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Marine Ecoregions of the World: A Bioregionalization of Coastal and Shelf Areas

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The conservation and sustainable use of marine resources is a highlighted goal on a growing number of national and international policy agendas. Unfortunately, efforts to assess progress, as well as to strategically plan and prioritize new marine conservation measures, have been hampered by the lack of a detailed, comprehensive biogeographic system to classify the oceans. Here we report on a new global system for coastal and shelf areas: the Marine Ecoregions of the World, or MEOW, a nested system of 12 realms, 62 provinces, and 232 ecoregions. This system provides considerably better spatial resolution than earlier global systems, yet it preserves many common elements and can be cross-referenced to many regional biogeographic classifications. The designation of terrestrial ecoregions has revolutionized priority setting and planning for terrestrial conservation; we anticipate similar benefits from the use of a coherent and credible marine system.

In the absence of compelling global coverage, numerous regional classifications have been created to meet regional planning needs. This, of course, does not satisfy the need for a global system that is consistent across the many marine realms and coastal zones.

Biogeographic classifications are essential for developing ecologically representative systems of protected areas, as required by international agreements such as the Convention on Biological Diversity’s Programme of Work on Protected Areas and the Ramsar Convention on Wetlands. Marine space is still grossly underrepresented in the global protected areas network (only about 0.5% of the surface area of the oceans is currently protected; Chape et al. 2005), a fact that adds urgency to the need for tools to support the scaling up of effective, representative marine conservation. The key idea underlying the term “representative” is the intent to protect a full range of biodiversity worldwide—genes, species, and...
higher taxa, along with the communities, evolutionary patterns, and ecological processes that sustain this diversity. Biogeographic classifications provide a crucial foundation for the assessment of representativeness (Olson and Dinerstein 2002, Lourie and Vincent 2004).

The growing commitment by governments and the United Nations (UN; e.g., the UN Law of the Sea, the UN Fish Stocks Agreement) to implement comprehensive arrangements for ocean governance provides an additional arena in which marine biogeographic classifications are needed. Biogeographic regions are natural frameworks for marine zoning, which is a tool increasingly used by regional fisheries management organizations.

In this article, we present a new biogeographic classification for the world’s coastal and shelf areas, which draws heavily on the existing global and regional literature. We believe that this classification will be of critical importance in supporting analyses of patterns in marine biodiversity, in understanding processes, and, perhaps most important, in directing future efforts in marine resource management and conservation.

**Approaches for defining boundaries**

Observations of global biogeographic patterns in the marine environment include early works by Forbes (1856), Ekman (1953, first published in German in 1935), and Hedgpeth (1957a), and more recent publications by Briggs (1974, 1995), Hayden and colleagues (1984), Bailey (1998), and Longhurst (1998). These authors used a variety of definitions and criteria for drawing biogeographic divisions. For example, Briggs (1974, 1995) focused on a system of coastal and shelf provinces defined by their degree of endemism (> 10%). This strong taxonomic focus and clear definition have led to relatively widespread adoption of Briggs’s system, including its use by Hayden and colleagues (1984), with minor amendments, as a part of their “classification of the coastal and marine environments.” Adey and Steneck (2001) provided independent verification of many of Briggs’s subdivisions in a study that modeled “thermogeographic” regions of evolutionary stability.

Another important systematic approach, aimed mainly at pelagic systems, is the two-tier system devised by Longhurst (1998), which focuses on biomes and biogeochemical provinces. These subdivisions were based on a detailed array of oceanographic factors, tested and modified using a large global database of chlorophyll profiles. The results represent one of the most comprehensive partitionings of the pelagic biota, but the scheme is of limited utility in the complex systems of coastal waters, a fact acknowledged by the author, who has recommended combining his open ocean system with others for coastal and shelf waters (Watson et al. 2003; Alan R. Longhurst, Galerie l’Academie, Cajarc, France, personal communication, 2 November 2004).

The system of large marine ecosystems (LMEs) was developed over many years by a number of regional experts, with considerable input from fisheries scientist Ken Sherman (e.g., Sherman and Alexander 1989, Hempel and Sherman 2003, Sherman et al. 2005). Unlike the systems of Briggs and Longhurst, LMEs represent an expert-derived system without a rigorous, replicable core definition. LMEs are “relatively large regions on the order of 200,000 km² or greater, characterized by distinct: (1) bathymetry, (2) hydrography, (3) productivity, and (4) trophically dependent populations” (www.lme.noaa.gov/Portal/). LMEs are largely conceived as units for the practical application of transboundary management issues (fish and fisheries, pollution, habitat restoration, productivity, socioeconomics, and governance). The LME system focuses on productivity and oceanographic processes, and in its present form omits substantial areas of islands in the Pacific and the Indian oceans.

These and other global systems continue to play an important role in developing our understanding of marine biogeography and in practical issues of natural resource management. However, improvements are clearly possible and desirable. An ideal system would be hierarchical and nested, and would allow for multiscale analyses. Each level of the hierarchy would be relevant for conservation planning or management interventions, from the global to the local, although it is beyond the scope of the present effort to classify individual habitats or smaller features, such as individual estuaries or seagrass meadows.

