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# The Diversity of the Seas: a regional approach

by the

**World Conservation Monitoring Centre**

WORLD CONSERVATION
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Editors

**B. Groombridge and M.D. Jenkins**

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**This document**

This report has its origin in a compilation of country-level coastal and marine biodiversity data prepared under contract to UNEP in 1995. The structure of the material was revised in late 1995 to give an overview of biodiversity in sea areas covered by the UNEP Regional Seas programme. New information was added in 1996, and additional support to allow the document to be completed in its present format was provided by IUCN, the UK Joint Nature Conservation Committee, and WCMC.

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# INTRODUCTION

### Purpose

The marine component of biological diversity is of immense importance to humankind. Despite this, information on the status of marine living resources and ecosystems remains much less complete, or less readily available, than that for terrestrial ecosystems. Clearly there is a need for far more attention to be paid to marine systems in order to improve our current state of knowledge; indeed this issue has been given explicit emphasis by the Parties to the Convention on Biological Diversity (CBD). The Second Meeting of the Conference of the Parties to the CBD identified the need for a comprehensive ecosystem-based approach to marine and coastal biodiversity (Annex II to decision II/10) (CBD, 1996).
We seek here to present information in a format that begins to meet the need for an integrated approach as identified by the CBD, and which is capable of modification or further elaboration as appropriate.

It is not the purpose of this document to review systematically the principal issues involved in conservation and management of marine biodiversity. Several such reviews exist, among them: Committee on Biological Diversity in Marine Systems (CBDMS) (1995), Norse (1993), Thorne-Miller and Catena (1991). Numerous research, planning and management activities are currently being developed in relation to the focus provided by the CBD, its Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA) and the International Waters portfolio of the Global Environment Facility (GEF).

### Contents

The major part of this document consists of a region by region presentation of information on different themes central to marine biodiversity management. The regional framework adopted is based on the UNEP Regional Seas programme (see Annex I). Within each regional setting we have assembled information on Large Marine Ecosystems, biodiversity and fisheries issues. Please consult **Notes and Sources** (p 32) for details of information quality and sources. In further developing this approach it will be desirable to integrate these classes of information more explicitly and more fully, and to consider additional data sets, eg. coastal settlement patterns, cultural factors, non-fishery use of marine resources, other elements of biodiversity, and so on.

The regional material is prefaced by a brief introduction in which key aspects of marine biodiversity are outlined and information on forces for change presented.

### Coverage

Map 1 shows the approximate geographic area covered by each Regional Seas agreement (note that this is not an official UNEP representation of these areas and it implies no expression of opinion in respect of national boundaries). The map distinguishes those regions to which a formal Convention applies from those covered by an Action Plan (or where such a plan is under discussion). The exact geographic coverage of each Regional Seas area is not precisely delineated. The map is based on the assumption that Regional Seas in general extend to the limit of the maritime boundary of each state concerned.

There remains a number of countries or regions that either are not associated with a UNEP Regional Sea or have parts of the coast thus associated, but not all parts (eg. Australia). Such areas have been here defined as 'regions' for the purposes of this document, and are also indicated on the map. The regions so defined are: North Atlantic, South Africa, Northeast Pacific, Southwest Australia. The map does not represent the Arctic and Antarctic regions used herein and which also are not formally part of the Regional Seas programme.

# MARINE BIODIVERSITY

## THE MARINE BIOSPHERE

Oceans cover 71% of the world's surface. They are on average around 3.8 km deep and have an overall volume of some 1370 million cubic kilometres (see Table 1). The whole of the ocean is theoretically capable of supporting life, so that the marine part of the biosphere is far larger than the terrestrial part. However, as on land, life in the oceans is very unevenly distributed. This section is intended to introduce some fundamental features of the marine biosphere as a basis for discussion of marine biodiversity and its use as presented in the regional accounts below.

### THE BASIS OF LIFE IN THE SEAS

In the sea, as on the land, the process of *photosynthesis* is the driving force behind maintenance of life. Photosynthesis is the process by which green plants (and other organisms possessing chlorophyll) use water, carbon dioxide and the energy of sunlight to generate simple sugars which are used as a source of energy or as a basis for other new organic substances. With few exceptions, this process is the only means by which new energy is captured to sustain life on earth.

*Primary productivity* is the rate at which the sun's energy is captured by photosynthesis and stored or transformed, and is usually expressed as weight of material per unit area per unit time (eg. grams of carbon/$m^2$/year). With some exceptions, this tends to be lower in marine environments than terrestrial ones, especially if highly-managed terrestrial agricultural systems are considered (see Table 2). In the marine environment, photosynthesis takes place only in littoral zones and in sunlit waters of the open ocean (the *photic* zone); all other marine organisms, including those of the unlit middle depths and the deep sea are dependent ultimately on growth of primary producers in areas that may be widely distant from them in time and space. The most important exceptions to this are the bacteria living around hydrothermal vents associated with rift zones in the ocean floor. The water here can be 10°C warmer than adjacent areas and the bacteria are able to grow using as an energy source hydrogen sulphide gas emitted at the vents, and they in turn are used by other organisms.

Until the 1980s it had been believed that photosynthesis in the pelagic ocean was carried out only by single-celled phytoplankton, between 1 and 100 microns in diameter (1 micron = .001 mm), and also that vast expanses of open ocean where phytoplankton could not be detected were in terms of productivity the marine equivalent of deserts. New observational techniques have since revealed the presence in great abundance of exceptionally small and previously unknown organisms, collectively termed *picoplankton*. These include unicellular *cyanobacteria*, around 1 micron in size, and even smaller *prochlorophytes*, about 0.6 micron in size, and other new types of algae. Because of their extraordinary abundance, and despite their minute size, these organisms play a crucial role in productivity of open ocean waters: some 100 million cells may be present in one litre (Vaulot, 1995).

The following points summarise some of the key features of marine ecology, and ways in which the marine biosphere differs from the terrestrial:

- Water absorbs sunlight strongly and, while different wavelengths penetrate more deeply than others, light is completely absorbed at 200-400 metres; primary production from photosynthesis is thus limited to the continental shelf area and surface waters of the open ocean which together make up a very small proportion of the total volume of the oceans.

· Most marine primary production is by microscopic organisms (eg. diatoms, dinoflagellates) and the dominant herbivores are similarly small animals (eg. copepod crustaceans) that feed upon them; marine herbivores generally consume entire organisms whereas terrestrial ones consume small parts leaving the plant *in situ.*

· Average biomass (amount of living tissue per unit area) in the oceans has been estimated at around one-thousandth that on land, and average marine productivity at about one-fifth of that in terrestrial environments.

· With the exception of the large brown algae (Phaeophyceae) known as kelp, there are no large plants in the sea, and none analogous to the terrestrial woody plants that so enrich terrestrial environments by providing food sources and structurally complex habitats for other organisms.

· Seawater is several hundred times more dense than air; this means that small organisms and particles can remain suspended in it, and many kinds of organism exist by filtering these particles out of the water mass; filter-feeding is a key step in many marine food chains.

**Table 2**Area and maximum depth of the world's oceans and seas

| | Area ($km^2$) | Depth (metres) | | Area ($km^2$) | Depth (metres) |
|---|---|---|---|---|---|
| Pacific Ocean | 165,384,000 | 11,524 | Sea of Okhotsk | 1,528,000 | 3,475 |
| Atlantic Ocean | 82,217,000 | 9,560 | East China Sea | 1,248,000 | 2,999 |
| Indian Ocean | 73,481,000 | 9,000 | Yellow Sea | 1,243,000 | 91 |
| Arctic Ocean | 14,056,000 | 5,450 | Hudson Bay | 1,233,000 | 259 |
| Mediterranean Sea | 2,505,000 | 4,846 | Sea of Japan | 1,008,000 | 3,743 |
| South China Sea | 2,318,000 | 5,514 | North Sea | 575,000 | 661 |
| Bering Sea | 2,269,000 | 5,121 | Black Sea | 461,000 | 2,245 |
| Caribbean Sea | 1,943,000 | 7,100 | Red Sea | 438,000 | 2,246 |
| Gulf of Mexico | 1,544,000 | 4,377 | Baltic Sea | 422,000 | 460 |

Source: Times Atlas of the Oceans

## THE CONTINENTAL SHELF

Marine waters around major landmasses are typically shallow, lying over a continental shelf which may be anything from a few kilometres to several hundred kilometres wide. The most landward part is the *littoral* or intertidal zone where the bottom is subject to periodic exposure to the air. Water depth here varies from zero to several metres. Seaward of this the shelf slopes gently from shore to depths of one to several hundred metres, forming the sublittoral or shelf zone. Waters below low tide mark in this region are referred to as *neritic*.

The neritic or continental shelf zone forms only 7-8% of the world's ocean area, but is easily the best known and studied part. It includes the large marine ecosystems from which most of the world's fishery production is extracted. It is also, as noted below, the part which has suffered most impact from mankind's activities. The entire region below the reach of sunlight (the *aphotic* zone) comprising by far the largest volume and area of the world's oceans, is still very little known.

With the present configuration of landmasses, a major part (37%) of the world ocean is within the tropics, and about 75% lies between the 45° latitudes. The largest continental shelf areas are in high northern latitudes, but about 30% of the total shelf area is in the tropics; within the tropics, the shelf is most extensive in the western Pacific (China Seas south to north Australia) and least so along eastern coasts.

**Table 3**Comparative estimates of productivity in representative marine and terrestrial habitats

| **MARINE** | **productivity gC/m$^2$/yr** |
|---|---|
| Coral Reef | 1,500-5,000 |
| Tropical seagrass | 4,000 |
| Tropical kelp | 2,000 |
| Temperate seagrass | 500-1,000 |
| Temperate kelp | 800 |
| Temperate inshore | 300-400 |
| Temperate open sea | 70-120 |
| Antarctic seas | 100 |
| Tropical open sea | 18-50 |
| Arctic Ocean | 1 |
| **TERRESTRIAL** | |
| Agricultural land | 2,000-7,500 |
| Tropical forest | 2,000-5,000 |
| Temperate grassland | 500 |
| Desert scrub | 70-50 |

Source: data from Nybakken (1993).

The extent, gradient and superficial geology of continental shelf areas are determined by many factors, including levels of tectonic activity in the earth's crust. A small number of mainly tropical rivers dominate transport of sediment from land to sea. More than 80% of the global volume of river-borne sediment is deposited in the tropics (and an estimated 40% of it by just two river systems: the Huang He or Yellow River and the Ganges-Brahmaputra) (Longhurst and Pauly, 1987), and this is reflected in the extent of shelf areas in parts of the tropics (especially the east Indian Ocean and west Pacific), and in the high turbidity of coastal waters in monsoon regions. Most shelf areas in the tropics are overlain by sands or muds composed of sediment of terrestrial origin (terrigenous deposits).

Mangroves and coral reefs are undoubtedly the two best known tropical coastal ecosystems, although only a minor part of the world's tropical coastline is dominated by them: the former are extensive mainly in deltaic or other low-lying coastal plains; the latter are important only where insignificant amounts of terrestrial sediment are transported into coastal waters (Longhurst and Pauly, 1987). Unvegetated soft-bottom habitats are probably the most widespread systems, although sea-grass and sea-weed beds occupy important areas.

At the outer edge of the shelf there is an abrupt steepening of the sea bottom, forming the continental slope which descends to depths of 3-5 km. The sea-bottom along the slope is referred to as the bathyal zone. At the base of the continental slope are huge *abyssal* plains which form the floor of much of the world's oceans. The plains are punctuated by numerous submarine ridges and sea-mounts which may break the surface to form islands. There are also a number of narrow trenches which have depths of from

7,000 to 11,000 m. These constitute the *hadal* zone. All marine areas beyond the continental shelf are referred to as *oceanic*.

**Table 4**Relative areas of continental shelves and open ocean

| | **Open ocean % total area** | **Continental shelf % total area** |
|---|---|---|
| Polar and boreal (45-90$^o$) | 26.6 | 40.9 |
| Temperate (20-45$^o$) | 36.8 | 28.8 |
| Tropical (0-20$^o$) | 36.6 | 30.3 |
| Total areas | 360.3 million $km^2$ | 26.7 million $km^2$ |

Source: from Longhurst and Pauly (1987), after Moiseev.

## THE OCEANIC PELAGIC ZONE

Pelagic organisms are those living in open water, away from the sea bed; the pelagic zone includes continental shelf waters (neritic; see above) and the remainder, the oceanic pelagic zone. Given that the oceans cover some 71% of the globe, and that the shelf area is relatively narrow, the oceanic pelagic zone is by far the most extensive ecosystem on Earth.

The oceanic pelagic zone is dominated by the activity of the plankton in the surface waters where sunlight penetrates. Plankton are by definition drifting or weakly-swimming organisms, and comprise microscopic photosynthetic organisms (eg. diatoms, dinoflagellates), the animals that consume them, and the bacteria that consume their organic debris. Plankton tend to be unevenly distributed - concentrated along major circulation currents (gyres), contact zones and upwellings. Species richness appears to vary with depth and latitude. For example ostracod diversity in the North Atlantic was found to peak at depths of around 1000 m, while planktonic diversity in general in the same region was found to be at a maximum in the tropics and a minimum at high latitudes (Angel, 1993). At any one locality, planktonic species richness can compare with richness at terrestrial sites, but the very large scale of oceanic ecosystems means that species composition tends to be uniform over large areas, eg. the richest locality in samples from the northeast Atlantic included 81 ostracod species while the entire region has a maximum of around 120 species overall (Angel, 1993).

Free-swimming pelagic organisms, predominantly fishes but also cetaceans and cephalopod molluscs (squid), are collectively termed *nekton*. These organisms, when adult, are predators of plankton or smaller nekton. They in turn - as vertically-migrating fishes or larvae, and as dead organic material, provide food for deep sea and *benthic* (bottom-living) organisms. With few exceptions, the only other food source for creatures in the aphotic zone is the 'rain' of organic matter, such as faeces, moulted crustacean exoskeleton, and a variety of other organic material derived from plankton in the surface waters of the ocean.

## DIVERSITY IN THE SEAS

It is well known that diversity at higher taxonomic levels (Phyla and Classes) is much greater in the sea than on land or in freshwater: 34 phyla and 73 classes in the marine environment compared with 15 phyla and 33 classes on land (Briggs, 1994). This is believed to be because most of the fundamental patterns of organisation and body plan, ie. the different basic kinds of organism that are distinguished as phyla, originated in the sea and remain there, but only a subset of them have spread to the land and into freshwaters. It has generally been assumed that diversity at much lower taxonomic levels, notably among species, is much lower than on land. However, recent work concerned particularly with benthic faunas (outlined below) and with very small planktonic organisms (picoplankton, see above), has revealed unsuspected levels of diversity. There are many more species of small-sized benthic organisms (eg. nematodes) than assumed, and local diversity of higher taxa can be marked (eg. around hydrothermal vents). Nevertheless, much remains to be discovered about the diversity of life in the seas. The text below provides a selective introduction to some important elements of marine and coastal biodiversity.

### Deep-sea communities

Approximately 51% of the earth's surface is covered by ocean over 3,000 m in depth. Deep-sea communities are thus prevalent over a major proportion of the planet. All deep-sea habitat is in the aphotic zone, well below the distance sunlight can penetrate. As deeper and deeper levels are reached biomass falls exponentially (Rowe, 1983).

Despite their enormous volume, the deep oceans appeared to be relatively simple ecosystems, and to make little contribution to global species diversity, but discoveries during the past decade have shown that in some regions, species diversity in the benthic community increases with increasing depth. This was revealed by novel sampling techniques, principally the epibenthic sled (Hessler and Sanders, 1967). Speculative extrapolation from sample data suggests that the deep sea may hold several million species. However it is uncertain to what extent results can reasonably be extrapolated. The rate of discovery of new species and the proportion of species currently known from only one sample both suggest that a great number remain to be discovered (Angel, 1991, Grassle, 1991).

In the megafauna, echinoderms of several classes are often the dominant mobile life forms on or in association with the sea bottom. Giant scavenging amphipods, growing up to about 18 cm in length, are also characteristic in many areas. However, the high mobility of these animals means they are rarely caught in trawls and have been less well studied than less active animals. Other arthropods include a variety of sea spiders (Pycnogonida) and decapods of several families. Mobile animals of several other taxa occur, including polychaetes, hemichordates, cephalopods and fish. Sponges (Porifera), especially the glass sponges, and coelenterates (Cnidaria), particularly anthozoans, are also well represented.

### Ocean trenches

Ocean trenches are formed as a consequence of plate tectonic processes where sectors of expanding ocean floor are compressed against an unyielding continental mass or island arc, resulting in the crust buckling downwards (subducting) and being destroyed within the hot interior of the Earth. As oceanic crust ages and cools, it becomes denser and stiffer, resulting in a steeper angle of subduction and a deepening trench. Trenches along the western edge of the Pacific are deepest and oldest. Seismically, ocean trenches are highly active, as subduction is an episodic rather than continuous process. This results in an unstable and unpredictable habitat compared to the relative environmental stability of the adjacent abyssal plains (Angel, 1982).

Ocean trenches are typically close to land masses and tend to have high rates of sedimentation, a significant amount of which is of organic origin and an important available food source for trench communities. Several trenches also underlie highly productive cold water upwelling zones, the organic fallout from which contributes greatly to their richness. The water within trenches generally originates from the surrounding bottom water, which is derived from cold surface water at high polar latitudes and is relatively well oxygenated (Angel, 1982).

Trenches tend to be isolated linear systems with high seismic activity; trench faunas are not rich in species but are often high in numbers of endemic species. There are some 25 genera restricted to the ultra-abyssal (*hadal*) zone, representing some 10-25% of the total number of genera present, and two known endemic hadal families; the Galatheanthemidae (Actinaria) and Gigantapseudidae (Crustacea). The latter family contains a single species: *Gigantapseudes adactylus*. The greatest number of endemic species known from a single trench is a sample of 200 from the Kurile-Kamchatka Trench; this may be compared with 10 endemic species known from the Ryukyu and Marianas Trenches.

**Hydrothermal vents**

Hydrothermal vent communities were first discovered in 1977, at a depth of 2,500 m on the Galápagos Rift. They are now known to be associated with almost all known areas of tectonic activity at various depths. These tectonic regions include ocean-floor spreading centres, subduction and fracture zones, and back-arc basins (Gage and Tyler, 1991). Cold bottom-water permeates through fissures in the ocean floor close to ocean-floor spreading centres, becomes heated at great depths in the Earth's crust, and finds its way back to the surface through hydrothermal vents. The temperature of vent water varies greatly, from around 23°C in the Galápagos vents, to around 350°C in the vents of the East Pacific Rise, and they may be rich in metalliferous brines and sulphide ions (Angel, 1982). Most species live out of the main flow at temperatures of around 2°C, the ambient temperature of deep-sea water. The biomass of vent communities is usually high compared to other areas of similar depth, and dense colonies of tube-worms, clams, mussels and limpets typically constitute the major components.

Vent communities are separated by gaps of between one and 100 km, and although they may persist only for several years or decades, sites of vent activity move relatively slowly allowing dispersal of vent organisms (Gage and Tyler, 1991). Vent communities could be part of a unique ecosystem as old as plate tectonic activity on Earth (Grassle, 1985).

Hydrothermal vent communities are of particular interest in that they flourish in the dark at high pressures and low temperatures (Grassle, 1986), and unique in that they are supported by a non-photosynthetic source of organic carbon, ie. chemosynthetic primary production. The enriched hydrothermal fluid supports large numbers of bacteria (predominantly *Thiomicrospira* species) which form dense bacterial carpets, and are capable of deriving energy from reduced compounds such as hydrogen sulphide (Grassle, 1986; Gage and Tyler, 1991). Many of the vent species filter-feed on these bacteria, whilst others rely on symbiotic sulphur bacteria for energy (Angel, 1982).

The overall species diversity at vents is low compared with other deep-sea soft-sediment areas (Grassle, 1986), but endemism is high. More than 20 new families or sub-families, 50 new genera and nearly 160 new species have been recorded from vent environments, including brine and cold seep communities (Grassle, 1989; Gage and Tyler, 1991).

**Other seeps**

There are two further seep patterns. Cold sulphide and methane-enriched groundwater seeps occur near the base of the porous limestone of the Florida Escarpment, as well as in the Gulf of Mexico. The seeps support a dense faunal community associated with a covering or mat of bacteria on the sediment surface. These communities are strikingly similar in taxonomic composition to the hydrothermal vents of the east Pacific, a fact which points to a common origin and evolutionary history for both community types (Hecker, 1985). The community consists of large mussels and the vestimentiferan worm *Escarpia laminata*, as well as galatheid crabs, serpulid worms, anemones, soft corals, brittle stars, gastropods and shrimps. Methane-rich seeps occur in the North Sea, the Kattegat, and elsewhere.

Tectonic subduction zone seeps are more diffuse and lower in temperature than hydrothermal vent seeps, and are rich in dissolved methane. They are known to occur off Oregon, where the fauna includes species of *Lamellibrachia* and large vesicomyid bivalves, and in the Guaymas Basin in the Gulf of California, where thick bacterial mats cover the sulphide and hydrocarbon-coated sediment. The cold Japanese subduction zone seeps occur at a depth of 1,000 m in Sagami Bay near Tokyo and in the subduction zones of the trenches off the east coast of Japan. The communities vary, but include dense benthic assemblages dominated by *Calyptogena* clams associated with a stone crab *Paralomis* sp., sepulid worms, sea anemones, galatheid crabs, swimming holothurians and amphipods (Gage and Tyler, 1991).

**Corals and coral reefs**

Corals are members of the phylum Cnidaria, which includes such diverse forms as sea anemones, jellyfish and hydroids. Within this phylum, corals and sea anemones comprise the class Anthozoa. Corals may be categorised as hermatypic (reef-building) or ahermatypic (non-reef-building). The great majority of hermatypic corals belong to the order Scleractinia, the stony corals. They collectively deposit calcium carbonate to build colonies. The coral polyps have symbiotic algae (zooxanthellae) within their tissues which process the polyps' waste products. The zooxanthellae use the nitrates, phosphates and carbon dioxide produced by the coral, and through photosynthesis generate oxygen and organic compounds that provides much of the polyps' nutrition. The zooxanthellae give corals their colour (IUCN, 1993). Ahermatypic, non-symbiotic corals do not form reefs and can exist in deeper colder waters. Not all reefs are constructed primarily by corals. Several genera of red algae in particular grow heavily calcified encrustations which bind the reef framework, forming structures such as algal ridges.

The term *coral reef* applies to a variety of calcium carbonate structures developed by stony corals and calcareous algae. Coral reefs are tropical shallow water ecosystems of high biodiversity largely restricted to the seas between the latitudes of 30°N and 30°S (Wilkinson and Buddemeier, 1994). They occur in around 110 countries. Coral reefs are most abundant in shallow, well flushed marine environments characterised by clear, warm, low nutrient waters that are of oceanic salinity and super-saturated with calcium carbonate (Wilkinson and Buddemeier, 1994). There are two basic categories: *shelf reefs*, which form on the continental shelves of large land masses, and *oceanic reefs*, which are surrounded by deeper waters and are often associated with oceanic islands. Within these two categories there are a number of reef types: *fringing reefs*, which grow close to shore; *barrier reefs* which develop along the edge of a continental shelf or through land subsidence in deeper waters and are separated from the mainland or island by a relatively deep wide lagoon; and *atolls*, which are roughly circular reefs around a central lagoon and are typically found in oceanic waters, probably originating from the fringing reefs of long submerged islands. Two other less clearly defined categories are *patch reefs* which form on irregularities on shallow parts of the seabed and *bank reefs*, which occur in deeper waters, both on continental shelf and in oceanic waters (WCMC, 1992).

Coral reefs are one of the most productive and diverse of all natural ecosystems. Around the world coral reefs have suffered a dramatic decline. In the past, severely stressed coastal ecosystems have been primarily temperate, but this is no longer true. The major human impacts (aside from fishing) on temperate coasts, such as heavy industrialization, large coastal developments, dredging and pollutants including sewage and oil, are now affecting the coastal areas of developing tropical nations. Among other effects, these are damaging coral reefs (Talbot, 1995): about 10% may already have been degraded beyond recovery and another 30% are estimated to decline seriously within the next 20 years (IUCN, 1993).

Central parts of the Indo-West Pacific contain the highest number of reef fish species, and richness decreases with increasing distance from this core area. Most reef fish species are relatively rare in terms of individuals in the community. Thus, at Toliara (southwest Madagascar) only about 25% (136) of the total number of fish species present were ranked as abundant (Harmelin-Vivien, 1989). Many families of coral reef fishes have a circum-tropical distribution, although there are pronounced differences at species level; the number of reef fish species within a single zoogeographic region varies between 100s and 1,000s. Most families in tropical seas include species that occur in the coral reef fauna, and some families are almost entirely restricted to reefs, such as Chaetodontidae, Scaridae, and Labridae. Within the demersal component (feeding on benthic organisms), the families Acanthuridae, Balistidae, Belennidae, Holocentridae, Ostraciodontidae, Pomacentridae (damselfish) and Serranidae tend to dominate. Principal pelagic families associated with reefs, other than the top predators such as Carangidae, *Sphyraena* and sharks, include Atherinidae (silversides), Pomacentridae and small lutjanids such as *Caesio* and its relatives (Longhurst and Pauly, 1987). Small-sized species tend to predominate, although the range is from 2-3cm for some *Eviota* species to over 5m for some sharks.

**Table 5** Species richness of corals and reef fishes at selected regions and sites

| coral reef site | number of fish species | number of coral species | coral reef site | number of fish species | number of coral species |
|---|---|---|---|---|---|
| Philippines | 1,500 | 400 | Moorea (Society Is) | 280 | 48 |
| Great Barrier Reef | 1,500 | 350 | St Gilles (Réunion) | 258 | 120 |
| New Caledonia | 1,000 | 300 | Tutia Reef (Tanzania) | 192 | 52 |
| French Polynesia | 800 | 168 | Tadjoura (Djibouti) | 180 | 65 |
| Heron Island (Great Barrier) | 750 | 139 | Baie Possession (Réunion) | 109 | 54 |
| Society Islands | 633 | 120 | Kuwait | 85 | 23 |
| Toliara (Madagascar) | 552 | 147 | Hermitage (Réunion) | 81 | 30 |
| Aqaba | 400 | 150 | | | |

**Source:** WCMC (1992), data from Harmelin-Vivien (1989), also Weber (1993).

There is a strong positive correlation between coral and fish species richness at given sites, although this is less evident on a small scale within reef zones (Table 4). It has also been suggested that there is a positive correlation between the degree of live coral cover and species richness and abundance of reef fishes (Bell and Galzin, 1984). In addition, the presence of dietary specialist fish species is often related to specific coral growth forms; for example, the exclusive coral feeders in the Chaetodontidae are positively correlated with the abundance of tall-branched coral colonies (Bouchon-Navarro *et al.*, 1985).

**Seagrasses**

Seagrasses are flowering plants (not true grasses) that are adapted to live submerged in seawater. There are approximately 48 species found in shallow coastal areas between the Arctic and Antarctic. Seagrasses are placed in two families: Potamogetonaceae (9 genera, 34 species) and Hydrocharitaceae (3 genera, 34 species) (Philips and Meñez, 1988). They occur from the littoral region to depths of 50 or 60 m but appear to be most abundant in the immediate sublittoral area. The are more species in the tropics than in the temperate zones, and of the 12 seagrass genera, 7 are confined to tropical seas and 5 to temperate seas (Philips and Meñez, 1988).

Most seagrass species are very similar in external morphology, with long thin leaves and an extensive rhizome root system which enables them to fasten to the substrate. A variety of substrates are occupied from sand and mud to granite rock, but the most extensive beds occur on soft substrates (Nybakken, 1993).

Seagrass beds have a very high productivity rate and contribute significantly to the total primary production of inshore waters. Seagrass beds serve a number of important functions in inshore areas. They are a significant source of food for many organisms both by direct grazing and detritus feeding, including invertebrates, fishes, birds, the green turtle *Chelonia mydas*, the West Indian manatee *Trichechus manatus* and the dugong *Dugong dugon*. The beds also serve as nursery grounds for many commercial species such as the bay scallop *Aquipecten irradians* and shelter the inhabitants from predators and adverse environmental conditions. They serve to protect coastlines from the erosive force of wave action.

## Mangroves

Mangroves (or mangals) are shrubs and trees which live in or adjacent to the intertidal zone. They are a polyphyletic group from a wide range of families comprised of approximately 69 taxa (62 species and 7 hybrids) (Duke, 1992). Mangrove communities are largely restricted to the tropics between 30°N and 30°S, with extensions beyond this to the north in Bermuda (32°20'N) and Japan (31°22'N) and to the south in Australia (38°45'S) and New Zealand (38°03'S) (Woodroffe and Grindrod, 1991). They are only able to grow on shores that are sheltered from wave action. Mangrove forests are particularly well developed in estuarine and deltaic areas. They may also extend some distance upstream along the banks of rivers, for example as far as 300 km along the Fly River in Papua New Guinea.

**Table 6** Diversity of mangroves

| Order | Family | Species |
|---|---|---|
| Filicopsida | Adiantaceae | 3 |
| Plumbaginales | Plumbaginaceae | 2 |
| Theales | Pelliciceraceae | 1 |
| Malvales | Bombacaceae | 2 |
| | Sterculiaceae | 3 |
| Ebenales | Ebenaceae | 1 |
| Primulales | Myrsinaceae | 2 |
| Fabales | Leguminosae | 2 |
| Myrtales | Combretaceae | 5 |
| | Lythraceae | 1 |
| | Myrtaceae | 1 |
| | Sonneratiaceae | 9 |
| Rhizophorales | Rhizophoraceae | 19 |
| Euphorbiales | Euphorbiaceae | 2 |
| Sapindales | Meliaceae | 3 |
| Lamiales | Avicenniaceae | 8 |
| Scrophuliariales | Acanthaceae | 2 |
| | Bignoniaceae | 1 |
| Rubiales | Rubiaceae | 1 |
| Arecales | Palmae | 1 |

Source: Duke (1992).

Mangroves occur over a larger geographical area than coral reefs and, unlike reefs, are well developed along the western coasts of the Americas and Africa. They have a more restricted distribution than coral reefs in the South Pacific. There are two main centres of diversity, termed the eastern and western groups. The eastern group occurs in the Indo-Pacific (the Indian Ocean and western part of the Pacific Ocean) and is the most species-rich (Tomlinson, 1986; Spalding *et al.* 1996). The western group, although centred around the Caribbean, includes mangal communities along the west coast of the Americas and Africa.

Mangrove communities are unique: due to the vertical extent of the trees, true terrestrial organisms can occupy the upper levels and true marine animals can occupy the bases (Nybakken, 1993). A wide variety of organisms is associated with the mangrove system. These include among the flora a number of epiphytes, parasites and climbers, and among the fauna large numbers of crustaceans, molluscs, fishes and birds (WCMC, 1992). It is estimated that more than 50% of the world's mangrove forest have already been destroyed by both human and natural causes (Lasserre, 1995).

## Algae and Kelp Forests

Algae lack vascular tissue (the transport system for water and nutrients) found in higher plants. They are almost exclusively aquatic; three of the four principal groups comprised of large-sized species are mainly marine in occurrence. These three, the green, brown and red algae ('seaweeds'), are all cosmopolitan in distribution and occur in a range of environments, although some constituent families have somewhat restricted ranges. In contrast to the prevailing pattern in many organisms, the cold and cool temperate regions of the world are rich in species. On present incomplete information, the region around Japan (northwest Pacific), the North Atlantic, and the tropical and subtropical western Atlantic, hold the most species of marine algae. Southern Australia is not so species-rich but appears to have the highest proportion of endemics. There are few species of larger algae in regions of cold water upwelling, such as western tropical Africa and the west coast of South America; small isolated islands and polar regions also have few species. There are more species of red algae (Rhodophyta) than the greens (Chlorophyta) and browns (Phaeophyceae) combined. The brown algae include the kelps (order Laminariales), disjunctly distributed in temperate waters of both northern and southern hemispheres.

As noted above, coral reefs support a unique and generally diverse algal flora that includes many crustose coralline algae (more species of which are likely to be discovered). Mangrove areas are also restricted to the tropics and subtropics and support a well-defined and interesting algal vegetation, contrasting with that of saltmarshes in the temperate zones, which are generally more species-poor. Sandy coastlines hold few species of large algae and often form barriers to seaweed dispersal. Some anthropomorphic changes to the coastline involving creation of additional habitats have locally enhanced species diversity; pollution, in contrast, has reduced species diversity, especially in lagoons, mangrove areas and coral reefs; in reef systems, pollution-tolerant weedy species tend to replace pollution-sensitive species. Land reclamation, rice-paddies and salt-pan development have led to the loss of algal habitat in many coastal areas in the tropics.

**Table 7**Diversity of marine algae

| | orders | genera | species | habitat |
|---|---|---|---|---|
| Chlorophyta (Green Algae) | 8 | 170 | 1,040 | mostly marine |
| Phaeophyceae (Brown Algae) | 14 | 265 | 1,500 | marine |
| Rhodophyta (Red Algae) | 16 | >555 | >2,500 | mostly marine |
| Charophyta (Stoneworts) | | 6 | 440 | freshwater |

Source: modified from text by DM John and I Tittley, in WCMC (1992).

**Table 8** Species richness of marine algal floras

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Japan | 1,503 | E Africa | 643 | Viet Nam | 424 | Colombia | 123 |
| N Atlantic | 1,116 | NW America | 635 | Red Sea | 383 | Macquarie I | 103 |
| W Atlantic | 1,058 | Antarctica | 563 | Tropical W Africa | 299 | St Helena | 68 |
| Chile | 751 | S Africa | 547 | Angola | 196 | Ascension I | 52 |
| California | 668 | E Mediterranean | 430 | Peru | 156 | | |

Source: modified from text by DM John and I Tittley, in WCMC (1992).

Throughout a large part of the cold temperate regions of the world, hard subtidal substrates are occupied by very large brown algae collectively known as kelps. These associations are known technically as kelp beds if the algae do not form a surface canopy, and kelp forests where there is a floating surface canopy (Nybakken, 1993). These formations occur primarily in the cold currents of the Atlantic and Pacific oceans and may be found in tropical areas, typically in areas of upwelling and cold water surface currents. The extent of the kelp beds and forests on various coasts depends on several factors: kelps flourish with a hard substrate for attachment, moderate wave surge, cool, clear ocean water and high-nutrient waters (Dybas, 1993). Kelps are attached to the substrate by a structure called a holdfast. A stem arises from the holdfast, and this bears one or more broad flat blades. Kelps obtain their nutrients directly from the seawater and the main site of photosynthesis is in the blades (Dybas, 1993).

