Porcupine Seabight to the Porcupine Abyssal Plain, nearly 500nm to the south west of Ireland, and the Rockall Bank to the west of the British Isles (Gubbay, 2003).

The European Deep Sea Transect (EDT)
Potential qualifying criteria - representative, site integrity

The EDT was established during the 1980s and 1990s and connects three 'science hot spots' where the benthos and benthic processes have been intensively studied for many years. The three areas are the *Porcupine Seabight* (~51ºN, 13ºW), the *Porcupine Abyssal Plan* (~48º50'N, 16º30W) and the *BIOTRANS* area (centred around 47ºN, 21ºW), where work has been done on investigating biological transport and carbon flux in the near bottom water area. Data gathered from these locations have helped to build a broad basic knowledge of deep sea communities and ecological processes.

The Rockall Bank
Potential qualifying criteria - representative, diverse, functionally critical, threatened

The Rockall Bank extends in a SE-NW direction between 55-58.30° N and 18-13° W (1000m isobath). Its eastern slopes are in the EEZ of the UK and Ireland, and the western part in international waters, but on the continental shelf claimed by UK and Ireland. The Bank is of great significance in the north east Atlantic region owing to its extensive coral-associated communities from 150-1000 m depth, which harbour rich biological resources in terms of fish populations. There is a diverse demersal fish fauna of in excess of 130 species between about 400 metres and abyssal depths. Large concentrations of blue whiting occur over the Bank in early spring, and use the area as a spawning ground. Fishing around Rockall probably dates back more than two centuries although it was originally confined to the shallower areas. Deep sea fisheries took off in this area in the 1970s and are now concentrated on the continental slope, banks and seamounts in the area. Decades of trawling are likely to have caused substantial damage to the *Lophelia pertusa* colonies, thickets and possibly reefs, as well as to the soft-sediment slope regions. Oil and gas exploration has been licensed on its eastern margins.

1.3 The International Maritime Organization (IMO) developed guidelines for the designation of Particularly Sensitive Sea Areas (PSSA) within and beyond the limits of the territorial sea (IMO, 2001). The criteria can be used by IMO to designate PSSAs beyond the territorial sea with a view to the adoption of international protective measures regarding pollution and other damage caused by ships. A PSSA is defined as "an area that needs special protection through action by IMO because of its significance for recognized ecological, socio-economic or scientific reasons and which may be vulnerable to damage by international shipping activities" (IMO, 2001). To be identified as a PSSA, a candidate site must meet at least one of the ecological, socio-economic or scientific criteria in section 4 of the Guidelines (http://www.imo.org/includes/blastDataOnly.asp/data_id%3D10469/927.pdf), and an area must be at risk from international shipping activities. The ecological criteria are detailed below.

IMO guidelines for the identification and designation of particularly sensitive sea areas (PSSAs):

Uniqueness or rarity - An ecosystem can be unique or rare. An area or ecosystem is unique if it is "the only one of its kind". An area or ecosystem is rare if it only occurs in a few locations or has been seriously depleted across its range. An ecosystem may extend beyond country borders, assuming regional or international significance. Nurseries or certain feeding areas may also be rare or unique.

Critical habitat - A sea area may be a critical habitat for fish stocks or rare or endangered marine species, or an area of critical importance for the support of large marine ecosystems.

Dependency - Ecological processes of PSSAs are highly dependent on biotically structured systems (e.g. coral reefs, kelp forests, mangrove forests, seagrass beds). Such biotically structured ecosystems often have high diversity, which is dependent on the structuring organisms. Dependency also embraces areas representing the migratory routes of marine fish, reptiles, birds and mammals.

Representativeness - These areas have highly representative ecological processes, or community or habitat types or other natural characteristics. Representativeness is the degree to which an area represents a habitat type, ecological process, biological community, physiographic feature or other natural characteristic.

Diversity - These areas have a high variety of species or genetic diversity or include highly varied ecosystems, habitats, and communities.

Productivity - The area has a high natural biological productivity. Production is the net result of biological and physical processes which result in an increase in biomass in areas of high natural productivity such as oceanic fronts, upwelling areas and some gyres.

Spawning or breeding grounds - The area may be a critical spawning or breeding ground or nursery area for marine species which may spend the rest of their life-cycle elsewhere, or may be a migratory route for sea birds or marine mammals.

Naturalness - The area has a high degree of naturalness, as a result of the lack of human induced disturbance or degradation.

Integrity - The area is a biologically functional unit, an effective, self-sustaining ecological entity. The more ecologically self-contained the area is the more likely it is that its values can be effectively protected.

Vulnerability - The area is highly susceptible to degradation by natural events or the activities of people. An area already subject to environmental stresses owing to human activities or natural phenomena (e.g. natural oil seepage) may be in need of special protection from further stress, including stress arising from international shipping activities.

Bio-geographic importance - An area that either: contains rare biogeographic qualities or is representative of a biogeographic “type” or types, or contains unique or unusual geological features.

Research - The area has high scientific interest.

Baseline and monitoring studies - The area provides suitable baseline conditions with regard to biota or environmental characteristics.

Education - The area offers the opportunity to demonstrate particular natural phenomena.

1.4 The 1995 Protocol Concerning Mediterranean Specially Protected Areas and Biological Diversity in the Mediterranean provides for the establishment of a list of Specially Protected Areas of Mediterranean Interest (SPAMI) (Official Journal of the European Communities, 1999). SPAMIs may be created within areas of national jurisdiction and on the high seas. The Protocol is applicable to the seabed and its subsoil and to the terrestrial coastal areas designated by each party, including wetlands. To establish a SPAMI located partly or wholly on the high seas, a proposal must be made 'by two or more neighbouring parties concerned'. To be eligible for inclusion in the SPAMI list, an area must fulfill at least one of the following criteria:

a) **Uniqueness** – The area contains unique or rare ecosystems, or rare or endemic species.
b) **Natural representativeness** – The area has highly representative ecological processes, or community or habitat types or other natural characteristics. Representativeness is the degree to which an area represents a habitat type, ecological process, biological community, physiographic feature or other natural characteristic.
c) **Diversity** – The area has a high diversity of species, communities, habitats, or ecosystems
d) **Naturalness** – The area has a high degree of naturalness as a result of the lack or low level of human-induced disturbance and degradation.
e) **Endangered species -** Presence of habitats that are critical to endangered, threatened or endemic species.
f) **Cultural representativeness** – The area has a high representative value with respect to the cultural heritage, due to the existence of environmentally sound traditional activities integrated with nature which support the well-being of local populations.

1.5 A set of scientific criteria is used for designation of Special Areas of Conservation (SACs) and Special Protection Areas (SPAs) under Natura 2000 (McLeod *et al.,* 2005; Johnston *et al.,* 2002). Natura 2000 is a European network of protected sites which represent areas of the highest value for natural habitats and species of plants and animals which are rare, endangered or vulnerable in the European Community. The SAC and SPA directives are fully applicable and enforceable up to the 200 m offshore limit of Member States' jurisdiction (Schmidt *et al*., 2004). The criteria for site selection differ for the identification of habitats and functional habitats for migrating species.

The collective EU process (Natura 2000) and criteria for site selection.

The process is broken down into two stages:

Stage 1: assessment of the relative importance of sites containing examples of the individual Annex I habitat types and Annex II species in each Member State;

Stage 2: assessment of the overall importance of the sites in the context of the appropriate biogeographical region and the EU as a whole.

The criteria to be employed in *Stage 1* can be summarized as:

Assessment criteria for habitat types:
a. Degree of representativeness of the natural habitat type on the site;
b. Area of the site covered by the natural habitat type in relation to the total area covered by the natural habitat type within the national territory;
c. Degree of conservation of the structure and functions of the natural habitat type concerned and restoration possibilities;
d. Global assessment of conservation value (i.e., an overall assessment, based on a-c above).

Site assessment criteria for functional habitats:

a. Population size and density;
b. Degree of conservation of the features of the habitat that are important for the species, and restoration possibilities;
c. Degree of isolation of the population in relation to the species' natural range;
d. Global assessment of conservation value (i.e., an overall assessment, based on a-c above).

Member states are required to classify sites on their national lists according to their relative value for each habitat type and species, and to identify which of the sites in their national lists are selected for priority habitat types and species.

Some additional principles may be used for the site selection for both types of habitats:

a. Priority/ non-priority status
b. Geographical range
c. Special responsibilities
d. Multiple interest
e. Rarity

The criteria used in *Stage 2* are intended to be used to assess the sites at the level of the nine biogeographical regions and the EU as a whole. The *Stage 2* criteria may be summarised as:

a. Relative value of the site at national level;
b. Geographic situation of the site in relation to migration routes of species in Annex II or its role as part of an ecosystem on both sides of one or more Community frontiers;
c. Total area of the site;
d. Number of Annex I habitat types and Annex II species present;
e. Global ecological value of the site at the level of the biogeographical region and/or EU as a whole.

The *Stage 1* and *Stage 2* criteria must be read alongside other site selection requirements or qualifications set out in the Directive. More specific requirements for site selection include:

a. Restrictions on the site selection obligations in respect of widely dispersed and aquatic species (Article 4.1);
b. The requirement to contribute towards the maintenance of favourable conservation status[3] (Article 2.2 and Article 3.1);
c. The obligation on each Member State to select a series of sites that reflects the proportion of the EU resource of a given habitat or species within their national territory (Article 3.2).

1.6 Nationally important marine nature conservation features and areas in the United Kingdom are identified using a set of ecological criteria based largely on the OSPAR MPA selection criteria as well as the criteria published by the IUCN's World Commission on Protected Areas (Conner *et al.*, 2002; Laffoley *et al.*, 2000). The overall approach centers on full representation of marine biodiversity in the UK, with additional attention focused on particular features. Three sets of criteria have been developed to address three discrete aims: 1) identification of areas that best represent the range of seascapes, habitats and species present in the UK, 2) identification of seascapes, habitats and species for which member states have a special responsibility in a national, regional, or global context, and 3) identification of seascapes, habitats and species that have suffered significant decline in their extent or quality, or are threatened with such decline, and can thus be defined as being in poor status. The criteria are summarized below.

Guidelines for the identification of nationally important marine nature conservation features and areas in the UK:

1) Identifying best representative areas

Typicalness - the area contains examples of seascapes, habitats and ecological processes or other natural characteristics that are typical of their type in their natural state.

Naturalness - the area has a high degree of naturalness, resulting from the lack of human-induced disturbance or degradation; seascapes, habitats and populations of species are in a near-natural state. This is reflected in the structure and function of the features being in a near-natural state to help maintain full ecosystem functioning.

Size - the area holds large examples of particular seascapes and habitats or extensive populations of highly mobile species. The greater the extent the more the integrity of the feature can be maintained and the higher the biodiversity it is likely to support.

Biological diversity - the area has a naturally high variety of habitats or species (compared to other similar areas).

Critical area - the area is critical for part of the life cycle (such as breeding, nursery grounds/area for juveniles, feeding, migration, resting) of a mobile species.

Area important for a nationally important marine feature - features that qualify as special features or which are declined or threatened should contribute to the selection of these areas. The assessment should consider whether such features are present in sufficient numbers (species), extent (habitat) or quality (habitats, seascapes) to contribute to the conservation of the feature.

2) Identifying features of special importance

Proportional importance - A high proportion of the seascape, habitat, or population of a species (at any time of its life cycle) occurs within the UK. This may be related to either the global or north-east Atlantic/European extent of the feature, with global importance being of greater significance. Features may be categorized as follows:

- *Globally important*: a high proportion of the global extent of a seascape or habitat or a high proportion of the global population of a species (at some stage in its life cycle) occurs within the UK. ‘High proportion’ is considered to be more than 50%, when known.

- *Regionally important*: a high proportion of the regional (north-east Atlantic) extent of a seascape or habitat, or a high proportion of the regional population of a species (at some stage in its life cycle) occurs within the UK. ‘High proportion’ is considered to be more than 50%, when known.

Rarity - Seascapes, habitats and species that are sessile or of restricted mobility (at any time in their life cycle) are considered rare if their distribution is restricted to a limited number of locations. Rarity can be assessed at global, regional or national level as follows:

- *Globally rare*: No guidelines available.
- *Regionally rare*: ‘The ‘limited number of locations’ is set at 2% of the 50 km by 50 km UTM grid squares for each of the following three bathymetric zones in the north-east Atlantic:

    a. littoral (intertidal zone and splash zone)
    b. sublittoral (down to 200 m depth)
    c. bathyal / abyssal (below 200 m depth)

- *Nationally rare*: recorded in 1-8 of the 10 km x 10 km squares in GB (i.e. less than 0.5% of the total numbers of squares - based on the numbers of 10 km squares in which the feature is recorded in comparison with the total number of squares within the 3 nm limit). [Needs modifying to extend to NI and offshore]. In the case of a mobile species, the total population size will determine rarity [needs further guidance].