We focus here on coastal and shelf waters, combining benthic and shelf pelagic (neritic) biotas. These waters represent the areas in which most marine biodiversity is confined, where human interest and attention are greatest, and where there is often a complex synergy of threats far greater than in offshore waters (UNEP 2006). From a biodiversity perspective, it is not simply that coastal and shelf waters have greater species numbers and higher productivity, but also that they are biogeographically distinct from the adjacent high seas and deep benthic environments (Ekman 1953, Hedgpeth 1957a, Briggs 1974).

Our intention was to develop a hierarchical system based on taxonomic configurations, influenced by evolutionary history, patterns of dispersal, and isolation. We drew up initial guidelines on definitions and nomenclature to guide the first data-gathering phase, then reviewed and refined them iteratively on the basis of the available data.

We reviewed over 230 works in journals, NGO (non-governmental organization) reports, government publications, and other sources. For each of these, we looked at the underlying data and at the process of identification and definition of biogeographic units; we also considered the objectives of the classifications. To facilitate comparisons, we used digital mapped versions of many of the existing biogeographic units. More than 40 independent experts provided further advice (see the acknowledgments section). We refined a draft classification scheme through an assessment and review process that involved a three-day workshop. In arriving at our classification scheme, we adhered to three principles for our classification: that it should have a strong biogeographic basis, offer practical utility, and be characterized by parsimony.
A strong biogeographic basis. All spatial units were defined on a broadly comparable biogeographic basis. Existing systems rely on a broad array of source information—range discontinuities, dominant habitats, geomorphological features, currents, and temperatures, for example—to identify areas and boundaries. In many cases these divergent approaches are compatible, given the close links between biodiversity and the underlying abiotic drivers (see the comparisons below). We preferred to be informed by composite studies that combined multiple divergent taxa or multiple oceanographic drivers in the derivation of boundaries, as these were more likely to capture robust or recurring patterns in overall biodiversity.

A number of systems we reviewed were broadly biogeographic, but with some adjustments to fit political boundaries. Where it was possible to discern the biogeographic elements from the political, these systems were still used to inform the process.

Practical utility. We sought to develop a nested system, operating globally at broadly consistent spatial scales and incorporating the full spectrum of habitats found across shelves. We thus avoided very fine-resolution systems that separated coastal and shelf waters into constituent habitats. We chose not to try to define minimum or maximum spatial areas for our bioregions, but in some cases we did seek out systems that subdivided very large spatial units (such as Briggs’s Indo-Polynesian Province, which covers more than 20% of the world’s shallow shelf areas) or that amalgamated fine-scale units such as single large estuaries or sounds.

 Parsimony. There are a number of respected and widely utilized global and regional systems, and lack of agreement between such systems can be problematic. In developing a new system, we sought to minimize further divergence from existing systems, yet still to obtain a truly global classification system. We did this by adopting a nested hierarchy that (a) utilized systems that are already widely adopted (e.g., the Nature Conservancy’s system in much of the Americas and the Interim Marine and Coastal Regionalisation for Australia) and (b) fitted closely within broader-scale systems or alongside other regional systems.

Definitions
After the review process, we arrived at a set of critical working definitions.

Realms. The system’s largest spatial units are based on the terrestrial concept of realms, described by Udvardy (1975) as “continent or subcontinent-sized areas with unifying features of geography and fauna/flora/vegetation.” From our marine perspective, realms are defined as follows:

Very large regions of coastal, benthic, or pelagic ocean across which biotas are internally coherent at higher taxonomic levels, as a result of a shared and unique evolutionary history. Realms have high levels of endemism, including unique taxa at generic and family levels in some groups. Driving factors behind the development of such unique biotas include water temperature, historical and broadscale isolation, and the proximity of the benthos.

This article, with its focus on coastal and shelf areas, does not consider realms in pelagic or deep benthic environments. This is an area requiring further analysis and development.

Provinces. Nested within the realms are provinces:

Large areas defined by the presence of distinct biotas that have at least some cohesion over evolutionary time frames. Provinces will hold some level of endemism, principally at the level of species. Although historical isolation will play a role, many of these distinct biotas have arisen as a result of distinctive abiotic features that circumscribe their boundaries. These may include geomorphological features (isolated island and shelf systems, semienclosed seas); hydrographic features (currents, upwellings, ice dynamics); or geochemical influences (broadest-scale elements of nutrient supply and salinity).

In ecological terms, provinces are cohesive units likely, for example, to encompass the broader life history of many constituent taxa, including mobile and dispersive species. In many areas, the scale at which provinces may be conceived is similar to that of the detailed spatial units used in global systems such as Briggs’s provinces, Longhurst’s biogeochemical provinces, and LMEs.

Ecoregions. Ecoregions are the smallest-scale units in the Marine Ecoregions of the World (MEOW) system and are defined as follows:

Areas of relatively homogeneous species composition, clearly distinct from adjacent systems. The species composition is likely to be determined by the predominance of a small number of ecosystems and/or a distinct suite of oceanographic or topographic features. The dominant biogeographic forcing agents defining the ecoregions vary from location to location but may include isolation, upwelling, nutrient inputs, freshwater influx, temperature regimes, ice regimes, exposure, sediments, currents, and bathymetric or coastal complexity.

