# Using Biogeography to Help Set Priorities in Marine Conservation

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**Abstract:** *Biogeographic information has great potential to enhance systematic conservation planning, although it has yet to be routinely incorporated in marine situations. Fundamental differences between marine and terrestrial environments (physical, biological, and sociopolitical) mean that biogeographic data are harder to obtain for marine systems, biogeographic boundaries more difficult to define, and the outcomes of similar conservation approaches may differ. Despite these challenges, an understanding of spatial context, connections, and scales of processes is needed to set conservation priorities that ensure the representation and continued persistence of species and habitats within functioning ecosystems. As we discovered in our review, scientific knowledge of marine systems is increasing rapidly thanks to recent advances in genetics, remote sensing, and geographical information systems. Such knowledge and tools have important implications for marine planning. We also reviewed the degree to which biogeography is incorporated into current marine conservation projects at spatial scales ranging from global to local. Overall, initiatives are becoming more regional in scope and incorporating biogeographic data in an increasingly rigorous manner. However, initiatives that use few or no data are also on the rise and need to be treated with due caution. We recommend undertaking global and regional reviews within biogeographic frameworks; combining analytical approaches to determine biogeographic classifications and to define a range of potential conservation areas with stakeholder involvement to set priorities; understanding contemporary processes that maintain species distributions; and acquiring knowledge of historical distributions to provide appropriate baselines for current conservation. The urgent need for marine conservation, however, means that planning should proceed with the best currently available biogeographic information even while biogeographic research continues.*

**Key Words:** biogeographic classification, ecoregion, marine protected areas, review, systematic planning

Uso de la Biogeografía como Ayuda para Definir Prioridades en Conservación Marina

**Resumen:** *La información biogeográfica tiene gran potencial para mejorar la planeación de la conservación sistemática, aunque aún debe ser incluida rutinariamente a situaciones marinas. Las diferencias (físicas, biológicas y sociopolíticas) fundamentales entre ambientes marinos y terrestres significan que los datos biogeográficos son más difíciles de obtener para sistemas marinos, es más difícil definir los límites biogeográficos y los resultados de métodos de conservación similares pueden diferir. A pesar de estos retos, se requiere entendimiento del contexto espacial, conexiones y escalas de procesos para definir prioridades de conservación que garanticen la representación y persistencia continuada de especies y hábitat dentro de ecosistemas funcionales. En nuestras revisiones descubrimos que nuestro conocimiento de los sistemas marinos está aumentado rápidamente gracias a los avances recientes en genética, percepción remota y sistemas de información geográfica. Estas herramientas han tenido importantes implicaciones en la planeación marina. También revisamos el grado en que la biogeografía es incorporada a los proyectos actuales de conservación en escalas espaciales que varían de globales a locales. En general, las iniciativas se están volviendo más regionales en alcance y están incorporando datos biogeográficos de manera cada vez más rigurosa. Las iniciativas que utilizan pocos o ningún dato también están incrementando y deben ser tratados con la debida precaución.*

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*Recomendamos abordar revisiones globales y regionales en contextos biogeográficos, mediante la combinación de métodos analíticos para determinar clasificaciones biogeográficas y definir un rango de áreas de conservación potenciales y la participación del público para fijar prioridades; el entendimiento de los procesos contemporáneos que mantienen la distribución de especies; y la adquisición de conocimiento de las distribuciones históricas para proporcionar bases apropiadas para la conservación actual. Sin embargo, la urgente necesidad de la conservación marina significa que la planeación debe proceder con la mejor información biogeográfica disponible actualmente aún mientras la investigación biogeográfica continúa.*

**Palabras Clave:** áreas marinas protegidas, clasificación biogeográfica, ecoregión, planeación sistemática, revisión

## Introduction

Biogeography, the study of the geographical distributions of organisms, has the potential to play a pivotal role in systematic marine conservation planning. Systematic planning has been advocated as a method to enhance terrestrial conservation initiatives (Margules & Pressey 2000; Wikramanayake et al. 2002), and similar approaches are needed in marine conservation (Beck 2003). Systematic planning involves an overview of an entire system: identifying conservation targets, collecting information, establishing goals, assessing the contribution of existing areas to reaching goals, assembling a portfolio of areas for consideration, and identifying priority areas for conservation action (Groves et al. 2002). Biogeography can strengthen the scientific basis of conservation planning by providing (1) biological distribution maps at different spatial scales (ecosystems, species, genes); (2) biological distribution models based on environmental surrogates; (3) biologically meaningful classifications within which representative areas can be identified; (4) information on tectonic, oceanographic, physical, chemical, and ecological processes that determine and maintain biological distributions and the spatial and temporal scales at which they operate; (5) tools for analyzing and communicating information.

Marine systems differ from terrestrial systems in ways that have implications for both biogeography and conservation planning (Steele 1985; Carr et al. 2003). Physical connections among areas are typical due to the sea's large size, enormous volume, continuity of habitats, and ubiquitous currents. These lead to biological connections, particularly among organisms that spend part or all of their lives in the pelagic environment (the high density of seawater enables a planktonic lifestyle that is absent among terrestrial biota). The resulting connectivity can be ecological, via individuals or nutrients moving among habitats, or genetic, through movement of propagules. These connections mean that marine systems are truly three dimensional and that biogeographic boundaries may be blurred over space and time.