In the case of a mobile species, the total population size will determine rarity. The assessment should be dependent on scientific judgment regarding natural abundance, range or extent and the adequacy of recording.

3) Identifying features that have declined or are threatened

Decline - an observed, estimated, inferred or suspected significant decline in numbers, extent or quality of a seascape, habitat, or species (for species, quality refers to life history parameters). The decline may be historic, recent or current and may be throughout UK waters, or at a regional or global level.

Threat of significant decline - The feature is expected to suffer significant decline in the foreseeable future due to its expected high level of exposure to damaging activities and to its inherent sensitivity to those activities. Where such potential decline is inferred or estimated, a precautionary approach should be adopted.

1.7 The United Nations Environment Programme (UNEP) developed a set of "*Common Guidelines and Criteria for Protected Areas in the Wider Caribbean Region: Identification, Selection, Establishment and Management*" (UNEP, 1996). The criteria listed in this report are summarized below. In a subsequent document, UNEP (2004) drafted a grid to assist in the objective evaluation of proposals in the SPAW (Specially Protected Areas and Wildlife in the Wider Caribbean Region) protected areas list. Features of candidate sites are 1) evaluated for presence/absence, or 2) qualified in a semi-quantitative way according to predetermined classes of 0-1-2-3 (null, low, medium and high degree, respectively). A section of the grid that covers biological/ecological criteria has been reproduced in Table 3.

Common guidelines and criteria for protected areas in the Wider Caribbean Region.

Identification

Protected Areas shall be established in order to conserve, maintain and restore, in particular:

a. representative habitats of coastal and marine ecosystems, habitats and associated ecosystems of adequate size to ensure their long-term viability and to maintain biological and genetic diversity;
b. habitats and their associated ecosystems critical to the survival and recovery of endangered, threatened or endemic species of flora and fauna;
c. the productivity of ecosystems and natural resources that provide economic or social benefits and upon which the welfare of local inhabitants is dependent; and
d. areas of special biological, ecological, educational, scientific, historic, cultural, recreational, archeological, aesthetic, or economic value, including in particular, areas which ecological and biological processes are essential to the functioning of the Wider Caribbean ecosystems.

Areas that require protection to safeguard their special value, such as those that: a) sustain vital ecosystem processes; b) are particularly important for biodiversity conservation because of richness of species or because they are habitats to endangered or threatened species; or c) sustain activities such as fisheries, tourism, fuel production (fuel wood and charcoal production), education and research, shall be given a high priority for protected status to sustain their benefits.

The most important factors to be used in identifying protected areas are **significance**, **representativeness** and **feasibility**.

Significance

Significance is a measure of the value of an area for illustrating the natural or cultural heritage of a country or a region.

Factors to be considered among others in determining the significance of a natural area include: degree of uniqueness, naturalness, diversity, ecological integrity, opportunities for sustainable development, and scientific value. Explanations for a number of these terms are included in Appendix I.

Representativeness

In natural areas representativeness is a measure of the extent to which the site or area is representative of a particular natural or biogeographical element, in terms of its location in key or natural zones of major importance within a biogeographical unit. Areas or sites with a high or medium degree of naturally occurring features, located in transition zones between two or more biogeographical units are considered priority, since there is the possibility of obtaining a high level of natural representativeness by establishing a single conservation unit.

For an area to be identified, selected and ranked as important for inclusion in a national system of protected areas, it should represent a natural or cultural theme or resource type that is not adequately represented in the system or is not comparably represented and protected. Adequacy of representation is determined on a case-by-case basis by comparing the area to other existing or potential areas for differences or similarities in the character, quality, quantity, or combination of resources.

In order to ensure optimum conservation, a national system of protected areas should, where possible, include one (1) or more important samples of each type of a country's ecosystem. More effective conservation and representation of the important ecosystems of each country is probable if two (2) or more areas with these ecosystems are protected. A list of these ecosystems and their definitions should be developed as appropriate.

Feasibility

Feasibility refers to the degree to which an area can be adequately protected and managed in order to achieve its conservation objectives. The feasibility of managing an area depends on a number of ecological, political, economic, social and administrative factors including: size of the area, isolation, configuration, accessibility, land ownership and ancestral rights, population density, acquisition costs, economic interests in the area, environmental impacts, and staff or development requirements. A number of these terms are discussed in Appendix II.

Although an area may have achieved the significance and representativeness criteria, it still may not be feasible to include this area in a protected area system.

Selection

For the selection of terrestrial and marine natural areas, the most common criteria to be considered, among others, by the Governments, are the following:

- Presence of biogeographical units, ecological environments, highly diversified natural units or biological richness.
- Presence of threatened or endangered species, particularly those which require their habitats regulated against human intervention.

- Contribution of the area to the maintenance of ecological and environmental functions or processes, including the life cycles of biological species and communities of particular interest.
- Concentration of wildlife, or of communities and species of scientific, ecological or economic interest. In this regard, Governments must consider as priority the protection of habitats which contain useful populations of economically important genetic resources (wild "strains" of related industrial crops, vegetables fruits, plants used in the manufacture of pharmaceuticals, etc.).
- Protection of watersheds, particularly those which are essential to stability and protection and proper functioning of important coastal and marine environments (coastal lakes, beaches, mangrove swamps, coral reefs etc.).
- Special sites for migratory species, especially those associated with wetland areas.
- Areas where great concentrations of spawning and/or breeding of marine organisms and birds occur.
- Areas which are downstream sources of larvae.
- Presence of plant formations, associations or communities of scientific, environmental or scenic interest.
- Existence of endemic species, particularly local species, with limited distribution and populations.
- Transition zones between the main types of ecosystems which may include high-altitude gradients, humidity, types of forest and other relief, distinct microclimates etc. These transition zones are essential to the conservation of genetic or biological diversity.
- Presence of unique or rare natural, historical or cultural resources at the national, regional and global levels.

The Governments must prioritize for selection, those conservation units which, on an individual basis, meet most of the criteria in a highly satisfactory manner.

Defining priority areas

Governments should give the highest priority to units requiring protection in' light of their high significance or representativeness, as well as the immediate or near-term threats which can affect them. Measures aimed at instituting an effective management system must be enforced immediately, if the quality of these sites is to be maintained.

Areas of highest priority may include:

- The presence of the endangered and locally endemic species, considering in particular the species contained in Annexes I and II of the SPAW Protocol;
- The presence of unique or rare national, regional, or international landscapes or ecosystems;
- Special sites of high importance to sustain the nesting, feeding, wintering and breeding of migratory species;
- Areas of high biodiversity within each biogeographical province, especially important to maintain the genetic evolution and resources within them;
- Areas with biological or geographical characteristics which confer and sustain high economic and social value, especially those particularly important in ensuring the long-term survival and well-being of the population; and
- The presence of populations of species considered rare at the local level.

1.8 Fisheries and Oceans Canada put forward a framework to guide identification of areas that are *Ecologically and Biologically Significant* (Fisheries and Oceans Canada, 2005). Under this framework, areas can be evaluated with regard to their Ecological and Biological significance along three main dimensions (1-3 below), with due consideration given to two additional dimensions (4-5 below):

1) **Uniqueness** – Ranked from areas whose characteristics are unique, rare, distinct, and for which alternatives do not exist to areas whose characteristics are widespread with many areas which are similar in most important features. Uniqueness may be considered in a regional, national, and global context, with increased importance at each scale.

2) **Aggregation** – Ranked from areas where:
   a. most individuals of a species are aggregated for some part of the year, OR
   b. most individuals use the area for some important function in their life history, OR
   c. some structural feature or ecological process occurs with exceptionally high density,

   to areas where:

   d. individuals of a species are widespread and even areas of comparatively high density do not contain a substantial portion of the total population, OR
   e. individuals may congregate to perform a life-history function, but the area in which they perform the function varies substantially over time, OR
   f. structural property or ecological process occurs in many alternative areas.

3) **Fitness Consequences** - Ranked from areas where the life history activity(ies) undertaken make a major contribution to the fitness of the population or species present to areas where the life history activity(ies) undertaken make only marginal contributions to fitness.

4) **Resilience** – From areas where the habitat structures or species are highly sensitive, easily perturbed, and slow to recover to areas where the habitat structures or species are robust, resistant to perturbation, or readily return to the pre-perturbation state.

5) **Naturalness** – From areas which are pristine and characterized by native species to areas which are highly perturbed by anthropogenic activities and/or with high abundances of introduced or cultured species.

Areas that rank highly on even one of 1-3 for a single species or habitat feature may be considered Ecologically and Biologically Significant Areas. Evaluations should also consider cumulative importance for a wide range of attributes. Areas that do not qualify as Biologically and Ecologically Significant within this evaluation framework may not warrant an *enhanced* level of protection relative to other similar areas.

Spatial scale was identified as an important factor in determining the appropriate boundaries of areas being evaluated within the framework. Structural features of the habitat, importance of life history function being performed in the area, features of community structure, and connectivity among sites are important spatial-scale considerations in boundary determination. Temporal scale was also identified as relevant for determining the boundaries of an Ecologically and Biologically Significant area. Except for some fixed structural habitat features, many of the properties which justify identifying an area as Ecologically and Biologically Significant are not *guaranteed* to occur in a specified place all the time. The framework deals with this source of uncertainty at three different "stages": site evaluation (e.g., higher scores are given to areas where the structural or functional property has a comparatively high probability of being used), management (e.g., different protection measures for different seasonal conditions), and monitoring (e.g., periodic reviews of how regions and areas have been evaluated with the framework and informed adaptive management).

1.9 Parks Canada (2003) has developed a plan to represent the full range of marine ecosystems found in Canada's Atlantic, Arctic and Pacific oceans, and the Great Lakes. Criteria/considerations that guide the establishment of NMCAs include:

1. Identify representative marine areas. Candidate sites take into consideration:
   - geologic features (such as cliffs, beaches, and islands on the coast; and shoals, basins, troughs and shelves on the seabed);
   - marine features (tides, ice, water masses, currents, salinity, freshwater influences)
   - marine and coastal habitats (wetlands, tidal flats, estuaries, high current areas, protected areas, inshore and offshore areas, shallow and deep water areas)
   - biology (plants, plankton, invertebrates, fish, seabirds and marine mammals)
   - archaeological and historic features

2. Select a potential NMCA from the candidate sites identified, taking into consideration:
   - quality of regional representation;
   - relative importance for maintaining biodiversity;
   - protecting critical habitats of endangered species;
   - exceptional natural and cultural features;
   - existing or planned marine protected areas;
   - minimizing conflict with resource users;
   - threats to the sustainability of marine ecosystems;
   - implications of Aboriginal claims and treaties;
   - potential for education and enjoyment; and
   - value for ecological research and monitoring

1.10 ANZECC (Australian and New Zealand Environment and Conservation Council, 1998) developed a set of "*Guidelines for Establishing the National Representative System of Marine Protected Areas*". Biodiversity and environmental criteria are the primary criteria for identification of candidate areas for the NRSMPA (National Representative System of Marine Protected Areas). Social, cultural and/or economic criteria are applied primarily in the selection of MPA sites from the candidate areas. The biological and ecological criteria, summarized below, are generally derived from Kelleher & Kenchington (1992) and Thackway (1996). A potential MPA site may meet one or many of the listed criteria. Depending on the objectives for the site, one or more criteria may be considered to have greater 'weight' in the consideration process (ANZECC, 1998).

Biological and ecological criteria to be used as a basis for the identification of a national representative system of MPAs, developed by ANZECC:

Representativeness

Will the area:

- Represent one or more ecosystems within an IMCRA bioregion, and to what degree;
- Add to the representativeness of the NRSMPA, and to what degree.

Comprehensiveness

Does the area:

- Add to the coverage of the full range of ecosystems recognized at an appropriate scale within and across each bioregion;
- Add to the comprehensiveness of the NRSMPA.

Ecological importance

Does the area:

- Contribute to the maintenance of essential ecological processes or life-support systems;
- Contain habitat for rare or endangered species;
- Preserve genetic diversity, i.e., is diverse or abundant in species;
- Contain areas on which species or other systems are dependent, e.g., contain nursery or juvenile areas or feeding, breeding, or resting areas for migratory species;
- Contain one or more areas which are a biologically functional, self-sustaining ecological unit.