In ecological terms, these are strongly cohesive units, sufficiently large to encompass ecological or life history processes for most sedentary species. Although some marine ecoregions may have important levels of endemism, this is not a key determinant in ecoregion identification, as it has been in terrestrial ecoregions.
We suggest that the most appropriate outer boundary for these coastal and shelf realms, provinces, and ecoregions is the 200-meter (m) isobath, which is a widely used proxy for the shelf edge and often corresponds to a dramatic ecotone (Forbes 1856, Hedgpeth 1957b, Briggs 1974). Such a sharp boundary can only be indicative: Shelf breaks are not always clear; the bathymetric location of an “equivalent” biotic transition is highly variable; and there is considerable overlap and influence between shelf, slope, and adjacent pelagic biotas. At the same time, most of the classifications that we reviewed have been heavily influenced by data from nearshore and intertidal biotas, and data from deeper water typically had decreasing influence on boundary definitions. We believe that beyond 200 m, other biogeographic patterns will increasingly predominate, altering or hiding the patterns represented by the system proposed here.

**A global, nested system**

We propose a nested system of 12 realms, 62 provinces, and 232 ecoregions covering all coastal and shelf waters of the world.

As the MEOW system is based on existing classifications, variation and mismatch among systems led to challenges and compromises. The global coastal classifications of Briggs and Hayden, for example, do not show great congruence with the LMEs. The Briggs and related Hayden systems appeared to be more closely allied to our need for a system with a stronger biogeographic basis than the current LME delineations. Both the Briggs and Hayden systems and the LMEs show considerable variation in the size of their spatial units; the Briggs approach of using 10% endemism distinguishes many isolated communities around oceanic islands, but fails to disaggregate vast areas with gradual faunal changes, even where the incremental effects of such changes are very large indeed (e.g., the Indo-Pacific). The large spatial units in all of these systems clearly encompass significant levels of internal biogeographic heterogeneity, which we were keen to disaggregate through a more detailed system of ecoregions.

We found regional systems for almost all coastal and shelf waters, although many are described only in the gray literature. Notable exceptions were the Russian Arctic and the continental coasts of much of South, Southeast, and East Asia. For these areas, we relied heavily on global data sets and unpublished expert opinion, using more focused biogeographic publications (where available) for refining individual boundaries.

Figure 1 depicts the review process, showing four biogeographic schemes: Briggs’s system of provinces (1974, 1995); an expert-derived system combining biotic and abiotic features for South America (Sullivan Sealey and Bustamante 1999); the current LMEs; and a regional classification based on a single taxonomic grouping (decapod crustaceans; Boschi 2000). Despite their different origins, these systems show a re-
markable congruence at a number of key biogeographic boundaries.

Thus, it was possible to adopt a single system as a primary source, and the MEOW provinces (figure 1, right) were based almost entirely on Sullivan Sealey and Bustamante (1999), while remaining well aligned with the other systems. At a finer resolution, the ecoregions for South America are derived almost entirely from the same publication (Sullivan Sealey and Bustamante 1999), this being the only comprehensive system for these coasts. Even at this scale, however, efforts were made to locate independent verification of boundaries, and it is reassuring to note that these more detailed subdivisions were often supported by data from other oceanographic and ecological literature (see, e.g., Strub et al. [1998], Fernandez et al. [2000], Ojeda et al. [2000], and Camus [2001] for data concerning the Chilean coast).

Although the boundaries in other regions were not as simple to resolve as those along the South American coast, we applied the same approaches. The section that follows gives some information on the key sources used in drawing boundaries.

**Marine Ecoregions of the World**

Box 1 and figures 2 and 3 give a summary of the entire MEOW system, which covers all coastal and shelf waters shallower than 200 m. The shaded area of each map (figures 2, 3) extends 370 kilometers (200 nautical miles) offshore (or to the 200-m isobath, where this lies further offshore),

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**Figure 2. Final biogeographic framework: Realms and provinces. (a) Biogeographic realms with ecoregion boundaries outlined. (b) Provinces with ecoregions outlined. Provinces are numbered and listed in box 1.**
### Box 1. Marine Ecoregions of the World.

Numbers for the provinces and ecoregions match those shown in the figures 2b and 3. Realms are indicated in boldface, provinces (1–62) in italics, and ecoregions (1–232) in roman type.