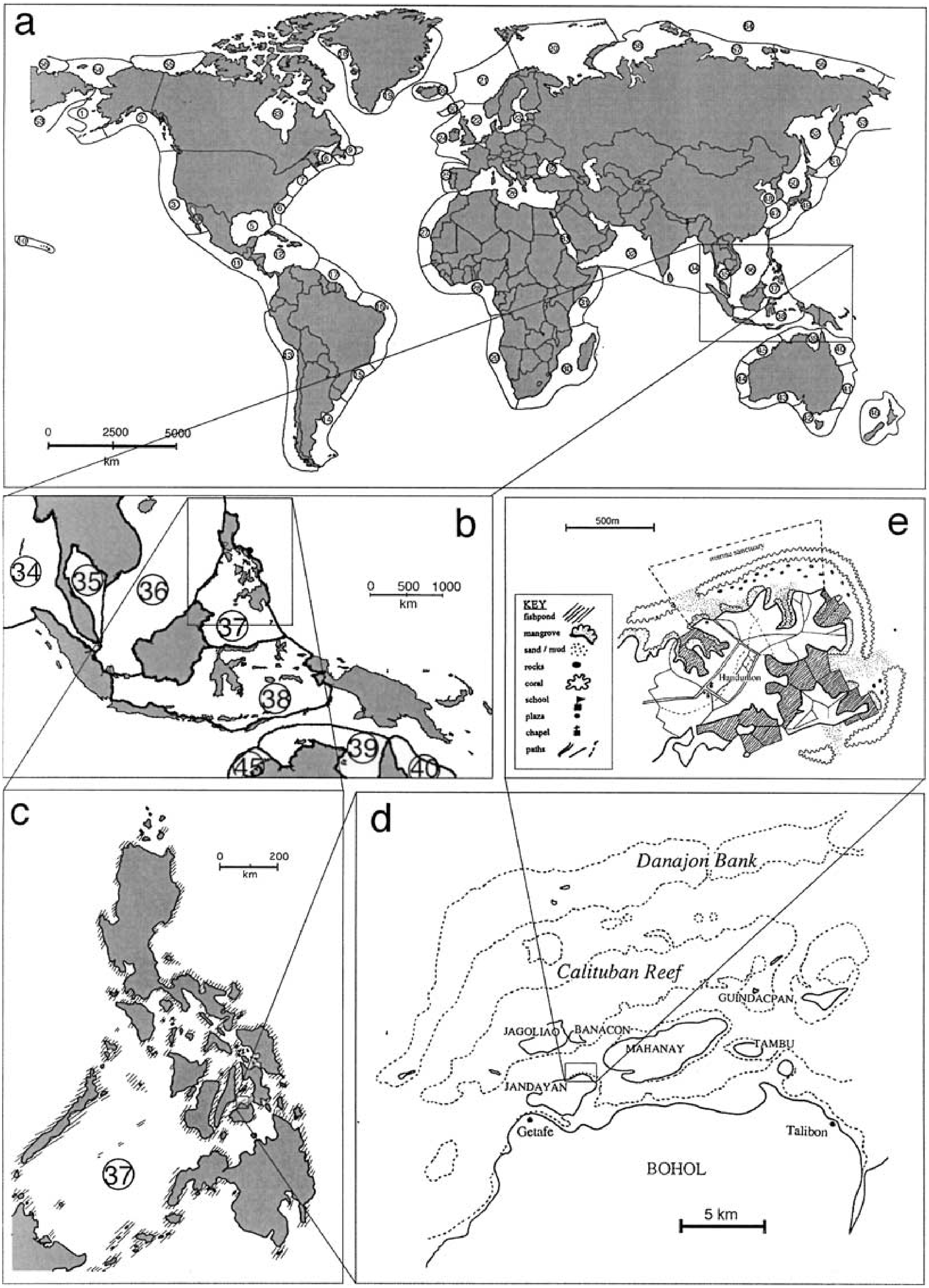
Societal issues also affect our understanding of marine systems and our management priorities. Only recently have we been able to study aquatic organisms in situ, and humans are generally unfamiliar with the marine realm, despite our extensive use of the sea and the fact that nearly 40% of the world's population lives within 100 km of the coast (http://earthtrends.wri.org/). Our unfamiliarity is reflected in the dearth of scientific data available for systematic planning and in public attitudes toward marine conservation. Furthermore, historical perceptions of fish as resources rather than wildlife, oceans as open-access and infinite, and political division of the oceans into exclusive economic zones (EEZs) that bear no relation to ecological reality all do little to encourage appropriate marine stewardship.

Both marine biogeography and marine conservation lag far behind their terrestrial counterparts (Beck 2003). However, escalating threats to the marine environment (Pew Oceans Commission 2003) and increasing governmental and nongovernmental attention to marine issues (de Fontaubert et al. 1996) argue the need for a solid, appropriate, and objective foundation for decision making. Biogeography could provide such a basis.

We (1) review the current status of marine biogeography, (2) assess ways in which current marine conservation projects incorporate biogeographic information into their planning, and (3) provide recommendations for the future use of biogeography in marine planning.

## The Status of Marine Biogeography

Biogeography can contribute to marine conservation planning in five main areas: (1) biological distributions, (2) models, (3) classifications, (3) processes, and (4) tools, each of which are discussed below. Additional complexity is involved in marine conservation planning because biodiversity exists on a multitude of scales biologically, spatially, and temporally (Fig. 1), and these scales are, to some extent, independent of one another. For example, two species could operate on very different spatial scales even though they are of a similar biological scale (species); one may be very widespread (large spatial scale) and the other may be endemic (small spatial scale). Furthermore, physical processes (climate, seasons, winds, tides, waves), human societies (international conventions, governments, local communities), threats (global warming, chronic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pollution, trampling by tourists), and conservation activities (global, regional, provincial, local) also operate on a variety of spatial and temporal scales.

Conservation initiatives must incorporate a clear understanding of the scale at which they are working and the scales at which their targets (biological units) operate. Conservation priorities may often be set at large spatial scales, yet their implementation will often occur at small scales. Coarse scales of analysis may bring globally significant features into focus but may overlook regionally important ones, even though they may in turn support the globally important ones (e.g., to benefit turtles, both feeding and nesting sites must be protected). Ideally, conservation initiatives at the global, regional, provincial (national), and local level need to be nested and linked through partnerships and collaboration (Costanza et al. 1998; Mace 2000).

## Marine Distributions

Knowledge of marine distributions provides specific information on conservation targets (ecosystems, species, and genes), and forms the basis for biogeographical classifications and future monitoring. As on land, conservation in the sea is moving toward ecosystems (or habitats) as targets (Groves et al. 2002). Additionally, particular threatened, commercial, or habitat-specific species may be an important focus if ecosystem-oriented plans are insufficient (Beck & Odaya 2001).

Global ecosystem (or habitat) mapping has so far been limited to shallow-water coral reefs (Spalding et al. 2001), mangroves (Spalding et al. 1997), and, most recently, seagrasses (Green & Short 2003). These reviews provide appropriate frameworks for global to regional reef-, mangrove-, or seagrass-focused conservation priority setting (Bryant et al. 1998). Other biological communities such as kelp forests, oyster beds, deep-water corals, submarine canyons, and seamounts (Richer de Forges et al. 2000; WWF & IUCN 2001) have yet to be comprehensively mapped. Smaller habitat-mapping projects, important for planning at the local level, are also underway in a number of countries (Kendall et al. 2001).

At the next-smaller biological scale, species distributions are primarily known from taxonomic monographs or from field guides. The former are commonly difficult to access, and the latter often suffer from inaccuracies or oversimplification (Gill 1999). Increasing awareness of the practical importance of taxonomy to conservation, however, is leading to increased funding that should benefit our understanding of species distributions (Vecchione & Collette 1996). Additionally, rapid assessments and species-level inventories are being deployed in geographical areas for which few data exist (Allen & Werner 2002).

At the genetic level, the burgeoning field of phylogeography is providing insights into the spatial context of population and genetic connections (Avise 2000). Phylogeographic studies of marine species are increasing (Muss et al. 2001), although few comparative studies that elucidate general patterns have yet been undertaken.

## Biogeographical Modeling in the Sea

Where detailed species-distribution data are lacking, models based on environmental or habitat data have been used in the terrestrial realm (Kleyer et al. 2000). Such models may be a useful addition to field-based mapping because the latter is often costly and impractical for large areas. However, their use in the marine realm is still relatively new and untested (Mumby & Harborne 1999; Wright & Bartlett 1999; Turner et al. 2003). There is also a role here for reconstructing the historical ranges of species (such as the giant otter [*Pteronura brasiliensis*]), through either palaeoecological studies or modeling, in order to provide appropriate baseline distribution data for conservation planning (Pitcher 2001).

