# PROTECTING INTERNATIONAL MARINE BIODIVERSITY: INTERNATIONAL TREATIES AND NATIONAL SYSTEMS OF MARINE PROTECTED AREAS

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## I. INTRODUCTION

The oceans are one of the truly global resources. All parts of the ocean are connected. Moreover, at least some marine resources that humans deem important have world-wide ranges. Bluefin tuna, for example, are some of the most expensive fish in the world. Buyers in Japan will pay upwards of $80 a pound for high quality bluefin tuna for sushi,[1] and since bluefin tuna can grow up to 1500 pounds,

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1. Eugene H. Buck, *Atlantic Bluefin Tuna: International Management of a Shared*

a single fish can be worth $45,000 or more.[2] Thus, lots of fishers would love to be able to catch more bluefin tuna.

Bluefin tuna have a wide geographic range and are "distributed throughout the Atlantic and Pacific Oceans in subtropical and temperate waters."[3] Nevertheless, increased tuna harvests face two major obstacles. First, bluefin tuna have been overfished to precarious levels.[4] Second, effective sustainable management of bluefin tuna is severely hampered by the fact that bluefin tuna are, from a human perspective, almost completely unpredictable. Such tuna have known near shore feeding and mating grounds, but they also migrate across the oceans for thousands of miles, often halfway around the globe or further.[5] Until recently, once the tuna set off into the open ocean they more or less just disappeared from human observation.[6] Thus, conserving bluefin tuna — and all signs are that they need protection — requires a global effort, in terms of scientific research, fisheries management, and legal protections. Nations of the world have recognized this reality: several countries, including the United States, Canada, Japan, Spain, and France signed the International Convention for the Conservation of Atlantic Tunas in 1966 "to specifically address the conservation issues facing the bluefin and other highly migratory species."[7] Almost three decades later, on the other side of the world, Australia, Japan, and New Zealand formalized the 1994 Convention for the Conservation of Southern Bluefin Tuna "to ensure, through appropriate management, the conservation and optimum utilisation [sic] of the global [Southern Bluefin Tuna] fishery."[8]

Bluefin tuna are only one of several living marine resources whose fate depends on international cooperation and hence on

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*Resource* (CRS Report to Congress 95-367 ENR) (Mar. 8, 1995), *available at* http://www.ncseonline.org/NLE/CRSReports/Marin e/mar-5.cfm ("In 1991, a Japanese importer paid a record price of $68,503 (or about $96.65 per pound) for a single giant bluefin tuna!").

2. Susie Gardieff, Florida Museum of Natural History, *Ichthyology: Bluefin Tuna*, *at* http://www.flmnh.ufl. edu/fish/Gallery/Descript/BluefinTuna/BluefinTuna.html (last visited Feb. 12, 2005).

3. *Id*.

4. *Id*; Buck, *supra* note 1.

5. Buck, *supra* note 1.

6. *Id*.; *see also Tracking Bluefin Tuna* (National Public Radio Morning Edition radio broadcast, Aug. 17, 2001), *available at* http://www.npr.org/ programs/morning/features/2001/aug/bluefintuna/010817. bluefintuna.html [hereinafter NPR] (describing Stanford University researcher Barbara Block's work in *Science* on bluefin tuna tracking).

7. Gardieff, *supra* note 2.

8. Commission for the Conservation of Southern Bluefin Tuna, *About the Commission*, *at* http://www.ccsbt. org/docs/about.html (last visited Feb. 2, 2005). Korea, Taiwan, and the Philippines also participate in implementing the Convention, and Indonesia and South Africa are considering cooperative non-membership status. *Id*.

international law.[9] Increasingly, preservation of marine biodiversity is recognized as an international law issue, and both general and specific treaties have been extended to protect and restore marine biodiversity. However, there is also increasing recognition that such international legal efforts must be tied to evolving scientific knowledge regarding the causes of marine biodiversity loss. In the case of the bluefin tuna, for example, "[i]n the early 1990s, the western Atlantic bluefin stock appeared to resume its decline while some eastern Atlantic fishing nations continued to ignore ICCAT's [the International Commission for the Conservation of Atlantic Tuna, which implements the Convention] 1974 recommendations" regarding acceptable fishing rates, but there was little understanding of how the western Atlantic and eastern Atlantic populations of bluefin tuna interacted.[10] Recent scientific research reveals that "[t]una in the western Atlantic migrate to feeding grounds in Europe and the Mediterranean. . . . That's important because limits on tuna catches are much tighter in the western Atlantic than in Europe. What fishery managers now realize is that overfishing in Europe may be depleting the Atlantic bluefin population."[11] As a result, ICCAT's recommendations are important to both "stocks" of tuna.

This article reviews the intersection of science and international law in the area of preserving marine biodiversity. It provides an overview of how the science concerning marine biodiversity preservation has changed focus in the last decade or so and then looks at how international law is beginning to react to that change in scientific emphasis in the international preservation of marine biodiversity. It ends with both a recommendation that nations adopt a more comprehensive approach to marine biodiversity preservation and a recognition that such comprehensive protection packages are beginning to become a part of international law.

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9. United Nations Education, Scientific, and Cultural Organization (UNESCO), *Marine Biodiversity*, 21:1 CONNECT INTERNATIONAL SCIENCE, TECHNOLOGY & ENVIRON- MENTAL EDUCATION NEWSLETTER 1, 2 (Mar. 1996) ("Conservation of marine biodiversity is thus an urgent, global issue as physically, oceans cannot be limited by political frontiers. … As in all global problems, there has to be international concertation to deal with problems relating to marine biodiversity if ways are to be found to safeguard it for the future without depriving those that currently depend upon it for their existence.").

10. Buck, *supra* note 1.

11. NPR, *supra* note 6.

## II. THE IMPORTANCE OF MAINTAINING MARINE BIODIVERSITY

### *A. Biodiversity in General*

According to the United Nations Convention on Biological Diversity, also known as the Biodiversity Convention, "'[b]iological diversity' means the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems."[12] As this definition suggests, three levels of biodiversity are important: genetic diversity, species diversity, and ecosystem diversity.[13]

Genetic diversity relates to the variability within a given species, or, more specifically, to "the variation in the amount of genetic information within and among individuals of a population, a species, an assemblage, or a community."[14] For example, in many modern supermarkets, customers often have a choice of five or six commercially grown potatoes. Around the world, however, there are dozens of different kinds of potatoes, each with a slightly different genetic makeup and hence each with a different ability to adapt and respond to different environmental conditions. The value of this genetic variability is reflected in the fact that "[a]t least a dozen countries have established controls over access to their genetic resources, and an equal number of nations are developing such controls."[15]

Species diversity refers to the number of different species in the world,[16] or, more specifically, "the variation in the number and

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12. Convention on Biological Diversity, June 5, 1992, art. 2, 31 I.L.M. 818 (1992), 1993 A.T.S. 32 (entered into force Dec. 29, 1993).

13. Center for Biodiversity and Conservation, American Museum of Natural History, *What Is Biodiversity? Questions and Answers*, *at* http://research.amnh.org/ biodiversity/center/ what.html (last updated 2003); The Natural History Museum, *Measuring Biodiversity Value*, *at* http://www.nhm.ac.uk/science/projects/world map/diversity/index.html (last visited Mar. 2, 2005); *see* Stanford Encyclopedia of Philosophy, *Biodiversity*, *at* http://plato.stanford.edu/ entries/biodiversity (last updated June 11, 2003); *see also* UNESCO, *Marine Biodiversity*, *supra* note 9, at 1 ("Biodiversity is a collective term that encompasses the variety of all living organisms — plants, animals and micro-organisms — on Earth. It includes diversity within species, between species and of ecosystems.").

14. Center for Marine Biodiversity, Canada, *What Is Marine Biodiversity*, *at* http://marinebiodiversity.ca/en/ what.html (last visited Mar. 3, 2005).

15. Convention on Biological Diversity, United Nations Environmental Programme [hereinafter UNEP], "International Level, International Action," *in Sustaining Life on Earth: How the Convention on Biological Diversity Promotes Nature and Human Well-being, at* http://www.biodiv.org/doc/publications/guide.asp?id= action-int (last visited Mar. 1, 2005).

16. UNEP, "Biodiversity – The Web of Life," *in Sustaining Life on Earth: How the Convention on Biological Diversity Promotes Nature and Human Well-being, at* http://www.biodiv.org/doc/publications/ guide.asp?id=web (last visited Mar. 5, 2005).

frequency of species in a biological assemblage or community. Species diversity is the most commonly used synonym for biodiversity, where species richness (number of species in a given habitat) is the main index used for its measurement."[17] According to the United Nations Environmental Programme (UNEP), to date scientists have identified 1.75 million species in the world.[18] The consensus figure among biologists is that probably around 13 million species exist,[19] although individual estimates run as high as 100 million species.[20]

Together, genetic and species diversity contribute to the health and resiliency of individual ecosystems. Within each ecosystem are a number of trophic levels, or levels of hierarchy within the food web, reflecting the fact that different species play different roles in the food web.[21] In a very simplified schematic, for example, plants are photosynthesizers that convert the sunlight into food for other organisms.[22] Herbivores eat the plants, carnivores eat the herbivores (and often each other), omnivores eat both, and decomposers break down the dead plants and animals and their wastes.[23] Higher biodiversity results in greater redundancy at each level, giving ecosystems as a whole, greater resiliency and a greater ability to respond to environmental changes.

Finally, "[e]cosystem diversity is the variation in the collection of assemblages, communities, and habitats within a region."[24] A number of different types of ecosystems exist in the world — tropical rainforest, Arctic tundra, sand desert, pine forests, and so on — each supporting a different set of species exhibiting different genetic variations. "The World Wildlife fund and National Geographic Society recently mapped 867 terrestrial ecoregions of the world."[25] Loss of ecosystems involves loss of habitat, generally considered one of the gravest threats to biodiversity. "While the loss of individual species catches our attention, it is the fragmentation,

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17. Center for Marine Biodiversity, *supra* note 14.

18. UNEP, "Biodiversity — The Web of Life," *supra* note 16.

19. *Id*. *But see* Peter J. Bryant, "Global Patterns of Biodiversity," *in Biodiversity and Conservation: A Hypertext Book*, ch. 6, *at* http://darwin.bio.uci.edu/~sustain/bio65/lec06/b651ec06.htm#MEASURING%20 BIODIVERSITY (2002) (noting "[a] dramatic upward revision in these estimates to 30 million" species as a result of new research).

20. UNEP, "Biodiversity — The Web of Life," *supra* note 16.

21. The Geography Portal, *What are Trophic Levels?*, *at* http://www.kesgrave.suffolk.sch.uk/learningzone/ subjects/geography/trophic.html (last visited Feb. 2, 2005).

22. *Id*.

23. *Id*.

24. Center for Marine Biodiversity, *supra* note 14.

25. Bryant, *supra* note 19; *see also* National Geographic, *Terrestrial Ecoregions of the World*, *at* http://www.nationalgeographic.com/wildworld/terrestrial.html (last visited Feb. 3, 2005) (showing the map of these ecoregions).

degradation, and outright loss of forests, wetlands, coral reefs, and other ecosystems that poses the gravest threat to biological diversity."[26]

According to the UNEP, terrestrial biodiversity is threatened in many parts of the world, especially in crowded industrialized nations.[27]

> The loss of biodiversity often reduces the productivity of ecosystems, thereby shrinking nature's basket of goods and services, from which we constantly draw. It destabilizes ecosystems, and weakens their ability to deal with natural disasters such as floods, droughts, and hurricanes, and with human-caused stresses, such as pollution and climate change.[28]

### *B. Marine Biodiversity*

Despite the growing concerns regarding world biodiversity loss, until recently, little has been done to assess the biodiversity of — and losses of biodiversity within — the world's oceans.[29] There are two basic explanations for this knowledge gap. First, the oceans are difficult for humans to explore.[30] As a result, "marine systems have been relatively neglected because they are 'out of sight, out of mind' to most people, including most scientists."[31] Second, until recently,

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26. UNEP, "We Are Changing Life on Earth," *in Sustaining Life on Earth: How the Convention on Biological Diversity Promotes Nature and Human Well-being*, *at* http://www.biodiv.org/doc/publications/guide.asp?id=changing (last visited Apr. 5, 2005).