Kelp beds and forest are extremely productive and provide the framework for an associated community including many different species of algae, invertebrates, and fishes. Despite the enormous productivity of the kelp, relatively few herbivores graze directly on the plants. It has been estimated that only 10% of the net production enters the food web through grazing and the remaining 90% enters the food chain in the form of detritus or dissolved organic matter (Nybakken, 1993). The main causes of kelp mortality can be attributed to mechanical forces, mainly wave action, and nutrient depletion, mainly nitrogen. Adult plants are only occasionally destroyed by grazing herbivores (Nybakken, 1993). Giant kelp is harvested not for direct consumption but for compounds such as algin, which is used as a emulsifier in food products, drugs, textiles, paints, and paper products (Dybas, 1993).

## PRESSURES ON MARINE RESOURCES

### HUMAN USE OF THE OCEANS

The seas provide many biological resources used by humans. In the form of marine fisheries they provide by far the most important source of wild protein, a source which is of particular importance to many subsistence communities around the world and which makes use of a wide range of animal species, notably fishes, molluscs and crustaceans. Marine algae are also an increasingly important foodstuff, notably in the Far East, with current annual world production of around two million tonnes. Marine organisms are also proving extremely fruitful sources of pharmaceuticals and other materials used in medicines. More minor although locally important uses include exploitation of coastal resources for building materials (eg. coral limestone, mangrove poles) and other industrial products (eg. tannins from mangroves).

Access to marine resources is not equitably distributed amongst the world's nations. Most obviously, some 39 states are landlocked, ie. have no seaboard (three of these have seaboards on the Caspian, a sea-like inland water body not treated herein). Those that do have seaboards show great variation in length of coastline, and area of territorial waters and Exclusive Economic Zones (EEZs - see below), both absolutely and relative to their land areas. They also show great variation in their capacities to exploit marine resources, both on the high seas and within their territorial waters and EEZs.

Human activities, directly and indirectly, are now the primary cause of changes to marine biodiversity. Approximately 50% of the world's human population lives in the coastal zone (within 60 km of the sea) and some projections suggest that this will have risen to as much as 75% by the year 2020 (UNCED, 1992). Pressures exerted by this, and indeed by the remainder of the human population, on the marine biosphere are immense and increasing.

## THREATS TO MARINE BIODIVERSITY

Most identified threats relate to coastal and inshore (continental shelf) areas. However, threats to the oceanic realm are undoubtedly increasing: fisheries and their attendant physical effects, such as habitat alteration owing to dredging and trawling, have entered deeper continental slope waters having previously been largely confined to the epipelagic zone, and deep water oil and gas mining is planned. Even abyssal and hadal areas are susceptible to human impact. A small, steady increase in abyssal temperature of 0.32°C in 35 years has been attributed to global climate change brought about by the activities of man. Ocean waste dumping and the potential for deep water mining and mineral extraction are also causes for concern, as are the changes in biomass and species composition in the waters above these regions (CBDMS, 1995).

The US National Research Council (NRC) Committee on Biological Diversity in Marine Systems (CBDMS, 1995) has identified the following five activities as the most important agents of present and potential change to marine biodiversity at genetic, species and ecosystem levels:

- fisheries operations;
- chemical pollution and eutrophication;
- alteration of physical habitat;
- invasions of exotic species;
- global climate change.

All these factors are likely to interact with each other, making the effective, long-term management of marine resources one of the major - and most intractable - problems currently facing humankind.

Below, we firstly discuss recent events in the Black Sea and the Baltic, which exemplify the complexity and magnitude of forces for change in the marine environment, and secondly, provide an overview of marine fisheries, which while helping meet basic nutritional needs in many human communities, are now clearly seen to be capable of having long-term adverse effects on resources that had seemed inexhaustible.

The two case studies illustrate very well several of the key factors leading to degradation of the marine environment, and the effect of several factors acting simultaneously. They serve as a sobering presentiment of what is likely to befall many of the world's inshore marine areas.

## CASE STUDY I: THE BLACK SEA

The following review is drawn largely from Mee (1992) and Griffin (1993), with some additional information from FAO (1994). In the present century human influences have had an increasing impact on the Black Sea ecosystem. Six countries have coastlines on the sea: Bulgaria, Romania, Ukraine, Russian Federation, Georgia and Turkey. However, the sea's drainage basin also includes some or all of Hungary, Slovakia, the Czech Republic, Moldova, Belarus, Germany, Austria, Serbia, Croatia, Bosnia-Herzegovina, Switzerland and Albania. Through discharge into rivers, or abstraction of water, all these countries may have an influence on the Black Sea environment. Over 160 million people live in this area, around half of these in the Danube basin alone.

Major factors are: eutrophication as a result of massively increased nutrient loads arising from human activities in the river basins and along the sea coast, coupled particularly in the Sea of Azov with decreased water flow as rivers have been dammed and diverted for agricultural or industrial activities; pollution; inadequately controlled fishing; and the introduction (generally accidental) of exotics in the Black Sea itself.

### Chemical pollution and eutrophication

In 1992 the Danube alone was estimated to introduce some 60,000 tonnes of phosphorus and *c* 340,000 tonnes of inorganic nitrogen a year into the Black Sea, along with 1000 tonnes of chromium, 900 tonnes of copper, 60 tonnes of mercury, 4500 tonnes of lead and 50,000 tonnes of oil. Nitrogen loads in the Danube have increased at least three-fold in the past 25 years, it is believed largely as a result of intensification of agriculture. Three-fold increases in concentration of nitrate and seven-fold increases of phosphate have similarly been recorded in the Dniester since the 1950s.

The increased nutrient supply (eutrophication) has led to intensification of phytoplanktonic blooms, particularly in the shallower northern and western areas. The blooms have led to a shallowing of the euphotic zone throughout the sea. In the open sea the depth of the euphotic zone has decreased from 50-60 m in the early 1960s to around 35 metres; on coastal waters it is often less than 10 m. This decreased light penetration has led to massive decreases in the living biomass of benthic (bottom-dwelling) macrophytic algae or seaweeds, formerly an important harvested resource. Thus the area of *Phyllophora* is believed to have been reduced to around 5% of its original extent. At the same time, deposition of dead organic matter (mostly from the algal blooms) on the shallow shelf bottom here has led to an increasing tendency to anoxia (loss of oxygen in the water owing to the activities of bacteria), resulting in the mass die off of benthic fauna, including commercially valuable stocks of bivalve molluscs and fishes such as turbot. Virtually the whole of the northern and western continental shelf, including all the Sea of Azov, is now prone to anoxia. It is also reported that formerly pristine benthic faunal communities are now being affected on the eastern and south-eastern coasts, a large distance away from the source of pollutants.

### Fisheries operations

Around 26 species of fishes have traditionally been commercially harvested in the Black Sea, including some valuable species such as sturgeon, bluefish, bonito and turbot. Until 1983, a large, direct porpoise *Phocoena phocoena* fishery existed within the region. It is possible that this will re-open once stock-assessment has been completed.

Although increased nutrient loads evidently had an adverse effect on the Black Sea benthos from an early stage, they also initially led to an increase in marine productivity, correlating in the 1960s with a dramatic expansion in fisheries effort by most of the nations bordering the sea. Fisheries effort was particularly directed to the larger, more valuable species, including anadromous fishes such as sturgeons and river herring, and pelagic, often migratory species, such as bonito, bluefish and mackerel as well as porpoise. These rapidly became overfished, both within the Black Sea and the connecting Sea of Marmara which served as a migration route for stocks of these species between the Mediterranean and Black Seas.

Most of these larger species are predators. Severe reductions in the populations of these coupled with the increasing nutrient load seems to have led to an increase in biomass of small pelagic species, most notably of the anchovy *Engraulis encrasicolus*. Declared landings, mostly of anchovy, rose from a previous level of around 350,000-400,000 tonnes to nearly 1 million tonnes during the late 1970s. This represented only a proportion (perhaps 60%) of actual catch, as there is known to be considerable under-declaration of catches in the region.

At the same time there was a general decrease in planktonic species diversity, accompanied by explosive blooms of one species of zooplankton (*Noctiluca miliaris)* and, during the 1980s, by dramatic increases in population of the jellyfish *Aurelia aurita*, whose biomass in the sea was estimated to reach an extraordinary 450 million tonnes at that time.

At the end of the 1980s, the anchovy catch collapsed. Declared harvest in the Black Sea proper (excluding the Sea of Azov) decreasing from around 520,000 tonnes in 1988 to around 160,000 tonnes in 1989. The Sea of Azov anchovy fishery had declined from *c* 30,000 tonnes in 1986 to virtually zero in 1989. Overall catch has continued to decline, dropping to below 100,000 tonnes in 1990 and 1991.

**Invasions of exotic species**

It is difficult to be certain of the cause of this collapse. Overfishing is very likely to have been a contributory factor, but fisheries biologists believe that a significant cause has been the accidental introduction of the predatory ctenophore (comb-jelly) *Mnemiopsis leidyi*, native to estuaries in North America and thought to have been introduced into the Black Sea in discharged ballast water from oil tankers travelling from the USA to Black Sea ports. The ctenophore feeds on plankton, including fish eggs and fry, and appears to have no known predators in the Black Sea. Populations of this species exploded in the late 1980s, reaching a peak of some five kg per square metre of water column by 1991. Densities have subsequently decreased somewhat but the species is now well established, with seasonal blooms which occur during the breeding season.

In 1992 *Mnemiopsis* was also recorded in the Sea of Marmara and the Turkish part of the Mediterranean. There are serious concerns that it might spread in ballast water to other areas of enriched estuarine outflow in the Mediterranean, such as the Gulf of Lions, the Adriatic and the Nile estuary.

Overall it seems as if nutrient enrichment combined with excessive fishing may have led to major, conceivably irreversible, changes in food-chains within the Black Sea ecosystem, principally by favouring small, fast-growing and short-lived species which feed on plankton and also by creating opportunities for alternative invertebrate plankton-feeders, such as ctenophores and jellyfish (medusan cnidarians), to flourish. This eutrophication has also led to a drastic decrease in the amenity value of the area

**CASE STUDY II: THE BALTIC SEA**

The Baltic Sea covers around 413,000 $km^2$. It is very shallow, having an average depth of around 57 metres, although in places it reaches depths of up to 460 metres. It communicates with the North Sea through the Great and Little Danish Belts and the Öresund, which together form the so-called Belt Sea. This and the Kattegat form a transition zone between the North Sea and the Baltic proper.

The great majority of water input into the Baltic comes from rivers, which contribute an estimated 430-470 square kilometres of freshwater annually. Unlike the Black Sea, where one river (the Danube) dominates water inflow, no single river has dominance. The three largest rivers are the Neva, Wisla and Oder, which together contribute only just over one fifth of the overall freshwater input. Inflow of water varies seasonally and also over longer time periods.

Over the past 12,000 years the Baltic has alternated several times from being a large freshwater lake to being a truly marine sea, although for the last 3000 years it appears to have been a relatively stable brackish water system. Salinity of surface waters varies from 1-3 ppt in the Bothnian Bay to 6-8 ppt in the Baltic proper. In the Kattegat region salinity is higher and much more variable, from 15-30 ppt. Bottom waters (those below 60 m) are of higher salinity, being fed by a current of saline water from the North Sea through the Great and Little Danish Belts and the Öresund, via the Kattegat and Skagerrak sea areas. Periodically, persistent westerly winds can also generate high volume inflows of saline surface water here. These inflows may occur only once every few years (before 1993 the last were in 1975 and 1976), but are of considerable ecological significance.

The low and historically varying salinity of the Baltic has led to a considerably reduced level of both plant and animal diversity compared with nearby marine areas. The number of marine species decreases steeply with distance from the North Sea/Baltic Sea transition zone. Endemism rates are negligible, although some marine species show distinct morphology in the Baltic and there are some unique floral and faunal assemblages where freshwater, brackish water and marine species coexist.

The following countries have coastlines on the Baltic: Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Norway (in the transition zone with the North Sea only), Poland, Russia and Sweden. The drainage basin feeding the Baltic also extends into Belarus and, marginally, into the Czech Republic and the Ukraine. The basin has a human population of around 80 million people.

### Chemical pollution and eutrophication

Major inputs come from domestic sewage, industrial and agricultural effluents, marine traffic and atmospheric deposition. Major industrial activities are paper and wood-pulp processing, which was formerly a major contributor of mercury and is still a dominant source of organochlorides, mining, steel and other metal manufacture and fertiliser production. Studies of metal content in bottom sediments indicate that atmospheric deposition (largely of residues from burning fossil fuels) is probably the major source of these contaminants (Hallberg, 1991).

It is estimated that total loads of nitrogen have doubled and of phosphorus have quadrupled in the Baltic since 1950. Of these, 75% of total nitrogen load and 90% of phosphorus load are believed of anthropogenic origin. Some contaminants, however, show a decreasing trend, notably lead and PCBs. The latter appear to have stabilised at around one third of the maximum levels recorded in the 1970s. This decrease is associated with improved pollution controls during the past 15 years in northern and western states bordering the Baltic. However, central and eastern European countries usually have technologically outdated industrial plants which continue to cause significant pollution.

Primary productivity of phytoplankton in the Kattegat and central Baltic appears to have doubled in the past twenty-five years. It seems likely that this is mainly a result of anthropogenic influence, although it is difficult to separate this from natural factors, particularly the lack of major inflow of North Sea waters during the period 1976-1993. The increase in primary production has led to a corresponding increase in algal sedimentation and decomposition in benthic waters, producing a deterioration of oxygen supply there. This decrease is most marked in the deeper basins of the Baltic but has also spread to shallower areas, leading to marked changes in the composition of benthic communities. Turbidity has also increased, so that the clear water zone is now generally two to three metres shallower than at the start of the century. Algal blooms, sometimes toxic, appear to be increasing in frequency and intensity, but to date there does not appear to have been any drastic change in the species composition or overall relative abundance in the phytoplankton, or in pelagic communities more generally.

### Fisheries operations

The most important fishery in the Baltic Sea has been cod *Gadus morhua*. Declared landings of cod during the period 1980-1985 were at an all time high, of between 335,000 and ca 440,000 tonnes. Mortality rates have consistently exceeded recruitment so that the spawning stock size of the large central Baltic population has decreased from an estimated 800,000 tonnes in 1980 to under 100,000 tonnes in 1992. It has been below the minimum biologically acceptable level (MBAL) for several years. The International Council for the Exploration of the Sea (ICES) have recommended catch levels for many years. Total Allowable Catches (TACs) have been set since 1989 but have consistently been higher than those recommended by ICES so that the spawning stock size has continued to decrease. In addition as TACs have become lower, misreporting and illegal catches have increased so that actual catches have usually exceeded TACs. In face of this, ICES recommended a total stop on cod fisheries in the central Baltic in 1995, with a very low catch permissable for the western Baltic. Nevertheless, managers recommended a TAC of 100,000 tonnes for the whole of the Baltic in 1995, meaning that a high level of fishing mortality would continue for the central Baltic stocks. This would be partially offset by the appearance in the catch of a reasonable 1991 year-class, but would certainly not allow the stock to start recovering.

Recruitment to the stock has shown a generally declining trend since 1976. This has been ascribed to a deterioration in environmental conditions as well as to overharvest. This deterioration was probably linked to a decline in salinity and oxygen content of deep water in the Baltic, through eutrophication and a lack of major inflows of high salinity water rich in oxygen from the North Sea. Cod eggs sink on hatching and may have suffered increased pre-hatching mortality. In 1993 an inflow from the North Sea occurred, leading to an amelioration of conditions in the Baltic; however, it is feared that the cod spawning stock may be too small to take advantage of this.

In contrast to cod, herring stocks in the Baltic have experienced decreased fishing mortality and increased spawning stock size - the latter is now approaching an estimated 2 million tonnes. It is not clear if this change in dominance from a larger predator (cod) to a smaller one (herring) is a parallel of the changes in the Black Sea discussed above: certainly causal factors (eutrophication and overfishing of large predators) seem to be the same, if less severe in the case of eutrophication.

Multispecies stock assessment in the form of Multi-Species Virtual Population Analysis (MSVPA) has been carried out in the Baltic, in the realisation that stocks of particular species cannot be assessed in isolation from their prey and their major predators. In the Baltic the main fish component of the marine food web is relatively simple, comprising cod as the only major predator and herring, sprat and small cod as the fish prey. Analysis of interactions between these various populations gives a much clearer picture of mortality than examination of single species in isolation. One major discovery is the importance of cannibalism by cod as a source of juvenile mortality. To date MSVPA has only been used in the Baltic in assessment of herring and sprat stocks, but it is hoped to extend this to cod in the future. However, without the political will to impose realistic catch limits and the means to enforce these limits, it is abundantly clear that stocks here as elsewhere, fishing mortality will continue to exceed acceptable limits leading to continuing decline and probably eventually complete collapse of the fishery.

## WORLD MARINE CAPTURE FISHERIES

Annual world landings of aquatic resources have increased nearly five-fold in the last 40 years, from 22 million tonnes per year between 1948 and 1952 to just over 100 million tonnes in 1989 and 1993 (FAO, 1990, 1991, 1995a). At that time, almost 70% of total landings were used for human consumption, while the remainder were used for animal feed, fertiliser etc. The vast majority of the catch (>90%) comprises fishes (marine, diadromous and freshwater). Molluscs, crustacea and other animals are relatively unimportant in terms of global landings, although many species command high prices per kg and have a disproportionately high economic value.

Just over 80% of the 100 million tonnes world landings in 1989 comprised marine capture fisheries, the remainder being inland capture fisheries and aquaculture, both marine and freshwater (marine and coastal aquaculture is discussed below). After 1989 overall fisheries landings declined to around 97 million tonnes in 1990 and 1991, increasing to *c* 99 million tonnes in 1992 and 101 million tonnes in 1993. The increase in landings since 1991 has come almost entirely from increases in aquaculture, as capture fisheries have continued to decline, although more slowly than the major drop between 1989 and 1990. This recent decline is now universally acknowledged to represent a major crisis in the world's capture fisheries which will require major commitment, and international cooperation, on the part of the world's fishing nations to resolve. Although some progress has been made, there are currently few causes for optimism.

Map 3 (end of book) summarises data on marine capture fisheries and discards in each fishing area.

**Distribution of marine fisheries**

The location of the world's marine fisheries is governed principally by the distribution of the floating plants on which they depend for food. Phytoplankton production is principally dependent on adequate supplies of nutrients, and is largest in areas of upwelling.

Climatic fluctuations can greatly alter the pattern of ocean circulation, and hence fisheries production, around the world. Perhaps the most famous of these events is the disruption in some years of the circulation pattern off the coast of Peru, a phenomenon known as `El Niño', which intermittently leads to the near total collapse of the coastal fisheries.

The relative importance of the catches in the different fishing areas reflect the differences in production. The four major fishing areas (as defined for statistical purposes by FAO) in descending order of annual tonnage of landings are the Northwest Pacific, the Southeast Pacific, the Northeast Atlantic and the Western Central Pacific.

**Composition of marine fisheries**

Although there are approximately 22,000 species of fish, of which more than 13,000 are marine (Nelson, 1984), only a very small fraction are of major commercial importance. FAO statistics (FAO, 1991) break down aquatic animals and plants into 980 "species items" (species, genera, or families) which are then further categorised into 51 groups of species. Of these, only 17 groups contributed more than 1% (= one million tonnes) towards total recorded world landings, which approached 100 million tonnes in 1989. The most important groups were the herrings, sardines and anchovies, of which 24.5 million tonnes were landed in 1989, followed by the cods, hakes and haddocks, of which 12.8 million tonnes were landed.

The fisheries industry is based on a remarkably small number of species. Over one million tonnes each of 10 individual marine fish species were caught in 1993: together these comprised 27 million tonnes, or just under one third of marine capture fisheries. The single largest species fishery was the Anchoveta *Engraulis ringens* of which 8.3 million tonnes were landed, followed by the Alaska Pollock *Theragra chalcogramma* of which 4.8 million tonnes were landed.

**Recent trends in marine fisheries**

A notable change in the fishing industry in the 1980s was the increase in levels of national and international controls designed to ensure the conservation of fish stocks. This reduced the importance of long-range fishing in many areas and allowed the development of short- or medium-range fishing fleets, (FAO, 1990b). Thus in the early 1970s long-range catches formed 79% of the North-eastern Pacific catch, but had declined to only 8% in 1988, having been replaced by local fleets and joint fishing ventures (FAO, 1990b).

The most important step to facilitate the sustainable exploitation of fish stocks has been the establishment by coastal states of jurisdiction up to 200 miles from their shores; 99% of the marine fisheries catch is currently taken within this limit (FAO, 1990b). Most countries are now declaring or have declared 200-mile fishing exclusion zones around their coasts, providing increased potential for rational and sustained use of resources, (FAO, 1981).

Reported world landings have generally increased over the past 25 years. During the 1960s, total landings increased steadily as new stocks were discovered, while improved fishing technology and an expansion of fishing effort enabled fuller exploitation of existing stocks of both pelagic (surface water or open sea) and demersal (deep water or bottom-dwelling) species. Long-range fleets increased in size during this period, concentrating their efforts in the richest ocean areas, and were largely responsible for the rapid increase in world catches.

In the early 1970s, the Peruvian anchoveta fishery peaked at just over 13 million tonnes, constituting by far the largest single fishery that has ever existed. This then subsequently collapsed, so that for the next few years there was very little increase in the total catch. Landings of most demersal fish stocks remained relatively constant, implying that they were close to full exploitation and, whilst landings of pelagic fish stocks changed from one species to another in certain areas, there was no appreciable change in total pelagic landings (FAO, 1990b). Long-range fleets continued to expand in importance.

The 1980s once again saw a period of continuous growth (averaging 3.8% a year) in world landings. As in the 1970s landings of demersal stocks were generally static or declining so that shoaling pelagic species provided most of the increase in fish production. In fact, just three pelagic species (Peruvian Anchoveta *Engraulis ringens*, South American Sardine *Sardinops sagax*, and Japanese Sardine *Sardinops melanostictus*) and one semi-demersal species (Alaska Pollock *Theragra chalcogramma*) accounted for 50% of the increase in world landings during the 1980s (FAO, 1990b). Most of this increase appears to have been because of favourable climatic effects on stock sizes rather than new fishery developments or improved management practices (FAO, 1990b).

FAO (1994: Table 4) identifies the four fishery areas showing the largest recorded declines between 1970 and 1990 in species covered by catch statistics. These are: area 67, the Northeast Pacific, corresponding closely to the Northeast Pacific Regional Sea (as defined here); area 21, Northwest atlantic, contained within the North Atlantic Region (again, not a UNEP Regional Sea); and 47, the Southeast Atlantic, which includes parts of the West and Central Africa Regional Sea area and South Africa.

The three major problems in world capture fisheries are overfishing of target stocks; increased mortality of non-target species though bycatches and ghost fishing; habitat alteration and destruction through use of intrusive fishing methods.

**Overfishing**

Direct overfishing - at its simplest, the removal of fishes faster than they can reproduce - is the most obvious threat to world fisheries. FAO (1995) have estimated that around 70% of major fish stocks (including finfishes and marine invertebrates) which have been assessed are overexploited or in serious danger of being so (that is fully fished, overfished, depleted or recovering). The proportion of high value fisheries (eg. many demersal finfishes such as cod and hake, many crustacean fisheries) in this state is even higher. There are three major reasons for this. First, and most fundamental, most fisheries have traditionally been regarded as an "open access" resource, so that, in essence, it pays any one fisher to harvest as much as possible at any given time because if they do not, somebody else will. Secondly, technological innovations have made fishing much more efficient. Thirdly, extreme over-capitalisation of the world's commercial fishing fleet (partly a consequence of the nature of fisheries as an open access resource but also for complex socio-economic and political reasons) has intensified fishing pressure.

Attempts to date to control overfishing have been largely unsuccessful. Not only is enforcement of regulations often extremely difficult and expensive, but in many cases there is strong political pressure to set catch limits higher than those recommended by fisheries scientists. Furthermore, there is increasing evidence that the single-species population models generally used to assess fish stocks and make recommendations for catch limits have been too simplistic, as they do not adequately take into account interactions between species and environmental perturbations. Fisheries models which take into account these factors are being developed, but are very complex and as yet generally experimental.

**Bycatches and discards**

A 1994 FAO global assessment of bycatches and discards estimated that 18 to 40 million tonnes (mean 27 million tonnes) of marine fisheries catch were discarded annually. This represented just over 25% of annual estimated total catch (ie. landings represent around 75% of actual catch). Although figures are not available, it is generally assumed that a large proportion of discards die. Further losses are caused by mortality of animals which escape from fishing gear during fishery operations, but it is impossible at present to estimate the importance of this. Shrimp fishing produces the largest volume of discards (around 9 million tonnes annually).

Bycatches include non-target, often low-value or "trash" species, as well as undersized fish of target species. Non-target species may include marine mammals, reptiles (sea-turtles) and seabirds, as well as finfishes and invertebrates. Of particular concern in recent years has been mortality of marine mammals, especially dolphins, in pelagic drift nets, of sea-turtles in shrimp trawls and more recently, of diving seabirds, especially albatrosses, in long-line fisheries.

Discarding may be a side-effect of management systems intended to regulate fisheries (eg. non-transferable quotas may cause discarding of over-quota catch; species-specific licensing may cause discard of non-license but still commercially valuable species).

Solutions to bycatches and discards will be found essentially through improvement in the selectivity of fishing gear and fishing methods. Much of the research in this has been carried out in higher latitudes and is not readily transferable to multispecies tropical fisheries, where the tropical shrimp trawls still produce high rates of by-catch. Improved utilisation of by-catch either as fish-meal or human food-fish is also a possibility; however, this does not address the problem of mortality of potentially threatened species (sea turtles, seabirds, cetaceans), nor the wasteful capture of immature specimens of harvestable species.

FAO estimate that it should be possible to reduce discards by 60% by the year 2000 by: a concentrated effort to improve the selectivity of fishing gear; the development of international standards for research; greater interaction between research staff, industry and fisheries managers; and the application of technology through fisheries regulations. Where overfishing is occurring and quotas set in response, eg. in EU waters, it may be unrealistic to expect radical reduction in discarding without similar reduction in effort.

A further problem in the efficient utilisation of marine resources is post-harvest loss. It is almost impossible to estimate this accurately, but FAO believe it to exceed 5 million tonnes per year (ie. around 5% of harvest). Most significant are physical losses of dried fish to insect infestations and loss of fresh fish through spoilage. These problems are particularly significant in developing countries.

**Habitat destruction**

It is increasingly evident that some fishing methods, most extensively bottom-trawling but also techniques such as dynamite fishing and *muro-ami* (using rocks on ropes to drive fishes into nets), can have a highly disruptive influence on marine benthic habitats. It has been estimated, for example, that every spot in the southern part of the North Sea is trawled by a bottom trawler on average more than once a year (FAO, 1995). In this case, beam trawling has the most damaging effect whereas other trawling (eg. otter trawling) has relatively little. Trawlers tend to return over the same tracks because catch may increase for a period as fishes move in to feed on dead or moribund individuals. On the other hand, some areas of seabed cannot be trawled because of obstructions. The direct impact of trawling on marine benthic communities is inadequately understood at present but is bound to be severe. More work is clearly needed in this area.

## MARINE AQUACULTURE

Given the universally acknowledged crisis in world capture fisheries, attention is increasingly focusing on aquaculture as a means of meeting human food requirements. FAO (1995a) calculate that to maintain present per capita fish consumption levels of 13.00 kg per head per year to the year 2010, 91 million tonnes of foodfish (both finfishes and aquatic invertebrates) would be required. This is an increase of some 19 million tonnes over estimated actual foodfish production in 1993. There is no realistic likelihood of obtaining this increase from capture fisheries. Indeed in view of the general failure to manage these fisheries effectively, it seems as if yields from capture fisheries (both marine and inland) will almost certainly decline, at least in the short to medium term.

The only realistic hope of meeting this target, therefore, is through increased aquaculture production. If capture fisheries remain roughly constant over this period, doubling of current (1993) world aquaculture production will cover the shortfall and lead to aquaculture providing over 40% of all fish for human consumption. FAO consider this a real possibility, albeit a challenging one.

Aquaculture involves the rearing in water of animals or plants in a process in which at least one phase of growth is controlled or enhanced by human action. The animals used are generally finfishes, molluscs and crustaceans although a number of other groups are also cultured in small quantities (eg. sea-squirts phylum Tunicata, sponges phylum Porifera, frogs and marine turtles). Aquaculture of plants largely involves various seaweeds.

Currently, some 60% of world animal aquaculture production by weight is inland, the remainder being classified as marine or brackish. Freshwater aquaculture will not be further considered here. Data used are almost exclusively from FAO.

### Finfish Production

Aquaculture of finfish is still very heavily dominated by production of herbivorous freshwater species, especially carp and other cyprinids. This group alone accounted for over 75% of estimated production of *c* 9.4 million tonnes in 1992, most of this in China, whose production of nearly 5 million tonnes of freshwater fishes in 1992 accounts for over half of all finfish aquaculture. Marine and brackish water aquaculture accounts for somewhat over 10% of global production (over 1 million tonnes in 1992). Some 30% of this consists of production of the herbivorous milkfish *Chanos chanos* in two south-east Asian countries, Indonesia and the Philippines.

### Crustacean aquaculture

Between 1984 and 1992 annual production by aquaculture of crustaceans, 90% of which is in marine and brackish water species, grew over threefold to nearly 1 million tonnes. This represents just under 20% of annual crustacean production. Along with the salmonids, this was the fastest growth of any form of aquaculture.

The great majority of marine crustacean aquaculture takes place in Asia and is dominated by *Penaeus* species; globally this genus produces over 90% of aquaculture crustacean supply by weight. The Giant Tiger Prawn *Penaeus monodon* is the most widely cultivated and accounts for nearly half of all aquaculture production. The two other important species are *P. chinensis* which is cultured in China and accounts for around one quarter of production, and the Whiteleg Shrimp *Penaeus vannamei* which is cultured in the Americas and normally accounts for just under 15% of estimated global supply, around 90% of this originating in Ecuador. Other marine crustaceans cultivated include other *Penaeus* species, some *Metapenaeus*, and spiny lobsters *Panulirus*. These groups, however, make an insignificant contribution to global supply.

Growth in crustacean aquaculture has been fuelled by the high value of the product: the market in 1993 was estimated to be worth over US$6 billion (FAO, 1995). Production is aimed at the export market, primarily to Europe, the USA and Japan, and to a lesser extent at the domestic luxury market. Pressure is high to produce maximum returns on investment so that increasingly intensive farming methods are used. These are widely acknowledged to be having adverse social and environmental impacts in the countries of production, as well as leading to increasing difficulties in maintaining supply, owing to the spread of major diseases. Impacts include:

- loss of mangrove habitat;
- abstraction of freshwater;
- introduction of pathogens and other damaging non-native species;
- escape of cultured non-native species;
- pollution;
- diversion of low quality or cheap fish food resources (may lead to more efficient use of by-catches and trash fish, but may lead to more indiscriminate catch fisheries);
- diversion of effort from other forms of aquaculture (notably milkfish *Chanos chanos*).

**Mollusc aquaculture**

Virtually all production of molluscs by aquaculture takes place in marine water, with a small amount recorded by FAO as occurring in brackish water and negligible quantities in freshwater. Overall production in 1993 was just over 4 million tonnes, considerably more than the production of marine and brackish water finfishes and crustaceans combined. Mariculture accounts for nearly 40% of all mollusc production, a far higher proportion than either finfishes or crustaceans. It has generally grown more slowly over the past decade than marine and brackish water finfish or crustacean production; indeed productivity largely stagnated between 1988 and 1991. However, 1992 and 1993 have shown large rises, so that 1993 production is over twice that of 1984 production.

Most of the increase in production from 1984 to 1993 can be attributed to one country: China. In 1993 just over 2.2 million tonnes of molluscs (54% of all mollusc mariculture) originated in China, over six times the quantity produced by that country in 1984. The rest of Asia accounted for around 1.1 million tonnes in 1993, a relatively small increase over 1984 production (830,000 tonnes). In total, therefore, Asia now accounts for around 80% of all mollusc mariculture production. Most of the remainder (*c* 560,000 tonnes or around 14%) originates in Europe, where production has declined slightly since 1984. Production in North America has also declined, while that in Oceania (chiefly New Zealand and

Australia) has increased more than three-fold (to nearly 60,000 tonnes, which is still only 1.5% of global production).

FAO record aquaculture of around 50 species of mollusc, virtually all bivalves. Some production is classified only to family or genus level although is unlikely to involve a significant number of additional species. As with most culture systems, production is heavily skewed to a small number of taxa. In 1993 one species, the Japanese or Yesso Scallop *Pecten yessoensis*, accounted for nearly one quarter of all mollusc production. Three quarters of production was in China, the remainder in Japan. The two other important groups are mussels (Mytilidae) and oysters (mainly *Crassostrea*).

## MARINE ECOSYSTEMS AND MANAGEMENT

### Problems with managing human use of the oceans

All marine resources outside territorial waters (usually up to 12 nautical miles (nm) from shore) were traditionally considered 'open-access' resources. This covered most of the world's oceans and virtually all deep-sea areas. These resources were theoretically highly susceptible to overexploitation, although, with a few exceptions (eg. whales), harvesting technologies until relatively recently were not sufficiently sophisticated to pose a serious threat. In the past few decades this has changed dramatically and many open-ocean resources have been gravely depleted leading to the collapse of a number of fisheries, sometimes bringing individuals and nations into conflict. With the introduction of the Exclusive Economic Zone (EEZ) under the United Nations Convention of the Law of the Sea (UNCLOS), which allows nations control over resources (including living resources) in an area up to 200 nm offshore, a far greater proportion of the world's seas now come within the control of individual nations.

This control should theoretically allow better management of resources in these areas, although improvements are not yet generally apparent. The reasons for this are complex. In part they are the result of a lack of resources (financial and technical) and, sometimes, political will on the part of nations to invest heavily in management of the marine biosphere; in part they are a product of the ecological characteristics of marine areas.

There is a fundamental distinction between the processes and patterns observed in open oceans, dominated by global winds and large-scale vertical and horizontal movement of water masses, and those observed nearer to coasts, where shelf bathymetry, coastal winds and local input of nutrients, pollutants and sediments generate a diversity of smaller-scale phenomena.

Coastal and near-shore waters, along with smaller sea basins (eg. Mediterranean), make up one of the four primary domains defined by Longhurst (1995) in an approach intended to classify the entire world ocean within a coherent oceanographic system. Long-term and geographically extensive data on sea surface colour (obtained by the CZCS radiometer carried by the Nimbus orbiting satellite during 1978-1986) were analysed. These data reflect chlorophyll concentrations and remain the only observation of a biological feature over the entire world ocean (Longhurst, 1995). Estimates of primary production rates, and changes over time, have been generated on a one-degree grid (Longhurst *et al*. 1995). These values, together with numerous other data sets, have been used as the basis of a classification of the world ocean into four ecological domains and 56 biogeochemical provinces (Longhurst, 1995).