## Marine Biogeographical Classifications

Conservation planning may be systematic from the point of view of individual targets (e.g., selecting the best place to conserve a species of whale) and/or it may be systematic from the point of view of a geographical region (e.g., selecting conservation areas within the Gulf of Mexico). In the latter case, classification schemes are needed to group subareas into biogeographically similar units that can be compared meaningfully. These units can then be used to address goals of comprehensiveness, adequacy, and representation (CAR principles). The CAR principles

*Figure 1. Physical, temporal, and biological patterns and processes at various spatial scales and their relationship to various levels of conservation planning: (a) global approximate map scale 1:100 million—ocean basin divisions, major currents, global climate, historical biogeography, highly migratory species, large marine ecosystems (LMEs, marked by numbers); (b) regional, 1:10 million—regional currents, historical biogeography, genetic connectivity, widespread species, individual LMEs or ecoregion; (c) provincial, 1:1 million—small-scale currents, upwelling, genetic connectivity, major habitats within LME or ecoregion (coral reefs marked by diagonal lines), restricted-range species, bioregion; (d) local, 1:500,000—local gyres and eddies, watershed runoff, coastal geomorphology, ecological connectivity, single reef system within one bioregion, planning unit; (e) site, 1:10,000—tides, watershed runoff, ecological connections, habitat specialists, habitats within planning unit, zoning for marine protected area.*

ensure that multiple examples (adequate) of all (comprehensive) types of habitats and ecosystems present within the region (representative) are included within a system of conservation areas (Environment Australia 1999; Day et al. 2003).

Unfortunately, there is still no generally accepted marine biogeographical classification scheme at any spatial scale. The lack of consensus in marine biogeography stems partially from our limited knowledge of the marine realm and partially from the sea's physical nature. Processes affecting abyssal communities differ greatly from those affecting coastal communities, and the three-dimensional and connected nature of marine systems complicate matters further. Distinct boundaries in the sea are generally lacking, particularly in pelagic environments, and broad zones of transition may exist between what are considered biogeographic regions. In some cases these overlap zones, or "biotones," can be larger than the "core provinces" themselves (CSIRO 1996; Environment Australia 1998).

Terrestrial biogeographic regions are generally defined by biomes, or ecological communities of long-lived rooted plants, nested within realms defined by continental plates (Udvardy 1975). Transitions between biomes are relatively swift in space and enduring over a scale of decades. By contrast, phytoplankton dominate primary production in the sea and are hard to map because they are so dynamic in space and time (Longhurst 1998). Although easier to map, "rooted" marine organisms such as kelp, tube-worm colonies, and coral constitute only a tiny fraction of the marine biota and living space.

Marine biogeographical classifications at global and regional scales have been based on climate, ocean basins, oceanography, bathymetry, and biotic distributions (Table 1) (Ekman 1953; Dietrich 1957; Briggs 1974; Bailey 1998; Longhurst 1998). At provincial and local scales, some schemes stress physical characteristics such as coastal morphology, undersea topography, substrate type, wave exposure, and vertical mixing as surrogates for species and habitats (Zacharias et al. 1998; Day & Roff 2000). Others emphasize biotic distributions or some combination of biotic and physical characteristics (Hayden et al. 1984; CSIRO 1996; Environment Australia 1998; Day et al. 2003). At local-site scales, biological features are generally used to modify larger physically defined units (Allee et al. 2000; Davies & Moss 2002).

Consistent and standardized classification systems employed within and among regions would facilitate the assessment of conservation goals. Ideally they should fit into a hierarchical scheme that reflects the variety of scales at which biodiversity operates. It has been argued that "the biogeographic classification scheme used by a country. . . need not be universally applicable" (Kelleher & Kenchington 1992). However, it is "desirable that regional [and local] classifications be somewhat comparable in order to take into account larger scale biogeographic patterns and processes" (Mumby & Harborne 1999).

In fact, many recent marine classifications have been specifically motivated by the needs of particular governmental or nongovernmental conservation initiatives (Table 1)—for example, large marine ecosystems (LMEs) (Sherman 1993; Duda & Sherman 2002), Interim Marine and Coastal Regionalization for Australia (Environment Australia 1998), Great Barrier Reef Bioregions (Day et al. 2003), the National Oceanographic and Atmospheric Administration (NOAA) marine and estuarine classification (Allee et al. 2000), and the World Conservation Union (IUCN) habitat authority file (DiBenedetto 2002). The Australian regionalization comes the closest to producing a classification scheme that operates on all spatial scales (Environment Australia 1998).

One aspect of marine systems that has yet to be included adequately in biogeographic classifications is their three-dimensional nature. Generally, separation of pelagic and benthic zones is as far as classification schemes go, although a multivariate analysis of the fauna of the Bering Strait shows how biogeographic provinces can be defined in three dimensions (Ray & Hayden 1993). Creative conservation approaches suggest that three-dimensional classification schemes may become more useful in the future (e.g., the Tasmanian Seamounts Marine Reserve has different zoning regulations at different depths [Environment Australia 2002]).

Another issue that is not taken into account in present classification schemes is that the marine realm, even more than the terrestrial, is highly dynamic in space and time. Knowledge of the spatial context of the physical and biological processes that maintain species distributions will help fine-tune marine conservation initiatives, even though these processes are inherently difficult to map at present. Biogeographical connections and movement among areas, rather than static patterns and boundaries, may be a more appropriate way to represent marine biogeography in the longer term (Craw et al. 1999)

## Marine Processes

Although biogeographic patterns are visible, depictable, and valuable to conservation planning, they are merely the outcome of a multitude of dynamic processes. It is these processes that ultimately need to be conserved to ensure the long-term persistence of biodiversity. Scientific knowledge of the relative roles of different processes—such as historical vicariance, oceanography, dispersal, competition, and nutrient flows—in structuring marine communities and determining biogeographic regions is limited. Continuing biogeographic research, however, can help elucidate some of the processes that have been responsible for determining, maintaining, and now altering marine distributions (Briggs 2003). Such knowledge becomes increasingly valuable as climate change