27. *Id*.

28. *Id*.

29. *See* Peter M. Vitousek et al., *Human Domination of Earth's Ecosystems*, 277 SCI. 494, 495 (July 25, 1997) ("Human alterations of marine ecosystems are more difficult to quantify than those of terrestrial ecosystems, but several kinds of information suggest that they are substantial."); UNESCO, *Marine Biodiversity*, *supra* note 9, at 1 ("Though biodiversity encompasses all living organisms on earth, perhaps due to semantics, people generally tend to think of biodiversity in terms of terrestrial living organisms."); Elizabeth Culotta, *Is Marine Biodiversity at Risk?*, 263 SCI. 918, 919 (Feb. 18, 1994) ("Only about 7% of the world's oceans has been sampled for biodiversity, and even moderately rare species are easy to miss.").

30. G. Carleton Ray & J. Frederick Grassle, *Marine Biological Diversity: A Scientific Program to Help Conserve Marine Biological Diversity is Urgently Required*, 41:7 BIOSCI. 453, 453 (July-Aug. 1991) ("The inaccessibility of most marine environments to all but divers means that there is little common experience about natural events there, and that observations and experiments there tend to be short-term and narrow in spatial extent.").

31. *Id*.; *see also* Tatiana Brailovskaya, *Obstacles to Protecting Marine Biodiversity through Marine Wilderness Preservation: Examples from the New England Region*, 12:6 CONSERVATION BIOLOGY 1236, 1238 (Dec. 1998) ("Unlike terrestrial wildlife, most commonly known marine species in New England are usually considered food. Most people rarely venture into the underwater marine environment, and they tend to see marine species only in the seafood case at the supermarket. Recognizing this inherent human detachment from

humans tended to view the oceans as too vast for humans to affect much – what has been called the paradigm of inexhaustibility.[32] As scientist Jeremy B.C. Jackson commented in 2001, "[t]he persistent myth of oceans as wilderness blinded ecologists to the massive loss of marine ecological diversity caused by overfishing and human inputs from the land over the past centuries."[33]

As a result, our knowledge about ocean biodiversity is limited, although growing. As author Colin Woodward has noted in his book, *Ocean's End*, "We are better informed about the Moon and Mars than about the bottom of the ocean floor; we know more about the life cycle of stars than those of the sperm whale, giant squid, and many of the creatures sought by the world's fishing fleets."[34] The U.S. Senate, similarly, commented in connection with the Oceans Act of 2000[35] that "many ocean ecosystems, particularly the ocean's deepest regions, remain undiscovered and unexplored."[36]

Nevertheless, any nation or group of nations that cares about preserving biodiversity should view the preservation of marine biodiversity as a high priority — especially given that "ocean health and human health are inextricably linked."[37] Moreover:

> Marine ecosystems are major national capital assets. In addition to providing valuable goods, such as

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marine life as an impediment to support for marine conservation, the National Audubon Society's Living Oceans Program has chosen to address the public's terrestrial wildlife bias as part of its program, adopting the motto that 'fish are wildlife, too.'") (citations omitted).

32. John C. Ogden, *Maintaining Biodiversity in the Oceans*, 43:3 ENV'T 28, 29 (2001) (noting that in 1884, "the population of the world was slightly more than one billion, and the oceans were perceived as mysterious and limitless"); Steve Connor, *Marine Life Being Massacred as the World's Oceans Are Turning Toxic*, THE INDEPENDENT (London), Sept. 3, 1999, at 3 ("Just 30 years ago, scientists believed that the oceans were so vast that they would remain relatively immune from human influence, but recent evidence shows that the seas have become as vulnerable as the terrestrial environment.").

33. Jeremy B.C. Jackson, *What was Natural in the Coastal Oceans?*, 98:10 PROCEEDINGS NAT'L ACAD. OF SCI. (PNAS) 5411, 5411 (May 8, 2001), *available at* http://www.pnas.org/cgi/doi/10.1073/pnas.091092898.

34. COLIN WOODWARD, OCEAN'S END: TRAVELS THROUGH ENDANGERED SEAS 30 (2000). *See also* Ogden, *supra* note 32, at 30 (noting that "it is said that humans know more about the surface of the moon than about the oceans"); C.D. Harvell et al., *Emerging Marine Diseases — Climate Links and Anthropogenic Factors*, 285 SCI. 1505, 1505 (Sept. 3, 1999) ("The paucity of baseline and epidemiological information on normal disease levels in the ocean challenges our ability to assess the novelty of a recent spate of disease outbreaks and to determine the relative importance of increased pathogen transmission versus decreased host resistance in facilitating the outbreaks."); UNESCO, *Marine Biodiversity*, *supra* note 9, at 1 ("[O]ne has to admit perforce that even scientists today have a better idea of the surface of the dark side of the moon than the depths of the oceans!").

35. Oceans Act of 2000, Pub. L. No. 106-256, 114 Stat. 644 (Aug. 7, 2000).

36. S. REP. NO. 106-301, at 3 (2000), *reprinted in* 2000 U.S.C.C.A.N. 534, 537.

37. Nancy Knowlton, *Ocean Health and Human Health*, 112:5 ENV'T HEALTH PERSPS. A262 (Apr. 2004), *available at* http://ehp.niehs.nih.gov/docs/2004/112-5/editorial.html.

> fisheries and minerals, they provide critical life support services, such as diluting, dispersing, and metabolizing the effluents of society, thus purifying waters for recreation. The value of a healthy ocean is difficult to overestimate.[38]

"The oceans cover more than 71 percent of the Earth and, taking depth into account, contain more than 99 percent of the space available for life."[39] The oceans' size thus already suggests their importance as biodiversity reservoirs, and "[m]arine systems are extraordinarily diverse in all aspects, from genetic to taxonomic to ecological."[40] For example, the oceans are important repositories of genetic diversity. Biologists classify all living organisms through a seven-layer hierarchy of groupings of organisms with similar characteristics. From the most general to the most specific, this hierarchy is: kingdom, phylum, class, order, family, genus, and species.[41] The more general the grouping, the more genetic diversity exists among groups at each level. For example, the two most well-known kingdoms are the animal kingdom and the plant kingdom, a distinction that recognizes the significant genetic distinctions between plants and animals.[42] Scientists agree that the oceans contain more phyla — the second most general classification groupings — than exist in terrestrial ecosystems, testifying to the vast genetic diversity that the oceans contain. Canada's Center for Marine Biodiversity, for example, reports that "in the marine environment there are 32 out of the 33 animal phyla present;[43] only 12 occur on land.[44] Moreover, according to the United Nations Education, Scientific, and Cultural Organization (UNESCO), "at least 43 of the more than 70 phyla . . . of *all* life forms are found in the oceans, whereas only 28 are found on land."[45] Most importantly, 45 percent of known phyla exist *only* in the ocean,[46] and "[n]inety

38. Ogden, *supra* note 32, at 31.

39. *Id*.

40. Ray & Grassle, *supra* note 30, at 453; *see also* Harvell et al., *supra* note 34, at 1505 ("The oceans harbor enormous biodiversity in terrestrial terms, much of which is still poorly described taxonomically.").

41. E.D. Hirsch, Joseph F. Kett & James Trefil, "Linnean Classification," *in The New Dictionary of Cultural Literacy* (3d ed. 2002), *available at* http://www.bartelby.com/59/21/linneanclass.html.

42. E.D. Hirsch, Joseph K. Kett & James Trefil, "Kingdom," *in The New Dictionary of Cultural Literacy* (3d ed. 2002), *available at* http://www.bartelby.com/59/21/kingdom.html.

43. Center for Marine Biodiversity, *supra* note 14.

44. Sylvia A. Earle, *Forward to* BOYCE THORNE-MILLER, THE LIVING OCEAN xiii (2d ed. 1999).

45. UNESCO, *Marine Biodiversity*, *supra* note 9, at 1.

46. *See* Ray & Grassle, *supra* note 30, at 453 ("Because phyla represent fundamentally different life forms, marine systems may be the most diverse on our planet.").

percent of all known classes [the next level of classification] are marine."[47] Thus, marine species represent a wide range of genetic diversity, often without parallel representation on land.

Marine species have been less well catalogued than terrestrial species, and in the 1990s "estimates of the number of deep-sea species alone…ranged from fewer than 500,000 to 10 million."[48] According to UNESCO, however:

> [T]aking into account the large amount of information extracted every day from samples gathered from diverse marine environments, it would not be far-fetched to assume that half – or even more – of the earth's living species are to be found in the diverse marine and coastal habitats, ranging from coral reefs, mangroves, sea grasses, rocky or sandy beaches down to the soft sediments of the deepest ocean floors and all the water column in between.[49]

Marine biologists estimate that there may be as many as 10 million undescribed species living in the ocean.[50] While scientists suspect that marine species have gone extinct as a result of human activities, moreover, "documentation of actual extinctions of marine species is just beginning."[51]

Finally, the oceans support a variety of different kinds of ecosystems, such as coral reefs, seagrass meadows, and kelp forests.[52] These ecosystems, like their counterparts on land, vary considerably in the numbers of species they support and in their overall biological productivity. For example, "[c]oral reefs are the most taxonomically diverse marine ecosystems and provide complex habitat for myriad sessile and mobile organisms."[53] In contrast, "[t]ropical American seagrasses are less diverse than corals, but seagrass meadows cover much greater areas than coral reefs."[54]

Human self-interest should provide sufficient reason for protecting this marine biodiversity. For example, marine algae and other marine plants are responsible for 50 to 75 percent of the

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47. Earle, *supra* note 44, at xiii.
48. Culotta, *supra* note 29, at 919.
49. UNESCO, *Marine Biodiversity*, *supra* note 9, at 1.
50. Center for Marine Biodiversity, *supra* note 14.
51. Jackson, *supra* note 33, at 5411.
52. *Id*. at 5412-14.
53. *Id*. at 5412; *see also* Eric Wolanski et al., *Mud, Marine Snow and Coral Reefs*, 91 AM. SCIENTIST 44, 44 (Jan.-Feb. 2003) ("Coral reefs are the most diverse of all marine ecosystems, and they are rivaled in biodiversity by few terrestrial ecosystems.").
54. Jackson, *supra* note 33, at 5412.

oxygen in the atmosphere.[55] According to some estimates, the open ocean provides ecosystem services worth $8.4 *trillion* a year,[56] while the coastal oceans provide $12.6 trillion in ecosystem services every year.[57]

Finally, the oceans' stores of genetic diversity have enormous potential for the development of pharmaceuticals and other commercial products. For example, the ocean is home to the only known non-photosynthesis-based ecosystems.[58] Hydrothermal vents were discovered in the 1970's along the mid-ocean ridge, a ridge which covers 23 percent of the planet's surface.[59] These vents are home to a variety of species that live at temperatures of 80 degrees Celsius/ 176 degrees Fahrenheit — almost hot enough to boil an egg![60] The creatures that live in and near hydrothermal vents are sometimes called extremophiles because they live under such extreme ecological conditions.[61] As a result, they use unique enzymes and other chemicals that allow them to live at such high temperatures — enzymes and other chemicals that other life forms on Earth do not have, and that are potentially valuable in medicine and commercial products. In addition, vent species live through chemosynthesis, not photosynthesis, relying on hydrogen sulfide — a chemical that is toxic to most other forms of life.[62] Again, the enzymes and other chemicals that allow these species to engage in chemosynthesis are potentially commercially valuable and unlikely to be found elsewhere on Earth.