#### Arctic
1. Arctic (no provinces identified)
   1. North Greenland
   2. North and East Iceland
   3. East Greenland Shelf
   4. West Greenland Shelf
   5. Northern Grand Banks–Southern Labrador
   6. Northern Labrador
   7. Baffin Bay–Davis Strait
   8. Hudson Complex
   9. Lancaster Sound
10. High Arctic Archipelago
11. Beaufort–Amundsen–Viscount Melville–Queen Maud
12. Beaufort Sea—continental coast and shelf
13. Bering Sea
14. Eastern Bering Sea
15. East Siberian Sea
16. Laptev Sea
17. Kara Sea
18. North and East Barents Sea
19. White Sea

#### Temperate Northern Atlantic
2. Northern European Seas
   20. South and West Iceland
   21. Faroe Plateau
   22. Southern Norway
   23. Northern Norway and Finnmark
   24. Baltic Sea
   25. North Sea
   26. Celtic Seas
3. Lusitanian
   27. South European Atlantic Shelf
   28. Saharan Upwelling
   29. Azores Canaries Madeira

#### Mediterranean Sea
4. Mediterranean Sea
   30. Adriatic Sea
   31. Aegean Sea
   32. Levantine Sea
   33. Tunisian Plateau/Gulf of Sidra
   34. Ionian Sea
   35. Western Mediterranean
   36. Alboran Sea

#### Cold Temperate Northwest Atlantic
5. Cold Temperate Northwest Atlantic
   37. Gulf of St. Lawrence–Eastern Scotian Shelf
   38. Southern Grand Banks–South Newfoundland
   39. Scotian Shelf
   40. Gulf of Maine/Bay of Fundy
   41. Virginian

#### Warm Temperate Northwest Atlantic
6. Warm Temperate Northwest Atlantic
   42. Carolinian
   43. Northern Gulf of Mexico

#### Black Sea
7. Black Sea
   44. Black Sea

#### Temperate Northern Pacific
8. Cold Temperate Northwest Pacific
   45. Sea of Okhotsk
   46. Kamchatka Shelf and Coast
   47. Okhotsk Current
   48. Northeastern Honshu
   49. Sea of Japan
   50. Yellow Sea

#### Warm Temperate Northwest Pacific
9. Warm Temperate Northwest Pacific
   51. Central Kuroshio Current
   52. East China Sea

#### Cold Temperate Northeast Pacific
10. Cold Temperate Northeast Pacific
    53. Aleutian Islands

    54. Gulf of Alaska
    55. North American Pacific Fjordland
    56. Puget Trough/Georgia Basin
    57. Oregon, Washington, Vancouver Coast and Shelf
    58. Northern California

#### Warm Temperate Northeast Pacific
11. Warm Temperate Northeast Pacific
    59. Southern California Bight
    60. Cortezian
    61. Magdalena Transition

#### Tropical Atlantic
12. Tropical Northwestern Atlantic
    62. Brazil
    63. Bahamian
    64. Eastern Caribbean
    65. Greater Antilles
    66. Southern Caribbean
    67. Southwest Caribbean
    68. Western Caribbean
    69. Southern Gulf of Mexico
    70. Floridian
    71. North Brazil Shelf
    72. Amazonia

#### Tropical Southwestern Atlantic
13. Tropical Southwestern Atlantic
    73. Sao Pedro and Sao Paulo Islands
    74. Fernando de Noronha and Atol das Rocas
    75. Northeastern Brazil
    76. Eastern Brazil
    77. Trindade and Martin Vaz Islands

#### West Africa Transition
14. West Africa Transition
    78. St. Helena and Ascension Islands
    79. Cape Verde
    80. Sahelian Upwelling

#### Gulf of Guinea
15. Gulf of Guinea
    81. Gulf of Guinea West
    82. Gulf of Guinea Upwelling
    83. Gulf of Guinea Central
    84. Gulf of Guinea Islands
    85. Gulf of Guinea South
    86. Angolan

#### Western Indo-Pacific
16. Western Indo-Pacific
    87. Northern and Central Red Sea
    88. Southern Red Sea
    89. Gulf of Aden
    90. Arabian (Persian) Gulf
    91. Gulf of Oman
    92. Gulf of Oman
    93. Central Somali Coast
    94. Northern Monsoon Current Coast
    95. East African Coral Coast
    96. Seychelles
    97. Cargados Carajos/Ironselin Island
    98. Mascarene Islands
    99. Southeast Madagascar
    100. Western and Northern Madagascar
    101. Bight of Sofala/Swamp Coast
    102. Delagoa

#### South and West Indian Ocean
17. South and West Indian Ocean
    103. Western India
    104. South India and Sri Lanka
    105. Maldives
    106. Chagos

#### Coral Sea
18. Red Sea and Gulf of Aden
    107. Eastern India
    108. Northern Bay of Bengal

#### Andaman
19. Andaman
    109. Andaman and Nicobar Islands
    110. Andaman Sea Coral Coast
    111. Eastern Sumatra

#### Central Indo-Pacific
20. Central Indo-Pacific
    112. Gulf of Tonkin
    113. Southern China
    114. South China Sea Oceanic Islands

#### Sunda Shelf
21. Sunda Shelf
    115. Gulf of Thailand
    116. Southern Vietnam
    117. Sunda Shelf/Java Sea
    118. Malacca Strait

#### Java Transition
22. Java Transition
    119. Southern Java
    120. Cocos-Keeling/Christmas Island

#### South Kuroshio
23. South Kuroshio
    121. South Kuroshio

#### Tropical Western Pacific
24. Tropical Western Pacific
    122. Ogasawara Islands
    123. Mariana Islands
    124. East Caroline Islands
    125. West Caroline Islands