**Table 1. Examples of marine biogeographic divisions at a variety of spatial scales (roughly largest to smallest) and the primary information on which each is based.***

| *Divisions* | *Spatial scale** | *Primary basis for classification* | *Reference* |
|---|---|---|---|
| Biogeographic realms | global | major ocean basins (originally based on terrestrial biogeography; Olson & Dinerstein 1998) | World Wildlife Fund 2000 |
| Realms | global | depth and position in water column | Briggs 1974 |
| Biomes | global | oceanic biomes based on prevailing winds plus one coastal biome | Longhurst 1998 |
| Domains | global | climate, water types, ice conditions | Bailey 1998 |
| Hydrographic regions | global | characteristic motions of surface layer (direction, velocity, and persistence of surface currents), ice conditions at higher latitudes | Dietrich 1957 |
| Realms | global | ocean currents, winds, ice, coastal and oceanic | Hayden et al. 1984 |
| Regions | global | climate, depth, fauna | Ekman 1953 |
| Statistical areas | global | political boundaries and arbitrary divisions of oceans | Food and Agriculture Organization 2003 |
| Zoogeographic regions | global/regional | climate, faunal distributions plus one oceanic region | Ray 1975 |
| Ecoregions | global/regional | biomes subdivided by ocean basin and regional oceanography | Longhurst 1998 |
| Divisions | global/regional | domains subdivided by prevailing currents plus continental shelf areas (considered shallow variations of division involved) | Bailey 1998 |
| Subregions | global/regional | faunal distributions | Ekman 1953 |
| Regions | global/regional | climate, currents, faunal changes | Briggs 1974 |
| Large marine ecosystems (LME) | regional | bathymetry, hydrography, trophic dependence | Sherman 1993; Duda & Sherman 2002 |
| Zones | regional | physical characteristics of ocean plus shelf | CSIRO 1996 |
| Biomes | regional | depth and postion in water column | CSIRO 1996 |
| Ecoregions | regional | five major habitat types nested within four marine biogeographic realms | World Wildlife Fund 2000 |
| Ecozones | regional | ocean basins, archipelagos, ice regimes, global climate | Zacharias et al. 1998 |
| Provinces | provincial | faunal distributions, especially presence of endemics | Briggs 1974 |
| Provinces | provincial | faunal distributions | Ekman 1953 |
| Coastal biotic provinces | provincial | coastal geomorphology, water mass characteristics, biotic associations | Ray 1975 |
| Provinces | provincial | physical discontinuities (e.g., current divergences), upwellings, sea surface temperatures, faunal distributions | Hayden et al. 1984 |
| Core provinces | provincial | endemic fish distributions | CSIRO 1996 |
| Zootones and biotones | provincial | overlapping fish distributions | CSIRO 1996 |
| Provinces and biotones | provincial | as for CSIRO 1996 plus water mass characteristics and topology | Environment Australia 1998 |
| Meso-scale regions | provincial | biological and physical data, geographic distance along coast | Environment Australia 1998 |
| Ecoprovinces | provincial | ocean surface circulation, continental margins | Zacharias et al. 1998 |
| Ecoregions | provincial | marginal seas, marginal shelf | Zacharias et al. 1998 |
| Major habitat type | provincial | temperature, upwelling, coral reef, continental shelf | World Wildlife Fund 2000 |
| Biogeographical provinces (three dimensional) | provincial | distributions of fish, mammals, and birds | Ray & Hayden 1999 |
| Pacific islands | local | geomorphology | Holthus & Maragos 1995 |
| Domains and subsystems | local | within some enclosed LMEs, basis unclear | Sherman 1993; Duda & Sherman 2002 |
| Bioregions | local | habitats, communities and physical features | Day et al 2003 |
| Ecosystems/ communities | local | not yet completed, satellite images and ground truthing | Environment Australia 1998 |
| Ecosections | local | mixing and stratification | Zacharias et al. 1998 |
| Ecounits | local | 5 physical factors: current, depth, substrate, topology, exposure | Zacharias et al. 1998 |
| Biounits | local | geomorphology, geology, oceanography, biotic, and ecological features | ANZECC TFMPA 2000 |
| Habitats | local/site | exposure, substrate type, salinity, circulation, biotic characteristics | Ray 1975 |
| National Oceanic and Atmospheric Association habitats | site | primary environmental variables with modifiers to allow general description to become incrementally more specific | Allee et al. 2000 |
| European University Information Systems habitats | site | similar to Allee et al. 2000, but includes freshwater and terrestrial habitats as well as marine habitats | Davies & Moss 2002 |
| World Conservation Union habitats | site | physical and biotic variables | Di Benedetto 2002 |
| Benthic habitat types | site | aerial photographs | Kendall et al. 2001 |

**Approximate mapping scales: global, 1:100 million; regional, 1:10 million; provincial, 1:1 million; local, 1:100,000; site, 1:10,000.*

alters temperatures, currents, and upwellings (Salm 2002), as anthropogenic actions decimate wild populations, transport species to novel habitats, and pollute from terrestrial sources, and as conservation initiatives strive to maintain connections among populations in an increasingly fragmented and overexploited world (Roberts 1998).

## Methods and Tools

Marine systems present challenges to the collection, collation, analysis, and communication of biogeographic information (Wright & Bartlett 1999). In spite of the difficulties, however, methods and tools are developing rapidly (Palumbi et al. 2003).

The size, depth, and nature of the sea means that humans can only explore it directly with sophisticated technology such as SCUBA and submersibles. Remote sensing—including satellite imaging, aerial photography, and sonar, —is used increasingly to provide data in the form of biodiversity surrogates. Satellite and aerial images are limited, however, because they penetrate only the first few meters of the sea, and ground truthing may be difficult. Still, such data have been used for habitat mapping, classification, and modeling over large geographical areas (Mumby & Harborne 1999; Wright & Bartlett 1999; Turner et al. 2003). Drifters and other in situ measurement devices are providing oceanographic data, while at the other end of the scale ecological and genetic studies are providing information about species-level connections, gene flow, dispersal capabilities, and metapopulation dynamics (Palumbi et al. 2003).

For collating and displaying biogeographic data, spatially explicit geographical information systems (GIS) have become the standard method. Geographical information systems are becoming increasingly useful for marine data, thanks to expanding capabilities for dealing with large, complex, three-dimensional, and dynamic data sets (Wright & Bartlett 1999; Zhang & Grassle 2002).

The Internet has also enabled the construction of centrally compiled and globally disseminated databases that involve hundreds of collaborators around the world (e.g., www.obis.org, www.fishbase.org and www.reefbase.org). Such databases have great potential, especially if they are designed to be flexible and fully updatable. In most cases they now include a simple GIS interface that allows users to create their own maps. As a communication tool these are excellent, but they may give a false impression of data precision, may contain inaccurate records, or may enable users to "zoom in" beyond the scale of resolution at which the data were collected initially. As such databases become more common, it is vital that globally accepted standards are in place, data-set integration is rigorous, data quality is checked, data sources are readily accessible, database architecture is flexible enough to accommodate new data, and users are aware of database limitations (von Meyer et al. 1999).