Sherman and Busch (1995; and see AAAS 1986-1993) have identified a large number of ecosystem units based on the world's coastal and continental shelf waters, and discuss at some length the problems and challenges of assessing human use of marine ecosystems. They regard the concept of the Large Marine Ecosystem (LME) as central to such analysis. LMEs are:

> *Regions of ocean space encompassing near-coastal areas from river basins and estuaries out to the seaward boundary of continental shelves and the seaward margins of coastal current systems. They are relatively large regions of the order of 200,000 km$^2$ or larger, characterised by distinct bathymetry, hydrography, productivity, and trophically dependent populations.*

Nearly 95% of the usable annual global biomass yield of fishes and other living marine resources is produced within 49 identified LMEs which lie within and immediately adjacent to the boundaries of EEZs of coastal nations (Sherman and Busch, 1995).

Many LMEs include the coastal waters of more than one state. In these cases, it will be effectively impossible for individual nations to assess whether their use of marine resources is sustainable in isolation from neighbouring nations. Coordination between states in monitoring and resource management will thus become increasingly necessary as the pressures placed on these areas increase. At present no single international body is in a position to coordinate action and reconcile the needs of individual nations operating within particular LMEs.

It appears that the long-term sustainability of resource species in coastal ecosystems as sources for healthy economies is diminishing. A growing awareness of these problems has accelerated efforts to assess, monitor, and reduce the stresses on coastal ecosystems (Sherman, 1994). A strategy for implementing a biodiversity inventory and monitoring programme for the LMEs is given in the *Global Biodiversity Assessment* volume (UNEP, 1995).

A critical need in monitoring marine ecosystems is the development of a consistent long-term database for understanding between-year changes and multi-year trends in biomass yields. For example, during the late 1960s when there was intense fishing within the Northeast US Continental Shelf LME, marked alterations in fish abundances were observed. The biomass of economically important finfish species (eg. cod, haddock, flounders) declined by approximately 50%. This was followed by increases in the biomass of small elasmobranchs (dogfish and skates), and led to the conclusion that the overall carrying capacity of the ecosystem for finfish did not change (Anthony 1993; Collie 1991). However, the excessive fishing effort on the more highly valued species allowed for the lower-valued elasmobranchs to increase in abundance. Management of marine fisheries will need to take these kinds of species dominance shifts into account in developing strategies for long-term, economic sustainability of the fisheries (Anthony, 1993; Murowski, 1996). The theory, measurement, and modelling relevant to monitoring the changing states of LMEs are discussed in reports on ecosystems with multiple steady states, and on the pattern formation and spatial diffusion within ecosystems (AAAS, 1986, 1989, 1990, 1991, 1993; Beddington 1984; Levin, 1993; Mangel, 1991).

Among the LMEs being assessed, monitored, and managed from a more holistic ecosystem perspective are the Yellow Sea (Tang, 1989); the Benguela Current (Crawford *et al*, 1989); the Great Barrier Reef (Kelleher, 1993); the Northwest Australia Continental Shelf (Sainsbury, 1988); and the Antarctic marine ecosystem (Scully *et al*, 1986). Movement toward ecosystem-level assessment, monitoring and management is emerging also for the North Sea (NSQSR, 1993); the Barents Sea (Eikeland, 1992); and the Black Sea (Hey and Mee, 1993). The driving forces of variability in biodiversity and biomass yields are currently being examined in several LMEs.

Programmes intended to enhance sustainability and ecosystem health are being implemented for several LMEs adjacent to developing nations. The programmes are being supported by international agencies as part of an effort by the World Bank, the Global Environment Facility, UNDP, and UNEP to assist countries in: (1) conducting transboundary diagnostic analayses that would identify priority transboundary productivity, and environmental concerns; (2) developing a Strategic Action Programme (SAP) to address high priority assessment, monitoring, and management actions; and (3) implementing use of science-based technologies and innovations in these activities.

A principal objective of the World Bank/GEF financial support for implementing an LME-oriented Strategic Action Programme is to aid countries bordering an LME to achieve long-term socio-economic benefit from the shared ecosystem resources, in accordance with the UNCED declaration on the oceans. This recommends that nations: (1) prevent, reduce, and control degradation of the marine environment, so as to maintain and improve its life-support and productive capacities; (2) develop and increase the potential of marine living resources to meet human nutritional needs, and other socio-economic goals; and (3) promote the integrated management and sustainable development of coastal areas and marine environment. Within the context of the UNCED oceans declaration, the GEF Operational Guidelines note the importance of measures to ensure biodiversity protection (GEF, 1996).

The GEF has included Large Marine Ecosystems as a focus for funding proposals under the International Waters Programme. Interest is growing among coastal countries in Asia and Africa in developing LME projects within this programme. Countries participating in the Gulf of Guinea GEF project are Benin, Cameroon, Côte d'Ivoire, Ghana and Nigeria. Other countries in the advanced planning stage of LME projects include: Kenya and Tanzania, focusing on the Somali Coastal Current LME; Angola, Namibia and South Africa (Benguela Current LME); China and South Korea (Yellow Sea LME); Bangladesh, India, Indonesia, Malaysia, Maldives, Sri Lanka, Thailand (Bay of Bengal LME).

# REGIONAL ACCOUNTS

The first section below is intended to give a short comparative review of some of the data presented in the subsequent regional accounts. The next section provides information on sources and data quality and coverage; this is followed by a series of standardised accounts of each Regional Sea.

## REVIEW OF REGIONAL DATA

**Congruence of areas defined for different purposes**

If Large Marine Ecosystem units were congruent with areas under the jurisdiction of individual countries or areas subject to international agreements negotiated by countries, and with statistical areas for reporting of marine fishery catches, the planning and implementation of integrated management would be in principle straightforward, insofar as it is technically possible. The extent of mismatch between these geographic areas must be a major determinant of the difficulty involved in effecting such management. It may be instructive to examine the extent of congruence and mismatch, taking the political framework of the Regional Seas areas as the primary reference, because all management procedures are ultimately undertaken by countries participating in such a framework or acting independently at national level.

There is complete or near complete congruence between Regional Seas, LMEs and FAO areas in only five of the 19 regions.

The Black Sea and Mediterranean areas, numbered 1 and 2 respectively in this document, are entirely congruent with the Black Sea and Mediterranean LMEs, numbered 26 and 25 respectively in Map 2. Fisheries in both areas together are jointly reported as FAO area 37. The Southeast Pacific overlaps with the Humboldt Current LME, #13 and with FAO fishery area #87. Antarctica (not a UNEP Regional Sea), corresponds with the Antarctic LME, #49, and FAO areas 48, 58, and 88. The very large South Pacific region includes LMEs 11, 39 and 40; Insular Pacific-Hawaii, Great Barrier Reef and New Zealand Shelf, respectively. The region includes large parts of three FAO fishery areas.

Nine of the remaining Regional Seas include entire LMEs and parts of other LMEs shared with adjacent Regional Seas areas. The Northwest Pacific and North Atlantic (not a formal Regional Seas area) are particularly complex; these include, respectively, ten and six LMEs and share four and two others.

Four of the remaining areas include only LMEs shared with other regions; the Southwest Australia region (not a UNEP Regional Sea) does not include a defined LME.

Considering only the extent to which UNEP Regional Seas correspond with Large Marine Ecosystems, and ignoring other relevant international agreements, and the innumerable other factors involved, it might be expected that ecosystem-based planning has highest likelihood of success in the Black Sea, Mediterranean, Southeast Pacific, South Pacific and Antarctica. At the other extreme are those regions that do not include an entire LME within their boundaries: South Africa, Kuwait, South Asia, Arctic. The first and last of these are not UNEP Regional Seas areas; the first-named included the inshore marine waters of a single nation. The present damaged state of the Black Sea ecosystem, where a Regional Sea area and associated Convention corresponds with an entire LME, gives little cause for optimism in more complex cases.

**Table 8** Congruence between Regional Seas areas, LMEs and FAO fishery areas

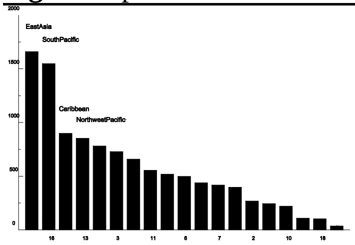
| Regional Seas area | Large Marine Ecosystem | FAO fishing area |
|---|---|---|
| **1** Black Sea | 26 | (37) |
| **2** Mediterranean | 25 | (37) |
| **3** North Atlantic* | 6, 7, 8, 9, (10), (17), 18, (19), 20, 21, 23, 24, (27), 48 | 21, 27, (34) |
| **4** Caribbean | 5, (6), 12, (16) | 31 |
| **5** Southwest Atlantic | 14, 15, (16) | 41 |
| **6** West & Central Africa | (27), 28, (29) | (34, 47) |
| **7** South Africa* | (29, 30) | (47, 51) |
| **8** East Africa | (30), 31 | (51) |
| **9** Red Sea & Gulf of Aden | (32), 33 | (51) |
| **10** Kuwait | (32) | (51) |
| **11** South Asia | (32, 34) | (51, 57) |
| **12** East Asian Seas | (34), 35, 36, 37, 38 | (57, 61, 71) |
| **13** Northwest Pacific | (1), 41, 42, 43, 44, 45, 46, (47) | (61) |
| **14** Northeast Pacific* | (1), 2, 3, 4 | 67, (77) |
| **15** Southeast Pacific | 13 | 87 |
| **16** South Pacific | 11, 39, 40 | (71, 77, 81) |
| **17** Southwest Australia* | - | (57) |
| **18** Antarctica* | 49 | 48, 58, 88 |
| **19** Arctic* | (10, 17, 19) | 18, (27) |

Notes: An asterisk indicates areas defined for the purpose of this document that are not components of the UNEP Regional Seas programme. Numbers in the LME column refer to areas identified in Map 2; numbers in the FAO column are the standard codes for statistical fishery areas (see Annex II). Numbers in parentheses ( ) indicate areas shared between more than one Regional Seas area.

## Biodiversity in UNEP Regional Seas Areas

Biodiversity data tabulated and briefly discussed in each regional account below vary in quality and refer to a limited number of groups of organisms. Nevertheless, they are reasonably sound overall and cover a wide range of groups (in terms of body size, systematic position and ecological rôle), and so may be taken as indicative of general levels of biodiversity in each Regional Seas area. These data refer to absolute levels of species richness, which is the parameter of interest in the present context. Within broad latitude bands, the values, as might be expected, tend to be positively correlated with the area of each region.

**Figure 6**Species richness and endemism in groups assessed in Regional Seas areas




Notes: Black = endemic species, grey tone = non-endemic species. Y axis shows numbers of species. X axis refers to regions as follows: **1** Black Sea, **2** Mediterranean, **3** North Atlantic, **4** Caribbean, **5** Southwest Atlantic, **6** West & Central Africa, **7** South Africa, **8** East Africa, **9** Red Sea & Gulf of Aden, **10** Kuwait, **11** South Asia, **12** East Asian Seas, **13** Northwest Pacific, **14** Northeast Pacific, **15** Southeast Pacific, **16** South Pacific, **17** Southwest Australia, **18** Antarctica, **19** Arctic. Bar graph refers only to groups assessed in this document.

Two regions stand out as being particularly rich in species: East Asian Seas and South Pacific. The Caribbean and Northwest Pacific head the remaining regions, but overall these last show a steady decrease in total species number. Consideration of additional groups would probably change the sequence of regions in terms of overall species richness, but it appears likely that the East Asian Seas region would continue to support the highest number.

The East Asian Seas region has the most species overall (in the groups covered here): it has more corals (assessed at generic level), molluscs, shrimps, lobsters and sharks. The South Pacific has most seagrass species, and by far the most seabird species, has jointly with the Southwest Atlantic the most cetaceans, and has the second-highest totals of molluscs, lobsters and sharks. The Caribbean and Northwest Pacific have generally high numbers of species in most groups.

Regions with the highest species totals are not always those with the most endemic species. The South Pacific has the most regionally-endemic molluscs and lobsters, by far the most endemic seabirds (corresponding with maximum seabird species), and, with East Asia, has the equal highest count of endemic sharks. The Caribbean region is generally rich in endemic species: the region has most endemic coral genera, the second highest number of endemic lobsters and of sharks. The Northwest Pacific has, with Southwest Australia, equal highest number of endemic seagrasses and a good number of endemic lobsters. Three regions bordering the Pacific Ocean each have remarkably high counts of endemic seabirds, in descending order: South Pacific, Southeast Pacific and Northeast Pacific. The last two regions each have two endemic pinnipeds, surpassed only by Antarctica, which has four. Antarctica also has the fourth highest number of endemic seabirds (and a high total seabird species count).

**Figure 7** Species richness and endemism in selected groups in Regional Seas areas

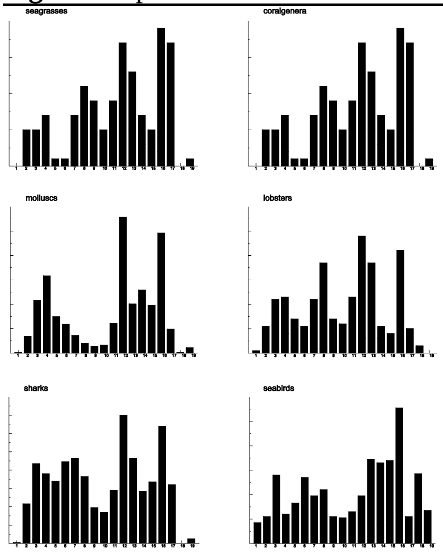
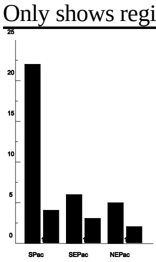



**Figure 8** Globally-threatened species endemic to Regional Seas areas in groups assessed in this document. Grey tone = seabirds. Black = marine mammals. Only shows regions with >2 threatened species in group.




Notes: Black = endemic species, grey tone = non-endemic species. Y axis shows relative numbers of species. X axis refers to regions as follows: **1** Black Sea, **2** Mediterranean, **3** North Atlantic, **4** Caribbean, **5** Southwest Atlantic, **6** West & Central Africa, **7** South Africa, **8** East Africa, **9** Red Sea & Gulf of Aden, **10** Kuwait, **11** South Asia, **12** East Asian Seas,

**13** Northwest Pacific, **14** Northeast Pacific, **15** Southeast Pacific, **16** South Pacific, **17** Southwest Australia, **18** Antarctica, **19** Arctic. Bar graph refers only to groups assessed in this document.

The same three regions with most endemic seabirds (South Pacific, Southeast Pacific and Northeast Pacific) also have the highest number of endemic seabirds categorised as globally-threatened, and as with total seabird species, the South Pacific has by far the most: 22, followed by six and five. These same regions, in the same sequence, have most threatened cetaceans and pinnipeds (the absolute numbers are relatively low: four, three, two).

The conservation status of most of the species tabulated above as endemic to the various regions has not been assessed, and nor in many cases is their detailed distribution within a region well-known; these qualifications apply in particular to the invertebrate animals. No attempt has been made, at the scale of this analysis, to collate information on species that are threatened within a region but not globally, or which are threatened globally and occur within more than one region (eg. cetaceans).

Regions bordering the Pacific Ocean tend overall to be among the most species-rich, and to have high numbers of endemics. Whilst the preliminary and indicative nature of these assessments should be noted, at a macro scale these findings clearly point to regions where action to maintain overall levels of biodiversity should be pursued.

## NOTES AND SOURCES

As outlined in the Introduction, the intention of this document is to present thematic information in a format that begins to meet the need for an integrated and regional approach to biodiversity assessment and planning in the marine sphere.

The remaining part of the report consists of a region by region presentation of information on different themes central to marine biodiversity management. The regional framework adopted is based on the UNEP Regional Seas programme. Within each regional setting we have assembled information on Large Marine Ecosystems, biodiversity and fisheries issues.

Map 1 shows the approximate geographic area covered by each Regional Seas agreement (note that this is not an official UNEP representation of these areas and it implies no expression of opinion in respect of national boundaries). The map distinguishes those regions to which a formal Convention applies from those without a formal agreement. A number of countries or regions are either not associated with a UNEP Regional Sea or have parts of the coast thus associated, but not all parts (eg. Australia). Such areas outside the present Regional Seas framework have been here defined as 'regions' for the purposes of this document, and are also indicated on the map. The regions so defined are: North Atlantic, South Africa, Northeast Pacific, Southwest Australia. The map does not represent the Arctic and Antarctic regions used herein and which also are not formally part of the Regional Seas programme.

### Geopolitical coverage

The scope of each region has been indicated by the list of countries or territories under the main heading of each regional account. Names in **bold** indicate countries or territories participating in the UNEP Regional Seas programme for that region. If in bold and italics (eg. ***Mexico***) the country has different coastlines bordering two different Regional Seas region; if in bold but not italicized (eg. **Kenya**), the country is involved in a single region. Names in plain font are countries not at present participating in the Regional Seas programme, or countries within the regions defined solely for this document.

## Large Marine Ecosystems

The map included in this document (Map 2) has been produced with permission from generalised published maps (eg. Sherman, 1994; Sherman and Busch, 1995) and the descriptions have been compiled from these sources and from draft descriptive text kindly made available by Kenneth Sherman. The boundaries of LMEs cannot always be precisely defined, and this map is for guidance only.

## Biodiversity

With some exceptions, the fauna and flora of the coastal and marine regions discussed in this document remain very incompletely known. Our intention here has been to collate or assemble global datasets that can together provide a useful and coherent indication of comparative biodiversity at the regional level. The values given for species richness and endemism in the regional accounts that follow must be taken as approximations. No attempt has been made to collate biodiversity data that refer only to a locality or region but that are incomplete at global level and so not immediately of use for comparative purposes.

**Seagrasses** Information collated from Phillips and Meñez (1988).

**Coral genera** Data derived from maps in Veron (1993), these refer to reef-building (hermatypic) corals at the generic level.

**Molluscs** The data refer to marine mollusc species, primarily coastal and shallow-water marine forms in the classes Gastropoda and Bivalvia, that produce shells of commercial and scientific interest. This sample constitutes around 15% of all the marine species in these classes, but a far higher proportion of the continental shelf species that are of significant size.

**Shrimps and prawns** The data cover species traditionally placed in the decapod suborder Natantia (shrimps and prawns) which are of interest to fisheries, being either used for human consumption, as bait or for processing, or which might have potential commercial value. All figures were derived from information in Holthius (1980).

**Lobsters** The data cover species traditionally placed in the decapod suborder Reptantia (including Astacidea, marine lobsters and freshwater crayfish; Palinuridea, spiny lobsters; Thalassinidea, mud lobsters) which are of interest to fisheries, being either used for human consumption, as bait or for processing, or which might have potential commercial value. All figures were derived from information in Holthius (1991).

**Sharks** Data collated from maps and text in Compagno (1984a, 1984b). Information on endemic species in the three regional sea areas around Australia has been revised according to Last and Stevens (1994); the information on total shark species in these areas has not been harmonised with Compagno (1984a, 1984b).

**Seabirds** The birds treated here as seabirds are those listed by Croxall *et al.* (1984) and Croxall (1991). Taxonomy follows Sibley and Monroe (1990 & 1993). These accounts have been supplemented by numerous national and regional checklists. The data tables refer to species breeding in the region.

**Marine mammals** Data principally from Reijnders *et al.* (1993) and Jefferson *et al*. (1993).

**Fisheries**

Information principally from publications of the UN Food and Agriculture Organization, including FAO 1995a, 1995b.

# EAST AFRICA

**Comoros, Kenya, Madagascar, Mozambique, Réunion and dependencies** (to France), **Seychelles, Somalia, Tanzania,** Mauritius, Mayotte (to France)

## LARGE MARINE ECOSYSTEMS

The mainland sector of the East Africa Regional Seas area includes all of the Somali Coastal Current LME and much of the Agulhas Current LME.

### Somali Coastal Current

This LME, extending over some 50 million km$^2$, is one of the world's largest. It is based on the Somali Current - a typical Western Boundary Current (a surface current along an eastern continental margin). The South Equatorial Current flows from east to west throughout the year; on approaching the east coast of Africa it divides into the north-flowing East Africa Coastal Current and the south-flowing Mozambique Current. During the southern monsoon (April-October), the northern sector of the East Africa Coastal Current (the Somali Current) continues to flow north at speeds up to 7 knots. This flow, combined with strong offshore winds generates major upwelling of cold waters along the northern Somali coast (the Ras Hafun upwelling). During the northern monsoon (November-March) the Somali Current reverses to flow southward. The phenomena of upwelling and seasonal current reversal are associated with high fishery productivity.

### Agulhas Current

This major Western Boundary Current is a product of the Mozambique Current (see above) flowing south between Madagascar and mainland Africa, and the Madagascar Current, flowing south down the eastern coast of Madagascar. The Agulhas Current is fast and warm (rarely below 21°C), and flows south throughout the year. It appears to be less productive than eg. the Somali Current system but has high fish diversity. South Africa is not within the Eastern Africa Regional Seas area, but its entire east coast is subject to the effects of the Agulhas Current.

## BIODIVERSITY

**East Africa Regional Sea: biodiversity data**

| | endemic | T | % | | endemic | T | % |
|---|---|---|---|---|---|---|---|
| seagrasses | 0 | 11 | 23 | sharks | 3 | 73 | 21 |
| coral genera | 0 | 63 | 57 | seabirds | 2 | 44 | 15 |
| molluscs | 0 | 80 | 2 | cetaceans | 0 | 27 | 35 |
| shrimps | 0 | 54 | 16 | sirenians | 0 | 1 | 25 |
| lobsters | 2 | 37 | 25 | pinnipeds | - | 0 | - |

Notes: the data refer to species except for coral genera. Column headings: endemic = restricted to the region; T = total species richness in the region; % = species richness in the region as a percentage of the world species richness in each group of organism. A dash (-) in a cell means no data or not applicable. See **Notes and Sources** in the introductory text for further information on the sources, coverage and quality of the data tabulated.

**East Africa Regional Sea: regional endemic species**

| | scientific name | common name | status |
|---|---|---|---|
| lobsters | *Nephropsis malhaensis* | Saya de Malha lobsterette | |
| | *Palinustus mossambicus* | Buffalo blunthorn lobster | |
| sharks | *Chiloscyllium caerulopunctatum* | Bluespotted bambooshark | |
| | *Ctenacis fehlmanni* | Harlequin catshark | |
| | *Ginglymostoma brevicaudatum* | Short-tail nurse shark | |
| seabirds | *Pseudobulweria aterrima* | Mascarene petrel | CR |
| | *Pterodroma baraui* | Barau's petrel | CR |

Notes: letters in the 'status' column indicate the conservation status of species that have been assessed and classified as threatened. In the revised IUCN Red List category system the term 'threatened' refers only to species in any of the following three categories: CR - Critically Endangered, EN - Endangered, VU - Vulnerable. Seabirds have been assessed by BirdLife International, Collar *et al*. (1994); all status categories are recorded in IUCN (1996).

### Biodiversity Notes

**Seagrasses** are diverse, with nearly a quarter of the world's species present in the region, although again none is endemic. Generic diversity of **hermatypic corals** is high, although there are no endemic genera. Diversity among **molluscs** and **shrimps** is low, but moderate in **lobsters**, with two regional endemic species.

From available information, there is a diverse **shark** fauna (although less diverse than in adjacent South Africa) with three species apparently endemic. Five **marine turtle** species nest in the region: the Green Turtle *Chelonia mydas*, Loggerhead *Caretta caretta*, Hawksbill *Eretmochelys imbricata*, Olive Ridley *Lepidochelys olivacea* and Leatherback *Dermochelys olivacea*. Nesting populations in general are poorly known but generally not suspected to be of major importance except in the case of Green Turtles on Europa and Tromelin. **Seabirds** are moderately diverse; two critically endangered species: the Mascarene Black Petrel *Pseudobulweria* (or *Pterodroma*) *aterrima*, known only from Réunion and from subfossil remains on Rodrigues (Mauritius) and Barau's Petrel *Pterodroma baraui*, of which a population of somewhere between 1,500 and 3,000 pairs survives on Réunion.

There are no **pinnipeds** resident in the region; amongst **sirenians,** significant populations of the widespread but vulnerable Dugong *Dugong dugon* survive.

## FISHERIES

The region comprises the southern part of FAO Statistical Area 51. Annual recorded landings by the countries in the region have been around 220,000 tonnes since 1990, having grown steadily from around 130,000 tonnes in 1983. A substantial proportion of the catch here is by artisanal fishers for subsistence purposes and goes largely unrecorded. Nevertheless, overall catch here is undoubtedly still very low compared with other parts of the world and comprises an insignificant proportion of the world total. Of recorded catch, Madagascar accounts for something over one third (70,000-80,000 tonnes annually), with Tanzania and Mozambique together accounting for a further 40% or so. Much of the catch comprises demersal species and shrimps.

Some fisheries in the area are believed fully fished or overexploited. These include the demersal trawl fishery off Somalia, the shallow water shrimp fishery off Mozambique and Madagascar and the handline fishery for demersal stocks on offshore banks between Mauritius and Madagascar. It is believed that more effective management of the shrimp fishery could lead to harvests being maintained with a 75% reduction in fishing effort. There may be opportunities for increased finfish catches in the region, notably in small pelagic stocks off Mozambique and Somalia, demersal trawl fishes off Mozambique, Madagsacar and Tanzania, increased utilisation of by-catch from shrimp trawlers and some further expansion of artisanal fisheries off Madagascar and Somalia. However, lack of reporting from subsistence fisheries means that exploitation of demersals in particular may be higher than catch statistics imply, so that opportunities for expansion are more limited than appears.

Overall, there is an urgent need for improved data collection on fish stocks and fisheries in much of the region to allow for rational development of fisheries.

# RED SEA AND GULF OF ADEN

***Egypt*, Eritrea, Jordan, *Saudi Arabia*, Somalia, Sudan, Yemen,** Djibouti,

**ContainsDatafor PostscriptOnly.**

## LARGE MARINE ECOSYSTEMS

This region includes the Red Sea LME and, separated by the straits at Bab el Mandeb, the Gulf of Aden, which is not part of an identified LME.

### Red Sea

The Red Sea is located in an arid tropical zone; it is highly-enclosed, has no permanent riverine inputs, and is the warmest and most saline of the world's seas. The Red Sea is around 2,000 km long and up to 280 km wide, with a mean depth of 500 m and maximum of 2,000 m. It is unique among deep bodies of water in having stable warm temperatures throughout its deeper waters (a near constant 21°C below about 300m depth). These temperatures are largely maintained through a density-driven water circulation in which warm waters from the Gulf of Suez sink and flow steadily southwards. Very high rates of evaporation (1-2 m per year) and low freshwater input (10 mm per year) lead to a considerable net inflow of water into the Red Sea from the Gulf of Aden. Although at depth there is a constant outflow of dense and more saline waters, surface currents are more complex and show a distinct seasonality. Tides are not a major feature in the Red Sea, they show an oscillatory pattern, with central portions being almost tideless and the tides at the northern and southern regions barely reaching 1 m amplitude during spring tides.

The Red Sea was formed some 70 million years ago and has been subjected to numerous changes in condition as it broke and re-established links between the Mediterranean and the Indian Ocean, particularly during the recent ice ages, causing considerable changes in sea levels and salinity. The current rich species assemblage is thought to have originated from the Indian Ocean probably only around 10,000 years ago.

The surface waters of the Gulf of Aden have lower salinity and generally lower temperatures than those of the Red Sea. Towards the mouth of the Gulf of Aden and around the island of Socotra the pattern of ocean currents is complex, affected by seasonal monsoonal systems from the east and southwest, and, importantly from a cold-water upwelling in the northern Arabian Sea.

Coral reefs are perhaps the best known habitat in the region and occur in all areas, particularly the northern Red Sea. Coral reef development is more restricted in the Gulf of Aden, particularly in the areas affected by the cool water upwellings; although corals occur they have not developed into true reef systems. In parts of the Gulf of Aden, hard substrates are dominated by kelp communities. Other habitat types include seagrass beds, limited mangrove communities, saltmarshes and saltflats (*sabkhas*, often seasonally rather than tidally inundated).

## BIODIVERSITY

### Red Sea Regional Sea: biodiversity data

| | endemic | T | % | | endemic | T | % |
|---|---|---|---|---|---|---|---|
| seagrasses | 0 | 11 | 23 | sharks | 0 | 39 | 11 |
| coral genera | 1 | 53 | 49 | seabirds | 0 | 22 | 8 |
| molluscs | 0 | 57 | 1 | cetaceans | 0 | 25 | 28 |
| shrimps | 0 | 24 | 7 | sirenians | 0 | 1 | 25 |
| lobsters | 0 | 14 | 9 | pinnipeds | - | 0 | - |

Notes: the data refer to species except for coral genera. Column headings: endemic = restricted to the region; T = total species richness in the region; % = species richness in the region as a percentage of the world species richness in each group of organism. A dash (-) in a cell means no data or not applicable. See **Notes and Sources** in the introductory text for further information on the sources, coverage and quality of the data tabulated.

### Biodiversity Notes

**Seagrass** diversity is relatively high compared to surrounding areas of the Arabian Sea and the Gulf, although there are no recorded endemics. The diversity of **mangroves** is very low because of the very demanding temperature and salinity levels. One of the four species recorded, *Bruguiera gymnorhiza* may no longer be present.

At the generic level, **corals** of the Red Sea represent an important westward extension of high diversity in the Indo-Pacific region. Endemism among Red Sea corals, around 6% of the species, is not high; endemism stands at around 17% for Arabia together with the western Indian Ocean. One genus is reportedly endemic to the Red Sea.

Data for other marine invertebrates are more limited: about 170 echinoderm species have been recorded, with rates of endemism at about 7%; around 1,000 species of mollusc are recorded from the Arabian region as a whole, although endemism in this group is lower; a survey of polychaetes in the northern Red Sea listed some 250 species from 136 genera, although the total for this group is likely to be much higher. The data sources reviewed here indicate low diversity in **molluscs, shrimps** and **lobsters** in the Red Sea region.

About 1,000 fish species have been recorded from the Red Sea (including non-reef fishes). This is about one-third of the total present in the region of maximum fish diversity (Indonesia-Philippines), and therefore highly significant. Endemism is also high; around 17% for fishes overall, and much higher within some families.

Three species of **marine turtle** are known to nest in the region: the Green Turtle *Chelonia mydas*, Hawksbill *Eretmochelys imbricata* and Leatherback *Dermochelys coriacea*. There are, however, believed to be major concentrations of both Green Turtle and Hawksbill.

**Shark**, **seabird** and **cetacean** diversity are all relatively low, with no endemic species. There are no

**pinnipeds** but one species of **sirenian** the Dugong *Dugong dugon* is present.

## FISHERIES

From a global perspective, fisheries in the Red Sea and Gulf of Aden are insignificant, amounting to an estimated 160,000 tonnes or so per year (Sanders and Morgan, 1989). For most of the countries in the region, however, they provide an important source of fish, and often the only source.

Most of the landings are made by small scale, artisanal fishermen exploiting inshore coastal waters, typically these are multispecies fisheries associated with the coral reefs.  Some large scale industrial fishing is undertaken, for example by Yemen. Inshore stocks are intensively exploited in some areas and in these areas there is believed to be little room for expansion. Extensive areas of upwelling in the Gulf of Aden have given rise to a high biomass of small pelagics and mesopelagic species, which are currently very little exploited compared with potential yields. Mesopelagic stock is described in more detail under the South Asian Seas.

Generally, increased exploitation in the region is dependent on expansion into new fishing areas. This will entail the use of more advanced fishing methods. Exploitation of the mesopelagic stock, which remains little known at present, is currently not considered economically or technically viable.

Much attention has been given to fisheries development in Eritrea since independence. At the end of the protracted war of independence, fishing capacity was low because of destruction and deterioration of vessels and infrastructure. Agreements are being negotiated with a number of countries seeking access to Eritrean waters.

**ANNEX I. The role of UNEP in Conservation of Marine Biodiversity**

The overall coordination of UNEP's programme for the management and conservation of marine biodiversity has been a responsibility of the Oceans and Coastal Areas Programme Activity Centre (OCA/PAC). The Oceans and Coastal Areas Programme was action-oriented and focused not only on mitigation but also on the causes of environmental degradation. It was created as a global programme that is implemented through regional components as represented by the Regional Seas Programmes. Changes to the Programme Division of UNEP during 1996 have resulted in formation of a Water Unit that combines the functions of OCA/PAC and the freshwater section.

**The Regional Seas Programme**

The Regional Seas Programme was launched by UNEP in 1974. At present it includes twelve regional action plans and has over 140 coastal States participating in it.

The regions presently covered are: Mediterranean; West and Central Africa; Caribbean; East Asia; Eastern Africa; South Asia; Black Sea; North-west Pacific; Kuwait; South-east Pacific; Red Sea and Gulf of Aden; South Pacific. Action plans have been prepared for all regions except the Black Sea and North-west Pacific where they are under development.

The Water Unit provides the secretariat functions for all regional seas action plans except the Kuwait Action Plan, South-east Pacific Action Plan, Red Sea and Gulf of Aden Action Plan and South Pacific Action Plan.

The activities in each programme are wide in nature and are carried out in cooperation with many partners including UN agencies, intergovernmental and non-governmental organizations. The focus of the oceans and coastal activities within the Water Unit are both regional and inter-regional, as follows:

(a) **Integrated Coastal Area Management**, as a framework within which coastal and marine areas should be managed. Current and planned activities within this focal area include: the development of tools and guidelines, and national strategies and plans; the conduct of regional and national training programmes and workshops; and the implementation of pilot projects in integrated management. The 1996/97 UNEP Work Programme will specifically promote cooperation and integration in the management of coastal and marine areas and associated river basins, and the special needs of small island developing States.

(b) **Protection of the marine environment from land-based activities**. Current and planned activities within this focal area include: the development of national and regional strategic programmes which include river basin management; capacity building for governments and national environmental authorities in the prevention and control of coastal degradation; and the assessment of pollutant loads and establishment of monitoring programmes for the protection of the marine environment. The 1996/97 UNEP Work Programme will specifically promote implementation of the Global Programme of Action for the Protection of the Marine Environment from Land-Based Activities. The special needs of small island developing States will be specifically addressed.

(c) **Protection and management of marine living resources**. Many of the activities that are undertaken under this focal area are directly related to the management and conservation of marine biodiversity and are an integral part of UNEP's contribution to the implementation of the Convention on Biological Diversity. Recognizing FAO's role and mandate, UNEP has concentrated on species and ecosystems not commercially exploited. The 1996/97 UNEP Work

Programme will specifically promote implementation of Regional Seas Protocols on Specially Protected Areas and Wildlife (SPAW), International Coral Reef Initiative and Marine Mammal Action Plan. Current and planned activities within this focal area are detailed below.