International or national importance
Is the area rated, or have the potential to be listed, on the world or a national heritage list or declared as a Biosphere Reserve or subject to an international or national conservation agreement.

Uniqueness
Does the area:
- Contain unique species, populations, communities or ecosystems;
- Contain unique or unusual geographic features.

Productivity
Do the species, populations, or communities of the area have a high natural biological productivity.

Vulnerability assessment
Are the ecosystems and/or communities vulnerable to natural processes.

Biogeographic importance
Does the area capture important biogeographic qualities.

Naturalness
How much has the area been protected from, or not been subjected to, human induced change.

1.11 The New South Wales (NSW, 2000) Marine Parks Authority identify marine protected areas using nine different criteria to evaluate candidate sites.

Comprehensiveness: The extent to which the area contributes to conserving the full range of ecosystems and habitats within its bioregion.

Representativeness - Requires that areas selected for reserves should reasonably reflect the range of biological diversity of communities within ecosystems and habitats. Ultimately, this criteria aims to represent all marine species found in NSW in the marine protected area network. The degree to which the area adds to the NSW representative system of marine protected areas and National Representative System of Marine Protected Areas.

Naturalness - The extent an area has been protected from, or has not been subjected to, human induced change.

Biogeographic importance - Either contains rare biogeographic qualities or is representative of an ecosystem. Adds to coverage of the full range of ecosystems recognized at an appropriate scale within and across each bioregion.

- Ecological importance
- Important for maintaining Indigenous ecological knowledge
- Contributes to maintaining essential ecological processes or life-support systems
- Contains habitat for rare or endangered species
- Preserves genetic diversity, i.e., is diverse or abundant in species
- Contains areas on which species or other systems depend, e.g., contains nursery or juvenile areas or feeding, breeding or resting areas for migratory species
- Contains one or more areas that are biologically functional, self-sustaining ecological units (factors such as size, shape, connectivity and condition)

International or national importance - Is, or has the potential to be, listed on the World or a National Heritage List, Ramsar convention, declared a Biosphere Reserve or is subject to an international or national conservation agreement.

Uniqueness and endemism - Contains unique species, populations, communities or ecosystems. Contains unique or unusual geographic features.

Ecological productivity - Species, populations, or communities with a high natural biological productivity.

Vulnerability - Degree to which the area undergoes change due to natural processes. Vulnerability and susceptibility to human-induced changes and threatening processes.

1.12 A selection of criteria were proposed for the establishment of a network of MPAs for the Gulf of Maine (Brody, 1998). Satisfying all criteria is not necessary for an area to be selected, and the criteria may be used and weighted differently, depending on the specific objectives for selecting a particular site. Candidate MPA sites can be measured by the ecological value of species and ecosystems through the following terms:

Representativeness - the degree to which an area is representative of a habitat type, ecological process, biological community, physiographic feature, or other natural characteristics. The area under consideration is often characteristic of the Biogeographic or physiographic region in which it is located.

Diversity - the extent to which an area under consideration is significant for the variety and number of life forms and communities that occur within the specified habitat type or within the biogeographic region. The area will contain a diversity of habitats, communities, and species, populations, and gene pools found within the designated region or habitat. This criterion can refer to genetic, biological, or physical diversity.

Ecological Importance - the degree to which an area contributes to maintenance of particular species, species groups, and essential ecological processes. These areas include critical habitats, such as breeding or juvenile areas, feeding, and rest areas.

Ecological Sensitivity - the degree to which an area contains habitats for endangered, threatened, rare, or sensitive species or biological assemblages.

Uniqueness - the degree to which an area contains rare or unique species, habitats, or features. The area is considered 'one of a kind' and characteristics are found only in that area.

Naturalness - the extent to which an area has been protected from, or has not been subjected to, human-induced change. Degraded systems have little value for fisheries or tourism and do not make strong biological contributions.

Integrity - the extent to which an area encompasses a complete system or is an effective self-sustaining ecological entity. Integrity often relates to the size of the candidate MPA. Because an MPA would have to be extremely large to encompass a complete system, this criterion may be difficult to apply when selecting individual sites for a network. The goal of multiple sites, however, could be to protect integrity as a whole.

Biological Productivity - the degree of primary and/or secondary production within an area that benefits species or humans. It should be noted that high productivity may not always be a benefit. Increased productivity through human influence may lead to eutrophication, adversely impacting the natural environment.

Degree of Threat/Urgency - the present and potential threats from direct exploitation and development projects. Sites should be evaluated for the immediacy of the need to implement a program of comprehensive and coordinated conservation and management. Urgency of need for protection is judged according to the degree to which immediate action must be taken before values within the area are lost.

Size - how much of the various habitats need to be included for adequate protection. The size of an MPA is determined by the area required to protect the resources of significance. In the case of biological resources, the site should encompass an area large enough to protect a functioning, self-sustaining ecological community. Because the size criterion is often used to protect an ecological system or functioning component of a system, it is closely related to the integrity criterion. Determining size, however, is derived from feasibility considerations while integrity is measured solely through ecological factors.

International significance - The degree to which a site could be considered internationally significant (e.g. World Heritage Site, Biosphere Reserve) or is the subject of an international agreement.

1.13 Kelleher (1999) identified a set of nine factors or criteria that can be used to decide whether an area should be included in a marine protected area, or in determining the boundaries of an MPA. The biological/ ecological criteria include:

Biogeographic criteria

- Presence of rare biogeographic qualities or representative of a biogeographic "type" or types.
- Existence of unique or unusual geological features.

Ecological criteria

- Ecological processes or life-support systems (e.g., as a source for larvae for downstream areas)
- Integrity, or the degree to which the area, either alone or in association with other protected areas, encompasses a complete ecosystem
- The variety of habitats
- Presence of habitat for rare or endangered species
- Presence of nursery or juvenile areas
- Existence of rare or unique habitat for any species
- Degree of genetic diversity within species

Naturalness

- Extent to which the area has been protected from, or has not been subject to, human-induced change

Kelleher (1999) recommends using the Delphic approach to apply the selection criteria, since the assumptions made under this approach can readily be identified, analyzed, and changed if necessary.

1.14 Salm *et al.* (2000) put forward a set of social, economic, ecological, regional, and pragmatic criteria to help guide selection of marine protected areas. The ecological criteria are summarized below. The criteria are similar to those published by Kelleher & Kenchington (1992), and are based on IUCN (1981) and Salm & Price (1995) with minor modifications. For each site under consideration, the authors suggest quantifying or scoring the different criteria (e.g., on a scale of 1 to 5 for lowest to highest value). The scores are summed for each site, and priority areas identified based on the highest scores. If conservation of biodiversity is the objective, criteria 1-5 are most important.

Ecological criteria developed by Salm *et al.*, (2000) to guide selection of marine protected areas:

Diversity: Variety or richness of ecosystems, habitats, communities, and species. Areas having the greatest variety should receive higher ratings.

Naturalness: The lack of disturbance or degradation. Degraded systems will have little value to fisheries or tourism, and will make little biological contribution. A high degree of naturalness scores highly. If restoring degraded habitats is a priority, a high degree of degradation may score highly.

Dependency: The degree to which a species depends on an area, or the degree to which an ecosystem depends on ecologic processes occurring in the area. If an area is critical to more than one species or process, or to a valuable species or ecosystem, it should have a higher rating.

Representativeness: The degree to which an area represents a habitat type, ecological process, biological community, geological feature or other natural characteristic. If a habitat of a particular type has not been protected, it should have a high rating. A biogeographic classification scheme for coastal and marine areas is desirable in applying this criterion.

Uniqueness: Whether an area is "one of a kind". Habitats of endemic or endangered species occurring only in one area are an example. The interest in uniqueness may extend beyond country borders, assuming regional or international significance. Unique sites should always have a high rating.

Integrity: The degree to which the area is a functional unit – an effective, self-sustaining ecological entity. The more ecologically self-contained the area is, the more likely its values can be effectively protected, and so a higher rating should be given to such areas.

Productivity: The degree to which productive processes within the area contribute benefits to species or to humans. Productive areas that contribute most to sustain ecosystems should receive a high rating. Exceptions are eutrophic areas.

Vulnerability: The area's susceptibility to degradation by natural events or the activities of people.

1.15 Levings & Jamieson (1999) reviewed some of the semi-quantitative methods for choosing locations for MPAs and discussed their potential use for MPA site selection in Canada's Pacific region. Factors to consider when scoring criteria were discussed in relation to three objectives:

1) Protection of marine biodiversity, representative ecosystems and special natural features (abbreviated as the "biodiversity objective");
2) Protection and conservation of fishery resources and their habitats (abbreviated as the "sustainability objective"); and
3) Providing opportunities for increased scientific research on marine ecosystems, organisms (e.g., long term monitoring of undisturbed populations, special features, and sharing of traditional knowledge) (abbreviated as "opportunities for increased scientific research).

The authors proposed a list of criteria that could be used to rate specific sites proposed for MPAs, categorized by the three natural science objectives listed above. The criteria and considerations for scoring the criteria are reproduced in Table 4. The authors suggest rating the criteria using a simple semi-quantitative approach using terminology such as "high, medium and low (H, M, or L) with appropriate weighting functions. They also recommend creating a board of representative regional scientific experts to help identify and evaluate sites that available data suggest are worthy potential MPAs.

1.16 Roberts *et al.* (2003a) developed a selection scheme that permits preliminary evaluation of candidate sites according to their biodiversity, the processes which underpin that diversity, and processes that aid fisheries management and provide a spectrum of other services important to people. The criteria described by Roberts *et al*. (2003a) (summarized in Table 5) can be approached at many scales (local, regional, and national levels), and although they were developed to evaluate candidate sites in coastal regions, the criteria may also be useful in the identification of potential marine reserves on the high seas.

Procedures for the evaluation and selection of fully protected marine reserves and reserve networks are described in a companion paper by Roberts *et al*. (2003b). The criteria, the sequence in which the criteria should be considered, and ranking strategies are summarized in Table 6.

Airame *et al*. (2003) applied the ecological criteria developed by Roberts *et al.* (2003a) to design a network of marine reserves for the California Channel Islands (Table 7). The authors used a simulated annealing algorithm with data on representative and unique habitats and distributions of vulnerable species, to identify reserve network scenarios with the potential to achieve conservation and fisheries goals.

The analysis produced a variety of potential reserve network scenarios that all met the established goals. Flexibility was cited as a major advantage to the approach, as specific criteria could be added or deleted depending on reserve goals and the available data. The limited availability of data was the most frequent constraint cited, however the authors concluded that even in the absence of data on many ecological criteria, it is possible to identify potential reserve networks using only a subset of the criteria. For example, in the Channel Islands there were many sources of data on habitat distributions, but data on larval dynamics and population growth of particular species were scarce or nonexistent. Based on the results of this case study, the authors state that in such cases, "a habitat-based approach may be an effective and practical alternative to identifying reserves based on individual species needs. Protection of a substantial proportion of all habitats is likely to conserve many populations of concern" (Airame *et al.* 2003, p.S181). However, there are limitations to using habitat as the only criterion for reserve design. For example, the static nature of most of the data on habitat distributions does not account for environmental variation and climate regime shifts. Additional design considerations may reduce the probability that large scale events will impact all reserved areas simultaneously: 1) reserves should be placed in a network such that all reserves will not be affected by large scale events in the same way, 2) the risk of negative impacts on reserves from catastrophic events can be reduced by increasing individual reserve size and the overall network size (e.g., by using an "insurance multiplier").

1.17 Hockey & Branch (1997) developed a methodology for selecting sites for a national network of marine protected areas for South Africa based on 14 objectives for MPAs and 17 criteria against which to judge them. The first four objectives are to protect 1) biogeography, 2) habitat diversity, 3) the habitats and endemic species, and 4) areas essential during vulnerable life stages of species. Objectives 5-8 relate directly to fisheries management: 5) reduce fishing mortality, 6) protect vulnerable life-history stages of mobile and migratory species, 7) improve or sustain yields in fishing areas, 8) improve or maintain spawning stock biomass within protected areas. The final six objectives relate to human use of MPAs. Protected areas should allow: 9) research, 10) monitoring, 11) development of tourism, 12) low impact, non-consumptive recreation, 13) education, and 14) sustainable exploitation of selected organisms.