Biogeographic data analysis is important at two main steps in representative marine conservation planning: first in determining classifications and second, in selecting potential priority areas that will theoretically contribute in an efficient manner toward conservation success. In the past, classifications such as those discussed above have generally been based on qualitative descriptions (Ekman 1953; Briggs 1974; Hayden et al. 1984). More recently, numerical methods (multivariate analysis) have been used to derive classifications by defining clusters of units that share physical (Zacharias et al. 1998) or biological (Ray & Hayden 1993) characteristics or both (Environment Australia 1998). The apparent objectivity and repeatability of such methods are appealing from a scientific point of view, but as with any method the outcome is highly dependent on the underlying data. Different regionalizations may be derived depending on the type of data used, their quality and quantity, the scale at which they are aggregated (i.e., units of analysis), the way inherent variability is treated (e.g., seasonal current changes), and the order in which hierarchical criteria are applied.

An aid in the second step, that of selecting conservation areas, is the growing number of mathematical reserve-selection algorithms for marine applications (e.g., SITES and MARXAN; see www.ecology.uq.edu.au/marxan.htm) (Possingham et al. 2000). Building on terrestrial approaches to gap analysis, protected-area selection, and adaptive management, these programs seek to achieve specified goals (such as the inclusion of at least 20% of each identified habitat) while minimizing some kind of "cost function" (such as the overall perimeter of the protected areas). Different types of algorithm (e.g., hotspot, greedy, or simulated annealing) operate in slightly different ways (Beger et al. 2003; Leslie et al. 2003). Advantages of quantitative analyses are their scientific basis, objectivity, repeatability, and defensibility. Major disadvantages, however, are that they require extensive data, time, GIS expertise, and understanding of the scientific process.

In situations where data, resources, and time are insufficient to enable numerical analyses, "expert workshops" are sometimes convened (Kramer & Kramer 2002; Ong et al. 2002). These can be used for one or both steps outlined above. In the first (classification) step, biogeographical boundaries are based on consensus opinions from regional experts. In the second (selection) step, regional experts suggest priority areas for conservation action. Such "delphi" approaches have advantages in terms of speed and fewer technical requirements, although they do not produce a scientifically defensible outcome and suffer from a lack of repeatability and transparency. They rarely result in efficient designs (M. Beck, personal communication), and the assumption that they are better than a random guess in areas where appropriate classifications do not exist needs to be tested. They do, however, provide an opportunity for collating existing data sets, creating initial biogeographic databases, evaluating gaps in biogeographic knowledge, and stimulating future research. A database can form the basis for future review and the next generation of more quantitative marine conservation planning.

Involvement of stakeholders in the second (selection) step, either through "consensus" methods or a more data-driven approach, can lead to broader support for the final conservation decisions than one arrived at by "experts" alone (Mascia 2003).

## Biogeography in Marine Conservation Approaches

Historically, both on land and in the sea, choosing areas to protect has been driven "more by opportunity than design, scenery rather than science" (Hackmann 1995, cited in Day & Roff 2000). Where marine conservation initiatives have been systematic in considering entire systems, efforts have often been target-focused, particularly toward charismatic species such as cetaceans (Reeves & Leatherwood 1994) or ecosystems such as tropical coral reefs (Bryant et al. 1998; Roberts et al. 2002). Meanwhile, other important but perhaps less charismatic or well-known biota such as soft-bottom communities have either been assumed to be conserved de facto under the umbrella of the charismatic targets or ignored. Furthermore, marine planning has generally proceeded within the context of political boundaries rather than ecological ones.

An increasing awareness of the interdependence among marine ecosystems has led to the endorsement of ecoregional planning (Beck & Odaya 2001), the CAR principles (Environment Australia 1999; Day et al. 2003;), and a more explicit acknowledgment of ecological and genetic connectivity (Roberts et al. 2003). Furthermore, thanks to long-distance water currents, reproduction and recruitment in the sea may be spatially decoupled so that recruitment in one area is highly dependent upon production elsewhere (Roberts 1998). This leads to the much greater need for "networks" of protected areas in the sea than on land (Sala et al. 2002) and a regional rather than local view of conservation planning (Beck 2003). Informed decisions with respect to these factors depend heavily on biogeographic information.

To assess the degree to which biogeographic information is incorporated into marine conservation planning, we investigated a wide range of marine conservation initiatives that operate at global to local scales. We identified two questions: (1) what types of biogeographic data are consulted (e.g., taxon distributions, biogeographical classifications, and data-regarding processes) and (2) how these data are used to make decisions (e.g., use of biogeographic tools). When possible, we also determined the outputs and current status of each project. This review is not designed to be exhaustive but to provide an overview of selected conservation programs.

### Biogeographic Data Used

Approaches that use no biogeographic data (e.g., the Gulf of Maine International Ocean Wilderness, initiative 26; the creation of Apo Island Marine Protected Area, initiative 34) create a framework based on political or other nonbiological features (in Table 2).

In site-by-site approaches (i), sites are evaluated individually without a systematic framework. Biogeographical information is limited to a snap-shot view of the species present at a particular site, although endemic species may be weighted highly (e.g., Ramsar Convention on Wetlands, initiative 8; World Heritage Convention, initiative 9). Nonsystematic approaches such as these are commonly favored in situations such as international conventions, where implementation is the responsibility of individual countries. In these cases there is no overall plan for each conservation area's contribution to the goals of the convention.

In the simplest systematic approaches, target taxon ranges may be mapped and assessed in their entirety (ii) (e.g., Conservation International's hotspots, initiative 5; Reefs at Risk, initiative 4, 14; and South African marine fish hotspots, initiative 28). These provide adequate data for taxon-focused approaches.

To satisfy a conservation goal of representativeness, classifications at appropriate scales are required (iii). These may be based primarily on taxon distributions (iiia) or abiotic factors (iiib). Biogeographic classifications guide programs such as WWF's Global 200 (initiative 2), Australia's National Representative System of Marine Protected Areas (initiative 23), and the Great Barrier Reef Representative Areas Program (initiative 25). To the extent that the CAR principles can maintain ecological integrity, these approaches are appropriate. It must be remembered, though, that only mapped habitats can be included in the representation. If the location of sponge beds is unknown, for example, then their representation cannot be assessed.

To achieve long-term persistence of biodiversity, conservation of key ecological processes will be needed (iv). No single approach has yet been developed for objectively including underlying processes into systematic conservation planning. Several initiatives are incorporating processes via oceanography, metapopulation dynamics, recruitment, and whole-watershed planning (e.g., Spratly Islands Marine Park Proposal, initiative 21; the Mesoamerican Caribbean Reef, initiative 16). Dynamic ecosystem modeling, with software such as Ecopath, Ecosim, and Ecospace, could also have implications for conservation planning, although they are currently used for purposes of fisheries management (initiative 10).

