AoA Region: North West Atlantic Ocean

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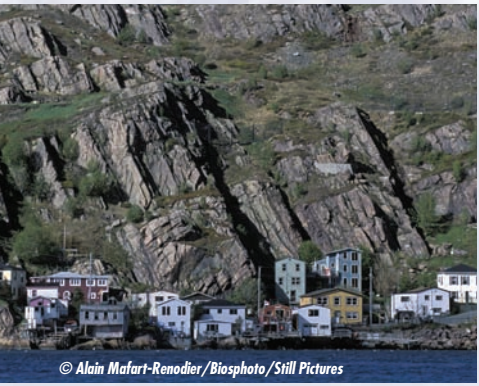

The region includes major historical fishing grounds. Fisheries are a major employer and a vital economic and cultural activity.

The North West Atlantic Ocean region extends across the northern Atlantic and includes Canada, the United States of America (USA) and Greenland (Denmark).

1. BROAD ECOLOGICAL CHARACTERISTICS

The environmental features of the North West Atlantic Ocean region include harsh conditions as well as extensive and persistent sea ice in the most northerly areas and warm coastal and Gulf Stream waters in the south. Major oceanographic features include the northward-flowing Gulf Stream along the Continental Shelf of the eastern USA and southern Canada and the southward-flowing Labrador Current along the Canadian east coast. The gyre systems of the Gulf of Maine and Georges Bank along with the nutrient enrichment of estuaries along the entire coast contribute to the maintenance on the shelf of relatively high levels of phytoplankton and zooplankton. The Labrador Current and the Gulf Stream, as well as the formation of warm and cold core rings of the latter, have important influences on the ecology of the region. The cold intermediate layer is a dominant feature in the northern half of the North West Atlantic Ocean region with its depth and position being a major driver of inter-annual variation in productivity and distribution of marine species.

The North West Atlantic Ocean region ecosystems are highly productive, supporting major fisheries as well as other populations of marine species, including marine mammals, birds and invertebrates. Human population

density is high in the southern part of the ecosystem and low in the northern part. The broad continental shelf off the east coast of Canada and the United States of America south to the Caribbean includes the major historical fishing grounds off the Labrador Coast, the Flemish Cap, Newfoundland, the Grand Banks, the Scotian Shelf and Georges Bank, with many other important coastal fishing areas further south. In addition, there are major estuarine areas such as Chesapeake Bay and tidal areas such as the Bay of Fundy along the coast which also are important fishing grounds. In the northern part of the North West Atlantic Ocean region, fisheries are a major employer and a vital economic and cultural activity, with oil production also increasing in economic importance. In the southern part of the North West Atlantic Ocean region, fisheries remain as important contributors to culture and the economy, although tourism, coastal development, aquaculture, and transportation are dominant economically.

2. INSTITUTIONS UNDERTAKING ASSESSMENTS

Various institutions contribute to assessment work in the region including international organizations, notably the North Atlantic Fisheries Organization (NAFO) and the International Council for the Exploration of the Sea (ICES) – primarily with regard to methodology and comparative work in European waters – as well as Canadian and United States governmental and academic institutions. The North Atlantic Salmon Commission (NASCO) also undertakes regular assessments of Atlantic salmon while the North Atlantic Marine Mammal Commission (NAMMCO) carries out similar assessments on exploited marine mammals.

The Canadian Department of Fisheries and Oceans (DFO) and the United States National Oceanic and Atmospheric Administration (NOAA) are the primary agencies in their respective countries carrying out assessment work. Other government departments such as Environment Canada and the United States Environmental Protection Agency are important contributors, particularly regarding water quality. Extensive academic research programmes in both countries are major contributors also to assessments with respect to specific topics, particularly with regard to processes and methodologies. These activities provide advice to policy-makers in both nations as well as to international organizations. Smaller research stations on the west coast of Greenland conduct research and some assessments for waters around Greenland.

3. DATA

3.1 Ecosystem data

For the North West Atlantic Ocean region there are extensive data in time-series covering most of the past 50 years on the biophysical environment. These data come from fisheries, coastal development, oil exploration and drilling, transportation as well as activities undertaken by non-government organizations (NGOs) or government. There is a well-developed science programme for the region, including cooperative Canada-USA studies on various topics. Very extensive data collection systems are operating in both countries, including research surveys operating year-round and newly developed ocean observing systems which are coming on stream. Reporting from commercial fisheries on catch results is generally reliable, particularly when augmented by observer data and constitutes another source of data on the exploited components of the ecosystem.

Data are most complete for commercially exploited fish and invertebrate populations, marine mammals, seabirds and physical and chemical oceanographic parameters. Multi-species surveys of coastal fish communities from central Labrador to Florida also have been conducted systematically since at least the 1970s. In contrast, systematic zooplankton surveys are patchy spatially and the time-series are shorter, but they are available for several areas from the Newfoundland Banks to the United States southeastern coast. Satellite monitoring and continuous plankton recorder records are major contributors to data series on primary productivity.

Water quality assessments and habitat mapping also have been extensive, although less comprehensive in time and space.

3.2 Socio-economic data

Socio-economic data are contained in individual management planning and environmental assessment documents associated with specific management actions. They are not widely available, however, nor are they synthesized as are the biophysical data. Some synoptic data are available from the USA in the United States Ocean Economy project, but there is little time-series information and cannot really be used to evaluate status and trends. While extensive data on fishing activities in the region are available, data on other human activities are not as prevalent.

Almost all human demographic data and, to the extent that they exist, data on employment in ocean-related industries and economic returns from these industries, among others, are collected by states and provinces. No central

repository exists for most of these datasets at the national scale and they often are impossible or difficult to access, even at the state, provincial, or local scales. The primary government institutions are the principal holders of data although there are some national data repositories in the United States such as the National Ocean Data Center of NOAA and the Marine Environmental Data System of DFO. This centre, however, primarily deals with oceanographic information and not the broader array of data needed for integrated assessment.

4. ASSESSMENTS

4.1 Thematic/sectoral assessments

A substantial body of assessment work is carried out in the North West Atlantic Ocean region either annually or regularly on fisheries, water quality, habitat and ecosystem processes. These assessments are used by government agencies in management processes for activities such as setting annual fishery regulations and measures to protect habitat as well as measures to protect species of particular concern under the Canadian Species at Risk Act and the United States Marine Mammal Protection Act and Endangered Species Act. NAFO is the regional fisheries management organization for the northern part of the North West Atlantic Ocean region and its oceanographic reviews cover the entire northwest Atlantic. NAFO also assesses the status of a few fish and other stocks which occur beyond national jurisdiction, but otherwise there are few assessments of ecosystem components of the High Seas. Other organizations such as the International Commission for the Conservation of Atlantic Tunas (ICCAT), the International Whaling Commission (IWC), NASCO and NAMMCO conduct regular assessments of specific species, but not for the ecosystem as a whole.

Academic research studies provide substantial data and information for specific areas and ecosystem components. These data, however, are more difficult to obtain other than through the primary academic literature.

4.2. Integrated assessments

While there has been no overall synthesis of the information on the North West Atlantic Ocean region ecosystems, there are major assessments for the ecosystems along the coast under the auspices of government agencies. Notable are the two Canadian series on the State of the Oceans and the Ecosystem Overview and Assessment Reports and the United States Coastal Condition report. Synthesis studies such as the United States Coastal Condition

report give a broader overview of the entire coast but at much lower resolution. Integrated ecosystem assessments are in development in both countries. Assessments for these areas are included in the United Nations Environment Programme (UNEP) UNEP/GEF/NOAA Large Marine Ecosystem (LME) report.

5. PRIORITIZED ISSUES

Fisheries sustainability is a major issue in the North West Atlantic Ocean region, with many stocks seriously depleted after periods of over-exploitation over past decades. Recovery plans are attempting to reverse this situation in both countries and are meeting with some success for species such as scallops, haddock, swordfish and seals. However, recovery efforts have not been successful for other stocks including the various cod and salmon stocks, halibut, bluefin tuna, sharks and several species of whales and turtles. Interest in eco-certification of fisheries in the North West Atlantic Ocean region has sparked increased efforts at assessing ecosystem components rather than only the exploited species. There have been increased efforts also at assessing the potential for greater sustainability of fisheries practices.

A major concern is land-sea connections, particularly in the more developed southern portion of the North West Atlantic Ocean region. Important coastal areas including the southern New England coast, Chesapeake Bay and Pamlico Sound have been subjected to high levels of nutrient loading from land-based sources and have experienced loss of wetland and subtidal habitats and in some areas the natural hazard protection has been significantly diminished. The loss of ecosystem function in Chesapeake Bay caused by the depletion of filter-feeding oyster beds in the bay is a major issue. Coastal water quality in some areas remains substandard and harmful algal bloom events have increased in recent years due to a combination of factors.

The control of alien invasive species (AIS) is a major challenge for the region because of their potential impact on ecosystem function. In this context, another management challenge is presented through the growth of marine aquaculture in the Gulf of Maine and Bay of Fundy region, which often introduces new species or new strains.

Coastal development is being affected by strong population pressure as well as by the advent of several new uses of ocean and coastal areas, including offshore liquefied natural gas ports, other energy infrastructure such as tidal and wind power facilities, and potential offshore aquaculture development.

Currently, many of these activities are in the rapid development stage, but they have the potential to change both the social structure and economy of the coast as well as affect the natural system.

An over-riding emerging issue for the North West Atlantic Ocean region is the impacts of climate change. The projected scenarios for the effects of global warming show that the current warming trend is likely to affect sea ice, water temperature and upwelling as well as species distributions and other factors. Although climate prediction is challenging and the spatial pattern of changes is difficult to forecast, climatic effects are known to change productivity, coastal processes, storm patterns and other features of the ecosystem. Sea level rise may have major impacts in some areas and warming seas may have broad ecological effects.

6. SUPRA-REGIONAL ISSUES

The North West Atlantic Ocean region has direct connections with the Arctic and other portions of the Atlantic. Changing climate which is resulting in shifts in species ranges and habitats, changing transportation routes for shipping and developing energy infrastructure, and potential shifts in ocean and atmospheric circulation patterns will be important supra-regional issues. Highly migratory species of large fishes, marine mammals, turtles and seabirds, many of which are depleted, need strong conservation measures not only in the North West Atlantic Ocean region but also in the Atlantic as a whole.

7. CAPACITY OF THE REGION TO UNDERTAKE ASSESSMENTS

Regional capacity for assessment is very high although capacity in the North West Atlantic Ocean region for social and economic assessment appears to be lagging seriously behind that for biophysical assessment. There are only three competent national jurisdictions, the USA, Canada and Greenland/Denmark, and one regional fisheries management organization, NAFO, plus the species-specific fisheries organizations such as ICCAT and IWC, all of which invest significantly in monitoring, assessment and ecological research. Efforts to integrate assessments are being undertaken in parts of the North West Atlantic Ocean region which are closest to major centres of assessment expertise, but the integration is primarily of different components of the biological and physical ecosystems. Assessments integrating socio-economic and ecological information are progressing much more slowly.

Detailed and targeted studies, particularly academic studies need to be better incorporated into both thematic/sectoral and integrated assessments. Land-sea-climate interaction studies are a major new area of research which need to be brought into policy making settings as soon as possible.

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AoA Region: North West Pacific Ocean

Andrew A. Rosenberg

The North West Pacific Ocean region is adjoined by five countries, China, Japan, the Democratic People's Republic of Korea, the Republic of Korea and the Russian Federation, and is made up of four Large Marine Ecosystems (LMEs), the Kuroshio Current, the Sea of Japan, the Oyashio Current, and the Sea of Okhotsk LMEs.

Climate change is of major concern in this region. Regime shifts have been well-documented, with warming in the western North Pacific observed when the eastern areas cool.

1. BROAD ECOLOGICAL CHARACTERISTICS

To the east of Japan the western Kuroshio and Oyashio boundary currents exert a major influence on the productivity and climate of the western North Pacific. The North West Pacific Ocean region is characterized by a high diversity of marine ecosystems, from boreal to subtropical. It is known that the mean depth of the Sea of Okhotsk and the Sea of Japan go down as low as 821metres (UNEP 2008) and 1350 metres (Sherman and Hempel 2008), respectively. The areas of the Oyashio Current and the Kuroshio Current are down to a depth of about 2000 m.

These ecosystems are highly productive and support major fisheries as well as important populations of marine mammals, seabirds, sea turtles and invertebrates. Major environmental drivers of system dynamics for most of the North West Pacific Ocean region are the Pacific Decadal Oscillation (PDO), and the North Pacific Gyre Oscillation, along with variability in the position of the subtropical front. Region-scale changes in primary and secondary productivity and in the productivity of a number of fish and macro-invertebrates important to both the functioning and human uses of the marine ecosystems, especially fisheries, have been attributed to the PDO and to variability in other oceanographic features.

Human population densities and the distribution of industries vary widely in North West Pacific Ocean region coastal areas. In the northern part of the North West Pacific Ocean region around the Sea of Okhotsk, fishing, transportation, and in some areas oil drilling are major activities, although human population density is relatively low. In the Sea of Japan, and the Yellow and East China Seas in the adjacent East Asian Seas region, coastal population density is higher, with increasing human influence on coastal and estuarine water quality, marine and riparian habitats and fisheries. Major metropolitan areas, intense fisheries, shipping and large-scale manufacturing and processing industries have a significant impact on these ecosystems.

2. INSTITUTIONS UNDERTAKING ASSESSMENTS

Various institutions contribute to the assessment work in the region, including international organizations, notably the North Pacific Marine Science Organization, the North West Pacific Regional Seas Programme and the North West Pacific Action Plan of the United Nations Environment Programme (UNEP) as well as national institutions in the bordering countries.

The North Pacific Marine Science Organization (PICES) areas covers the northern North Pacific and adjacent seas, including the Sea of Okhotsk, the Oyashio Current, Kuroshio Current, the Sea of Japan, the Yellow Sea and the East China Sea. PICES, which was established under a convention by the North Pacific countries, held its first annual meeting in 1992. The organization brings together government and non-government scientists from around the North West Pacific Ocean region. Although PICES does not play a formal advisory role to governments on policy or management questions, it does conduct scientific assessments of ecological issues which are relevant to policy and management. PICES has summarized the major assessments which cover a number of issues in the region (PICES 2004). Many of the component assessments in this synthesis come from government organizations and have a direct link to policy development in national and international decision making bodies.

The North West Pacific Action Plan (NOWPAP) region mainly includes the Sea of Japan and the Yellow Sea. NOWPAP maintains the Regional Coordinating Unit, co-hosted by Japan and the Republic of Korea and four Regional Activity Centres. They include:

a. The Special Monitoring and Coastal Environmental Assessment Regional Activity Centre in Toyama (Japan);

b. The Data and Information Network Regional Activity Center in Beijing (China);
c. The Marine Environmental Emergency Preparedness and Response Regional Activity Center in Daejeon (Republic of Korea); and
d. The Pollution Monitoring Regional Activity Center in Vladivostok (the Russian Federation).

All four Regional Activity Centres have coordinated important regional assessment activities in recent years.

3. DATA

3.1 Ecosystem data

Extensive data on the biophysical environment in much of the region have been collected over the past 30 years. These data come from fisheries and directed research and monitoring efforts of governments and academia. The 2004 PICES synthesis includes much of the oceanographic and fisheries information for the North West Pacific Ocean region. The NOWPAP assessments consider biodiversity patterns and marine pollution, including harmful algal blooms (HABs) and marine litter. These data are primarily collected by national institutions in North West Pacific Ocean region countries. NOWPAP has developed and maintains the "NowpapIR" database. This is the portal to provide access to available coastal, marine, ecological and marine environment information on NOWPAP areas of each member country. NOWPAP also has a database on marine litter monitoring, collected by national institutions in the NOWPAP region.

3.2 Socio-economic data

The extent and availability of socio-economic data for the North West Pacific Ocean region was not determined at the time of writing of this summary. Basic socio-economic data such as population, industry, trade and fishery is available from national statistical centers at least in Japan and the Republic of Korea. However, there is no regional database that aggregates such data.

4. ASSESSMENTS

4.1 Thematic/sectoral assessments

A substantial body of assessment work on fisheries, water quality, habitat and ecosystem processes has been summarized by PICES (PICES 2004) and NOWPAP (NOWPAP 2007a, 2007b). PICES is preparing a second version of the North Pacific Ecosystem Status Report and its publication

is scheduled in spring, 2010. The individual assessments conducted by national institutions were not reviewed for this summary.

4.2 Integrated assessments

The Global International Waters Assessment (GIWA) project has conducted integrated assessments for the Kuroshio Current, Sea of Japan, Oyashio Current, and Sea of Okhotsk LMEs. The UNEP/GEF/NOAA LME report includes assessments of all four LMEs.

5. PRIORITIZED ISSUES

Fisheries sustainability is a major issue in the North West Pacific Ocean region, particularly in the densely populated coastal areas. Fisheries in the northern areas have not declined to the same degree as those in the southern areas, but are at growing risk from increasing fishing pressure. Other large marine animal populations including marine mammals, seabirds and turtles are at risk also from fishing, pollution and habitat degradation.

Pollution of coastal and marine waters from both atmospheric deposition and effluent discharges has increased with growing industrialization, particularly in the southern part of the North West Pacific Ocean region. As noted by NOWPAP, other major concerns are oil spill risks, persistent toxic substances, HABs and marine litter.

Several countries have vital aquaculture industries which are at risk from poor water quality and the increasing prevalence and intensity of HABs. The introduction of invasive species through aquaculture and ballast water is also of concern. These factors can have major impacts on wild biota, as can overfishing and habitat loss.

An over-riding emerging issue for the North West Pacific Ocean region is the impact of climate change. Regime shifts have been well-documented, with warming in the western North Pacific observed when the eastern areas cool. Projected scenarios for the effects of global warming show that the current warming trend will affect sea ice, water temperature, ocean acidification and upwelling as well as freshwater input and other processes. Although climate prediction is challenging and the spatial pattern of changes is difficult to forecast, climate effects are known to change coastal processes and storm patterns as well as marine productivity and other ecosystem features.

6. SUPRA-REGIONAL ISSUES

The connections between the eastern and western North Pacific and the Arctic are strengthening further with changing climate. Issues of ocean circulation and changing contaminant patterns, species range and habitat changes, transportation and energy infrastructure development, and conservation are all relevant supra-regional issues in the North West Pacific Ocean region. A major supra-regional concern is the intensification of industrial impacts, including air and water borne pollution. The large dam construction and/or large-scale river improvement works in the East China Sea coast may have a severe influence on the marine environment and ecosystems of the Sea of Japan in this region.

7. CAPACITY OF THE REGION TO UNDERTAKE ASSESSMENTS

Regional capacity for assessment appears to be high, although capacity for social and economic assessment may be lower than that for biophysical assessment. Important concerns have been raised regarding the availability and integration of databases, resource limitations and sharing of expertise around the North West Pacific Ocean region and across disciplines.

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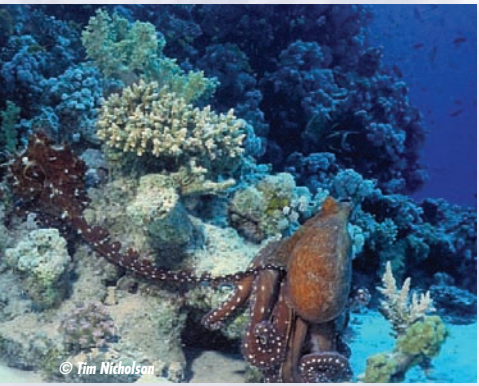
AoA Region: Red Sea And Gulf of Aden

Wajih Naqvi



A coral reef in the Egyptian Red Sea.

The Red Sea and Gulf of Aden region includes nine countries, Egypt, Eritrea, Ethiopia, Israel, Jordan, Saudi Arabia, Somalia, Sudan and Yemen and contains the Red Sea Large Marine Ecosystem (LME).

1. BROAD ECOLOGICAL CHARACTERISTICS

The Red Sea and Gulf of Aden region covers two distinct ocean provinces because the Red Sea and the Gulf of Aden are separated by a sill. Oceanographic and ecological processes of the region have been described by Grasshoff (1969), Morcos (1970), and Sheppard and others (1992). The Red Sea is a landlocked basin connected to the Arabian Sea (Indian Ocean) through the Strait of Bab-el-Mandeb and to the Mediterranean Sea through the man-made Suez Canal. The Red Sea is about 2 000 kilometres (km) long and up to 350 km wide, occupying an area of approximately 450 000 square kilometres (km^2). Its depth reaches a maximum of about 2 500 metres (m) in the narrow central median trench which is flanked by shallow shelves. The average depth of the basin is about 500 m, but the sill depth at the Bab-el-Mandeb Strait is only 137 m, which determines the hydrographic characteristics of the basin. Excessive evaporation drives an inflow of fresher surface water and a subsurface outflow of dense Red Sea water through the Strait. In the Red Sea itself the deep water below the sill depth is formed as a result of winter cooling of highly saline surface waters in the Gulf of Aqaba, which forms the northernmost extension of the Red Sea.

As a result of strong evaporation and negligible river run-off, the Red Sea water is among the most saline in the world's oceans. The high salinity level is very close to the physiological limits of many species,

which highlights the potential sensitivity of the Red Sea biota to localized anthropogenic salinity increases (e.g. due to discharge from desalination plants). The salinity is slightly lower in the surface layer as compared to the deep waters (by ~3 on the PS scale in the southern Red Sea) as a result of inflow from the Arabian Sea but it gradually increases northwards. Except in the most northern parts in winter, the upper water column is strongly stratified, restricting reflux of nutrients from the subsurface to the surface layer. In addition, the Red Sea receives negligible runoff from land and the inflowing water from the Arabian Sea/Gulf of Aden is nitrate-depleted, although it contains significant amount of phosphate, which promotes some nitrogen (N_2)-fixation. As a result, primary production in the water column remains low throughout the year. Unlike the Red Sea, the Gulf of Aden, which is also semi-enclosed but much deeper (up to 5 000 m), is not topographically isolated from the Arabian Sea. This gulf is strongly affected by the monsoon-related seasonal changes, with the Yemeni coast experiencing strong upwelling and being highly productive during the Southwest Monsoon.

