Diversity

# Rationale for a System of International Reserves for the Open Ocean

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*"The sea! the sea! the open sea! The blue, the fresh, the ever free!"*
—Bryan W. Procter, ca. 1837

There appears to have been little consideration given to the concept of marine reserves in open-ocean ecosystems, whereas a large number of protected areas for coastal marine and estuarine ecosystems have been or are now being developed around the world (Agardy 1994; Rowley 1994). We argue that, given the rapidly rising pressures on the oceans due to human overpopulation and associated resource extraction, ocean conservation and management in the twenty-first century should include an international system of marine reserves for the open ocean. Such a system would be practical, and the benefits would be of global importance. We define *open ocean* as including both the water column (the pelagic realm) and the sea floor (the benthic realm) in international waters, that is beyond 200 miles (320 km) from a nation's coastline. We have little doubt that there are long-buried and passing references in scattered literature to some aspects of the concepts we present. For example, de Fontaubert et al. (1996) note without further elaboration that certain ecosystems embraced by coastal marine protected areas might extend across legal national boundaries and "into the high seas." Similar statements can probably be found in the burgeoning literature of marine conservation, biodiversity, and coastal marine reserves, but we have not found a distinct argument or proposal for reserves on the open ocean.

Why should there be reserves on the high seas? Mid-ocean waters remain largely without international environmental protection. The U.S. National Research Council (1995) identified the "pelagic open ocean" and the "deep sea" as two of six important regional model systems for study of the processes that control the origin and maintenance of marine biodiversity (along with estuaries and bays, coral reefs, temperate rocky shores, and shelf-slope systems). Whereas a few coastal marine sanctuaries encompass small areas of both of these environments, those marine protected areas are within a nation's sovereign territories, the 200-mile exclusive economic zone (EEZ) and, thus, do not encompass mid-ocean (high seas) ecosystems thousands of kilometers from land.

The open ocean reserve concept fits clearly within one of the major elements of the 1995 Jakarta Mandate of the Convention of Biological Diversity, relative to the need to establish marine protected areas "for the conservation and sustainable use of threatened species, habitats, living marine resources and ecological processes" (as reviewed by de Fontaubert et al. 1996). It also relates strongly to the concept of "particularly sensitive sea areas," as initially proposed by the United States International Maritime Organization, relative to regions outside a nation's territorial sea or exclusive economic zone (World Wildlife Fund 1997).

If a system of open-ocean reserves is to be established, we envision regions with no commercial shipping activities (thus minimizing the discharge of waste products), little to no fishing pressure, no deep sea mining, no dumping, no deployment or testing of weapons, and no floating cities (the first of which is already taking subscriptions). Such reserves could provide a platform for long-term, large-scale experimental research in regions with minimum human perturbation.

What benefits would there be and to whom? There are compelling reasons from the points of view of both conservation biology and oceanography to set aside areas of

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the mid-ocean, regions of rich biodiversity (Angel 1993; McGowan & Walker 1993), for marine reserves. From the point of view of conservation, the decline of pelagic fisheries in the open ocean is widely recognized as one of the critical conservation issues of our time (Safina 1995), rivaling the decline of near-shore fisheries. Tuna and shark fisheries, for example, are severely over-fished globally, and the biological and ecological impacts on non-target species of drift-net and long-line fishing on the high seas are now recognized as profound. Enormous areas of the oceans that are regularly fished are without any sort of fisheries management (Weber 1996). Parsons (1996) points out that the removal of many millions of tons of commercial fish from the ocean should have an ecological impact beyond that of any sort of pollution. Potentially linked to the ubiquitous removal of top finfish predators from the open ocean pelagic realm is the prospective replacement of predatory fish by predatory jellyfish (medusae and siphonophores) and comb jellyfish (ctenophores), thus leading to the potential for massive species replacement and ecosystem alteration (Mills 1995).

The open ocean has been widely but erroneously viewed as a vast wasteland and dumping ground (Carson 1961), a concept resulting partly from rejection of coastal sites due to "not in my backyard" thinking (R. Carney in National Research Council 1995). Present internationally sanctioned regulations permit the release of nonbiodegradable plastic wastes in waters 50 miles from continental margins (United Nations International Marine Organization 1978). During his highly publicized voyages across the Atlantic in a papyrus boat, Heyerdahl (1971) observed the nearly ubiquitous presence of tar balls on the surface of the ocean, a sobering "wake-up call" that the high seas were not immune to human modification.