**Table 2. Selected examples of marine initiatives arranged by descending spatial scale and highlighting the use of biogeography in their planning.**$^{a}$

| *Initiative number and name* | *Spatial extent* | *Defined by* | *Current status* | *Biogeographic information used (code and selected examples)*$^{b}$ | | *Decision-making methods, tools, planning units*$^{c}$ | *Reference* |
|---|---|---|---|---|---|---|---|
| 1 Global Representative System of Marine Protected Areas (World Conservation Union [IUCN]) | global | existing marine protected areas (MPAs) | initial attempt to review global system of MPAs within a biogeographic framework limited due to lack of agreed-upon biogeographic classification; update due in 2003 | i, ii, (iiia, iiib) | descriptive summary of main physical and biological characteristics of marine environment (also based on political boundaries); distribution of major habitats and taxa | opinion based: literature survey, regional working groups, discussions, existing MPAs assessed for their coverage of biogeographic zones and political (country) units | Kelleher et al. 1995 |
| 2 Global 200 (World Wildlife Fund [WWF]) | global | shelf regions and upwellings | 43 priority marine ecoregions defined; guiding principle for WWF's current conservation focus | iiia, iiib | five major habitat types nested within four marine biogeographic realms | relative scoring and opinion based: representation of habitat types on a global scale, biodiversity value and threat index, planning units are defined ecoregions | WWF 2000 |
| 3 High Seas Marine Protected Areas (WWF) | global | seas outside jurisdiction of coastal states | current status unknown; discussion documents in circulation | i, (ii) | distribution of biodiversity-related resources outside the jurisdiction of coastal states | ad hoc or opinion based? | Cripps & Christiansen 2001 |
| 4 Reefs at Risk (World Resources Institute) | global | coral reefs | used by Conservation International to define hotspots and by WWF to help define priority ecoregions | ii | distribution of coral reefs mapped onto grid-based database of threats | analytical: threat index, geographic information system (GIS), planning units are 50,000-km$^2$ grid cells | Bryant et al. 1998 |
| 5 coral reef hotspots (Conservation International [CI]) | global | coral reefs | 10 hotspots identified in 2002, but current status unknown | ii | distributions of restricted-range fish, coral, lobsters, and molluscs mapped onto grid-based database of threats | analytical: selection based on highest species richness, endemism, and threat index; GIS; planning units are 50,000-km$^2$ grid cells | Roberts et al. 2002 |
| 6 IUCN Red List of Threatened Species | global | individual threatened species | basis for species action plans; current status depends on the species | ii | species-by-species distributions; habitat modeling | expert opinion? tools and planning units depend on the species and data available | IUCN 2002*a* |
| 7 Particularly Sensitive Sea Areas (PSSA)(International Maritime Organisation) | global | areas with shipping activity | 5 PSSAs established | o, i | distribution of ecologically important areas within areas heavily frequented by shipping | ad hoc: proposals by individual countries, primary criterion is threat from shipping, no standardized planning units | Gjerde 2001 |
| 8 Ramsar Convention on Wetlands (United Nations) | global | wetlands (including coastal and shallow marine) | 1288 sites already designated (June 2003) including marine and coastal | i, iiia, iv | classification of wetland type, watershed processes, migration routes | ad hoc: proposals by individual countries (although strategic planning within biogeographical regions is encouraged), criteria include representation of wetland type within biogeographic region, globally significant population numbers, presence of endemic species | RAMSAR 1999 |
| 9 World Heritage Convention (United Nations) | global | natural and cultural heritage | 730 sites designated (June 2003) including 34 marine and coastal; IUCN currently reviewing biogeographic representation of these sites | i | site-by-site information | ad hoc: proposals by individual countries, criteria are historical, cultural, aesthetic, or ecological but no overall framework or planning units | IUCN 2002*b* |

*continued*

**Table 2. (continued)**

| Initiative number and name | Spatial extent | Defined by | Current status | Biogeographic information used (code and selected examples)$^b$ | | Decision-making methods, tools, planning units$^c$ | Reference |
|---|---|---|---|---|---|---|---|
| 10 Sea Around Us Project (Fisheries Centre, University of British Columbia) | regional | large marine ecosystems | used primarily for fisheries management but still largely theoretical | ii, iv | time-series distributions of fish biomass based on catch and effort data and stock assessments; habitat modeling | analytical: spatially explicit ecosystem modeling, some data based on expert opinion, planning units are 0.5-degree grid squares | Pauly 2000 |
| 11 Latin America and the Caribbean (TNC) | regional | political Exclusive Economic Zone (EEZ) (Central and South America) | brought more funding and attention to Gulf of Panama; in some situations stimulated planners to think on larger scale (e.g., initiative 17), but in general conservation in Caribbean still locally focused | ii, iiia, (iv) | oceanic circulation, coastal geomorphology, major fauna distributions, classification of coastal systems by primary habitat | relative scoring and opinion-based: expert workshop, indicators as direct/indirect measures of conservation status, ranking among ecoregions within biogeographic provinces and among coastal systems within ecoregions | Sullivan Sealey & Bustamante 1999; K. Sullivan Sealey, personal communication |
| 12 Southern Ocean Whale Sanctuary (International Whaling Commission) | regional | whales | in force since 1993 | ii | distributions of whales | ad hoc: proposal by France, delimited by ocean basin and by 40°S line of latitude | Reeves & Leatherwood 1994 |
| 13 Southeast Asia Regional Marine Programme (IUCN through World Commission on Protected Areas) | regional | political EEZ | current status unknown; working group formed in 2000 | (ii, iii, iv) | ecoregion classification, mapping of connectivity | unknown, not yet implemented, criteria will apparently include resilience, connectivty, representation | Gomez 2002 |
| 14 Reefs at Risk in Southeast Asia (World Resources Institute) | regional | coral reefs in Southeast Asia | widely circulated data set used by local, national, and regional conservation planners to identify priority sites | ii | see initiative 6 | see initiative 6 | Burke et al. 2002 |
| 15 Baja to Bering Initiative (Marine Conservation Biology Institute) | regional | political West Coast EEZ of Mexico, U.S.A., and Canada | priority-setting workshop held in early 2003 | ii | bathymetry, topography, sea surface temperature, chlorophyll data, deep-sea coral records, turtle and whale tracks | opinion-based: expert workshop, base maps, CD-rom of biological and social data available to workshop participants, no standardized planning units | N. Ban, personal communication |
| 16 Mesoamerican Reef (WWF) | regional | WWF ecoregion | guiding principle for WWF's Central America programs and funding priorities in the region; used by many local and national groups as a strategic framework for their conservation actions | ii, (iiib), iv | distributions of focal species, oceanography, satellite data, ecological processes (e.g., spawning areas); habitat representation only assessed post hoc, and based on broad categories (i.e., land/watershed, deep water, mangrove, lagoon, lake, coastal) | relative scoring and opinion-based: expert workshop, rankings, drawing on maps, working groups separated first by taxa then by subregion, GIS, 1 × 1 m thematic maps, no standardized planning units | Kramer & Kramer 2002; S. Marin, personal communication |
| 17 Barcelona Protocol (United Nations Environmenal Programme [UNEP]–Mediterranean Action Plan) | regional | political EEZ/large marine ecosystem | current status unknown; came into force in 1999; 4 taxon action plans adopted at same time | i | site-by-site information on presence of threatened taxa (e.g., monk seal, turtles, cetaceans, marine vegetation) | ad hoc: proposals by individual countries, criteria are historical, cultural, aesthetic, or ecological but no overall framework or planning units, transboundary proposals encouraged | UNEP 2002 |