Despite the highly saline conditions, the Red Sea supports a number of rich and diverse ecosystems, the most important of these being coral reefs. More than 1 100 species of fish are recorded in the Red Sea, of which more than 10 per cent, including scores of deepwater fish, are endemic to this sea. The coral reefs, which contribute to the rich biodiversity of the Red Sea, fringe about 2 000 km of the coastline. The reefs form platforms and sometimes lagoons along the coast. Other important marine habitats include seagrass beds, salt pans, mangroves and salt marshes.

Since the construction of the Suez Canal, the Red Sea has been one of the busiest shipping routes in the world, which makes it particularly vulnerable to pollution. Because of the spectacular coral reefs it contains, the Red Sea is a popular tourist destination. The other, more traditional use of the sea, fishing, is an important source of food and employment for the coastal communities. Although the Red Sea and Gulf of Aden region does not yet have offshore oilfields, a large volume of crude oil is transported through the Suez Canal, and several oil handling and processing facilities such as terminals and refineries are located on the Red Sea shores.

2. INSTITUTIONS UNDERTAKING ASSESSMENTS

Assessments in the Red Sea and Gulf of Aden region have been carried out mostly by the Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden (PERSGA) which is an intergovernmental organization dedicated to the conservation of the coastal and marine environments in the region. PERSGA member states are Djibouti, Egypt, Jordan, Palestine, Saudi Arabia, Somalia, Sudan and Yemen, but it does not include the regional states of Eritrea and Israel. The legal foundation for PERSGA is the Regional Convention for the Conservation of the Red Sea and Gulf of Aden Environment (Jeddah Convention) of 1982. The Secretariat for PERSGA was formally established in Jeddah following the Cairo Declaration of September 1995.

PERSGA's mandate is to perform functions necessary for the management of the Jeddah Convention and its Action Plan. As a result, PERSGA, in close collaboration with relevant regional and international organizations, began implementing activities and programmes to deal with the various threats facing the coastal and marine environments in the Red Sea and Gulf of Aden region. The Strategic Action Programme (SAP) for the Red Sea and Gulf of Aden, executed by PERSGA with support from the Global Environment Facility (GEF), was one of the most ambitious programmes undertaken in the region. The SAP was largely executed through a diverse set of training activities, workshops, surveys and action plan development, which resulted in a substantial number of documents, including the Country Reports, being published together (PERSGA 2001). The availability of this information formed the basis for the production of the State of the Marine Environment Report (SOMER) 2006 for the Red Sea and Gulf of Aden (PERSGA 2006). The purpose of this report, which is updated every three years, includes providing a foundation for improved decision making at all levels and increasing awareness and understanding of environmental trends and conditions, their causes and consequences among all stakeholders.

3. DATA

3.1 Ecosystem data

A large amount of data collected for the most part during major expeditions to the Red Sea over the past several decades is available in international oceanographic databases such as the World Data Center for Oceanography (http://www.nodc.noaa.gov/General/NODC-dataexch/NODC-wdca.html). These expeditions have led to an excellent

understanding of the broad oceanographic processes in the Red Sea and its exchanges with the Indian Ocean (Grasshoff 1969, Morcos 1970). However, information is relatively sparse and of variable quality for areas closer to the coast which are most affected by human activities while at the same time, containing some of the most interesting and sensitive ecosystems such as coral reefs and mangroves (Sheppard and others 1992). In the absence of regular, organized data collection, including monitoring for time-series measurements, most of the observations have been made for a specific, narrowly targeted purpose, resulting in the data collected being of limited scope in terms of the parameters measured. For example, while substantial taxonomic information is available on fish and hard corals, much less is known about other organisms such as microbes, phytoplankton and zooplankton and soft bottom fauna. There is a general lack also of integrated biogeochemical and ecological studies. In addition, the geographical coverage seems also to be associated with the political situation and the economics of any given sub-region, with some sub-regions being least investigated, particularly the Somali coast.

3.2 Socio-economic data

Most socio-economic data in the assessments are from the member states and directed at the fisheries sector. The data is available from PERSGA, although the extent to which the national datasets are accessible for international assessments is not known. There are several other activities which provide significant employment and/or affect the lives of the Red Sea and Gulf of Aden riparian human populations including industrialization, tourism and recreation, shipping, urbanization and coastal development as well as utilization of biological resources such as mangroves. There is, however, relatively little socio-economic information available on these activities.

4. ASSESSMENTS

The characteristics of the Red Sea LME have been described briefly (http://www.edc.uri.edu/lme/text/red-sea.htm) but the Gulf of Aden forms a part of another LME. The Global International Waters Assessments (GIWA) considers the Red Sea LME and the Gulf of Aden separately (http://www.unep.org/dewa/giwa/areas/regions_and_network.asp).

4.1 Thematic/sectoral assessments

PERSGA has conducted a few thematic assessments of marine living resources (PERSGA 2002), coral reefs (PERSGA/GEF 2003), and

mangroves (PERSGA/GEF 2004) in the Red Sea and Gulf of Aden region. A thematic assessment of land-based sources and activities affecting the marine environment in the Red Sea and Gulf of Aden was undertaken by UNEP/PERSGA (1997). This information, which is included in the report by the Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP) global analysis of land-based activities (UNEP 2001), is utilized also in an updated form in the SOMER 2006 (PERSGA 2006), described in some detail below.

4.2 Integrated assessments

SOMER 2006 is a broad-based assessment which comprehensively covers various activities affecting the marine environment of the Red Sea and Gulf of Aden. For each of its components, the assessment evaluates the current status, progress made and constraints to continued progress. The assessment begins with an overview of the physical environment of the Red Sea and Gulf of Aden region with a synthesis of available information on geography/geomorphology, climate and circulation as well as key biogeochemical variables such as oxygen, nutrients and primary productivity. This is followed by an assessment of resources of various habitats, namely sabkha or salt flats, salt marshes, sandy and muddy shores, rocky shores, mangroves, algal reefs, seagrass beds, subtidal soft bottoms and coral reefs. In addition to invertebrates, the groups assessed include fishes and elasmobranches, turtles, seabirds and marine mammals. Causes of coral destruction from influences such as bleaching and crown-of-thorns starfish also are examined.

The assessment also deals in detail with both sea-based and land-based activities as well as sources of pollution. The former includes maritime transport of oil and chemicals through the region, the emerging issue of alien invasive species carried in ships ballast water and the effect of port and terminal development in various member states. Land-based activities are more important in the Red Sea region than in most other oceanic areas because of the land-locked nature and small size of the basin. A country-wide status for this sector is presented.

Special attention has been given in the assessment to marine living resources. In addition to the capture fisheries, including cetaceans (sharks, rays, skates) and ornamental fishes, the assessment also covers aspects of aquaculture. Emphasis is placed on fisheries regulation and management through *sub-regional fisheries research and training centres, monitoring control and surveillance systems, regional commission on fisheries,*

improving capacity to manage marine living resources and regional cooperation in this sector. Socio-economic aspects of both the small-scale fisheries and semi-industrial and industrial fisheries in the region have been given due importance.

The assessment makes important recommendations for priority actions that include acquisition of the needed information, management of maritime transport, promoting conservation measures, management of living resources, capacity building and institutional strengthening, regional cooperation and networking and issues associated with climate change and political and socio-economic aspects.

SOMER 2006 provides an excellent example of how regional cooperation can produce reliable assessment of the marine environment, even in developing regions. However, the assessment does have a few shortcomings. The most notable is that it focuses largely on coastal waters, and even in the Gulf of Aden an open coast, and deep-sea areas remain uncovered. In addition, there appears to be insufficient information on the levels of key pollutants and on some important components of the ecosystem as mentioned above, as well as on temporal changes in the system based on time-series measurements. PERSGA, however, is putting mechanisms in place for regular monitoring and it is hoped that the next SOMER will address these deficiencies and follow a more integrated approach which will involve the whole ecosystem and the pressures exerted on it by human activities.

5. PRIORITIZED ISSUES

The assessment identifies a number of continuing and emerging issues for the environment of the Red Sea and Gulf of Aden. They are:

a. Habitat degradation and destruction by pollution, coastal development and tourism;
b. Overfishing and its associated socio-economic consequences for coastal populations;
c. Limited technical capacity, management experience, scientific knowledge and monitoring of key habitats, species and processes;
d. The risks of further coral bleaching events and sea level rise attributed to global climate change; and
e. The spread of alien invasive species.

6. SUPRA-REGIONAL ISSUES

The Red Sea receives lower salinity surface waters from the Arabian Sea and supplies warm saline water to the mesopelagic zone of the Arabian Sea. This water exchange between the Red Sea and the rest of the Indian Ocean is strongly dependent on climate and circulation and is likely to be altered by any change in the Afro-Asian monsoon forced by global warming. Besides causing changes in the local marine environment through factors such as salinity, nutrients and oxygen levels and their associated ecological consequences, a modified water exchange through the Bab-el-Mandeb Strait may also disturb the already precarious oxygen balance at mid-depths in the Arabian Sea. Similarly, coastal upwelling off Yemen contributes to the high biological productivity of the Arabian Sea and maintenance of the mid-depth oxygen deficiency. Any changes in the upwelling intensity as a result of global climate change also may affect the oxygen minimum zone processes, with potentially significant changes in global nitrogen budget and the Arabian Sea's marine living resources.

7. CAPACITY OF THE REGION TO UNDERTAKE FUTURE ASSESSMENTS

The available assessments have been carried out largely with the help of consultants from outside the Red Sea and Gulf of Aden region who have been actively involved in research in the two ocean provinces. As a result, with the exception of some countries such as Egypt and Saudi Arabia, the availability of trained personnel with the required technical expertise to carry out various environmental, ecosystem, and socio-economic analyses is limited, as is the infrastructure to collect the required data. Fortunately, sufficient financial resources are available at least in parts of the region, and through PERSGA mechanisms established to ensure capacity building in the Red Sea and Gulf of Aden region and to put in place necessary observational programmes. Despite this, the need for continued outside support to carry out further assessments will be unavoidable in the immediate future. PERSGA appears to be conscious of the issues involved and how to address them, including the need to develop and maintain appropriate databases.

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AoA Region: The Regional Organization for the Protection of the Marine Environment/Regional Commission for Fisheries (ROPME/RECOFI) Area

Wajih Naqvi

The green turtle, an endangered species of the Persian Gulf.

The ROPME/RECOFI or ROPME Sea Area includes eight countries, Bahrain, Iran, Iraq, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates and contains part of the Arabian Sea LME.

1. BROAD ECOLOGICAL CHARACTERISTICS

The ROPME Sea Area comprises three geographically/oceanographically different zones:

a. The Persian Gulf – the inner ROPME Sea Area;
b. The Gulf of Oman – the middle ROPME Sea Area; and
c. The open coastal waters of Oman in the Arabian Sea – the outer ROPME Sea Area.

The Persian Gulf is a shallow marginal sea with a mean depth of about 35 metres (m) and an area of 239 000 square kilometres (km^2) (ROPME 2004). Lying in a highly arid zone with limited river runoff, the Gulf has a Mediterranean type circulation, with surface inflow of low salinity water from the Gulf of Oman and near-bottom outflow of dense, saline water through the Hormuz Strait. The highest salinities of up to 70 ppt (parts per thousand) found along the southernmost parts of the Gulf are probably above the physiological tolerance limit for most common organisms. As the Persian Gulf extends northward to subtropical latitudes, and is landlocked and shallow, the annual surface temperature range is very large (12 to 35°C). The waters are generally nutrient depleted, but

the shallow depths facilitate active nutrient recycling, fuelling moderate primary production (~0.5 g C m^{-2} d^{-1}).

The Gulf of Oman is a deep basin reaching to more than 2 500 m. It does not experience the same level of monsoon influence to which the open coast of Oman in the Arabian Sea is exposed. The most prominent feature of the latter is upwelling during the Southwest Monsoon season which peaks between about June and September and is among the most intense observed anywhere along the oceans' western boundaries. During the Northeast Monsoon season from December to March, large parts of the northern and north western Arabian Sea, including the Gulf of Aden, experience convection which extends below 100 m and erodes the upper thermocline. Nutrient enrichment of the euphotic zone resulting from upwelling and convection-driven mixing supports high rates of primary production (>1 g C m^{-2} d^{-1}) and rich fisheries throughout the year except for the brief spring intermonsoon season (Barber and others 2001, Naqvi and others 2003). An important oceanographic feature of the Arabian Sea and Gulf of Oman is the occurrence of almost complete oxygen depletion within a thick layer below the thermocline. Upwelling of oxygen depleted waters sometimes causes massive fish kills along the coast of Oman.

Despite the highly saline conditions, the Persian Gulf supports a number of rich and diverse ecosystems, including mangroves and coral reefs (Sheppard and others 1992, Price and Robinson 1993; Khan and others 2002). Extensive coral growth also occurs along the Oman coast of the Gulf of Oman and the Arabian Sea, with greater diversity resulting from a more moderate environment. The reefs in the Persian Gulf are highly productive, but cover only a small area. Seagrasses (mainly *Halodule uninervis, Halophiloa ovalis* and *Halophila stipulacea*) are common in shallow areas of less than 10 m and form the basis of a number of food chains. They also provide important habitats for commercial shrimp, pearl oysters and many other organisms. Mudflats occupy extensive areas of the intertidal zone. Their productivity is often enhanced by Cyanophya-dominated algal mats. The mangrove *Avicennia marina* is found in association with tidal flats. The Gulf's fisheries for penaeid shrimp, groupers, jacks and Spanish mackerel are of major regional and global importance. Fauna important to conservation include seabirds, green and hawksbill turtles, dolphins and dugong.

Production and export of crude oil and natural gas is the mainstay of the economies of the ROPME Sea Area countries, while fishing and agriculture are the other major economic activities. Because of the maritime transport

of oil and gas, shipping is also important, while infrastructure such as ports and roadways built to support this activity, is helping countries to diversify their economies and to rapidly industrialize. As a consequence of the wealth generated by oil and gas exports, important commercial hubs such as Dubai have developed in the ROPME Sea Area.

2. INSTITUTIONS UNDERTAKING ASSESSMENT

The Organization for the Protection of the Marine Environment (ROPME), an intergovernmental organization, conducts regular assessments in the ROPME Sea Area region. The Regional Conference of Plenipotentiaries on the Protection and Development of the Marine Environment and the Coastal Areas of Bahrain, Iran, Iraq, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates, was convened in Kuwait in April 1978. The Conference adopted the following initiatives:

a. An Action Plan for the Protection and Development of the Marine Environment and the Coastal Areas;
b. The Kuwait Regional Convention for Cooperation on the Protection of the Marine Environment from Pollution; and
c. A Protocol concerning Regional Cooperation in Combating Pollution by Oil and Other Harmful Substances in Cases of Emergency.

Since its establishment, ROPME has provided technical coordination to the Kuwait Action Plan, which was created under the auspices of the UNEP Regional Seas Programme, and assisted its eight member states in the implementation of the Convention and its Protocols. It has also undertaken a number of projects covering environmental assessment and environmental management, including public awareness and training.

ROPME published its first State of the Marine Environment Report (SOMER) in 1999 in accordance with the provision of Article XVII (d-ii) of the Kuwait Convention pertaining to the functions of the ROPME Council *to review and evaluate the state of marine pollution and its effects on the Sea Area on the basis of reports provided by the Contracting States and the competent international or regional organizations*. The report was updated in 2000 and 2003. As decided by the ROPME Council, one of the major objectives of this report is *to suggest regional strategies and priority actions commensurate with these concerns and issues to enable governments and decision-makers to meet these challenges at the national level, as well as in the regional and global contexts.*

The main objective of the Regional Commission for Fisheries (RECOFI) is to promote the development, conservation, rational management and best use of living marine resources as well as the sustainable development of aquaculture within its area of agreement (http://www.fao.org/fishery/rfb/recofi).

3. DATA

3.1 Ecosystem data

A substantial amount of data are available in the international oceanographic databases, mostly collected during major expeditions over the past several decades to the Persian Gulf (Dietrich and others 1966, Brewer and Dyrssen 1985, Price and Robinson 1993) and western Arabian Sea (http://www1.whoi.edu/research/arabian.html). This body of data has led to an excellent understanding of the broad oceanographic processes in the Persian Gulf and its exchanges with the Indian Ocean. The understanding obtained in these expeditions has been enhanced through observations since 1990 on cruises by research vessels *Mt. Mitchel*, *Unitak Maru*, *Kuds* and *Mukhtabar Al-Bihar* belonging to the University of Qatar which has been running a continuous monitoring programme since the early 1980 covering Qatar's Exclusive Economic Zone (EEZ). However, information from areas closer to the coast which are most affected by human activities and contain some of the most interesting and sensitive ecosystems, such as coral reefs and mangroves, is relatively sparse and of variable quality. There are some established institutions in the region, including the Sultan Qaboos University in Oman, the University of Qatar and the Kuwait Institute for Scientific Research, all of which have fairly well-developed observation programmes and datasets, including coastal time-series data. ROPME organizes basin-scale cruises from time to time. The Ministry of Agriculture and Fisheries of Oman recently deployed an array of instruments to record several key environmental variables in real time, off its coast in what is the first cabled seabed observatory in the North Indian Ocean. However, there is still a general lack of integrated biogeochemical and ecological studies due to insufficient technical expertise. Moreover, in view of the volatile security and political situation prevailing in the region, there are several serious impediments for data collection in some key regions such as the Shatt-al-Arab Estuary.

3.2 Socio-economic data

A considerable amount of information exists on various socio-economic aspects for the ROPME Sea Area (ROPME 2004). This includes country-wide

data on gross domestic product (GDP), human population growth including in coastal settlements, industrial activities, especially those related to the oil and natural gas sector, power and desalination. Significant data are available also on recreation and tourism, utilization of freshwater resources and modification of flow to the coastal zone as well as exploration and exploitation of living (fisheries) and non-living resources. However, a detailed, combined analysis of these data has not been undertaken. Extraction and transportation of oil is one of the most economically important activities in the ROPME Sea Area. The activity also poses one of the most serious threats to its marine environment. It is not known if a central repository of the data exists and to what extent data are available for global assessments. Most of the data are in the custody of the respective national authorities.

4. ASSESSMENTS

4.1 Thematic/ sectoral assessments

The marine ecology of the ROPME Sea Area has been under increasing pressure from rapid changes associated with military conflicts and economic growth arising from the region's vast energy reserves. The region was subjected to particularly extreme environmental stress during the 1991 Gulf War when more than nine million barrels of oil spilled into the marine environment along with atmospheric deposition of significant quantities of particulate material originating from burning oil wells. In order to investigate the effects of the war on the Persian Gulf's marine environment, a multidisciplinary oceanographic expedition was conducted on the United States of America's National Oceanographic and Atmospheric Administration (NOAA) ship, *Mt Mitchell*, during February to June 1992. The results of the expedition were published in more than 40 papers in a special issue of the *Marine Pollution Bulletin* (Price and Robinson 1993). This comprehensive scientific compilation, the largest of its kind from the Persian Gulf, provides background information on the area's marine environment. Besides the post-war biophysical assessment, it also covers aspects of the physical environment, marine and coastal ecosystems and fish and fisheries. Papers dealing with pollution control and conservation included in this special issue emphasized the need for trans-disciplinary research for assessing major impacts on the environment, particularly through integration of natural and social sciences.

Another notable collection of works dealing with various aspects of the Persian Gulf's marine environment, biodiversity and ecology is by Khan and others (2002).

A thematic assessment of land-based sources of pollution and activities affecting the marine environment in various member states of the ROPME Sea Area, was undertaken by UNEP (1999). Such pollution can be detrimental in the Persian Gulf because it is a small area and surrounded by land that is subjected to rapid development. The main pollution sources identified include power and desalination plants, sewage treatment facilities, industrial facilities, solid waste, recreation and tourism facilities, oil refineries, agriculture facilities, coastal construction, mining and quarrying activities and port facilities. The assessment established priorities and evaluated and selected management strategies for addressing the prioritized problems. However, the data available from various national sources were considered to be inconsistent, underlining the need for their verification and updating. This task clearly falls within the scope of ROPME. To what extent this has been done in the subsequently published State of the Marine Environment Reports is not clear, but these reports also address in some detail, the problems of land-based pollution (also see GESAMP's global analysis of land-based activities, UNEP 2001).

More recently, present sources and levels of marine pollution in the Persian Gulf and their effects on biota and ecosystems have been reviewed by Abuzinada and others (2008). This assessment also identifies preventive and remedial measures which are required.

4.2 Integrated assessments

The latest version of SOMER (ROPME 2004) takes into consideration all previous assessments, and is based on updated data and consequently provides the most reliable information on the status of the marine environment in the ROPME region. This assessment is broad-based and deals with various compartments of the marine system. It provides information on variations in a number of physicochemical and biological parameters, including the concentrations of a wide range of pollutants in water, sediments and biota. It also gives a fairly detailed account of the biological diversity in the ROPME Sea Area on groups ranging from plankton to mammals and birds. Some of these animals, such as green turtles and dugongs, face a serious threat of extinction and are designated as endangered/protected species. This is particularly the case with dugong, which in the past had been abundant in the Persian Gulf, but their numbers have been greatly reduced as a result of human activities. The socio-economic drivers of the environmental changes are identified in the assessment.