#### Western Coral Triangle
25. Western Coral Triangle
    126. Palawan/North Borneo
    127. Eastern Philippines
    128. Sulawesi Sea/Makassar Strait
    129. Halmahera
    130. Papua
    131. Banda Sea
    132. Lesser Sundas
    133. Northeast Sulawesi

#### Eastern Coral Triangle
26. Eastern Coral Triangle
    134. Bismarck Sea
    135. Solomon Archipelago
    136. Solomon Sea
    137. Southeast Papua New Guinea

#### Sahul Shelf
27. Sahul Shelf
    138. Gulf of Papua
    139. Arafura Sea
    140. Arnhem Coast to Gulf of Carpentaria
    141. Bonaparte Coast

#### Northeast Australian Shelf
28. Northeast Australian Shelf
    142. Torres Strait Northern Great Barrier Reef
    143. Central and Southern Great Barrier Reef

#### Northwest Australian Shelf
29. Northwest Australian Shelf
    144. Exmouth to Broome
    145. Ningaloo

#### Tropical Southwestern Pacific
30. Tropical Southwestern Pacific
    146. Tonga Islands
    147. Fiji Islands
    148. Vanuatu
    149. New Caledonia
    150. Coral Sea

#### Lord Howe and Norfolk Islands
31. Lord Howe and Norfolk Islands
    151. Lord Howe and Norfolk Islands

#### Eastern Indo-Pacific
32. Eastern Indo-Pacific
    152. Hawaii
    153. Marshall, Gilbert, and Ellis Islands
    154. Marshall Islands

#### Southern China
33. Southern China
    155. China

#### South China Sea
34. South China Sea
    156. South China Sea

#### Japan
35. Japan
    157. Japan

#### Philippine Sea
36. Philippine Sea
    158. Philippine Sea

#### West Caroline Islands
37. West Caroline Islands
    159. West Caroline Islands

#### Southern China
38. Southern China
    160. Southern China

#### East China Sea
39. East China Sea
    161. East China Sea

#### Yellow Sea
40. Yellow Sea
    162. Yellow Sea

#### Kuroshio
41. Kuroshio
    163. Kuroshio

#### Central Indo-Pacific
42. Central Indo-Pacific
    164. Central Indo-Pacific

#### Coral Sea
43. Coral Sea
    165. Coral Sea
but, as already noted, we consider the principal focus of this classification to be the benthos above 200 m and the overlying water column.

Key sources included the following:

- Biogeographic assessments in the peer-reviewed literature, including the global studies already mentioned and many regional publications (e.g., Bustamante and Branch [1996] and Turpie et al. [2000] for temperate southern Africa, Linse et al. [2006] for the Southern Ocean)

- Ecoregional assessments conducted by NGOs (e.g., Sullivan Sealey and Bustamante [1999] for Latin America, WWF [2004 and unpublished reports] for much of Africa, Green and Mous [2006] for the Coral Triangle provinces)

- Government-derived or supported systems (e.g., Thackway and Cresswell [1998] for Australia, Powles et al. [2004] for Canada)

- Input from several of the authors of this article and assessments commissioned explicitly for the MEOW process (e.g., unpublished reports by Jerry M. Kemp in 2005 for the Middle Eastern seas and by S. A. L. in 2006 for the Andaman to Java coasts); the system for the Indo-Pacific oceanic islands was developed by one of us (G. R. A.) on the basis of many years of field experience, expert review, and networking with other scientists across the region

These schemes were assessed alongside other biogeographic literature, and in some cases alterations were made to better represent the arguments of biogeography, utility, and parsimony outlined above. A full listing of the sources referenced can be found at www.nature.org/MEOW or www.worldwildlife.org/MEOW.

The proposed realms adopt the broad latitudinal divisions of polar, temperate, and tropical, with subdivisions based on ocean basin (broadly following the oceanic biomes of Longhurst [1998]). In the temperate waters of the Southern Hemisphere, we diverge from this approach. We consider the differences across the oceans too substantial, and the connections around the continental margins too great, to support either ocean basin subdivisions or a single circumglobal realm (equivalent to Longhurst’s Antarctic Westerly Winds Biome), and hence we have adopted continental