To evaluate the degree to which different MPAs fulfill particular objectives, the authors suggest using a series of criteria. Sites are assessed on a scientific basis by asking:

1. How regionally representative is it?
2. Is the biogeographic region currently represented?
3. How high is biodiversity?
4. Are there any vulnerable or fragile habitats?
5. How well are vulnerable species represented?
6. Will vulnerable life-history stages be protected?
7. What is the present condition like?
8. Are there important natural features?
9. Does it contain exploited species?
10. Will it restock fishing areas?

Potential sites are selected against the criteria to determine how well they meet protected area objectives. A potential scoring system, for example, could award 0 points if the site would be ineffective at meeting a criterion, 1 if it was moderately effective, and 2 if it was highly effective. The scoring system devised by Hockey & Branch (1997) is reproduced as Table 8. The table matches the 14 objectives against the criteria to generate a series of scores assessing the degree to which the objectives would be met by a marine protected area. Once the matrix has been completed and scores are assigned to all objectives for all relevant criteria, it is possible to obtain a total score on the left-hand side of the table for each criterion or at the bottom for each objective. useful as an example of a scoring system.

1.18 Gladstone *et al.* (2003) reviewed current and proposed regional networks of MPAs for the Red Sea and Gulf of Aden. The review was presented as a case study in 1) the selection of sites participating in a regional network of MPAs, 2) the development of a regional management framework for a regional network, 3) the potential benefits for national, regional and global sustainable resource usage and conservation, and 4) the potential constraints to effective implementation of a regional network of MPAs. To identify MPAs for inclusion in a regional network in the Red Sea and Gulf of Aden region, the following biological criteria were used:

- Participating MPAs should be representative of the region's biogeography and include typical examples of each biogeographic subunit.
- Participating MPAs should include viable proportions of all major habitat types within each biogeographic subunit, with an emphasis on key habitats, such as coral reefs, seagrass beds and mangroves.
- Participating MPAs should protect indigenous plant and animal communities representative of each biogeographic subunit. Bird and turtle nesting sites, and seagrass beds used by dugong deserve special attention.
- Participating MPAs should include unique cultural heritage, interesting geological formations and beautiful landscape.
- Feeding, breeding and roosting sites, larval sources and sinks, migratory routes of key biota need to be considered in the design of a network.
- Sufficiently large terrestrial sectors should be included in coastal MPAs, to serve as buffer zones.

Based on these criteria (and a sixth criterion of a political nature), twelve MPAs were selected for the regional network of MPAs for the Red Sea and Gulf of Aden. The network includes representatives of all major biogeographical sub-units (Gulf of Aden; north, central and southern Red Sea; Gulf of Aqaba; Socotra Archipelago), except for the Gulf of Suez; major habitat types within each sub-unit; prime examples of all types of coastal and marine habitats and species communities. Implementation of a common, regionally agreed management framework and development of the necessary technical capacity and expertise in the planning and management of MPAs were two factors identified by the authors as being critical to success of the network.

Part Two

2. Ecosystems, habitats, and communities of the high seas that have been identified as areas of ecological and biological importance

This section provides a review of:

- characteristics / features that might be used to identify areas of ecological and biological importance on the high seas; and
- areas on the high seas that have been identified as potential conservation targets (i.e., these areas serve a specific ecological function, or have a specific ecological property).

Evaluation or analysis of the material is *not* provided, and the information summarized below is quoted directly from the source.

2.1 Habitat features that might be used to identify and implement MPAs to protect far-ranging pelagic species were reviewed by Hyrenbach *et al*. (2000). The authors identified three areas of ecological and biological importance in pelagic systems, and classified them according to their predictability dynamics: static bathymetric, persistent hydrographic, and ephemeral hydrographic features. Key characteristics of each, along with design recommendations for pelagic MPAs, are summarized below.

Static bathymetric features (e.g., reefs, shelf breaks, submarine canyons, seamounts)

- Irregularities of the sea floor alter water flow above them, enhance mixing, and promote upwelling of nutrient-rich waters. Increased turbulence and water-column mixing promote localized production and the aggregation of planktonic prey at secondary convergence zones, and persistent eddies and fronts.
- Shelf breaks and submarine canyons constitute important foraging habitats for pelagic vertebrates, including seabirds, pinnipeds, cetaceans, salmon and swordfish. These marine predators exploit elevated primary production and high standing stocks of zooplankton, fish, and squid in the vicinity of shelf breaks.
- Obstacles such as islands and guyots interact with ocean currents and promote water-column mixing, which in turn stimulates primary production. Eddies and stationary vortices (Taylor columns) stimulate primary production in the vicinity of guyots by bringing cold, nutrient-rich water closer to the surface. The closed circulation associated with these features likely retains the enhanced local production in the vicinity of seamounts, and, in turn, this localized production is transferred to resident predators (e.g., euphausiids, rockfishes), which support dense aggregations of mobile predators (e.g., seabirds, tuna, marine mammals).

Persistent hydrographic features (e.g., currents and frontal systems)

- Fronts are important features of the circulation, biogeography and ecology of the world's oceans. On continental shelves they are regions of elevated biological activity where seabirds, marine mammals and tunas aggregate to exploit prey concentrations supported by elevated production and retention at convergences. In pelagic systems, changes in the types and abundances of marine organisms often occur at persistent fronts, where waters of different temperature and salinity meet. Fronts may also be important for the delineation of pelagic migratory routes.
- One example of a front that has been identified as being of particular biological importance is the Transition Domain, a narrow region of strong temperature and salinity gradients in the North Pacific. The fronts delineating the extent of this oceanographic domain delimit the ranges of subarctic and subtropical species, and influence the distribution of far-ranging fish, seabirds, and marine mammals. These frontal zones contain the highest standing stocks of micronekton in the North Pacific during the boreal spring and summer.

These predictable prey aggregations are exploited by a variety of far-ranging predators which migrate into subarctic waters seasonally. This region is also a vital foraging habitat and migratory route for many species, including valuable fisheries resources and vulnerable non-target species. In addition, the Transition Domain is a breeding and nursery ground for far-ranging organisms such as squids and sharks, and a nursery for the juveniles of far-ranging species (e.g., albacore tuna) during their first years at sea.

Ephemeral hydrographic features

- These ecologically important marine environments are neither fixed in space nor persistent. A variety of physical forcing mechanisms, including upwelling, eddies and filaments generate ephemeral fronts responsible for enhanced production and convergence. They are defined by short-lived gradients in water properties, and they vanish once they mix with the surrounding waters. Highly-mobile pelagic species find and exploit ephemeral fronts while they persist.
- Transient gradients in water properties are created by upwelling forcing. Upwelling replenishes surface nutrients and enhances primary production by vertically transporting cool, nutrient-rich water to the surface. Upwelling is temporally predictable and occurs seasonally in response to favourable wind conditions. Upwelling episodes can persist from days to weeks, and plumes of recently-upwelled water may extend for tens of kilometers across the shelf and for hundreds of kilometers in the along-shore direction. Pelagic predators find and exploit these ephemeral and highly dynamic features before they disintegrate.
- Short-lived fronts are also created along the edges of eddies, which are highly dynamic and ephemeral features formed as a result of flow instabilities along current edges and bathymetric obstacles. Eddies are large, conspicuous, and long-lived hydrographic features, with diameters in the order of tens to hundreds of kilometers, and life spans of up to several months. The significance of eddies as habitat features is underscored by evidence that regions where permanent and transient eddies predictably occur are characterized by elevated primary production, high zooplankton biomass, and the aggregation of pelagic fishes, seabirds and marine mammals.
- Wind forcing, deep convection and buoyancy fluxes can create small-scale fronts and convergence zones, features that promote patchiness by aggregating floating objects and weakly-swimming zooplankton. The ecological significance of these ephemeral fronts is poorly understood, but they appear to constitute important nurseries and foraging habitats for many pelagic species, including sea turtles and billfishes.

2.2 Worm *et al.* (2003) identified pelagic biodiversity hotspots in the open ocean using a compilation of scientific-observer data from U.S. and Australian longline fisheries collected between 1991 and 2000. The data included counts of all large tuna, billfishes, and other bony fish, sharks, sea turtles, seabirds, and marine mammals that are caught by pelagic longlines and recorded by independent, scientifically trained observers. Longlines are particularly useful for assessing pelagic diversity because they catch a wide range of species in a similar way, over vast spatial scales, and capture most known species that are of current conservation concern (Worm *et al.,* 2003). Key findings and conclusions from this study include:

1) Species diversity peaked consistently at intermediate latitudes and close to prominent topographic features such as islands, shelf breaks, or seamounts. High latitudes were characterized by low diversity, and tropical regions showed intermediate diversity. Within a latitudinal band, diversity appeared to be highest along the shore and declined toward offshore regions. Around islands such as the Hawaiian Islands and the Antilles, diversity was often highest on the leeward side, relative to the main wind and current direction.
2) On an ocean-basin scale, diversity seemed to peak consistently between 20° and 30° latitude. Very similar latitudinal patterns of species diversity are seen in five major zooplankton taxa: Fish larval, ostracod, decapod, and euphausiid species richness peaked at 20° latitude along a northeast Atlantic transect, and planktic foraminiferal richness consistently peaked at 20-30° latitude in all oceans. Within these latitudinal bands, clear

foraminiferal hotspots were found around Hawaii and off Florida. These patterns suggest that hotspot regions may overlap for disparate trophic groups.

3) On a local scale, diversity hotspots consistently seem to be associated with prominent topographic features such as reef islands, shelf breaks, or seamounts. Oceanographically, these features are characterized by increased turbulence, mixing, and mesoscale eddies, which can enhance local production by transporting nutrients into the euphotic zone. They also tend to concentrate food supply and have been shown to provide key feeding areas for pelagic species. In food-stressed habitats such as the open ocean, these features may be critical to a large number of species.
4) Three hotspots were found within or directly adjacent to coral reef hotspots, located around the Great Barrier Reef, Lord Howe Island, and the Hawaiian Islands. The rich habitat structure and dynamic oceanographic conditions associated with coral reefs may favour adjacent pelagic hotspots, which may mean that efforts to conserve existing coral hotspots should consider expanding protection into adjacent pelagic waters.

2.3 An independent study commissioned by WWF and IUCN (Baker *et al.,* 2001; WWF 2003), identified discrete or localized geographic features, habitats and biological communities in deep-sea and open ocean environments that have particular scientific, societal or economic interest:

- Hydrothermal vents
- Deep-sea trenches
- Gas hydrates
- Seamounts
- Deep-sea coral reefs
- Cold seeps and pockmarks
- Submarine canyons
- Polymetallic nodules
- Seabirds
- Transboundary fish stocks
- Cetaceans

For each area of interest, the report reviews habitat characteristics, global distribution, associated fauna, exploitation value, biodiversity issues, and potential/ actual threats. The summary review of high seas areas, geographic features, 'habitats', biological communities of scientific, societal or commercial interest, and report recommendations regarding the need for protection and potential HSMPA status, is reproduced below. Table 9 provides a tabular summary of key environmental characteristics.

Hydrothermal vents

- Highly localized sites of high temperature fluid-escape from the seabed
- Typically located on mid-ocean ridges (10s known, 100s suspected)
- Typically support abundant biological populations, fuelled by chemosynthesis
- Highly specialized fauna, of relatively low diversity, but high endemism
- Vents and their communities are ephemeral (10s of years)
- Subject of intensive scientific study – an actual threat
- Considerable biotechnology potential ("extremophiles") – a potential threat
- Interest in commercial resource (ores and energy) exploitation – a potential threat
- Recommendation: The ephemeral natural of hydrothermal vent communities suggests the need to 'protect' relatively large areas of mid-ocean ridge, perhaps a ridge segment at a time to ensure the long-term survival of these communities within particular geographic areas.

Deep-sea trenches

- A feature of subduction zones, the deepest areas on the planet
- Few in number (37), but up to 1,000s of kilometres in length
- Most lie within EEZs
- Largely endemic fauna, adapted to extreme hydrostatic pressure
- Interest in biotechnology potential – a potential threat
- Interest in use as waste disposal sites – a potential threat
- Significant potential for direct influence from terrestrial pollutants – a potential threat

- Recommendation: Trenches are presently at relatively minimal threat and have comparatively low levels of 'interest'; consequently, there is little HSMPA need/ potential at present. This should be kept under review.

Gas hydrates

- Frozen methane gas
- Probably abundant and widespread in deep-sea environments
- Associated fauna little known
- Interest in biotechnology potential – a potential threat
- Considerable interest in direct exploitation – a potential threat
- Recommendation: There is currently insufficient information on biological communities that may be associated with gas hydrates to warrant their separate consideration as HSMPAs at this time. For the present, gas hydrates should be considered jointly with cold seep communities (particularly those fuelled by hydrocarbon escapes).