Besides the land-based activities mentioned earlier, the major threat to the ROPME Sea Area's marine environment and ecosystems comes from maritime activities, especially those associated with the oil and gas sector. Despite the threats, the assessment suffers from a lack of data on some crucial components of the ecosystem, particularly microbes, and from an absence of well-organized monitoring programmes. Also, while the assessment suggests measures which should be undertaken to address various threats to the ecosystems, it does not rigorously evaluate various policy options. As a result, there is an urgent need for integrated assessments covering the whole ecosystem and the pressures exerted on it from human activities.

5. PRIORITIZED ISSUES

The assessment identifies a number of current and emerging environmental issues to be addressed by policy-makers and managers. They are:

a. Degradation of major habitats and habitat loss due to sea reclamation for infrastructural projects;
b. Pollution from river basins, coastal areas (land-based activities including thermal pollution from industry), offshore operations and ships including introduction of aquatic invasive species;
c. Lack of continuity in regional monitoring programmes to fill data gaps and improve the consistency, quality, and reliability of data and information; and
d. Lack of harmonization and strict implementation of environmental regulations.

Some recommended measures to address these issues are:

a. Conservation and restoration of threatened/damaged ecosystems. Given the relative wealth of the countries involved in ROPME, it would be timely to consider a baseline ecological survey of the whole Gulf with special emphasis on threatened groups such as turtles and sea mammals;
b. Regulation of coastal developmental activities through Integrated Coastal Zone Management; and
c. Capacity building for both research and management, and effective dissemination of information among Gulf countries.

6. SUPRA-REGIONAL ISSUES

The Persian Gulf plays an important role in the biogeochemistry of the Arabian Sea because the subsurface outflow from this marginal sea forms an important component of the highly oxygen-deficient zone in the Arabian Sea. Along with the eastern tropical North Pacific and the eastern tropical South Pacific, the Arabian Sea is a major oceanic water-column denitrification location and is an important producer of nitrous oxide, a potent greenhouse gas (Naqvi and others 2003). Any changes in the physical conditions such as in temperature or salinity, or in organic loading in the Persian Gulf, could therefore have significant global implications. Similarly, coastal upwelling off Oman is crucial for sustaining the high biological productivity of the Arabian Sea, thereby contributing to the maintenance of the mid-depth oxygen deficiency. Any changes in upwelling intensity resulting from global climate change (Goes and others 2005) are also expected to have deleterious effects on regional living resources and biogeochemical processes and possibly the global climate.

7. CAPACITY OF THE REGION TO UNDERTAKE ASSESSMENTS

There is sufficient technical expertise available in several countries of the ROPME member states to undertake environmental monitoring and carry out broad-based assessments, although a few countries either do not have the infrastructure such as the United Arab Emirates, or are too unstable politically to make any meaningful contribution to the regional efforts. Some sector-specific assessments such as fisheries can be undertaken by a few countries which possess the necessary technical capabilities, but for other aspects, including some important topics such as eutrophication and its impact on various compartments of the ecosystem, outside support to carry out further in-depth assessments will be unavoidable. ROPME appears to be well aware of the issues involved and how to address them, including the need to develop and maintain the appropriate databases.

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AoA Region: South Asian Seas

Wajih Naqvi

The South Asian Seas region lies in the northern extreme of the Indian Ocean. It includes the Arabian Sea and Bay of Bengal Large Marine Ecosystems (LME) along with their marginal basins as well as the Laccadive Sea and the Andaman Sea. Counties bordering this AoA region include Iran, Oman and Yemen in the Arabian Sea and Myanmar in the Bay of Bengal as well as the five countries that form the South Asian Seas regional cluster of UNEP's Regional Seas Programme, namely Bangladesh, India, the Maldives, Pakistan and Sri Lanka.

Mandovi Estuary in Goa, India. Human activities are adversely affecting water quality of the estuary and its ecosystems such as the mangoves and wetlands.

1. BROAD ECOLOGICAL CHARACTERISTICS

The South Asian landmass limits the northern expanse of the Indian Ocean to low latitudes, which has several far-reaching consequences for physical and biogeochemical processes and for the ecology of coastal and marine systems (Sherman and others 1998, Sen Gupta and Desa 2001, Naqvi and others 2003; UNEP/GPA 2003, 2006). Located in the tropical monsoon belt, the region is strongly affected by monsoons and is vulnerable to storm surges and cyclones The unique monsoonal circulation which reverses completely every six months introduces marked seasonality in oceanographic and biogeochemical processes, and results in unusual features. Among them are the location of the most vigorous and productive upwelling systems along the Indian Ocean's western boundary instead of the eastern boundary and the occurrence of the most intense oxygen minimum zone (OMZ) in the northern part of the ocean, especially in the Arabian Sea. This OMZ impinges upon a large area of the continental margin, accounting for roughly two-thirds of the total global continental margin area in contact with the OMZs, and has significant effects on benthic ecology. Moreover, countries bordering the North Indian Ocean account for roughly one quarter of the world's population, which makes the region's coastal environment and resources especially vulnerable to human influences.

The Indian peninsula divides the North Indian Ocean into two zones, with the Arabian Sea and Laccadive Sea in the North West Indian Ocean and the Bay of Bengal and Andaman Sea in the North East Indian Ocean. These zones are hydrographically very different because evaporation in the North West Indian Ocean far exceeds precipitation, while the reverse is the case in the North East Indian Ocean, and also because most of the South Asian rivers flow into the North East Indian Ocean. In addition, the North West Indian Ocean experiences much more intense upwelling, making it more productive than the North East Indian Ocean.

Because of the diversity of the prevailing hydrographic conditions, the South Asian Seas region hosts a wide variety of ecosystems. Mangroves and coral reefs are the two most important habitats in the region. The mangrove ecosystem supports important coastal fisheries and provides direct sustenance to coastal communities from timber and other products. It is endowed also with rich biodiversity and wildlife. The most extensive mangrove forest in the region and the world's second largest are the Sunderbans located in the Ganges-Brahmaputra delta in India and Bangladesh. Similarly, the Indus River delta on the Pakistani coast supports luxuriant mangrove vegetation. Significant mangrove growth also occurs along most other parts of the coasts, including the offshore islands, especially in the Andaman and Nicobar Islands. Major coral reefs in the region are found in the Laccadives/Maldives region in the form of coral atolls, and in the Gulf of Mannar/Palk Strait as well as the Andaman and Nicobar Islands in the form of fringing reefs.

The presence of several major rivers gives rise to large estuarine networks along the coasts of Pakistan, India, Bangladesh and Myanmar, especially in the Bay of Bengal. These habitats contain a range of environmental conditions, provide breeding grounds for commercially important fish and support high biological diversity. The island nations of the Maldives and Sri Lanka have quite different ecological characteristics, with the former comprising of coral atolls endowed with rich reefs. Most coastal regions, especially off Pakistan, western India and Sri Lanka are quite productive, supporting rich fisheries. Natural hypoxia develops along the Indian west coast and possibly along the Pakistani coast during late summer and autumn. Available data suggest that natural hypoxia has intensified during the past few decades, presumably as a result of increased nutrient loading from the land (Naqvi and others 2000). Elsewhere, shelf waters remain well-oxygenated

throughout the year. The OMZ is characterized by a different (anaerobic) ecosystem, especially in the Arabian Sea, which surprisingly supports an immense biomass of mesopelagic fish (Naqvi and others 2003).

Major economic activities are concentrated in coastal areas. These include ports and harbours, fisheries and aquaculture, tourism and rapidly expanding industrial activities with agriculture forming a major part of the overall economic activity. In some areas, mining also is important and although the production of oil and natural gas is limited, a significant volume of crude oil is transported by tankers through the region.

2. INSTITUTIONS UNDERTAKING ASSESSMENT

The United Nations Environment Programme (UNEP) has been involved in a number of environmental assessments in the South Asian Seas region.

The South Asian Seas Programme was initiated in 1995 with the objective to protect and manage the shared marine environment and coastal ecosystems of the maritime countries Bangladesh, India, Maldives, Pakistan, and Sri Lanka. These states have developed an Action Plan (http://www.sacep.org/pdf/SASR%20Action%20Plan.pdf) through their participation in the South-Asia Cooperative Environment Programme (SACEP). This plan focuses on Integrated Coastal Zone Management (ICZM), oil-spill contingency planning, human resource development and the environmental effects of land-based activities. Detailed assessments for the Arabian Sea LME are not yet available (http://na.nefsc.noaa.gov/lme/text/lme32.htm). With a grant from the Global Environment Facility (GEF), the participating States of the Bay of Bengal LME (BOBLME) project, which included South Asian Seas region countries Bangladesh, India, the Maldives and Sri Lanka, prepared respective country reports (http://www.fao.org/fi/boblme/website/reports.htm), some of which are fairly comprehensive.

The Bay of Bengal Programme Intergovernmental Organization, which includes Bangladesh, India, the Maldives and Sri Lanka, and engages in some fisheries assessments (http://www.bobpigo.org/) was set up to promote, facilitate and secure the long-term development and utilization of coastal fisheries resources of the Bay of Bengal based on responsible fishing practices and environmentally sound management programmes. The Food and Agriculture Organization (FAO) has been actively involved in assessments of the South Asian Seas region's living resources (http://www.fao.org/fi/oldsite/eims_search/advanced_s_result.asp?progna

me=3&sortorder=3&form_c=AND&lang=en). Another intergovernmental organization, the Indian Ocean Tuna Commission (IOTC), has responsibility for the management of tuna and tuna-like species in the Indian Ocean, a task that requires understanding of the biology and assessment of tuna stocks (http://www.iotc.org/English/index.php). In addition to the work by these regional/international organizations, assessments are being carried out by national institutions in the Indian Ocean's riparian countries.

3. DATA

3.1 Ecosystem data

A large amount of data has been collected over the past four decades on all aspects of oceanography from the open ocean in both the Arabian Sea and the Bay of Bengal. Most of these data can be accessed through global data centres, such as the World Data Centre for Oceanography (http://www.nodc.noaa.gov/General/NODC-dataexch/NODC-wdca.html). The Arabian Sea in particular has been subjected to intensive studies under a number of international programmes such as the Joint Ocean Global Ocean Flux Study (http://www1.whoi.edu/research/arabian.html). Much of the research under such programmes was carried out by scientists from developed countries and hundreds of articles have been published in scientific journals, providing an excellent understanding of the biogeochemical and ecological processes in the open sea (Naqvi and others 2003). However, the processes operating over continental shelves and in coastal waters, including estuaries, are not so well known. This is largely because access to these waters is restricted and some countries in the region do not have the infrastructure and resources to undertake their own quality research. Even in cases where such capability exists, there are restrictions on the exchange of data obtained from territorial waters.

Organized and sustained observations in the coastal ocean are quite limited at present in the South Asian Seas region. However, India does have a long-term monitoring programme, the Coastal Ocean Monitoring and Prediction System (COMAPS) which is coordinated and funded by the Indian Ministry of Earth Sciences (MoES) (http://www.icmam.gov.in/comaps/index.html) and covers almost the entire coastline. The MoES is in the process of developing a Geographical Information System (GIS) package for the data on the health of the Indian coastal region collected since 1991 under COMAPS. Assessment of the water quality has led to the identification of 13 hot spots for year-round monitoring of the health of

the seas, which helps the Central and State Pollution Control Boards to take steps to reduce the adverse impacts of pollutants on the coastal and marine ecosystem of the Bay of Bengal and the Arabian Sea.

3.2 Socio-economic data

A considerable amount of information exists on various socio-economic aspects for all countries in the South Asian region. The Country Reports for the BOBLME project (http://www.fao.org/fi/boblme/website/reports.htm) provide fairly detailed information concerning marine fisheries and aquaculture. The reports also cover, to varying extents, data related to country's economy, urbanization, population growth, industrialization, agriculture, generation of various kinds of waste, utilization of freshwater resources, shipping and other transport and recreation and tourism. The UNEP reports also provide some important socio-economic data for the South Asian Seas region countries (http://www.rrcap.unep.org/reports/soe, UNEP/GPA 2006).

4. ASSESSMENTS

4.1 Thematic/ sectoral assessments

The offshore parts of the Arabian Sea and to a lesser extent the Bay of Bengal have been subjected to numerous biogeochemical and ecological investigations, the results of which have been published in various scientific literature. As a result, there is a very good understanding of the oceanographic processes in the South Asian Seas region (Sherman and others 1998, Sen Gupta and Desa 2001, Naqvi and others 2003, Naqvi and others 2006). The thematic assessments from the South Asian Seas region deal with either fisheries or pollution or both (see the assessments posted at The Bay of Bengal Programme Intergovernmental Organization and the FAO websites referred to above). Of particular relevance is an environmental assessment for the entire Bay of Bengal region (BOBP/REP/67) prepared for the Swedish Centre for Coastal Development and Management of Aquatic Resources by Holmgren (1994) under the Bay of Bengal Programme. This assessment provides information for Bangladesh, India, the Maldives and Sri Lanka on their fisheries and aquaculture, their mangroves, coral reefs, seagrass/algal beds and estuarine marine habitats as well as marine pollution from domestic and industrial wastes, agricultural waste, oil, heavy metals and pesticides. The national assessments such as COMAPS in India are focused largely on pollution aspects.

The State of the Environment Reports prepared by UNEP for Bangladesh, India, the Maldives and Sri Lanka deal with marine environmental issues in these countries (http://www.rrcap.unep.org/reports/soe). Such a report is not available for Pakistan, but a brief account of the state of the marine environment is available (http://www.environment.gov.pk/PRO_PDF/PositionPaper/Marine%20pollution.pdf). A marine assessment for the South Asian Seas region is provided by UNEP/GPA (2006).

A thematic assessment of land-based sources and activities affecting the marine environment in the South Asian Seas region was undertaken by UNEP/GPA (2003). This assessment also covers socio-economic aspects as well as policy and legal matters. The Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP) global analysis of land-based activities (UNEP 2001) includes information on the South Asian Seas region.

Under the Environment Management-Capacity Building Project implemented by the Indian Ministry of Environment and Forests with funding support from the World Bank, the Integrated Coastal and Marine Area Management-Project Directorate (ICMAM-PD) of MoES has conducted an assessment of 11 critical coastal habitats, including mangroves, coral reef beds, turtle nesting grounds and areas of rich biodiversity along the Indian coastline. As a result of the assessment, ICMAM-PD has developed the Critical Habitat Information System (CHIS) for these coastal habitats, using remote sensing data and GIS collected during 1988–1998. These reports contain a wealth of information on the geophysical, physico-chemical and biological features of these coastal habitats along with threats they face and other issues. The reports also contain suggestions for conserving and protecting these critical habitats (http://www.icmam.gov.in/).

4.2 Integrated assessments

The BOBLME Country Reports deal almost entirely with the coastal areas. These reports provide broad-based assessments, but with varying coverage of various activities and issues. The Country Report for India (Sampath, 2003) is the most comprehensive. It provides an in-depth analysis of the status and development potential of the coastal and marine environment and living resources of the east coast of India. The land-based and sea-based sources of pollution are identified, and major habitats of mangroves, coral reefs and sea grass beds, turtle

nesting grounds, lagoon ecosystems, wetlands and other waterways are described in detail for all coastal segments. Utilization of living resources through fisheries and aquaculture is one of the major foci of the assessment in which the socio-economic and management aspects are adequately covered. The report identifies and ranks threats to the coastal and marine environment and its living resources, including endangered species such as dugongs, marine turtles and salt water crocodiles. It also identifies the socio-economic drivers behind those threats. The institutional and legal mechanisms for management of the environment and utilization of living resources are examined and gaps in information, policies, legislation, and other aspects are identified. Finally, the report suggests remedial measures, prioritizing actions for addressing the threats, both at the national and regional levels.

The other Country Reports are less comprehensive. In general, they do not offer much information on several key parameters including biological parameters such as plankton and chemical variables such as trace metals, pesticides and nutrients. Nevertheless, the main sources of pollution and threats to the environment are identified, and in most cases future policy options and their potential benefits are evaluated. The fisheries sector, including aquaculture and the associated socio-economic aspects are dealt with in relatively greater detail for all the countries. The reports also provide a reasonably good account of the status of the mangrove and coral reef ecosystems. Many of the problems identified such as degradation of major habitats, overexploitation of fishery resources, and disposal of wastes are common to all countries, and some are transboundary including changes in freshwater flows and the introduction of alien species. Other issues are of special concern to some countries in the region such as projected sea level rise for Bangladesh and the Maldives.

5. PRIORITIZED ISSUES

Based on the assessments, a number of issues need to be addressed by policy-makers and managers. They include:

Causes:

a. Land use changes such as deforestation, agriculture, urbanization and coastal development as well as construction of ports, highways and other infrastructure, and utilization of freshwater resources;
b. Overexploitation of resources;
c. Industrialization and other land-based pollution; and

d. Marine pollution including oil spills, introduction of alien invasive species (AIS) through ballast water discharges and ocean debris.

Effects:
Degradation of major habitats such as coral reefs, mangroves, estuarine and lagoon ecosystems and turtle nesting grounds and other areas. Such degradation results in the loss of biodiversity;

Recommendations:
a. Regulation of coastal developmental activities and the need for ICZM;
b. Introduction and enforcement of environmental laws and regulations; and
c. Capacity building through the creation of technical capacity and infrastructure for the maintenance of databases and monitoring programmes, and availability of sufficient financial resources

6. SUPRA-REGIONAL ISSUES

The North Indian Ocean contains diverse hydrographical and biogeochemical regimes and sensitive ecosystems which are significant to global biogeochemical fluxes and elemental cycles through influences such as denitrification), as well as through climatic events such as monsoons and the El Niño-Southern Oscillation (ENSO). Being densely populated, the South Asian Seas region's physical, chemical and biological processes are especially sensitive to human-induced changes because of greenhouse warming on the global scale and to inputs of material such as freshwater, organic carbon and nutrients from land on the regional scale. The globally important OMZ in the South Asian Seas region may experience significant impacts as a result of changes in oceanic thermohaline circulation, stratification and upwelling as well as terrestrial inputs. Moreover, because the strong stratification in the Bay of Bengal is believed to promote precipitation in the region through maintenance of high sea surface temperature, any change in river run-off is likely to provide a feedback to climate change.

7. CAPACITY OF THE REGION TO UNDERTAKE FUTURE ASSESSMENTS

Even though there is adequate technical expertise and infrastructure in a few South Asian Seas region countries to undertake environmental monitoring and carry out both broad-based and sector-specific assessments, others do not have similar capability and resources. The South Asian Seas region as

a whole does have adequate capability and resources to initiate a region-wide assessment programme which should focus on capacity building in some South Asian Seas region countries, to put in place an effective environmental monitoring system and maintain databases. This may be organized through UNEP's Regional Seas Programme and SACEP. The latter's Action Plan holds a great deal of promise in this regard.

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AoA Region: South East Pacific Ocean

Rodrigo Bustamante

The coast of Antofagasta in northern Chile, where the desert meets the cold Pacific Ocean, in one of the most intense upwelling areas of the Humboldt Current system.

The South East Pacific Ocean region includes the eastern shores of the Pacific Ocean along the coasts of South America and a small part of southern Central America, from 57°S to 7°N. It consists of the entire Humboldt Current and the southern portion (Pacific Colombian) of the Pacific Central American Coastal Large Marine Ecosystems (LMEs), covering about three million square kilometres (km^2). The region includes the entire coasts of Chile, Colombia, Ecuador and Peru.

1. BROAD ECOLOGICAL CHARACTERISTICS

The South East Pacific Ocean region contains a mix of both temperate and tropical marine ecosystems. One of the major upwelling systems of the world, the Humboldt, occurs in the south while northern section contains a unique dynamic mix of highly productive coastal and ocean currents along the Equator and the southern portion of the Panama Bight. The main ocean currents in the region are the south eastern part of the temperate-cold Cape Horn, Humboldt and tropical-cold Cromwell undercurrent, and the tropical-warm South and North Equatorial Currents. The northern part of the South East Pacific Ocean lies within the sweep of the Intertropical Convergence Zone (ITCZ), which buffers seasonal climate variability and dictates the rainfall and climate patterns of the region. As a whole, the South East Pacific Ocean is responsible for extremely high levels of endemism and organic production and contains one of the most productive fisheries in the world as well as large wildlife concentrations, including macroalgae, mammals, seabird, reptiles and fish (UNEP 2006a, 2006b).

The southern temperate ecosystems are large and diverse, with large biomass of a few highly abundant pelagic species including sardine, anchovies, mackerel, lantern fish and squid, while diverse invertebrate biota

and macroalgal and kelp forests dominate the coastal inshore benthos. The northern tropical ecosystems are relatively species-poor compared with those in the west Pacific. Nevertheless, they still contain abundant pelagic megabiota including sharks, whales, sea turtles, tuna and billfishes as well as inshore coastal invertebrate and reef fish communities. The tropical and subtropical offshore ecosystems contain large international pelagic fisheries, targeting mostly yellow fin and big eye tunas (IATTC, 2005, 2006). The tropical shallow coastal and continental substrates are mostly sedimentary with large mangrove and estuarine ecosystems as well as scattered patches of rocky and coral reefs.

The ecology of the region is greatly influenced by the cyclic alternation between El Niño and La Niña climate-ocean oscillations. Although the pelagic ecosystems are relatively well-studied, the benthic ecosystems are not well-known, particularly in the tropics and in the southern fjords of Chile. The South East Pacific Ocean contains vast deep-sea areas which remain virtually unexplored by scientists, despite increasing development of deep-sea fishing. The main activities include coastal development, fishing, shipping, tourism, some nearshore petroleum extraction and coastal aquaculture, mostly shrimp farming in the north and salmon in the south.