### Box 1. (continued)

<table>
<thead>
<tr>
<th>Numbers for the provinces and ecoregions match those shown on the maps in figures 2b and 3. Realms are indicated in boldface, provinces (1–62) in italics, and ecoregions (1–232) in roman type.</th>
</tr>
</thead>
<tbody>
<tr>
<td>39. Central Polynesia</td>
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<tr>
<td>155. Line Islands</td>
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<tr>
<td>156. Phoenix/Tokelau/Northern Cook Islands</td>
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<tr>
<td>157. Samoan Islands</td>
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<tr>
<td>40. Southeast Polynesia</td>
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<td>158. Tuamotus</td>
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<td>159. Rapa-Pitcairn</td>
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<td>160. Southern Cook/Atuial Islands</td>
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<td>161. Society Islands</td>
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<td>41. Marquesas</td>
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<tr>
<td>162. Marquesas</td>
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<td>42. Easter Island</td>
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<td>163. Easter Island</td>
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<tr>
<td><strong>Tropical Eastern Pacific</strong></td>
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<td>43. Tropical East Pacific</td>
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<td>164. Revillagigedos</td>
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<td>165. Clipperton</td>
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<td>166. Mexican Tropical Pacific</td>
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<td>167. Chiapas–Nicaragua</td>
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<td>168. Nicoya</td>
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<td>169. Cocos Islands</td>
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<td>170. Panama Bight</td>
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<td>171. Guayaquil</td>
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<td>44. Galapagos</td>
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<td>172. Northern Galapagos Islands</td>
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<td>173. Eastern Galapagos Islands</td>
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<td>174. Western Galapagos Islands</td>
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<tr>
<td><strong>Temperate South America</strong></td>
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<td>45. Warm Temperate Southeastern Pacific</td>
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<td>175. Central Peru</td>
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<td>176. Humboldtian</td>
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<td>177. Central Chile</td>
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<td>178. Araucanian</td>
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<td>46. Juan Fernández and Desventuradas</td>
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<td>179. Juan Fernández and Desventuradas</td>
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<td>47. Warm Temperate Southwestern Atlantic</td>
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<td>180. Southeastern Brazil</td>
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<td>181. Rio Grande</td>
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<td>182. Rio de la Plata</td>
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<td>183. Uruguay–Buenos Aires Shelf</td>
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<td>48. Magellanic</td>
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<td>184. North Patagonian Gulfs</td>
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<td>185. Patagonian Shelf</td>
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<td>186. Malvinas/Falklands</td>
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<td>187. Channels and Fjords of Southern Chile</td>
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<td>188. Chiloense</td>
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<tr>
<td>49. Tristan Gough</td>
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<td>189. Tristan Gough</td>
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<tr>
<td><strong>Temperate Southern Africa</strong></td>
</tr>
<tr>
<td>50. Benguela</td>
</tr>
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<td>190. Namib</td>
</tr>
<tr>
<td>191. Namqua</td>
</tr>
<tr>
<td>51. Agulhas</td>
</tr>
<tr>
<td>192. Agulhas Bank</td>
</tr>
<tr>
<td>193. Natal</td>
</tr>
<tr>
<td>52. Amsterdam–St Paul</td>
</tr>
<tr>
<td>194. Amsterdam–St Paul</td>
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<tr>
<td><strong>Temperate Australasia</strong></td>
</tr>
<tr>
<td>53. Northern New Zealand</td>
</tr>
<tr>
<td>195. Kermadec Island</td>
</tr>
<tr>
<td>196. Northeastern New Zealand</td>
</tr>
<tr>
<td>197. Three Kings–North Cape</td>
</tr>
<tr>
<td>54. Southern New Zealand</td>
</tr>
<tr>
<td>198. Chatham Island</td>
</tr>
<tr>
<td>199. Central New Zealand</td>
</tr>
<tr>
<td>200. South New Zealand</td>
</tr>
<tr>
<td>201. Snares Island</td>
</tr>
<tr>
<td>55. East Central Australasian Shelf</td>
</tr>
<tr>
<td>202. Tweed Moreton</td>
</tr>
<tr>
<td>203. Manning-Hawkesbury</td>
</tr>
<tr>
<td>56. Southeast Australian Shelf</td>
</tr>
<tr>
<td>204. Cape Howe</td>
</tr>
<tr>
<td>205. Bassian</td>
</tr>
<tr>
<td>206. Western Bassian</td>
</tr>
<tr>
<td>57. Southwest Australian Shelf</td>
</tr>
<tr>
<td>207. South Australian Gulfs</td>
</tr>
<tr>
<td>208. Great Australian Bight</td>
</tr>
<tr>
<td>209. Leeuwin</td>
</tr>
<tr>
<td>58. West Central Australasian Shelf</td>
</tr>
<tr>
<td>210. Shark Bay</td>
</tr>
<tr>
<td>211. Houtman</td>
</tr>
<tr>
<td><strong>Southern Ocean</strong></td>
</tr>
<tr>
<td>59. Subantarctic Islands</td>
</tr>
<tr>
<td>212. Macquarie Island</td>
</tr>
<tr>
<td>213. Heard and Macdonald Islands</td>
</tr>
<tr>
<td>214. Kerguelen Islands</td>
</tr>
<tr>
<td>215. Crozet Islands</td>
</tr>
<tr>
<td>216. Prince Edward Islands</td>
</tr>
<tr>
<td>217. Bouvet Island</td>
</tr>
<tr>
<td>218. Peter the First Island</td>
</tr>
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<td>60. Scotia Sea</td>
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<tr>
<td>219. South Sandwich Islands</td>
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<tr>
<td>220. South Georgia</td>
</tr>
<tr>
<td>221. South Orkney Islands</td>
</tr>
<tr>
<td>222. South Shetland Islands</td>
</tr>
<tr>
<td>223. Antarctic Peninsula</td>
</tr>
<tr>
<td>61. Continental High Antarctic</td>
</tr>
<tr>
<td>224. East Antarctic Wilkes Land</td>
</tr>
<tr>
<td>225. East Antarctic Enderby Land</td>
</tr>
<tr>
<td>226. East Antarctic Dronning Maud Land</td>
</tr>
<tr>
<td>227. Weddell Sea</td>
</tr>
<tr>
<td>228. Amundsen/Bellinghausen Sea</td>
</tr>
<tr>
<td>229. Ross Sea</td>
</tr>
<tr>
<td>62. Subantarctic New Zealand</td>
</tr>
<tr>
<td>230. Bounty and Antipodes Islands</td>
</tr>
<tr>
<td>231. Campbell Island</td>
</tr>
<tr>
<td>232. Auckland Island</td>
</tr>
</tbody>
</table>
Figure 3. Final biogeographic framework, showing ecoregions. Ecoregions are numbered and listed in box 1.
margin realms for temperate Australasia, southern Africa, and South America. The paucity of existing literature discussing these broadest-scale biogeographic units from a global perspective presents a stark contrast to the terrestrial biogeographic literature.