In addition, the discovery of the hydrothermal vent ecosystems underscores the fact that we know very little about what else might be in the ocean. For example, at the other extreme, in 1997 researchers discovered iceworms living in frozen natural gas in cold seeps at the bottom of the ocean.[63] These iceworms are another extremophile species, presumably with a completely different set of

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55. THORNE-MILLER, *supra* note 44, at 11.

56. Robert Costanza et al., *The Value of the World's Ecosystem Services and Natural Capital*, 387 NATURE 253, 257 (May 15, 1997).

57. *Id*.

58. *See* THOMAS E. SVARNEY & PATRICIA BARNES-SVARNEY, THE HANDY OCEAN ANSWER BOOK 371 (2000).

59. Bryant, *supra* note 19.

60. *Id*. (noting that 300 new species were discovered along these vents); University of Delaware, *Voyage to the Deep: Questions and Answers*, *at* http://www.ocean.udel.edu/deepsea/questions/question.html #creature (last visited Feb. 2, 2005).

61. Bryant, *supra* note 19.

62. *See* University of Delaware, *Voyage to the Deep: Tubeworm*, *at* http://www/ocean.udel.edu/deepsea/level-2/creature/tube.html (last visited Mar. 4, 2005); University of Delaware, *Voyage to the Deep: Chemosynthesis*, *at* http://www.ocean.udel.edu/deepsea/level-2/chemistry/chemo.html (last visited Mar. 4, 2005).

63. Penn State University, *Methane Ice Worms Discovered on Gulf of Mexico Sea Floor*, *at* http://www.science.psu.edu/iceworms/iceworms.html (July 29, 1997).

enzymes and other chemicals that allow it to live in extremely cold temperatures.

## III. CONCERNS ABOUT MARINE BIODIVERSITY AND SCIENTIFIC EXPLANATIONS FOR ITS LOSS

### *A. Evidence of Loss of Marine Biodiversity*

Concerns about loss of marine biodiversity did not really emerge until the 1990s.

> Th[e] tale of species found, then lost . . . [was] a new story for many marine biologists. Except for large vertebrates like mammals and birds, marine organisms rarely appear on lists of extinct and endangered species. Indeed, although the fossil record is full of such extinctions, marine organisms were believed to be resistant to human-caused extinction, because many sea creatures have larvae that can drift long distances and most are thought to have large geographic ranges.[64]

Nevertheless, several indications have emerged over the last decade and a half that the concerns about loss of marine biodiversity are not misplaced. "[T]he relentless growth of human populations to the present 6 billion is exerting a tremendous influence on the oceans, fundamentally changing their biological diversity and threatening a critical part of the Earth's life support system."[65] "As of 1995, 22% of recognized marine fisheries were overexploited or already depleted, and 44% more were at their limit of exploitation."[66] More recently, according to the Food and Agriculture Organization of the United Nations (FAO), 25 percent of the world's 200 major commercial fishery stocks are overfished or significantly depleted, while another 47 percent are fully fished.[67]

Domestic statistics in the United States underscore the FAO's findings. In 1999, according to the National Marine Fisheries Service (now NOAA Fisheries), only 12 percent of the 844 federally

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64. Culotta, *supra* note 29, at 918; *see also* Ogden, *Maintaining Biodiversity*, *supra* note 32, at 30-31 (noting that during the development of the U.N. Convention on Biological Diversity in 1992, "[b]ecause there was no perceived crisis of extinction in the oceans, they were not featured in the convention").

65. Ogden, *supra* note 32, at 30.

66. Vitousek et al., *supra* note 29, at 495.

67. FOOD & AGRICULTURE ORGANIZATION OF THE UNITED NATIONS (FAO), THE STATE OF WORLD FISHERIES AND AQUACULTURE 23 (2002), *at* http://www.fao.org/documents/show_cdr.asp?url_file=/docrep/005/y7300e/ y7300e00.htm.

managed fish stocks in the United States were overfished or approaching overfished; however, the status of another 64 percent of those stocks was "unknown."[68] Similarly, of the 163 stocks of marine mammals subject to federal management, only five percent are known to be declined — but the status of 66 percent of those stocks is unknown,[69] and 29 species of marine mammals are listed for protection under the federal Endangered Species Act.[70] Moreover, it should be remembered that whales have been protected under federal law since 1949[71] and that all marine mammals have been protected under federal law since 1972.[72] The picture is even bleaker for the stocks of sea turtles found in United States waters: all seven species of sea turtle are listed for protection under the Endangered Species Act,[73] two of the 12 stocks in the United States are known to be decreasing,[74] and the status of another two stocks is unknown.[75]

Historical examinations of marine ecosystems also provide cause for concern. Such studies reveal centuries-long depletions of these ecosystems that, perversely have gone largely unnoticed until recently "because our concept of what is natural today is based on personal experience at the expense of historical perspective. Thus, 'natural' means the way things were when we first saw them or exploited them, and 'unnatural' means all subsequent change."[76] In contrast, historical perspectives in particular ecosystems reveal, for example, that "[s]pecies composition of Caribbean coral communities was stable for at least 125 thousand years, until the collapse in the 1980s."[77]

### *B. The Traditional Explanation: Marine Pollution*

A number of human activities threaten marine biodiversity, including coastal development, destruction of marine habitats, introduction of invasive species, and overfishing.[78] Traditionally,

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68. NATIONAL MARINE FISHERIES SERVICE, NATIONAL OCEANIC & ATMOSPHERIC ADMINISTRATION, U.S. DEPARTMENT OF COMMERCE, OUR LIVING OCEANS: REPORT ON THE STATUS OF U.S. LIVING MARINE RESOURCES 63 (1999).

69. *Id*. at 231 table 22-1, 235-39 table 23-1, 248-49 table 24-1.

70. *Id*. The Endangered Species Act is codified at 16 U.S.C. §§ 1531-1544 (2004).

71. Whaling Convention Act of 1949, 16 U.S.C. §§ 916-916(*l*) (2005).

72. Marine Mammal Protection Act of 1972, 16 U.S.C. §§ 1361-1421a (2004).

73. NATIONAL MARINE FISHERIES SERVICE, *supra* note 68, at 262.

74. *Id*.

75. *Id*.

76. Jackson, *supra* note 33, at 5411.

77. *Id*. at 5412.

78. *See generally* Robin Kundis Craig, *Oceans and Estuaries*, *in* STUMBLING TOWARD SUSTAINABILITY 227-55 (John C. Dernbach ed. 2002) (discussing threats to the sustainability of marine ecosystems and living marine resources).

however, both scientists and policymakers have focused on marine pollution as the most important problem affecting marine biodiversity. Most prominently, moreover, they have focused on oil pollution and headline-grabbing incidents such as the *Torrey Canyon* oil spill off of England[79] and the *Exxon Valdez* oil spill in Alaska.[80] Such oil spills can kill the birds and other wildlife that become coated with the oil, interfere with respiration and feeding, and destroy marine habitat, often for decades. The *Exxon Valdez* spill, for example, occurred in 1989, and the area affected, Prince William Sound, is still recovering.[81]

Despite the obviousness of oil spills, however, they are a relatively small ocean pollution problem. While the world's oceans receive about 3.25 million tons of oil each year, the majority of that oil comes from street runoff instead of tanker spills.[82] Accidental spills and shipping are responsible for only about 12 percent of all marine pollution, while offshore oil and gas drilling and mining are responsible for another 1 percent.[83] Instead, 77 percent of all marine pollution comes from land-based sources — 44 percent from land-based water pollutant and 33 percent from land-based air pollution.[84] As Nancy Knowlton at the Center for Marine Biodiversity at the Scripps Institution of Oceanography has summarized:

> The most obvious problems stem from our propensity to view dilution as the solution to pollution. Human numbers continue to grow, as do per capita amounts of waste, and much of this waste ultimately finds its way into the ocean. Some waste is toxic, some carries human pathogens, and some alters marine food chains in ways detrimental to human well-being.[85]

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79. IMO, *International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (MARPOL 73/78), at* http://www.imo.imo.org/Conventions/contents.asp?doc_id=678&topic_id=258 (last visited Feb. 2, 2005).

80. Craig, *supra* note 78, at 237.

81. *See Exxon Valdez* Oil Spill Trustee Council, *Restoration Projects*, *at* http://www.evostc.state.ak.us/restoration (last visited Feb. 2, 2005) (discussing ongoing restoration efforts at the site).

82. SVARNEY & BARNES-SVARNEY, *supra* note 58, at 431.

83. *Id*. at 433.

84. *Id*. *See also* UNESCO, *Marine Biodiversity*, *supra* note 9, at 1 ("Over 70% of marine contamination comes from the mainland whether due to dumping of waste products, pesticides, hydrocarbons or toxic products. Even air pollution started on land is eventually deposited on the water surface.").

85. Knowlton, *supra* note 37, at A262.

Land-based air pollution can arise from both natural events, such as desert sand storms and dust storms, and human-caused events, such as forest fires and industrial air pollution. This pollution can acidify ocean waters, increase the concentration of heavy metals and other toxic pollutants in the oceans, and increase sedimentation of the oceans, blocking sunlight, interfering with photosynthesis, and smothering coastal ecosystems such as coral reef.[86] Land-based water pollution can also carry toxics and sediment into the seas, causing similar problems.[87] In addition, toxic pollutants, in combination with rising sea temperature, "are lowering the natural resistance of marine organisms to infections."[88] Thus, for example, organochloride pollution has been linked to "the mass mortality of Mediterranean monk seals off the coast of Mauritania, which died after becoming infected with a distemper virus of dolphins."[89]

In addition, land-based water pollution, especially from agriculture, carries nutrients (fertilizers) and pesticides into the ocean.[90] Excess nutrients, in turn, result in algal blooms in the ocean — relatively quick explosions in the concentrations of various kinds of algae.[91] With many species of algae, the result is Harmful Algal Blooms (HABs) that can lead to red tides and contamination of fish and shellfish as the algae produces neurotoxins.[92] A variety of kinds of HABs have occurred, and recurred, off of every United States coast since at least 1985, including the coasts of Alaska, Hawaii, and Puerto Rico.[93] In addition, after the algae dies, its decomposition uses up much of the oxygen available in the seawater, causing eutrophic conditions and, eventually, "dead zones" (or, more scientifically, hypoxic zones) void of all animal life.[94] "The number of oxygen-starved areas in oceans and bays

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86. *See generally* SVARNEY & BARNES-SVARNEY, *supra* note 58, at 431-34.

87. Craig, *supra* note 78, at 237.

88. Connor, *supra* note 32, at 3; *see also* Harvell et al., *supra* note 34, at 1505 ("In the North Atlantic, frequency of mass mortalities of marine mammals appears to be increasing, particularly along heavily polluted coastal areas, suggesting human activity as a factor in disease dynamics.").

89. Connor, *supra* note 32, at 3.

90. Zoë Chafe, *Ocean Dead Zones Multiplying*, 17:4 WORLD WATCH 10 (July/Aug. 2004); Anne Simon Moffat, *Global Nitrogen Overload Problem Grows Critical*, 279 SCI. 988, 988 (Feb. 13, 1998).

91. Chafe, *supra* note 90, at 10; Vitousek et al., *supra* note 29, at 495.

92. Moffat, *supra* note 90, at 988; Vitousek et al., *supra* note 29, at 495 ("A recent increase in the frequency, extent, and duration of harmful algal blooms in coastal areas suggests that human activity has affected the base as well as the top of marine food chains.").

93. U.S. Environmental Protection Agency, *Major Harmful Algal Bloom Events in the Coastal U.S. 1985-1997, at* http://www.epa.gov/owow/oceans/maps/hab.gif (last visited Feb. 2, 2005).