2. INSTITUTIONS UNDERTAKING ASSESSMENTS

Several institutions have carried out and are conducting assessments in the South East Pacific Ocean region, including the Food and Agriculture Organization (FAO), the UN Environment Programme (UNEP) and three regional institutions. The assessments reviewed to date have been undertaken by:

a. The Permanent Commission for the South Pacific or Comisión Permanente del Pacífico Sur (CPPS);
b. The Inter-American Tropical Tuna Commission (IATTC); and
c. The Latin-American Organization for Fisheries Development or Organización Latinoamericana De Desarrollo Pesquero (OLDEPESCA).

The CPPS was created in 1952, although intergovernmental maritime collaboration has existed in the region since 1947. It became fully operational in 1979 as the regional agency in charge of coordinating all maritime policies of the four original member countries, Chile, Peru, Ecuador and Colombia. Panama joined the CPPS in 1981 for the implementation of the Plan of Action for the Protection of the Marine Environment and Coastal Areas of the South Pacific (Plan de Acción para la Protección del Medio Marino y Áreas

Costeras del Pacífico Sudeste), under the Southeast Pacific Regional Seas Programme (Lima Convention). This Action Plan, together with its associated protocols (such as those for regional cooperation in combating pollution by hydrocarbons, protection against pollution from land-based sources, conservation and management of protected marine and coastal areas and for protection of the marine environment from radioactive pollution), are providing important governing instruments for regional conservation management (UNEP 2008). The Action Plan is implemented within the framework of inter-agency cooperation between the CPPS, UNEP, and some two dozen agencies, programmes and Convention Secretariats. The CPPS has been acting as a regional strategic and tactical alliance to coordinate member countries' conservation and research activities in the South East Pacific Ocean.

Assessments by the CPPS are part of both the implementation of the regional environmental Action Plan and their scientific research, and are focused largely on economics and scientific regional actions. Five of the eight assessments completed to date on wastewater, marine litter, fisheries, aquaculture and the Global International Waters Assessment (GIWA) were implemented by or through the CPPS as the coordinating agency. All these assessments were either the result of the implementation of a regional Action Plan or part of global initiatives including the Intergovernmental Oceanographic Commission (IOC), FAO and UNEP Regional Seas assessments. The CPPS has an evolving website which contains a substantial amount of information and data, but lacks access to the primary information other than that contained in the assessments. The material posted on the site is mostly in Spanish (http://www.cpps-int.org/).

The IATTC was established in 1950 by a regional international convention for the conservation and management of fisheries for tuna and other species, including cetaceans, turtles and seabirds taken by tuna-fishing vessels in the Eastern Pacific Ocean. Thirteen member countries as well as regional economic organizations are involved in the IATTC. These member countries include all the South East Pacific Ocean countries except Chile. The role of the IATTC is to cooperate in the gathering and interpretation of factual information on pelagic fish and other species taken during the fisheries operations. These data are used to conduct regular stock assessments and to establish regional and national fishing quotas for maximum sustained catches. The South East Pacific Ocean's catch quotas for the tuna, shark and billfish fisheries as well as for additional by-catch mortalities are based on their regular assessments (IATTC 2005, 2006, 2007). There are regular annual assessments of high

seas pelagic fisheries, species and ecosystems, which in general include most of the South East Pacific Ocean region. There are no individual country reports, although some tabulated data are presented by country, so the wide scope of these regional assessments makes it impossible to extract what is relevant for this focal region. The IATTC directly conducts and/or commissions most of the relevant research in tuna tagging, ecosystem studies, on-board observations and early life history studies of target species. Most of the reports are available on the IATTC website and are updated periodically, and although secondary data are accessible, there is no access to primary data. (http://www.iattc.org/HomeENG.htm).

The OLDEPESCA was formed in 1981 as a regional cooperation institution for fisheries development. It has 11 member countries from the Pacific and Caribbean, but only Ecuador and Peru from the South East Pacific Ocean region. To date no assessment has been found which covers the South East Pacific Ocean region, but some country statistics or global assessments beyond it are available. The website has secondary data from member countries which includes some production and socio-economic time-series data for marine fisheries and aquaculture. To date no assessment from the OLDEPESCA has been reviewed for the South East Pacific Ocean. (http://www.oldepesca.org/)

The creation of a South Pacific Regional Fisheries Management Organization (SPRFMO) has been under negotiation since 2006. The aim is to act as a venue for the international conservation and management of non-highly migratory fisheries and the protection of biodiversity in the marine environment in high seas areas of the whole South Pacific Ocean. The SPRFMO will include all the predominantly discrete high seas pelagic and demersal stocks as well as those stocks which straddle the high seas and the economic exclusion zones (EEZs) of coastal states. The spatial coverage will include the high seas contained in all or part of FAO's statistical areas 57, 71, 77, 81 and 87. The SFRFMO will include more than 20 states as well as Intergovernmental Organization (IGOs) and Non-governmental Organizations (NGOs) (http://www.southpacificrfmo.org/).

3. DATA

3.1 Ecosystem data

The strength of the South East Pacific Ocean's ecosystem data is associated mainly with fisheries research and climate-ocean monitoring. The fisheries ecosystem data coverage is extensive, well-reported and well-kept, with substantial time-series residing largely in each country and in the FAO Fisheries

Global Information System (FIGIS) as well as in the IATTC and OLDEPESCA databases. In addition to the national fisheries databases, the IATTC databases in particular are increasing their coverage on non-target species such as seabirds, turtles and cetaceans, and other ecosystem components including food web and stable isotopes, as well as the life history of a range of biota (IATTC 2006, 2007). Ecological data on benthic ecosystems do not exist at the regional level, but countries are stepping up their benthic surveys and coverage. No regional benthic or coastal assessments currently exist. There is, however, some country-specific assessment of coastal habitats, in particular for mangrove ecosystems, but the data are not publicly available. Since 1998, biophysical climate-ocean characterization has been increasing. The best environmental data are associated with El Niño and La Niña oscillation monitoring. Periodic climate-ocean alerts are found in the bulletins of the El Niño Phenomenon Regional Study, or Estudio Regional del Fenómeno El Niño (ERFEN) which is an IOC/WMO/CPPS programme and in the regional Global Ocean Observing System (GOOS), which concentrates the regional information on the South East Pacific Ocean and provides summaries and secondary climate-ocean data (CPPS 2008). The CPPS does not have public access to the oceanographic primary data.

Additional ecosystem monitoring data are being compiled by a Chile-Peru Humboldt Current Ecosystem Integrated Management Programme, which is a Global Environment Facility (GEF)/ United Nations Industrial Development Organization (UNIDO) programme. To date, however, no reports or data are available. Each country of the South East Pacific Ocean region, as signatories of the Convention on Biological Diversity, has various national instruments for the protection of endangered and threatened species. With the exception of Colombia, all South East Pacific Ocean countries are Parties to the Convention on the Conservation of Migratory Species of Wild Animals (CMS), which embraces species such as albatrosses and petrels. There are several regional governance instruments also for the protected species of the South East Pacific Ocean, in particular for sea turtles through a regional conservation programme approved in 2007 and for marine mammals with an Action Plan introduced in 2004.

3.2 Socio-economic data

For the South East Pacific Ocean region, assessments conducted as part of GIWA, provide the widest ranging and integrated socio-economic assessments by their chosen human-related impacts on freshwater, pollution, habitat/community modification, overexploitation and global change. For

the region, GIWA provides selected summary data tables by country with a focus on pressures and consequences (UNEP 2006a, 2006b). The GIWA also provides some tabulated summaries of scores for their indicators, but does not provide geographical coverage at a sub-regional level. These scores allow some semi-quantitative assessment of the likely status of the affected ecosystems. However, it focuses largely on the consequences for economics and human health. Other assessments on areas such as wastewater, marine litter and aquaculture have some substantial underlying socio-economic data, but without time series or specific spatial coverage (CPPS/UNEP 2001, CPPS 2007, Morales and Morales 2005). These assessments rely mainly on official or published information which, in some cases, was collected for other purposes. The marine litter assessment collected specific and primary data, but provides only tabulated summaries as well as sub-regional (country) coverage (CCPS 2007). The fisheries and aquaculture assessment does not contain any detailed socio-economic data other than the data needed for assessing fishing capacities and effort such as the number of boats, type of equipment, people and technology. All assessments point to the overall degradation of marine and coastal habitats and communities (FAO 2006, IATTC 2005, 2006).

4. ASSESSMENTS

The coverage of the seven assessments reviewed for the South East Pacific Ocean region includes the specific themes of wastewater, marine litter, aquaculture and fisheries. The two GIWA reports (UNEP 2006a, 2006b) and the LMEs status reviews (Sherman, and Hempel 2008) were the only regionally integrated assessments considered. The reviewed assessments do not contain explicit indicators (except the GIWA), but most of them have enough information for the development of indicators, in particular for wastewater and litter. The fisheries assessment contains all information and variables needed for the establishment of both indicators and reference points, but the assessments do not present that information. However, it is safe to say that the direct fisheries management at the national levels at least does contain indicators and reference points. The assessments conducted under GIWA contain a range of explicit environmental impact indicators as a measurement to quantify the magnitude of environmental impacts, and socio-economic proxy indicators to quantify the magnitude of economic impacts, health impacts and social and community impacts. These series of indicators are an integral part of the GIWA methodology, but the methodology does not establish reference points.

4.1 Thematic/sectoral assessments

The marine litter assessment attempts to establish some regional framework and baseline information to propose regional and national actions. The main pressure has been the steady growth of coastal populations and maritime traffic. The overall discharge of litter at sea remains unknown but wastewaters from domestic and agro-industrial discharges are the main sources of marine pollution and pressure on the ecosystems. The assessment found that environmental and human health pressures along with economic losses are derived from inadequately treated and dumped wastewater. This wastewater comes from sectors associated with the coastal and marine environment such as tourism, recreation, agriculture, aquaculture and fishing. The fisheries assessments clearly identify excess fishing capacity, including introduction of additional capacity from outside the region, mostly in the form of fishing vessels flying flags of convenience (e.g., European Union, Taiwan) and overexploitation as the main sources of ecosystem pressures.

The region is also known for experiencing large environmental changes through the El Niño and La Niña oscillations which significantly alter the abundance of key species such as small pelagics. This high variability and the increase in fishing has resulted in steady declines of pelagic and benthic species, with major social and economic impacts at national, regional and global levels (e.g., in 2002 the region accounted for more than 16 per cent of the world's marine fish production). The recent increase in destructive fishing practices in deeper waters, continental shelves and slopes as well as in shallow sedimentary bays is threatening these benthic and coastal habitats, particularly off Ecuador, Chile and Peru. The estuaries and mangrove communities have also been substantially modified and in many areas, have been lost. The impacts have been so great that mangroves in Ecuador are now considered endangered.

4.2 Integrated assessments

The two GIWA assessments considered here integrate across the full spatial coverage, themes, analyses and policy options for the South East Pacific Ocean region. In this author's opinion, this is the closest to what the Regular Process should be, but with a broader regional coastal-marine focus beyond the LMEs. Of the two assessments reviewed, the Humboldt Current (GIWA 64) and the southern portion of the Pacific Central American Coastal (GIWA 65), only the latter has sub-regional assessments. The two assessments provide an adequate analysis of policy options on the two main issues, pollution and overexploitation. The common causes for both were *"…regarding social, cultural and economic issues such as poverty, migration*

to urban centres, a lack of economic resources to invest in technology and a lack of knowledge, which delay the adoption of integrated management policies that are based upon a regional approach" (UNEP 2006a, 2006b). Another integrated assessment for the region's LMEs is included in the NOAA/GEF/UNEP LME report, which concentrates on the overall description of the region's productivity and its relation to the impacts of fisheries which have led to "*…system destabilization through an increase in the amplitude of annual stock variations*" (Sherman and Hempel 2008). This assessment also concludes that the sustainability of the South East Pacific Ocean region is strongly dependent on the ability to apply management regimes which incorporate natural environmental variability.

5. PRIORITIZED ISSUES

GIWA identified two issues. One is land-based pollution in coastal ecosystems and the other is unsustainable exploitation of fish and other living resources as *"…the priority environmental concerns affecting the transboundary waters of the region"* (UNEP 2006a, 2006b). These two emerging issues were justified because of their impacts on economic, social and health issues as well as present and future ecosystem services the regional ocean provides. These conclusions are consistent with the NOAA/UNEP LMEs review (Sherman and Hempel 2008). Furthermore, all assessments and partial diagnostics such as UNIDO (2003) also identified that poor knowledge of the ecosystem variability and its functioning are high priority issues for further development. Additionally, these assessments in one way or another recognize that institutional and governance weaknesses, and the lack of regional collaboration, hamper regional management. It is clear from all assessments that the region needs integrated fishing and coastal zone management policies with a focus on the ecosystem approach.

For the South East Pacific Ocean region, only the GIWA assessments presented explicit policy option analyses to address the main prioritized issues. This analyses was preceded by a formal causal-chain analyses and resulted in a coherent narrative describing the problems to be mitigated or solved, a few alternative courses of action and a set of projected outcomes.

6. SUPRA-REGIONAL ISSUES

The Transboundary Diagnostic Analysis (TDA) prepared under the GEF Humboldt Current LME project provided a good integrated appraisal of the major transboundary problems. These include current non-optimal exploitation

of fishing resources, insufficient knowledge of ecosystem variability, threats to the biodiversity of the system are relevant to fisheries production; and progressive deterioration of coastal zone habitats (UNIDO 2003).

7. CAPACITY OF THE REGION TO UNDERTAKE ASSESSMENTS

Colombia, Ecuador and Peru have environmental Ministries, with Chile expected to create a Ministry soon. Laws at the sub-regional level will soon mandate environmental monitoring, evaluation and reporting processes. In principle, this means that soon enforcing environmental standards to minimize the impacts of human activities will be possible, including mandatory environmental impact assessments for public infrastructure and development. Additionally, the region is experiencing an increase in public environmental consciousness to favour more benign methods and technologies to limit the impacts of human activities on the South East Pacific Ocean region's ecosystems. The presence of these Ministries will offer a strong sub-regional legal and institutional basis for potential intergovernmental collaboration, or at least for the creation of sub-regional data and assessments.

The region also has legally binding mechanisms for regional cooperation. The most important operational instrument is the Plan of Action for the Protection of the Marine Environment and Coastal Areas of the South Pacific, which has as its Executive Secretariat the CPPS. There are several complementary instruments, such as protocols and agreements, which have not been fully implemented at the regional level. In 2002, South East Pacific Ocean countries renewed their commitment for regional maritime cooperation by signing a new declaration supporting the role of the CPPS and other regional protocols. As a result, the CPPS offers a robust, simple and proven institutional arrangement for future assessments and monitoring. This is largely due to the various successful partnerships by the CPPS, for example with the IOC of UNESCO, the UNEP Regional Seas Programme and the International Maritime Organization, in both the technical area and in environmental policy development.

All four countries (Chile, Colombia, Ecuador and Peru) are strengthening their marine infrastructure and expertise, but there are some critical gaps, for example, in applied research in marine conservation, fisheries and aquaculture bio-economics as well as in applying the ecosystem approach to management and socio-ecological integration and decision support analyses. In addition, few high-level national postgraduate trainees in marine sciences are being produced or attracted back to the South East

Pacific Ocean region because of the lack of employment opportunities and relatively low wages. The GOOS Regional Alliance for the Southeast Pacific (GRASP) and ERFEN (IOC/WMO/CPPS) programmes as well as the Humboldt Current LME project offer good examples for ecosystem monitoring. However, some further work on data integration, data assimilation and publication and distribution remains undeveloped.

The creation of the SPRFMO will add a greater role in the future assessment of pelagic and benthic fisheries resources and can act as a central body for the high seas data sets. There are still some organizational, structuring and funding issues, but there are agreements already with regards of management measures and data standards.

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AoA Region: Southern Indian Ocean

Michael E. Huber

The Southern Indian Ocean region has not yet been assessed as a regional unit, but available assessments indicate that the marine environment is generally in good condition at the regional scale.

The coastal states in the Southern Indian Ocean region are Australia, France, Indonesia, South Africa, and Timor-Leste. The majority of the region's coastal waters are under Australian jurisdiction. Indonesia and Timor-Leste border the Sea of Arafura and the Timor Sea area. Indonesia also borders the Indian Ocean proper, west of the Timor Sea, which is addressed in the East Asian Seas regional summary. The Southern Indian Ocean region also includes a number of sub-Antarctic island groups including Kerguelen, Crozet, and Amsterdam-St. Paul archipelagos (France), Prince Edward Islands (South Africa), and Heard and McDonald Islands (Australia). Geographically, the Southern Indian Ocean also includes east Africa and the western Indian Ocean islands, but for the Assessment of Assessments (AoA) these areas are addressed separately in the East African Seas regional summary.

Four Large Marine Ecosystems (LMEs) are found in the Southern Indian Ocean region, North Australian Shelf, Northwest Australian Shelf, West-Central Australian Shelf, and Southwest Australian Shelf LMEs. None of these have been defined as transboundary LMEs. The sub-Antarctic islands are strongly linked ecologically to the Antarctica LME although they do not fall within its politically defined boundaries.

1. BROAD ECOLOGICAL CHARACTERISTICS

The northern part of the Southern Indian Ocean region is strongly influenced by the Indonesian Throughflow (ITF), a net flow of warm surface water from the Pacific Warm Pool north of Papua New Guinea through the Indonesian archipelago to the southeastern Indian Ocean. The ITF has a major influence on global climate (You and others 2008). It also influences the Leeuwin Current, a narrow coastal current which flows 5 500 kilometres (km) south

along the edge of the continental shelf of Western Australia, then east into the Great Australian Bight and eventually the southern tip of Tasmania (Ridgway and Condie 2004). The Leeuwin Current flows counter to the West Australian Current (WAC), which lies further offshore, and is unique in being an eastern boundary current which flows polewards, bringing warm water along the west coast of Australia. At the subtropical convergence, which varies between 35°S and 45°S, the mean surface temperature drops from about 12°C to 7– 8°C. The Polar Frontal Zone, at 48–61°S, oceanographically marks the northern boundary of the Antarctic Circumpolar Current (ACC), that is, the boundary between the Southern Indian Ocean and the Southern Ocean. At the basin scale, surface circulation in the Southern Indian Ocean is dominated by the anti-cyclonic Southern Indian Ocean Gyre, which is formed by the ACC, the WAC, the South Equatorial Current and the Agulhas Current.

The Southern Indian Ocean region includes tropical, temperate and sub-polar shallow-water systems. Under the influence of the Leeuwin Current, which functions both in maintaining warm water temperatures and in the dispersal of biota, tropical seagrass, mangrove, coral and associated communities, extend south to about the Houtman Abrolhos Islands (29°S). Some individual species range even farther, with corals, for example, being found as far south and east as Esperance (34°S) on the south coast of Western Australia (Walker 2000). Tropical shallow-water communities are also found on a number of offshore systems including Christmas and the Cocos (Keeling) Islands in the equatorial Indian Ocean and Ashmore, Scott, and Seringapatam Reefs and Rowley Shoals on the outer continental shelf. The offshore reef systems are thought to be important in maintaining connectivity between the ecosystems on the Western Australian shelf and the Indonesian seas. South of the Houtman Abrolhos Islands and into the Great Australian Bight, the shallow marine communities are progressively more dominated by cold temperate biota including kelps, temperate seagrasses, rocky reef communities and megafauna which includes penguins, seals, and sea lions (Edyvane 2000, Walker 2000). The sub-Antarctic islands have a sub-polar flora and fauna and are important breeding sites for a number of sub-Antarctic and Antarctic marine mammals and seabirds.

Nutrient supply, and therefore marine productivity, is generally low in the region. Temperature stratification limits nutrient inputs in tropical and sub-tropical areas. Productivity is generally higher in the temperate areas because of reduced stratification and extensive wind and wave mixing, but the subtropical convergence isolates the Great Australian Bight from the rich nutrient supplies of the Southern Ocean. Sporadic upwelling occurs on many parts of the Australian

shelf, but there is no sustained, large-scale upwelling. As a result, the large demersal fisheries common on other continental shelves are generally absent in this area. The sub-Antarctic islands have higher nutrient supply and productivity.

2. INSTITUTIONS UNDERTAKING ASSESSMENTS

As nearly all of the continental shelf area in the region is under Australian jurisdiction, most assessment activities are undertaken by the Australian Government and academic institutions. The Australian Government Department of the Environment, Water, Heritage and the Arts (DEWHA) has primary responsibility for implementing integrated marine assessment and related activities in Commonwealth waters, which extend from the three-mile limit to the outer boundary of Australia's Exclusive Economic Zone, under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act). The State of Western Australia and the Northern Territory have jurisdiction within the three-mile limit. Under the EPBC Act, DEWHA assesses management arrangements for fisheries managed under Commonwealth legislation, as well as those for fisheries in state waters that have an export component, to determine whether stocks are being managed in a sustainable manner and to promote continuous improvement, and also to consider potential impacts on species protected under the EPBC Act.

The Commonwealth Scientific and Industrial Research Organization (CSIRO) – Division of Marine and Atmospheric Research conducts scientific research, data collection and management, modelling, and assessment activities to support integrated marine assessments through its Coastal and Oceans Management and Marine Ecosystems and Resources research themes. These activities cover relevant human uses and activities as well as natural systems. The Australian Institute of Marine Science (AIMS) has facilities in Western Australia and the Northern Territory and is particularly active in research and habitat mapping of tropical shallow-water systems including coral reefs, mangroves and seagrass beds. The Western Australian Museum has conducted extensive biodiversity research in both deep and shallow waters. The Western Australian Marine Science Institution (WAMSI) was established to improve collaboration and coordination among marine scientific organizations to improve the scientific underpinning of marine conservation and management in Western Australia and the broader Southern Indian Ocean region. WAMSI is a collaborative initiative among 13 parties, including CSIRO, AIMS, the Western Australian Museum, universities, and Commonwealth and State agencies.