The level of internal heterogeneity of biotas within different realms is quite varied. For some realms, the differences in biota at the provincial level are substantial, including the warm temperate faunas on either side of the Temperate South America realm and the tropical faunas on either side of the Tropical Atlantic realm. By contrast, we have subdivided the widely used Indo-Pacific “realm” into three units. This is the region of greatest diversity, and it covers a vast area. Across this region are clinal changes in taxa that lack clear breaks, but are sufficiently large that faunas at either end bear little resemblance to each other. Our Indo-Pacific subdivisions (which might be appropriate to consider as subrealms) follow less clearly defined biogeographic boundaries than other realms, but these divisions produce spatial units that are more comparable to other realms in overall biodiversity, levels of endemism, and spatial area.

At broader scales, we undertook a simple spatial analysis to explore the links or possible crossovers between the MEOW system, LMEs, and Briggs’s provinces. The incomplete coverage of the LME system is clearly limiting for global conservation planning: 78 of our 232 ecoregions include a substantive area (greater than 10% of their total area) that is not covered by any LME. Of the remainder, some 49% of LMEs show good congruence (>90% of shelf area) with either single ecoregions or ecoregion combinations. (The boundary of the Arctic LME has not been mapped, and so was ignored in these calculations.) In comparison, 30 of Briggs’s 53 provinces (57%) show good congruence (>90% of shelf area) with single ecoregions or ecoregion combinations. This figure rises to 39 (74%) if we include congruence at 85% of the shelf area.

We also used the MEOW system to look at the coverage of the marine and coastal network of Ramsar sites. Contracting

### Table 1. The geographic spread of marine and coastal Ramsar sites within the Marine Ecoregions of the World classification.

<table>
<thead>
<tr>
<th>Realm</th>
<th>Total Ramsar sites</th>
<th>Number with Ramsar sites</th>
<th>Ecoregions</th>
<th>Percentage with Ramsar sites</th>
<th>Provinces</th>
<th>Number with Ramsar sites</th>
<th>Total number</th>
<th>Percentage with Ramsar sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arctic</td>
<td>26</td>
<td>10</td>
<td>19</td>
<td>53</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>100</td>
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<tr>
<td>Temperate Northern Atlantic</td>
<td>374</td>
<td>21</td>
<td>25</td>
<td>84</td>
<td>6</td>
<td>6</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Temperate Northern Pacific</td>
<td>38</td>
<td>12</td>
<td>17</td>
<td>71</td>
<td>4</td>
<td>4</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Tropical Atlantic</td>
<td>117</td>
<td>17</td>
<td>25</td>
<td>68</td>
<td>4</td>
<td>6</td>
<td>67</td>
<td></td>
</tr>
<tr>
<td>Western Indo-Pacific</td>
<td>41</td>
<td>14</td>
<td>25</td>
<td>56</td>
<td>7</td>
<td>7</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Central Indo-Pacific</td>
<td>35</td>
<td>16</td>
<td>40</td>
<td>40</td>
<td>10</td>
<td>12</td>
<td>83</td>
<td></td>
</tr>
<tr>
<td>Eastern Indo-Pacific</td>
<td>11</td>
<td>1</td>
<td>12</td>
<td>8</td>
<td>1</td>
<td>6</td>
<td>83</td>
<td></td>
</tr>
<tr>
<td>Tropical Eastern Pacific</td>
<td>29</td>
<td>8</td>
<td>11</td>
<td>73</td>
<td>2</td>
<td>2</td>
<td>100</td>
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<tr>
<td>Temperate South America</td>
<td>14</td>
<td>9</td>
<td>15</td>
<td>60</td>
<td>3</td>
<td>5</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>Temperate Southern Africa</td>
<td>9</td>
<td>3</td>
<td>5</td>
<td>60</td>
<td>2</td>
<td>3</td>
<td>67</td>
<td></td>
</tr>
<tr>
<td>Temperate Australasia</td>
<td>25</td>
<td>9</td>
<td>17</td>
<td>53</td>
<td>5</td>
<td>6</td>
<td>83</td>
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<tr>
<td>Southern Ocean</td>
<td>0</td>
<td>0</td>
<td>21</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>709</td>
<td>120</td>
<td>252</td>
<td>52</td>
<td>45</td>
<td>62</td>
<td>73</td>
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</tbody>
</table>
providing a wider spatial perspective. Rooted in existing regional systems, the base units of the MEOW already underpin conservation efforts at regional levels, and a strong body of marine ecoregional planning literature illustrates how global or regional concerns can be converted into field-based conservation action (Banks et al. 2000, Beck and Odaya 2001, Larsen et al. 2001, Kramer and Kramer 2002, Ferdaña 2005).