94. SVARNEY & BARNES-SVARNEY, *supra* note 58, at 444; Stephanie Joyce, *The Dead Zones:*

around the world ha[d] doubled [by 2003] to 246 since 1990,"[95] and by April 2004, UNEP had "identified 150 'dead zones' in the world's oceans as a result of sewage and agricultural pollution,"[96] the result of "an excess of nutrients — mainly nitrogen — being released into the sea."[97] Nitrogen pollution and the resulting hypoxia have been deemed the cause of "the collapse of the Baltic Sea cod fishery in the early 1990s . . . ."[98] In the United States, hypoxic zones began to develop in the 1970s and have since been recorded in at least 36 coastal locations.[99] The most dramatic of these zones is the dead zone in the Gulf of Mexico, which often covers an area the size of New Jersey and which scientists "have linked … to algae blooms caused by nitrogen fertilizer poured into the gulf by the Mississippi River."[100] Nitrogen pollution and hypoxia are affecting marine biodiversity, especially "in many estuaries, where a few phytoplankton species have flourished, choking out other species."[101]

The remaining 10 percent of ocean pollution comes from ocean dumping, that is, the disposal of wastes at sea.[102] Many different kinds of materials are dumped in the ocean, both on purpose, for disposal, and accidentally, such as when fishers lose nets. Many of these materials are obviously detrimental to marine biodiversity. For example, before 1972 in the United States, ocean dumping resulted in 100 million tons of petroleum products, 100,000 tons of organic chemical wastes, 38 million tons of dredged materials (often contaminated with toxics), 4.5 million tons of sewage sludge, 4.5 million tons of industrial wastes, two to four million tons of acid chemical wastes, a million tons of heavy metals, and 500,000 tons of construction materials being added to the offshore waters each

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*Oxygen Starved Coastal Waters*, 108 ENVTL. HEALTH PERSP. (Mar. 2000), *available at* http://ehp.niehs.nih.gov/docs/2000/108-3/focus.html.

95. Chafe, *supra* note 90, at 10; *see also* Knowlton, *supra* note 37, at A262 (noting that "[t]oxic algal blooms . . . are increasingly common in coastal areas worldwide") (citation omitted).

96. *UN Sounds the Alarm on Dead Zones in Ocean*, UTILITY WEEK, Apr. 23, 2004, at 12.

97. *Id.*; *see also* Chafe, *supra* note 90, at 10 ("Several types of pollution — including excess chemical fertilizers, human waste, airborne industrial waste, and traffic fumes — can cause nitrogen concentrations to reach damaging levels.").

98. Moffat, *supra* note 90, at 988.

99. PEW OCEANS COMMISSION, AMERICA'S LIVING OCEANS: CHARTING A COURSE FOR SEA CHANGE 22 (2003), *available at* http://www.pewtrusts.org/pdf/env_pew_oceans_final_report.pdf [hereinafter PEW OCEANS COMMISSION].

100. Moffat, *supra* note 90, at 988.

101. *Id*. at 989. In addition, HABs are detrimental to human health. "As with pollutants, the toxins from these blooms are concentrated as they move up the food chain, but they can also cause human health problems through skin and aerosol contact." Knowlton, *supra* note 37, at A262.

102. SVARNEY & BARNES-SVARNEY, *supra* note 58, at 433.

year.[103] In addition, between 1946 and 1970, dumpers disposed of over 55,000 containers of radioactive wastes into American waters.[104]

However, even more benign-appearing trash, especially plastics, can harm the creatures of the ocean. First, some creatures mistake trash for food. Sea turtles, for instance, normally eat jellyfish, and plastic sacks can look a lot like jellyfish. In addition, creatures can become physically entangled in marine trash and for creatures that need to breathe, like whales, birds, seals, and turtles, such entanglements can often lead to drowning or strangulation.[105] Marine debris can also physically damage or destroy the habitat that marine species need to live.[106] This problem is especially acute for coral reefs and delicate sea grass beds.[107] In fact, derelict fishing gear is the primary threat to the Northwestern Hawaiian Islands' coral reefs, which are arguably the most pristine coral reef ecosystems in the world.[108]

Finally, most recently, scientists have linked plastic debris in the oceans to colonizations by alien marine species, "one of the greatest threats to global biodiversity."[109] Noting that anthropogenic sources of marine debris, especially plastics, have been increasing dramatically recently —– "for example, the amount of debris doubled from 1994 to 1998 around the coastline of the United Kingdom, and in parts of the Southern Ocean it increased 100-fold during the early 1990s" — David Barnes reported in 2002 in *Nature* that "[m]any types of animal use marine debris as a mobile home" and that, "[c]ompared with boats, . . . man-made debris is longer lasting, more pervasive and travels more slowly, factors that could favour the survival of colonists."[110] He concludes that:

> Rubbish of human origin in the sea has roughly doubled the propagation of fauna in the subtropics and more than tripled it at high (>50?) latitudes,

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103. U.S. Environmental Protection Agency, *Ocean Regulatory Programs: Ocean Dumping before the MPRSA*, *at* http://www.epa.gov/owow/oceans/regulatory/mprsa/before.html (last updated July 29, 2004).

104. *Id*.

105. SVARNEY & BARNES-SVARNEY, *supra* note 58, at 435. *See* David K.A. Barnes, *Invasions by Marine Life on Plastic Debris*, 416 NATURE 808, 809 (Apr. 25, 2002).

106. National Ocean & Atmospheric Administration (NOAA), *Northwestern Hawaiian Islands Coral Reef Ecosystem Reserve: the Region*, *at* http://hawaiireef.noaa.gov/region/region.html (last revised July 1, 2002).

107. *See id.*

108. *Id*.

109. SVARNEY & BARNES-SVARNEY, *supra* note 58, at 808.

110. *Id*.

> increasing the potential for alien invasions and adding to the problems already created by sea-borne plastic materials in the form of injuries and mortality among marine mammals and birds.[111]

### *C. The More Recent Explanation: Overfishing*

While marine pollution, especially land-based marine pollution, remains a serious problem for marine biodiversity, scientists in the last decade have identified another threat that, historically, has almost certainly been more important in causing the loss of marine biodiversity: overfishing. "A threat to marine biodiversity, overfishing refers to the practice of commercial and non-commercial fishing which depletes a fishery by catching so many adult fish that not enough remain to breed and replenish the population."[112] However, "[w]ith the competing claims of deforestation, desertification, energy resource exploitation and other biodiversity depletion dilemmas, the magnitude of the problem of overfishing is sadly overlooked."[113]

Overfishing contributes to loss of marine biodiversity in several ways. Most obviously, overfishing depletes the species that are the targets of the fishing, especially given the capacities of modern commercial fishing vessels. In 1986, for example, a single Norwegian fishing boat could catch 120 million fish, and 12 Boeing 747s can fit in the largest trawl nets that commercial "factory ships" use in their operations.[114] As early as 1996, UNESCO reported that "[t]hanks to technological advances, fishing techniques are increasingly sophisticated, leading to the over exploitation of marine resources with devastating impact on important fishing grounds. It is estimated that no fewer than 9 of the world's 17 fishing grounds are already on the way to exhaustion."[115] A year later, scientists reported in the journal *Science* that "humans use about 8% of the primary production of the oceans, [and] that fraction grows to more than 25% for upwelling areas and to 35% for temperate continental shelf systems."[116]

Overfishing is having measurable effects on biodiversity. In 2002, according to the Pew Oceans Commission, the status of 655

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111. *Id*. at 809.
112. Udy Bell, *Overfishing: A Threat to Marine Biology*, XLI:2 UN CHRONICLE 17, 17 (2004), *available at* http://www.un.org/Pubs/chronicle/2004/issue2/0204p17.asp.
113. *Id*.
114. Worldwatch Institute, *Biodiversity Factors*, 16:1 WORLD WATCH 39 (Jan.-Feb. 2003).
115. UNESCO, *Marine Biodiversity*, *supra* note 9, at 2.
116. Vitousek et al., *supra* note 29, at 495.

of the 959 commercially fished stocks worldwide, or 68.3 percent of the stocks, was simply unknown.[117] Nevertheless, of the 304 stocks whose status *is* known, 93 (or 31.7 percent), are overfished, experiencing overfishing, or both.[118] The FAO's statistics are even more disturbing: it "has calculated that over 70 per cent of the world's fish species are either fully exploited or depleted."[119] As Nancy Knowlton has more colorfully summarized, "[w]e have already eaten about 90% of the big fish that live on continental shelves and the open ocean . . ., and in many coastal waters densities have been reduced to a far greater extent."[120]

The basic biology and life cycles of many targeted species exacerbate the effects of overfishing. For example, fishers quite rationally target the biggest fish. However, the biggest fish also produce the most gametes — sometimes *ten times* as many eggs and sperm as smaller fish.[121] Moreover, many commercially important species of fish go through a sex change as they mature.[122] Thus, in targeting the largest individuals, fishers effectively wipe out one entire sex.[123] As a result, ordinary fishing practices severely interfere with targeted species' abilities to reproduce and replenish their numbers.

In addition, most commercial fishing methods result in "bycatch" of non-target species, extending the biodiversity effects of overfishing too many other species.[124] In particular, indiscriminate fishing practices such as huge nets and trawling operations catch numerous individuals of a variety of species that the fishers do not want and cannot sell,[125] and the fishers generally just toss this dead and dying bycatch back into the ocean.[126] Bycatch represents, conservatively, 25 percent of the total fish caught, a total of 27 million tons of wasted biodiversity every year.[127]

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117. PEW OCEANS COMMISSION, *supra* note 99, at 37 fig. 1.
118. *Id*.
119. Bell, *supra* note 112, at 17.
120. Knowlton, *supra* note 37, at A262.
121. CALLUM M. ROBERTS & JULIE P. HAWKINS, FULLY-PROTECTED MARINE RESERVES: A GUIDE 17 (WWF Endangered Seas Campaign 2000), *available at* http://www.panda.org/downloads/marine/marinereservescolor.pdf.
122. *See id.* at 26.
123. *Id*.
124. THORNE-MILLER, *supra* note 44, at 18.
125. *See* KATE WING, NATIONAL RESOURCES DEFENSE COUNSEL, KEEPING OCEANS WILD: HOW MARINE RESERVES PROTECT OUR LIVING SEAS 3 (Apr. 2001), *available at* http://www.nrdc.org/water/oceans/kow/kow.pdf.
126. THORNE-MILLER, *supra* note 44, at 19.
127. Vitousek et al., *supra* note 29, at 495 (finding "commercial marine fisheries around the world discard 27 million tons of nontarget animals annually, a quantity nearly one-third as large as total landings"); *see also* Caroline Ash, *A Desktop View of Overfishing*, 305 SCI. 1242, 1242 (Aug. 27, 2004) (noting in a book review that the waste involved in commercial fishing

Certain fishing practices also destroy essential habitat for marine species, further reducing marine biodiversity. Bottom trawling is generally considered the most destructive fishing practice worldwide[128] and "has been compared to catching squirrels by cutting down forests. Bottom trawl nets scour and destroy an estimated global area of fish habitat the equivalent of 150 times the area of forests cut annually worldwide, and a great proportion of the catch — the so-called by-catch — is discarded."[129]

Numerous coastal nations — including, unfortunately, many developing nations — are already feeling the effects of this loss of biodiversity through commercial overfishing. Research indicates that nations that opened their ocean waters to foreign fishing fleets have experienced "eventual costs, in terms of loss of income for local fishermen, environmental damage and the depletion of native fish stocks, [that] can far outweigh the short-term financial gains generated from foreign Governments and fleets."[130]

In addition, recent studies have indicated that recreational fishing affects marine biodiversity — in some cases, especially where commercial regulation is in place, more than commercial fishing. An August 2004 study in the journal *Science*, suggested "that the millions of weekend fishermen who go out on party boats or stand along the sand with their rods are having a significant effect — and in some areas catching more fish than commercial crews."[131] The same study "found that although recreational fishing accounted for only 4 percent of the total catch nationwide, among 'species of concern,' or those species that the federal government classifies as overfished, recreational fishermen catch 23 percent."[132] Moreover, for specific species of concern in specific areas, that percentage can be even higher — up to 59 percent of eight species caught off of California, Oregon, and Washington, for example.[133]

One of the most important discoveries regarding marine biodiversity, however, is that overfishing can affect not just individual targeted and bycaught species but also the function of

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"is pitiful: even trawlermen will eat fish, especially a fat haddock, but they cannot consume all the nonquota fish they catch and these (dead on arrival at the surface) are flung to the kittiwakes and gannets"); UNESCO, *Marine Biodiversity*, *supra* note 9, at 2 ("What is even more alarming for marine biodiversity is that with the new fishing techniques using trawling and drift nets which capture anything indiscriminately, at times up to 70% of the catch has to be thrown away!").