Seamounts

- Undersea mountains of volcanic / tectonic origin
- May interact with upper water column (e.g. enhancing surface ocean productivity)
- Found in all ocean, 30-40,000 known
- Tops and upper flanks of seamounts may be biological 'hot spots'
- Hard substrate suspension feeding communities (sponges, corals etc) may be common
- Potentially high species diversity and endemism
- May act as 'stepping stones' for transoceanic dispersal of species
- Fish and seabird populations may be enhanced over seamounts
- Considerable commercial fishing – an actual threat
- Interest in commercial resource (ores) exploitation – a potential threat
- Recommendation: Seamount biological communities and fisheries are already under considerable threat and should be seen as an urgent and appropriate case for HSMPA designation. The widely distributed nature of seamounts, and their role as 'biological islands' and 'stepping stones' requires special attention, and particularly suggests the need for an HSMPA network.

Deep-sea coral reefs

- Several species (e.g. *Lophelia pertusa*) of deep-sea coral are capable of forming 'reefs'
- They are widely distributed in the world's oceans, from 10s to 1,000s m water depth
- Occur in wide variety of environmental settings
- They vary in size from individual colonies (10s cm) to extended patch-reefs of 10 km extent
- Provide habitat for high diversity of associated species (few or no obligate associates known)
- Extensive damage by commercial trawling evident – an actual threat
- Deep-water oil exploitation within areas of known occurrence – an actual threat
- Interest in biotechnology potential – a potential threat
- Recommendation: Extensive destruction of deep-sea coral communities is already evident, and has probably occurred for the last 100 years; protection of these important habitats is therefore urgently needed.

Cold seeps and pockmarks

- Highly localized sites of low temperature fluid escape from the seabed
- Occur in a wide variety of physiographic and geological settings
- Typically support abundant biological populations, fuelled by chemosynthesis
- Highly specialized fauna, of relatively low diversity, but high endemism
- Seeps and their communities may be ephemeral
- Interest in biotechnology potential – a potential threat
- Connection with deep-water oil exploitation – a potential threat
- Recommendation: Though less publicized, cold seep communities should warrant the same conservation value as hydrothermal vent communities. However, their occurrence in the

deep sea is less well known and less ‘predictable’ than is the case with hydrothermal vents, consequently the selection of appropriate sites/areas may be problematic.

Submarine canyons

- Common deep-sea features that cut across continental slopes
- They influence local bottom water flows and may acts as traps for organic matter
- They may be biological ‘hot spots’ with enhanced benthic populations
- Fish (and possibly cetacean) populations may also be enhanced
- Commercial fishing (trap and long-line) may be important – and actual threat
- Significant potential for direct influence from terrestrial pollutants – a potential threat
- Recommendation: Deep-sea canyons are common and widespread but do have distinct biological significance. The greatest threats to these environments probably lie within EEZs; canyons are nevertheless clear candidates for HSMPA status.

Polymetallic nodules

- ‘Manganese’ nodules may occur in vast fields on the deep-ocean floor
- Provide a hard substratum for epifaunal species, increasing local / regional diversity
- Considerable potential for commercial exploitation – a potential threat
- Pilot scale mining studies have been undertaken
- Environmental impact studies have been undertaken
- Recommendation: The need for HSMPA designation is questionable, and certainly of a low priority only.

Seabirds

- ca. 22% of the world’s seabird species are “threatened” species
- Many seabirds have low reproductive rates; they are sensitive to additional sources of mortality
- Pelagic and demersal long-lining fisheries are the largest threat to seabirds
- Changes in long-lining methods and better regulation may reduce seabird casualties
- Recommendation: Many species of oceanic seabirds, cetaceans and fish are already under considerable threat, both from direct exploitation and as bycatch. HSMPAs could usefully contribute to the protection and re-establishment of these species.

Transboundary fish stocks

- Fish do not respect national EEZ boundaries
- Over-fishing on the high-seas has become particularly acute in recent years
- Some deep-sea species have life histories that make them very susceptible to exploitation and over fishing
- High-seas fishing fleets typically use non-selective equipment producing high by-catch mortalities

Cetaceans

- Some species migrate thousands of miles during their lifetime
- Many whale populations have failed to recover despite many years of protection
- Whale mortalities arise mainly from commercial whaling and fishing
- Molecular genetic methods indicate significant illegal sales of whale products

2.4 Gubbay (2003) identified seamounts, deep-sea coral reefs, and hydrothermal vents as priorities for HSMPAs. All three of the proposed priority habitats/ecosystems fulfill the recommended criteria for identifying HSMPAs that were listed in section 1.2 above. The main reasons for the inclusion of these habitats/ communities as priorities are summarized below.

The main reasons for putting forward **seamounts** as priority habitats/ecosystems for enhanced protection on the High Seas can be summarized as:

- The high seas species diversity at these locations including many species new to science, and the likelihood that the number of species present is far greater than the number currently recorded;
- The highly localized distribution of many seamount species with a large percentage of endemic species;
- The functionally critical nature of seamounts for certain species that congregate in these areas for spawning and mating;
- The apparently limited dispersal between seamounts, the extreme longevity and slow recruitment of many species and the limited fixed habitat, making seamount fauna sensitive to the impacts of fishing and the likelihood of very long time scales for recovery if damaged.

The main reasons for putting forward **deep-water coral reefs** as priority habitats/ecosystems for
MPAs on the High Seas can be summarized as:

- The high species diversity at these locations; The potential importance of the reefs as spawning and nursery areas for some fish;
- The delicate structures and slow growth of the corals, which means that the reef structures are easily damaged and take a long time to recover if at all;
- The extensive destruction of areas known to have previously supported deep-sea coral reefs.

The main reasons for putting forward **hydrothermal vents** as priority habitats/ecosystems for MPAs on the High Seas can be summarized as:

- The unusual nature of the vent faunas;
- The unique range of habitat diversity;
- Their function as refuges for close relatives of ancient forms of life;
- The relative rarity of hydrothermal vents as a habitat on the High Seas;
- The small geographic area covered by hydrothermal vent systems;
- The highly localized distribution of many species & large % of endemics; and
- The demonstrable link between human activity and threats to biodiversity of hydrothermal vents.

Gubbay (2003) identified regions as some potential areas of search for MPAs that would include these priority habitats/ ecosystems. The regions have been selected to give examples from each of the major oceans of the world.

Arctic Mid-Ocean Ridge / Gakkel Ridge
Priority habitats/ecosystems of likely interest – hydrothermal vents

The Arctic Mid-Ocean Ridge (86ºN, 90ºE) extends from the Kolbeinsey Ridge at the northern margin of Iceland (~ 69ºN, 17º30 W) to the termination of the Mid-Atlantic Ridge (MAR) spreading system on the Laptev Shelf in the Arctic Ocean (~75ºN, 130ºE). Of the hydrothermally unexplored ridges, these are the most remote with almost every segment of the Arctic ridge system being anomalous in some way, with the Gakkel Ridge anomalously deep and the slowest spreading major ridge segment in the world's oceans. It is not known whether the Scotland-Iceland and Iceland-Greenland sills have served as barriers to dispersal of Atlantic vent species to the ridge system or if the Arctic faunas are derived from Atlantic faunas. The only documented biological community associated with hydrothermal venting north of Iceland is at Kolbeinsey where modified benthic communities have been found at vents.

Antarctic Seamounts
Priority habitats/ecosystems of likely interest – seamounts

The Pacific-Antarctic Ridge (62ºS, 157ºW) extends from a point midway between New Zealand and Antarctica northeast to where it joins the East Pacific Rise off the margin of South America. It is around 4,000 miles long and a number of seamounts have been discovered along it including the Foundation seamounts. Other seamounts in the Antarctic include the Scott seamounts, the Marie Byrd seamount and the De Gerlache seamounts. There is little information available about these seamounts at the present time.

Central Indian Ocean Ridge
Priority habitats/ecosystems of likely interest - seamounts & hydrothermal vents

A 275 km long section of the southern part of the Central Indian Ocean Ridge, from 23ºS to the Rodriguez Triple Junction near 25º 30'S. The rift valley is between 5-8km wide and has relief ranging from 500m to 1000m. Sites of particular interest in the area are the Kairei vent field, the Edmond vent field, and the Knorr Seamount.

Previous unknown chemolithoautotrophic thermophilic and heterotrophic bacteria have been isolated from these vent fields. The invertebrate community of the Kairei Field is characterized by an abrupt transition between the centrally located complexes of black smokers, dominated by dense swarms of shrimp (*Rimicaris aff. exoculata*) and an ambient-temperature peripheral zone dominated by anemones (*Marianactis* sp.). The invertebrate fauna of the Edmond Field is a subset of that found at Kairei. The physical setting and ecology of the Kairei and Edmond Fields differ only in detail from known vent sites on mid-ocean ridges, yet the invertebrate species composition is such that the fauna belongs to a newly found biogeographic province.

The Mid-Atlantic Ridge vent fields
Priority habitats/ecosystems of likely interest - hydrothermal vents

Hydrothermal vents associated with the Mid-Atlantic Ridge (MAR) have been reported over a range of depths. Two High Seas examples are the Rainbow field (36º 11'N, 33º 57'W) at a depth of 2,300m and the Logatchev vent field (14°45'N 44°58'W), which is the southernmost hydrothermal vent field on the MAR known at the present time. The Rainbow field has about 10 groups of very active black smokers. The hydrothermal fluids have very high particle content and temperatures (360ºC), enriched in copper, nickel, zinc and cobalt. Thirty-two species have been identified at the site, and the biological community is dominated by shrimps. Many of the chimneys have no animals around them. The Logatchev field (two distinct areas) has sulphide mounds, an active chimney complex and diffuse flow through soft sediment. There are extensive massive sulphide deposits in the area containing an unprecedented high concentration of copper, zinc, gold and an anomalously high uranium concentration. With an estimated 50 species from several different taxa including anemones, crabs, mussels and sea-stars, Logatchev has the highest species diversity known at present in the region.

Lord Howe Sea Mount Chain – seamounts
Priority habitats/ecosystems of likely interest – seamounts

Lord Howe Rise (28ºS, 161ºE) extends from north of Lord Howe Island to the South Island of New Zealand. Part of the Lord Howe Rise lies within EEZs (of Australia and France (New Caledonia) but sections also lie within international waters. Seamounts in this area that have been sampled are Argo, Kelso, Nova and Capel, which range in depth from 150-3000m. These seamounts appear to be isolated marine systems and provide an exceptional opportunity to examine evolution and speciation in the deep sea.

Conclusion

The considerable task of identifying High Seas EBSAs is not an end in itself. It is the solid, science-based platform upon which future comprehensive marine conservation systems should be constructed. It is clear from the foregoing review that there is a good deal of commonality amongst the different criteria that have been advanced to determine areas of biological and ecological significance in ocean ecosystems. However, there are many challenges to be resolved. The terminology and the scientific basis for criteria are often not stated convincingly, few systems have been field tested, and there are no examples where different systems have been applied on a comparative basis to the same area. This would be especially critical in terms of examining potential weighting systems, perhaps the weakest point in current efforts. Finally, data availability will be a major limitation in applying these criteria. Some global data compilation systems are currently under construction and new means of data collection, such as undersea cable internet stations are moving ahead rapidly. Any system devised will only be as good as the data available to fuel the system. Nonetheless, there are areas of the High Seas where there is clearly some consensus that enhanced levels of protection are required in some form. It would be a mistake to delay thinking about, and implementing various forms of protection for such areas, whilst awaiting perfection of a globally acceptable system for EBSA identification as well as all the data required to implement the system.

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Table 1. Summary of criteria developed for identifying candidate marine sites of ecological and biological significance.