The Indian Ocean Tuna Commission (IOTC) was established in 1993 to manage tuna and tuna-like species in the Indian Ocean and adjacent seas. The area of the Convention for the Conservation of Southern Bluefin Tuna (CCSBT), also established in 1993, covers a large part of the Southern Indian Ocean. The area of the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR) includes the sub-Antarctic islands of the Indian Ocean. CCAMLR was established in 1982 to conserve Southern Ocean marine life, mainly in response to concerns about increased krill catches.

The Western Australian Global Ocean Observing System (WAGOOS), an informal organization with representatives from government, academia and industry, was established in cooperation with the Perth office of the Intergovernmental Oceanographic Commission (IOC) and with seed funding from the Australian Bureau of Meteorology. The aim of WAGOOS is to establish GOOS in Western Australia to help coordinate and improve local knowledge of coastal seas. WAGOOS is a partner in WAMSI.

3. DATA

Data and models are available for a range of relevant oceanographic, biological and socio-economic parameters in the Southern Indian Ocean region, but the spatial and temporal resolution is generally lower than, for example, the east coast of Australia. This is a consequence of the low population density, large size and remote nature of the region.

In Australia, data are generally held by the respective institutions which collected the data, and usually are available, sometimes for a fee and sometimes freely online. Currently, there is no central data portal, but initiatives are underway to provide more centralized data management and dissemination. The Australian Ocean Data Centre Joint Facility (AODCJF) is developing a data management system to provide a national infrastructure for government-wide, online access to ocean data to meet national and international requirements.

In order to work towards better data integration, WAMSI held two seminars on marine data management in Western Australia in 2007 and 2008. WAMSI is working towards the creation of a Western Australian node of the AODCJF and has launched an online index of past, current and future marine projects.

The IOTC maintains databases for nominal fisheries catch, catch-effort, discards, fish size-frequency, fishing craft and environmental data. Nominal

catch, catch-effort and fishing craft data are available online, although there is a lack of uniformity in the recording of fishing craft data. Size-frequency data are available on request from the IOTC, but only metadata (data catalogue and data reference documentation) are available online. Environmental data and fisheries discard statistics are also available on request. The IOTC notes that as a result of inconsistent reporting, it will be some time before the discards database provides meaningful data. The CCSBT maintains databases of total catch, catch-effort and catch-at-size data, all of which are available online.

Data collected by the CCAMLR Ecosystem Monitoring Programme are held by the CCAMLR and are freely available to CCAMLR members for analysis and reporting. To maintain confidentiality, commercially-sensitive information is aggregated or encrypted prior to release to members, the CCAMLR Scientific Committee or working groups. Data collected for scientific purposes are generally held in national data centres or scientific institutions, and are freely available after publication.

4. ASSESSMENTS

No assessments have been conducted, nor are there any assessment processes, for the Southern Indian Ocean region as a whole. This is not surprising given the vast size and ecological diversity of the region. Further, it is questionable whether assessment of the Southern Indian Ocean region as a unit, were it feasible, would provide significant benefit.

The State of the Marine Environment Report (SOMER) for Australia (Zann 1996) encompasses most of the region's coastal area, although not as a regional unit. The SOMER was produced in 1996 under the auspices of the Department of the Environment, Sport, and Territories (now DEWHA), and covered all Australian waters including the Southern Indian Ocean. The scope of the assessment was established by a workshop of experts from marine science, marine resource management and industry. An expert SOMER Advisory Committee was established and experts were commissioned to produce a series of technical papers on individual topics. Following peer review these papers were published as technical annexes. The technical papers were synthesized in the context of management implications and reviewed by authors, the SOMER Advisory Committee and relevant government departments before being published as a Technical Summary. The major findings were also published as a non-technical report and a brochure. The SOMER had a major influence on other processes,

including conservation and education planning and the development of the Australian National Oceans Policy.

Australian National State of the Environment reports are produced by DEWHA every five years and include an Oceans and Coasts theme. These reports are prepared by an independent committee appointed by the relevant Australian Government Minister. The Coasts and Oceans theme is based on a peer-reviewed, integrative commentary document commissioned by the committee.

Australia's National Oceans Policy establishes the primary policy framework for marine assessment and management in Australia. Marine assessment processes in Australia are being undertaken through a process of bioregional planning in which Marine Bioregional Plans prepared under the EPBC Act will provide guidance for all management decisions made under the Act. They will also inform the development of a network of representative Marine Protected Areas. Australia's marine bioregionalization is a spatial framework for dividing ocean habitats into units which make ecological sense and are at a useful scale for planners and managers. Two of the five major Australian marine bioregions are located in the Southern Indian Ocean: the Northwest region, extending from Kalbarri at 28ºS slightly north of the Houtman Abrolhos islands to the Timor Sea, and the Southwest region extending from Kalbarri to Kangaroo Island, at the eastern end of the Great Australian Bight. These major bioregions are subdivided into smaller units on the basis of geological, oceanographic and biological considerations. The first step in the bioregional planning process is the preparation of a bioregional profile, which constitutes an integrated environmental assessment and involves major scientific institutions and key data holders. The profile synthesizes information about the ecosystems in a given region, as well as information on the human uses. Bioregional profiles have been completed for both the Northwest and Southeast regions (http://www.environment.gov.au/coasts/mbp/index.html).

The North West Shelf Joint Environmental Management Study (NWSJEMS) was an integrated assessment of an area of about 110 000 square kilometres (km^2) on the northwest Australian shelf, conducted from 2000 to 2007. NWSJEMS was jointly funded by the CSIRO and the Western Australian Government, and involved inputs from a number of scientific and other organizations as well as broad stakeholder consultation. The study concluded that the area is in good condition generally, but that management measures are needed to accommodate future human pressures. In addition to assessing the condition of the area, the study sought to develop and

demonstrate science-based tools to support integrated regional planning and management. NWSJEMS had four components:

a. Compiling and integrating existing information and filling key gaps with new data collection and the development of new data products;
b. Developing models for ocean currents and connectivity, sediment transport, nutrient cycling and primary production, food web interactions and habitat dynamics;
c. Developing a modelling framework to evaluate management effectiveness, incorporating not only ecosystem dynamics, but also human use sectors and management processes; and
d. Developing tools for interactive access and analysis of results by study participants and stakeholders.

The IOTC and the CCSBT produce regular fisheries stock assessments. IOTC assessments are produced in reports of the IOTC Scientific Committee as well as in reports of working groups and expert consultations on the basis of data provided in national reports to IOTC. CCSBT assessments are produced by a Stock Assessment Group established to separate the technical evaluation and scientific advisory roles of the CCSBT Scientific Committee. CCSBT has also established a working group on species which are ecologically related to southern bluefin tuna (SBT) with regard to both species which may be affected by SBT fisheries and to predator and prey species which may affect SBT stocks.

The Scientific Committee of the CCMLAR is responsible for undertaking assessments in the CCAMLR region, which includes the sub-Antarctic islands of the Southern Indian Ocean. Assessments are carried out through scientific working groups on the basis of data collected according to CCAMLR procedures. Assessments in the CCAMLR region are also carried out by the Scientific Committee for Antarctic Research. These assessments are described in more detail in the Southern Ocean regional summary.

5. PRIORITIZED ISSUES

As the Southern Indian Ocean region has not been assessed as a regional unit, no priorities have been established at the regional level. Available assessments indicate that the marine environment is generally in good condition at the regional scale, in large part because of low coastal development and population density. Overfishing, habitat loss and modification, and pollution from both land-based and offshore sources are all issues at local scales in some places. Alien invasive species are a

widespread issue and of particular concern on the sub-Antarctic islands, where introduced species have had major impacts on breeding colonies of seabirds. Historical overharvesting has reduced seal and whale populations to levels which are of concern. Some of these populations have been slow to recover. Illegal, unregulated and unreported fishing is a significant issue in remote areas.

6. SUPRA-REGIONAL ISSUES

Climate change is obviously an issue for the Southern Indian Ocean region, not least because variation in the Leeuwin Current is linked to the El Niño-Southern Oscillation phenomenon. Ocean acidification is also of relevance. The northern part of the Southern Indian Ocean region overlaps with the East Asian Seas region, while the southern part, especially the sub-Antarctic islands, is strongly linked to the Southern Ocean.

7. CAPACITY OF THE REGION TO UNDERTAKE ASSESSMENTS

Australia has a high technical, institutional and financial capacity to undertake marine assessments. Nonetheless, the large size and remoteness of the Southern Indian Ocean region are significant constraints to the development of regular assessment and reporting. In the open Southern Indian Ocean, data availability is low, even by open-ocean standards.

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AoA Region: Southern Pacific Ocean

Michael E. Huber

Sea level rise and coastal vulnerability are two of the region's many concerns.

The Southern Pacific Ocean region includes Australia, Cook Islands, Federated States of Micronesia, Fiji, France (French Polynesia and New Caledonia), New Kiribati, Marshall Islands, Nauru, New Zealand, Niue, Palau, Papua New Guinea, Samoa, Solomon Islands, Tokelau, Tonga, Tuvalu, United Kingdom (UK) (Pitcairn Islands), United States of America (American Samoa), and Vanuatu. The Large Marine Ecosystems (LMEs) defined in the region include the Northeast Australian Shelf/ Great Barrier Reef, East-Central Australian Shelf, Southeast Australian Shelf and New Zealand Shelf LMEs. None of these are transboundary LMEs, and the large majority of the region does not lie within a recognized LME.

1. BROAD ECOLOGICAL CHARACTERISTICS

Mass surface circulation is dominated by the South Equatorial and East Australian Currents, but a large area of the Southern Pacific Ocean region lies in the central South Pacific Gyre. The northern part of the Southern Pacific Ocean region is influenced by the Equatorial Counter-Current and North Equatorial Current. Circulation regimes are more complex at sub-regional scales, particularly in the west where the South Equatorial Current reaches Papua New Guinea and Australia. The Southern Pacific Ocean region is also strongly influenced by the El Niño Southern Oscillation and the associated east-west movement of the Indo-Pacific Warm Pool.

The Southern Pacific Ocean region is geographically dominated by islands with little or no continental shelf, except for the eastern Australian shelf and extensive areas of shelf to the south and east of New Zealand, specifically, the Chatham Rise and Campell Plateau. The islands are separated by large expanses of oligotrophic open ocean within the tropics, with more productive pelagic systems found at temperate latitudes.

The most prominent shallow-water systems in the region are tropical coral reef lagoon systems with associated mangrove communities. Australia and New Zealand also have extensive temperate systems, such as temperate rocky reefs and kelp beds which do not occur in the rest of the region. Other shallow marine and coastal habitats and communities, including the rocky intertidal, mudflats, seagrass beds, unvegetated soft bottoms, sandy beaches, estuaries and salt marshes are common in both tropical and temperate areas. The region also incorporates sub-Antarctic ecosystems. The Southern Pacific Ocean region has a high proportion of the world's seamount communities, as well as other deep-sea habitats and communities including hydrothermal vents and trenches.

2. INSTITUTIONS UNDERTAKING ASSESSMENTS

Assessment processes in the Pacific Islands Countries and Territories (PICTs) tend to be institutionally decoupled from those in Australia and New Zealand. Although Australia, and to a lesser extent, New Zealand are sometimes included in regional assessments, assessments in these two countries are generally conducted by national and sub-national institutions. Both Australia and New Zealand produce five-yearly national State of the Environment reports which include marine environmental assessments based on selected indicators. These national assessments are typically more technically advanced and quantitative than assessments in the broader region. This is largely due to the much greater technical, institutional and financial capacity in Australia and New Zealand compared to PICTs. The substantive roles of Australia and New Zealand in regional assessments generally lie in capacity building, technical and financial assistance and coordination. Many PICTs are required to regularly report on their environmentally related activities under regional regimes such as the Noumea and Waigani Conventions.

The Secretariat of the Pacific Community (SPC), Pacific Islands Applied Geoscience Commission (SOPAC), South Pacific Regional Environment Programme (SPREP), University of the South Pacific (USP) and Forum Fisheries Agency (FFA) have all been involved in assessments in the Pacific Islands region. SPC, SOPAC, SPREP and FFA are intergovernmental organizations with varying memberships, which ultimately report directly or indirectly to the Pacific Islands Forum, the region's peak political and economic policy organization. USP is a regional university supported by most Pacific Islands governments. All these organizations participate in the Council of Regional Organizations in the Pacific (CROP), a regional

coordinating body formerly known as the South Pacific Organizations Coordinating Committee (SPOCC).

Other organizations which have had significant involvement in assessments in the Southern Pacific Ocean region include the United Nations Environmental and Social Commission for Asia and the Pacific (ESCAP), International Ocean Institute (IOI), through nodes in Australia and Fiji, the Global Coral Reef Monitoring Network (GCRMN), the USA National Oceanographic and Atmospheric Administration (NOAA), the Australian Institute of Marine Science (AIMS) and the French Institut de Recherche pour le Développement (IRD, formerly known as ORSTOM), particularly through its centre in New Caledonia.

The Western and Central Pacific Fisheries Commission (WCPFC) could participate in aspects of regional fisheries assessments involving highly migratory species, including in areas beyond national jurisdiction. Negotiations are being conducted on the establishment of a South Pacific Regional Fisheries Management Organization (SPRMFO). When established, SPRMFO could participate in assessments involving non-highly migratory species in areas beyond national jurisdiction, as well as in areas which straddle the high seas and areas of national jurisdiction.

The Australian Cooperative Research Centre for the Great Barrier Reef World Heritage Area (Reef CRC) has provided coordination and technical assistance to a number of assessments in the region. The Reef CRC was recently consolidated into the Reef and Rainforest Research Centre, which manages the Australian Marine and Tropical Sciences Research Facility.

A number of international, regional and national non-governmental organizations (NGOs) are involved in marine environmental issues in the Southern Pacific Ocean region, particularly in conservation and sustainable development initiatives. Some NGOs have also been involved in assessment-related activities including monitoring and the collation, synthesis and review of information. In many instances NGOs work cooperatively with national agencies and/or intergovernmental agencies, including through the establishment of Memoranda of Understanding to implement long-term projects and programmes. NGOs, donors, governments and the CROP agencies participate in the Pacific Islands Roundtable for Nature Conservation, established in 1997 at the request of governments to strengthen regional coordination of conservation activities. The Roundtable produces an Action Strategy for Nature Conservation in the Pacific Islands Region at five-yearly intervals, with the most recent covering 2003–2007.

The Roundtable meets yearly, except every five years when the Roundtable meeting is replaced by the Pacific Islands Conference on Nature Conservation and Protected Areas, the 8th of which took place in 2007.

3. DATA

3.1 Ecosystem data

In most of the Southern Pacific Ocean region, reasonably reliable time-series data are available for only a few high-level indicators, including some oceanographic parameters, industrial-scale fisheries (primarily tuna), population and demographics, gross economic indicators (e.g., GDP, imports/exports and overseas development assistance) and some indicators of human and economic development. Most assessments of environmental status and trends rely heavily on expert opinion, case studies, grey literature and snapshot studies. Reasons for the lack of quantitative time series include a lack of human, technical, institutional and financial capacity in PICTs as well as the geographic distribution of PICTs over a vast, remote and generally rural area. Integrated marine environmental assessments of the Southern Pacific Ocean region will be based primarily on expert opinion, based in turn on a mosaic of available data and information, for the foreseeable future.

Much of the time-series data that do exist is collected and held within the Southern Pacific Ocean region. The SPC maintains a database for commercial tuna and billfishes. WCPFC also holds tuna fisheries data provided by the SPC and member governments. The SPC maintains an online digital library for its coastal and oceanic fisheries programmes. The Pacific Islands Marine Resource Information System (PIMRIS), maintained by the University of the South Pacific in Fiji, provides an online database of publications and information, mostly relevant to fisheries and marine resources.

SPREP maintains an online list of SPREP publications, some of which are available for download. SPREP also hosts the Pacific Environment Information Network, which maintains links to a wide range of country profiles held in other databases as well as a directory of regional frameworks and action plans.

SOPAC maintains data relating to the geology of the Pacific as a set of MapInfo data layers. It also hosts a database of indicators (http://www.vulnerabilityindex.net/) of environmental vulnerability. Data from the

South Pacific Sea Level and Climate Monitoring Project is held by the Australian National Tidal Facility. The New Zealand National Institute of Water and Atmospheric Research (NIWA) has compiled extensive data on climate in the region.

The Pacific Island Roundtable maintains an inventory of conservation activities conducted by Roundtable members and an online database of protected areas including marine protected areas, hosted by the Pacific Biodiversity Information Forum (http://www.pbif.org).

The Seagrass Watch monitoring programme (http://www.seagrasswatch.org), which is jointly supported by several Australian government agencies, maintains a database of results from community-based monitoring of intertidal seagrass beds at sites in a number of countries in the region. The database is hosted by the Queensland Department of Primary Industries and Fisheries. Summary reports by monitoring site are available online, but raw data and metadata, including quality control information and data analysis methodology, are not publically available.

Time-series of satellite data on sea surface temperature and chlorophyll are available for the entire Southern Pacific Ocean region. Time-series data for other water quality parameters are available for many coastal areas in Australia and New Zealand but do not exist in most of the Pacific Islands region.

3.2 Socio-economic data

The SPC maintains a database of population and demographic data and is attempting to develop a regional database of socio-economic indicators in conjunction with national statistical offices through the Pacific Islands Regional Information System (PRISM) initiative (http://www.spc.int/prism/). The United Nations ESCAP maintains a database of economic and social indicators for some countries in the region. The SOPAC environmental vulnerability indicators include some socio-economic indicators.

4. ASSESSMENTS

4.1 Thematic/sectoral assessments

Regular thematic reporting or assessments which cover most or all of the Southern Pacific Ocean region include SPC stock assessments for highly migratory fisheries and yearbooks of fisheries catch-effort data produced by WCPFC in cooperation with the SPC (e.g., Lawson 2007), predominantly

socio-economic reporting in ESCAP's *State of the Environment in Asia and the Pacific* reports produced every five years (ESCAP 2006), and GCRMN state of coral reef reports (Wilkinson 2004). The status of coral reef ecosystems in American Samoa, Federated States of Micronesia, and Marshall Islands is also reported by NOAA, with the most recent report in 2008 (Waddell 2008).

Most other significant assessments in the Southern Pacific Ocean region have been conducted on a one-off project basis. SPREP produced national assessments of vulnerability and adaptation to climate change in 10 Pacific Island countries, Cook Islands, Federated States of Micronesia, Fiji, Kiribati, Republic of Marshall Islands, Nauru, Samoa, Solomon Islands, Tuvalu and Vanuatu, as well as a regional synthesis. Separate climate change assessments were conducted for Niue and Papua New Guinea. SPREP and UNEP Global Programme of Action also produced an assessment of the effects of land-based activities (LBAs) on the marine environment, the associated human activities and strategies and measures for mitigation (UNEP 2000).

SPREP executed the coastal component of a five-year GEF International Waters project, which produced a series of reports on a wide range of topics, including coastal fisheries, water quality, marine protected areas, community-based conservation, policy and legislation, waste management, priority identification and environmental economics. SPREP and other organizations have produced many assessments of specific aspects of the natural environment in various parts of the region, including individual towns, lagoons, islands or countries, to meet specific needs, or on a case study basis. Such assessments are generally carried out as one-off projects, generally on the basis of technical reports by one or more experts.

SOPAC has produced a number of assessments relating to oceanography (e.g., lagoon circulation) and coastal and other geomorphological processes, including coastal vulnerability relating to dredging and sand and gravel extraction. SOPAC has also developed an Environmental Vulnerability Index (EVI) based on a set of 50 environmental and socio-economic indicators. The EVI has been used to develop vulnerability profiles for all countries in the Southern Pacific Ocean region and some 235 countries and territories globally (SOPAC 2005). All countries and territories in the Southern Pacific Ocean region have been assessed since 2005, although data for a number of indicators are lacking in many cases.

The Science Working Group for the International Consultations on the Establishment of the SPRMFO is producing a number of fisheries profiles of non-highly migratory species which occur wholly or partly in areas outside national jurisdiction, and has developed templates for profiles of associated and dependent species as well as habitats.

4.2 Integrated assessments

There are no established processes for regular, integrated assessments of the state of the marine environment in the Southern Pacific Ocean region as a whole. The Global International Waters Assessment (GIWA) covered the aspects of the natural environment of the Pacific Islands defined by the GIWA methodology, as well as human activities affecting the environment and policy options (UNEP 2004). Draft GIWA scaling and scoping assessments for the Great Barrier Reef and Coral Sea covered the GIWA aspects of the natural environment. SPREP-coordinated National State of the Environment Reports and National Environmental Management Strategies prepared for a number of PICTs covered the natural environment in general. The UNEP/GEF/NOAA LME report (Sherman and Hempel 2009) includes assessments of the LMEs in this region, but most of the region lies outside recognised LMEs and is not covered in the report.

Broadly speaking, assessment and related projects in the Pacific Islands region have been either externally initiated ("top down") processes undertaken for global reporting and assessment, or processes initiated by governments or regional organizations within the region to meet the needs of national and regional action plans and other frameworks. The global processes typically undertake assessment at a primarily regional level, sometimes underpinned by national reports to workshops, and generally lack direct links to national and regional policy frameworks, strategies or action plans. These processes are sometimes perceived as a reporting burden by regional organizations and governments. Regionally initiated assessment processes (except in the case of pelagic fisheries) tend to focus on the national level, with some emphasis on regional synthesis. In these processes regionalization tends to be for pragmatic purposes such as resource mobilization and sharing, capacity building, project coordination and donor liaison, as opposed to the conceptual goal of integrated regional assessment.