Despite these perturbations, open-ocean ecosystems remain as perhaps the least disturbed parts of the marine realm, especially compared to near-shore waters. The open oceans are a critical link for a number of species, such as eels and sea turtles, that live alternately between continental waters and open-ocean waters. There is marked attenuation of continentally derived pollutants proceeding away from continental margins (Weiss et al. 1985), and confirmed human-mediated introductions of exotic species remain unknown in the open ocean. Destination tourism is presently nonexistent on the high seas, and open ocean recreation is negligible, so arguments between conservation and tourism are minimal for now.

From the point of view of oceanographic and atmospheric processes, the open oceans are now well recognized as critical to global climate regulation (Siegenthaler & Sarmiento 1993), a role so profound as to constitute on its own a sufficient rationale for protection. In addition, although the open ocean has been the subject of extensive study since the mid-nineteenth century, revolutionary new discoveries continue. The general view that the open ocean is a desert (Ryther 1969) has been modified by a variety of discoveries over the past two decades. In the water column or pelagic zone, an enormous overlooked biomass comprised of tiny organisms—picoplankton and nanoplankton—has been discovered, and production estimates have increased dramatically (Kerr 1986). For example, a new group of organisms, the prochlorophytes, are now thought to contribute almost as much to primary production in some regions as all previously known primary producers (Chisholm et al. 1988). On the deep sea floor, the discoveries in the 1980s of high biodiversity (Grassle & Maciolek 1992) were not anticipated; some of these species are members of an ancient relict or "living fossil" fauna (Zezina 1994). The novel and unexpected hydrothermal vent habitats are another revolutionary discovery. All of these recent findings suggest that the open ocean is a complex and rich ecosystem of global significance and worthy of protection.

Where should these reserves be located? Modern physical oceanography and biogeography have resolved that the high seas, rather than being homogeneous, are composed of a mosaic of environments, each with a unique combination of physical, chemical, and biological signatures. At local levels the environments form mosaics within mosaics of fronts and eddies, upwelling and downwelling regions, boundary currents, and gyres (Longhurst 1981), yet the unique nature of the major water masses is maintained on a day-to-day and year-to-year basis. Ideally, marine reserves should take into account these distinct biogeographic regimes in all oceans, including boreal, temperate, and tropical waters. The centers of the great ocean gyres, which are believed to have maintained their faunistic identities for 70 million years (Angel 1996), might be worthy locations for reserves.

Consideration should be given to selection of regions that are outside of well-established shipping lanes, thus reducing the need to reroute ships. This would concomitantly address issues of the potential release of ballast water in marine reserves because open-ocean ballast exchange has been identified as a means of controlling coastal nonindigenous species invasions (National Research Council 1996). For example, the United States Congress has recently passed the "National Invasive Species Act of 1996," calling for ships to voluntarily discharge and exchange coastally derived water in the mid-ocean.

The sizes of the reserves, their locations, and the extent to which resource extraction would be permitted must be addressed by the international community. Significant issues and challenges will need to be addressed in the actual conceptualization and establishment of a system of open-ocean reserves. These include the probable costs of regular environmental assessments (monitoring in order to measure the success of the reserves in terms of lessening human activities), focused, large-scale experimental research programs, specific regulations on the nature and scale of continued human activities and the attendant enforcement issues, and the formulation of a rigorous research agenda. For the latter, an example of comprehensive and well-structured research questions potentially applicable to open-ocean reserves are detailed in a recent National Research Council (1995) treatise on marine biodiversity. Finally, a potentially productive early step would be to assemble an international working group of scientists, environmental managers, and others who have been long engaged in marine reserves, preserves, and other protected regions to begin a dialogue and establish the philosophical and scientific foundations for open-ocean reserves.

We believe that the creation of oceanic reserves would be a practical and achievable endeavor. International management and preservation of vast nonterritorial ecosystems have precedent, for example, in the international administration of Antarctica, which might serve as a model. Although setting the boundaries of open-ocean reserves would require international discussion, respect for such boundaries is now greatly facilitated by the presence of electronic navigation systems (satellite-supported global positioning systems), which permit precise location recognition, aboard most ocean-going vessels (ranging from sailboats to cargo ships).

It might be argued that we do not know enough yet to choose the best locations or optimal sizes for open-ocean reserves. We reply that refuges should be established soon, without holding out for more data. Furthermore, historical claims to coastal ocean zones have run more or less in parallel with the technological ability to protect such claims. Technological advances in the near future could easily allow countries to claim ocean boundaries far beyond the presently recognized 200-mile exclusive economic zones. Making some decisions now will buy time for the oceanic species, habitats, and processes likely to be most affected by human activities. Environmental reserves around the world have typically been established retroactively, after perturbation by humans has already taken a fundamental toll on the natural ecosystem. Establishing marine reserves on the high seas—regions not yet as direly affected as those coastal or terrestrial reserves adjacent to the major centers of human population—may provide the last opportunity to reach ahead of the destructive waves that accompany human endeavor.