128. Vitousek et al., *supra* note 29, at 495.

129. Ogden, *supra* note 32, at 33.

130. Bell, *supra* note 112, at 17.

131. Paul Rogers, *Overfishing Now a Problem for Recreational Fishermen, Study Says*, SAN JOSE MERCURY NEWS, Aug. 27, 2004, *available at* 2004 WL 59250901, at *1.

132. *Id*.

133. *Id*.

entire marine ecosystems. Even the so-called "simplest" marine ecosystems depend on complex interactions between species, and, together, the effects of overfishing destroy the "normal" interactions in a marine ecosystem, reducing biodiversity.[134] Moreover, because fisheries tend to target the largest apex predators in a given ecosystem — like tuna — overfishing distorts the balance of trophic levels within that ecosystem.[135] The composition of Jamaican coral reef ecosystems, for example, have changed dramatically over two centuries as a result of overfishing,[136] and as early as 1993 "overfishing was deemed one of the three most serious threats to reefs" one reason being that it "reduces species diversity on reefs."[137]

Some scientists — notably Jeremy B.C. Jackson — have used historical and geological records to argue that human overfishing has been disturbing marine ecosystems ever since humans learned to fish, causing a variety of biodiversity and other ecological effects.[138] For example, oysters in the Chesapeake Bay were once so plentiful that they could filter all the water in the Chesapeake Bay in less than a week.[139] Beginning in the 19th century, however, overfishing severely depleted the oyster population, and it now takes oysters 46 weeks to filter the water, severely affecting the water quality in the Bay.[140] In part as a result of this loss of ecosystem function, "[d]uring the 20th century, once very extensive meadows of seagrasses, oyster beds, clams, blue crabs, and fish declined precipitously, while abundance and production of phytoplankton, eutrophication, and episodes of hypoxia and anoxia correspondingly increased."[141]

Jackson has also tied other ecosystem collapses to overfishing of key species. For example, the collapse of Caribbean coral communities in the 1980s was most proximately caused by "overgrowth by macroalgae that exploded in abundance after an unidentified pathogen caused mass mortality of the enormously

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134. Ogden, *supra* note 32, at 29.

135. Vitousek et al., *supra* note 29, at 495 ("Many of the fisheries that capture marine productivity are focused on top predators, whose removal can alter marine ecosystems out of proportion to their abundance.").

136. PEW OCEANS COMMISSION, *supra* note 99, at 8 fig. 2.

137. Callum M. Roberts, *Effects of Fishing on the Ecosystem Structure of Coral Reefs*, 9:5 CONSERVATION BIOLOGY 988, 989 (Oct. 1995) (citations omitted).

138. *See generally, e.g.*, Jeremy B.C. Jackson et al., *Historical Overfishing and the Recent Collapse of Coastal Ecosystems*, 293 SCI. 619 (July 27, 2001); Ransom A. Myers & Boris Worm, *Rapid Worldwide Depletion of Predatory Fish Communities*, 423 NATURE 280 (May 15, 2003).

139. Jackson, *supra* note 33, at 5414.

140. *Id*.

141. *Id*. at 5413 (citation omitted).

abundant grazing sea urchin *Diadema antillarum* in 1983-1984,"[142] but the less proximate cause appears to be overfishing, which eliminated both the sea urchins predators and the "large herbivorous fishes that had competed with *Diadema* for algal food."[143] As a result, "[o]verfishing allowed *Diadema* to increase in abundance and conpensate for loss of herbivorous fishes that ate macroalgae before overfishing began. Then, when *Diadema* died out there were no other large grazers remaining to consume the algae."[144] In other words, loss of biodiversity, as a result of overfishing the large plant-eating fish in the 19th century, resulted in a loss of redundancy of ecosystem function which left the entire coral reef vulnerable to a disease in one species, the sea urchins. Because of this overfishing and other factors, "[t]he coral reefs of the Caribbean are close to extinction . . . . Just 10 per cent of the Caribbean's reefs remain inhabited by the species of hard coral that created them, compared with 50 per cent cover just 25 years ago."[145]

Other marine ecosystems are threatened with similar fates as a result of historical and continuing overfishing and the resulting disruption of ecosystem function. "Seagrasses along the Florida coast experienced mass mortality in the 1980s because of a wasting disease", in part as a result of the ecological extermination of green sea turtles since the times of Columbus; sea turtles eat the seagrasses, reducing the spread of disease and "reduc[ing] 20-fold the flux of detritus and nitrogen to seagrass sediments."[146] In the 1920s, introduction of mechanized fishing led quickly to overfishing of large cod in the Gulf of Maine's rich kelp forests, allowing sea urchins to reproduce unchecked and to consume "all of the kelp, which was replaced by structurally 'barren' substrata covered by encrusting coralline algae."[147] Loss of the kelp eventually reduced the population of sea urchin, as well, but while the kelp eventually returned, the ground fishes that it originally supported did not.[148]

Jackson notes five biodiversity-related trends in his historical studies of marine overfishing. First, "[l]arge, long-lived vertebrates such as manatees, sea turtles, large fishes, and sharks were the first to disappear from coastal ecosystems in response to human activities because of their life history characteristics and large body

142. *Id*. at 5412 (citation omitted).
143. *Id*. (citation omitted).
144. Jackson, *supra* note 33, at 5414.
145. Fred Pearce, *Extinction Looms for Caribbean "Rainforest of the Oceans,"* 179 NEW SCIENTIST 0262-4079 (July 26, 2003).
146. Jackson, *supra* note 33, at 5413.
147. *Id*. at 5414.
148. *Id*.

size that attracted the most attention."[149] Second, the elimination of "ecosystem engineers" — that is, "species that modify, maintain, or create habitats," including "[r]eef-building corals, seagrasses, oysters, and kelps" — through overharvesting results in loss of habitat structure, decreased growth and larval recruitment, increased mortality, and "precipitous" drops in "[d]iversity and abundance of associated species."[150] Third, the connections between human activities (overfishing) and biodiversity effects can be difficult to detect because of "[l]engthy time lags between initial harvesting and many of the resulting ecological consequences" — "time lags of decades to centuries" — resulting from, as in the examples above, initial redundancies in ecological function.[151] Fourth, overfishing of the large vertebrates leads to "[f]ishing [d]own [f]ood [w]ebs," with the result that "[s]maller and smaller fishes, sea urchins, lobsters, and shrimps are replacing large fishes, turtles, and sharks as the remnant fisheries in all of the coastal ecosystems discussed . . . ."[152] Finally, overfishing combined with land-based pollution "are resulting in increas[ed] abundance and widespread dominance of ecosystem processes by microbes."[153] Increasingly frequent invasions of exotic species also seem to accompany loss of species and normal ecosystem function.[154]

## IV. THE INTERNATIONAL RESPONSE TO THE SCIENTIFIC EXPLANATIONS OF MARINE BIODIVERSITY LOSS

### *A. International Treaties Governing Marine Pollution*

The international legal community "gets" that marine pollution is a problem, and a long series of international treaties govern various aspects of marine pollution. One of the first was the 1914 International Convention for the Safety of Life at Sea (SOLAS). The original version of SOLAS was adopted in 1914 in response to the *Titanic* disaster.[155] The parties substantially amended SOLAS in 1929, 1948, 1960, 1974, and 1978.[156] Most relevant to marine pollution issues, SOLAS's 1978 Protocol was adopted at the International Conference on Tanker Safety and Pollution

149. *Id*.
150. *Id*. at 5415.
151. Jackson, *supra* note 33, at 5415.
152. *Id*.
153. *Id*.
154. *Id*. at 5416.
155. International Maritime Organization (IMO), *International Convention for the Safety of Life at Sea (SOLAS), 1974, at* http://www.imo.org/conventions/contents.asp?topic_id=257&doc_id=647 (last visited Feb. 10, 2005).
156. *Id*.

Prevention in February 1978 and came into force on May 1, 1981.[157] This Protocol requires tankers carrying crude oil and other products to have substantial protections against spills.[158] For example, tankers over 20,000 dead weight tons must have an inert gas system to contain oil.[159]

A more important treaty governing maritime oil pollution is the International Convention for the Prevention of Pollution of the Sea by Oil. This Convention came into force on December 8, 1961, and addressed pollution resulting from routine tanker operations and from ships' discharges of oily wastes.[160] The Convention prohibited discharges of concentrated amounts of these materials within 50 miles of land and encouraged parties to provide facilities to handle and treat ships' oily wastes.[161]

One of the most important general international marine pollution treaties is the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, better known as the London Convention, which was adopted in London in November 1972 and came into force on August 30, 1975.[162] Its purpose is to "prevent the pollution of the sea by the dumping of waste and other matter that is liable to create hazards to human health, to harm living resources and marine life, to damage amenities or to interfere with other legitimate uses of the seas."[163] The 1972 Convention allows the parties to divide dumped materials into three categories: Annex I wastes, the dumping of which is completely prohibited; Annex II wastes, which cannot be dumped at sea without a prior special permit; and all other wastes, the dumping of which requires a prior general permit.[164] For example, in 1993, the parties instituted a ban on the ocean disposal of low-level radioactive wastes.[165]

Currently, the parties to the London Convention are debating whether to make it even more protective. The 1996 Protocol to the

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157. *Id*.
158. *Id*.
159. *Id*.
160. *See generally* International Convention for the Prevention of Pollution of the Sea by Oil, 1954 (May 12, 1954), T.I.A.S. No. 4900, 327 U.N.T.S. 3, 12 U.S.T. 2989 (entered into force Dec. 8, 1961).
161. *Id*. art. III.
162. IMO, Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972, at http:www.imo.org/Conventions/contents.asp?topic_id= 258&doc_id= 681 (last visited Feb. 2, 2005).
163. Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, Dec. 29, 1972, art. I, T.I.A.S. No. 8165, 26 U.S.T. 2403 (entered into force Aug, 30, 1975) [hereinafter London Convention].
164. *Id*. at art IV.
165. London Convention, *supra* note 163.