This national level focus for assessment, management and policy probably reflects in part the geography of the region, where no states or territories except Papua New Guinea share land borders with other states or territories,

and only Australia and Papua New Guinea have adjoining coastal areas. Therefore the national level is often the most appropriate for intervention.

The national-level focus also reflects a general emphasis on the implementation of agreed management interventions rather than integrated assessment and monitoring for purposes which are not directly linked to national and regional priorities. Data acquisition and assessment activities by regional organizations, therefore, often focus on collecting specific information needed for management responses (e.g., a series of national solid-waste characterization studies by SPREP, assessments of offshore aggregate resources by SOPAC) rather than on integrated, ecosystem-based assessment. This action-oriented approach to assessment is pragmatic, particularly given the very limited capacity for ongoing environmental and socio-economic monitoring and assessment in most of the Southern Pacific Ocean region. The general lack of a regular assessment function, however, could compromise the region's ability to, among other things, identify new and emerging issues and evaluate progress and the effectiveness of policies, strategies and measures. Most major environmental initiatives in the Pacific Islands region are undertaken as donor-funded projects, with little if any follow-up evaluation after project termination.

5. PRIORITIZED ISSUES

Regional assessments over the past three to four decades have consistently identified the major marine environmental issues in the Southern Pacific Ocean region to include (with no prioritization) adaptation to climate change, coastal vulnerability and the effects of coastal modification and altered lagoon hydrodynamics, overexploitation and destructive practices in coastal fisheries, increased sediment and nutrient loads on coral reefs and lagoons resulting from land-use change, solid waste disposal in coastal lagoons and wetlands, liquid organic effluents (particularly from sewage and food-processing plants), habitat loss and alteration (particularly coral reefs, mangroves and seagrass beds), conservation of threatened species, and, mostly in a few urban areas, microbiological and toxicant pollution.

6. SUPRA-REGIONAL ISSUES

Climate change is obviously a major supra-regional issue and ocean acidification and increased anthropogenic nitrogen input are of clear relevance to the Southern Pacific Ocean region. Overexploitation and destructive practices in some coastal fisheries (for example, for live reef fishes

and sedentary species such as *bêche-de-mer* and shells) are driven by market demand from outside the Southern Pacific Ocean region. Tuna fisheries are dominated by fleets from outside the Southern Pacific Ocean region.

The regional mechanisms involving PICTS in the Southern Pacific Ocean region have strong links to Guam, the Northern Marianas Islands and Hawaii, which are included in the North Central Pacific Ocean region for the purposes of the Assessment of Assessments (AoA). Guam and the Northern Marianas are members of ESCAP, SPC and SPREP, and Guam is also a member of SOPAC. Academic and research organizations in the North Central Pacific region, including the University of Hawaii, Bernice P. Bishop Museum, and the University of Guam, are active in the region. The Pacific Science Association covers both the Southern Pacific Ocean region and North Central Pacific Ocean region as delineated for the purposes of the AoA.

The PICTs and the Southern Pacific Ocean region are sometimes generally grouped with Asia in supra-regional assessment processes, for example in the Global Environment Outlook and ESCAP. In some cases the Pacific Islands are dealt with separately. When Asia and the Pacific are dealt with as a single "region," the particular context of the Pacific, especially PICTs, is generally overshadowed, given the much larger economies, populations and capacities of Asian countries. Grouping Asia and the Pacific may also tend to mask interactions between the two regions, for example the effects of market demand from Asia on fisheries in PICTs.

International organizations including IUCN, the Census of Marine Life, UNEP World Conservation Monitoring Centre and the Global Marine Species Assessment have or are in the process of conducting global assessments of species or groups, including sharks, groupers, corals, and the dugong, and habitats or community types, including mangroves, seagrasses, seamounts and coral reefs, for which the Southern Pacific Ocean region supports a high proportion of global diversity and/or abundance. In many cases these include specific information at national or regional level.

7. CAPACITY OF THE REGION TO UNDERTAKE ASSESSMENTS

Except for Australia and New Zealand, the Southern Pacific Ocean region has very limited capacity for ongoing environmental and socio-economic monitoring and assessment. Coastal fisheries are a prominent example

of the disconnect between local and regional needs and capacities and an expectation of a global assessment system based on quality-controlled, quantitative data series. Coastal fisheries and their supporting habitats have been identified as a priority issue in virtually every regional assessment of the Pacific Islands region, because of their high nutritional, economic and social importance to local communities and their potential contribution to economic development. At best, however, assessment of coastal fisheries in most of the Southern Pacific Ocean region is based on expert opinion. In part, this results from a severely limited capacity for stock and catch-effort assessments as well as the widely dispersed and remote nature of coastal fisheries, as noted above. Another factor is that coastal fisheries in PICTs are multi-species fisheries which involve dozens and even hundreds of species, greatly complicating monitoring and assessment using conventional fisheries management models and methods. Furthermore, the coastal fisheries catch in the region is overwhelmingly dominated by subsistence and locally traded artisanal catches, making it almost impossible to collect reliable catch statistics, much less impose management measures.

Government-based coastal resource management measures are widely acknowledged to have failed in the Southern Pacific Ocean region because of the above-mentioned technical and logistical difficulties in assessing coastal resources using conventional approaches as well as a pervasive lack of capacity to enforce command-and-control management measures. The Southern Pacific Ocean region, however, has very strong cultural traditions of customary tenure and community control of local resources, and the ongoing trend is to rehabilitate, reinforce and adapt traditional and community-based systems for the management of marine resources, including community-based monitoring systems, although regional organizations do receive core funding from donor countries. It will be a challenge to accommodate these local-level monitoring and management systems in national and regional systems that report to a Regular Process. NGOs could have a particularly important role in this respect.

Most environmental initiatives in the region are donor-funded because of the lack of financial capacity in PICTs. This results in negotiation of projects, programmes and priorities with donors, and funding of most regional environmental initiatives on a project basis, although regional organizations do receive core funding from donor countries. Any development of a regular, regional assessment capacity for a Regular

Process will require financing on a sustainable, programmatic basis for at least the short and medium terms (up to 10 years). In the long term, effective capacity building is required to enable national institutions to undertake the necessary monitoring, reporting and assessment activities as part of their regular work programmes. In this context it is worth noting that PICTs have used only 40 per cent of GEF funding for which they are eligible (Waddell 2005). This may reflect at least in part the difficulties the small countries in the Southern Pacific Ocean region experience in dealing with GEF processes. A GEF-Pacific Alliance for Sustainability has been established to assist Pacific Island countries in accessing GEF support.

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AoA Region: South West Atlantic Ocean

Beatrice Padovani Ferreira

Tourism on the reefs of Porto de Galinhas Beach, Pernambuco state, Brazil.

The South West Atlantic region includes four Large Marine Ecosystems (LME), the North Brazil Shelf LME, the East Brazil Shelf LME, the South Brazil Shelf LME and the Patagonian Shelf LME, and corresponds to the coastal states of Brazil, Argentina and Uruguay. The South West Atlantic region corresponds to the Food and Agriculture Organization (FAO) Fishing Statistical Area 41. Brazil represents around 2/3 of the coast, accounting for the entire East and South Brazil shelf areas, while Argentina and Uruguay border the Patagonian Shelf LME. The Patagonian Sea is also defined as the area of the southwest Atlantic influenced by the Malvinas Current and incorporates the whole continental Patagonian platform. The Malvinas Current also influences waters under the jurisdiction of Argentina, Brazil, Uruguay and Chile as well as international waters.

1. BROAD ECOLOGICAL CHARACTERISTICS OF THE REGION

At the North Brazil Shelf, there is a significant width of continental shelf along the whole province with the widest point in the region of the Amazon mouth where it reaches about 200 kilometres (km). Many rivers discharge into this province from the rain forest regions of continental South America. The coastal regime is consequently highly turbid, especially north of the Amazon mouth, and the resulting mud banks migrate along the coast. Under the Atlantic Coastal Biome classification, the Guianas coastal province extends north to Trinidad (10°N), to encompass an area of the Wider Caribbean Region, which is under the same conditions of strong continental water influence (Longhurst 1998).

As the Amazon River discharges into the Atlantic Ocean, the flow of water and sediment deposits carve underwater deltas and canyons into the North Brazilian shelf, which is also influenced significantly by the fresh water and

sediment discharge. The Amazon discharges more water than any other river in the world, with 220,000 cubic metres per second (m^3sec^{-1}) causing a turbidity front. The salinity front is strong only at 100 km offshore, over the shallow shelf which, at this distance, is only about 15 metres (m) deep. The North Brazil Current heads north to the Caribbean and is joined by the South Equatorial Current through a trans-equatorial flow. Adjacent to the northern shelf circulation is the Brazil Current, which has its origins in the southern portion of the southernmost of three branches of the South Equatorial Current. This warm western boundary current, while weaker than the North Atlantic Gulf Stream in terms of mass transport, is energetically comparable to its North Atlantic counterpart, particularly in the region of confluence with the northward-flowing Malvinas Current at approximately 38°S (Longhurst 1998).

Along the East Brazil Shelf, riverine muds give way to calcareous deposits and biogenic shoals. Offshore, in fracture zones of the Mid Atlantic Ridge, there are islands and sea mounts, and in the Fernando de Noronha Chain, there is the Fernando de Noronha Archipelago and the only atoll in the South Atlantic Ocean, the Atol das Rocas. The East Brazil Shelf is steep and mostly narrow, extending about 20 km east. Coral reef formations are developed in this area, mostly parallel to the coast, which widens in south Bahia at Abrolhos bank (Ferreira and Maida 2005).

From the eastern tip of South America southward to Argentina, the long straight coastline backed by the Brazilian highlands is remarkably straight, with prominent topographic features only north of Rio de Janeiro (25oS) at Sao Tome and Cabo Frio capes. In contrast, the seabed environment is a complex topography of valleys and submarine canyons (Longhurst 1998).

The continental shelf widens gradually toward the south and marine regions in the area experience seasonal wind-driven upwelling of cold, nutrient-rich waters. In particular, the Cabo Frio region has long been known for its active wind-induced upwelling. A counter-circulation exists on the shelf in the Santos Bight inshore from the Brazil Current. On occasions, this may be associated with the northern end of a cold and fresh shelf current which originates on the Argentine shelf. Apparently these waters are modified by surface heat fluxes over the Argentine shelf and by discharge at 35°S from the Rio de la Plata River and at 32°S by the Patos Lagoon Estuary outflow. These phenomena may represent a major conduit for heat exchange and for nutrients and biota, the latter having significant economic importance (Campos and others 1995; Marques and others 2004). The presence of eddies and meanders in the Brazil Current is a characteristic

feature, in particular the Vitoria Eddy, a cyclonic vortex in the Brazil Current immediately to the south of the Vitoria-Trindade chain (Campos 2006).

From the Rio de la Plata River south to Tierra del Fuego there is the Patagonian shelf, one of the widest and flattest continental shelves anywhere in the oceans, reaching about 800 km into the Falklands/Malvinas[1] plateau (Longhurst 1998). The waters of the Patagonian-South West Atlantic are very cold and turbulent because of strong currents from Antarctica, but waters remain calm and somewhat warmer in lagoons and gulfs. The Patagonian Shelf is characterized by high and consistent levels of primary productivity and supports robust national and international fisheries activities.

There is well developed agriculture and livestock farming dating back centuries along the coast of the South West Atlantic region which has one of the highest coastal population densities in the world concentrated in large populated cities. Principal uses and activities in the South West Atlantic region are fishing, hydrocarbon exploitation, navigation and tourism. Fishing is an important activity, both artisanal and industrial, the latter concentrated in the more productive northern and southern areas. Multi-national fishing fleets operate in the region targeting tuna-like fish and demersal fish species. Petroleum extraction in the South West Atlantic region is carried out on the sea shelf floor and there have been constant developments on the coast associated with the oil industry. Tourism has been on the increase in the South West Atlantic region during the past decade. Mariculture also has developed along the coast during recent decades which has led to conflicts over the occupation of mangrove areas by shrimp farmers on the East Brazil Shelf.

2. INSTITUTIONS UNDERTAKING ASSESSMENTS

Since the late 1970's, several international agreements towards sustainable ecosystem management of the South West Atlantic region were signed and/or ratified by coastal states, such as the United Nations Convention on the Law of the Sea (UNCLOS), the Convention on the Conservation of Wild Species of Migratory Animals or the Convention on Migratory Species (CMS) and Convention on Biological Diversity (CBD). This created a need for assessment of the state of the environment in the South West Atlantic region. International cooperation in the study of the marine environment

1 A dispute exists between the Governments of Argentina and the United Kingdom of Great Britain and Northern Ireland concerning sovereignty over the Falkland Islands (Malvinas).

of the South West Atlantic region exists through a multitude of agreements and projects. Countries have also developed their own programmes, and there are projects of cooperation between non-government organizations (NGOs), international agencies and government agencies within the South West Atlantic region area of jurisdiction.

Created in 1991 as a result of the Asunción Treaty, MERCOSUR[2], Mercado Común del Sur (http://www.mercosur.int), is made up of Argentina, Brazil, Paraguay and Uruguay, and includes two associated states, Chile and Bolivia. Although it is a customs alliance whose purpose is to speed up the economic and social development of the state Parties, the Treaty has a sustainable development text expressing the intention to include environmental issues in the policies defined for the common market. It has a working subgroup dedicated to environmental issues, as well as a "Meeting of Ministers of the Environment" which brings together the environmental authorities' hierarchy of the state Parties. Consequently, from a strategic viewpoint, MERCOSUR could become a valid channel for the proposal, discussion and agreement of regional policies on environmental matters. MERCOSUR recently signed a Framework Agreement on the Environment that establishes the guiding principles of regional environmental policy by providing for sectoral agreements on the treatment of specific subjects, including protected areas, the conservation of biodiversity and sustainable fishing.

The South West Atlantic region is not part of the United Nations Environment Programme (UNEP) Regional Seas Programme although the UNEP Water Branch is providing initial secretariat services in support of the development of this cooperative programme for the protection and management of the marine and coastal environment in the South West Atlantic region, in cooperation with the Governments of Argentina, Brazil and Uruguay as well as the coordinators of the Programa Regional para o Oceano Atlântico Sul Ocidental Superior[3] (ASOS). ASOS is the formal cooperation in place from the Mercosul Regional Trade Agreement between Argentina, Brazil, Paraguay and Uruguay which is aimed at coordinating specialist research in marine pollution, living and non-living resources and ocean circulation between Cabo Frio (Brazil) and Península Valdéz (Argentina).

The Global International Waters Assessment (GIWA) is a partnership led by the UNEP and is funded by the Global Environment Facility (GEF) and other major

2 Southern Common Market
3 Upper South West Atlantic Programme

donors. It started in 1999 and aimed at developing a comprehensive strategic assessment based on secondary data which could be used by GEF and its partners to identify priorities for remedial and mitigating actions in international waters and to achieve significant environmental benefits at national, regional and global levels. The South West Atlantic region corresponds to the Eastern South America megaregion. Regional reports are already available for the Brazil Current and the Patagonian Shelf water regions.

The International Commission for the Conservation of Atlantic Tuna (ICAAT) is an arrangement aimed at the conservation of tuna and tuna-like species in the Atlantic Ocean (http://www.iccat.int/). ICAAT coordinates research, including stock assessment, develops management advice, provides a mechanism for contracting Parties to agree on management measures and produces publications.

There are several international projects which have been developed in varying degrees through the years. They include:

a. The Global Ocean Observing System (GOOS);
b. The Global Investigation of Pollution in the Marine Environment (GIPME);
c. Ocean Science in Relation to Non-Living Resources (OSNLR);
d. Training, Education and Mutual Assistance (TEMA);
e. The Global Sea-Level Observing System (GLOSS);
f. The World Climate Research Programme (WCRP);
g. International Geosphere-Biosphere Programme (IGBP);
h. Land-Ocean Interactions in the Coastal Zone (LOICZ);
i. Global Ocean Ecosystem Dynamics (GLOBEC);
j. The Inter-American Institute for Global Change Research (IAI);
k. Programa Regional para o Oceano Atlântico Sul Ocidental Superior (ASOS);
l. Train-Sea-Coast;
m. Ocean Science in Relation to Living Resources (OSLR);
n. Harmful Algal Blooms (HAB);
o. Climate Variability and Predictability (CLIVAR);
p. Tropical Ocean Global Atmosphere (TOGA);
q. The World Ocean Circulation Experiment (WOCE); and
r. The Scientific Committee on Oceanic Research (SCOR).

OCEATLAN is the GOOS Regional Alliance (GRA) in the South West Atlantic, and is composed of representatives from Argentina, Brazil and Uruguay (http://www.oceatlan.org). GOOS/BRASIL (http://www.goosbrasil.org) was approved in 1995 and embraces the Programa

Nacional de Boias[4] (PNBOIA) for oceanographic and climatic forecasts and the Pilot Research Moored Array in the Tropical Atlantic (PIRATA), which is a joint operation involving Brazil, the USA and France with 12 fixed buoys for collecting data to evaluate climatic change. GOOS/BRASIL also sponsors the Brazilian participation in GLOSS, the contribution to the Argo Project and the development of the ANTARES Project, a South American initiative which contributes to the Chlorophyll Ocean Global Integrated Network (ChlorOGIN). The Brazilian GOOS also supports the project for Monitoring the Regional Variability of Heat Transport in the Surface of the South Atlantic Ocean between Rio de Janeiro and Trindade Island (MOVAR).

The Comissão Interministerial para Recursos do Mar[5] (CIRM) was created in Brazil by decree in 1974 to support the President in the National Policy for Sea Resources. Since 1982, Brazil has been expending efforts to assess the state of the living and non-living resources within its Exclusive Economic Zone (EEZ). The Ministry of Science and Technology has also stimulated science programmes directed to Brazilian Centres of Excellence under the Millennium Development Goals.

To fulfil the CBD targets, the Brazilian Ministry of Environment established the Programa Nacional para Diversidade Biologica[6] (PRONABIO) in 1994 and with funds from GEF supported several projects to assess biodiversity and identify threats and opportunities for conservation and sustainable use of natural resources. In 2006 the Brazilian Ministry of Environment concluded the National Plan for Protected Areas which recognized the importance of establishing no-take zones or marine reserves as a fisheries management tool. The Ministry of Environment and The Nature Conservancy (TNC) jointly conducted an Assessment of Priority Coastal and Marine Areas for Conservation.

Brazil is part of the Global Coral Reef South American Node of the Global Coral Reef Monitoring Network (GCRMN) along with Costa Rica, Panama, Colombia, Venezuela and Ecuador, but because Brazil is not part of the wider Caribbean Regional Seas Programme of UNEP, it is not entitled to financial support for monitoring coral reefs. Brazil has participated with funds from the Ministry of Science and Technology and

4 National Buoy Programme (www.dsr.inpe.br/pnboia/pnboia.html)
5 Inter ministerial Commission for Sea Resources
6 National Programme for Biological Diversity

from the Ministry of Environment, which, in cooperation with universities and NGOs, conducts the National Coral Reef Monitoring Programme.

An area held in common by both Argentina and Uruguay is the Rio de la Plata River. A treaty for the exploitation of shared living resources in the river and estuary, the Tratado del Río de la Plata y sus Frente Maritimo[7], was signed and came into force in 1974. An Argentine-Uruguayan Technical Commission for the Rio de la Plata Maritime Front has jointly managed the shared hake stock since 1975. Two Commissions set up in 1976, the Comisión Técnica Mixta del Frente Marítimo[8] (CTMFM) (http://www.ctmfm.org), and the Comisión Administradora del Río de la Plata[9] (CARP), are responsible for the conservation and rational use of living aquatic and marine resources and for the prevention and control of pollution in the water bodies. The CTMFM has regulatory powers for setting quotas for each Party in the common fishery zone, which includes areas of the EEZ of Uruguay and Argentina. It undertakes research on fishing capacity or effort and has established a task group on catch reporting and processing. Another priority issue being addressed in a GEF project to which the CTMFM is a Party is the protection of the common fishing zone marine environment.

The Foro para la Conservación del Mar Patagónico y Áreas de Influencia is an international forum which proposes to promote collaboration between organizations for the maintenance of the ecosystem integrity and effective management of the Patagonian Sea and its area of influence in association with the private and public sectors (http://www.marpatagonico.org).

3. DATA

3.1 The ecosystem

Studies ranged from basic mapping of physical, biological and oceanographic aspects to monitoring and assessment. The most important driver for assessments has been the management of commercial fisheries, many of which are overexploited. The University of British Columbia Fisheries Centre has fish catch statistics for all LMEs included in the South West Atlantic region (http://www.seaaroundus.org).

7 Rio de la Plata and Maritime Front Treaty
8 Binational Technical Commission for the Maritime Front
9 Administrative Commission for the Rio de la Plata

In Brazil, fisheries statistics data are gathered in a national database and made available in annual reports by Federal (http://www.ibama.gov.br) and State fisheries bodies. Data on living and non-living resources in the Brazilian EEZ have been gathered through several programmes since the 1970's, and are available through publications or reports and in databases held by the Brazilian Ministry of Environment. In Uruguay, Dirección Nacional de Recursos Acuáticos (DINARA) (http://www.dinara.gub.uy), formerly INAPE, is responsible for fisheries statistics and stock assessments. In Argentina, the Subsecretaría de Pesca y Acuicultura, under the Secretaria de Agricultura, Ganaderia, Pesca y Alimentos (SAGPyA) is responsible for fisheries statistics and management in the country. Reports on catches and regulations are available online (http://www.sagpya.mecon.gov.ar). An important initiative is BIOMARE – A Fisheries Oceanography Information System, under development by Instituto Nacional de Investigación y Desarrollo Pesquero (INIDEP) (http://www.inidep.edu.ar).