**Regional Seas Protocols on Specially Protected Areas and Wildlife (SPAW)**

The Regional Seas Protocols concerning Specially Protected Areas and Wildlife (SPAW) have been adopted by the parties to four Regional Seas Conventions (Mediterranean, Caribbean, South-East Pacific and East Africa). In each region the Protocol differs and may or not contain listing of species included in the Protocol. In addition, as a consequence of the adoption of the Protocols specific Action Plans or Programmes have been formulated and institutional frameworks developed in the form of Regional Activities Centres. In 1993, governments in the Wider Caribbean region recognized and agreed that the SPAW Protocol is an appropriate mechanism to assist with the implementation of the Convention on Biological Diversity in relation to the marine environment.

A Regional Activity Centre (RAC/SPA) has been established in Tunis in 1985 to oversee the implementation of the Protocol in the Mediterranean and a similar RAC is in the final planning stages for the Caribbean. The long term objective of the Tunis RAC/SPA is to "help promote the development of a network of Mediterranean marine and coastal protected areas through the implementation of the Protocol concerning Mediterranean Specially Protected Areas... and to help promote the protection of endangered species and the conservation of biological diversity in the Mediterranean through the implementation of the Protocol and adopted Action Plans...". The development of these programmes are at different stages in each region and how they are structured and function differ in accordance with the needs of governments of the region.

The programme in the Caribbean includes the development of common guidelines for identification, establishment and management of coastal and marine protected areas and implementation of management plans for endangered species such as marine mammals and sea turtles, with ecotourism guidelines. Marine pollution programmes are also promoting conservation of biodiversity through assessment of the effect of pollutants, such as in site-specific studies of damaged ecosystems (sea grass beds and coral reefs). In the Mediterranean, additional protected areas of biological and environmental interest were established and the number of sites increased from 74, mentioned in the Directory of Specially Protected Areas in the Mediterranean, to 128 sites. In the South-east Pacific, the preparation of National Marine Biodiversity studies in order to identify marine ecosystems with high levels of biodiversity is being planned as the basis for the creation of new marine protected areas.

**International Coral Reef Initiative (ICRI)**

In recognition of the importance of coral reefs and associated ecosystems to the sustainable development and well-being of human populations worldwide, particularly coastal communities, and their significance to global marine biodiversity, UNEP is giving priority assistance to the implementation of ICRI now and in the 1996/97 Work Programme. UNEP is giving support to six regional workshops corresponding to the Caribbean, East Asia, Red Sea/Middle East, South Asia, South Pacific and Western Indian Ocean/Eastern African regions. A goal of each workshop is to develop a regional policy framework and programme of action for the protection and management of coral reefs and associated ecosystems (ie. mangrove forests and seagrass beds), including a strategy for its implementation which would be adopted by governments of the region.

Other current or planned activities in support of the ICRI include: (a) national and regional reviews of the status and threats to coastal ecosystems; (b) development and regional agreement on methodologies for the rapid assessment of coral reefs for the management of coastal ecosystems; (c) development of a global framework for the protection, restoration and sustainable use of coral reefs and associated ecosystems; and (d) support to the International Coral Reef Symposium.

**Marine Mammal Action Plan (MMAP)**

The MMAP was developed between 1978 and 1983 jointly by UNEP and FAO, in collaboration with other international organizations concerned with marine mammal issues, and was adopted by UNEP in 1984. The basic objective of the plan is to promote the effective implementation of a policy for conservation, management and utilization of marine mammals which would be widely accepted by governments and the public. The MMAP is built around five concentration areas, namely, policy formulation, regulatory and protective measures, improvement of scientific knowledge, improvement of law and its application and enhancement of public understanding. As envisaged by the Plan, major international agencies concerned with marine mammals were invited to join in a Planning and Co-ordinating Committee (PCC), composed of both intergovernmental (UNEP, FAO, IOC/UNESCO and IATTC) and nongovernmental organizations (IUCN, WWF, Greenpeace and IFAW) through which they co-ordinate their work in this field. UNEP has assigned a Secretary to the Action Plan since 1985.

The 1996/97 work programme include the completion and adoption of a re-focused updated Action Plan to deal with new issues of importance since the MMAP was formulated. It will also include training courses and workshops on biology and survey methodologies, publication of awareness materials and field projects on the status of several marine mammal species.

**Other activities relevant to marine biodiversity**:

UNEP is also engaged in a wide range of other activities which have bearing on the maintenance of marine diversity including:

(a) Developing guidelines for Integrated Coastal Area Management (ICAM).

(b) Developing guidelines for the selection, establishment and management of Coastal and Marine Specially Protected Areas.

(c) Assisting in the establishment of regional management plans for threatened species (sea turtles and/or marine mammals) in the Wider Caribbean, South-East Pacific, and Mediterranean.

(d) Developing methodologies for assessment of the biological effects of marine pollution, and providing guidelines and manuals on quality assurance, quality control and good laboratory practices.

(e) Fostering assessment in the Wider Caribbean of the effect of pollutants, such as in site-specific studies of damaged ecosystems, ie. sea grass beds and coral reefs.

(f) Preparing monographs on coastal and marine protected areas of the South-East Pacific with FAO funding.

(g) Elaboration of national marine biodiversity studies in order to identify marine ecosystems of high biodiversity are also under way in the South-East Pacific.

## ANNEX II. FAO Fishery Areas

| FAO Code | FAO designation | Designation used in this report |
|---|---|---|
| Atlantic Ocean and adjacent seas | | |
| 18 | Arctic Sea | |
| 21 | Atlantic, Northwest | Northwest Atlantic |
| 27 | Atlantic, Northeast | Northeast Atlantic |
| 31 | Atlantic, Western Central | Western Central Atlantic |
| 34 | Atlantic, Eastern Central | Eastern Central Atlantic |
| 37 | Mediterranean and Black Sea | Mediterranean, Black Sea |
| 41 | Atlantic, Southwest | Southwest Atlantic |
| 47 | Atlantic, Southeast | Southeast Atlantic |
| Indian Ocean and adjacent seas | | |
| 51 | Indian Ocean, Western | Western Indian Ocean |
| 57 | Indian Ocean, Eastern | Eastern Indian Ocean |
| Pacific Ocean and adjacent seas | | |
| 61 | Pacific, Northwest | Northwest Pacific |
| 67 | Pacific, Northeast | Northeast Pacific |
| 71 | Pacific, Western Central | Western Central Pacific |
| 77 | Pacific, Eastern Central | Eastern Central Pacific |
| 81 | Pacific, Southwest | Southwest Pacific |
| 87 | Pacific, Southeast | Southeast Pacific |
| Southern ocean and adjacent seas | | |
| 48 | Atlantic, Antarctic | Antarctic |
| 58 | Indian Ocean, Antarctic | Antarctic |
| 88 | Pacific, Antarctic | Antarctic |

**ANNEX III. Acronyms**

| | |
|---|---|
| AAAS | American Association for the Advancement of Sciences |
| ACC | Antarctic Circumpolar Current |
| CAFSAC | Canadian Atlantic Fisheries Scientific Advisory Committee |
| CBD | Convention on Biological Diversity |
| CBDMS | Committee on Biological Diversity in Marine Systems |
| CCSBT | Convention for the Conservation of Southern Bluefin Tuna |
| CCAMLR | Convention for the Conservation of Antarctic Marine Living Resources |
| CPPS | Permanent Commission for the Southeast Pacific |
| EEZ | Exclusive Economic Zone |
| ERS | Environment Assessment Programme |
| FAO | Food and Agriculture Organisation |
| GEF | Global Environment Facility |
| GIS | Geographical Information System |
| IATTC | Inter-American Tropical Tuna Commission |
| ICAM | Integrated Coastal Area Management |
| ICES | International Council for the Exploration of the Sea |
| ICRI | International Coral Reef Initiative |
| ICSEAF | International Commission for the Southeast Atlantic Fisheries |
| IFAW | International Federation Against Whaling |
| INFOTERRA | International Environment Information System |
| IOC | Intergovernmental Oceanographic Commission |
| IRPTC | International Register of Potentially Toxic Chemicals |
| LME | Large Marine Ecosystem |
| MBAL | Mimimum Biologically Acceptable Level |
| MMAP | Marine Mammal Action Plan |
| MPA | Marine Protected Area |
| MSVPA | MultiSpecies Virtual Population Analysis |
| NASCO | North Atlantic Salmon Conservation Organisation |
| NOAA | National Oceanic and Atmospheric Administration |
| NRC | National Research Council |
| NSQSR | North Sea Quality Status Report |
| PCC | Planning and Co-ordinating Committee |
| RAC/SPA | Regional Activity Centre/Specially Protected Areas |
| SAP | Strategic Action Programme |
| SBSTTA | Subsidiary Body on Scientific, Technical and Technological Advice |
| SEAFDC | SouthEast Asia Fisheries Development Centre |
| SPAW | Specially Protected Areas of Wildlife |
| TAC | Total Allowable Catch |
| TRAFFIC | Trade Records Analysis of Flora and Fauna in Commerce |
| UN | United Nations |
| UNCED | United Nations Conference on Environment and Development |
| UNCLOS | United Nations Convention of the Law of the Sea |
| UNEP | United Nations Environment Program |
| UNESCO | United Nations Educational Scientific and Cultural Organisation |
| WCMC | World Conservation Monitoring Centre |
| WWF | World Wide Fund for Nature |

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# ANTARCTICA

This marine region is not within an existing Regional Seas area and has been defined here for the purposes of this document.

## LARGE MARINE ECOSYSTEMS

There is only one LME defined within the Antarctic proper.

### Antarctic

The Antarctic LME is described as the marine area south of the Antarctic Convergence, a natural oceanographic boundary where the cold waters of the Antarctic continent meet the warmer sub-Antarctic waters situated between 48°S and 60°S.

The Antarctic Circumpolar Current (ACC) is the primary way by which water is exchanged between ocean basins. It therefore plays an essential role in the global thermohaline circulation, including redistribution of heat and salinity. After the Antarctic Convergence, the second major oceanographic feature is the Antarctic Divergence, close to the Antarctic continent at 65°S. This is associated with deeper water flowing southward and gradually rising, reaching the surface at the Divergence. This upwelling results in a great abundance of nutrients in the surface layer, and this is the basis for great phytoplankton growth during the southern spring and summer.

The Southern Ocean is circumpolar and a source of intermediate and deep water masses moving into the world ocean. One of the deepest water masses is the Antarctic Bottom Water. This is formed during the austral winter as a result of the sea water freezing. This process generates highly saline, dense, cold water that sinks and spreads northward (having been detected as far north as the North Atlantic). The formation and sinking of water masses results in a significant exchange in heat, freshwater, and gases, such as carbon dioxide, between the oceans and the atmosphere.

The continental shelf of the Antarctic is abnormally deep, with the continental shelf edge averaging 460 m deep, compared with an average 200 m depth for other continents. Two shelf patterns can be distinguished: facing the ocean, and the shelf around major embayments (such as the Ross Sea, Weddell Sea and Prydz Bay). The former are generally narrow, usually around 150 km; the latter are typically covered to a significant extent with permanent ice shelves.

Sea surface temperatures vary in the Antarctic. South of the Antarctic Divergence, water temperatures in summer reach 0°C, but during winter they are at minus 1.8°C, the freezing point for sea water. Between the Divergence and the Convergence, the temperature increases northwards to 4-5°C at the Convergence.

## BIODIVERSITY

The tables below include sub-Antarctic islands administered by Australia, France, South Africa, Norway, and the UK.

## Antarctic Regional Sea: biodiversity data

| | endemic | T | % | | endemic | T | % |
|---|---|---|---|---|---|---|---|
| seagrasses | - | 0 | - | sharks | - | 0 | - |
| coral genera | - | 0 | - | seabirds | 14 | 51 | 17 |
| molluscs | 0 | 7 | 0 | cetaceans | 1 | 13 | 15 |
| shrimps* | - | 0 | - | sirenians | - | 0 | - |
| lobsters | 2 | 3 | 2 | pinnipeds | 5 | 7 | 23 |

Notes: the data refer to species except for coral genera. Column headings: endemic = restricted to the region; T = total species richness in the region; % = species richness in the region as a percentage of the world species richness in each group of organism. A dash (-) in a cell means no data or not applicable. * Does not include krill (pelagic shrimp-like crustaceans in the order Euphausiacea), a group of special importance in Antarctic waters. See **Notes and Sources** in the introductory text for further information on the sources, coverage and quality of the data tabulated.

## Antarctic Regional Sea: regional endemic species

| | scientific name | common name | status |
|---|---|---|---|
| seabirds | *Aptenodytes forsteri* | Emperor penguin | |
| | *Catharacta maccormicki* | South polar skua | |
| | *Chionis alba* | Snowy sheathbill | |
| | *Chionis minor* | Lesser sheathbill | |
| | *Eudyptes schlegeli* | Royal penguin | |
| | *Fulmarus glacialoides* | Southern fulmar | |
| | *Pachyptila salvini* | Medium-billed prion | |
| | *Pagodroma nivea* | Lesser snow-petrel | |
| | *Phalacrocorax bransfieldensis* | Antarctic shag | |
| | *Phalacrocorax georgianus* | South Georgia shag | |
| | *Pygoscelis adeliae* | Adelie penguin | |
| | *Pygoscelis antarctica* | Chinstrap penguin | |
| | *Sterna virgata* | Kerguelen tern | VU |
| | *Thalassoica antarctica* | Antarctic petrel | |
| cetaceans | *Lagenorhynchus cruciger* | Hourglass dolphin | |
| pinnipeds | *Arctocephalus gazella* | Antarctic fur seal | |
| | *Hydrurga leptonyx* | Leopard seal | |
| | *Leptonychotes weddellii* | Weddell seal | |
| | *Lobodon carcinophagus* | Crabeater seal | |
| | *Ommatophoca rossii* | Ross seal | |

Notes: letters in the 'status' column indicate the conservation status of species that have been assessed and classified as threatened. In the revised IUCN Red List category system the term 'threatened' refers only to species in any of the following three categories: CR - Critically Endangered, EN - Endangered, VU - Vulnerable. Seabirds have been assessed by BirdLife International, Collar *et al*. (1994); all status categories are recorded in IUCN (1996).

**Biodiversity Notes**

There are no **hermatypic corals**, **seagrasses, marine turtles** or **sirenians** in the Antarctic. Diversity in **molluscs** and **lobsters** is very low, and an absence of **shrimp** (in the sense used here; see **Notes and Sources**).There is an absence of information on **sharks**. Recorded **cetacean** diversity is low, but **seabird** and **pinniped** diversity is high.

## FISHERIES

The Antarctic region comprises the whole of FAO Statistical Areas 48 (Southern Atlantic), 58 (Southern Indian Ocean) and 88 (Southern Pacific).

Fisheries in the Antarctic, entirely carried out by distant water fleets, have declined recently from around 400,000-500,000 tonnes annually from 1985-1990 to just over 90,000 tonnes in the 1992/1993 fishing season. The decline was attributed to a large decrease in fishing effort by distant water Russian and Ukrainian fleets. The major stock, and the major fishery, in the Antarctic region is krill, which comprised around 90% of the total catch by weight for the period 1989-90. Most of the catch is taken from around the islands of South Orkney and South Georgia in the Atlantic Sector.

Major catches of finfishes consist of lanternfishes (Myctophidae), mackerel icefish *Chamsocephalus gunnari* and Patagonian toothfish *Dissostichus eleginoides*. In the 1992/1993 season the only catches recorded south of 60°S were of the Patagonian toothfish, with a catch of just under 6000 tonnes.

Atlantic fisheries south of 60°S are managed by the Convention for Conservation of Antarctic Marine Living Resources (CCAMLR). CCAMLR is highly unusual amongst international regulatory bodies in that it has a statutory obligation to take into consideration ecosystem interactions in the management of marine resources. Thus, ecological relationships must be maintained between harvested resources and other species which are dependent on those resources; depleted populations must be managed to restore them to a level at which the greatest net annual biomass increment occurs. Any risk of changes that are not potentially reversible over two or three decades must be minimized.

To meet these objectives, precautionary approaches to fisheries management are adopted which may serve as models for management elsewhere. Because of these precautionary approaches, and because the annual net production of krill is believed to be low compared with its biomass, potential yields are much lower than might be thought from the very high biomass estimates (eg. around 30 million tonnes estimated in the Southern Atlantic). Similarly, finfish resources are limited and have too small a yield to sustain a high fishery. This is evinced by the past history of fisheries in the Southern Oceans, which is one of continual shifting from one overfished stock to another less exploited one.

Issues of concern at present include the by-catch of juvenile icefish and other species taken in the krill fishery and the regulation of fishing of straddling stocks (eg. of Patagonian toothfish) part of which lie immediately outside the region regulated by CCAMLR. There is currently no effective fisheries management policy for these stocks outside the CCAMLR area.

# ARCTIC

Canada; Finland; Greenland (to Denmark); Norway; Russia; USA

This marine region is not within an existing Regional Seas area and has been defined here for the purposes of this document.

## LARGE MARINE ECOSYSTEMS

There are two LMEs within the Arctic region: the Barents Sea LME and the Arctic Ocean LME

### Barents Sea

This area is located between 70° and 80°N on the North European Continental Shelf. The Barents Sea is shallow and stretches from the northernmost parts of Norway and continental Russia to Svalbard and Novaya Zemlya. The southern part is dominated by the Atlantic Current and this keeps the Norwegian coast free of ice throughout the year. The Barents Sea is a high-latitude transition zone where the relatively warm, inflowing Atlantic water is cooled and transformed into cold Arctic water. The southerly outflow of cold water through the Fram Strait is the major source of deep ocean water in the Atlantic. During the winter approximately two thirds of the sea surface is covered with ice and in spring an ice-edge phytoplankton bloom occurs in response to the melting ice.

### Arctic Ocean

The Arctic Ocean is semi-enclosed and major water inflow and outflow takes place through the Greenland Sea. Roughly 80% of the water entering and leaving the Arctic basin passes through this narrow channel between Greenland and Svalbard into the Atlantic and less than 20% passes through the shallow Bering Sea into the Pacific. The surface water circulation forms two systems: a broad clockwise gyre in the Canadian region and a more direct flow sweeping in an arc over the shallower relief of the Asian region.

For much of the year the Arctic Ocean is entirely covered by ice, which may reach a thickness of up to 2 metres. The ice is continually broken by the opening and closing of water channels. Large icebergs, formed from the glaciers of Canada and Greenland, are carried south by currents into the North Atlantic Ocean. Ice cover recedes from the edges of the continents in the summer and massive inflows of freshwater from the melting ice and rivers result in localized areas of reduced salinity.

The Arctic Ocean although small in comparison to other oceans has a complex and varied seabed topography. The basin is divided by three major submarine ridges: the Arctic Mid-Ocean Ridge, the Lomonosov Ridge, and the Alpha Ridge. The Arctic Mid-Ocean Ridge is an active seafloor spreading centre and part of the global system of major spreading ridges. It is separated by the Pole Abyssal Plain from the Lomonosov Ridge, a chain of submarine mountains. The Lomonosov Ridge dominates the Arctic basin, rising on average 3,000 m above the abyssal plain and reaching within 900 m of the surface at its highest points. On the Canadian side of the Lomonosov Ridge the ocean basin is divided by the Alpha Ridge, an irregular submarine mountain chain. Between the Alpha Ridge and the Canadian coast lies the Canada Abyssal Plain, the largest of the Arctic sub-basins, with an average depth of more than 3,600 metres.

The continental shelf of the Arctic is the largest in the world and underlies almost one-third of the total ocean area. Off the northern coastlines of Alaska, Canada, and Greenland, the shelf is 80-200 km wide but off the coast of northern Asia the shelf extends more than 1,600 km at its widest and nowhere is less than 480 km wide. This vast shelf area is subdivided by island groups and peninsulas into a number of interconnected shallow seas, the largest of which are the Chukchi, East Siberian and Laptev seas.

## BIODIVERSITY

### Arctic Regional Sea: biodiversity data

| | endemic | T | % | | endemic | T | % |
|---|---|---|---|---|---|---|---|
| seagrasses | 0 | 1 | 2 | sharks | 0 | 5 | 1 |
| coral genera | - | 0 | - | seabirds | 0 | 27 | 9 |
| molluscs | 0 | 44 | 1 | cetaceans | 0 | 14 | 19 |
| shrimps | 0 | 9 | 3 | sirenians | - | 0 | - |
| lobsters | - | 0 | - | pinnipeds | 0 | 9 | 26 |

Notes: the data refer to species except for coral genera. Column headings: endemic = restricted to the region; T = total species richness in the region; % = species richness in the region as a percentage of the world species richness in each group of organism. A dash (-) in a cell means no data or not applicable. See **Notes and Sources** in the introductory text for further information on the sources, coverage and quality of the data tabulated.

### Biodiversity Notes

There are no **corals** in the Arctic, and only one **seagrass** species has been recorded. Very few **molluscs** or **shrimp** are present, and no **lobsters**. Recorded **shark** diversity is very low. **Sea turtles** are absent. Neither **seabird** nor **cetacean** diversity is high.

Interestingly, cetacean diversity is very similar to that in the Antarctic (where thirteen species are recorded) although many of the species involved are different. **Pinniped** diversity is also similar to the Antarctic, although no Arctic pinnipeds are strictly confined to Arctic waters. There are no **sirenians**. The Polar Bear *Ursus maritimus* is largely restricted to the Arctic Ocean but also extends into the northern parts of the Atlantic (see North Atlantic Region) and Pacific (see Northeast Pacific and Northwest Pacific Regions).

## FISHERIES

The FAO does not report catch or landing data for the Arctic Sea (statistical area 18). Arctic waters in this area are ice-covered for most of the year and do not support large-scale commercial fisheries. Arctic water affected by the gulf stream are included in Area 27 (Northeast Atlantic); see discussion under North Atlantic Region.

# SOUTHWEST ATLANTIC

**Argentina, Brazil, Uruguay**

Contains Data for

Postscript Only.

## LARGE MARINE ECOSYSTEMS

Two LMEs are wholly contained within the region: the Patagonian Shelf and the Brazil Current; the southern part of the Northeast Brazil Shelf is also included here (the northern part is included in the Caribbean).

### Brazil Current

The Brazil Current LME runs from the Recife area in Brazil southwards to the mouth of the Río de la Plata, thereby taking in the southern half of the Brazilian coastline and the Atlantic coast of Uruguay. The northern part of this LME has a very narrow steeply sloping shelf, from 15-75 km wide; in the southern part this becomes wider and gentler, reaching out to 150 km or so. The dominant oceanographic feature is the southward flowing Brazil Current, which starts at around 10°S and is strongest from the Abrolhos Archipelago south to the Tropic of Capricorn, after which it becomes progressively weaker. The northern part of this current is relatively oligotrophic but to the south it becomes increasingly productive.

### Patagonian Shelf

The Patagonian Shelf LME extends along the southern Atlantic coast of South America from the Río de la Plata south to southern Patagonia and Tierra del Fuego. The continental shelf here is one of the widest in the world, encompassing the Falklands/Malvinas Islands some 760 km east of the mainland. Oceanographically, the area is dominated by the cold Falklands/Malvinas Current which flows northward along the coast from the extreme south. It is generally slow flowing, but fastest (around 2 km/hour) at the outer edge of the continental shelf. Prevailing westerly winds produce upwellings of cold Antarctic waters here, which lower the surface temperature. The northern limit of the current varies: it usually extends as far north as Buenos Aires in Argentina, but sometimes exerts its influence as far north as Rio de Janeiro. In the Río de la Plata region there is extensive mixing of this current with the southward flowing warm Brazil Current resulting in a highly productive confluence zone. Hydrographically this region is very complex, having additional influence from upwellings and low salinity coastal waters (principally outflow of the Río de la Plata). The region of mixed waters typically extends between 25°S and 45°S.

### Northeast Brazil Shelf

This LME is described briefly under the Caribbean Region. Of major note is the outflow of the Amazon, the most voluminous source of freshwater outflow in the world.

## BIODIVERSITY

### Southwest Atlantic Regional Sea: biodiversity data

| | endemic | T | % | | endemic | T | % |
|---|---|---|---|---|---|---|---|
| seagrasses | 0 | 1 | 2 | sharks | 6 | 68 | 19 |
| coral genera | 1 | 10 | 9 | seabirds | 1 | 33 | 11 |
| molluscs | 0 | 299 | 7 | cetaceans | 2 | 43 | 49 |
| shrimps | 0 | 32 | 9 | sirenians | 0 | 1 | 25 |
| lobsters | 2 | 14 | 9 | pinnipeds | 0 | 5 | 15 |

Notes: the data refer to species except for coral genera. Column headings: endemic = restricted to the region; T = total species richness in the region; % = species richness in the region as a percentage of the world species richness in each group of organism. A dash (-) in a cell means no data or not applicable. See **Notes and Sources** in the introductory text for further information on the sources, coverage and quality of the data tabulated.

### Southwest Atlantic Regional Sea: regional endemic species

| | scientific name | common name | status |
|---|---|---|---|
| lobsters | *Metanephrops rubellus* | Urugavian lobster | |
| | *Scyllarides deceptor* | Hooded slipper lobster | |
| sharks | *Centroscyllium granulatum* | Granular dogfish | |
| | *Mustelus schmitti* | Narrownose smooth-hound | |
| | *Mustelus fasciatus* | Striped smooth-hound | |
| | *Schroederichthys tenuis* | Slender catshark | |
| | *Scyliorhinus besnardi* | Polkadot catshark | |
| | *Squatina argentina* | Argentine angelshark | |
| seabirds | *Larus atlanticus* | Olrog's gull | VU |
| cetaceans | *Cephalorhynchus commersonii* | Commerson's dolphin | |
| | *Pontoporia blainvillei* | La Plata river dolphin | |

Notes: letters in the 'status' column indicate the conservation status of species that have been assessed and classified as threatened. In the revised IUCN Red List category system the term 'threatened' refers only to species in any of the following three categories: CR - Critically Endangered, EN - Endangered, VU - Vulnerable. Seabirds have been assessed by BirdLife International, Collar *et al*. (1994); all status categories are recorded in IUCN (1996).

### Biodiversity Notes

Recorded **seagrass** diversity is very low, with only one species known from the area, although is likely to be an underestimate. Generic diversity of **hermatypic corals** is low, as elsewhere in the Atlantic outside the Caribbean; there is one apparently endemic genus. The region is moderately rich in **molluscs**,

**shrimps** and **lobsters**.

**Shark** diversity is reasonably high; recorded **seabird** diversity is relatively low, with only one endemic species. Five **sea turtle** species are recorded as nesting in the region (the Green Turtle *Chelonia mydas*, Loggerhead *Caretta caretta*, Hawksbill *Eretmochelys imbricata*, Olive Ridley *Lepidochelys olivacea* and Leatherback *Dermochelys coriacea)*. However, none of the nesting populations is known to be of major global importance.

A moderate number of **cetacean** species is recorded from the region, although two species are apparently endemic or largely endemic. The **pinniped** fauna is relatively diverse and one species of **sirenian**, the West Indian Manatee *Trichechus manatus* occurs in the northern part of the region (the Amazonian Manatee *Trichechus inunguis* occurs in the Amazon delta region but is strictly a freshwater species).

## FISHERIES

The region lies within FAO fisheries region 41, Southwest Atlantic.

Total reported fisheries in this area increased from around one million tonnes in the mid-1970s to 2.4 million tonnes in 1987, declining to 2.0 million tonnes in 1990 and then increasing slightly to reach 2.2 million tonnes by 1992. This represents around two percent of the global total. The most important fisheries are of demersal species, particularly squid (chiefly short-fin squid *Illex* sp. and common squid *Loligo* sp.), whose catch reached around 700,000 tonnes in 1992, and Common or Argentinean Hake *Merluccius hubbsi* whose 1992 catch was 455,000 tonnes, down from 521,000 tonnes in 1991. Squid and hake together account for over half of the total catch. Other important catches are of Sardinella *Sardinella brasiliensis*, Anchoita *Engraulis anchoita*, and Blue Whiting *Micromesistius australis*.

Over 80% of stocks in this region are considered fully fished, overfished, depleted or recovering. The stock of Anchoita off southern Brazil, Uruguay and northern Argentina is believed to have a potential of a few hundreds of thousands of tonnes per year but is little harvested at present. Stocks of most species, particularly squids, are reported to vary widely from year to year owing to natural causes. Excessive fishing may hinder recovery from natural decreases, as is likely to be the case with the Sardinella, where catches dropped from over 100,000 tonnes per year in the 1970s to 32,000 tonnes in 1990 (and has subsequently increased somewhat). Overall discard rate is estimated at around 27%, near the global average.

Various management measures have been in force in the region for some years, including restricted licensing of national vessels and mesh-size regulations, specifically to control hake fishing. Control measures have also been brought in for the large squid stocks.

The large-scale annual variability of many of the stocks in the region means that close monitoring is required to ensure that they are not overexploited. A major concern has been the rapid build-up in the region of offshore fishing by distant-water fleets. This has become better controlled since the adoption of 200 nm limits, and since the re-establishment of diplomatic relations between Argentina and the United Kingdom, allowing the development of cooperative monitoring. Further north, Argentina and Uruguay cooperate in research and management of fisheries, particularly in the Argentinean/Uruguayan Common Fishing Zone.

*Southwest Atlantic*

# WEST AND CENTRAL AFRICA



**Angola, Benin, Cameroon, Cape-Verde, Congo, Côte d'Ivoire, Equatorial Guinea, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mauritania, Namibia, Nigeria, São Tomé e Príncipe, Senegal, Sierra Leone, Togo, Zaire**

St Helena and dependencies (to UK) are included in the biodiversity section below.

## LARGE MARINE ECOSYSTEMS

The West African coast from Mauritania south to Namibia includes the southern part of the Canary Current LME, the whole of the Guinea Current LME and most of the Benguela Current LME. The Canary Current LME is described under the North Atlantic Region.

### Guinea Current LME

The Guinea Current LME extends from the Bissagos Islands off Guinea in the north, through the Gulf of Guinea and Bight of Biafra, to Cape Lopez in Gabon. It is characterised principally by the wind-driven warm water Guinea Current flowing southward along the coast of the Gulf of Guinea almost to the equator (essentially a continuation of the Equatorial Counter-Current).

A major influence on the region is the input of freshwater from the numerous rivers in this high-rainfall region, most notably the Niger and Zaire (the former being the second largest delta in the world). This results in large masses of warm (above 24°C) and low salinity (less than 35 ppt) water circulating in the Gulf of Guinea above colder water masses. These waters are permanent off Sierra Leone and Liberia and in the Gulf of Biafra (off Nigeria, Cameroon and Gabon) but seasonal along the central part of the north coast of the Gulf of Guinea (from Côte d'Ivoire to Benin). Here there are strong seasonal upwellings during the summer months. North of Sierra Leone, upwellings occur from October to April.

### Benguela Current LME

The Benguela Current is a major northward flowing cold-water current and upwelling system running along the coast of South Africa, Namibia and Angola, veering offshore at around 6°S. Unusually for an upwelling system, it is bounded both to north and south by warm-water currents (the Guinea Current and Agulhas Current respectively). Upwelling is intense and more or less permanent in the central part of the system but is seasonal to the north and south, being strong in the austral winter (August) and weaker in summer (November to February). This region receives very little input from rivers, particularly in its central part. Indeed the coastal region of Namibia is one of the most arid parts of the world.

## BIODIVERSITY

### West and Central Africa Regional Sea: biodiversity data

| | endemic | T | % | | endemic | T | % |
|---|---|---|---|---|---|---|---|
| seagrasses | 0 | 1 | 2 | sharks | 1 | 89 | 25 |
| coral genera | 1 | 10 | 9 | seabirds | 2 | 51 | 18 |
| molluscs | 1 | 238 | 6 | cetaceans | 1 | 38 | 43 |
| shrimps | 0 | 36 | 10 | sirenians | 1 | 1 | 25 |
| lobsters | 3 | 11 | 7 | pinnipeds | 0 | 5 | 15 |

Notes: the data refer to species except for coral genera. Column headings: endemic = restricted to the region; T = total species richness in the region; % = species richness in the region as a percentage of the world species richness in each group of organism. A dash (-) in a cell means no data or not applicable. See **Notes and Sources** in the introductory text for further information on the sources, coverage and quality of the data tabulated.

### West and Central Africa Regional Sea: regional endemic species

| | scientific name | common name | status |
|---|---|---|---|
| molluscs | *Conus balteus* | | |
| lobsters | *Callianassa turnerana* | Cameroon ghost shrimp | |
| | *Palinurus charlestoni* | Cape Verde spiny lobster | |
| | *Scyllarides herklotsii* | Red slipper lobster | |
| sharks | *Scyliorhinus cervigoni* | West African catshark | |
| seabirds | *Fregata aquila* | Ascension frigatebird | CR |
| | *Pterodroma incerta* | Atlantic petrel | VU |
| cetaceans | **Cephalorhynchus heavisidii* | Heaviside's dolphin | |
| sirenians | *Trichechus senegalensis* | African manatee | VU |

Notes: letters in the 'status' column indicate the conservation status of species that have been assessed and classified as threatened. In the revised IUCN Red List category system the term 'threatened' refers only to species in any of the following three categories: CR - Critically Endangered, EN - Endangered, VU - Vulnerable. Seabirds have been assessed by BirdLife International, Collar *et al*. (1994); all status categories are recorded in IUCN (1996).
* Heaviside's Dolphin also occurs off South Africa, but is apparently endemic to the Benguela Current and is therefore included here.

### Biodiversity Notes

Recorded **seagrass** diversity is extremely low, although this may reflect lack of information. As with most of the Atlantic, **hermatypic coral** diversity is very low at the generic level, although there is some endemism. richness of **molluscs**, **shrimps** and **lobsters** is only moderate.

**Shark** diversity is high. Five **sea turtle** species nest in the region (the Green Turtle *Chelonia mydas*, Loggerhead *Caretta caretta*, Hawksbill *Eretmochelys imbricata*, Olive Ridley *Lepidochelys olivacea* and Leatherback *Dermochelys coriacea)*. However, none of the nesting populations is known to be of major global importance. Numbers of **seabird** species are relatively high, although lower than in the Pacific regions, and there is low endemism.

Recorded **cetacean** diversity is moderate. One species, Heaviside's Dolphin, is apparently confined to the Benguela Current and is therefore confined to this region and northern South Africa. One **sirenian**, the West African Manatee *Trichechus senegalensis* is confined to the region. However, it is only marginally a marine or coastal species as most of the population occurs in freshwaters, particularly in the inland delta region of the Niger River. Five **pinnipeds** occur in the region; none is endemic although the northern sector of the Mauritanian coast holds (or at least held) a major population of the critically endangered Mediterranean Monk Seal *Monachus monachus* (Critically Endangered), which also occurs in the North Atlantic and Mediterranean Regions.