Convention, designed to replace the 1972 Convention, would reverse the 1972 presumption that dumping is allowed, adopt a precautionary approach, and forbid ocean dumping of *anything* unless the parties to the Convention specifically allow such dumping.[166] The 1996 Protocol will come into force 30 days after the 26th country ratifies it,[167] but so far only 21 countries have done so.[168]

The International Convention for the Prevention of Pollution from Ships, better known as the MARPOL Convention, was adopted in 1973 and, together with the 1978 Protocol, came into force on October 2, 1983.[169] The Convention was inspired by the 1967 *Torrey Canyon* tanker spill in the United Kingdom,[170] and its goal is to prevent and minimize pollution from ships.[171] The Convention's six Annexes address just about every kind of ship pollution possible:

- ANNEX I: Regulations for the Prevention of Pollution by Oil. Annex I entered into force on October 2, 1983, but a revised Annex I will enter into force on January 1, 2007.[172]
- ANNEX II: Regulations for the Control of Pollution by Noxious Liquid Substances in Bulk. Annex II entered into force on April 6, 1987, but a revised Annex II will enter into force on January 1, 2007.[173]
- ANNEX III: Prevention of Pollution by Harmful Substances Carried by Sea in Packaged Form. Annex III entered into force on July 1, 1992.[174]
- ANNEX IV: Prevention of Pollution by Sewage from Ships. Annex IV entered into force on September 27, 2003.[175]
- ANNEX V: Prevention of Pollution by Garbage from Ships. Annex V entered into force on December 31, 1988.[176]

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166. 1996 Protocol to the Convention on the Prevention of Marine Pollution by Dumping and Other Matter, 1972, Nov. 7, 1996, arts. 3.1, 4, 1996 WL 1056820.
167. *Id*.
168. IMO, *Summary of Status of Conventions*, *at* http://www.imo.org/Conventions/mainframe.asp?topic_id=247 (last updated Dec. 31, 2004).
169. IMO, *International Convention for the Prevention of Pollution from Ships*, 1973, *supra* note 79.
170. *Id*.
171. *Id*.
172. *Id*.
173. *Id*.
174. IMO, *International Convention for the Prevention of Pollution from Ships, 1973*, *supra* note 79.
175. *Id*.
176. *Id*.

- ANNEX VI: Prevention of Air Pollution from Ships. The parties to the Convention adopted Annex VI in September 1997, and it will enter into force on May 19, 2005.[177]

Annex I of the Convention also allows the parties to designate some regions of the ocean as "special areas," and since then the parties have so designated the Mediterranean Sea (1973), the Black Sea (1973), the Red Sea (1973), the Gulfs area (1973), the Gulf of Aden (1987), the North Sea (1989), Antarctica (1990), the Wider Caribbean Region (1991), and the Northwest European waters (1997).[178] "Special areas" "are considered to be so vulnerable to pollution by oil that oil discharges within them have been completely prohibited, with minor and well-defined exceptions."[179]

The International Convention on Oil Pollution Preparedness, Response and Cooperation was adopted in November 1990 and came into force on May 13, 1995.[180] However, before it actually came into effect, it was put into practice on a provisional basis in 1991 to respond to oil pollution in the Persian Gulf as a result of the first Gulf War.[181] The goal of the Convention is to prevent marine pollution by oil using a precautionary approach.[182] It requires parties to adopt adequate response measures for oil spills, to provide mutual assistance and cooperation in responding to oil spills, to craft oil pollution emergency plans, to stockpile oil pollution equipment, and to adopt reporting requirements for oil spills.[183]

Finally, and most recently, the Global Programme of Action for the Protection of the Marine Environment from Land-Based Activities is not a true treaty but rather a global agreement to take action to protect the oceans from land-based pollution.[184] It was adopted in 1995 by 108 countries and the European Commission at a UNEP conference in Washington, D.C.[185] The agreement

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177. *Id*.
178. *Id*.
179. IMO, *International Convention for the Prevention of Pollution from Ships, 1973, supra* note 79.
180. IMO, *International Convention on Oil Pollution Preparedness, Response, and Cooperation, 1990, at* http://www.imo.org/Conventions/mainframe.asp?topic_id=258&doc_id=682 (last visited Feb. 2, 2005).
181. National Ocean Service, NOAA, *International Convention on Oil Pollution Preparedness, Response, and Cooperation (OPRC), 1990, at* http://international.nos.noaa.gov/conv/oprc.html (last visited Feb. 3, 2005).
182. *Id*.
183. *Id*.
184. UNEP, *About the GPA Global Programme of Action, at* http://www.gpa.unep.org/about/default.htm (last updated Dec. 4, 2003).
185. *Id*.

encourages participants to adopt national programs of action to reduce land-based marine pollution.[186] The United States has already relied on the Global Programme to enter side agreements under the North American Free Trade Agreement to protect the California Bight and the Gulf of Maine.[187]

There is evidence that these international treaties and agreements have been effective in addressing various kinds of marine pollution, especially oil pollution and ocean dumping. According to the International Maritime Organization (IMO), which implements the MARPOL Convention, oil pollution from ships, from all sources, has decreased steadily worldwide since 1973.[188] As for ocean dumping, the IMO reports that "[u]nregulated dumping has largely been halted since" nations ratified the London Convention and similar regional treaties.[189] "In early 1991, incineration at sea operations came to a halt,"[190] and dumping of industrial wastes dropped from 17 million tonnes per year in the 1970s to 8 million tonnes per year in the 1980s; "[f]or the period 1992-1995 the total quantity dumped varied from 4.5 million to 6 million tonnes, most of which was dumped by Japan and the Republic of Korea."[191] Since 1996, moreover, none of the 80 parties to the London Convention has issued any permits for the dumping of industrial waste.[192] "Currently, only three Contracting Parties dump sewage sludge at sea: Japan, Philippines and Republic of Korea,"[193] and, as noted, a moratorium on the dumping of radioactive wastes has been in place since 1983.[194] As a result, currently, the largest component of materials dumped in the seas is relatively clean dredged material.[195]

Control of land-based ocean pollution remains more elusive, although even here some progress has been made. UNEP, for example, has focused on control of land-based water pollution, especially sewage, as part of its Millennium Development Goals and

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186. *Id*.

187. International Program Office, National Ocean Service, *Global Programme of Action for the Protection of the Marine Environment from Land-Based Activities*, *at* http://international.nos.noaa.gov/conv/gpa.html (last visited Feb. 2, 2005).

188. *See* INTERNATIONAL MARITIME ORGANIZATION, MARPOL — 25 YEARS (Oct. 1998), *at* http://www.imo.org/includes/blast_bindoc.asp?doc_id=432&format=PDF.

189. IMO, *A Brief Description of the London Convention 1972 and the 1996 Protocol*, *at* http://www.londoncon vention.org/London_Convention.htm (last revised Dec. 16, 2003).

190. *Id*.

191. *Id*.

192. *Id*.

193. *Id*.

194. IMO, *A Brief Description of the London Convention 1972 and the 1996 Protocol*, *at* http://www.londoncon vention.org/London_Convention.htm (last revised Dec. 16, 2003).

195. *Id*.

to meet the Plan of Implementation goals developed at the 1992 World Summit on Sustainable Development.[196]

> Several countries and regions have already begun to take steps to limit the pollution that creates and aggravates dead zones. Near the Rhine River in Europe, where several countries have agreed to halve the levels of nitrogen they discharge, the quantities of nitrogen entering the North Sea have been reduced by 37 percent.[197]

In addition, "[w]aste treatment facilities in Europe and North America are using new technologies to reduce agricultural runoff."[198]

### *B. Dealing with Overfishing: International Treaties Encouraging Marine Protected Areas*

Numerous treaties, like the International Convention for the Conservation of Atlantic Tuna, exist to regulate individual imperiled marine species. This focus on individual species, however, has proven largely ineffective at addressing the effects of overfishing on nontarget species, habitat, and marine ecosystems.[199] For example, for biodiversity purposes, one of the most important limitations of regulation directed specifically at fishing is that such regulation tends to focus exclusively on the targeted species, without consideration of the larger ecosystem on which it depends.[200] In addition, with respect to treaties directly addressing international overfishing, enforcement of catch limits is difficult, and certain fishers and entire nations have reputations for underreporting the amount of fish — and especially of bycatch — that they catch.[201]

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196. Chafe, *supra* note 90, at 10.
197. *Id*.
198. *Id*.
199. *See*, Ogden, *supra* note 32, at 29-30.
200. *See*, *e.g.*, *id.* at 29 (discussing the failure of the United States' Magnuson-Stevens Fisheries Conservation and Management Act); Brailovskaya, *supra* note 31, at 1240 (noting that the United States' Sustainable Fisheries Act, 16 U.S.C. § 1801, "continues to support the targeting of previously unexploited species of marine life for commercial use. Protection of non-commercial marine biodiversity is not within the scope of the act; it is unreasonable to expect it to be a Marine Biodiversity Protection Act" and that "protection of marine biodiversity should be a separate, primary goal rather than a by-product of fisheries management.").
201. Buck, *supra* note 1.

As a result, given the prevalence of overfishing and its side effects, and especially with a growing appreciation of the complexity of the ocean and its inhabitants, scientists increasingly recommend marine protected areas (MPAs), marine reserves, and national systems of MPAs and marine reserves as the best means of preserving and restoring marine biodiversity.[202] In general, an MPA is any area of the ocean set aside by law and protected from at least some uses.[203] The most protective kind of MPA is a marine reserve.[204] Marine reserves generally prohibit all extractive uses, such as fishing, within their boundaries, although they usually permit non-extractive uses such as diving and scientific research.[205] Marine reserves are thus often instrumental in promoting diving-based ecotourism as well as increased marine biodiversity.[206]

Neither international law nor the popular imagination has quite caught up with science in promoting MPAs, however. According to UNEP only about one percent of the oceans are currently protected through MPAs or marine reserves.[207] Nevertheless, a few helpful conventions and treaties do exist that coastal nations can rely upon in pursuing increased use of MPAs and marine reserves to protect and perhaps even restore marine biodiversity.

One of the first biodiversity-related treaties was the Convention Concerning the Protection of the World Cultural and Natural Heritage, better known as the World Heritage Convention, which was adopted in November 1972[208] and came into force on December

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202. Ogden, *supra* note 32, at 34 ("The recent rapid implementation of marine protected areas has pointed to the need for more comprehensive zoning of the oceans."); Brailovskaya, *supra* note 31, at 1239 ("Designating parts of the territorial sea as a national marine wilderness preservation system would enable the protection of marine biodiversity to occur in its own right, rather than allocating the whole marine environment to the commercial fishing industry for use as a source of products."); John C. Ogden, *Marine Managers Look Upstream for Connections*, 278 SCI. 1414, 1415 (Nov. 21, 1997) (noting that "reserves are being advanced all over the world by economic arguments").

203. Robin Kundis Craig, *Taking Steps Toward Marine Wilderness Protection? Fishing and Coral Reef Marine Reserves in Florida and Hawaii*, 34:1 MCGEORGE L. REV. 155, 167-68 (Winter 2003).

204. *Id*. at 169.

205. *Id*. at 169-70.

206. Geoffrey P. Jones et al., *Coral Decline Threatens Fish Biodiversity in Marine Reserves*, 101:21 PROCEEDINGS NAT'L ACAD. OF SCI. (PNAS) 8251, 8253 (May 25, 2004) *available at* http://www.pnas.org/ cgi/doi/10.1073/pnas.0401277101; Craig, *supra* note 203, at 192-96.

207. Bell, *supra* note 112, at 17; *see also* Ogden, *supra* note 32, at 33 ("Most people are astonished to learn that the total area of fully protected marine habitat in the United States is approximately 50 square miles."); Brailovskaya, *supra* note 31, at 1237 ("A comparison of protected-area coverage on land and sea in the United States shows that there is approximately 1500 times more designated protection for no-take wilderness on U.S. lands than for no-take protection in U.S. waters.").