*continued*

Table 2. (continued)

| Initiative number and name | Spatial extent | Defined by | Current status | Biogeographic information used (code and selected examples)[b] | | Decision-making methods, tools, planning units[c] | Reference |
|---|---|---|---|---|---|---|---|
| 18 Northern Gulf of Mexico Plan (TNC) | regional | ecoregion (inshore bays/estuaries only) | guiding principle for TNC's conservation action in region | ii, iiia,b | distributions of focal species and habitats, ecoregion classification | analytical and opinion-based: sites computer algorithm, GIS, expert workshop, planning units are bays/estuaries within subregions of ecoregion | Beck et al. 2000; Beck & Odaya 2001 |
| 19 Mid-Atlantic Priority Areas (Natural Resources Defense Council) | regional | fishery management, oil/gas leasing region, federal waters | status unknown; workshop report available on internet | ii, iv | distribution of focal speices, migratory pathways, nursery areas, physical features (e.g., canyons), oceanography (but no actual data used) | opinion based: expert opinion, drawing lines on maps, no standardized planning units or quantitative data | NRDC 2000 |
| 20 Gulf of California (Scripps Institution of Oceanography) | regional | geography | theoretical but apparently incorporated into ecoregional priority-setting plan by WWF and CI | ii, iiia, iv | species and habitat distributions, dispersal, oceanography, canonical correspondance analysis to identify zoogeographic regions | analytical: GIS, sites algorithm, planning units are islands, archipelagoes <50 km long, and individual mangroves all within 5 km of shore | Sala et al. 2002; E. Sala, personal communication |
| 21 Spratly Islands Marine Park | regional | larval connectivity | endorsed by IUCN and World Heritage Marine Biodiversity Workshop but not officially included in the South China Sea Marine Planning because of disputes over territorial ownership | iv | genetic connectivity, larval dispersal, oceanographic data | opinion based: genetic data | McManus 1994; J. W. McManus, personal communication |
| 22 National Marine Conservation Area System Plan (Parks Canada) | provincial | political EEZ | 2 currently operating sites, discussions or work underway for 5 others | iiib | large-scale biogeographic regions (see initiative 23); smaller scale not yet integrated | opinion based and ad hoc? research and public consultations, no standardized planning units | N. Ban, personal communication; A. Latourelle, personal communication |
| 23 National Representative System of Marine Protected Areas (Australia) | provincial | political EEZ | strategic plan endorsed in 1999; current focus on southeast marine region (SEMR); bioregionalization completed; MPAs being created in each of 11 "broad areas of interest" | ii, iiia,b iv | Interim Marine and Coastal Regionalisation for Australia, species distributions, physiographic and oceanographic features, integrated watershed planning | opinion based: stakeholder forums include government, sectoral and scientific experts; "operational criteria" used for identifying and selecting a comprehensive, adequate, and representative (CAR) system of MPAs; "broad areas of interest" as planning units | CSIRO 1996; Environment Australia 1998; M. Carr, personal communication |
| 24 CI priority-setting process (e.g., Philippines) | provincial | CI hotspot (in case of Philippines this is also political) | guiding principle for CI in the Philippines and also national biodiversity action plan | ii, iiia, b, iv | reef fish assemblages, geology, connectivity and dispersal features, biogeographic representation, biological importance, habitat quality, research need | opinion based: expert opinion, maps, no standardized planning units | Ong et al. 2002 |

*continued*

**Table 2. (continued)**

| Initiative number and name | Spatial extent | Defined by | Current status | Biogeographic information used (code and selected examples)$^b$ | | Decision-making methods, tools, planning units$^c$ | Reference |
|---|---|---|---|---|---|---|---|
| 25 Representative Areas Program (Great Barrier Reef Marine Park Authority) | provincial | ecology (extent of Great Barrier Reef) | providing guidance for revision of GBRMPA planning and especially siting of new no-take protected areas | iiia, b | biological and physical data sets, geomorphology and oceanography, special features | analytical: biophysical principles provided recommendations for the amount of no-take areas in each bioregion and each known habitat type; MARXAN and TRADER computer algorithms; individual reefs or 10- or 30-km$^2$ hexagons (in non-reef areas) are planning units | Day et al. 2003 |
| 26 Gulf of Maine International Ocean Wilderness (American Oceans Campaign) | provincial | Gulf of Maine continental shelf | proposed in 2000 but not yet in force | o | none, but being perpendicular to the shore the proposed protected area would contribute greatly to protecting a variety of different marine habitats | ad hoc: based on political boundary | Zeman & Willison 2001 |
| 27 United Kingdom Offshore Natura 2000 (European Union Habitats Directive) | regional | political EEZ | not yet in force but will extend the current remit of the United Kingdom's commitment to Natura 2000 (European Union Habitats Directive) to offshore regions | i, ii | locations of threatened species and habitats | unknown | Johnston 2002 |
| 28 South African marine hotspots | provincial | political, inshore | no new MPAs yet in force, but paper has been quoted extensively, and 2 successful funding applications for MPAs have been based on analysis | ii, iiia | shorefish distributions, cluster analysis and multidimensional scaling to define biogeographic provinces | analytical: hotspot and complementarity analyses, areas of highest species richness, 50-km-long analysis units along coast | Turpie et al. 2000; L. Beckley, personal communication |
| 29 Great Australian Bight Marine Park | local | geography | current status unknown; in force as of 2000 | ii, iii | habitat distribution, distribution of southern right whale and Australian sea lion, Interim Marine and Coastal Regionalisation for Australia | unknown | Environment Australia 2000 |
| 30 Extension of Florida Keys National Marine Sanctuary and creation of an ecological reserve | local | MPA boundary | ecological; no-take reserve in force as of 2001 | ii, iv | physical oceanography and recruitment, fish and fisheries, benthic communities | opinion-based: expert opinion, GIS, maps of resources and use, drawing lines on maps, discussion, 1-minute grid cells | National Oceanic and Atmospheric Administration 2000 |
| 31 Reserve selection in Kimbe Bay, Papua New Guinea | local | geography | theoretical; given to TNC and local nongovernmenal organizations and used as first approximation, but MPAs will probably be sited close to shore as result of limited resources | i, (iiia) | species lists at 37 sites, multidimensional scaling to derive biogeographical classification | analytical: variety of reserve-selection algorithms, sampling sites as planning units | Beger et al. 2003; M. Beger, personal communication |

continued

**Table 2. (continued)**

| *Initiative number and name* | *Spatial extent* | *Defined by* | *Current status* | *Biogeographic information used (code and selected examples)*$^b$ | | *Decision-making methods, tools, planning units*$^c$ | *Reference* |
|---|---|---|---|---|---|---|---|
| 32 Zoning in Bunaken Marine Protected Area, Indonesia | local | MPA boundary | in force | iiia, iiib | habitat distributions (secondary criteria only) | opinion based: stakeholder discussions, primary criteria are tourism related, secondary criteria are habitat distributions | Salm & Clark 2000 |
| 33 Ngerumekaol Channel, Palau (temporal closure) | local | geography | status unknown | iv | location of spawning aggregation for grouper and >50 other species | ad hoc: fish life history and behavior | Johannes et al. 1999 |
| 34 Apo Island, Philippines (no-take MPA) | local | geography | protected since 1982 | o | none | ad hoc: species richness, local community agreement, sociopolitical will | Russ & Alcala 1996 |