## FISHERIES

This region comprises the majority of both FAO fisheries area 34 (Eastern Central Atlantic) and area 47 (Southeast Atlantic). The northern part of area 34 lies in the North Atlantic, while the remainder of area 47 lies within South Africa. The two fishing regions, which correspond largely to the two main LMEs outlined above, have very different characteristics from a fisheries point of view, and are discussed separately.

### Southeast Atlantic

The Benguela Current upwellings create a highly productive fishery region, although one whose overall fishery potential remains inadequately known.

Total catches in the region remained reasonably stable throughout the 1980s, varying from 2.1 million to 2.7 million tonnes. However, they declined to 1.5 million tonnes in 1990 and have remained fairly constant at this level. Discards in this region are believed to be well below the global average, amounting to an estimated 14% of the catch in the period 1988-92.

The fish stock, and the fishery, is dominated by pelagic and demersal finfish, with relatively few species making up most of the biomass. Hake (*Merluccius capensis* and *M. paradoxus*) are the major demersal species and are present both inshore and offshore. Cape Horse Mackerel (*Trachurus trachurus*) comprises the major offshore pelagic stock while Pilchard (*Sardinops ocellata*) and Anchovy (*Engraulis capensis*) are the most abundant inshore pelagic species, characteristic of the coastal upwellings. There are smaller but still economically important stocks of a variety of other species (squid, rock lobster, sole). The status of these stocks remains very inadequately known.

Most demersal and pelagic stocks are believed to be fully or overexploited. Hake stocks have been overexploited in the past, with catches reaching a peak of 800,000 tonnes per year in the early 1970s. By 1989 the catch had decreased to under 450,000 tonnes with some stocks starting to show signs of recovery.

As elsewhere, pelagic stocks are highly variable from year to year, and also show longer term changes.

*West and Central Africa*

Cyclical changes in dominance of low trophic level fishes, with sardines and anchovies alternating in abundance, are of particular note. Extensive sardine fisheries began after World War II, peaking in 1968 at around 1.5 million tonnes, and then collapsed. Anchovy catches grew as sardine catches declined, peaking at around 1 million tonnes in 1987 and subsequently collapsed. Evidence from landings, and other sources such as seabird diet, indicates that sardines may now be replacing anchovies as the dominant species. These changes appear to be linked to (though not necessarily in phase with) similar changes in the Pacific associated with El Niño events; it is unclear to what extent the fishery itself may have influenced the pattern.

A major factor in fisheries in this area has been the impact of distant water fleets. Up to 1990, over 40% of the catch in the southeast Atlantic was taken by distant water fleets, particularly those from the ex-USSR, operating mainly off Angola and Namibia. This arose because until independence was granted to Namibia in 1990 there was no coastal state control over fishing off the Namibian coast. With the declaration elsewhere of 200 nm EEZs subsequent to UNCLOS entering into force, this region became one of the few major fishing grounds in the world with open access. In 1990 Namibia requested all foreign fleets to cease their fishing activities off the Namibian coast while fisheries laws and management strategies were developed. Quotas and regulations have been introduced since then which are intended to allow biomass of important stocks such as hake to increase.

**East-central Atlantic**

As well as the countries included within the UNEP West and Central Africa Region Sea, this fishery area also includes the Canary Islands (to Spain) and the Atlantic coast of Morocco, here considered as part of the North Atlantic. The northern part of the region comprises the Canary Current LME, the southern part the Guinea Current LME.

Landings in this region have fluctuated widely over the past 25 years, rising from around 2.5 million tonnes in the early 1970s to 3.8 million tonnes in 1977, falling to around 3 million tonnes in the mid-1980s and then reaching an all-time peak in the late 1980s of over 4 million tonnes, before dropping again to around 3.2 million tonnes by 1992. Much of this fluctuation can be ascribed to variations in landings of smaller pelagic resources such as horse mackerel and sardine, whose populations vary greatly as a result of climatic change and changes in fishing pressure. Estimated discard rates for 1988-1992 here are similar to those for the Southeast Atlantic at around 14%, considerably lower than the global average.

The great majority of stocks in this region appear to be fully exploited or overexploited. Demersal fisheries in the Mauritania-Senegal region have been seriously reduced and catches have remained static or decreased despite major increases in fishing pressure; increases in octopus and shrimp abundance in the area are taken as signs of ecosystem stress from overfishing. There are important but highly variable pelagic stocks of sardine, mackerel and horse mackerel which are difficult to assess.

The state of resources within much of the Gulf of Guinea from Sierra Leone south remains inadequately known. There is a wide range of multi-species fisheries, including both demersal and small pelagic species. The most important, though high unstable, stocks are the small pelagics associated with the seasonal upwellings along the coast from Côte d'Ivoire to Benin. These have shown collapse in the past, probably owing to a combination of high fishing pressure and unfavourable climatic conditions, but since the early 1980s have been at high levels, although are believed to be fully exploited.

As in the Benguela Current LME, a high proportion of the catch (just under 60% during 1989 and 1990) has been taken by distant water fleets. This reflects policy decisions taken by coastal states in the region and also their current difficulty in exploiting fisheries resources themselves, particularly given the volatility of the important pelagic stocks. In 1990, 40% of the catch here (primarily small pelagics off West Africa) was taken by the former USSR As the former Eastern European economies, including the ex-USSR, undergo structural adjustment and their fleets begin to operate under market forces it is expected that their activities in this region will decrease considerably. Catches of pelagics may be expected therefore to decline at least in the short term. This provides an opportunity for the countries in the region to develop their fisheries in a rational manner.

There is a clear need in this region for more detailed evaluations of many stocks, and more rapid updating of information, particularly for the highly volatile pelagic stocks which are generally shared by a number of countries.

# SOUTH PACIFIC

**American Samoa (to USA); *Australia*; Cook Islands (to New Zealand); Federated States of Micronesia; Fiji; French Polynesia; Guam (to USA); Hawaii and central Pacific US dependencies (to USA); Kiribati; Marshall Is; Nauru; New Caledonia (to France); New Zealand; Niue (to New Zealand); Northern Mariana Islands (to USA); Palau; Papua New Guinea; Pitcairn Islands (to UK); Solomon Islands; Tonga; Tuvalu; Vanuatu; Wallis and Futuna Islands (to France); Western Samoa**



## LARGE MARINE ECOSYSTEMS

The South Pacific region is comprised of three LMEs: The Insular Pacific-Hawaiian complex, the Great Barrier Reef, and the New Zealand Shelf. Easter Island and Sala-y-Gómez (to Chile), in mid-Pacific, are biogeographically within this region, but politically related to the Southeast Pacific Regional Sea agreement.

### Insular Pacific-Hawaiian

This complex includes many LMEs which are linked by the EEZs (Exclusive Economic Zones) of the islands that they contain. The LME includes Hawaii, New Caledonia, Papua New Guinea, Western Samoa, Northern Mariana Islands, Solomon Islands, Fiji, Marshall Islands, Micronesia and others. Their actual physical extent is defined by the areas of resource extraction associated with adjacent reef biotopes. The area is characterized by very warm surface waters that vary little in temperature over the year. The temperature on the southern boundary of the LME drops to only 22°C in the austral winter (south of New Caledonia) and remains above 24°C in the northern winter (north of the Marianas). Temperatures higher than 29°C are found over almost half the South Pacific region in each hemisphere during the respective summers. The main currents influencing this area are the North and South Equatorial Currents and the Equatorial Counter Current. The El Niño-Southern Oscillation has an important periodical effect on this region.

### Great Barrier Reef

The Great Barrier Reef is the largest single reef system in the world. It extends for 2,000 km from the lowland tropics to temperate zones off the east coast of Australia, and occupies an area of approximately 350,000 km$^2$. The inshore continental islands provide great habitat diversity. The circulation in the Great Barrier Reef is immensely complicated and is governed by the properties of the Coral Sea, land runoff, evaporation, the southeast trade winds, and forced upwellings owing to strong tidal currents in narrow reef passage and coastal waters. Sea surface temperatures vary from 15-26°C in winter to 26-30°C in the summer.

### New Zealand Shelf

The continental shelf surrounding New Zealand is irregular. It varies greatly in width, with the northwest and southeast plateau sections extending as far as 3,000 km, while the narrow northeast and southwest sections drop off at about 150 km. The northern half of the LME is influenced by the warm South

Equatorial Current and the southern half by the cooler West Wind Drift. These currents meet in a broad zone of convergence (the Subtropical Convergence) off the New Zealand coast marked by sudden changes of temperature and salinity.

## BIODIVERSITY

### South Pacific Regional Sea: biodiversity data

| | endemic | T | % | | endemic | T | % |
|---|---|---|---|---|---|---|---|
| seagrasses | 2 | 19 | 40 | sharks | 35 | 128 | 37 |
| coral genera | 0 | 76 | 70 | seabirds | 39 | 115 | 39 |
| molluscs | 7 | 984 | 23 | cetaceans | 1 | 43 | 49 |
| shrimps | 0 | 63 | 18 | sirenians | 0 | 1 | 25 |
| lobsters | 13 | 42 | 28 | pinnipeds | 3 | 8 | 26 |

Notes: the data refer to species except for coral genera. Column headings: endemic = restricted to the region; T = total species richness in the region; % - species richness in the region as a percentage of the world species richness in each group of organism. A dash (-) in a cell means no data or not applicable. See **Notes and Sources** in the introductory text for further information on the sources, coverage and quality of the data tabulated.

### South Pacific Regional Sea: regional endemic species

| | Scientifc name | Common name | status |
|---|---|---|---|
| seagrasses | *Halophila hawaiiana* | | |
| | *Halophila tricostata* | | |
| molluscs | *Clypeolum granosum* | Granose Nerite | |
| | *Conus abbreviatus* | Abbreviated Cone | |
| | *Conus cabritti* | Cabrit's Cone | |
| | *Mitra pellisserpentis* | Snake-tongue Mitre | |
| | *Natica zealandica* | New Zealand Moon | |
| | *Neocancilla arenaceae* | Orange Mitre | |
| | *Scabricola newcombii* | Newcomb's Mitre | |
| lobsters | *Arctides antipodarum* | Rough Spanish lobster | |
| | *Callianassa australiensis* | Australian ghost shrimp | |
| | *Ibacus brucei* | Glabrous fan lobster | |
| | *Jasus edwardsii* | Red rock lobster | |
| | *Jasus verreauxi* | Green rock lobster | |
| | *Metanephrops challengeri* | New Zealand lobster | |
| | *Palibythus magnificus* | Musical furry lobster | |
| | *Panulirus marginatus* | Banded spiny lobster | |
| | *Panulirus pascuensis* | Easter Island spiny lobster | |
| | *Parribacus caledonicus* | Caledonian mitten lobster | |

| | Scientifc name | Common name | status |
|---|---|---|---|
| lobsters (continued) | *Parribacus holthuisi* | Red-spotted mitten lobster | |
| | *Parribacus scarlatinus* | Marbled mitten lobster | |
| | *Thaumastochelopsis wardi* | Australian prince lobster | |
| sharks | *Apristurus* sp. E | | |
| | *Asymbolus analis* | | |
| | *Asymbolus* sp. D | | |
| | *Asymbolus* sp. E | | |
| | *Brachaelurus waddi* | | |
| | *Centroscymnus plunketi* | Plunket shark | |
| | *Cephaloscyllium nascione* | Whitefinned swellshark | |
| | *Cephaloscyllium* sp. B | | |
| | *Cephaloscyllium* sp. C | | |
| | *Cephaloscyllium* sp. D | | |
| | *Etmopterus baxteri* | New Zealand lanternshark | |
| | *Etmopterus* sp. D | | |
| | *Etmopterus* sp. F | | |
| | *Etmopterus villosus* | Hawaiian lanternshark | |
| | *Galeus* sp. B | | |
| | *Gogolia filewoodi* | Sailback houndshark | |
| | *Gollum attenuatus* | Slender smoothhound | |
| | *Halaelurus dawsoni* | New Zealand catshark | |
| | *Hemitriakis* sp. B | | |
| | *Heterodontus galeatus* | Crested bullhead shark | |
| | *Heteroscyllium colcloughi* | Bluegray carpetshark | |
| | *Iago garricki* | Longnose houndshark | |
| | *Mustelus lenticulatus* | Spotted estuary smooth-hound | |
| | *Parascyllium collare* | Collared carpetshark | |
| | *Parascyllium ferrugineum* | Rusty carpetshark | |
| | *Parascyllium multimaculatum* | Tasmanian carpetshark | |
| | *Parmaturus* sp. A | | |
| | *Pristiophorus* sp. A | | |
| | *Pristiophorus* sp. B | | |
| | *Scymnodalatias sherwoodi* | Sherwood dogfish | |
| | *Squalus melanurus* | Blacktailed spurdog | |
| | *Squalus rancureli* | Cyrano spurdog | |
| | *Squalus* sp. A | | |
| | *Squalus* sp. B | | |
| | *Squalus* sp. F | | |
| seabirds | *Chlidonias albostriatus* | Black-fronted tern | VU |
| | *Diomedea bulleri* | Buller's albatross | |
| | *Diomedea cauta* | Shy albatross | |
| | *Diomedea epomophora* | Royal albatross | |
| | *Eudyptes pachyrychus* | Fiordland penguin | VU |
| | *Eudyptes robustus* | Snares penguin | VU |

| | Scientifc name | Common name | status |
|---|---|---|---|
| | *Eudyptes sclateri* | Erect-crested penguin | VU |
| seabirds (continued) | *Gygis microrhynca* | Little white-tern | |
| | *Larus bulleri* | Black-billed gull | |
| | *Megadyptes antipodes* | Yellow-eyed penguin | VU |
| | *Nesofregetta fuliginosa* | Polynesian storm-petrel | |
| | *Phalacrocorax campbelli* | Campbell shag | VU |
| | *Phalacrocorax carunculatus* | Rough-faced shag | VU |
| | *Phalacrocorax chalconotus* | Bronze shag | VU |
| | *Phalacrocorax colensoi* | Auckland Island shag | VU |
| | *Phalacrocorax featherstoni* | Pitt shag | VU |
| | *Phalacrocorax onslowi* | Chatham shag | VU |
| | *Phalacrocorax punctatus* | Spotted shag | |
| | *Phalocrocorax ranfurlyi* | Bounty shag | VU |
| | *Procellaria parkinsoni* | Black petrel | VU |
| | *Procellaria westlandica* | Westland petrel | VU |
| | *Procelsterna albivitta* | Grey noddy | |
| | *Pseudobulweria macgillivrayi* | Fiji petrel | CR |
| | *Pterodroma alba* | Phoenix petrel | |
| | *Pterodroma axillaris* | Chatham petrel | CR |
| | *Pterodroma brevipes* | Collared petrel | |
| | *Pterodroma cookii* | Cook's petrel | VU |
| | *Pterodroma inexpectata* | Mottled petrel | |
| | *Pterodroma leucoptera* | Gould's petrel | |
| | *Pterodroma magentae* | Magenta petrel | CR |
| | *Pterodroma nigripennis* | Black-winged petrel | |
| | *Pterodroma pycrofti* | Pycroft's petrel | VU |
| | *Pterodroma solandri* | Providence petrel | VU |
| | *Pterodroma ultima* | Murphy's petrel | |
| | *Puffinus bulleri* | Buller's shearwater | |
| | *Puffinus gavia* | Fluttering shearwater | |
| | *Puffinus huttoni* | Hutton's shearwater | |
| | *Puffinus newelli* | Newell's shearwater | EN |
| | *Sterna lunata* | Grey-backed tern | VU |
| cetaceans | *Cephaloryhnchus hectori* | Hector's dolphin | VU |
| pinnipeds | *Arctocephalus forsteri* | New Zealand fur seal | EN |
| | *Monachus schauinslandi* | Hawaiian monk seal | EN |
| | *Phocarctos hookeri* | Hooker's sea lion | VU |

Notes: letters in the 'status' column indicate the conservation status of species that have been assessed and classified as threatened. In the revised IUCN Red List category system the term 'threatened' refers only to species in any of the following three categories: CR - Critically Endangered, EN - Endangered, VU - Vulnerable. Seabirds have been assessed by BirdLife International, Collar *et al*. (1994); all status categories are recorded in IUCN (1996).

**Biodiversity Notes**

Recorded **seagrass** richness is the highest in the world, despite there being only two endemic species. The region is second only to the adjacent East Asian Seas in **hermatypic coral** diversity, although has no genera endemic to it. Similarly, the region is second only to the East Asian Seas area in apparent species richness of **molluscs**, and **lobsters**; endemism in both groups is highest of all regions. **Shrimp** diversity is also high, but with no recorded endemism in the groups surveyed.

High diversity, and regional endemism, is also shown by **sharks** and, particularly, by **seabirds**. More than twice as many seabird species are recorded here than in any other region; the region also has the highest number of endemic and threatened seabirds. Six of the world's seven **marine turtle** species nest in the region, the exception being Kemp's Ridley *Lepidochelys kempii* which is confined to the Caribbean. Breeding populations of Green Turtle *Chelonia mydas* (New Caledonian islands) and Hawksbill *Eretmochelys imbricata* (Solomon Islands) are of global significance. Leatherback *Dermochelys coriacea* numbers in Papua New Guinea are also important.

**Cetacean** diversity is high, although only one species is apparently confined to the region; the only **sirenian** present is the Dugong *Dugong dugon*, and **pinniped** diversity is moderate. Two species, the Hawaiian monk seal *Monachus schauinslandi* (Endangered) and Hooker's sea lion *Phocarctos hookeri* are confined to the region.

## FISHERIES

The region includes western parts of FAO Statistical Area 81 (Southwest Pacific), a large part of Area 71 (West-central Pacific) and southwestern parts of Area 77 (East-central Pacific). This region is characterised by a very small land area, including a large number of small island states, in relation to a very large total EEZ area.

The recorded catch in this region is moderate in global terms, but local use of fish resources, particularly reef fishes and other nearshore and inshore stocks, is extremely important socially and economically in the small island states of the region. In addition there are globally significant stocks of highly valuable pelagic tunas; these account for a substantial portion of recorded landings in the region.

Most coastal shrimp stocks on the continental shelf around northern Australia are fully exploited; over-capitalisation is an important factor. A compulsory vessel reduction scheme may now be having an effect, but has been countered by a great increase in fishing power, mainly from GPS. Landing from trawl fisheries in southeast Australia remain reasonably stable. Tune cathches are regulated under the tripartite agreement between Australia, New Zealand and Japan.

In Area 81, Hoki (or Blue Grenadier) *Macruronus noveazealandiae* is the main species landed by New Zealand, almost entirely for export (the value of fish exports from New Zealand currently exceeds that of wool exports). Stocks appear to be in good condition after a number of strong year classes, but quotas remain conservative. Incidental mortality to Hooker's Sea Lion and seabirds, such as albatross, has been reduced as a result of changes to fishery practice and gears.

Management of Orange Roughy *Hoplostethus atlanticus* has been subject to considerable disagreement; many believe current harvest levels of this very long-lived species (potentially in excess of 100 years) are unsustainable and that reduced quotas are needed. Rock Lobster *Jasus edwardsii* stocks are under pressure, also with disagreement on quota levels. Recruitment to the stock appears to be related to El Niño events. Market demand remains strong, but squid landings have been depressed as a result of low prices.

New Zealand has put much emphasis on the Individual Transfer Quotas (ITQ) management system. This was being expanded from 160 species to cover all significant stocks in 1992. Recently ITQ has been changed from a fixed tonnage to a proportion of a variable overall Total Allowable Catch (TAC). Quotas are currently set on the east coast of Australia. Bluefin Tuna stocks are strictly managed under tripartite agreement between Australia, Japan and New Zealand (see Southwest Australia account).

Tuna (especially Skipjack and Yellowfin) are foremost among fishery species in the Pacific Islands making up large parts of FAO areas 71 and 77. Tuna are most abundant off Papua New Guinea, the Solomon Islands and Kiribati. Much exploitation is by foreign vessels which pay access rights to fish local EEZs; these fees have been negotiated by the South Pacific Forum Fisheries Agency (FFA) based in the Solomons. FFA members in the region have strongly encouraged use of local ports for trans-shipment purposes, and this adds to the revenue generated. Domestic fisheries are increasingly targeting tuna stocks in the region.

Owing to their dispersed nature and the fact that much of the fishing is for subsistence purposes, reef-associated fisheries are very difficult to monitor. Island fishers are making increasing use of Fish Aggregating Devices (FADs) to enhance catches, where these had previously been used for offshore by non-local vessels.

Inshore resources, mostly based on reef systems, have received relatively little research and money attention in relation to tuna, but although the monetary benefits from these resources tend to be low they are often of very great subsistence value locally.

Around half of nearshore landings for both commercial and subsistence purposes are made up of reef finfish. A minor proportion is for the aquarium trade. Some stocks are known to be depleted, eg. reef and lagoon fishes in Palau and Kiribati; bone fish, milkfish and parrotfish off the Cook Islands; large serranids and lutjanids in Fiji; reef and small pelagic fishes in Western Samoa.

Invertebrates make up a very significant part of the catch: sea cucumbers, sea urchins, giant clams, pearl oysters, sea snails, cephalopods and spiny lobster. Markets for some of these species have existed for centuries. Sharks are an important resource for subsistence fishers both as a food source and dried fins for sale.

Few countries in the region have formulated fisheries management plans. Data collection by the Southeast Asian Fisheries Development Centre (SEAFDC) has had limited success for stock assessment purposes although unfortunately does not play a major role in management decision.

# SOUTHWEST AUSTRALIA

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This marine region is not within an existing Regional Seas area and has been defined here for the purposes of this document. It consists of the Australian coastline that does not fall within an established Regional Seas area; extending from Shark Bay in Western Australia south to the border of Southern Australia and New South Wales.

The region has no defined Large Marine Ecosystem within it. It is influenced by the Southern Ocean Current. The continental shelf is narrow, the shelf edge being as close as 35 km from shore. The western section of this area covers a latitudinal transition from the tropical to the warm temperate climatic zones, whilst the southern section lies entirely within the temperate climatic zone.

## BIODIVERSITY

**Southwest Australia Regional Sea: biodiversity data**

| | endemic | T | % | | endemic | T | % |
|---|---|---|---|---|---|---|---|
| seagrasses | 5 | 17 | 35 | sharks | 7 | 64 | 18 |
| coral genera | 0 | 62 | 57 | seabirds | 0 | 22 | 8 |
| molluscs | 0 | 197 | 5 | cetaceans | 0 | 36 | 41 |
| shrimps | 0 | 15 | 4 | sirenians | 0 | 1 | 25 |
| lobsters | 1 | 10 | 7 | pinnipeds | 1 | 6 | 18 |

Notes: the data refer to species except for coral genera. Column headings: endemic = restricted to the region; T = total species richness in the region; % - species richness in the region as a percentage of the world species richness in each group of organism. A dash (-) in a cell means no data or not applicable. See **Notes and Sources** in the introductory text for further information on the sources, coverage and quality of the data tabulated.

**Southwest Australia Regional Sea: regional endemic species**

| | scientific name | common name | status |
|---|---|---|---|
| seagrasses | *Amphibolis griffithii*<br>*Posidonia angustifolia*<br>*Posidonia ostenfeldii*<br>*Posidonia sinuosa*<br>*Thalassodendron pachyrhizum* | | |
| lobsters | *Panulirus cygnus* | Australian spiny lobster | |
| sharks | *Apristurus* sp. F<br>*Asymbolus* sp. B | | |

| | scientific name | common name | status |
|---|---|---|---|
| | *Asymbolus* sp. C | | |
| | *Asymbolus* sp. F | | |
| | *Aulohalaelurus labiosus* | | |
| | *Parascyllium* sp. A | | |
| | *Sutorectus tentaculatus* | Cobbler wobbegong | |
| pinnipeds | *Neophoca cinerea* | Australian sea lion | |

**Biodiversity Notes**

**Seagrass** richness is very high, second only to the South Pacific. The region also has a remarkable number of endemic seagrass species. The region has very high **hermatypic coral** diversity, although no recorded endemic genera. There is apparently low diversity among **molluscs**, **shrimp** and **lobsters**, with a single endemic in the last group.

Recorded **shark** diversity is moderate to high. Amongst **sea turtles** there is significant nesting of Green Turtle *Chelonia mydas*, Loggerhead *Caretta caretta* and Hawksbill *Eretmochelys imbricata*. No other sea turtle species is known to nest. **Seabird** diversity is fairly low. Average numbers of **cetacean** species have been recorded and one species of **sirenian**, the Dugong *Dugong dugon*, for which Shark Bay is a very important refuge. **Pinniped** diversity is surprisingly high, with one species confined to the region.

## FISHERIES

The seas around Southwest Australia comprise part of the southern region of FAO statistical area 57 (Eastern Indian Ocean).

The annual recorded landings for all of area 57 totalled 3.3 million tonnes in 1992 of which Australia accounts for a maximum of 15%. Landings are mostly from pelagic species, the largest catches coming from elasmobranchs (sharks and rays) and clupeoids. Most landings have increased since the 1970s except catches of Southern Bluefin Tuna *Thunnus maccoyii* which have fallen 16,000 tonnes since 1985.

Australian scallop landings in the southern sector of area 57 have increased twelve fold between 1990 and 1992 to around 72,000 tonnes, which amounts to almost 20% of the overall increase in invertebrate landings by all countries in the area. Other mollusc landings include catches of abalones, yielding 6,000 tonnes, and mussels and oysters, yielding 13,000 tonnes in 1990.

The Western Australian rock lobster fishery makes a significant contribution to the total Australian catch for this region and is the highest value single-species fishery in the country. Lobster catches increased in 1990 producing landings of 19,000 tonnes. The rock lobster catch consisted of two species; the Western Rock Lobster (*Panulirus cygnus*) and the Southern Rock Lobster (*Jasus edwardsii*).

The Convention for the Conservation of Southern Bluefin Tuna (CCSBT), a regional initiative involving Japan, Australia and New Zealand was agreed in 1993. The aim of the CCSBT is to conserve stocks and optimise use of Southern Bluefin Tuna. The Commission for the CCSBT first met in May 1994. The stock remains severely depleted but it is believed that catch limits made in 1988 and 1989 will shortly reverse this decline, and the Commission agreed to maintain the 1994/95 global quota limit of 11,750 tonnes.

Both lobster species targeted in Australia have been subject to a management plan for a considerable time. The objective is to constrain fishing effort so that catches are maintained at a sustainable yield of between 8,000-12,000 tonnes annually. Fishing power has increased through growing use of Global Positioning Systems (GPS) and other electronic aids.

# BLACK SEA

**Contains Data for Postscript Only.**

**Bulgaria, Georgia, Romania, Russia, *Turkey*, Ukraine**

## LARGE MARINE ECOSYSTEMS

The Black Sea, which comprises a single LME, covers some 461,000 km$^2$ in southeast Europe, approximately between 27-41°E and 41-47°N. It is relatively deep; most of it exceeds 500 m in depth and much of the central part reaches 2,000 m (max 2,212 m). There are extensive shallow water areas along the western and northern shores, in the latter particularly where the 15,000 km$^2$ Sea of Azov is largely isolated from the rest of the Black Sea by the Crimean Peninsula, and has a mean depth of only 8 m. The Black Sea is almost entirely landlocked but receives some inflow of saline water (and aquatic organisms) from the Mediterranean by way of the Sea of Marmara and the Bosphorus Channel, which is 31 km long with an average width of only 1.6 km. Major water input comes from a series of large rivers which flow into the northern and western parts of the Black Sea. These are the Danube, which contributes *c* 200 km$^3$ of water annually, the Dnieper (*c* 54 km$^3$ per year), Don (28 km$^3$ per year, into the Sea of Azov), Kuban (13 km$^3$) and Dniester (*c* 9 km$^3$ per year).

The waters of the Black Sea are horizontally separated (at around 150-200 m depth) by a permanent salinity boundary; the upper surface layer is oxygenated and had reduced salinity, the waters below this lack oxygen but are rich in hydrogen sulphide. Over 90% of the volume of the sea is therefore essentially without life apart from anaerobic bacteria. Inflow of water from the major river systems coupled with limited outflow have led to the Black Sea being nutrient-rich and highly productive, although of lower diversity than the adjacent Mediterranean.

## BIODIVERSITY

**Black Sea Regional Sea: biodiversity data**

| | endemic | T | % | | endemic | T | % |
|---|---|---|---|---|---|---|---|
| seagrasses | - | 4 | 8 | sharks | - | 1 | - |
| coral genera | - | 0 | - | seabirds | 1 | 17 | 6 |
| molluscs | 0 | 6 | 0 | cetaceans | 0 | 3 | 3 |
| shrimps | 0 | 6 | 2 | sirenians | - | 0 | - |
| lobsters | 0 | 1 | 0 | pinnipeds | 0 | 1 | 3 |

Notes: the data refer to species except for coral genera. Column headings: endemic = restricted to the region; T = total species richness in the region; % = species richness in the region as a percentage of the world species richness in each group of organism. A dash (-) in a cell means no data or not applicable. See **Notes and Sources** in the introductory text for further information on the sources, coverage and quality of the data tabulated.

**Black Sea Regional Sea: regional endemic species**

| | scientific name | common name | status |
|---|---|---|---|
| seabirds | *Larus armenicus* | Armenian gull | |

**Biodiversity notes**

Diversity in general is low. Four species of **seagrass** reportedly occur, mainly in the south, none is endemic. There are no **hermatypic coral** genera in the Black Sea. There are very few molluscs and larger crustaceans.  Only one species of **shark** has been recorded, although this may well be an underestimate. No **sea turtle** species is known to nest in the Black Sea; the Green Turtle *Chelonia mydas* and Loggerhead *Caretta caretta* have been recorded in Black Sea waters. **Seabird** diversity is low, although one species is endemic to the region. Three species of **cetacean** have been recorded. One of these, the Harbour Porpoise *Phocoena phocoena*, was formerly abundant but is now very reduced in numbers. There are no **sirenians** in the Black Sea, but one **pinniped**, the Mediterranean Monk Seal *Monachus monachus* (Critically Endangered) was formerly present, although is now believed extinct there.

## FISHERIES

The Black Sea is part of FAO area 37 (Mediterranean and Black Sea). See discussion on the Black Sea in Introduction. Some twenty-six species of fishes have traditionally been commercially harvested in the Black Sea, including valuable taxa such as sturgeon, bluefish, bonito and turbot.

There was a dramatic expansion in fisheries effort during the 1960s by most of the nations bordering the sea. This appears to have been linked with an increase in marine productivity because of increasing nutrient loads, although this went on to have an adverse effect on the Black Sea benthos. The larger and most valuable species (including sturgeons, river herring, and pelagic migratory species such as bonito and bluefish) rapidly became overfished, along with Porpoise *Phocoena phocoena*, within the Black Sea and in the Sea of Marmara. Severe reductions in the populations of these mainly predatory species, coupled with the increasing nutrient load, seem to have led to a increase in biomass of small pelagic species, most notably of the anchovy *Engraulis encrasicolus*. Declared landings, mostly of anchovy, rose from a previous level of around 350,000-400,000 tonnes to nearly 1 million tonnes during the late 1970s. During the same period, there was a general decrease in diversity of planktonic species and rapid blooms of one species of zooplankton (*Noctiluca miliaris*). In the 1980s there was dramatic increase in numbers of the jellyfish *Aurelia aurita*, whose biomass in the sea was estimated to reach an extraordinary 450 million tonnes at that time.

The anchovy fisheries collapsed at the end of the 1980s: declared harvest in the Black Sea proper (excluding the Sea of Azov) decreased from 520,000 tonnes in 1988 to around 160,000 tonnes in 1989; the Sea of Azov anchovy catch declined from 30,000 tonnes in 1986 to virtually zero in 1989. Overall catch has continued to decline, dropping to below 100,000 tonnes in 1990 and 1991.

Overfishing is an important factor, but biologists believe that the accidental introduction of the predatory ctenophore (comb-jelly) *Mnemiopsis leidyi* to Black Sea waters has been a major cause. This species is native to estuaries in North America and believed to have been introduced in discharged ballast water from oil tankers. This comb-jelly feeds on plankton, including fish eggs and fry, and appears to have no known predators in the Black Sea. Populations of this species exploded in the late 1980s and subsequently decreased, although the species is now well established, with seasonal blooms which occur during the breeding season.

# MEDITERRANEAN

**Albania, Algeria, Bosnia & Herzegovina, Croatia, Cyprus, *Egypt*, *France*, Greece, *Israel*, Italy, Lebanon, Libya, Malta, Monaco, *Morocco*, Slovenia, *Spain*, Syria, Tunisia, *Turkey*,** Gibraltar (to UK)

**Contains Data for PostScript Only.**

## LARGE MARINE ECOSYSTEMS

### Mediterranean Sea

The Mediterranean region is congruent with the Mediterranean Sea LME. This is a nearly enclosed basin with very narrow connections to three other water bodies: the Atlantic (through the Straits of Gibraltar), the Black Sea (through the Dardanelles and the Sea of Marmara), and the Red Sea (by the Suez Canal). The Mediterranean is about 2.6 million $km^2$ in extent. It is comprised of two main basins, the eastern larger than the western, separated by shallows around Sicily. The Mediterranean receives low freshwater input, mainly from northern shores, but a major inflow of well-oxygenated, nutrient-poor Atlantic surface water through the Straits of Gibraltar. Evaporation from the basin greatly exceeds freshwater input, so this exchange is critical for maintenance of oxygen, salinity and nutrient levels. There is a balancing outflow of deeper water, relatively rich in nutrients, westward into the Atlantic. The shelf zone is narrow generally, but with more extensive and relatively productive shallows in places (eg. the Gulf of Gabes, Tunisia). The basin is heavily impacted by pollutants from industrial, agricultural and sewage sources. There are local concentrations of small pelagic fishes around gyres and upwellings; most such stocks, except the anchovy, are only moderately exploited. Demersal fishery stocks and large pelagic species (eg. swordfish, tuna) are heavily exploited.

## BIODIVERSITY

### Mediterranean Regional Sea: biodiversity data

| | endemic | T | % | | endemic | T | % |
|---|---|---|---|---|---|---|---|
| seagrasses | 1 | 5 | 10 | sharks | 0 | 43 | 12 |
| coral genera | - | 0 | - | seabirds | 1 | 22 | 8 |
| molluscs | 0 | 138 | 3 | cetaceans | 0 | 16 | 18 |
| shrimps | 0 | 31 | 2 | sirenians | - | 0 | - |
| lobsters | 0 | 11 | 7 | pinnipeds | - | 1 | 3 |

Notes: the data refer to species except for coral genera. Column headings: endemic = restricted to the region; T = total species richness in the region; % = species richness in the region as a percentage of the world species richness in each group of organism. A dash (-) in a cell means no data or not applicable. See **Notes and Sources** in the introductory text for further information on the sources, coverage and quality of the data tabulated.