208. UNESCO, *World Heritage: Brief History*, *at* http://whc.unesco.org/pg.cfm?cid=169 (last updated Mar. 5, 2005).

17, 1975.[209] The Convention links nature conservation and preservation of cultural sites and encourages parties to accord emergency and long-term protection to sites of "outstanding universal value."[210] As of January 2005, 788 sites had been designated under the Convention — 611 cultural, 154 natural, and 23 mixed — in 134 countries that are parties to the Convention.[211] While the World Heritage Convention does not specifically target marine sites, nations that are parties to it have designated a number of marine sites as World Heritage Sites, including the Great Barrier Reef in Australia and the Galapagos Islands in Ecuador.[212]

On December 10, 1982, the United Nations adopted the third version of the United Nations Convention on the Law of the Sea (UNCLOS III), which came into force on November 16, 1994;[213] the United States is not (yet) a party.[214] Several provisions of UNCLOS III strengthen coastal nations' abilities to establish MPAs, marine reserves, and systems of MPAs and marine reserves. First, the Convention establishes the jurisdiction of coastal nations over various areas of the sea.[215] For example, coastal nations can exercise nearly complete sovereignty in their territorial sea,[216] which can extend from shore baselines to 12 nautical miles out to sea.[217] Coastal nations can also claim a contiguous zone extending up to 24 nautical miles out to sea, which they can use primarily for law enforcement purposes.[218] Most importantly for marine biodiversity purposes, however, parties to UNCLOS III can claim a 200-nautical-mile Exclusive Economic Zone, or EEZ, off their coasts,[219] where they can exercise "sovereign rights for the purpose

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209. UNESCO, *World Heritage: The States Parties*, *at* http://whc.unesco.org/pg.cfm?cid=246 (last updated Mar. 5, 2005).

210. UNESCO, *World Heritage: Overview*, *at* http://whc.unesco.org/pg.cfm?cid=167 (last updated Mar. 5, 2005).

211. UNESCO, *World Heritage: New Inscribed Properties*, *at* http://whc.unesco.org/pg.cfm?cid=277 (last updated Mar. 5, 2005).

212. UNESCO, *World Heritage List*, *at* http://whc.unesco.org/pg.cfm?cid=31 (last updated Mar. 5, 2005).

213. United Nations, *United Nations Convention on the Law of the Sea of 10 December 1982: Overview and Full Text*, *at* http://www.un.org/Depts/los/convention_agreements/convention_overview_convention.htm (last updated Jan. 5, 2005).

214. United Nations, *United Nations Convention on the Law of the Sea of 10 December 1982: Chronological list of ratifications*, *at* http://www.un.org/Depts/los/reference_files/chronological_lists_of_ratifications.htm (last updated Feb. 1, 2005).

215. United Nations Convention on the Law of the Sea, Dec. 10, 1982, art. 2, 21 I.L.M. 1261 (entered into force Nov.16, 1994), *available at* http://www.un.org/Depts/los/convention_agreements/texts/unclos/closindx.htm.

216. *Id*.

217. *Id*. at art. 3.

218. *Id*. at art. 33.

219. *Id*. at arts. 55, 57.

of exploring and exploiting, conserving and managing the natural resources, whether living or nonliving, of the waters superadjacent to the sea-bed and of the sea-bed and its subsoil . . . ."[220] Such rights, moreover, include jurisdiction for "the protection and preservation of the marine environment . . . ."[221]

Several other provisions of UNCLOS III create duties to protect marine biodiversity, although these duties are often in tension with the parties' rights to exploit the marine resources and to promote their optimum utilization. Thus, for example, the Convention clearly gives coastal states the right to determine allowable catch rates in their EEZs,[222] and "[t]he coastal State, taking into account the best scientific evidence available to it, shall ensure through proper conservation and management measures that the maintenance of the living resources in the exclusive economic zone is not endangered by over-exploitation."[223] Nevertheless, parties also "shall promote the objective of optimum utilization of the living resources in the exclusive economic zone . . . ."[224] Similarly, while "[s]tates have the obligation to protect and preserve the marine environment,"[225] they also "have the sovereign right to exploit their natural resources pursuant to their environmental policies and in accordance with their duty to protect and preserve the marine environment."[226]

UNCLOS III thus gives the parties to it a clear international law basis for protecting marine biodiversity through MPAs and marine reserves, but it does not set any specific biodiversity-related goals. Instead, typical of the international focus in 1982, its sections on "Protection and Preservation of the Marine Environment" emphasize the prevention of marine pollution.[227]

More significantly, in 1992, at the Rio Conference on Sustainable Development, numerous nations of the world adopted

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220. United Nations Convention on the Law of the Sea, Dec. 10, 1982, art. 56.1(a), 21 I.L.M. 1261 (entered into force Nov.16, 1994), *available at* http://www.un.org/Depts/los/convention_agreements/texts/unclos/closindx.htm.

221. *Id*. at art 56.1(b)(iii).

222. *Id*. at art. 61.1.

223. *Id*. at art. 61.2.

224. *Id*. at art. 62.1.

225. United Nations Convention on the Law of the Sea, Dec. 10, 1982, art. 192, 21 I.L.M. 1261 (entered into force Nov.16, 1994), *available at* http://www.un.org/Depts/los/convention_agreements/texts/unclos/closindx.htm.

226. *Id*. at art. 193.

227. *See generally id*. Part V: Protection and Preservation of the Marine Environment, especially art. 194: Prevent, reduce, and control pollution; art. 207: Pollution from land-based sources; art. 208: Pollution from seabed activities; art. 209: Pollution from activities in the Area; art. 210: Pollution by dumping; art. 211: Pollution from vessels; and art. 212: Pollution from or through the atmosphere. Article 196, however, does address the prevention of alien species introductions. *Id*. at art. 196.

Agenda 21, a global program for achieving worldwide sustainable development.[228] Chapter 15 of Agenda 21 promotes conservation of biological diversity in general, including "in situ conservation of ecosystems and natural habitats,"[229] suggesting a prominent role for protected areas. Chapter 17, in turn, addresses the "protection of the oceans, all kinds of seas, including enclosed and semi-enclosed seas, and coastal areas, and the protection and rational use and development of their living resources."[230] Chapter 17 builds on UNCLOS III as the "international basis upon which to pursue the protection and sustainable development of the marine and coastal environment and its resources,"[231] but it more specifically promotes integrated management of marine areas[232] and the "[c]onservation and restoration of altered critical habitats."[233] Most explicitly, Chapter 17 encourages signatories to "undertake measures to maintain biological diversity and productivity of marine species and habitats under national jurisdiction," including the "establishment and management of protected areas."[234]

The participants at the 1992 Earth Summit in Rio de Janeiro also adopted the United Nations Convention on Biological Diversity, which came into force on December 29, 1993.[235] The United States signed the Convention in April 1993, but has not yet ratified it,[236] despite the Pew Oceans Commission 2004 report strongly urging that the United States ratify this Convention as part of the reformation of its national ocean policy.[237]

The Biodiversity Convention's general objectives are "the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits

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228. United Nations Department of Economic & Social Affairs, *Agenda 21*: *Programme of Action for Sustainable Development*, United Nations Conference on Environment and Development (UNCED), 3-14 June 1992, Rio de Janiero, Brazil, *available at* http://www.un.org/esa/sustdev/documents/agenda21/index.htm (last updated Dec. 15, 2004).

229. *Id*. at ch. 15.5(g).

230. United Nations Department of Economic & Social Affairs, *Agenda 21*: *Programme of Action for Sustainable Development*, United Nations Conference on Environment and Development (UNCED), 3-14 June 1992, Rio de Janiero, Brazil, at ch. 17, *available at* http://www.un.org/esa/sustdev/documents/agenda21/english/agenda21chapter17.htm (last updated Dec. 15, 2004).

231. *Id*. at ch. 17.1.

232. *Id*. at ch. 17.5.

233. *Id*. at ch. 17.6(h).

234. *Id*. at ch. 17.7.

235. Center for International Earth Science Information Network (CIESIN) Columbia University, "CIESIN Thematic Guides, The Convention on Biological Diversity," *at* http://www.ciesin.org/TG/PI/TREATY/b io.html (last visited Mar. 5, 2005).

236. Secretariat of the Convention on Biological Diversity, UNEP, *Parties to the Convention on Biological Diversity/Cartagena Protocol on Biosafety*, *at* http://www.biodiv.org/world/parties.asp (last visited Mar. 5, 2005).

237. PEW OCEANS COMMISSION, *supra* note 99, at 80-81.

arising out of the utilization of genetic resources."[238] Its basic principle is that "States have . . . the sovereign right to exploit their own resources pursuant to their own environmental policies, and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction."[239] Each party to the Convention is supposed to "[d]evelop national strategies, plans or programmes for the conservation and sustainable use of biological diversity" and to "[i]ntegrate, as far as possible and as appropriate, the conservation and sustainable use of biological diversity into relevant sectoral or cross-sectoral plans, programmes and policies."[240] Finally, Article 8 of the Convention specifically requires the parties to "[e]stablish a system of protected areas or areas where special measures need to be taken to conserve biological diversity."[241]

While the Biodiversity Convention itself is fairly general in its terms, its biodiversity goals have been expressly extended to marine and coastal biodiversity since the 1995 second Conference of the Parties,[242] through the Jakarta Mandate.[243] Through the most recent decision of the parties implementing this mandate, adopted at the Seventh Conference of the Parties in February 2004, the parties noted "that marine and coastal biodiversity is under rapidly increasing and locally acute human pressure, such that globally, regionally and nationally marine and coastal biodiversity is declining or being lost."[244] Moreover, the decision specifically noted that marine and coastal protected areas contribute to biodiversity protection and sustainable use of biodiversity, and the parties agreed "that marine and coastal protected areas are one of the essential tools and approaches in the conservation and sustainable

238. United Nations Convention on Biological Diversity, June 5, 1992, art. 1, 31 I.L.M. 818, 1993 A.T.S. 32 (entered into force Dec. 29, 1993).

239. *Id*. at art. 3.

240. *Id*. at art. 6.

241. *Id*. at art. 8.

242. Secretariat of the Convention on Biological Diversity, UNEP, *Conference of the Parties – COP: Background and Status*, *at* http://www.biodiv.org/convention/cops.asp (last visited Feb. 2, 2005).

243. Secretariat of the Convention on Biological Diversity, UNEP, *Jakarta Mandate: Marine and Coastal Biodiversity — Introduction*, *at* http://www.biodiv.org/programmes/areas/marine/default.asp (last visited Feb. 2, 2005); *see also generally* CONFERENCE OF THE PARTIES, CONVENTION ON BIOLOGICAL DIVERSITY, DECISION II/10: CONSERVATION AND SUSTAINABLE USE OF MARINE AND COASTAL BIOLOGICAL DIVERSITY (NOV. 1995) (creating and implementing the Jakarta Mandate), *available at* http://www.biodiv.org/decisions/default.aspx?m=COP-02&id=7083&lg=0.