Much of the available data have been collected for scientific purposes and are held in scientific institutions. Recent assessments, such as GIWA and priority areas assessments have gathered this data through scientists and institutions. The characteristics of the four LMEs have been briefly described and are available on the website (http://www.lme.noaa.gov/).

Oceanographic data is available from different sources in the South West Atlantic region, including the Brazilian National Oceanographic Data Bank (BNDO), which is the nation's repository for observational data collected in the Atlantic. GOOS/BRASIL (http://goosbrasil.org) distributes data from PIRATA, PNBOIA, GLOSS-Brasil and ARGO. Remote sensing data is available at the ANTARES Portal (http://www.dsr.inpe.br/antares/). Argentina has the Centro Argentino de Datos Oceanográficos (CEADO) and descentralized components in other organizations/institutions such as the Instituto Nacional de Investigación y Desarrollo Pesquero (INIDEP), the Centro Nacional Patagonico (CENPAT) and the Comisión Nacional de Actividades Espaciales (CONAE).

Biogeographic data is available through the Ocean Biogeographic Information System (OBIS) which is an initiative sponsored by the Census of Marine Life. There are two main OBIS Portals for the South West Atlantic region, a Brazilian site (http://obisbr.cria.org.br/) and a South American site (http://obissa.cria.org.br:8080/).

3.2 Socioeconomic data

Socio-economic data are provided by national institutes. In Brazil, the Instituto Brasileiro de Geografia e Estatistica[10] (IBGE) (http://www.ibge.gov.br), during the past 69 years, has collected, analysed and published data including census of Brazilian population and its main characteristics, indexes and economic and social evolution. In Argentina there is the Instituto Nacional de Estadística y Censos[11] (INDEC) (http://www.indec.mecon.ar), which also publishes statistics on socio-economic indicators for Brazil. These data are available and accessible, and cover multiple socio-economic aspects. In 2000, the members of the MERCOSUL Regional Trade Agreement started to exchange experiences and information and coordinate data collection to establish a common database.

4. ASSESSMENTS

Studies started in the 1970's to assess the potential for exploitation of living and non-living resources, with focus shifting more recently to the state of conservation, sustainable use of the resources and climate change. Although a fisheries ecosystem approach is recognized as important, few initiatives have really dealt with the subject except where it involved a single species. Participation by stakeholders in fishing management decisions has always occurred, but recently activities have been expanded to include a greater cross-section of interested parties. Similarly, conservation of species has slowly evolved to conservation of ecosystems so that most projects undertaken recently include social aspects and have public and stakeholder participation within their agenda.

4.1 Thematic/sectoral assessments

Since 1982, Brazil has been expending great efforts to assess the state of the living and non-living resources of its EEZ. These include:

- REMPLAC, Recursos minerais da Plataforma Continental, is a Programme for the Assessment of the Potential for Mineral Exploitation of the Juridical Continental Platform and the establishment of policies for mineral exploitation;
- LEPLAC, Plano de Levantamento da Plataforma Continental Brasileira, was a programme created to establish the limits of the Brazilian continental shelf under its jurisdiction as determined by the UNCLOS;

10 Brazilian Institute of Geography and Statistics
11 National Institute of Census and Statistic

- The Project Recursos Vivos na Zona Economica Exclusiva[12] REVIZEE is a programme which has assessed the potential for exploitation and the status of exploited living resources of the EEZ in the South Brazil Shelf, East Brazil Shelf and North Brazil Shelf areas. Results have led to an official list indicating the status of fish stocks, including over-exploited resources. This programme also has included research on physical, geological and chemical oceanographic characteristics of the area as well as primary and secondary productivity. Documents are available online (http:// www.mma.gov.br/revizee).

An assessment of priority coastal and marine areas for conservation was conducted by the Brazilian Ministry of the Environment and TNC, to determine priority coastal and marine areas for conservation and to achieve a 2015 target. The assessment was completed in 2006 and set priority areas for conservation along the entire Brazilian coast (Chatwin 2007). Databases are available partially on the internet and partially upon request (http://www.mma.gov.br).

Brazil set up a National Coral Reef Monitoring Programme in 2002 to monitor and assess coral reefs distributed along 2000 km of the East Brazil Shelf. The program includes an assessment of effects of marine protected areas on coral reefs. The region is also part of the Sea Grass Net monitoring programme. Qualitative as well as quantitative data are collected and analysed in this programme to detect status and trends. The coral reef programme is linked to the GCRMN through the South American node, Reef Check and the Brazilian Ministry of Environment, International Coral Reef Initiative (ICRI) focal point. Mapping of coral reefs located in shallow waters was concluded and published by the Brazilian Ministry of Environment in 2006. Mangrove status evaluations, including analysis of trends in vegetation cover have been conducted in some areas.

Collection of fish catch data is common in the region, particularly for the main target species, but it's reliability has been questioned when a multi-species fishery is in place (Sabsay and others 2006). There are regular assessments based on catch and landings for some fish stocks in Brazil by the Instituto Brasileiro do Meio Ambiente[13] (IBAMA), Secretaria Especial de Aquicultura e Pesca[14] (SEAP) and associated institutions. In Uruguay,

12 Living Resources in the Exclusive Economic Zone
13 Brazilian Environmental Institute
14 Special Secretary of Fisheries and Aquaculture

Dirección Nacional de Recursos Acuáticos (DINARA) is responsible for fisheries stock assessments. In Argentina, the Subsecretaría de Pesca y Acuicultura[15], is responsible for fisheries statistics and management. Technical reference points are used in fisheries management and the management tools frequently used are 'input control' such as size limit, gear restriction, closed season, closed area and fishing permits. Fisheries management plans are developing and public consultation and stakeholder participation are usually part of the process. However, fisheries independent, survey based assessments are rare in the South West Atlantic region.

ICAAT compiles fishery statistics from its members and others fishing for tuna in the Atlantic Ocean and produces reports and publications.

4.2 Integrated assessments

The GIWA assessments in the Northeast Brazil Shelf region were divided into the Brazilian Northeast and Amazon sub-regions. The GIWA methodology involved the analyses of current problems and their societal root causes. It developed scenarios of the future condition of the world's water resources and analysed policy options. Other assessments were also conducted and the following regional assessment reports are available:

a. Brazil Current, GIWA Regional assessment 39. An assessment of the GIWA region Brazil Current, including drainage basins and their associated coastal/marine zones, with three sub-regions: the South/ Southeast Atlantic Basins, East Atlantic Basins, and São Francisco River Basin[16];
b. Patagonian Shelf, GIWA Regional assessment 38. An assessment of the Patagonian Shelf and associated river basins. The report focuses on the La Plata River Basin, identifying the root causes of environmental degradation in the Argentinean and Uruguayan Common Fishing Zone and the Uruguay River Basin, shared by Argentina, Brazil and Uruguay[17];
c. Northeast Brazil Shelf, GIWA Regional Assessment 40a. A Thematic preliminary report is available, outlining the key transboundary living marine resources issues for the Guianas–Brazil sub-region, the root causes and potential options for addressing them. The Guianas-Brazil sub-region is the marine area encompassing the North Brazil LME and the Gulf of Paria[18].

15 SubSecretary of Fisheries and Aquaculture
16 http://www.unep.org/dewa/giwa/areas/area39.asp
17 http://www.unep.org/dewa/giwa/publications/r38.asp
18 http://www.unep.org/dewa/giwa/areas/area40.asp

The GEF is currently financing the FREPLATA[19] project, Protección Ambiental del Río de la Plata y su Frente Marítimo: Prevención y Control de la Contaminación y Restauración de Hábitats. It is a joint initiative involving the governments of Argentina and Uruguay and is being carried out within the framework of the Treaty of the Rio de la Plata and its Maritime Front. The project is being undertaken by a consortium set up by CARP and CTMFM. The first stage resulted in a full scale technical Transboundary Diagnostic Analysis (TDA). The second stage is the design of a Strategic Action Programme to include proposals for specific measures to address the problems identified in the TDA. The TDA is based on the expert judgment of the best available data and results from five years of dedicated work by a large number of specialists from Argentina and Uruguay. It has resulted in more than 300 detailed scientific and technical reports containing the information that underpins the TDA. Full information on the project and its outputs is available at www.freplata.org.

There are several other GEF projects in the South West Atlantic region, both underway and in the pipeline. Among them is the Coastal Contamination Prevention and Sustainable Fisheries Management project aimed at Argentina's efforts to reduce pollution of the Patagonia marine environment and improve sustainable management of marine biodiversity; and the Integrated Management of Land-Based Activities in the São Francisco Basin Project, a watershed management programme for the Rio São Francisco Basin, which discharges into the South West Atlantic LME and Brazil Current.

The IBGE has been conducting a survey of basic information in Brazilian municipalities since 1999. The programme is called MUNIC, and is based on questionnaires distributed to Brazil's administrative organization. Finance and environmental management has been investigated in 5560 municipalities. One example, for the marine and coastal region, was the diagnosis of fisheries decline and its relationship to human produced impacts, mainly illegal fishing and deforestation of mangroves and riparian vegetation.

The Foro para la Conservación del Mar Patagónico y Áreas de Influencia[20] has prepared the Informe sobre el Estado del Mar Patagónico[21], a

19 Environmental Protection of the Rio de la Plata and its Maritime Front: Pollution Prevention and Control and Habitat Restoration.
20 Forum for the Conservation of Patagonian Sea and Areas under its Influence
21 Report on the State of the Patagonian Sea

publication including original articles of revision and synthesis prepared by members of the forum on the state of the Patagonian Marine Ecosystem and its biological diversity. It also includes an analysis of physical and biological characteristics, human activities and measurable environmental indicators (http://www.marpatagonico.org).

5. PRIORITIZED ISSUES

Fishing, including artisanal fishing, with many stocks depleted or collapsed and several endangered species, captured as targeted or by catch, is a main issue. Consequences of land based impacts and coastal development, including mariculture and tourism development, form the central issue for coastal ecosystem management and monitoring. Among those developments with specific impact on marine species through oil spills and noise pollution during seismic prospecting, is the hydrocarbon industry. Assessments of oil and gas exploration are expanding to play an important role in the coastal and marine scenario. These assessments can be conducted on a compulsory basis as a requirement for licences or as a precautionary approach through mitigation and compensation processes. In Brazil, on-board observers assess any impacts of oil and gas exploration and extraction activities on mammals and turtles as well as fish. There are also fisheries monitoring programmes to assess impacts of the industry's activities and to evaluate compensation claims.

Throughout the South West Atlantic region, there are several permanent programmes resulting from partnerships between government and NGOs which are directed at endangered species (such as turtles, marine mammals, sea birds and more recently, groupers) and which include by-catch monitoring. Invasive species are a concern as the number of invasive taxa has increased in recent years.

Global climate change and its influence on the oceans has been a concern in the South West Atlantic region. The influence of the changes on natural coastal hazards, through erosion and inundation, as well as their effects on biodiversity and fisheries, are major areas of concern. Brazil recently established a government Climate Network, and created the National Institute on Climate Change Research, both of which include a coastal and an oceanic component.

6. SUPRA REGIONAL ISSUES

In the North Brazilian Shelf, a joint scientific cooperation programme between Suriname, Brazil, Guianas and France for Studies of Coastal Tropical Ecosystems (ECOLAB) began in 1992. Led by IRD (ex ORSTOM), the programme resulted in the project Mangroves and Remote Sensing, which is aimed at studying the extensive mangroves located in the North Brazilian Shelf. Transboundary issues needing to be addressed in the North Brazilian Shelf area are land degradation and water pollution caused by mining activities. Recently, a GEF project is working with the United Nations Industrial Development Organization (UNIDO) to formulate a global action plan for countries (Philips 2007).

The Inter-American Institute (IAI) supports an international consortium for the study of oceanic related global and Climate changes. The South American Climate Change (SACC) is a supported initiative involving Argentina, Brazil, Chile, Uruguay and the USA. The project conducts interdisciplinary research including oceanographic cruises and numerical modelling in tidal and shelf break fronts, the Río de la Plata River and Lagoa dos Patos River freshwater discharges and coastal upwelling systems (http://www.sacc.org.uy/).

The GOOS Regional Alliance OCEATLAN, combines the effort of 20 institutions from Argentina, Brazil and Uruguay to implement an operational observing oceanographic system aimed at monitoring and investigating oceanic and coastal processes in the South West Atlantic region and tropical Atlantic (http://www.oceatlan.org).

The Basis for Sustainable Ecosystem Management of The Patagonian Sea is a publication resulting from a research project, Sea and Sky (www.sea-sky.org), which was a joint initiative of the Wildlife Conservation Society (WCS) and the Argentinean National Council for Scientific and Technical Research (CONICET). It was requested from the Fundación Ambiente y Recursos Naturales (FARN), in the framework of a joint project for sustainable ecosystem management of the Patagonian Sea.

Foreign fleets do operate in the South West Atlantic region, inside and outside EEZ boundaries, under licence issued by the relevant local government. In spite of a number of treaties and conventions for the South West Atlantic region, including several regarding effects of by-catch on endangered species, there is no assessment available for the high seas.

7. CAPACITY TO UNDERTAKE FUTURE ASSESSMENTS

The South West Atlantic is large and diverse, and from the Amazon to Patagonia, issues and problems vary enormously. There are many impacts of direct human activities along the region.

Countries have a strong commitment to international conventions, which has stimulated government programmes, including assessments of the status of conservation of ecosystems and resources. Several programmes directed at endangered species have been established on a permanent basis as a result of partnerships between government and NGOs. The success of these collaborations in achieving continuity represents a strength in the region. In the case of the South Atlantic Whale Sanctuary (SAWS), Argentina has accompanied Brazil in its proposal before the International Whaling Commission (IWC).

Results from assessments conducted by governments or NGOs in South West Atlantic region countries have indicated that the stocks of principal fish resources are overexploited. Although recommendations for effort reduction and regulations do exist, implementation is often hampered by economic considerations. Management of multi-species fisheries is a challenge for the entire South West Atlantic region where there is a disparity between efforts directed to assess and manage small and large-scale fisheries.

Regional capacity for assessment is good with several institutions and marine experts operating in the South West Atlantic region who are recognized worldwide. Recent broad assessments, successfully based almost totally on pre-existing data, reveal that there is information available to produce general assessments of the state of the marine environment. However, time series are lacking in most relevant sectors such as the lack of adequate data to evaluate climatic effects in the region. Provision of sufficient resources to establish a process for identifying and addressing gaps on a regular basis is also a source of concern.

Partnerships with external institutions and scientists are common and especially necessary in the more technology dependent fields such as climate change. Translating assessments, studies and efforts into public policies and subsequently into actions which lead to changes, in many cases, has been a long process. Clear evaluation of the effectiveness of the impact of those assessments is still largely missing and could be an important driver for the future.

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AoA Region: Western African Seas

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Fishermen unloading frozen fish from an industrial fishing vessel at the port of Tema, Ghana.

The Western African Seas region extends from the Atlantic coast of Morocco to South Africa on the western seaboard of Africa. In the United Nations Environment Programme (UNEP) Regional Seas Programme, the area is referred to as the West and Central Africa region (UNEP 2005a) and falls under the Abidjan Convention for Co-operation in the Protection and Development of the Marine and Coastal Environment of the West and Central African region. The area also makes up two statistical Divisions of the Food and Agriculture Organization (FAO), the Eastern Central Atlantic (area 34) and Southeast Atlantic (area 47). The 23 countries in this region are Angola, Benin, Cameroon, Cape Verde, Congo, Democratic Republic of Congo, Cote d'Ivoire, Equatorial Guinea, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mauritania, Morocco, Namibia, Nigeria, São Tomé and Príncipe, Senegal, Sierra Leone, South Africa, and Togo. This AoA region also includes the Canary (Spain) and Madeira (Portugal) Islands situated off the coast of Morocco-Mauritania. There are three Large Marine Ecosystems (LMEs) in the Western African Seas region, the Canary Current LME (CCLME) in the north of the region, the Guinea Current LME (GCLME) in the middle and the Benguela Current LME (BCLME) in the south.

1. BROAD ECOLOGICAL CHARACTERISTICS

The Canary and Benguela Currents are two of the world's major coastal upwelling systems. The Canary Current flows all year round, from north to south, between latitudes 30° N and 10° N. The CCLME is characterized by a permanent upwelling. The upwelling zone expands in winter and shrinks in the summer and fall. It also migrates meridionally as the seasons progress. It is a highly productive ecosystem (>300g Cm^{-2} y^{-1}) supporting

fish and huge populations of migrating birds. The relatively warm, generally eastward-flowing Guinea Current, overlays the westward flowing Guinea Under-Current and extends from the Bissagos Islands off Guinea Bissau in the north to Cape Lopez in Gabon in the south. The central part of the GCLME experiences seasonal coastal upwelling which is strongest in July-September. The BCLME is characterized by its temperate climate. It is a western boundary ecosystem, and the strongest wind-driven coastal upwelling system known (GEF 2000). This upwelling system is unique because it is bounded at both its northern and southern extremities by warm water systems, with the Angola Current at the Angola/Benguela Front to the north and the easterly Agulhas Current flowing from the Indian Ocean to the south. These systems impact significantly on the ecosystem.

The Benguela Current system is complex and highly variable, showing seasonal, inter-annual and decadal variability as well as regime shifts in fish populations (Shannon and O'Toole 1999 and 2003). The distinctive bathymetry, hydrography, chemistry and trophodynamics of the BCLME make it one of the most productive marine areas of the world. Based on the Sea-viewing Wide Field-of-view Sensor (SeaWiFS) annual primary productivity estimates, the LME is a Class I, highly productive ecosystem with productivity greater than 300 g $Cm^{-2}\,y^{-1}$.

A major influence on the Western African Seas region marine ecosystem is the input of freshwater from the numerous rivers, notably the Sebou, Souss, Senegal and the Gambia discharging into the Canary Current system, the Comoe, Volta, Niger, and the Congo discharging into the Guinea Current system and the Orange River discharging into the Benguela Current system.

The entire Western African Seas region coastline, especially in the Guinea Current area and off Gabon, Equatorial Guinea and the mouth of the Congo and Niger Rivers has extensive mangrove forests, dominated mainly by *Rhizophora*. The mangrove forests provide habitat for fish, crustaceans, molluscs and aquatic birds. They also support valuable artisanal fisheries and are harvested for timber and fuel wood. According to Abe and others (2003), coral reefs in the Gulf of Guinea are poorly documented, although corals are reported to occur off Cape Verde, Sierra Leone, Liberia, Côte d'Ivoire and Ghana as well as around the islands of São Tomé, Príncipe and Bioko. Another physical characteristic of the region is the occurrence of numerous coastal lagoons which are in themselves important reservoirs of biological diversity. They provide

spawning and breeding grounds for many fish, including transboundary species and shellfish, and also provide the basis for the regenerative capacity of fisheries in the Western African Seas region.

Frequent and widespread eruptions of toxic hydrogen sulphide occur off the coast of Namibia (Weeks and others 2004). Eruptions often seem to coincide with either increased intensity of wind-driven coastal upwelling or the passage of a low-pressure weather cell. In 2001, nine major hydrogen sulphide eruptions occurred with the largest covering 22 000 square kilometres (km^2) of ocean.

The countries of the region, especially those in the Gulf of Guinea, have experienced rapid industrialization and urbanization, population growth and increased oil and gas prospecting and production over the past 50 years. The Western African Seas region faces problems relating to fisheries depletion, water pollution including occasional spillage from crude oil production, public health and sanitation, habitat and biodiversity loss, poor land-use planning and coastal erosion. Recent regional and national assessments have found significant natural resource and biodiversity degradation of coastal and international waters and of freshwater catchment areas adjacent to the Western African Seas region (Abe and others 2003, UNEP 2005b, UNEP 2005c).

The principal uses of the Western African Seas region are artisanal and industrial fishing, shipping, oil and gas production and tourism. The region is rich in terms of diversity and abundance of fish and other marine organisms. According to FAO (2005), during the period 1950–2002, 22 coastal states and 47 distant water fishing nations reported about 190 species or groups of species in commercial catches from the part of the Western African Seas region under the influence of the Canary and Guinea currents. There are multi-national fishing fleets operating in the Western African Seas region, targeting tuna and highly valuable demersal fish species. Total production from capture fisheries in the Western African Seas region was about 3.2 million tonnes in 2007, including about 2.4 million tonnes produced by the region's coastal states (FAO 2009). Also in 2007, the countries making up the Western African Seas region produced about 5 500 barrels of crude oil per day, or about 52.1 per cent of the total African production, which in turn made up about 6.5 per cent of world production (EIA 2008).

A major characteristic of West Africa is the location of both heavy and light industries in coastal areas, which are also the most populated areas in these riparian countries.

2. INSTITUTIONS UNDERTAKING ASSESSMENTS

Earlier assessments in the region were conducted mainly by French and British colonial institutions. In the English-speaking countries, fisheries and oceanographic studies were pioneered by the West African Fisheries Research Institute (WAFRI), which was based in Freetown, Sierra Leone. The French Institut de Recherche pour le Développement (IRD), formerly known as Office de la Recherche Scientifique et Technique Outre-Mer (ORSTOM) carried out most of the assessments in the Francophone areas of the Western African Seas region.

The Science, Technology, and Research Committee of the Organization of African Unity (OAU-STRC) sponsored an extensive survey, the Guinean Trawling Survey (GTS), between August 1963 and June 1964 in the waters off West Africa. From about 1967, the FAO initiated and supported assessments through the establishment of the Fishery Committee for the Eastern Central Atlantic (CECAF) and the International Commission for the South-East Atlantic Fisheries (ICSEAF). CECAF covers the Atlantic coast of Africa from Morocco in the north to Angola in the south while ICSEAF, which ceased to function in the early 1970s, covered the area further south.