Source	Biogeographic representation	Habitat representation / heterogeneity	High diversity (habitat, sp.)	Genetic diversity	Degree / Nature of Threats / Disturbance	Productivity	Spawning / Breeding grounds	Size / shape / connectivity	Export functions	Viability	Management / Feasibility	Aggregations	Vulnerable habitats	Vulnerable life stages	Species or populations of special concern	Exploitable species	Ecosystem linkages / Dependency	Ecological services for humans	Naturalness	Uniqueness / Rare habitats	Rare / endemic species	Scientific value	Critical habitat	Comprehen-siveness	Site integrity	Int'l / nat'l importance
Gubbay, 2003	✓	✓	✓		✓		✓				✓									✓	✓				✓	
OSPAR Commission, 2003	✓	✓	✓		✓		✓	✓			✓		✓	✓	✓				✓			✓	✓			
IMO, 2001	✓	✓	✓			✓	✓						✓				✓		✓	✓		✓	✓		✓	
SPAMI, 1999		✓	✓												✓					✓	✓		✓			
Natura, 2000		✓													✓				✓	✓				✓		✓
Conner et al., 2002, Laffoley et al. 2000		✓	✓		✓			✓						✓	✓				✓	✓	✓		✓			✓
UNEP, 1996	✓	✓	✓	✓			✓		✓		✓			✓	✓	✓	✓	✓		✓	✓	✓	✓			
Fisheries & Oceans Canada, 2005												✓							✓	✓						
Parks Canada, 2003	✓	✓													✓							✓	✓	✓		
ANZECC, 1998	✓	✓		✓		✓	✓						✓						✓	✓	✓		✓	✓		✓
NSW, 2000	✓	✓		✓	✓	✓	✓	✓										✓	✓	✓	✓			✓		✓
Brody, 1998	✓	✓	✓		✓	✓		✓							✓				✓	✓	✓		✓		✓	✓
Kelleher, 1999	✓	✓	✓	✓			✓								✓				✓	✓	✓				✓	
Salm & Clark, 2000	✓	✓	✓			✓							✓				✓		✓	✓					✓	
Levings & Jamieson, 1999		✓	✓		✓	✓	✓		✓		✓		✓		✓	✓	✓		✓	✓	✓	✓	✓		✓	
Roberts, et al., 2003a	✓	✓			✓			✓	✓	✓	✓		✓	✓	✓	✓	✓	✓								
Hockey & Branch, 1997	✓		✓						✓				✓	✓	✓	✓									✓	
Gladstone et al., 2003	✓	✓					✓		✓																	
Total	**13**	**16**	**11**	**4**	**7**	**6**	**9**	**5**	**5**	**1**	**5**	**1**	**7**	**5**	**11**	**4**	**5**	**3**	**11**	**13**	**9**	**5**	**9**	**4**	**7**	**5**

Table 2. Guidelines for use of criteria to meet the aims of the OSPAR Network. *Source*: OSPAR Commission, 2003.

	AIMS OF THE OSPAR NETWORK		
Criteria / considerations	**Protect, conserve and restore species, habitats and ecological processes which are adversely affected as a result of human activities**	**Prevent degradation of and damage to species, habitats and ecological processes following the precautionary principle**	**Protect and conserve areas which best represent the range of species, habitats and ecological processes in the maritime area**
Ecological considerations	1.1. High priority habitats & species which meet the OSPAR criteria of 'Decline'	1.1. High priority habitats & species which meet the OSPAR criteria of 'high probability of a significant decline' 1.2. Important habitats & species which meet the other Faial criteria (global importance, local (species)/regional (habitats) importance, rarity, sensitivity, keystone species, ecological significance) 1.6. Sensitivity	1.3. Ecological significance 1.4. High natural biological diversity (of species within a habitat and of habitats in an area) 1.5. Representativity, including the biogeographic regions 1.7. Naturalness
Practical considerations	2.1. Size 2.2. Potential for restoration 2.3. Degree of acceptance 2.4. Potential for success of management measures 2.6. Scientific value	2.1. Size 2.3. Degree of acceptance 2.4.Potential for success of management measures 2.6. Scientific value 2.5. Potential damage to the area by human activities	2.1. Size 2.3. Degree of acceptance 2.4. Potential for success of management measures 2.6. Scientific value

Table 3. Grid for the objective evaluation of proposals for inclusion in the SPAW protected areas list.
Source: UNEP, 2004.

SECTION I: CARIBBEAN IMPORTANCE OF THE AREA

1. Contains ecosystems specific to the wider Caribbean region or the habitats of endangered species

1.1 Presence of ecosystems/habitats specific to the Wider Caribbean Region (*Habitat is any area in the range of a species of fauna or flora which contains suitable living conditions)*	**Y N**
1.2 Presence of habitats that are critical to endangered, threatened or endemic species. (*A critical habitat is an area essential to the conservation of the species concerned. This species should be related to those included in Annexes 1 and 2 of the Protocol)*	**Y N**

2. Importance for the conservation of components of biological diversity in the wider Caribbean region

2.1 Degree of Uniqueness *(The area contains unique or rare ecosystems, or rare or endemic species)*	**0**	**1**	**2**	**3**
2.2 Natural representativeness and adequate size *(The area has highly representative ecological processes, or community or habitat types or other natural characteristics.* *Representativeness is the degree to which an area represents a habitat type, ecological process, biological community, physiographic feature or other natural characteristic. Adequate size is a significant feature)*	**0**	**1**	**2**	**3**
2.3 Diversity *(The area has a specially high diversity of species, communities, habitats or ecosystems)*	**0**	**1**	**2**	**3**
2.4 Naturalness *(The area has a high degree of naturalness as a result of the lack or low level of human induced disturbance and degradation)*	**0**	**1**	**2**	**3**

Table 4. Criteria and considerations for scoring criteria for MPA site selection in Canada's Pacific region. *Source*: Levings & Jamieson, 1999.

Criterion	Relevant considerations when scoring	Comments
Objective: Biodiversity 1. Representativeness	How typical or similar are the species, habitats, and communities in the proposed MPA relative to other locations?	▪ the biodiversity objective does not specify what scale of spatial unit the MPA is to representative of ▪ if the MPA is to be representative of an ecosystem, a lexicon of marine ecosystems in the Pacific region will have to be devised, but there is no consensus among regional scientists on this matter ▪ it is very difficult to do a gap analysis and quantify what species are represented in a particular area; inventory data are usually lacking in coastal areas, and habitat-species associations are not well understood ▪ for most areas, this criteria will be difficult to rate without a biological survey unless the proposed area is in a very well studied part of the coast Possible alternative strategies: ▪ focus on one particular kind of easily identifiable group of organisms, e.g., fish or macro invertebrates. Nearly 5,000 marine species are known to occur on the BC coast and it is unrealistic to expect any on person to be able to identify all, or even most, of them ▪ for some sedentary organisms, relationships between habitats and biota may be useful ▪ it is difficult to extrapolate habitat information into an ecosystem context. However, because most marine organisms have specific temperature and salinity preferences, or tolerances, it might be possible to use water mass structure as a boundary to assess some of the above.
2. Degree of naturalness	How much of the proposed site consists of anthropogenic features?	▪ Areal data on bottom types and intertidal areas, and their characteristics (e.g., sediment type), should be available from GIS analyses from nautical chart databases ▪ Data on most common waterfront developments are available ▪ Data on water quality should be available from responsible agencies
3. Areas of high biodiversity and/or biological productivity	How many species are found in the area and how does this compare to the average number found in similar habitats in other ecosystems?	▪ In most areas data would have to be obtained but for data in some areas, the information may be published; regional checklists could be consulted, and museum specialists and other experts should be asked to review species lists that might be prepared by laypersons
	What are the main energy sources at the site and what is the level of primary production (g C m $^{-2}$ y $^{-1}$) from plant or algal communities relative to other areas?	▪ Levels of primary production are known for phytoplankton from a variety of pelagic habitats on the B.C. coast, but primarily from the Strait of Georgia ▪ There are data available on marsh and eelgrass beds, and kelps ▪ Relatively easy methods such as measurement of stem lengths could be used to assess vascular plant production since there are known relationships between lengths, biomass, and annual production ▪ Available regional data on primary production from marshes and macrophytic algae have been summarized but need wider distribution
4) Rare and endangered species	Are there species in the proposed MPA found only on the B.C. coast and how many are on the COSEWIC and/or Red List of IUCN?	▪ The status of the populations of rare and endangered species on the coast of BC can be determined using a variety of published check lists, including those available from COSEWIC, the IUCN red list, etc.; these sources do not give site-specific information but may be useful to help determine if the geographic range of the species is restricted ▪ A measure for this criterion might simply be the number of red and blue listed species in a proposed area ▪ Quantitative methods for assessing if a species is at risk or endangered, particularly because of harvesting, are poorly developed and so the placing of a species on the endangered list is often a judgment call by experienced taxonomists or museum personnel ▪ Geographic checklists for specific taxa from the BC coast are rarely or infrequently updated

Table 4. Criteria and considerations for scoring criteria for MPA site selection in Canada's Pacific region, *cont'd*. *Source*: Levings & Jamieson, 1999.

Criterion	Relevant considerations when scoring	Comments
5) Unique natural phenomena	How much of the proposed MPA is characterized by natural phenomena that are unusual features on the BC coast?	▪ A wide variety of unique natural phenomena are found on the BC coast, some of them not found elsewhere in Canada or perhaps internationally. These include hotsprings, intertidal springs, waterfalls, extremely swift tidal rapids, low DO basins, and others ▪ The BC Coast Pilot and nautical charts are valuable sources of information ▪ Topographic maps (NTS) series show features on the adjacent land that may be unique ▪ Maps and charts published by the Geological Survey of Canada are also likely sources of information on unusual landscape features
6) Ecological viability	For long term persistence, how many connections with numerous proximate or distal ecosystems are needed for energy flow, recruitment or structural aspect or is it a "stand alone" ecosystem? If connections are required, how many intact adjacent areas are nearby?	▪ Because marine ecosystems are connected by water currents, almost all areas would be expected to have some dependence on adjacent areas to some degree. ▪ Depending on the dispersal mechanism of the species within an ecosystem, there may be interchange of juvenile forms, on a variety of scales, which in turn may relate to home ranges ▪ Movement between ecosystems is limited to a few kilometers ▪ Some ecosystems such as deep sea vents (black smokers) exist independent from adjacent water masses, as their energy sources are immediately beneath them, in the earth's crust ▪ Sometimes catastrophes such as underwater slumping, internal waves along boundaries of water masses or turbidity currents can cause significant community disruptions
7) Vulnerability	How seriously is the ecological integrity of the area threatened by human activity that could affect the long term persistence of the ecosystems in the proposed MPA?	▪ This factor relates to localized changes caused by human intervention, and the spatial scale of the changes is important ▪ Given the dynamic nature of marine ecosystems, any proposed MPA is vulnerable to natural change, particularly from long term climate trends ▪ Ecosystem changes owing to natural phenomenon should be considered part of the characteristics of the site ▪ Phenomena such as global warming, that affect all systems, may not be relevant to choices among particular proposed MPAs ▪ Proposed MPAs may be vulnerable to direct or indirect effects of nearby industrial activities, such as dredging, log handling and storage, shoreline armouring and sea walls, upland forest harvesting, pulp mill pollution, housing developments, agricultural runoffs, sewage discharges ▪ Some elements of marine ecosystems are also susceptible to foreign biological factors such as predation or competition arising from non-indigenous species ▪ Past harvesting for industrial, sport or traditional reasons is another way in which the proposed MPA may have been vulnerable to human activities
8) Unique habitat	How many habitats found in the proposed MPA are unusual or represent minor components on the BC coast?	▪ Because of the lack of inventory and detailed ecological investigations on the BC coast, it will be difficult to address this criterion, except perhaps for intertidal areas; if an intertidal habitat does not feature at all in common lists, it may be a unique habitat type ▪ Whether or not a habitat is considered unique depends on measurement scale ▪ Unique habitat conditions may also be created by specific oceanographic conditions, such as shallow warm water masses from thermal stratification in the summer, seasonal anoxic conditions at depth in some inlets, or cold bottom water masses ▪ Subtidal and deep water habitats are poorly known on the coast and other than general sedimentary descriptions that can be produced by hydroacoustic methods (e.g., multi-beam sonar), there have been few efforts to map and groundtruth underwater habitats and their associated biota ▪ Examples of unique habitats in Canada's Pacific region include the discovery of black smokers at Endeavor Ridge off the west coast of Vancouver Island and the sponge beds in southwest Hectate Strait ▪ Some information on unique deep water habitats may be inferred from basic data on depth and bathymetry (e.g., Bowie Seamount off the west coast of Vancouver Island)

Table 4. Criteria and considerations for scoring criteria for MPA site selection in Canada's Pacific region, *cont'd*. *Source*: Levings & Jamieson, 1999.