244. CONFERENCE OF THE PARTIES, CONVENTION ON BIOLOGICAL DIVERSITY, DECISION VII/5: MARINE AND COASTAL BIOLOGICAL DIVERSITY ¶ 11 (Feb. 2004), *available at* http://www.biodiv.org/decisions/default.aspx?m=COP-07&id=7742&lg=0.

use of marine and coastal biodiversity."[245] The Decision urges parties to adopt, as a high priority, national marine and coastal management frameworks that incorporate marine and coastal protected areas.[246] It also urges international cooperation to establish marine and coastal protected areas in international waters.[247]

More specific in application is the International Coral Reef Initiative (ICRI), announced at the First Conference of the Parties under the Biodiversity Convention in 1994.[248] The ICRI is a partnership, originally entered by Australia, France, Japan, Jamaica, the Philippines, Sweden, the United Kingdom, and the United States, to increase knowledge about, and protections for, the world's coral reefs.[249] These countries pursued the ICRI as a means of implementing section 86 of Chapter 17 of Agenda 21,[250] which requires participants to identify and protect marine ecosystems exhibiting high levels of biodiversity and productivity, including coral reefs.[251]

On August 4, 1995, parties to UNCLOS III adopted the Agreement on Straddling Fish Stocks and Highly Migratory Fish Stocks, which came into force on December 11, 2001,[252] in order to address in more detail issues relating to management of fish stocks that crossed jurisdictional boundaries or traveled across the high seas.[253] While the focus of the Agreement is thus somewhat narrow, it does command — as UNCLOS III itself does not — that parties shall "protect biodiversity in the marine environment."[254] Moreover, at least with respect to the fish subject to the Agreement, the Agreement requires parties to use a precautionary approach in

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245. *Id*. ¶¶ 12, 16.
246. *Id*. ¶ 23.
247. *Id*. ¶ 30.
248. Secretariat of the International Coral Reef Initiative (ICRI), *What is ICRI, at* http://www.icriforum.org/router.cfm?show=/html/about.htm (last visited Mar. 5, 2005).
249. *Id*.
250. *Id*.
251. *See generally* United Nations Department of Economic & Social Affairs, *Agenda 21*: *Programme of Action for Sustainable Development*, United Nations Conference on Environment and Development (UNCED), *supra* note 230, at ch. 17.
252. United Nations, *The United Nations Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks*, *available at* http://www.un.org/Depts/los/convention_agreements/convention_overview_fish_stocks.htm (last updated Jan. 5, 2005).
253. United Nations Department of Economic & Social Affairs, *Agenda 21*: *Programme of Action for Sustainable Development*, United Nations Conference on Environment and Development (UNCED), *supra* note 230, at ch. 17.1.
254. Agreement on Straddling Fish Stocks and Highly Migratory Fish Stocks, Aug. 4, 1995, art. 5(g) (entered into force Dec. 11, 2001), *available at* http://www.un.org/Depts/los/convention_agreements/texts/fish_stocks_agreement/CONF164_37.htm.

management.[255] This Agreement thus signals that biodiversity concerns are being imported into UNCLOS III's "[c]onstitution for the oceans."[256] A year after this Agreement took effect, moreover, as part of the ten-year anniversary of Agenda 21 and the Rio Conference, "[c]oncerns regarding overfishing were addressed at the World Summit on Sustainable Development, held in Johannesburg, South Africa in 2002, and the importance of restoring depleted fisheries was stressed."[257] The Summit led to an implementation plan that "call[s] for the establishment of marine protected areas (MPAs), which experts believe may hold the key to conserving and boosting fish stocks."[258]

The United Nations Convention on Biodiversity and the 2002 World Summit on Sustainable Development have inspired both large nations with a lot of coast, and relatively isolated island nations, to at least create individual MPAs and marine reserves and often to implement national systems of marine protected areas. For example, Australia implemented its National System of Representative Marine Protected Areas, in part, to comply with the United Nations Convention on Biodiversity and Agenda 21.[259] Bermuda,[260] Canada,[261] Cuba,[262] New Zealand,[263] and the European Union[264] are all similarly in the process of creating national and international systems of MPAs and marine reserves to better protect their marine biodiversity.

In addition, these biodiversity-related treaties have inspired MPA-oriented revisions to pre-existing marine treaties — marine treaties that often previously had a pollution focus. For example, the Northeast Atlantic Ocean is governed by the 16-party

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255. *Id*. at art. 6.

256. United Nations, *United Nations Convention on the Law of the Sea of 10 December 1982: Overview and Full Text*, *supra* note 213 (Title of remarks by Tommy T.B. Koh, of Singapore, President of the Third United Nations Conference on the Law of the Sea).

257. Bell, *supra* note 112, at 17.

258. *Id*.

259. Department of the Environment and Heritage, Australia, *About the National Representative System of Marine Protected Areas (NRSMPA), at* http://www.deh.gov.au/coasts/mpa/nrsmpa/about.html#policy (last updated June 20, 2004).

260. Bermuda Biological Station for Research, *Evaluating Bermuda's No-Take Zones*, *at* http://www.bbsr. edu/pubs/ar01/ar01mpa/ar01mpa.html (last visited Feb. 2, 2005).

261. Parks Canada, *National Marine Conservation Areas of Canada*, *at* http://www.pc.gc.ca/progs/amnc-nmca/system/system1_E.asp (last updated Apr. 1, 2003).

262. *See generally* ENVIRONMENTAL DEFENSE, THE NATIONAL SYSTEM OF MARINE PROTECTED AREAS IN CUBA (2004), *available at* http://www.environmentaldefense.org/documents/3692_mpasCubaIngles.pdf.

263. Department of Conservation, New Zealand, *Marine Reserves*, *at* http://www.doc.govt.nz/Conservation/ Marine-and-Coastal/Marine-Reserves/index.asp (last visited Feb. 2, 2005).

264. *Experts Set to Identify Marine Protected Areas for Europe*, CORDIS NEWS, July 2, 2003, EU Business, *available at* http://www.eu business.com/imported/2003/07/113979/.

Convention for the Protection of the Marine Environment of the North-East Atlantic, better known as the OSPAR Convention.[265] As adopted in 1992, it was a pollution-control treaty, requiring countries to reduce their pollution of the Northeast Atlantic Ocean.[266] However, in 1998 all 16 parties adopted Annex V to the Convention specifically to implement the U.N. Biodiversity Convention in the Northeast Atlantic.[267] As a result, the parties have committed to the creation of an ocean-wide system of marine protected areas and marine reserves by 2010.[268]

## V. CONCLUSION: THE ENCOURAGING EMERGENCE OF A COMBINED APPROACH

The recognition of the role of overfishing in marine biodiversity decline, and the subsequent promotion of MPAs and marine reserves, has been a necessary corrective to international marine regulation, especially as losses of marine biodiversity become more evident. However, a complete switch in regulatory focus from marine pollution to overfishing would be as inappropriate as the non-recognition of overfishing's problems and the need for MPAs and marine reserves.[269]

Marine reserves are good at what they're good at: Setting aside portions of marine ecosystems and protecting the species that live there from exploitation. Studies have shown that fish and other species in marine reserves are bigger and more plentiful than outside marine reserves,[270] and there is increasing evidence that well-placed marine reserves can export fish and other species to other areas of the ecosystem and even other ecosystems, helping those other areas to maintain their biodiversity as well.[271] However, marine reserves cannot protect marine species from other kinds of threats, especially certain kinds of marine pollution.[272]

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265. Convention for the Protection of the Marine Environment of the North-East Atlantic, Sept. 22, 1992, 32 I.L.M. 1069.

266. *See generally id.*

267. OSPAR Commission, *Annex v: The Protection and Conservation of the Ecosystems of Biological Diversity of the Maritime Area*, 1998-15.1 (July 22-23, 1998), *at* http://www.ospar.org/eng/html/convention/ospar_conv10.htm.

268. Joint Ministerial Meeting of the Helsinki and OSPAR Commissions, Bremen, June 25-26, 2003, Declaration of the Joint Ministerial Meeting of the Helsinki and OSPAR Commissions ¶ 8, *at* http://www.os par.org/eng/html/md/joint_declaration_2003.htm.

269. *See, e.g.*, Jackson, *supra* note 33, at 5411 (noting that both "overfishing and human inputs from the land" have contributed to historical losses of marine ecological biodiversity).

270. Craig, *supra* note 203, at 171.

271. *Id.* at 170-71.

272. WING, *supra* note 125, at 23 ("Reserves alone will not address factors such as pollution, oil spills, or overfishing. Problems on land, such as poor septic systems and eroding sediments, must be solved or they will wash into the reserve."). For example, in May 2004,

Regarding coral reefs, for example, a group of Australian scientists recently concluded that:

> Although there is a large body of evidence that indicates that marine reserves can be an effective management strategy for protecting marine biodiversity, there is a growing recognition that such areas cannot protect reefs from large-scale pollution or global warming. Thus, although marine reserves are necessary to control the 'top-down' impact of human predation, they must be combined with management strategies that fundamentally address 'bottom-up' processes that appear to be a more likely path to extinction.[273]

More generally, Jeremy B.C. Jackson has argued that the combination of overfishing and land-based pollution has "result[ed] in increasing abundance and widespread dominance of ecosystem processes by microbes,"[274] a change in marine biodiversity that MPAs and marine reserves alone cannot address.

Given the multiple nature of the threats to marine biodiversity, one of the most promising developments in international law are regional treaties that combine marine pollution provisions with provisions that encourage or require parties to establish MPAs and marine reserves and to address other threats, such as alien species, to marine biodiveristy. The Seventh Conference of the Parties of the United Nations Convention on Biological Diversity, for example, encouraged "Parties to urgently address, through appropriate integrated marine and coastal management approaches, all threats, including those arising from the land (e.g., water quality, sedimentation) and shipping/transport, in order to maximize the effectiveness of marine and coastal protected areas and networks in achieving their marine and coastal biodiversity objectives . . . ."[275] Regionally, the 1983 Convention for the Protection and

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four scientists from James Cook University in Australia reported that marine reserves may be ineffective in protecting fish biodiversity in degrading habitats, such as when the coral reefs of Papua New Guinea experience a "devastating decline in coral cover . . . ." Jones et al., *supra* note 206, at 8251-52. One of the three causes of the coral's decline, moreover, was "a gradual increase in sedimentation from terrestrial run-off"; the other two were coral bleaching, generally caused by increased ocean temperatures, and outbreaks of the predatory crown-of-thorns starfish. *Id*. at 8252.

273. Jones, *supra* note 206, at 8253.

274. Jackson, *supra* note 33, at 5415.

275. CONFERENCE OF THE PARTIES, CONVENTION ON BIOLOGICAL DIVERSITY, DECISION VII/5, *supra* note 244, ¶ 26.

Development of the Marine Environment of the Wider Caribbean Region, also known as the Cartagena Convention, to which the United States is a party, came into force on October 11, 1986.[276] Article 4 of that Convention requires the parties to reduce and control marine pollution, including pollution from ships, ocean dumping, land-based sources of marine pollution, and airborne pollution.[277] At the same time however, the Convention imposes requirements on the exploitation of seabed resources and requires the parties to protect marine ecosystems and habitats in specially protected areas.[278] The 1986 Convention for the Protection of the Natural Resources and Environment of the South Pacific Region,[279] which came into force in 1990, and the 1985 Convention for the Protection, Management, and Development of the Marine and Coastal Environment of the Eastern African Region,[280] also known as the Nairobi Convention, which is not yet in force,[281] have similar combinations of requirements as the Cartagena Convention.

The threats to marine biodiversity are many. Only an international law regime that addresses *all* of those threats — pollution, overfishing and its associated problems, loss of habitat, and invasive species — both individually and collectively can effectively halt, and hopefully reverse, the increasing trend of marine species extinctions and loss of marine biodiversity at all levels. The next decades will be an important time in the evolution of the international law of the sea, but the regional treaties discussed above provide encouragement that the world will gradually comprehensively protect its most hidden, but arguably most important, natural resource.

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276. UNEP, *An Overview of the Cartagena Convention*, *at* http://www.cep.unep.org/law/cartnut.html (last updated Mar. 7, 2002).

277. Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region (Mar. 29, 1983), art. 4.1, T.I.A.S. No. 11085.

278. *Id*. at arts. 8, 10.

279. Convention for the Protection of the Natural Resources and Environment of the South Pacific Region, Nov. 25, 1986, arts. 4.1, 5 (pollution generally), 6 (pollution from vessels), 7 (pollution from land-based sources), 8 (pollution from sea-bed activities), 9 (airborne pollution), 14 (specially protected areas), 26 I.L.M. 38.

280. Convention for the Protection, Management, and Development of the Marine and Coastal Environment of the Eastern African Region, June 21, 1985, arts. 5 (pollution from ships), 6 (pollution caused by dumping), 7 (pollution from land-based sources), 8 (pollution from seabed activities), 9 (airborne pollution), 10 (specially protected areas) (1985), *available at* http://sedac.ciesin.org/entri/texts/marine.coastal.east.africa.1985.html.

281. Environmental Treaties & Resource Indicators, *Summary of Convention for the Protection, Management and Development of the Marine and Coastal Environment of the Eastern African Region*, *at* http://sedac.ciesin.org/entri/register/reg-134.rrr.html (last visited Mar. 5, 2005).