**Mediterranean Regional Sea: regional endemic species**

| | scientific name | common name | status |
|---|---|---|---|
| seagrasses | **Posidonia oceanica* | | |
| seabirds | *Puffinus yelkouan* | Levant shearwater | |

* near endemic

### Biodiversity Notes

There is moderate **seagrass** diversity, with one almost endemic species. There are no **hermatypic corals** in the Mediterranean. **Molluscs** are moderately rich in species, as are larger **crustaceans**, especially shrimps and prawns.

Recorded **shark** diversity is moderate; **seabird** diversity is relatively low, with only one species endemic to the region (and this, the Levant Shearwater *Puffinus yelkouan*, being only arguably a distinct species).

Amongst **sea turtles**, the Green Turtle *Chelonia mydas* and Loggerhead *Caretta caretta* nest regularly, but only the latter in large numbers; the Leatherback *Dermochelys coriacea* has been known to nest occasionally. The Green Turtle nests only in the extreme Mediterranean, in southeast Turkey and in Cyprus. The Loggerhead is more widespread.

Relatively few **cetacean** species have been recorded in the Mediterranean and no **sirenians**. The only **pinniped** is the critically endangered Mediterranean Monk Seal *Monachus monachus* which also occurs along in the Atlantic (in the North Atlantic and West and Central African Regions).

## FISHERIES

The Mediterranean comprises most of FAO Statistical Area 37, the remainder of this area being the Black Sea which is discussed above. Annual recorded landings in the Mediterranean have remained at around 1.2 million tonnes since the 1980s. However, a significant proportion of fishing in the Mediterranean is carried out by small vessels whose existence and catch are both seriously under-reported in FAO databases, so that actual landings in the Mediterranean are undoubtedly higher than this. Discards in the region are estimated at around 25% of actual catch, or close to the global average.

Fisheries involve demersals, large pelagics and small pelagics (notably anchovy). With the exception of a few wide-shelf areas (Gulf of Gabes, Catalonia Shelf, Gulf of Lions and Adriatic Sea), shelf and slope habitats of exploitable demersal populations within the Mediterranean are narrow and generally close to shore, although there are some valuable deeper water demersal resources (royal red shrimp, large hake, red coral). Much of the narrow shelf has an untrawlable bottom and is fished by small-vessels with a wide variety of fishing gear.

The Mediterranean has a long history of very high local fishing pressure leading to stock depletions, and research in support of fisheries management is only a relatively recent phenomenon.

Mediterranean demersal resources and anchovy are subject to very high fishing pressure along most continental shelves and their stocks are highly dependent on favourable recruitment. If recruitment levels drop owing to unfavourable environmental conditions, and fishing pressure remains high, stocks are likely to collapse. Few countries have yet taken action to control fishing effort, so that the these stocks remain permanently at risk from overfishing.

Similarly, pressure has increased greatly over the past twenty years on the large pelagics, notably bluefin tuna, swordfish, bonito and dolphin fish. Many swordfish and tuna fisheries in the Mediterranean now appear to be operating on very young, small fish, indicating overfishing. In some areas, however, recruitment rates appear to have increased, possibly as a result of increases in the small pelagic species which are the principal prey of the large pelagics.

Small pelagic species, with the exception of anchovy, do not appear to be very heavily fished. As elsewhere, populations show wide fluctuations which generally do not seem to relate directly to fishing pressure. Many stocks appear to have been increasing in abundance over the past 25 years. More generally, overall fishing yields in the Mediterranean have remained steady or risen over this time period, despite steadily increasing fishing effort, which would have been expected to have led to depletions. It is thought likely that this is the result of increased productivity through increased nutrient runoff from rivers and coastal areas, as a result of human activities. These effects are particularly marked in the Adriatic (from the Po River and others), the Aegean (which receives enriched water from the Black Sea) and the Gulf of Lions (from the Rhône River) all of which have shown increased landings. These productive areas correlate well with areas of high phytoplankton concentration as revealed by remote sensing imagery.

Although this anthropogenic eutrophication has arguably been beneficial to fisheries yields to date, its long term effect is likely to be less positive, as evinced by the virtual collapse of the Black Sea ecosystem. Predicted outcomes include increase in anoxia and hypoxia to bottom waters leading to decreases of valuable demersal stocks, increases in harmful algal blooms (already observed in the Adriatic) and possible large scale changes to trophic structure, particularly if fishing of larger predatory species is not controlled, so that small pelagics become the major components of fish biomass.

# BLACK SEA

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**Bulgaria, Georgia, Romania, Russia, *Turkey*, Ukraine**

## LARGE MARINE ECOSYSTEMS

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## BIODIVERSITY

**Black Sea Regional Sea: biodiversity data**

| | endemic | T | % | | endemic | T | % |
|---|---|---|---|---|---|---|---|
| seagrasses | - | 4 | 8 | sharks | - | 1 | - |
| coral genera | - | 0 | - | seabirds | 1 | 17 | 6 |
| molluscs | 0 | 6 | 0 | cetaceans | 0 | 3 | 3 |
| shrimps | 0 | 6 | 2 | sirenians | - | 0 | - |
| lobsters | 0 | 1 | 0 | pinnipeds | 0 | 1 | 3 |

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**Black Sea Regional Sea: regional endemic species**

| | scientific name | common name | status |
|---|---|---|---|
| seabirds | *Larus armenicus* | Armenian gull | |

**Biodiversity notes**

Diversity in general is low. Four species of **seagrass** reportedly occur, mainly in the south, none is endemic. There are no **hermatypic coral** genera in the Black Sea. There are very few molluscs and larger crustaceans.  Only one species of **shark** has been recorded, although this may well be an underestimate. No **sea turtle** species is known to nest in the Black Sea; the Green Turtle *Chelonia mydas* and Loggerhead *Caretta caretta* have been recorded in Black Sea waters. **Seabird** diversity is low, although one species is endemic to the region. Three species of **cetacean** have been recorded. One of these, the Harbour Porpoise *Phocoena phocoena*, was formerly abundant but is now very reduced in numbers. There are no **sirenians** in the Black Sea, but one **pinniped**, the Mediterranean Monk Seal *Monachus monachus* (Critically Endangered) was formerly present, although is now believed extinct there.

**FISHERIES**

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There was a dramatic expansion in fisheries effort during the 1960s by most of the nations bordering the sea. This appears to have been linked with an increase in marine productivity because of increasing nutrient loads, although this went on to have an adverse effect on the Black Sea benthos. The larger and most valuable species (including sturgeons, river herring, and pelagic migratory species such as bonito and bluefish) rapidly became overfished, along with Porpoise *Phocoena phocoena*, within the Black Sea and in the Sea of Marmara. Severe reductions in the populations of these mainly predatory species, coupled with the increasing nutrient load, seem to have led to a increase in biomass of small pelagic species, most notably of the anchovy *Engraulis encrasicolus*. Declared landings, mostly of anchovy, rose from a previous level of around 350,000-400,000 tonnes to nearly 1 million tonnes during the late 1970s. During the same period, there was a general decrease in diversity of planktonic species and rapid blooms of one species of zooplankton (*Noctiluca miliaris*). In the 1980s there was dramatic increase in numbers of the jellyfish *Aurelia aurita*, whose biomass in the sea was estimated to reach an extraordinary 450 million tonnes at that time.

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Overfishing is an important factor, but biologists believe that the accidental introduction of the predatory ctenophore (comb-jelly) *Mnemiopsis leidyi* to Black Sea waters has been a major cause. This species is native to estuaries in North America and believed to have been introduced in discharged ballast water from oil tankers. This comb-jelly feeds on plankton, including fish eggs and fry, and appears to have no known predators in the Black Sea. Populations of this species exploded in the late 1980s and subsequently decreased, although the species is now well established, with seasonal blooms which occur during the breeding season.

# MEDITERRANEAN

**Albania, Algeria, Bosnia & Herzegovina, Croatia, Cyprus, *Egypt*, *France*, Greece, *Israel*, Italy, Lebanon, Libya, Malta, Monaco, *Morocco*, Slovenia, *Spain*, Syria, Tunisia, *Turkey*,** Gibraltar (to UK)

**Contains Data for PostScript Only.**

## LARGE MARINE ECOSYSTEMS

### Mediterranean Sea

The Mediterranean region is congruent with the Mediterranean Sea LME. This is a nearly enclosed basin with very narrow connections to three other water bodies: the Atlantic (through the Straits of Gibraltar), the Black Sea (through the Dardanelles and the Sea of Marmara), and the Red Sea (by the Suez Canal). The Mediterranean is about 2.6 million $km^2$ in extent. It is comprised of two main basins, the eastern larger than the western, separated by shallows around Sicily. The Mediterranean receives low freshwater input, mainly from northern shores, but a major inflow of well-oxygenated, nutrient-poor Atlantic surface water through the Straits of Gibraltar. Evaporation from the basin greatly exceeds freshwater input, so this exchange is critical for maintenance of oxygen, salinity and nutrient levels. There is a balancing outflow of deeper water, relatively rich in nutrients, westward into the Atlantic. The shelf zone is narrow generally, but with more extensive and relatively productive shallows in places (eg. the Gulf of Gabes, Tunisia). The basin is heavily impacted by pollutants from industrial, agricultural and sewage sources. There are local concentrations of small pelagic fishes around gyres and upwellings; most such stocks, except the anchovy, are only moderately exploited. Demersal fishery stocks and large pelagic species (eg. swordfish, tuna) are heavily exploited.

## BIODIVERSITY

### Mediterranean Regional Sea: biodiversity data

| | endemic | T | % | | endemic | T | % |
|---|---|---|---|---|---|---|---|
| seagrasses | 1 | 5 | 10 | sharks | 0 | 43 | 12 |
| coral genera | - | 0 | - | seabirds | 1 | 22 | 8 |
| molluscs | 0 | 138 | 3 | cetaceans | 0 | 16 | 18 |
| shrimps | 0 | 31 | 2 | sirenians | - | 0 | - |
| lobsters | 0 | 11 | 7 | pinnipeds | - | 1 | 3 |

Notes: the data refer to species except for coral genera. Column headings: endemic = restricted to the region; T = total species richness in the region; % = species richness in the region as a percentage of the world species richness in each group of organism. A dash (-) in a cell means no data or not applicable. See **Notes and Sources** in the introductory text for further information on the sources, coverage and quality of the data tabulated.

**Mediterranean Regional Sea: regional endemic species**

| | scientific name | common name | status |
|---|---|---|---|
| seagrasses | **Posidonia oceanica* | | |
| seabirds | *Puffinus yelkouan* | Levant shearwater | |

* near endemic

**Biodiversity Notes**

There is moderate **seagrass** diversity, with one almost endemic species. There are no **hermatypic corals** in the Mediterranean. **Molluscs** are moderately rich in species, as are larger **crustaceans**, especially shrimps and prawns.

Recorded **shark** diversity is moderate; **seabird** diversity is relatively low, with only one species endemic to the region (and this, the Levant Shearwater *Puffinus yelkouan*, being only arguably a distinct species).

Amongst **sea turtles**, the Green Turtle *Chelonia mydas* and Loggerhead *Caretta caretta* nest regularly, but only the latter in large numbers; the Leatherback *Dermochelys coriacea* has been known to nest occasionally. The Green Turtle nests only in the extreme Mediterranean, in southeast Turkey and in Cyprus. The Loggerhead is more widespread.

Relatively few **cetacean** species have been recorded in the Mediterranean and no **sirenians**. The only **pinniped** is the critically endangered Mediterranean Monk Seal *Monachus monachus* which also occurs along in the Atlantic (in the North Atlantic and West and Central African Regions).

**FISHERIES**

The Mediterranean comprises most of FAO Statistical Area 37, the remainder of this area being the Black Sea which is discussed above. Annual recorded landings in the Mediterranean have remained at around 1.2 million tonnes since the 1980s. However, a significant proportion of fishing in the Mediterranean is carried out by small vessels whose existence and catch are both seriously under-reported in FAO databases, so that actual landings in the Mediterranean are undoubtedly higher than this. Discards in the region are estimated at around 25% of actual catch, or close to the global average.

Fisheries involve demersals, large pelagics and small pelagics (notably anchovy). With the exception of a few wide-shelf areas (Gulf of Gabes, Catalonia Shelf, Gulf of Lions and Adriatic Sea), shelf and slope habitats of exploitable demersal populations within the Mediterranean are narrow and generally close to shore, although there are some valuable deeper water demersal resources (royal red shrimp, large hake, red coral). Much of the narrow shelf has an untrawlable bottom and is fished by small-vessels with a wide variety of fishing gear.

The Mediterranean has a long history of very high local fishing pressure leading to stock depletions, and research in support of fisheries management is only a relatively recent phenomenon.

Mediterranean demersal resources and anchovy are subject to very high fishing pressure along most continental shelves and their stocks are highly dependent on favourable recruitment. If recruitment levels drop owing to unfavourable environmental conditions, and fishing pressure remains high, stocks are likely to collapse. Few countries have yet taken action to control fishing effort, so that the these stocks remain permanently at risk from overfishing.

Similarly, pressure has increased greatly over the past twenty years on the large pelagics, notably bluefin tuna, swordfish, bonito and dolphin fish. Many swordfish and tuna fisheries in the Mediterranean now appear to be operating on very young, small fish, indicating overfishing. In some areas, however, recruitment rates appear to have increased, possibly as a result of increases in the small pelagic species which are the principal prey of the large pelagics.

Small pelagic species, with the exception of anchovy, do not appear to be very heavily fished. As elsewhere, populations show wide fluctuations which generally do not seem to relate directly to fishing pressure. Many stocks appear to have been increasing in abundance over the past 25 years. More generally, overall fishing yields in the Mediterranean have remained steady or risen over this time period, despite steadily increasing fishing effort, which would have been expected to have led to depletions. It is thought likely that this is the result of increased productivity through increased nutrient runoff from rivers and coastal areas, as a result of human activities. These effects are particularly marked in the Adriatic (from the Po River and others), the Aegean (which receives enriched water from the Black Sea) and the Gulf of Lions (from the Rhône River) all of which have shown increased landings. These productive areas correlate well with areas of high phytoplankton concentration as revealed by remote sensing imagery.

Although this anthropogenic eutrophication has arguably been beneficial to fisheries yields to date, its long term effect is likely to be less positive, as evinced by the virtual collapse of the Black Sea ecosystem. Predicted outcomes include increase in anoxia and hypoxia to bottom waters leading to decreases of valuable demersal stocks, increases in harmful algal blooms (already observed in the Adriatic) and possible large scale changes to trophic structure, particularly if fishing of larger predatory species is not controlled, so that small pelagics become the major components of fish biomass.

# EAST ASIAN SEAS

***Australia*, Cambodia, *China*, Indonesia, Malaysia, Myanmar, Philippines, Singapore, Thailand, Vietnam,** Taiwan, Brunei

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## LARGE MARINE ECOSYSTEMS

The East Asian Seas region covers the eastern portion of the Bay of Bengal LME and the entirety of another four LMEs: South China Sea, Sulu-Celebes Sea, Indonesian Seas and the Northern Australian Shelf. The region is geomorphologically highly diverse; it includes shallow shelf zones, deep trenches, straits and channels separating many large and innumerable small islands, all carried on a complex pattern of tectonic plates. To the east of the region, at around the latitude of Luzon, the west-flowing North Equatorial Current divides into the Kuroshio Current, flowing north, and the Mindanao Current, flowing south. There is evidence that many rivers in the region are carrying an increasing load of terrigenous sediments into coastal waters, which are also heavily impacted by pollution from coastal industries and human settlements.

### South China Sea

This LME extends over some 3.5 million km$^2$, from the mainland coast of Asia, where it is divided into subsystems (eg. the Gulf of Thailand and the Gulf of Tonkin), to the western margins of the Philippines and the island of Borneo. Productivity tends to be high in coastal areas and low at depth. Coastal fishery resources have been heavily impacted by overfishing and pollution.

### Sulu-Celebes Seas

This is a semi-enclosed LME, extending over 900,000 km$^2$ between Palawan (Philippines) in the north and Sulawesi in the south. Much of the region has a depth greater than 3,000 m. The offshore waters are little exploited and fishing is mainly limited to coastal areas; coastal trawling for prawn is a major export base and artisanal fishing takes finfish for local consumption.

### Indonesian Seas

Centred on the Banda Sea, and including the Arafura Sea, this moderate-size (400,000 km$^2$) tropical LME lies entirely within Indonesian territory. The sea and its productivity are much influenced by annual monsoon effects, and to some extent by El Niño-Southern Oscillation events. Pelagic fish resources, apparently enhanced during seasonal upwellings, are generally underexploited.

### North Australian Shelf

This LME is composed of the continental shelf waters of north and northwest Australia. It supports a diverse and productive community of demersal fishes.

## BIODIVERSITY

### East Asian Regional Sea: biodiversity data

| | endemic | T | % | | endemic | T | % |
|---|---|---|---|---|---|---|---|
| seagrasses | 1 | 17 | 35 | sharks | 23 | 140 | 40 |
| coral genera | 4 | 82 | 75 | seabirds | 2 | 39 | 13 |
| molluscs | 0 | 1,114 | 27 | cetaceans | 0 | 28 | 32 |
| shrimps | 0 | 162 | 47 | sirenians | 0 | 1 | 25 |
| lobsters | 6 | 48 | 32 | pinnipeds | - | 0 | - |

Notes: the data refer to species except for coral genera. Column headings: endemic = restricted to the region; T = total species richness in the region; % = species richness in the region as a percentage of the world species richness in each group of organism. A dash (-) in a cell means no data or not applicable. See **Notes and Sources** in the introductory text for further information on the sources, coverage and quality of the data tabulated.

### East Asian Regional Sea: regional endemic species

| | scientific name | common name | status |
|---|---|---|---|
| seagrasses | *Cymodocea angustata* | | |
| lobsters | *Metanephrops arafurensis* | Arafura lobster | |
| | *Metanephrops australiensis* | Northwest lobster | |
| | *Metanephrops neptunus* | Neptune lobster | |
| | *Metanephrops sinensis* | China lobster | |
| | *Neoglyphea inopinata* | Fenix lobster | |
| | *Puerulus velutinus* | Velvet whip lobster | |
| sharks | *Apristurus herklotsi* | Longfin catshark | |
| | *Apristurus sibogae* | Pale catshark | |
| | *Apristurus sinensis* | South China catshark | |
| | *Apristurus verweyi* | Borneo catshark | |
| | *Asymbolus* sp. A | | |
| | *Atelomycterus* sp. A | | |
| | *Carcharhinus borneensis* | Borneo shark | |
| | *Centrophorus niaukang* | Taiwan gulper shark | |
| | *Cirrhoscyllium expolitum* | Barbelthroat carpetshark | |
| | *Cirrhoscyllium formosanum* | Taiwan saddled carpetshark | |
| | *Etmopterus decacuspidatus* | Combtoothed lanternshark | |
| | *Etmopterus* sp. C | lanternshark | |
| | *Etmopterus* sp. E | lanternshark | |
| | *Galeus schultzi* | Dwarf sawtail catshark | |
| | *Halaelurus immaculatus* | Spotless catshark | |
| | *Halaelurus* sp. A | | |

| | scientific name | common name | status |
|---|---|---|---|
| sharks (continued) | *Hemitriakis leucoperiptera* | Whitefin topeshark | |
| | *Hemitriakis* sp. A | | |
| | *Parmaturus melanobranchius* | Blackgill catshark | |
| | *Pentanchus profundicolus* | Onefin catshark | |
| | *Squalus* sp. D | | |
| | *Squatina formosa* | Taiwan angelshark | |
| | *Squatina tergocellatoides* | Ocellated angelshark | |
| seabirds | *Fregata andrewsi* | Christmas frigatebird | VU |
| | *Papasula abbotti* | Abbott's booby | VU |

Notes: letters in the 'status' column indicate the conservation status of species that have been assessed and classified as threatened. In the revised IUCN Red List category system the term 'threatened' refers only to species in any of the following three categories: CR - Critically Endangered, EN - Endangered, VU - Vulnerable. Seabirds have been assessed by BirdLife International, Collar *et al*. (1994); all status categories are recorded in IUCN (1996).

### Biodiversity Notes

**Seagrass** diversity is high, though marginally lower than the South Pacific Region; one species is apparently endemic.The East Asian Seas Region is the world centre of diversity for **hermatypic corals**. More than 80 genera are recorded, of which four appear to be endemic to the region. This region has the highest number of **molluscs** and **shrimps**, although none appears to be endemic. It also has high diversity of **lobsters**, with the second highest endemism count (six).

Similarly, recorded **shark** diversity is higher here than in any other region, with a correspondingly large number of endemics. **Sea turtle** diversity is very high, with six of the world's seven species nesting in the region (only Kemp's Ridley *Lepidochelys kempii* is absent). One species, the Flatback *Natator depressus*, is nearly endemic as a breeding species to the region, only occurring in northern Australia and patchily along the Great Barrier Reef (in the South Pacific Region). There are also globally important nesting populations of Green Turtle *Chelonia mydas*, Hawksbill *Eretmochelys imbricata* and Leatherback *Dermochelys coriacea*.

As with most other largely tropical areas, **seabird** diversity is only moderate, although there are two endemic species, both confined as breeding species to Christmas Island (to Australia) in the Indian Ocean.

Recorded **cetacean** diversity is only moderate, with no endemics. There are no **pinnipeds** but important, though declining, numbers of one **sirenian**, the Dugong *Dugong dugon* (Vulnerable).

## FISHERIES

The region comprises the western part of FAO Fisheries Statistical Area 71 (West-central Pacific) and the northeastern part of FAO Fisheries Statistical Area 57 (Eastern Indian Ocean). Although the southern part of China is part of this region, China's fisheries have been included under the Northwest Pacific Region.

Annual fishery landings in the region have grown steadily, from just under 7 million tonnes in the mid-1980s to nearly 9 million tonnes in 1991-1992. However, the rate of growth has slowed considerably recently. Indonesia and Thailand between then account for just under 60% of the recorded catch, with the Philippines contributing a further 20%. Estimated discard rate here is near the global average (around 25%).

The Sunda Shelf provides an extensive area of shallow water fishery in the region. Most of the catch consists of demersal species and small pelagics. Prawn aquaculture has grown dramatically in the region in the past decade and makes an increasingly large contribution to overall landings. Most of the landings in Indonesia and the Philippines are from small-scale artisanal fisheries. The Thai fishing industry is more industrialised.

The increase in catch in the region is largely attributable to the extension of fishing grounds into new areas, as many traditionally fished areas have been overfished. Demersal stocks in particular are overexploited in the Gulf of Thailand and Malacca Straits. Pelagic stocks, including mackerels, round scads and sardines are also heavily exploited here, particularly in the Bali Strait region and in nearshore Philippines waters.

The fishery in the Gulf of Thailand have been studied for many years. It is the site of a large trawl fishery which underwent explosive growth in the 1960s and 1970s once its potential was understood and a suitable, light-bottomed trawl was developed. The composition of the fish fauna has changed dramatically since the 1960s. Formerly, demersal finfishes, particularly in the family Leiognathidae, were dominant, but since the 1970s squids, particularly *Loligo*, which formerly comprised an insignificant proportion of the stock, have dominated (Longhurst and Pauly, 1987). This has been attributed to overfishing of the larger predatory finfish species. It seems very likely that, as in other enclosed or semi-enclosed systems (eg. the Black Sea and Baltic) eutrophication from vastly increased sediment and nutrient runoff has also had an impact.

More generally, the degradation of coastal environments in the region is a major and growing problem. Impacts include effluent runoff, land reclamation and clearance of mangrove. Increasing prawn aquaculture is one of the major causes of the last of these.

Few countries in the region have implemented fisheries management plans and in many areas fishing techniques are highly destructive (eg. dynamite and muro-ami fishing on reefs in the Philippines). With the exception of Northern Australia, where the most important fishery is for prawns, there is a pressing need for improved management and cooperation between countries. The political status of disputed areas, most notably the Spratly Islands and Paracel Shoals in the central part of the South China Sea exacerbates management problems.

# NORTHWEST PACIFIC

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***China;* Japan; North Korea; South Korea; *Russia*;** Hong Kong

## LARGE MARINE ECOSYSTEMS

There are seven LMEs wholly contained within the region: the East China Sea, the Yellow Sea, the Kuroshio Current, the Sea of Japan, the Oyashio Current, the Sea of Okhotsk, and the West Bering Sea.

### East China Sea

This is a semi-enclosed area bordered by the Yellow Sea, the Kuroshio Current, and the countries of China, South Korea, and Japan. It has a maximum depth of 2,700 m and is very productive. The shallow coastal waters provide spawning and nursery grounds for many species of pelagic fish. Local circulation patterns are influenced by the bordering Kuroshio (warm)-Oyashio (cold) Current system and by the Chang Jiang (Yangtze) river. The warm Tsushima Current originates in the East China Sea. Sea surface temperatures range between 8°C and 26°C.

### Yellow Sea

The Yellow Sea LME is also a semi-enclosed area, bounded by the Chinese mainland to the north and west, the Korean Peninsula to the east, and the East China Sea to the south. The continental shelf is one of the widest in the world and the average depth is 44 m. The whole area has a slow flushing rate and regional circulation is affected by the Kuroshio Current and the Huang He (Yellow River) which drains into the northern portion of the Yellow Sea. The sea surface temperatures vary between 3°C in winter and 24°C in summer.

### Kuroshio Current

The Kuroshio Current is a warm water current that extends along the Ryukyu Archipelago and divides at the southern tip of Kyushu, entering the Yellow Sea and the Sea of Japan. It is a large scale current approximately 100 km wide, with an average speed of 3-4 knots and a volume transport of 30-60 million tons¨sec$^{-1}$. The strongest currents occur along the Ryukyu Archipelago where the Kuroshio exceeds 10 knots throughout the year.

### Sea of Japan

The Sea of Japan LME is almost entirely enclosed by Japan, Russia, North Korea and South Korea. The maximum depth is 4,000 m, with an average depth of 1,000 m. This area is influenced by the Kuroshio-Oyashio current system. The Kuroshio Current enters the Sea of Japan as the Tsushima Current; fronts where this warm current and the cold Oyashio current meet off northern Japan give rise to very productive areas.

### Oyashio Current

This cold water current originates in the Sea of Okhotsk and is also called the Kurile Current. It flows southward along the coast of northern Japan.

### Sea of Okhotsk

The Sea of Okhotsk is a continental marginal water body with an area of about 1.6 million $km^2$. It is located between the Russian mainland, the Kamchatka Peninsula, the Kurile Islands and Hokkaido Island, Japan. Local circulation is strongly influenced by the Oyashio Current, which arises in this area. The maximum depth is 5,200 m, with an average depth of 1,000 m. It is largely ice covered during the winter.

### West Bering Sea

The West Bering Sea is defined as the deeper areas of the Bering Sea, to the west and south of the eastern continental shelf. The maximum depth of this area is 4,200 m but it has an average depth of 1,000 m. The deep Aleutian Basin determines bottom topography, and the main hydrographic influence is the very cold Subarctic Current.

## BIODIVERSITY

### Northwest Pacific Regional Sea: biodiversity data

| | endemic | T | % | | endemic | T | % |
|---|---|---|---|---|---|---|---|
| seagrasses | 5 | 13 | 27 | sharks | 9 | 93 | 27 |
| coral genera | 0 | 69 | 63 | seabirds | 6 | 69 | 24 |
| molluscs | 4 | 404 | 10 | cetaceans | 0 | 37 | 42 |
| shrimps | 0 | 91 | 26 | sirenians | - | 0 | - |
| lobsters | 7 | 37 | 25 | pinnipeds | 1 | 8 | 24 |

Notes: the data refer to species except for coral genera. Column headings: endemic = restricted to the region; T = total species richness in the region; % = species richness in the region as a percentage of the world species richness in each group of organism. A dash (-) in a cell means no data or not applicable. See **Notes and Sources** in the introductory text for further information on the sources, coverage and quality of the data tabulated.

**Northwest Pacific Regional Sea: regional endemic species**

| | scientific name | common name | status |
|---|---|---|---|
| seagrasses | *Phyllospadix iwatensis* | | |
| | *Phyllospadix japonicus* | | |
| | *Zostera asiatica* | | |
| | *Zostera caespitosa* | | |
| | *Zostera caulescens* | | |
| molluscs | *Euspira yokoyamai* | Yokoyama's Moon | |
| | *Natica janthostomoides* | Violet-mouthed Moon | |
| | *Natica tabularis* | Tabulated Moon | |
| | *Neverita vestita* | Adorned Moon | |
| lobsters | *Callianassa japonica* | Japanese ghost shrimp | |
| | *Callianassa petulara* | Flower ghost shrimp | |
| | *Metanephrops japonicus* | Japanese lobster | |
| | *Metanephrops sagamiensis* | Sculpted lobster | |
| | *Parribacus japonicus* | Japanese mitten lobster | |
| | *Thaumastocheles japonicus* | Pacific prince lobster | |
| | *Upogebia major* | Japanese mud shrimp | |
| sharks | *Apristurus japonicus* | Japanese catshark | |
| | *Apristurus longicephalus* | Longhead catshark | |
| | *Apristurus platyrhynchus* | Spatulasnout catshark | |
| | *Centroscyllium kamoharai* | Bareskin dogfish | |
| | *Centroscyllium ritteri* | Whitefin dogfish | |
| | *Cirrhoscyllium japonicum* | Saddle carpetshark | |
| | *Etmopterus unicolor* | Brown lanternshark | |
| | *Galeus nipponensis* | Broadfin sawtail catshark | |
| | *Parmaturus pilosus* | Salamander shark | |
| seabirds | *Cepphus carbo* | Spectacled guillemot | |
| | *Diomedea albatrus* | Short-tailed albatross | EN |
| | *Larus schistisagus* | Slaty-backed gull | |
| | *Oceanodroma matsudairae* | Matsudaira's storm-petrel | |
| | *Puffinus bannermani* | Bannerman's shearwater | |
| | *Synthliboramphus wumizusume* | Japanese murrelet | VU |
| pinnipeds | **Phoca largha* | Larga seal | |

Notes: letters in the 'status' column indicate the conservation status of species that have been assessed and classified as threatened. In the revised IUCN Red List category system the term 'threatened' refers only to species in any of the following three categories: CR - Critically Endangered, EN - Endangered, VU - Vulnerable. Seabirds have been assessed by BirdLife International, Collar *et al*. (1994); all status categories are recorded in IUCN (1996). * present in Alaska (Northeast Pacific) but not known to breed there.

**Biodiversity Notes**

**Seagrass** richness is very high, although lower than in the East Asian Seas or South Pacific; however, recorded rates of endemism are very high compared with elsewhere. Similarly, generic diversity of **hermatypic corals** is very high, although lower than the East Asian Seas or South Pacific Regions; no endemic genus has been recorded. Diversity of **molluscs**, **shrimp** and **lobsters** is high, with significant endemism in first and last groups.

**Shark** and **seabird** diversity are both high, with a notable number of endemics and one Endangered species, the Short-tailed Albatross *Diomedea albatrus*, which breeds on the southern Japanese islands. Four species of **Sea Turtle** are recorded as breeding (the Green Turtle *Chelonia mydas*, Loggerhead *Caretta caretta*, Hawksbill *Eretmochelys imbricata*, and Leatherback *Dermochelys coriacea*). The Loggerhead population is regionally important, and provides most of the young *Caretta* impacted by the North Pacific drift-net fishery, and which are known to feed off Baja California (Bowen *et al*., 1995).

**Cetacean** diversity is average, with no species apparently confined to the region. There are no extant resident populations of **Sirenian** although the Dugong *Dugong dugon* has been recorded off the Japanese Ryukyu islands and the now extinct Steller's Sea Cow *Hydrodamalis gigas* once occurred in the Bering Seas on the border of the Northwest and Northeast Pacific Regions. **Pinniped** diversity is moderately high and two other species of marine mammal occur, the Polar Bear *Ursus maritimus* and Northern Sea Otter *Enhydra lutris*. Neither is endemic; the Polar Bear is categorised as Lower Risk: conservation dependent.

## FISHERIES

Overall, the fishery in the northwest Pacific is the largest in the world, accounting for nearly one third of all recorded marine landings. If estimated discards are taken into account, this fishery is twice the size of the next largest, that in the southeast Pacific. In contrast to the latter, which is overwhelmingly dominated by small pelagics, demersal species (notably, Alaska Pollock) make a significant contribution to the overall catch, although the majority of the catch is still small pelagic species.

The recorded catch in the area peaked at nearly 27 million tonnes in 1987 but declined to 24.2 million tonnes in 1992, largely because of a decline in Japanese Sardine and Alaska Pollock catch. The decline would have been even more marked but for a large increase in mariculture production (largely in China), most notably of the Yesso Scallop.

The Alaska Pollock population is shared with the Northeast Pacific region, which accounts for about 30% of landings. It is by far the largest demersal fishery in the world. The catch has dropped consistently since 1986, when it exceeded 5 million tonnes, to 3.5 million tonnes in 1992 and all stocks are considered fully fished or overexploited. Catches increasingly consist of low-value, undifferentiated fish, this being a strong indication of overexploitation. Stocks in the Sea of Okhotsk and the Namuro Straits are believed particularly badly overfished.

The stocks of small coastal pelagic fishes exhibit large fluctuations in abundance and dramatic changes in dominance from one species to another. This is most apparent around Japan, where the main species involved are Pacific Herring, Pacific Saury, Japanese Sardine, Japanese Chub Mackerel, Japanese Anchovy and Japanese Jack Mackerel. Total annual catches during the late 1980s for these species were between 6 and 8 million tonnes. Since 1990 they have declined sharply, to just over 5 million tonnes in

1992, mostly as result of declines in Japanese Sardine catch.

Clearly, many fisheries in this area are in serious need of improved management, most notably those in the Yellow Sea and East China Sea and Alaska Pollock fisheries in the north.

**Yellow Sea**

Demersal stocks and those of the larger predatory pelagics here are seriously depleted and show little sign of recovery. They are estimated to be between one fifth and one tenth of their highest levels. Coastal fisheries using fine-mesh nets are thought to cause serious losses of post-larval and juvenile stages of these species, hampering any recovery. The region also suffers major environmental impacts, including land reclamation, extensive mariculture, heavy metal pollution and oil spills. Inflow from the sediment- and nutrient-laden Huang He (Yellow River), combined with the low circulation rate is almost certainly leading to eutrophication. The combined effect appears to be a switch in dominant fish biomass to the smaller (and less valuable) pelagics. Since the early 1980s anchovies have increased dramatically in abundance and are now the major component of the fish biomass. This situation appears similar to that in the Black Sea, which is discussed in some detail.