Criterion	Relevant considerations when scoring	Comments
Objective: Sustainability		
1) Areas supporting significant spawning concentrations or densities	How many populations or habitats connected with unique stocks, for example, those that have special size characteristics, are found in the proposed area? What is its potential productive capacity, based on habitat features, for spawning and reproduction?	▪ Fishery managers or others concerned with maintenance of historical levels of recruitment from spawning stocks for harvested species should be able to provide site-specific information on spawning areas for the species they manage or study ▪ Habitat features and historical fisheries data may be used to infer the potential of a proposed MPA ▪ Source and sink populations for any species have not been thoroughly determined in BC
2) Areas important for the viability of populations and genetic stocks	How many populations or habitats connected with unique stocks, for example those that have special size characteristics, are found in the proposed area? Have the stocks been "protected" from fishing effects for a substantial period of time?	▪ Stocks with unique characteristics – the uniqueness of characteristics of specific species' populations can be assessed from scientific publications, local knowledge, and direct observation ▪ Environmental conditions may profoundly affect such parameters as growth rates, maximum sizes and longevity's of fish and invertebrates ▪ Closure areas – since the distribution and duration of fishing closures for the Pacific region have been documented, proponents can determine if their particular area of interest is within a fishery closure area and how long it has been closed ▪ The length of time an area has been closed, its spatial extent, the number of species protected from harvesting, and the type of fishing gear that the closure forbids are all factors that might be used to index how much "investment" has gone into a particular closure area, and hence influence whether or not a proposed MPA might be accepted
3) Areas supporting critical species, life stages, and environmental support systems	How much of the proposed MPA includes populations or habitat for important forage species or habitats critical for life history transformations?	▪ Important forage species are those thought to be vital in the food chain ▪ Important habitats or environments are those that are critical for life-history stages, e.g., estuaries ▪ The concept of a required environmental support system could include consideration of the combined influence of habitat structure (e.g., relief, substrate, depth), and water environmental properties (e.g., temperature, salinity, nutrients, currents) of the particular locale. These combinations of factors can result in areas critical for a species health, larval retention areas, or particular subsurface features such as gullies ▪ Another example might be shear zone areas between currents around a point of land or a deep trough that conveys nutrients closer to the surface in an upwelling region
Objective: Increased opportunities for scientific research		
1) Value for developing a better understanding of the function and interaction of species, communities, and ecosystems	In the view of practicing marine scientists in the region, how important is the proposed area for advancing knowledge?	▪ Density, fidelity, and mean size are attributes of marine fish populations may indicate value; some of these attributes are available for a few commercial fish species in the Pacific region ▪ Some marine communities in the Pacific have been described in detail (e.g., demersal fish and benthic infaunal communities have been described for the Hectate Strait) ▪ There are few areas in the marine environment of the Pacific Region where ecosystem or habitat attributes have been assessed for long periods of time, i.e., decades. ▪ There are long time series of catch statistics for marine fish species, particularly groundfish, crabs, clams, etc., in certain areas, and these may be useful ▪ The strengths and weaknesses of any data series should be assessed as survey protocols may have changed over time

Table 4. Criteria and considerations for scoring criteria for MPA site selection in Canada's Pacific region, *cont'd*. *Source*: Levings & Jamieson, 1999.

Criterion	Relevant considerations when scoring	Comments
2) Value of determining the impact and results of marine management activities	How valuable is the area for application of adaptive management principles? A proposed MPA or network could be rated for marine management activities relating to fishery and habitat management activities. For example, if the area was closed for conservation of a particular species, how many data are there to investigate if recovery has occurred and is there enough science to understand why species did or did not recover?	▪ Scientists often make judgment calls about the importance of a particular area for research based on a combination of representativeness, uniqueness, existence of previous data, input from client groups if they are applied scientists, funding, and personal interest ▪ If the proposed MPA is representative of an area which has already been well studied, the area might not be highly valued; if the area has already been studied extensively and many baseline data are available, it might be an important area to springboard new research from
3) Value as a natural benchmark	How much of the proposed MPA contains species whose life history parameters (e.g., growth, survival) are described, communities that are well documented, or habitats that have been well mapped? Have the attributes been monitored for a substantial period of time, so that a defensible time series of data are available? Is the database "weak or strong"?	▪ A proposed MPA or network can be rated for marine management activities relating to fisheries and habitat management activities ▪ Proposed MPAs may be justified to build on management actions that were initiated years ago

Table 5. Summary of ecological criteria for evaluating candidate sites for marine reserves identified by Roberts *et al.* (2003a).

Biogeographic representation	- Coverage of all biogeographic regions is a prerequisite for protection of biodiversity. - Representing all the different biogeographic regions in a protected area network should be a core conservation objective, since assemblages of species will be distinct in each.
Habitat representation and heterogeneity	- Representing all habitats is an essential objective for a network of reserves. - Habitat heterogeneity can be used to guide the selection of individual reserve units; as the number of habitats within an area increases, so does the value of a site for a reserve. Habitat heterogeneity acts as a proxy for maximizing the number of species protected. - Habitat heterogeneity can only validly be compared between sites within regions (i.e., different Biogeographic regions cannot be compared directly).
Human threats	- A number of threats may seriously affect the viability of a marine reserve and preclude it from meeting its intended objectives. It is therefore important to consider past, present, and foreseeable future influence of human activities on a candidate site. - Mitigatable and non-mitigatable human threats should be identified and quantified where possible.
Natural catastrophes	- Areas that are focal points for episodic catastrophes make poor candidates for reserves. The more frequent the disturbance, the less desirable a site.
Size	- Independent of size, the creation of reserves leads to increases in abundance, biomass, size, and diversity of organisms. Both small and large reserves produce similar increases in each measure (Halpern, 2003). Since many biological effects of reserves do not appear to be size dependent, decisions about the actual size and distribution of reserves should focus on export functions, viability, disturbance, and management.
Export functions	- The large edge-to-area ratios of small reserves make them better at exporting larvae and adults, important for meeting fishery and conservation objectives (export to fishing grounds will help support yields, export to other reserves will promote long-term population persistence). - Fishery export is best served by subdivision of protected areas across the region of interest, which will provide local benefits to fisheries through juvenile and adult spillover, and more regional benefits through greater larval export.
Viability	- Small reserves may not support populations that are large enough to persist, particularly for mobile species that often cross reserve boundaries. Very small reserves will function only to the degree that essential linkages to other habitats are maintained. - Larger reserves will be needed to protect rare and fragmented habitats. - Populations of some species will only be viable if networks of habitat patches are protected that include vulnerable life stages (e.g., spawning aggregations).
Disturbance	- Small reserves are more vulnerable to periodic disturbances that could wipe out a reserve population in a single event. Larger reserves can help mitigate this vulnerability, but they also risk "putting all your eggs into one basket". A catastrophic event could drive entire populations to extinction in a single large reserve, whereas creating smaller reserves within a large network might avoid a similar fate.
Management	- Logistical concerns weigh heavily in decisions about reserve size. Many small reserves spread risk, but they are often more difficult to enforce than a few large ones, and a vast network of small reserves may prove too complex for compliance. Larger and fewer reserves are easier to enforce, but they may be more difficult for people to accept. - The greater the combined area covered by reserves, the greater their absolute benefits. Protecting 20% or more of each habitat present will be necessary to support fishery production and safeguard biodiversity over the long term.
Connectivity	- Exchange of offspring between places is critical to the functioning of reserves, as it can affect both sustainability of populations inside a reserve and the degree to which a reserve can serve as a source of recruitment to fishing grounds. - There must be sufficient connectivity to allow exchange and replenishment within the reserve, and to ensure populations in a reserve connect with others in unprotected areas or in other reserves. This will depend on dispersal distances for the organisms protected, reserve size, and local oceanography. - It is essential that network design consider dispersal distances and the protection of larval habitat.

Table 5. Summary of ecological criteria for evaluating candidate sites for marine reserves identified by Roberts *et al.* (2003a), cont'd.

Vulnerable habitats	-	Habitats especially vulnerable to disturbance may deserve particular consideration for inclusion in reserve networks. These include habitats with low ecological resilience (e.g., coral reefs), and regionally rare or threatened habitats.
Vulnerable life stages	-	Identifying life-stage transitions that are critical to a species' population dynamics can be useful in choosing among sites for inclusion in a reserve network. Where vulnerable life stages are known, the habitats or processes supporting them should be protected.
	-	If potential reserve sites contain habitat that supports vulnerable life stages for one or more species, those sites may be given higher priority than others. Understanding which life stages are most critical to population dynamics can help avoid misdirected site selection.
	-	When possible, reserve siting should include consideration of vulnerable stages and the habitats in which they occur. It may be important to include several, linked life stages in reserves.
Species or populations of special concern	-	Conservation value is assigned to species based on the size of their global geographic range; species that have a restricted range should be afforded higher conservation priority than species that are more widespread. Sites can be selected based on either the number of restricted-range species or the summed range-rarity (reciprocal of the range size of a species) values for the species present. The site that had the highest value according to one or other index would be selected first and subsequent sites could be added through an analysis of complementarity that would ensure inclusion of unrepresented sites.
	-	Relict species are also of special concern. Relicts are species that have persisted in particular regions following contraction or fragmentation of previously more extensive distributions over evolutionary time scales. The presence of such species would add value to sites being considered for serves, due to their scientific interest.
	-	Species that are globally rare are another category of species of special concern. (This approach is most applicable to larger and well-known taxa.)
	-	Genetic diversity of populations is another consideration in selecting reserve sites. Sites containing populations characterized by greater genetic diversity should be given greater priority. However, genetic diversity of populations of a single species should not dictate or heavily influence site selection.
Exploitable species	-	Marine reserves can and do lead to recovery of exploited species, but for reserves to fulfill fishery-management objectives they must either actually protect populations of exploitable species or be capable of protecting them.
Ecosystem linkages	-	Linkages are defined as the flow, or impediment, of materials from one system to another that allows, modifies, or modulates the functioning of a given marine and coastal area. The operative use of this criterion for the selection of marine reserves is not straightforward, but its implications are highly relevant.
Ecological services for humans	-	Intact ecological systems are essential to provide the services that humans use. Despite the lack of specific knowledge about many critical services, the fact that most are irreplaceable and subject to serious disruption should signal the importance of preserving them.

Table 6. Summary of criteria used in the evaluation of potential marine reserves. *Source*: Roberts *et al.*, 2003b.

CRITERIA	PRIORITIZATION
Prerequisite criteria	These criteria are of prime importance. They aim to capture the full spectrum of biodiversity in reserve networks.
1) Biogeography	- Determine what biogeographic regions exist within the overall target area. Analyze the distribution patterns of fauna and flora to determine if there are distinctive biogeographic provinces within the region. Multivariate analyses of assemblage composition (e.g., cluster analysis) can help in evaluating how abrupt the boundaries are between regions or whether clear boundaries exist at all. Isolated reserves may provide little long-term protection for species or habitats, and so there is a need for replication of reserves within biogeographic regions. - To achieve a balanced biogeographic representation while placing extra weight on the number of species present, use complementarity analysis, which gives the greatest conservation weight to the site with the most species. The next highest weight goes to the site that contains the greatest number of species not present in the first, and so on. - The traditional emphasis on targeting highly diverse areas for protection is appropriate if the focus is on species, but low-diversity areas must not be overlooked because they may be in greater need of protection to maintain ecosystem functioning.
2) Habitats a) Diversity b) Diversity not protected elsewhere	- Habitats should first be defined and agreement reached on the overall list of habitats that occur in a region. Several rules guide the selection of habitats: (1) all habitats must receive protection, (2) each habitat should be protected in more than one area as a guard against local catastrophes, to support exchange of propagules among sites, and to provide replicate sites for monitoring and research, (3) the total area set aside for the protection of each habitat should be approximately related to its relative prevalence in the region, (4) special care should be taken to guarantee inclusion of rare habitats, and if there are any habitats of special concern they may need additional protection. - All chosen reserves should contain a mix of habitats. The desirability of an area for conservation will increase in proportion to the diversity of viable sized habitats it encompasses. - Habitat heterogeneity in a given area can be quantified as the number of habitats present, divided by the possible total number within the biogeographic region. It should also be taken into account whether those habitats are already conserved elsewhere. This can be quantified as the number of habitats in the area that are not protected elsewhere. These quantitative measures can be converted into a score or rank for the area. - Habitats provide a proxy for species richness which enables decisions to be made regarding the value of sites as reservoirs of biodiversity in the absence of detailed data on the species present in each. However, where sufficient information is available, it may be possible to narrow the definition of habitats to those that demonstrably contain distinctive assemblages of species that will be lost if that habitat is not conserved.
Excluding criteria	These criteria may eliminate some areas from further consideration. If either human or natural threats will seriously compromise the value of an area as a reserve, that area should be eliminated from the array of candidate sites.
3) Human threats a) Non-mitigatable b) Mitigatable	- Marine reserves should not be placed where they will be subjected to damaging human impacts. Increased risks are associated with proximity to major ports, shipping lanes, oil pipelines, oil-production platforms and refineries, power-generating plants, and chemical production facilities. These are often non-mitigatable threats. An understanding of the spatial dynamics of such catastrophes will allow reserves to be placed in relatively low risk areas. - Reserve sites must be evaluated as to the relative level of threats, both current and anticipated, and the potential for mitigation and/or recovery. Sites where the overall level of human threat is too great or for which there is almost no potential for recovery should generally be excluded from consideration. Sites for which overall human threat is low should be rated highly, especially if protection will reduce anticipated future threats. Protected areas whose presence will mitigate existing threats are of especially high value.