> *There is the life of the plankton in almost endless variety; there are the many kinds of fish, both surface and bottom living; there are the hosts of different invertebrate creatures on the sea-floor; and there are those almost grotesque forms of pelagic life in the oceans depths. Then there are the squids and cuttlefish, and the porpoises, dolphins and great whales.*
>
> —Sir Alister Hardy, *The Open Sea,* 1956

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## Literature Cited

Agardy, M. T. 1994. Advances in marine conservation: the role of marine protected areas. Trends in Ecology and Evolution **9:**267–270.

Angel, M. V. 1993. Biodiversity of the pelagic ocean. Conservation Biology **7:**760–772.

Angel, M. V. 1996. Oceanic biodiversity: origins and maintenance. Pages 33–60 in G. Albertelli, A. De Maio, and M. Piccazzo, editors. Atti dell' 11° Congresso dell'Associazione Italiana di Oceanologia e Limnologia. Associazione Italiana di Oceanologia e Limnologia (A.I.O.L.), Geneva.

Carson, R. 1961. The sea around us. Revised edition. Oxford University Press, New York.

Chisholm, S. W., R. J. Olson, E. R. Zettler, R. Goericke, J. B. Waterbury, and N. A. Welschmeyer. 1988. A novel free-living prochlorophyte abundant in the oceanic euphotic zone. Nature **334:**340–343.

de Fontaubert, A. C., D. R. Downes, and T. S. Agardy. 1996. Biodiversity in the seas: implementing the Convention of Biological Diversity in marine and coastal habitats. World Conservation Union, Washington, D.C.

Grassle, J. F., and N. J. Maciolek. 1992. Deep-sea species richness: regional and local diversity estimates from quantitative bottom samples. American Naturalist **139:**313–341.

Hardy, A. C. 1956. The open sea: its natural history. Houghton Mifflin, Boston.

Heyerdahl, T. 1971. Atlantic Ocean pollution and biota observed by the 'Ra' expeditions. Biological Conservation **3:**164–167.

Kerr, R. A. 1986. The ocean's deserts are blooming. Science **232:**1345.

Longhurst, A. R., editor. 1981. Analysis of marine ecosystems. Academic Press, London.

McGowan, J. A., and P. W. Walker. 1993. Pelagic diversity patterns. Pages 203–214 in R. E. Ricklefs and D. Schluter, editors. Species diversity in ecological communities. University of Chicago Press, Chicago.

Mills, C. E. 1995. Medusae, siphonophores, and ctenophores as planktivorous predators in changing global ecosystems. ICES Journal of Marine Science **52:**575–581.

National Research Council. 1995. Understanding marine biodiversity. A research agenda for the nation. National Academy Press, Washington, D.C.

National Research Council. 1996. Stemming the tide. Controlling introductions of nonindigenous species by ships' ballast water. National Academy Press, Washington, D.C.

Parsons, T. R. 1996. Taking stock of fisheries management. Fisheries Oceanography **5:**224–226.

Rowley, R. J. 1994. Marine reserves in fisheries management. Aquatic Conservation: Marine and Freshwater Ecosystems **4:**233–254.

Ryther, J. H. 1969. Photosynthesis and fish production in the sea. Science **166:**72–76.

Safina, C. 1995. The world's imperiled fish. Scientific American **273:** 46–53.

Siegenthaler, U., and J. L. Sarmiento. 1993. Atmospheric carbon dioxide and the ocean. Nature **365:**119–125.

United Nations International Maritime Organization. 1978. MARPOL

73/78: the protocol of 1978 relating to the International Convention for the Prevention of Pollution from Ships 1973. United Nations, London.

Weber, M. L. 1996. Gaps in the international conservation of large migratory fishes in the Pacific Ocean. Ocean Wildlife Campaign, Washington, D.C.

Weiss, R. F., J. L. Bullister, R. H. Gammon, and M. J. Warner. 1985. Atmospheric chlorofluoromethanes in the deep equatorial Atlantic. Nature **314:**608–610.

World Wildlife Fund (WWF). 1997. Particularly sensitive sea areas. Marine update 29. Marine Conservation Programme, WWF-United Kingdom, Godalming, Surrey, United Kingdom.

Zezina, O. N. 1994. Bathyal zone of the ocean as a place for preservation of faunistic relics. Oceanology **34:**367–372.