**East China Sea**

The situation in the East China Sea is similar to that in the Yellow Sea, with a dramatic reduction in stocks of demersal species and larger pelagics. Overall catches in the region have risen by a factor of around 2.6 since the 1960s, but fishing fleet capacity has risen by a factor of around 7.6 so that catch per unit effort has dropped by a factor of three, indicating serious over-capitalisation. This has been accompanied, as in the Yellow Sea, by a shift to small, lower-trophic level fishes in the catch, which now comprises mostly juveniles. There is an urgent need for reduction in fishing effort in this region, combined with Integrated Coastal Zone Management.

**Northern Regions**

As in the Northeast Pacific, it appears that the large stocks of Alaska Pollock and other demersals present during the 1980s were a result of good recruitment during the late 1970s and early 1980s because of the El Niño conditions prevailing. Stocks are now undergoing a natural decline, exacerbated by overfishing in many areas: it is notable that the rate of decrease in landings here is faster than in the more tightly controlled northeast Pacific. Improved management is clearly required.

# KUWAIT

**Bahrain, Iran, Iraq, Kuwait, *Oman*, Qatar, *Saudi Arabia*, United Arab Emirates**

**Contains Data for Postscript Only.**

## LARGE MARINE ECOSYSTEMS

This region does not include a formally identified LME. It is comprised of the Persian (Arabian) Gulf and, separated by the Straits of Hormuz, the Gulf of Oman; the latter is contiguous with the northwest sector of the Arabian Sea LME. The Gulf is a shallow (maximum depth 31 m) sedimentary basin, with freshwater input mainly from the Tigris-Euphrates system, and subject to strong evaporation. Temperature and salinity in the Gulf range from high to very high during summer. Evaporation is greatest in southern sectors of the Gulf, where surface salinity is highest; this drives outward movement of dense water at depth through the Straits of Hormuz and inward movement of less saline surface waters from the Gulf of Oman.

## BIODIVERSITY

### Kuwait Regional Sea: biodiversity data

| | endemic | T | % | | endemic | T | % |
|---|---|---|---|---|---|---|---|
| seagrasses | 0 | 5 | 10 | sharks | 1 | 34 | 10 |
| coral genera | 1 | 37 | 34 | seabirds | 0 | 21 | 7 |
| molluscs | 0 | 66 | 2 | cetaceans | 0 | 26 | 30 |
| shrimps | 0 | 14 | 4 | sirenians | 0 | 1 | 25 |
| lobsters | 0 | 12 | 8 | pinnipeds | - | 0 | - |

Notes: the data refer to species except for coral genera. Column headings: endemic = restricted to the region; T = total species richness in the region; % = species richness in the region as a percentage of the world species richness in each group of organism. A dash (-) in a cell means no data or not applicable. See **Notes and Sources** in the introductory text for further information on the sources, coverage and quality of the data tabulated.

### Kuwait Regional Sea: regional endemic species

| | scientific name | common name | status |
|---|---|---|---|
| sharks | *Chiloscyllium arabicum* | Arabian carpetshark | |

**Biodiversity Notes**

Recorded **seagrass** diversity is low. Diversity of **hermatypic coral** genera is markedly lower than in the rest of the coralline areas of the Indo-Pacific, although there is one endemic genus. Diversity in **molluscs**, **sharks** and **lobsters** is low, although two lobster species appear to be endemic.

Relatively few **shark** species have been recorded, although one is apparently endemic. Four **marine turtle** species nest in the region: the Green Turtle *Chelonia mydas*, Loggerhead *Caretta caretta*, Hawksbill *Eretmochelys imbricata* and Olive Ridley *Lepidochelys olivacea*. The world's largest known population of Loggerheads nests on Masirah Island, Oman, and there are also major populations of Green Turtles and Hawksbills. **Seabird** diversity is low.

Moderate numbers of **cetacean** species have been recorded, with no endemics. There are no **pinnipeds**, but one **sirenian**: the Dugong *Dugong dugon*, which appears to be somewhat more abundant than had previously been thought.

## FISHERIES

Fisheries catches in this region are insignificant on a global scale, amounting to around half a million tonnes annually. Around half of the total is landed by Iran, where fisheries have increased considerably, standing in 1992 and 1993 at around 340,000 tonnes, compared with less than 100,000 tonnes in the early 1980s. Most of this increase is in unidentified species.

Locally, there is concern regarding the important Spanish Mackerel *Scomberomorus commersoni* fishery in the Gulf of Oman, which appears to be severely overfished, with 70-80% of the catch now consisting of small, immature animals. This stock is migratory and shared by a number of states, so that any control of fishing will require international cooperation.

Also of local importance has been the collapse of the shrimp *Penaeus semisulcatus* fishery in the Persian Gulf following the Gulf War. The spawning biomass of this species is believed to have fallen to less than 2% of the pre-war level, which may well lead to a recruitment collapse. Landings in Saudi Arabia have fallen from 4000 tonnes in 1989 to 25 tonnes in 1992. The biology of the species is not well enough understood to allow the reasons for this collapse to be identified with certainty, although they seem very likely to be linked to the war, and probably to the very large quantities of crude oil burnt off in Kuwait at that time.

Surveys indicate that the Gulf of Oman, along with adjacent areas of the Arabian Sea and northwest Indian Ocean, are highly productive, with a large biomass of small pelagics and of mesopelagic species; the latter are discussed in more detail in the South Asian region.

# SOUTH ASIA

Contains Data for Postscript Only.

**Bangladesh, India, Maldives, Pakistan, Sri Lanka,** British Indian Ocean Territory

## LARGE MARINE ECOSYSTEMS

The South Asia region includes the major part of two LMEs - the Arabian Sea, to the west of the Indian subcontinent and Sri Lanka, and the Bay of Bengal to the east. South of Sri Lanka lies the central Indian Ocean, not identified as an LME.

### Arabian Sea

The Arabian Sea is semi-enclosed, characterised centrally by low oxygen levels and low productivity. Surface water circulates in an anti-clockwise direction during the northeast monsoon (November-April) and clockwise during the southwest monsoon (May-October). Upwelling driven by monsoon winds tends to produce seasonal concentrations of fish stocks in coastal areas, especially in eastern sectors, where artisanal and commercial fisheries exist. The Arabian Sea is relatively saline; evaporation is high and the Indus River provides the only significant freshwater input (its annual discharge of some 450 million tons of sediment has produced an undersea delta many hundreds of square kilometres in extent).

### Bay of Bengal

The Bay of Bengal is another semi-enclosed water mass. It maintains a clockwise surface current regardless of monsoon season, and receives considerable freshwater input from precipitation and from the Ganges-Brahmaputra system, resulting in a two-layered stratified water column. The Ganges-Brahmaputra also contributes an enormous sediment load to the region.

## BIODIVERSITY

**South Asia Regional Sea: biodiversity data**

| | endemic | T | % | | endemic | T | % |
|---|---|---|---|---|---|---|---|
| seagrasses | 0 | 9 | 19 | sharks | 6 | 58 | 17 |
| coral genera | 1 | 63 | 58 | seabirds | 0 | 26 | 9 |
| molluscs | 0 | 246 | 6 | cetaceans | 0 | 28 | 32 |
| shrimps | 0 | 94 | 27 | sirenians | 0 | 1 | 25 |
| lobsters | 0 | 23 | 15 | pinnipeds | - | 0 | - |

Notes: the data refer to species except for coral genera. Column headings: endemic = restricted to the region; T = total species richness in the region; % = species richness in the region as a percentage of the world species richness in each group of organism. A dash (-) in a cell means no data or not applicable. See **Notes and Sources** in the introductory text for further information on the sources, coverage and quality of the data tabulated.

**South Asia Regional Sea: regional endemic species**

| | scientific name | common name | status |
|---|---|---|---|
| sharks | *Apristurus investigatoris* | Broadnose catshark | |
| | *Cephaloscyllium silasi* | Indian swellshark | |
| | *Eugomphodus tricuspidatus* | Indian sand tiger | |
| | *Glyphis gangeticus* | Ganges shark | CR |
| | *Halaelurus alcocki* | Arabian catshark | |
| | *Halaelurus hispidus* | Brisley catshark | |

Notes: letters in the 'status' column indicate the conservation status of species that have been assessed and classified as threatened. In the revised IUCN Red List category system the term 'threatened' refers only to species in any of the following three categories: CR - Critically Endangered, EN - Endangered, VU - Vulnerable. Status categories are recorded in IUCN (1996).

### Biodiversity Notes

**Seagrass** diversity is higher than the Atlantic but lower than much of the rest of the Indo-Pacific; there are no known endemic species. The South Asia region has high **hermatypic coral** diversity, although lower than the South Pacific and East Asia Seas Regions; one genus is endemic. **Mollusc** numbers are moderate, but the region is relatively rich in **shrimp** and **lobsters**; none of the species in the groups reviewed is endemic.

Recorded **shark** diversity is fairly low, although six species appear to be endemic. Five **marine turtle** species nest in the region: the Green Turtle *Chelonia mydas*, Loggerhead *Caretta caretta*, Hawksbill *Eretmochelys imbricata*, Olive Ridley *Lepidochelys olivacea* and Leatherback *Dermochelys olivacea*. Only the Olive Ridley nesting populations (notably those on the east coast of India in Orissa State) are of global significance. **Seabirds** are not particularly diverse, and there are no species endemic to the region.

**Cetacean** diversity is average; all species recorded in the region are widespread elsewhere. There are no **pinnipeds** but one species of **Sirenian**, the Dugong *Dugong dugon* (Vulnerable) is present although much reduced in numbers.

## FISHERIES

The region comprises the northeastern part of FAO Statistical Area 51 (Western Indian Ocean) and the northwestern part of Area 57 (Eastern Indian Ocean).

Overall annual landings in this region have increased from around 2.5 million tonnes in 1984-87 to around 4.5 million tonnes for the period 1989-1992. India accounts for just over half this total and Sri Lanka for a further 30% or so.

In the Arabian Sea, where India is the principal fishing nation, the catch mainly consists of a wide range of demersals (especially croakers, Bombay duck and catfishes) and small pelagics, including Indian oil sardine, Indian mackerel and anchovy. Much of the increase in catch since 1988 is in species not identified in FAO statistics. Demersal stocks, particularly shrimps, in the Bay of Bengal and along the eastern coast of India are fully exploited or overfished, with movement to exploit resources in deeper waters.

Small-scale artisanal and industrial prawn fisheries fish the same coastal areas off the Indian coast, leading to intense fishing pressure and conflict between the two sectors. There is also a considerable waste of resources here: an estimated 120,000 tonnes of fish is discarded annually as by-catch from shrimp trawls off the east India coast.

Within the Bay of Bengal some of the waters around the Andaman and Nicobar Archipelagos remain a refuge for fishes, with very little fishing recorded; on the western side of these islands, however, overfishing in coastal water has depleted stocks so that India has initiated joint venture fisheries in deeper waters.

It is widely believed that the two major as yet largely unexploited marine fish stocks are Antarctic krill and the mesopelagic finfishes, particularly in tropical oceans. Mesopelagic fishes occur at intermediate depths (usually 150-500 m) by day but may migrate to the epipelagic zone to feed at night. Study of mesopelagic faunas has been limited to date, as it requires the use of expensive high seas research vessels; knowledge of taxonomy, distribution and biology of most of the species concerned remains very incomplete (Longhurst and Pauly, 1987). Information was summarised by Gjøsaeter and Kawaguchi (1980), who regarded around 160 genera in 30 families as important components of the fauna. Most species are small <10 cm, and often bizarrely shaped. On the basis of a variety of surveys carried out they estimated global biomass of this stock to be very large indeed: of the order of 650 million tonnes, although this figure should be regarded with extreme circumspection (Longhurst and Pauly, 1987).

From data available at the time, it appeared that the mesopelagic biomass was greatest in the northern Indian Ocean, and particularly in the northern Arabian sea. Surveys here indicated extremely high biomass (25-250 g $m^{-2}$) in the Gulf of Aden (see Red Sea Region) and Gulf of Oman (see Kuwait Region) as well as off the western coastline of Pakistan. The rest of the region had lower, but still very high, biomass of 10-85 g $m^{-2}$. Concentration was highest just at or beyond the edge of the continental shelf and here biomass of 50-500 g $m^{-2}$ was commonly recorded. This compares with around 0.5 g $m^{-2}$ for the open Indian Ocean between India and Africa. Within the Arabian Sea the main concentration was at 150-350 m depth by day and in the upper 50 m by night. In the open Indian Ocean concentrations were deeper, at around 250-500 m.

These figures are around an order of magnitude higher than those recorded elsewhere in the tropics, indicating either great overestimate for the northern Indian Ocean, or underestimate elsewhere, or that this region genuinely is ten times as productive as the rest of the tropical ocean system. Although this appears as yet unresolved, it is nevertheless apparent that there is substantial global mesopelagic fish biomass and that the Arabian Sea is rich in these species. Their potential as an exploitable resource has been investigated but it is not yet regarded as economically viable. Capture and processing requires expensive, advanced technology, while the products would currently be of low value (fishmeal for animal feed, including aquaculture). Before large-scale exploitation is begun, far more information is required on the ecology and population dynamics of this fauna and how it relates to other components of the marine ecosystem.

# NORTH ATLANTIC

**ContainsDatafor PostscriptOnly.**

Belgium; Bermuda; *Canada*; Denmark; Estonia; Faroes; Finland; *France*; Germany; Greenland; Iceland; Ireland; Latvia; Lithuania; *Morocco*; Netherlands; Norway; Poland; Portugal; *Russia*; *Spain*; Sweden; *USA*; United Kingdom

This marine region is not within an existing Regional Seas area and has been defined here for the purposes of this document.

## LARGE MARINE ECOSYSTEMS

There are fourteen LMEs wholly contained within the North Atlantic Region: the Southeast US Continental Shelf, the Northeast US Continental Shelf, the Scotian Shelf, the Newfoundland Shelf, the West Greenland Shelf, the East Greenland Shelf, the Iceland shelf, the Norwegian Shelf, the North Sea, the Baltic Sea, the Celtic-Biscay Shelf, the Iberian Coastal, the Canary Current, and the Faroe Plateau.

### Southeast US Continental Shelf

This LME extends from the Straits of Florida to Cape Hatteras, North Carolina. The South Atlantic Bight (the area between Cape Hatteras and Cape Canaveral in Florida) has a shelf width of 50-200 km and an area of 90,600 $km^2$. The dominant features oceanographically are the Florida Current and the Gulf Stream. The coastal zone is characterized by high levels of plankton production throughout the year, whereas on the middle and outer continental shelf, upwellings along the Gulf Stream front and intrusions from it result in short lived plankton blooms.

### Northeast US Continental Shelf

The Northeast Shelf ecosystem runs from Cape Hatteras in the south to the Gulf of Maine in the north. In the southern section of this area the continental shelf is relatively broad and gently slopes eastward to the outer edge. Tidal amplitude is less than one metre. The northern section is relatively shallow, generally less than 200 m and has the largest tidal amplitude in the world, at the Bay of Fundy, with a range of 12 m. The warm Gulf Stream is the major influence in south of this area, with the Labrador Current playing an important rôle, whilst in the northern area the Labrador Current has the greatest influence, particularly at depth. A transition zone occurs where these currents meet with a cold water barrier at Cape Cod and a warm water barrier at Cape Hatteras. These boundaries shift northward and southward during summer and winter respectively.

### Scotian Shelf LME

This is the area surrounding Nova Scotia. The continental shelf extends in places 370 km from the Canadian coast. The shelf is dominated by a series of shallow banks ranging in depth from 25-100 m which are divided by a deep glacial trough, the Laurentian Channel, to form the Grand Banks and the Scotian Shelf. The area is dominated by the cold Labrador current, with the Gulf Stream having an impact along the continental margin. Mean tidal amplitude ranges between 1-2 m. Intense storms are quite frequent, particularly in the winter months, resulting in a very exposed storm-wave environment.

### Newfoundland Shelf

The Newfoundland Shelf LME extends off the eastern coast of Canada, including the areas of the Labrador Current and the Grand Banks. The continental shelf is relatively uniform, averaging 50-150 km in width, with depths of less than 70 m as far as 2 km from shore, although the steep continental slope rapidly reaches depths of over 3,000 m. During the winter, the fjords, bays and narrow coastal zone are bound in landfast ice, while close pack ice extends 150-225 km offshore. Icebergs are abundant year round and there is a significant Arctic water component within the main water mass. In this area the cold water Labrador Current and the large freshwater outflow of the St Lawrence River are the major factors influencing the composition of the water column.

**West Greenland Shelf**

Like other high latitude LMEs, ocean climate variability in the West Greenland Sea is a particularly important driving force. This area is usually partially ice covered during the northern winter.

**East Greenland Shelf**

This area is characterized by its glaciated margin and bottom topography. The irregular shelf varies greatly in width, from a maximum of about 750 km in the north to about 75 km in the south. The main hydrographic influence is the cold East Greenland Current. Ice cover is extensive during the winter and 90% of all icebergs in the northern hemisphere are derived from the glaciers on the east coast of Greenland.

**Iceland Shelf**

Unusually, this area has a wide volcanic margin marked by broad valleys. The continental slope is sharply defined, with wider rises to the south. The hydrography of the area is complex. Warm saline Atlantic water flows northward in east, and cold fresh Arctic water flows southward in the west; there is also a clockwise circulation gyre around the island. The entire area is covered with ice during the northern winter.

**Norwegian Shelf**

The margin off the Norwegian coast is separated from the rest of European margin by a trough, the Norwegian Deep, which originates in the Skagerrak and sweeps northward parallel to the Norwegian shore. The continental shelf averages 167 km in width although there are much narrower sections near 69°N. Cold low salinity waters found along the Norwegian coast are formed from waters derived from the Baltic Sea. High levels of phytoplankton and zooplankton are found along the coast.

**North Sea**

The North Sea is found on the continental shelf of West Europe, bounded by the coastlines of Scotland, England, Norway, Sweden, Denmark, Germany, the Netherlands, Belgium, and France. It has openings into the Atlantic Ocean to the north and in the southwest, via the English Channel. It opens into the Baltic Sea via the Skagerrak to the east. The North Sea occupies an area of approximately 750,000 $km^2$ and it has a volume of about 94,000 $km^3$. The current movement of surface waters is in a counter clockwise direction, with the flow of water down the east coast of Scotland and England, along the coasts of mainland Europe and up the western seaboard of Sweden and Norway. There is also a movement of Atlantic water at depth toward the coast of Norway.

**Baltic**

The Baltic Sea covers around 413,000 $km^2$. It is very shallow, with an average depth of around 57 metres, but locally reaches 460 metres. It communicates with the North Sea through the Great and Little Danish Belts and the Öresund, which together form the so-called Belt Sea. This and the Kattegat form a transition zone between the North Sea and the Baltic proper. Almost all water input to the Baltic comes from rivers, which contribute an estimated 430-470 $km^3$ of freshwater annually. The three largest rivers are the Neva, Wisla and Oder; these together contribute only just over one fifth of the overall freshwater input. Inflow of water varies seasonally and also over longer time periods; over the past 12,000 years the Baltic has alternated several times from being a large freshwater lake to being a truly marine sea.

**Celtic-Biscay Shelf**

The Celtic-Biscay Shelf is found off the coasts of Ireland and the west coasts of France and Great Britain. At its southern limits, off the French-Spanish border, it is steep and narrow, but it widens steadily along the west coast of France, merging with the broad continental shelf surrounding Ireland and Great Britain. The main oceanic influence is the North Atlantic Drift, a warm water current derived from the Gulf Stream.

**Iberian Coastal**

This area is defined as the continental shelf region of the eastern Atlantic Ocean lying between about 36°N (Gulf of Cadiz) and 44°N (Cantabrian Sea). The continental shelf varies in width from 15 to nearly 400 km. Much of this area experiences moderate upwelling and is an area of higher than average productivity.

**Canary Current**

The Canary Current flows southwest along the coast of northwest Africa transporting cool water towards the equator. Major upwellings that occur are determined by the orientation of the coastline, structure of the bottom, and interaction between water masses. The Canary Islands provide enrichment of the oceanic zone through increased current intensity. This a highly productive area.

**Faroe Plateau**

This LME is based on the relatively broad continental shelf surrounding the Faroe Islands. The islands and their shelf are affected by a branch of the north-flowing North Atlantic Drift.

## BIODIVERSITY

### North Atlantic Regional Sea: biodiversity data

| | endemic | T | % | | endemic | T | % |
|---|---|---|---|---|---|---|---|
| seagrasses | 0 | 5 | 10 | sharks | 4 | 87 | 25 |
| coral genera | 0 | 13 | 12 | seabirds | 4 | 56 | 19 |
| molluscs | 0 | 432 | 10 | cetaceans | 2 | 39 | 44 |
| shrimps | 0 | 55 | 16 | sirenians | 0 | 1 | 25 |
| lobsters | 1 | 22 | 15 | pinnipeds | 1 | 8 | 24 |

Notes: the data refer to species except for coral genera. Column headings: endemic = restricted to the region; T = total species richness in the region; % = species richness in the region as a percentage of the world species richness in each group of organism. A dash (-) in a cell means no data or not applicable. See **Notes and Sources** in the introductory text for further information on the sources, coverage and quality of the data tabulated.

### North Atlantic Regional Sea: regional endemic species

| | scientific name | common name | status |
|---|---|---|---|
| lobsters | *Homarus americanus* | American lobster | |
| sharks | *Apristurus atlanticus* | Atlantic ghost catshark | |
| | *Apristurus maderensis* | Madeira catshark | |
| | *Apristurus manis* | Ghost catshark | |
| | *Galeus murinus* | Mouse catshark | |
| seabirds | *Catharacta skua* | Great skua | |
| | *Larus fuscus* | Lesser black-backed gull | |
| | *Pterodroma cahow* | Bermuda petrel | EN |
| | *Pterodroma madeira* | Madeira petrel | CR |
| cetaceans | *Lagenorhynchus acutus* | Atlantic white-sided dolphin | |
| | *Mesoplodon bidens* | Sowerby's beaked whale | |
| pinnipeds | **Halichoerus grypus* | Grey seal | |

Notes: letters in the 'status' column indicate the conservation status of species that have been assessed and classified as threatened. In the revised IUCN Red List category system the term 'threatened' refers only to species in any of the following three categories: CR - Critically Endangered, EN - Endangered, VU - Vulnerable. Seabirds have been assessed by BirdLife International, Collar *et al*. (1994); all status categories are recorded in IUCN (1996). * Baltic subspecies EN.

## Biodiversity Notes

**Seagrass** diversity is low. Generic diversity of **hermatypic corals** is low, with no endemic genera. There is relatively high diversity of molluscs, and also of shrimps and lobsters, but only a single regional endemic in the species groups reviewed.

Recorded **shark** diversity is high, although this may be a reflection of how relatively well studied the fish fauna of this region is. Two **marine turtles**, the Green Turtle *Chelonia mydas* and Loggerhead *Caretta caretta*, are known to nest in the extreme south of the region, only the latter in significant numbers. The North Atlantic gyre and coastal waters, especially along the eastern seaboard of North America, provide important feeding grounds and migratory pathways for turtles, including Kemp's Ridley *Lepidochelys kempii*. **Seabird** diversity is also high, although lower than in equivalent areas of the Pacific. Two species of *Pterodroma* petrel are highly threatened and at least one endemic seabird species has become extinct (the Great Auk *Alca impennis*, from the Northern Atlantic, last recorded in 1844.

**Cetacean** diversity is high, with two species apparently confined to the region, although both are pelagic and may be expected to extend further south on occasion. One **Sirenian**, the West Indian Manatee *Trichechus manatus* occurs in the southeast of the region along the US coast. **Pinniped** diversity is relatively high, although there are no endemics, most species being shared with the Arctic Region or, in the case of the Mediterranean Monk Seal *Monachus monachus* (Critically Endangered) with the Mediterranean and West and Central African Regions.

## FISHERIES

The North Atlantic region as defined here includes parts of FAO statistical areas 21 (Northwest Atlantic), 27 (Northeast Atlantic) and small portions of 31 (Western central Atlantic) and 34 (Eastern central Atlantic). The northwest and northeast sectors of this region are experiencing some of the best-documented, most severe and socially most damaging catch declines known. This widespread decline has affected most high-value demersal stocks and some of the shoaling pelagics, and is attributed primarily to excess fishing pressure, in some instances complicated by changing environmental conditions, eg. lower than average water temperature in the northwest Atlantic. The Haddock *Melanogrammus aeglefinus* and Cod *Gadus morhua* populations in the northwest and northeast Atlantic have been categorised as Vulnerable in the *1996 IUCN Red List of Threatened Animals* (IUCN, 1996) (with the proviso that application of the new status category system to marine fishes requires further evaluation).

### Northwest Atlantic

Recorded landings for 1992 total 2.6 million tonnes, representing a 20% reduction since 1990 and below the annual average over the previous two decades. Catches of all main groundfish (*demersal*, or bottom-living species) have declined, especially Cod, Haddock and flatfishes. Half of the decline is attributed to reduced North Atlantic Cod (*Gadus morhua*) stocks. Stocks of demersal fishes in the northeast USA were at an all-time low in 1992 and expected to decline further in 1993. Catches have fallen despite great increases in efficiency and fishing effort. Cod stocks are estimated to be at around 5% of the long-term average abundance. Both excess fishing and a period of low temperature in northern coastal waters appear to have caused the decline, eg. there are indications that decline in American Plaice is mainly due to a reduction in ambient water temperature. Following the collapse in gadoid stocks, demersal fisheries have moved to formerly low value species.

Many vessels in the northern part of this region have now begun to target Greenland Halibut. This stock has a restricted Total Allowable Catch (TAC) within Canadian waters, and appeared relatively secure at the end of the 1980s, however, landings outside the EEZ had increased nearly tenfold by 1993. The stock is now greatly depleted. Haddock (*Melanogrammus aeglefinus*) stocks throughout the northwest Atlantic are over-exploited; juveniles are subject to high incidental catch in other fisheries. In the eastern area no direct fishery is permitted. Herring stocks on Georges Bank were subject to major international fishery in the 1960s and 1970s, producing an annual yield of 374,000 tonnes in 1968, but collapsed to apparent commercial extinction. Spawning stocks have now been identified and some recovery may be underway.

About one-third of total fishery landings for 1990 were molluscs and crustaceans. Landings of crustaceans (including crabs, American Lobster and Northern Prawn) have risen steadily since the 1970s to 276,000 tonnes during 1990. This is partly due to increases in aquaculture production but may have been promoted by warmer summer water temperatures.

Straddling stocks present in regions under the jurisdiction of Canada, Greenland and France (St. Pierre et Miquelin), and in adjacent international waters in the northwest Atlantic, are covered by catch quotas suggested by the Northwest Atlantic Fisheries Organisation (NAFO). All coastal states in the region, except USA, are members. NAFO has attempted to maintain stock levels within a 200 mile radius of the coastal shelf (except round the USA coast) by harvesting depleted fish stocks below the maximum sustainable yield thus allowing a recovery in annual recruitment. Fishing by non-Contracting Parties, and particularly by flag-of-convenience vessels, in the NAFO Regulatory Area is a continuing problem.

Within Canadian waters in the northwest Atlantic, assessments are conducted by the Canadian Atlantic Fisheries Scientific Advisory Committee (CAFSAC) who have also established catch quotas on fish stocks, and include a three year management plan for ground fish.

In attempting to avoid discards of by-catches, an aggregate quota for Cod, Haddock and Pollock was introduced in 1989. A Haddock nursery area was introduced in 1987 to aid stock rebuilding which has produced a slight recovery. Canada has declared a moratorium on several demersal stocks within its EEZ and the NAFO area beyond 200-mile limits. At the same time an extensive Northern Cod Adjustment and Recovery programme focusing on mitigation of social impact among local communities has been introduced. There is also a new and independent Fisheries Resource Conservation Council; this has recommended some very stringent closure and reduction actions. In New England, the Multispecies Fishery Management Plan calls for a reduction in fishery effort, increases in mesh size, and more restrictions on Haddock spawning ground.

**Northeast Atlantic**

Total recorded landings for the Northeast Atlantic were 2.6 million tonnes in 1992, down slightly from the previous year's catch of 3.0 million tonnes. One million tonnes consisted of invertebrates: catches of molluscs (oysters, Blue Mussel, scallops, Common Cockle, cephalopods) and crustaceans (crabs, lobsters, prawns, shrimps) both increased since the previous year.

Most demersal finfish stocks remain depleted; some show a continuing downward trend. Stocks of Atlantic Cod, Polar Cod, Haddock, Norway Pout, Capelin, Atlantic Herring, Anchovy and Sprat have fallen 2.9 million tonnes between 1970 and 1990 with current stocks still further depleted. The reduction in fish stock is due to increasing pressures from overfishing, large discards (33-50% of total catch), poor recruitment and overfishing of juvenile stocks. Environmental factors are also accountable for stock reduction.

In the North Sea, the Cod spawning stock is severely depressed; the present level, estimated at about 50,000 metric tonnes, is one-third the minimum desirable level. All but one year-class since the good 1985 year have been below average size. The stock may be beyond recovery unless fishing mortality is reduced, and this appears unlikely. The condition of the Cod stocks in the Baltic, Iceland and Greenland Seas is broadly similar, although in the Baltic, a reasonable 1991 year class was produced, and an influx of North Sea water in 1993 may improve water quality. There is some evidence of recovery in the Northeast Arctic stock, in part due to a low TAC.

Recruitment from average or above-average year classes has produced slight improvement in the North Sea spawning stock of Haddock since the record low in 1985. The Faeroe stock remains extremely low. North Sea Herring, North Sea Mackerel, Whiting and Plaice are all at low levels; Sole are presently well above the minimum desirable level, but still subject to heavy fishing. High mortality was caused to adult Herring in the North Sea and western Baltic by the fungus *Ichthyophonus* in 1991. The Norwegian spring spawning Herring stock has continued to recover and there are hopes that it might reach former levels. Harvesting started in 1993 with a low TAC designed to allow continued recovery. There has been recent interest in harvest of deep water species on the Atlantic slope, however, caution is needed because of the slow growth and long lifespan typical of such species.

The International Council for the Exploration of the Sea (ICES) is concerned with management and research activities in the region. The Total Allowable Catch (TAC) system has been used as the standard method in managing fish stocks throughout this area but ICES is now promoting Multi-species Virtual Population Analysis (MSVPA), which takes into account the fact that consumption of fish by other fish is a major cause of mortality for many species. Discards of undersize fish appear to be an increasing problem; ICES is attempting to quantify more accurately the discard level. ICES has also participated in the assessments made by the North Sea Task Force.

# CARIBBEAN

**Anguilla (to UK), Antigua and Barbuda, Aruba (to Netherlands), Bahamas, Barbados, Belize, British Virgin Islands (to UK), Cayman Islands (to UK), *Colombia*, *Costa Rica*, Cuba, Dominica, Dominican Republic, French Guiana (to France), Grenada, Guadeloupe (to France), *Guatemala*, Guyana, Haiti, *Honduras*, Jamaica, Martinique (to France), *Mexico*, Montserrat (to UK), Netherlands Antilles (to Netherlands), *Nicaragua*, *Panama*, Puerto Rico, St Christopher and Nevis, St Lucia, St Vincent and the Grenadines, Suriname, Trinidad and Tobago, Turks and Caicos (to UK), *USA*, US Virgin Islands (to USA), Venezuela**

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## LARGE MARINE ECOSYSTEMS

The Caribbean Region comprises the whole of two LMEs: the Gulf of Mexico and the Caribbean Sea, and the northern part of the Northeast Brazil Shelf LME.

### Gulf of Mexico

The Gulf of Mexico is a large, semi-enclosed water body with an area of *c* 1.6 million km$^2$. The Gulf receives freshwater input from rivers which drain two-thirds of the USA and half of Mexico, with a combined inflow of *c* 30,000 m$^3$/sec or around 2,600 km$^3$ per year, most notably from the Mississippi-Missouri. Surface temperatures in the southern part of the Gulf are relatively constant, at around 27°C, with seasonal fluctuations of around 3°C. In the northern part there is much more seasonal variation, from 16°C in winter to 28°C in summer.

The Gulf's main oceanographic feature is a loop current which exchanges water with the Atlantic Ocean and Caribbean Sea. This current flows north into the Gulf around the western end of Cuba then loops round to flow south and eastward through the Florida Straits between southern Florida and the northern coast of Cuba.

### Caribbean Sea

The Caribbean Sea covers an area of some 2.5 million km$^2$. It has an average depth of some 2,000 m. Most of the region is tropical, so that surface temperatures are constant at around 27°C, with seasonal fluctuations of around 3°C. Salinity is relatively high from January to May, but lower at other times owing to inflow of low salinity water from the Orinoco and Amazon Rivers and from the equatorial convergence.

The predominant currents are influenced by the trade winds and are westward flowing; they are the Guiana Current which flows around the coast of northern South America from Brazil and the Northern Equatorial Current which flows west through the Lesser Antilles. There are coastal countercurrents and several gyres.

Most of the region has narrow shelf areas, with the seafloor dropping precipitously a few kilometres from shore. There are, however, extensive shallow water areas off the coasts of Belize, Cuba and the Bahamas.

## Northeast Brazilian Shelf

The Northeast Brazilian Shelf runs from the boundary of the Caribbean Sea off Venezuela south to the easternmost coastal point of Brazil. The southern half of this LME has been included here in the Southwest Atlantic region. The shelf is 40-170 nm wide and has a gently sloping surface with some slight terracing. Major influences on this LME are the Orinoco and Amazon Rivers, the former lying within the Caribbean Region. As well as providing major sources of freshwater and nutrients, both have built submarine deltas onto the shelf.

## BIODIVERSITY

### Caribbean Regional Sea: biodiversity data

| | endemic | T | % | | endemic | T | % |
|---|---|---|---|---|---|---|---|
| seagrasses | 2 | 7 | 15 | sharks | 14 | 76 | 22 |
| coral genera | 9 | 25 | 23 | seabirds | 1 | 23 | 8 |
| molluscs | 0 | 633 | 15 | cetaceans | 0 | 30 | 34 |
| shrimps | 0 | 45 | 13 | sirenians | 0 | 1 | 25 |
| lobsters | 8 | 23 | 15 | pinnipeds | - | 0 | - |

Notes: the data refer to species except for coral genera. Column headings: endemic = restricted to the region; T = total species richness in the region; % = species richness in the region as a percentage of the world species richness in each group of organism. A dash (-) in a cell means no data or not applicable. See **Notes and Sources** in the introductory text for further information on the sources, coverage and quality of the data tabulated.