Table 6. Summary of criteria used in the evaluation of potential marine reserves, *cont'd*. *Source*: Roberts *et al.*, 2003b.

CRITERIA	PRIORITIZATION
4) Natural catastrophes	- Areas that are focal points for episodic catastrophes, if they can be identified, should be avoided as sites for reserves since species will have to recolonize from elsewhere following disturbances. The more frequent and widespread the catastrophe, the less desirable a site will be. Catastrophes that cause mass mortalities of organisms over large areas, such as severe anoxic events, place the greatest restrictions on candidate sites.
Modifying criteria	Modifying criteria can be used to gauge the relative values of sites as reserves. They can be applied in any sequence, and the order in which they are used depends largely on the objectives envisaged for reserves.
5) Adequacy of size a) for conservation b) for fisheries -	- Reserves must be large enough to be viable and fulfill the desired goals. There are no upper limits on size that are relevant to conservation goals, but to achieve an export of fishable stocks they should not be too large. What constitutes "too large" depends on the species involved and local oceanographic conditions. Most studies suggest that spillover of juvenile and adult fish from reserves will be localized. The probability of fish leaving a given reserve will decrease as the area of the reserve grows. The safest option will be to have a range of reserve sizes in the network.
6) Optimal distance apart a) for conservation b) for fisheries	- Connectivity (the transfer of offspring between places) is critical to the function of reserves. Reserves in a network must be close enough to allow organisms to transfer among them. Reserve-design optima will differ for short-distance compared to long-distance dispersers. Larger reserves will maximize the probability of self-recruitment within reserves for short-distance dispersers while for long-distance dispersers, smaller reserves spaced at broader intervals may have greater connectivity. - The likelihood of populations in different reserves interacting will grow as the distance between reserves falls. In spacing reserves, locations that lie mid-way between existing reserves might be favoured because they reduce inter-reserve distance and provide a stepping stone for recruitment. - Application of the connectivity criterion for fishery management might be guided by rules of thumb. For example, in places where currents are strongly directional, reserves sited in upstream locations will be more likely to supply recruits to the rest of a management area than those in downstream locations. Where currents are complex or reversing, a more even spread of reserve locations would be better. - There is no absolute figure as to how close reserves should be. There are too many variables for precise limits to be set for what constitutes "too far" or "too close" and it will be safest to have a range of distances among reserves.
7) Vulnerable habitats	- The presence of intact habitats that can easily be damaged or changed by human activities increases priority of an area as a reserve. Vulnerable high seas habitats include, for example, deep-sea coral communities, hydrothermal vents, and seamounts. Typically, such habitats are easily disturbed or transformed by human action, but recovery is slow, if it occurs at all. Because of slow recovery there is a great premium to be placed upon protection before human disturbance or damage modifies vulnerable systems.
8) Vulnerable life stages	- The inclusion of localities where a species becomes especially vulnerable, or which are vital for completion of their life cycles, adds value to a candidate site (e.g., the spawning ground of a commercially important species, or an area where it aggregates to breed and thus becomes vulnerable). If a site is clearly identified with the completion of a critical life stage, it must rank highly as a candidate for a reserve. This criterion is most easily applied at the level of individual species. However, if a habitat or site is critical for several key species, it will attract higher priority for a reserve.

Table 6. Summary of criteria used in the evaluation of potential marine reserves, *cont'd.* *Source*: Roberts *et al.*, 2003b.

CRITERIA	PRIORITIZATION
9) Species of special interest (rare, endemic, etc.)	- The presence of rare, endangered, relict, or restricted-range species, or populations with unique genetic composition, may heighten the need to protect an area. The relative value of different sites as reserves could be measured as the total number of species of special concern present, or alternatively, presence of some species might be weighted more heavily than others.
10) Inclusion of exploited species	- Protection of populations of exploitable species is a prerequisite for reserves to provide any fishery benefit. The relative value of sites can be gauged in several ways: as the total number of exploited species present, their aggregate abundance or biomass, or by some weighting approach according to economic value of the species present. All of these approaches measure the relative importance of candidate sites in restoring or sustaining stocks or aiding with their management.
11) Linkages (dependencies) between systems	- Maintenance of ecosystem functioning is a vital goal influencing the placement of reserves. Areas that support other habitats have a high value for meeting both conservation and fisheries objectives. Those dependent on other habitats are vulnerable unless adjacent support habitats are also protected. Important links among habitats must not be overlooked in assessment of candidate reserve sites. - To evaluate sites under this criterion, the following questions should be addressed: (1) is the area dependent on linkages from elsewhere and are those linkages secure, (2) to what extent does the area serve as a link to other areas, and (3) does the overall network of conserved areas incorporate links necessary for the survival of the ecosystems represented?
12) Ecosystem services for human needs	- Evaluation of reserve sites according the ecosystem services they provide should be guided by the extent to which such services depend on protection. IF the service will be provided irrespective of protection then it should not influence site selection.

Table 7. Application of ecological criteria for marine reserve design in the California Channel Islands. *Source*: Airame *et al.*, 2003.

Ecological criteria	Application to the Channel Islands	Limitations
Biogeographical representation	Three major biogeographical regions were identified using data on biota and sea surface temperature.	Boundaries of biogeographical regions are not fixed.
Habitat representation	Representative and unique marine habitats in each biogeographical region were classified using depth, exposure, substrate type, dominant plant assemblages, and a variety of additional features.	Data on the distributions of habitat types may be limited.
Habitat heterogeneity	This was not incorporated as a specific criterion, but the analysis required representation of 30-50% of all habitats within the smallest area possible, thus selecting areas of high habitat heterogeneity.	Data on the distributions of habitat types may be limited.
Vulnerable habitats	To insure adequate representation, vulnerable habitats were considered unique habitat types.	Data on the distributions of vulnerable habitats may be limited.
Species of special concern and critical life history stages	Island coastlines and emergent rocks were weighted according to the distributions of pinniped haul-outs and seabird colonies. The algorithm selected areas of high pinniped and bird diversity. Other species were not weighted due to insufficient data on their distributions.	Data on distributions and life-history characteristics of species of special concern may be limited.
Exploitable species	Habitats likely to support exploitable species, especially rockfishes (e.g., emergent rocks and submerged rocky features), were included for specific representation.	Data on distributions and life-history characteristics of exploitable species may be limited.
Ecosystem functioning and linkages	Not used	Determining the extent to which ecosystem linkages constrains reserve design may be difficult.
Ecosystem services	Locations of CINP (Channel Islands National Park) kelp forest monitoring sites were not included as a formal criterion, but borders of potential reserves will be adjusted, if needed, to include some of those sites.	Sufficient information on ecosystem services may not be available.
Human threats and natural catastrophes	The reserve size needed to meet reserve goals in a stable environment (30-50%) was multiplied by a factor that accounts for the frequency of severe disturbances (insurance factor of 1.2-1.8). No areas were excluded from the process.	Data on the frequency of severe disturbance may be limited.
Size and connectivity	At least one, and no more than four, reserves should be placed in each of the three biogeographical regions. For one region (650 nmi^2), two to three reserves (~60-160 nmi^2 each) was recommended.	Optimal number of reserves ill generally depend on the size of each biogeographical region. Reserve placement will depend on dispersal among sites.

Table 8. Example of the COMPARE procedure as applied to Cape Point Nature Reserve in South Africa (scoring uses a scale of 0-2). *Source*: Hockey & Branch, 1997.

		UTILIZATION						FISHERIES MANAGEMENT				PROTECTION				OBJECTIVE
PERCENTAGES (F)	**TOTALS for CRITERIA (E)**	**14 Exploitation**	**13. Education**	**12. Low impact recreation**	**11. Ecotourism**	**10. Monitoring**	**9. Research**	**8. Spawner biomass**	**7. Adjacent yield**	**6. Vulnerable stages**	**5. Reduced fishing mortality**	**4. Vulnerable stages**	**3. Rare/endemic species**	**2. Habitat diversity**	**1. Biogeography**	**CRITERION**
70	7		2		1	1	2								1	1. Regionally representative?
12	1							0		0			0		1	2. Not conserved elsewhere?
50	5		2		1	1	1							1		3. Habitat diversity high?
87	7		2			1	2							2		4. Includes fragile habitats?
50	5		1		1	1	1						1			5. Houses rare or endemic spp.?
50	4						1			1		1	1			6. Protects vulnerable stages?
100	10		2		2	2	2							2		7. Pristine or restorable?
13	1		1		0		0								0	8. Special natural features?
75	12	2	2			2	2	1	1	1	1					9. Supports exploited spp.?
50	2								1	1						10. Supplies adjacent areas?
61	17	1	2	2	1	2	2	1	1	1	0	1	1	1	1	11. Large enough?
78	14		2		1	2	2			2	2	1	1	1		12. Adjacent terrestrial reserve?
93	26	2	2	2	1	2	2	2	2	2	1	2	2	2	2	13. Effective management?
100	8		2	2	2									2		14. Aesthetically appealing?
100	12	2	2	2	2	2	2									15. Accessible to people?
67	4		1	2	1											16. Satisfies social needs?
33	1		1		0		0									17. Preserves historical sites?
	136	7	23	10	13	16	19	4	5	8	4	5	6	11	5	TOTALS for OBJECTIVES (A)
	69	88	82	100	54	80	73	50	63	57	50	63	50	79	50	PERCENTAGES (B)

136	88	21	27	OVERALL TOTALS (C)
69	76	55	61	OVERALL PERCENTABGES (D)

Table 9. Tabular summary of environmental characteristics of high seas and deep ocean areas of interest identified by WWF and IUCN (2001)

Type	Typical depth	Scale	Frequency/ extent	Typical depths	Geological characteristics	Biological characteristics	Natural stability
Hydrothermal vents	500-4000 m	< 1 km	100s	Sublittoral to hadal	High temperature fluid escape, tectonic/ volcanic	Chemosynthesis, endemism, and enhanced productivity	Ephemeral Fluid flow dependent
Deep-sea trenches	6,000-11,000 m	100s-1,000 km	10s	Hadal	Subduction zones	Ultra-extreme environment	Focal sites for tectonic activity
Gas hydrates	>300 m	<1-100s km	Vast resource	Bathyal to abyssal	Frozen methane	Chemosynthesis	Stable?, potentially subject to catastrophic outgassing
Seamounts	10s-5,000 m (summit depth)	10s-100 km	1,000	Sublittoral to abyssal	Tectonic/ volcanic	Biological 'hot spots', endemism, and enhanced productivity	Variable, possible seismic and volcanic activity
Deep-sea coral reefs	80-1,000 m	<1-10s km	Common	Sublittoral to bathyal	Various settings	Biological 'hot spots', enhanced diversity	Stable
Seeps and pockmarks	10s-6,500 m	<1-10s km	? 1,000s	Sublittoral to abyssal	'Cold' fluid escape, various settings	Chemosynthesis	Ephemeral Fluid flow dependent
Submarine canyons	10s-3,500 m	10s-100s km	Common	Bathyal to abyssal	Continental slopes	Biological 'hot spots, enhanced productivity	Variable, may be subject to frequent or catastrophic natural disturbance (i.e., downslope sediment transport)
Manganese nodules	4,000-6,000 m (economic deposits)	100s-1,000s km	Vast fields	Abyssal	Abyssal plains	Enhanced diversity	Stable
Seabirds	N/a	N/a	N/a	Epipelagic	N/a	Breeding and feeding areas	<?>
Transboundary fish stocks	N/a	N/a	N/a	Epipelagic to bathypelagic	N/a	<?>	<?>
Cetaceans	N/a	N/a	N/a	Epipelagic to bathypelagic	N/a	Migration routes, breeding and feeding areas	<?>