The value of the MEOW system extends beyond conservation planning. Looking afresh at the broader-scale classes and taking advantage of the improved resolution offered by the MEOW system, it is possible to review wider issues of biodiversity distribution and evolution. At the broadest scales, the most important elements of biogeographic subdivision are the barriers that have separated substantial areas over evolutionary timescales (Adey and Steneck 2001). In the MEOW realms (noting the special case of the Indo-Pacific described above), these barriers consist of landmasses, wide ocean basins, and temperature gradients.

Although there is variation in degree, the provinces can be seen as finer-scale units of evolutionary isolation. They align with many of the more important factors driving recent and contemporary evolutionary processes. Temperature, or latitude, continues to play an important role (separating warm and cold temperate provinces), but so does the further isolation provided by deep water, narrow straits, or rapid changes in shelf conditions. Elsewhere, the connectivity provided by ocean currents, such as the Antarctic Coastal Current and the Canaries Current, can be seen in the classifications, and the importance of biological stepping-stones through various island chains is clearly illustrated. Finally, the ecoregions, which distinguish the MEOW system, reflect unique ecological patterns that extend beyond the broad drivers of evolutionary processes.

Of course, as Wallace (1876) noted, “nothing like a perfect zoological division of the earth is possible. The causes that have led to the present distribution of animal life are so varied, their action and reaction have been so complex, that anomalies and irregularities are sure to exist which will mar the symmetry of any rigid system” (p. 53). Consequently, the use of biogeographic data in a global classification is inevitably a process of accommodation and pragmatism. The lines we have drawn should be regarded as indicative, marking approximate locations of relatively rapid change in dominant habitats or community composition. Ocean boundaries shift continuously with weather patterns, with seasons, and with longer or more random fluctuations in oceanographic conditions. In the future, the impacts of climate change will add to the instability of many boundaries in the ocean (Sagarin et al. 1999, Beaugrand et al. 2002, Hiscock et al. 2004).

The need for a comprehensive, detailed, and globally consistent marine biogeography has been recognized for many years in marine conservation. The requirements for representative approaches to marine protected area designation in various national, regional, and global planning commitments and legal frameworks have given added urgency to this need. The MEOW system provides a basis for planning for coastal and shelf areas, and the links between this system and other global and regional systems make it possible to adopt and use it with minimal disruption to existing data sets or analytical approaches. The unique collaboration of conservation organizations in developing this system adds further value, and may reduce the duplication of effort that so often undermines global conservation approaches (Mace et al. 2000). In short, the system proposed here is powerful and robust, and should prove to be of great value in conservation planning and broader biogeographic discussion. Two international conservation agencies (the Nature Conservancy and WWF) have already begun to use this system and expect to use it more widely in the future. Similarly, members of the Scientific and Technical Review Panel of the Ramsar Convention who participated in developing this system are undertaking more detailed analyses to explore its utility to support the future identification and designation of coastal and marine Wetlands of International Importance.

Acknowledgments
The Marine Ecosystems of the World system draws heavily on the work of others, including the hundreds of contributors to the publications, gray literature, and workshops that created the many regional classifications. In addition, we would especially like to thank the following people, who have provided advice or commentary: Asa Andersson, Jeff Adrion, Allison Arnold, Paul Barber, Mike Beck, Carlo Niké Bianchi, John Bolton, George Branch, John Briggs, Georgina Bustamante, Rodrigo Bustamante, Jose Farina, Sergio Floeter, Angus Gascoigne, Serge Gofas, Charlie Griffiths, Huw Griffiths, Randy Hagenstein, Jon Hoekstra, David John, Peter Kareiva, Ken Kasseem, Jerry Kemp, Phil Kramer, Katrin Linse, Gilly Llewellyn, Stephan Lutter, Kasim Moosa, Alexis Morgan, Dag Nagoda, Sergio Navarrete, Kate Newman, (Bina) Maya Paul, Sian Pullen, Callum Roberts, Rod Salm, Andrew Smith, Jennifer Smith, Vassily Spiridonov, Victor Springer, Juan Luis Suárez de Vivero, Marco Taviani, Charlie Veron, Eleni Voultsiadou, Mohideen Wafar, Carden Wallace, Kathy Walls, and David Woodland.

References cited