### Caribbean Regional Sea: regional endemic species

| | scientific name | common name | status |
|---|---|---|---|
| seagrass | *Halophila engelmannii* | | |
| | *Halophila johnsonii* | | |
| lobsters | *Acanthacaris caeca* | Atlantic deep-sea lobster | |
| | *Eunephrops manningi* | Banded lobster | |
| | *Eunephrops bairdii* | Red lobster | |
| | *Eunephrops cadenasi* | Sculptured lobster | |
| | *Metanephrops binghami* | Caribbean lobster | |
| | *Nephropides caribaeus* | Mitten lobsterette | |
| | *Nephropsis neglecta* | Ruby lobsterette | |
| | *Thaumastocheles zaleucus* | Atlantic pincer lobster | |
| sharks | *Apristurus riveri* | Broadgill catshark | |
| | *Apristurus canutus* | Hoary catshark | |

| | scientific name | common name | status |
|---|---|---|---|
| | *Apristurus parvipinnis* | Smallfin catshark | |
| | *Eridacnis barbouri* | Cuban ribbontail catshark | |
| | *Etmopterus schultzi* | Fringefin lanternshark | |
| | *Etmopterus virens* | Green lanternshark | |
| | *Oxynotus caribbaeus* | Caribbean roughshark | |
| | *Parmaturus campechiensis* | Campeche catshark | |
| | *Pristiophorus schroederi* | Bahamas sawshark | |
| | *Schroederichthys maculatus* | Narrowtail catshark | |
| | *Scyliorhinus meadi* | Blotched catshark | |
| | *Scyliorhinus boa* | Boa catshark | |
| | *Scyliorhinus torrei* | Dwarf catshark | |
| | *Scyliorhinus hesperius* | Whitesaddled catshark | |
| seabirds | *Pterodroma hasitata* | Black-capped petrel | EN |

Notes: letters in the 'status' column indicate the conservation status of species that have been assessed and classified as threatened. In the revised IUCN Red List category system the term 'threatened' refers only to species in any of the following three categories: CR - Critically Endangered, EN - Endangered, VU - Vulnerable. Seabirds have been assessed by BirdLife International, Collar *et al*. (1994); all status categories are recorded in IUCN (1996).

**Biodiversity Notes**

**Seagrass** diversity is fairly low, in particular when compared with the tropical Indo-Pacific, although two species are endemic to the region.The Caribbean Region overall has considerably lower generic diversity of **hermatypic corals** than most of the tropical Indo-Pacific; it does, however, have the highest number of regionally endemic genera in the world, as might be expected in view of its geographical isolation from other major coral areas. The region is particularly rich in **molluscs**, after the East Asia Seas region and the South Pacific (the apparent absence of endemics is surprising and may be an artefact of data quality), and in larger **crustaceans**, with the second highest number of endemic lobsters.

**Shark** diversity is moderate although there are a significant number of apparently endemic species.
All species of **marine turtle** except the Flatback *Natator depressus* breed in the region. The critically Endangered Kemp's Ridley *Lepidochelys kempii*, is confined to the region as a nesting species. Virtually all nesting is at Rancho Nuevo in Tamaulipas State, Mexico, although sporadic nesting has been recorded elsewhere in Mexico, Colombia and the USA. Attempts are being made to establish a nesting colony at Padre Island, USA. At sea the species is widely recorded in the Atlantic and very rarely in the Mediterranean. There are also major nesting populations of Green Turtle *Chelonia mydas*, Hawksbill *Eretmochelys imbricata*, Loggerhead *Caretta caretta* and Leatherback *Dermochelys coraicea*. The Olive Ridley *Lepidochelys olivacea* is less common; the only significant nesting in the western Atlantic takes place in Suriname, with diffuse nesting in French Guiana and Guyana.

As with many tropical regions, **seabird** diversity is low, with the region only holding some 8% of the world's total. One species is endemic, the endangered Black-capped Petrel *Pterodroma hasitata* which breeds on Haiti, Dominican Republic, Cuba and probably Dominica (Collar *et al.*, 1994). One other species, the Jamaican Petrel *Pterodroma caribbaea*, formerly endemic to Jamaica, is now believed extinct.

**Cetacean** diversity is near the global average; there are no regional endemics, although the Tucuxi *Sotalia fluviatilis* is confined to rivers and coastal waters in the southern part of the region and the adjacent Southwest Atlantic Region. There are no extant **pinnipeds** in the region, the formerly endemic Caribbean Monk Seal *Monachus tropicalis* was last recorded in the early 1960s and is now regarded as extinct. Amongst **sirenians**, the West Indian Manatee *Trichechus manatus*, a Vulnerable species, is very nearly endemic to the region, although its range extends into the northern part of the Southwest Atlantic Region.

## FISHERIES

The Caribbean Region is contained entirely within FAO fisheries area 31, the Western Central Atlantic. Although the northern part of this fisheries area is more strictly considered part of the North Atlantic it will be considered here in this report.

At the macro-scale, fisheries in this area appear to be principally affected by fishing pressure and by variations in run-off from the rivers feeding the region, principally the Mississippi, Orinoco and Amazon, three of the largest river systems in the world. These undoubtedly have an influence across most of the region. Variations in runoff have been linked to El Niño events in the equatorial Pacific. At local scales, coastal habitat degradation, usually for coastal development and tourism, are implicated in decreases in reef fishery production. Hurricanes, to which the region is particularly prone, can also have a serious local impact on fisheries, although this appears to be more through effects on fishing vessels and facilities than on the marine environment.

Main fisheries within the area are for small and large pelagic finfish, reef-fishes, coastal demersal finfish, crustaceans and molluscs. Overall landings in the region rose steadily from around 1.5 million tonnes in 1970 to a peak of 2.6 million tonnes in 1984 and has since declined steadily to around 1.7 million tonnes in the early 1990s. The region accounts for only around 2% of total marine fisheries landing. However, FAO estimate that it has the highest percentage discard of any of the major fishing areas, with nearly half the actual catch believed to be discarded (mostly as a by-catch of shrimp trawling, particularly in the northern Gulf of Mexico).

Most of the recent decline in fisheries here is attributed to decreases in three major US-based fisheries: Gulf menhaden, American Oyster and Calico Scallop. Menhaden decline appears to be attributable mainly to overharvest, oyster decline to disease and scallop decline perhaps to natural fluctuations in abundance, which appear to occur at intervals of several years.

According to FAO's 1994 assessment, just over 35% of stocks in the region were regarded as overexploited (fully fished, overfished, depleted or recovering). This apparently places the region in a better overall position than almost all other FAO fisheries areas, but this may be misleading as mollusc stocks were not assessed. Just under 60% of demersal stocks were overexploited and just under 70% of pelagic stocks. Crustacean stocks were not generally considered overexploited.

The Caribbean region includes a large number of countries, of very widely varying social and economic status. This is reflected in the wide range of fisheries activities (industrial, artisanal and recreational) and approaches to management in the region, varying from highly managed (eg. US, Cuba) to unmanaged (eg. Haiti).

Generally, overexploitation of inshore (particularly reef) fishery resources and deterioration of inshore habitats, both around the islands and on continental shelves, has led countries to direct exploitation increasingly to offshore pelagic resources. These stocks have two major characteristics: they tend to be highly migratory, both within and beyond the region, and are thus shared by several countries, many of which will only have access on a seasonal basis; in addition, population levels of many of them appear to be naturally highly variable, dependant on medium or longer term environmental variation. The need for international cooperation in management of these resources is paramount.

Locally, there is a pressing need for rehabilitation of reef resources, both through improved fisheries management and habitat restoration, through Integrated Coastal Zone Management. Isolated island states are in a position to contemplate independent management of these stocks; however, many of the island states are small and under-resourced, both financially and in terms of scientific and technical expertise and would benefit greatly from international cooperation.

Of growing importance is the need to reconcile the interests of different fisheries sectors or user groups within individual countries. Recreational fisheries are increasing and may be a major contributor to the catch, although one which is notoriously difficult to assess. In the Caribbean sector of the US, these fisheries may account for half of the coastal demersal catch, and a notable proportion of the coastal pelagic catch. There has been considerable conflict between recreational and commercial fishers here. In addition there is potential conflict between mostly artisanal reef fisheries and the newly developed pelagic fleets, which may turn their attention to inshore demersal and reef fisheries during the off-season for pelagics.

# NORTHEAST PACIFIC

*Canada; USA; Mexico*

This marine region is not within an existing Regional Seas area and has been defined here for the purposes of this document.

**ContainsDatafor**

**PostscriptOnly.**

## LARGE MARINE ECOSYSTEMS

The Northeast Pacific Region comprises four LMEs: the Eastern Bering Sea, the Gulf of Alaska, the Californian Current, and the Gulf of California.

### Eastern Bering Sea

The continental shelf of the East Bering Sea is the largest in the world outside of the Arctic. It exceeds 500 km width at its narrowest point and spans 11° of latitude. This region is characterised by generally shallow water (rarely exceeding 100 m depth) and by gradual shelf gradients. Wind-driven currents and sea ice determine many oceanographic features of the region. Ice cover is seasonal and may last for up to 6 months. Surface temperatures in the Bering sea generally range between 6 and 12°C in the summer and 1.5 and 2.0°C in winter.

### Gulf of Alaska

The Gulf of Alaska LME lies off the southern coast of Alaska and the western coast of Canada. Hydrography is marked by the northward gyre of the Alaskan Coastal Current which flows as a narrow jet of low salinity water along the coast from British Columbia to Unimak Pass. In general, wind action in the Gulf of Alaska produces downwelling at the coast. Water temperatures are usually warmer than in the East Bering Sea. Surface temperatures range between 10-14°C in summer and 1-8°C in winter.

### Californian Current

The cool Californian Current flows southward along the west coast of North America, with its main influence extending from the Columbia River to central Baja California; for most of the year it remains offshore except in September when it flows quite near to the coast. Upwelling occurs seasonally from February to September, driven by the prevailing northwesterly winds, and is a very important factor in the high rates of productivity seen here. The rates and volume of upwelling observed in this LME are greater than anywhere else along the west coast of North America. Water temperatures are fairly constant throughout the year. Average surface water temperatures range between 9° and 11°C in winter and 13-15°C in summer.

### Gulf of California

This is a small semi-enclosed LME. It is an elongated marine basin with an approximate area of 200,000 km$^2$. As the Middle America Trench reaches into the Gulf, much of it has a depth greater than 200 m. Being semi-enclosed, the Gulf of California waters have fairly limited exchange with the open Pacific. Circulation within the Gulf is seasonally influenced by reversing winds and solar radiation. Upwelling occurs alternately along the eastern and western coasts, driven by northwesterly winds in winter along the eastern coasts and by southerly winds in summer along the western coasts. Seasonal variations in surface temperatures are extreme; in the northern part temperatures range between 14°C in February and 30°C in August and in the southern part between 20°C and 30°C.

## BIODIVERSITY

### Northeast Pacific Regional Sea: biodiversity data

| | endemic | T | % | | endemic | T | % |
|---|---|---|---|---|---|---|---|
| seagrasses | 3 | 7 | 15 | sharks | 5 | 57 | 16 |
| coral genera | 0 | 7 | 6 | seabirds | 14 | 66 | 22 |
| molluscs | 0 | 517 | 12 | cetaceans | 1 | 39 | 44 |
| shrimps | 0 | 34 | 10 | sirenians | - | 0 | - |
| lobsters | 6 | 11 | 7 | pinnipeds | 2 | 11 | 32 |

Notes: the data refer to species except for coral genera. Column headings: endemic = restricted to the region; T = total species richness in the region; % = species richness in the region as a percentage of the world species richness in each group of organism. A dash (-) in a cell means no data or not applicable. See **Notes and Sources** in the introductory text for further information on the sources, coverage and quality of the data tabulated.

### Northeast Pacific Regional Sea: regional endemic species

| | scientific name | common name | status |
|---|---|---|---|
| seagrasses | *Phyllospadix scouleri* | | |
| | *Phyllospadix serrulatus* | | |
| | *Phyllospadix torreyi* | | |
| lobsters | *Panulirus inflatus* | Blue spiny lobster | |
| | *Panulirus interruptus* | California spiny lobster | |
| | *Upogebia pugettensis* | Blue mud shrimp | |
| | *Callianassa biffari* | Beach ghost shrimp | |
| | *Callianassa californiensis* | Bay ghost shrimp | |
| | *Callianassa gigas* | Giant ghost shrimp | |
| sharks | *Cephalurus cephalus* | Lollipop catshark | |
| | *Galeus piperatus* | Peppered catshark | |
| | *Parmaturus xaniurus* | Filetail catshark | |
| | *Mustelus californicus* | Grey smooth-hound | |
| | *Triakis semifasciata* | Leopard shark | |
| seabirds | *Larus heermanni* | Heermann's gull | |
| | *Larus livens* | Yellow-footed gull | |
| | *Larus occidentalis* | Western gull | |
| | *Oceanodroma homochroa* | Ashy storm-petrel | |
| | *Oceanodroma melania* | Black storm-petrel | |

| | scientific name | common name | status |
|---|---|---|---|
| | *Oceanodroma microsoma* | Least storm-petrel | |
| | *Phalacrocorax penicillatus* | Brandt's cormorant | |
| | *Ptychoramphus aleuticus* | Cassin's auklet | |
| | *Puffinus auricularis* | Townsend's shearwater | VU |
| | *Puffinus opisthomelas* | Black-vented shearwater | VU |
| | *Rissa brevirostris* | Red-legged kittiwake | VU |
| | *Sterna elegans* | Elegant tern | |
| | *Synthliboramphus craveri* | Craveri's murrelet | |
| | *Synthliboramphus hypoleucus* | Xantus's murrelet | |
| cetaceans | *Phocoena sinus* | Vaquita | CR |
| pinnipeds | *Arctocephalus townsendi* | Guadalupe fur seal | VU |
| | *Mirounga angustirostris* | Northern elephant seal | |

Notes: letters in the 'status' column indicate the conservation status of species that have been assessed and classified as threatened. In the revised IUCN Red List category system the term 'threatened' refers only to species in any of the following three categories: CR - Critically Endangered, EN - Endangered, VU - Vulnerable. Seabirds have been assessed by BirdLife International, Collar *et al*. (1994); all status categories are recorded in IUCN (1996).

**Biodiversity Notes**

**Seagrass** species richness is low, but a high proportion of species appear to be endemic. Generic diversity of **hermatypic corals** in the region is very low, reflecting the distance away from the Indo-Pacific centre of coral diversity and the generally meagre reef formation in even the warmer parts of the region. Coral assemblages are limited to the southern part of the region, around Baja California and in the Gulf of California (although are absent south of this owing to the influence of cold water upwellings). Corals are found on the shore rather than offshore and do not form true reefs (UNEP/IUCN, 1988). The region is notably rich in **molluscs**, but has only moderate diversity of **shrimp** and **lobsters**, however six species of the latter appear to be endemic.

Recorded **shark** diversity is moderate to low, although five species have not been recorded elsewhere. Globally important populations of four **sea turtle** species nest in the southern part of the region, in Mexico. These are the Green Turtle *Chelonia mydas*, Hawksbill *Eretmochelys imbricata*, Olive Ridley *Lepidochelys olivacea* and Leatherback *Dermochelys coriacea*. Green and Leatherback populations are of major importance, although numbers of both are now much reduced. Large numbers of juvenile Loggerhead Turtles have been documented in the south of this region, feeding on pelagic Red Crab *Pleuroncodes planipes* in upwelling waters off Baja California (Bowen *et al*. 1995)

**Seabird** diversity and endemism are both high, with three of the endemic species considered Vulnerable.

**Cetacean** diversity is high; one species, the Vaquita or Cochito *Phocoena sinus* is endemic to the region, being confined to the northern part of the Gulf of California. It is classified as Critically Endangered and is regarded as the most threatened marine cetacean (probably one of the most threatened of all mammals).

There are no extant **sirenians**, although the huge but now extinct Steller's Sea Cow *Hydrodamalis gigas* formerly occurred in the Bering Sea (on the borders of this region and the Northwest Pacific Region). **Pinniped** diversity is the highest in the world, with two endemic species, one of which (the Guadalupe Fur Seal *Arctocephalus townsendi* from Guadalupe Island off northwest Baja California) is regarded as Vulnerable. This species was severely depleted by sealers to the extent that it was considered extinct by the 1920s. A colony was discovered in 1954 and the species has increased in numbers slowly since then. A second threatened species, Steller's Sea Lion *Eumetopias jubatus* (Endangered), is shared with the Northwest Pacific. Two other marine mammals are found in the region, the Polar Bear *Ursus arctos* (Lower Risk: conservation dependent) and the Northern Sea Otter *Enhydra lutris*; neither is endemic.

## FISHERIES

The region comprises the whole of FAO Fisheries Statistical Area 67 (Northeast Pacific) and most of Area 77 (East-central Pacific).

Total annual catch for the region in the early 1990s has been between 4.5 and 5 million tonnes, up to 70% of which is taken in the northern part (Fisheries Area 67). Catches in this area have remained between 3.1 and 3.5 million tonnes since the late 1980s, having grown steadily since the early 1980s. Catches in the southern part have decreased, from a little over 1.5 million tonnes in the mid-1980s to under 1.3 million tonnes in 1992. Estimated discard rate in the northern part is around the global average (22% of landings), while that in the East-central Pacific region overall is high (around 32% of catch), but this is almost certainly associated with by-catch from the inshore shrimp fishery, prevalent in the south (discussed under Southeast Pacific).

Catches in the southern area are dominated by small pelagics associated with the upwellings from the California Current, principally Californian Sardine *Sardinops sagax* and North Pacific Anchovy *Engraulis mordax*. The catch is almost entirely taken by Mexico. The decrease observed in the catch since 1990 is believed to be the result of a minor El Niño event which affected the area in 1991 and 1992.

In the north, there has been a gradual change in dominance of the fisheries since the mid-1980s from salmon, king crab and halibut to demersal fishes, particularly Alaska Pollock, and other crabs and molluscs. The Alaska Pollock stock, which is shared with the northwest Pacific region, is currently the second-largest fished stock in the world and by far the largest demersal fish stock. Catches of this species in the Northeast Pacific generally make up just under half of all landings in the region.

In general, there appears to have been a sustained period of good recruitment of many North Pacific fish stocks, particularly demersals, during the late 1970s and early 1980s, associated with El Niño-like conditions. These cause northward incursions of warmer water and associated species and apparently encourage recruitment in the northern Gulf of Alaska and Bering Sea, although they are generally detrimental to resident stocks further south. However, evidence from the past few years indicates that the stocks are now gradually declining.

There is also a locally important herring fishery (just under 100,000 tonnes per year). As elsewhere, stocks of this pelagic species vary in abundance from year to year. Little overall trend is discernible at present.

Much of the region is within the US 200 nm EEZ, although some is within Canada's EEZ, and there is a *doughnut hole* of high seas within the Bering Sea. All major fishery stocks are managed by catch quotas or harvest guidelines, including those off the British Columbian coast of Canada, which imposes limited entry policies. Strict by-catch limits are imposed for valuable catches such as halibut and king crab which, once reached, lead to other fisheries being closed even if their own quota allocation has not yet been reached. For new fisheries, fishing targets are set at not more than 80% of calculated MSY. Attempts are being made to determine new rules for multi-species fisheries so that revenues for the fisheries as a whole can be maximised without jeopardising any individual stock.

For the valuable salmon stocks there is concern about degradation of spawning and rearing habitats through logging, mining and coastal development. All five salmon species are considered over-exploited and some populations are threatened severely. There is additional concern that wild runs may be genetically swamped by hatchery production.

One of the Alaska Pollock stocks within the doughnut hole in the central Bering Sea has declined to a very low level owing to overfishing by fleets of several nations. All nations fishing in the area have agreed to suspend activities here for 1993 and 1994 to give the stocks a chance of recovery.

Generally, stocks in the region are closely managed, at least in comparison with most other marine fisheries stocks. Indeed it is built into the constitution of the State of Alaska that natural resources be exploited under criteria leading to sustained yield. This applies both to commercial fisheries and the very important sports fisheries here. The decline in stocks over the past few years, even under relatively conservative management regimes, illustrates that fish populations are under climatic and other influences beyond human control, and re-emphasises the importance of a precautionary approach to management.

# SOUTHEAST PACIFIC

Contains Data for Postscript Only.

**Chile; *Colombia*; *Costa Rica*; Ecuador; El Salvador; *Guatemala*; *Honduras*; *Nicaragua; Panama;* Peru**

## LARGE MARINE ECOSYSTEMS

There is only one LME contained within the Southeast Pacific Region: the Humbolt Current LME. Easter Island and Sala-y-Gómez (to Chile), in mid-Pacific, are not within an identified LME.

### Humbolt Current

This LME is one of the major upwelling systems of the world and extends along the western continental margins of South America, off Chile, Peru, and Ecuador. The cold, low salinity, nutrient-rich waters of the Humbolt Current are characterised by numerous gyres that are the source of local counter-currents and upwelling. This is in turn responsible for the extremely high levels of organic production in this region. The continental shelves in this LME are narrow, in places less than 10 km. Wider shelves can be found off the coast of Ecuador and in the Gulf of Panama.

Periodically the oceanography of this area is dramatically altered by the El Niño-Southern Oscillation, when warm, eastward flowing waters from the equator come to dominate the Humbolt Current. This causes a rise in seawater temperature that dramatically effects the levels of nutrients available in the surface waters. Productivity in the region is thereby reduced and this has a devastating effect on the marine fauna which rely on the normally highly productive waters.

## BIODIVERSITY

**Southeast Pacific Regional Sea: biodiversity data**

| | endemic | T | % | | endemic | T | % |
|---|---|---|---|---|---|---|---|
| seagrasses | 0 | 5 | 10 | sharks | 9 | 67 | 19 |
| coral genera | 0 | 8 | 7 | seabirds | 21 | 68 | 23 |
| molluscs | 2 | 393 | 9 | cetaceans | 2 | 39 | 44 |
| shrimps | 0 | 25 | 7 | sirenians | - | 0 | - |
| lobsters | 2 | 8 | 5 | pinnipeds | 2 | 8 | 24 |

Notes: the data refer to species except for coral genera. Column headings: endemic = restricted to the region; T = total species richness in the region; % = species richness in the region as a percentage of the world species richness in each group of organism. A dash (-) in a cell means no data or not applicable. See **Notes and Sources** in the introductory text for further information on the sources, coverage and quality of the data tabulated.

**Southeast Pacific Regional Sea: regional endemic species**

| | scientific name | common name | status |
|---|---|---|---|
| molluscs | *Natica brunneolinea* | Brown-lined Moon | |
| | *Polinices hacketti* | Hackett's Moon | |
| lobsters | *Jasus frontalis* | Juan Fernandez rock lobster | |
| | *Projasus bahamondei* | Chilean jagged lobster | |
| Sharks | *Aculeola nigra* | Hooktooth dogfish | |
| | *Centroscymnus macracanthus* | Largespine velvet dogfish | |
| | *Heterodontus quoyi* | Galápagos bullhead shark | |
| | *Apristurus stenseni* | Panama ghost catshark | |
| | *Halaelurus canescens* | Dusky catshark | |
| | *Schroederichthys chilensis* | Redspotted catshark | |
| | *Mustelus whitneyi* | Humpback smooth-hound | |
| | *Triakis acutipinna* | Sharpfin houndshark | |
| | *Triakis maculata* | Spotted houndshark | |
| seabirds | *Catharacta chilensis* | Chilean skua | |
| | *Creagrus furcatus* | Swallow-tailed gull | |
| | *Diomedea irrorata* | Waved albatross | |
| | *Larosterna inca* | Inca tern | |
| | *Larus belcheri* | Band-tailed gull | |
| | *Larus fuliginosus* | Lava gull | VU |
| | *Larus modestus* | Grey gull | |
| | *Oceanites gracilis* | White-vented storm petrel | |
| | *Oceanodroma hornbyi* | Ringed storm-petrel | |
| | *Oceanodroma tethys* | Wedge-rumped storm-petrel | |
| | *Pelecanoides garnotii* | Peruvian diving-petrel | EN |
| | *Pelecanus thagus* | Peruvian pelican | |
| | *Phalacrocorax harrisi* | Flightless cormorant | VU |
| | *Pterodroma defilippiana* | Defilippe's petrel | VU |
| | *Pterodroma externa* | Juan Fernandez petrel | |
| | *Pterodroma longirostris* | Stejneger's petrel | |
| | *Puffinus creatopus* | Pink-footed shearwater | VU |
| | *Spheniscus humboldti* | Humboldt penguin | |
| | *Spheniscus mendiculus* | Galápagos penguin | VU |
| | *Sterna lorata* | Peruvian tern | |
| | *Sula variegata* | Peruvian booby | |
| cetaceans | *Cephalorhynchus eutropia* | Black dolphin | |
| | *Mesoplodon peruvianus* | Lesser beaked whale | |
| pinnipeds | *Arctocephalus galapagoensis* | Galápagos fur seal | VU |
| | *Arctocephalus phillippi* | Juan Fernandez fur seal | VU |

Notes: letters in the 'status' column indicate the conservation status of species that have been assessed and classified as threatened. In the revised IUCN Red List category system the term 'threatened' refers only to species in any of the following three categories: CR - Critically Endangered, EN - Endangered, VU - Vulnerable. Seabirds have been assessed by BirdLife International, Collar *et al*. (1994); all status categories are recorded in IUCN (1996).

**Biodiversity Notes**

**Seagrass** diversity is low, with no endemics. As in the adjacent Northeast Pacific, **hermatypic coral** diversity is very low and there are no endemic genera. Diversity of **molluscs**, **shrimp** and **lobsters** is also low, although the first and last of these each have two endemic species.

**Shark** diversity is relatively high, as are apparent rates of endemism. Four species of **Sea Turtle** nest in the region. These are the Green Turtle *Chelonia mydas*, Hawksbill *Eretmochelys imbricata*, Olive Ridley *Lepidochelys olivacea* and Leatherback *Dermochelys coriacea*. The Olive Ridley nesting populations in Guancanaste Province in Costa Rica are of major importance, Along with those in Orissa, India (see South Asia Region), these are by far the largest known nesting populations in the world. **Seabird** diversity is very high, and endemism is second only to the South Pacific. A number of the seabirds are considered threatened and one, the Peruvian Diving Petrel, which breeds on islands off the coast of Peru and Chile, is considered Endangered.

**Cetacean** diversity is high and includes two species not recorded elsewhere, although neither of these is definitely known to be threatened. There are no **sirenians**, but there is a high diversity of **pinnipeds** with two endemic fur seal species. One of these, the Juan Fernandez Fur Seal, from the islands of that name off the Chilean coast, was formerly considered extinct, having been virtually hunted out by sealing. It was rediscovered in 1965 and has recovered in numbers since then, although is still considered Vulnerable. The Marine Otter *Lutra felina,* an Endangered species which breeds along the coasts of Chile and Peru, is endemic to the region.

## FISHERIES

The Southeast Pacific region includes the whole of FAO fisheries area 87 (Southeast Pacific) and a portion of fisheries area 77 (eastern central Pacific). The region has the second-largest fishery in the world, only the Northwest Pacific being larger. Around 80% of landings are of small pelagics within the Humboldt Current off Chile, Peru and Ecuador. Further north the region is characterised by a largely oligotrophic, tropical ecosystem. The most important fisheries are for shrimps inshore and for tuna and other large pelagic species offshore. Although small in volume, both these fisheries are of high value. There is also an area of nutrient-rich upwelling off the coast of Panama with a locally important stock of Central Pacific Anchoveta *Cetengrauilis mysticetus.*

Catches of pelagics within the Humboldt Current have been reasonably constant at around 13 million tonnes per year since 1990 (although 1991-1992 catches showed a slight decline over 1989 and 1990). This is similar to the catch recorded in the early 1970s, although species composition has changed. During the early 1970s virtually the whole catch was of Peruvian anchoveta *Engraulis ringens*, making it by far the largest single species fishery ever recorded. Between 1970 and 1973 the catch collapsed, to around 2 million tonnes as the result of a major El Niño event. From 1973 to 1989, landings have shown an increasing trend, with some year to year fluctuation. However, species composition has changed markedly, chiefly by becoming more diverse with Chilean Horse Mackerel *Trachurus symmetricus* and Sardine *Sardinops sagax* at least as important as Anchoveta in recent years. Species composition remains unstable, however, with Sardines having decreased markedly in importance since the mid-1980s and Anchoveta once again becoming the single most important species. These stocks, and most others in the region, are currently considered fully exploited or overexploited.

The pelagic fishery within the Humboldt Current LME is perhaps the best-known example of a fishery whose yields are dramatically affected by environmental variation on a decadal scale. It is unclear to what extent fishing mortality has influenced the rate of recovery of the stocks and subsequent changes in species composition. As with the Benguela Current region in southwest Africa, this region is relatively little affected by freshwater runoff, so that coastal zone management is of less significance in the management of the fishery. Rather, multi-species stock assessments and modelling to take into account environmental variation, particularly El Niño events, will be of prime importance in the long-term running of the fishery.

Further north, cooperation between states will be of increasing importance in the management of the highly migratory, and valuable, large pelagic species. The four coastal states in this region are members of the Permanent Commission for the Southeast Pacific (CPPS) which co-ordinates regional research activities in the area.

# SOUTH AFRICA

**ContainsDatafor PostscriptOnly.**

South Africa

This marine region is not within an existing Regional Seas area and has been defined here for the purposes of this document.

## LARGE MARINE ECOSYSTEMS

There are two LMEs partially contained within this region: the Benguela Current and the Agulhas Current. A more detailed account of these two systems can be found in the West and Central Africa Region and the East African Region respectively.

The area off the coast of South Africa is dominated by both the Benguela and Agulhas Currents. The Benguela Current transports cold water towards the equator along the west coast of South Africa at a speed of approximately 20 cm per second and the Angulhas Current transports warm equatorial waters along the east coast towards the Antarctic. The southern region of South Africa's 3,000 km coastline is a transition zone between these water masses, and has flora and fauna representative of both systems as well as its own endemic species.

## BIODIVERSITY

### South Africa Regional Sea: biodiversity data

| | endemic | T | % | | endemic | T | % |
|---|---|---|---|---|---|---|---|
| seagrasses | 0 | 7 | 15 | sharks | 7 | 93 | 27 |
| coral genera | 0 | 46 | 42 | seabirds | - | 39 | 13 |
| molluscs | 0 | 145 | 3 | cetaceans | 0 | 32 | 41 |
| shrimps | 0 | 20 | 6 | sirenians | - | 0 | - |
| lobsters | 2 | 22 | 15 | pinnipeds | 0 | 4 | 12 |

Notes: the data refer to species except for coral genera. Column headings: endemic = restricted to the region; T = total species richness in the region; % = species richness in the region as a percentage of the world species richness in each group of organism. A dash (-) in a cell means no data or not applicable. See **Notes and Sources** in the introductory text for further information on the sources, coverage and quality of the data tabulated.

### South Africa Regional Sea: regional endemic species

| | scientific name | common name | status |
|---|---|---|---|
| lobsters | *Homarus capensis* | Cape lobster | |
| | *Palinustus unicornutus* | Unicorn blunthorn lobster | |

| | scientific name | common name | status |
|---|---|---|---|
| sharks | *Apristurus saldanha* | Saldanha catshark | |
| | *Haploblepharus edwardsii* | Puffadder shyshark | |
| | *Haploblepharus fuscus* | Brown shyshark | |
| | *Poroderma marleyi* | Barbeled catshark | |
| | *Scyliorhinus capensis* | Yellowspotted catshark | |
| | *Scylliogaleus quecketti* | Flapnose houndshark | |
| | *Triakis megalopterus* | Sharptooth houndshark | |

**Biodiversity Notes**

**Seagrass** diversity is moderate with no endemics. Generic diversity of **hermatypic corals** is lower than in most of the coralline areas of the Indo-Pacific, but still higher than the Atlantic and Caribbean; there are no endemic genera. Richness in **molluscs**, **shrimps** and **lobsters** is low to moderate, with very low endemism.

Recorded **shark** diversity is very high, being exceeded only by the East Asian Seas and South Pacific Regions; seven species have not been recorded elsewhere. This high diversity is in part a reflection of South Africa's position at the meeting point of to major oceanographic regions (the Atlantic and Indo-Pacific), but is also probably a reflection of the better state of knowledge of South Africa's aquatic resources compared with adjacent regions. Only two species of **sea turtle -** the Loggerhead *Caretta caretta* and Leatherback *Dermochelys coriacea* are definitely known to nest, both on the Kwa-Zulu coast in the east. The Olive Ridley *Lepidochelys olivacea* may also nest in small numbers. The reasonably high **seabird** diversity is probably a more accurate reflection of the real situation as this group of birds has been fairly well documented, at least at the regional level. There appear to be no endemic seabirds in the region.

**Cetacean** diversity is fairly high. Heaviside's Dolphin *Cephalorhynchus heavisidii* is apparently confined to the Benguela Current and is therefore endemic to South Africa and the West and Central African Region. There are no **sirenians** recorded, although the Dugong *Dugong dugon* may be a vagrant in the east. Four **pinnipeds** occur in South Africa (and/or its associated islands). None is endemic to the country nor currently considered threatened.

**FISHERIES**

The seas around South Africa include parts of FAO statistical area 47 (Southeast Atlantic) and 51 (Western Indian Ocean); only a small part of the east coast borders the latter region.

**Southeast Atlantic** (see also West & Central Africa)

Nutrient upwellings generated by the north-flowing Benguela Current result in an exceptionally high biological productivity. Relatively few species account for most fish biomass: Hake *Merluccius*, Horse Mackerel *Trachurus* and Chub Mackerel *Scomber* offshore, with Pilchard *Sardinops* and Anchovy *Engraulis* as the inshore pelagics. The total annual catch remained relatively stable at 2.1-2.7 million tonnes in the 1970s and 1980s, but decreased heavily to 1.5 million tonnes in 1990 and remained around that level in 1992. This reduction may be largely due to decreased activity by distant water vessels.

Hakes, the most abundant demersal stock in the Southeast Atlantic, consist of two different species; *Merluccius capensis* and *M. paradoxus*. South African catches of hake have decreased from 450,000 tonnes in the 1970s to 309,000 tonnes in 1992. All Hake stocks are over-exploited although southern stocks are showing signs of recovery.

The stock of Cape Horse Mackerel (*Trachurus capensis*) appears in good condition; current policy is to maintain high level exploitation, and emphasise purse-seining offshore in order to minimise bycatch. The South Africa anchovy stock *Engraulis capensis* is almost entirely exploited by South African fishing vessels and produced landings of 373,000 tonnes in 1989, to be used mainly for fish meal production. These stocks were considered to be fully exploited but landings between 1990 and 1992 almost doubled to 186,000 million tonnes. The South African pilchard (*Sardinops ocellata*) which crashed in the 1960s still show no sign of recovery and continue to be depleted.

Up to 1989, stock exploitation was monitored by the International Commission for the Southeast Atlantic Fisheries (ICSEAF). The ICSEAF ceased its operations in early 1990 following the independence of Namibia. Fishery rights in Namibia's EEZ were mainly granted to South Africa in 1987 but elapsed in 1993.

**Western Indian Ocean**

No data are available on South Africa landings in the Western Indian Ocean.