[a] *Abbreviations: EEZ, exclusive economic zone; GBRMPA, Great Barrier Reef Marine Park Authority; GIS, geographical information system; IUCN, World Conservation Union; MPA, marine protected area; PSSA, particularly sensistive sea area; WWF, World Wildlife Fund.*

[b] *Biogeographic information used in each project is assessed as follows: o, no biogeographic information; i, using biological/biogeographic information on a site-by-site basis; ii, mapping individual targets; iii, creating/utilizing biogeographical classifications based on (a) taxon ranges and (b) abiotic surrogates; iv, incorporating processes determining/maintaining biodiversity.*

[c] *For priority-setting initiatives, the way biogeographic data are used is assessed as ad hoc, opinion-based, relative scoring, or analytical. Tools, methods, and planning units employed are highlighted where known. Question mark indicates approaches that are likely used but unconfirmed as such.*

Several initiatives use a combination of approaches, such as taxon focus and biogeographic representation, and thus require a variety of biogeographic data. Examples include ecoregional planning for the northern Gulf of Mexico (initiative 18).

### Priority-Setting Methods

Once the data have been gathered, conservation projects also vary in methods for deciding on priority areas. Ad hoc approaches, such as international conventions that rely on proposals by individual countries (initiatives 7, 8, 9), have no overall framework for comparison. Selection criteria may exist, but the sites are not considered in relation to one another simultaneously. Individual marine protected areas (MPAs) are also often created without a concept of the larger seascape within which they are maintained (e.g., initiatives 33, 34).

Opinion-based approaches, such as Conservation International's priority setting in the Philippines (initiative 24), the Baja to Bering Initiative (initiative 15), and zoning in Bunaken Marine Protected Area (initiative 32) involve delphi or stakeholder workshops. Again, selection criteria may exist, but they are descriptive rather than quantitative and planning units may or may not be formally defined.

In approaches that employ relative scoring, such as WWF's Global 200 (initiative 2), planning units are usually defined. These are assessed against criteria by a transparent scoring method and a simple combination of scores.

Analytical approaches involve mathematical algorithms to define potential sites for conservation action (e.g., The Nature Conservancy's Northern Gulf of Mexico Plan, initiative 18; the Gulf of California, initiative 20; and reserve selection in Kimbe Bay, initiative 31). The simplest of these is exemplified by Conservation International's (CI) hotspots analysis (initiative 5), which identifies areas of highest species richness, endemism, and threat. The appeal of this method is its simplicity, but such comparisons only make sense if they are made between biogeographically similar areas, which is not the case in the CI analysis because it made comparisons across regions (e.g., Caribbean versus Indo-Pacific) (Baird et al. 2002).

Conservation planning that involves analytical methods to determine biogeographical classifications and to define a range of potential sites that fulfill specified criteria, followed by stakeholder involvement to set priorities in a consensus workshop, may be the most expedient approach (Beck 2003).

## Discussion and Recommendations

Our review suggests that marine conservation practitioners are showing an increasing awareness of the need to consider biogeography in their plans. Many older conservation initiatives proceeded primarily on a site-by-site basis, via ad hoc methods and with limited biogeographical data. More recently, initiatives have become more regional in scope, are beginning to use analytic methods, and include more biogeographic data. These produce more defensible, appropriate, and scientifically credible priorities that enable strategic planning and on-going assessment of achievements with respect to overall goals. Nevertheless, the concurrent rise of initiatives that seem to use few or no data (e.g., NRDC 2000) must be met with due caution.

At the World Summit on Sustainable Development (September 2002), 192 participating nations committed to creating a global representative network of marine protected areas by 2012 and to adopting an ecosystem approach to conservation by the year 2010 (UN/DESA 2002). These goals will be implemented through the Convention on Biological Diversity and its Jakarta Mandate (de Fontaubert et al. 1996) under the guidance of an ad hoc technical expert group which proposes that the "goal for the future should be the development of an effectively managed, ecologically representative global system of marine and coastal protected area networks" (CBD 2002).

To ensure that such systems are truly representative, we need to map marine habitats that are still poorly known. These include oyster beds, rocky reefs, soft-bottom habitats, sponge gardens, deep-sea corals, seamounts, cold seeps, hydrothermal vents, and trenches. We need global and regional reviews, including a formal gap analysis, of existing MPAs and other conservation initiatives that assess projects within a biogeographic framework and assess the representation of habitats, communities, and ecosystems included within marine protected areas in each region. Such a review is already underway for World Heritage sites (World Conservation Union 2002*b*). Ideally, the results of such reviews will help provide a framework for the next generation of marine conservation initiatives.

Other challenges are to understand contemporary processes that maintain species' distributions, design innovative methods to display them, and find ways to incorporate them in spatial conservation planning. Large Marine Ecosystems and MPA networks are steps in this direction.

On a longer time scale, we need an increased understanding of historical distributions to provide more appropriate baselines and goals for long-term conservation than provided by the distributions of our present impoverished biota (Pauly 1995). To build resilience into our networks, we also need to understand the ephemeral nature of some systems such as hydrothermal vents (WWF/IUCN 2001) and the effect that climate change may have on the distribution of marine diversity (Salm & Clark 2000; Hannah et al. 2002).

We have stressed that biogeography should be at the forefront of determining spatial priorities for proactive marine conservation planning. The spatial distribution and scale of biodiversity, the processes maintaining it, and the threats to it need to be understood so that appropriate conservation measures may be initiated. We have highlighted advances in marine biogeography that are enabling us to develop data-rich plans that include information on the distributions of species and ecosystems and some of the processes that determine and maintain these patterns. Some of these advances have been stimulated by the needs of conservation planners, and it is likely that this feedback will continue.

Setting priorities is always controversial, but unless we do so, we risk compromising the long-term persistence of systems. Notwithstanding time constraints imposed by the rapid destruction of marine ecosystems worldwide, priority setting should be based on credible information and scientifically defensible methods while supporting and integrating knowledge as it becomes available. Of course, the final choices of conservation planners will be affected by, and their success ultimately dependent on, many social, cultural, and political factors in addition to biogeographical ones. Nevertheless, biogeography can play a pivotal role in providing the scientific basis for marine conservation planning. We believe that explicit incorporation of biogeography in conservation planning will move us closer to our goals of representative and viable networks of healthy marine systems.

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