Other oceanographic research and assessments were undertaken through the assistance of the Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization (IOC-UNESCO). The initiation of the UNEP West and Central Africa Regional Seas Programme in the early 1980s marked the beginning of sustained and large-scale coastal area assessments in the Western African Seas region.

Other assessments in the Western African Seas region began with the LME programmes funded by the Global Fisheries Interaction and Training (BENEFIT) Programme, a precursor to the BCLME Programme, developed in 1997 as a cooperative initiative for science capacity development by Angola, Namibia and South Africa, in partnership with NORAD, GTZ, and IOC-UNESCO. The functions and responsibilities of the Benguela Current Commission, which is a product of the BCLME Programme, include among others, the production of annual fish stock assessments.

Some assessments were also conducted under the GEF Medium Sized Project (MSP) on the Development and Protection of the Coastal and Marine Environment in Sub-Saharan Africa, also called the African Process, which was implemented from 1998 in some countries in Africa, including Côte d'Ivoire, the Gambia, Ghana, Nigeria and Senegal. The African Process devised a

portfolio of projects based on the assessment of key issues associated with the management of the coastal and marine environment in Sub-Saharan Africa.

Various other initiatives in the Western African Seas region have been national or sector-based and have involved national and international research institutions and scientists. Among these are the World Bank/GEF Ghana Coastal Wetlands Management project, the UNDP/World Bank/GEF project on Reversing Land and Water Degradation Trends in the Niger Basin and other biodiversity conservation and management projects. Through the IOC-UNESCO ODINAFRICA project, the Western African Seas region has developed a network of oceanographic data centres which are equipped with human resources and infrastructure. Fish stock assessment and oceanographic surveys have been carried out by national fisheries and oceanographic research institutes in the Western African Seas region. These institutions include the Institut National de Recherche Halieutique (INRH) in Morocco, the Centre de Recherches Océanographiques de Dakar Thiaroye (CRODT) in Senegal, the Centre National des Sciences Halieutiques de Boussoura (CNSHB) in Guinea (Conakry), the Centre de Recherches Océanologiques (CRO) in Côte d'Ivoire, the Marine Fisheries Research Division (MFRD) of the Ministry of Fisheries in Ghana, the Nigerian Institute for Oceanography and Marine Research (NIOMR), Station de Recherches Halieutiques et Oceanographiques (SRHO) in Cameroon, the National Marine Information and Research Centre (NatMIRC) in Namibia and a number of fisheries research institutes in South Africa.

A number of universities in western and southern Africa also have been involved in carrying out various types of assessments. Such universities have invaluable data and information which, if collected systematically, can be used to prepare assessments for the Western African Seas region.

In addition, a number of regional organizations and projects have coordinated the collection and management of data on marine resources in what may constitute elements of assessments. Examples are the Fisheries Information and Analysis System (FIAS) and the Sustainable Fisheries Livelihood Project (SFLP). The creation of the African Ministerial Conference on the Environment (AMCEN) in 1985 has also seen a commitment to sound environmental management which is reflected in the development of the Environment Action Plan of the New Partnership for Africa's Development (NEPAD).

Other institutions that have undertaken or sponsored some kind of assessment in the Western African Seas region are the International Commission for the

Conservation of Atlantic Tunas (ICCAT) and the South-East Atlantic Fisheries Organization (SEAFO).

Indicators, as measurable and quantifiable indices for evaluating performance and measuring success, are gradually being used in regional and national programmes. Regional strategic action programmes (SAPs) and national action plans all employ indicators for monitoring and evaluation. Indicators were used in some biodiversity projects for the Transboundary Diagnostic Analysis (TDA). However, these indicators are poorly defined and, in some cases, are not site specific.

3. DATA

3.1 Ecosystem data

A substantial amount of data has been collected from studies, surveys and assessments conducted in the region by the organizations mentioned above. There are a few reliable databases existing in the region such as:

a. Fish stock assessment and oceanographic survey data held by the research institutes listed above;
b. Data collected through international surveys of fisheries and oceanography such as surveys by the Norwegian research vessel *Dr Fridtjof Nansen* and assessments such as the Global International Waters Assessment (GIWA) and the African Process. The Institute of Marine Research (IMR) in Bergen (Norway) holds several years of fisheries survey and oceanographic data for the Western African Seas region. These data may be the only consistent regional datasets which could be considered as held in a central data repository. It is expected that the Fisheries Information and Analysis System (FIAS) datasets may also be accessible from the Sub-Regional Fisheries Commission in Dakar, Senegal;
c. Data collected through the preparation of TDAs for the three Western African Seas region's LMEs. The TDAs provide syntheses and assessment of information on various themes. In the case of the GCLME for example, the syntheses are compiled into a suite of six comprehensive reports on Fisheries, Oceanography and Environmental variability, Diamond mining, Coastal environments, Offshore oil and gas exploration/ production and Socio-economics of some key maritime industries;
d. The Africa Marine Atlas (geospatial datasets) is an atlas of environmental themes for Africa, under the sponsorship of the IOC-UNESCO ODINAFRICA project and the International Oceanographic Data and Information Exchange (IODE) Programme. The African Marine Atlas

includes a number of other geo-spatial data projects on and around the African continent (http://iodeweb2.vliz.be/omap/OMAP/index.htm). National Oceanographic Data Centres (NODCs) established under the auspices of the IOC-UNESCO have some very useful coastal/marine environment/oceanographic data which can be used to prepare assessments. Over the years, IOC-UNESCO has also supported monitoring of sea level variations in a number of locations in the Western African Seas region. The resulting data is held not only by NODCs, but also by the University of Hawaii;

e. Also available, but not readily, are data and information compiled through the FAO working groups on statistics and resource evaluation and the West and Central Africa Programme (coastal zone management).

All data held by the various institutions may be obtained directly from them, except the FAO/Nansen cruise data, which may be acquired from the countries in whose waters the surveys were conducted. The FAO/Nansen Programme and/or the IMR are not allowed to release survey data to a third party under the conditions of the surveys. Data from regional and sub-regional assessments such as the GIWA and the Africa Environment Outlook are held by, and may be obtained from, the University of Kalmar in Sweden and UNEP Division of Early Warning and Assessment, respectively.

According to the International Union for Conservation of Nature (IUCN), five endangered marine turtle species have been identified in the Western African Seas region. These are, the green turtle (*Chelonia mydas*), the hawksbill turtle (*Eretmochelys imbricata*), the loggerhead turtle (*Caretta caretta*), the leatherback turtle (*Dermochelys coriacea*) and the olive ridley turtle (*Lepidochelys olivacea*). These species are widely distributed in tropical and subtropical waters and are under threat everywhere due to over-harvesting of both eggs and adults and from accidental mortality in fishing nets and longlines. Major threats to marine turtles in the Western African Seas region are harvesting and over-exploitation of eggs, meat and other products, incidental capture by gillnets, trawlers and other fishing gear and loss and degradation of habitats. In most of the countries in this region, information concerning turtle habitats and population dynamics is incomplete. Regional collaboration in the collection and sharing of research data is needed to guide management actions and determine management priorities.

3.2 Socio-economic data

Socio-economic data are generally lacking except in a few instances, including sources mentioned above. Information collected for preparation of the TDAs for the three regional LMEs also include socio-economic data. For example, one of the reports for the GCLME TDA deals with the socio-economics of selected key maritime industries. National statistics offices and universities could also be repositories for huge amounts of socio-economic data. Assessments on a regional scale are virtually lacking, but are available on a national scale for most countries in West and Central Africa.

Socio-economic conditions in coastal areas are well-documented and typically similar for those in developing countries despite differences in Gross Domestic Product and in the state of development. Institutions such as the World Bank and the African Development Bank also have appreciable amounts of reliable socio-economic data for the countries of this region.

4. ASSESSMENTS

4.1 Thematic/sectoral assessments

Several thematic assessments have been conducted in the Western African Seas region, but most of these are generally localized and based on adapted methodology. They cover all the habitats found in the Western African Seas region. The African process, for example, covered the entire coastal and marine area. Earlier assessments in the Western African Seas region focused mainly on fisheries and oceanography. The objective of the Guinean Trawl Survey, for example, was to investigate the fisheries potential and distribution of demersal fish on the Gulf of Guinea continental shelf in relation to the marine environment (Williams 1968).

The West and Central Africa Programme was initiated and adopted in 1981 as the West and Central African Action Plan and the Abidjan Convention for Cooperation in the Protection and Development of the Marine and Coastal Environment of the West and Central African Region and associated Protocols. The Abidjan Convention is therefore the framework legal agreement and the West and Central Africa Action Plan states the agreed actions for implementing the agreement. As such the Convention is a regional legal framework that brings different partners together. The contracting Parties have in the past been requested to prepare State of the Coast Reports which will be invaluable in conducting regional

assessments. Initial projects of the Convention addressed pollution, coastal erosion, environmental impact assessment, environmental legislation and marine mammals. Subsequent programmes considered coastal ecosystems and the unsustainable use of living marine resources.

Under the UNEP Regional Seas Programme and the FAO-assisted Regional Fishery Bodies, a number of sector-specific studies have also been conducted, although these may not be strictly classified as assessments. The NEPAD coastal and marine programmes with the potential to contribute to regional assessments still require international financial support and policy measures which will be implemented regionally to address transboundary issues.

The FIAS is an ecosystem-based approach to resource management in West Africa, involving research institutions in the six northwest African countries of Cape Verde, Guinea, Guinea-Bissau, Mauritania, Senegal, and The Gambia, all of which are members of the Sub-Regional Fishery Commission. Also involved are research institutions in France, Portugal, and Spain as well as the FAO. The specific objective of the FIAS is to strengthen the capacities for improved resource management in the partner countries in northwest Africa, both at national and regional levels (FAO 2001).

The SFLP involved 25 West African countries in a project executed by FAO and funded by the Department for International Development (DFID) of the United Kingdom. It undertook a number of socio-economic studies in which valuable data on marine fisheries was assembled. For these studies, the time scales of the data ranged from two years and above. In general, long time-series data are inadequate and in some cases non-existent. The precursor to the SFLP project, the FAO-led Integrated Development of Artisanal Fisheries Project (IDAF), also based in Cotonou, Benin, provided substantial amount of information on the artisanal fisheries sector. However, socio-economic data are usually not current because of inadequate gathering, storing and archiving of the different types of socio-economic data collected (such as population, GDP, income levels, educational and health facilities, and birth rates).

Other significant studies involving extensive data collection and management, including socio-economic and poverty-related studies, have been carried out in the Western African Seas region. Examples of these have been documented in McGlade and others (2002), Neiland and Bene (2004) and UNEP/GPA (2006).

4.2 Integrated assessments

Assessments undertaken as part of the GEF LME programmes address priority transboundary environmental issues and the use of marine living resources. For example, the GEF-funded pilot project Water Pollution Control and Biodiversity Conservation in the Gulf of Guinea LME (1995–1999) was initiated to address some of these issues in six countries: Benin, Cameroon, Côte d'Ivoire, Ghana, Nigeria, and Togo. The development objective of the project was the restoration and sustenance of the health of the GCLME and its natural resources, particularly as it concerns the conservation of its biological diversity and the control of water pollution (Koranteng 2001). Similarly, the objective of the CCLME programme is to reverse degradation of the CCLME caused by overfishing, habitat modification and changes in water quality by adopting an ecosystem-based management approach (GEF 2000). In the BCLME, the GEF is supporting an ecosystem-based project which aims at integrated management, sustainable development, and environmental protection of the LME.

The TDA for the GCLME identified major environmental and natural resource problems similar to those documented in the GIWA. Assessments based on inputs from national reports to the GCLME project are suggestive of widespread deterioration in water quality (chronic and catastrophic) from land-based and sea-based activities, eutrophication and harmful algal blooms. In most cases, national assessment reports for the GCLME focus on fisheries. Furthermore, they are not systematic and so far have been characterized by several one-time assessments with significant gaps. Inadequate human and material capacity have been major factors which have worked against the conduct of regular assessments in the region.

The assessment entitled Inventory of Hotspots on Physical Alteration and Destruction of Habitats (PADH) in the GCLME region, involved 16 countries and was completed in 2006 under the UNIDO/GEF GCLME project. The report assessed and quantified the magnitude of land-based sources of PADH in hotspots and identified areas which have been severely degraded. It proposed remedial and mitigation responses to sources and effects in the priority areas, taking into consideration applications of remote sensing and Geographic Information Systems (GIS) techniques.

The assessment, Biodiversity Status and Trends in the GCLME, was conducted from 2003 to 2006 for each country in the GCLME area for species of special conservation significance, including rare, threatened and endangered species protected within their ecosystems (including in forest

and montane regions, savannah, agricultural land, wetlands and freshwater areas, and coastal and marine regions). The level of protection afforded to these species is dependent on the capacity for conservation of the various habitats within these ecosystems, and, as such, protection is loose, cannot be quantified and is unspecified.

The African Process also identified transboundary issues of concern which include pollution, modification of habitats, over-exploitation of fishery resources and climate change. A number of interventions were prepared to address these areas of concern, but none have been implemented. The African Process contributed to a growing recognition that sound environmental management is a cross-cutting issue which ultimately defines the long-term welfare of human populations as well as the potential for sustained economic growth and social stability. It incorporated environmental concerns in the development agenda of participating countries through targeted projects which addressed environmental aspects along with institutional, regulatory, policy and capacity elements. However, the objectives of the African Process have not been achieved, mainly because of a lack of funds and ineffective cooperation between states in the Western African Seas region and international funding agencies.

Coordinated and in-depth national assessments of the state of the marine environment in individual countries showed no systematic approach or regularity. Selected bilateral programmes which attempted to address national coastal issues through studies and mitigation, appeared to lack in-depth assessment of cause and effect associated with the hazards and coastal issues.

Despite the existence of several national, regional and international programmes and assessments in the region, integrated coastal area management (ICAM) is inadequate or non-existent in many parts and where it has been initiated, continuity and capacity are lacking. Some of the salient root causes of the problem include demographic trends, growing demand for water and other natural resources, increasing urbanization and industrialization, institutional constraints, sectoral approaches, national and international market demands and conflicting jurisdictions as well as weak enforcement mechanisms.

Although strategies and activities to address the issues identified in many assessments in the Western African Seas region are similar, site-specific differences may be evident because of differences in ecological conditions, local and national priorities and the availability of financial and human resources. There is increasing recognition of this situation, coupled with

greater political will to take necessary actions to improve the deteriorating situation. Efforts are being made, for example, to revitalize the Abidjan Convention through more targeted work plans and mechanisms such as cooperative arrangements with other UNEP Regional Seas Conventions.

5. PRIORITIZED ISSUES

The assessments of the Benguela, Guinea, and Canary Current LMEs ranked freshwater shortage, habitat and community modification and loss, pollution and unsustainable exploitation of living resources, among the priority issues. The GIWA assessments covered all aspects of the ecosystem, including the social and environmental aspects. However, as they focused on specific sites within the Western African Seas region, the assessments were unable to explore the cross-linkages using an ecosystem-based approach for the whole Western African Seas region. Nevertheless, they identified priorities, for both research and policy actions.

The issues identified by the various assessments are:

a. Physical alteration and destruction of habitats;
b. Water quality degradation by pollution;
c. Coastal development and tourism;
d. Overfishing and associated socio-economic consequences for coastal communities;
e. Ineffective policies and the lack of efficient management systems;
f. Lack of enforcement of existing legislation on coastal area management and the exploitation of marine resources;
g. Inadequate technical capacity for assessment and formulation of effective management plans;
h. Limited scientific knowledge and monitoring of key habitats, species and activities; and
i. High turnover of trained scientists.

Knowledge gaps in African marine biodiversity occur in the areas of taxonomic information, geographic regions and ecosystem/ biotope. Taxonomic information is poor for deep offshore and pelagic systems, and is particularly limited for benthos in all areas. Deep-sea and offshore fish are also poorly studied. Knowledge of benthic meiofauna is inadequate in most of the Western African Seas region. Some knowledge of these gaps results from human resource deficiencies. Data collation of all previous studies is required because existing data are not readily available to be collated to provide the whole picture for the Western African Seas region.

In addition, oceanographic studies are very limited because of a lack of capacity in areas such as technical expertise and financial availability. For various reasons most of the sea level data collected by numerous sea level monitoring stations are not used extensively.

6. SUPRA-REGIONAL ISSUES

Rapid rates of urbanization with associated population growth and increased pollution from land-based sources in the region as well as other factors such as poor governance and the contribution of the region's upwelling ecosystems to global fish production, make several issues in the Western African Seas region rather supra-regional in nature. The effect of climate change, invasive species and other issues in the priority list above have been the subject of global investigations which go beyond the boundaries of the Western African Seas region.

7. CAPACITY OF THE REGION TO UNDERTAKE FUTURE ASSESSMENTS

Capacity is somewhat limited in the Western African Seas region, to undertake future assessments that consider pressures in West and Central Africa such as climate change, pollution of coastal waters, physical alteration and destruction of habitats and over-exploitation of fisheries resources. Given adequate financial resources, the above-mentioned pressures can be handled easily with local expertise. There is a need to establish sustainable, long-term monitoring programmes with targeted parameters. Such a programme could be implemented by consolidating resources that are currently scattered in various national institutions which, in some cases, have similar mandates. Research and training institutions in the Western African Seas region have adequate human capacity to undertake most of these assessments, although partnerships with external institutions and scientists may be necessary for some assessments, such as those related to oceanography and climate change. In general, local financial resources are inadequate to undertake regular assessments as research institutions in the Western African Seas region have limited access to funding and equipment. This is a de-motivating factor which has led to the loss of scientists in the Western African Seas region to other sectors and countries.

The data management capacity of the countries, the network of databases and centres as well as the expertise created through the IOC-UNESCO programmes such as ODINAFRICA, seem to be working well. However,

there is a need to ensure sustainability of such centres after completion of such projects. Assessment capacity in the Western African Seas region needs to be strengthened through training and the provision of material resources.

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AoA Region: Wider Caribbean Region

Robin Mahon and Elva Escobar

Cancun's hotel zone and newly replenished beach. Coastal tourism in the Caribbean both depends on and has extensive impacts on marine ecosystems.

The Wider Caribbean Region extends from the mouth of the Amazon River, Brazil, through the insular Caribbean, Central America, the Gulf of Mexico and along the east coast of North America to Cape Hatteras in the United States of America. It includes 26 countries as well as 17 dependent territories of France, the Netherlands, the United Kingdom and the USA (see below). Several of the countries are Small Island Developing States (SIDS). The Wider Caribbean Region includes four Large Marine Ecosystems (LMEs), the Gulf of Mexico LME, the Caribbean Sea LME, the Southeast US Continental Shelf LME and the North Brazil Current LME. This summary focuses on the Caribbean Sea and North Brazil Shelf LMEs.

1. BROAD ECOLOGICAL CHARACTERISTICS

The region has an area of approximately 15 million square kilometres (km^2) of which some 1.9 million km^2 consist of shelf. Two of the world's largest rivers, the Amazon and the Orinoco, as well as numerous other large rivers enter the sea in the Wider Caribbean Region. Continental shelves associated with these rivers typically have mud bottoms and support diverse ecosystems with a large biomass of shrimp and groundfish. They are influenced mainly by the North Brazil Current. Throughout the Wider Caribbean Region, shallow coastal shelves provide ideal conditions for mangroves, seagrasses and coral reefs. Approximately seven per cent of the world's coral reefs are found in the Caribbean Sea LME. The Mesoamerican Barrier Reef System (MBRS) off Central America is the second largest in the world. The open ocean areas of the Wider Caribbean Region consist of mostly clear, nutrient-poor waters derived from the North Equatorial Current, which enters the Caribbean Sea through the channels between islands on its eastern extremity.

Countries and Territories of the Wider Caribbean Region

Independent countries

Antigua & Barbuda	Dominican Republic	Panama
Bahamas	Grenada	St. Kitts Nevis
Barbados	Guatemala	St. Lucia
Belize	Guyana	St. Vincent & the Grenadines
Brazil	Haiti	Suriname
Colombia	Honduras	Trinidad & Tobago
Costa Rica	Jamaica	United States of America (Mainland)
Cuba	Mexico	Venezuela
Dominica	Nicaragua	

Countries and territories

United Kingdom:

Anguilla	Cayman Islands	Turks & Caicos
British Virgin Islands	Montserrat	

United States of America:

Puerto Rico	US Virgin Islands

France:

Guadeloupe and St. Bartholemew	St. Martin
Martinique	French Guiana

The Netherlands:

Aruba	Bonaire	Saba
Curacao	St. Eustatius	St. Maarten

Coastal water quality has been declining throughout the Wider Caribbean Region mainly as a result of land-based sources of pollution arising from high population densities in coastal areas and the associated discharges of municipal and industrial waste as well as inflows from agricultural pesticides and fertilizers. Other economic activities such as shipping, tourism and petroleum extraction also are concentrated on the coast. About 30 per cent of Caribbean reefs are considered to be either destroyed or at extreme risk from anthropogenic pressures. The Wider Caribbean Region is affected also by hurricanes, which may severely damage coral reefs.

The fisheries of the Wider Caribbean Region are mainly small-scale but there are also large-scale commercial and recreational fisheries. The fisheries of greatest importance are those for offshore pelagics, reef fishes, lobster, conch, shrimps, continental shelf demersal fishes, deep slope fishes and coastal pelagics. There are many other fisheries of lesser importance. Fisheries for highly migratory large pelagic resources are also important and are exploited by countries from within the Wider Caribbean Region as well as by foreign nations.

2. INSTITUTIONS UNDERTAKING ASSESSMENTS

In 1991 the International Maritime Organization (IMO) designated the Wider Caribbean Region and the Gulf of Mexico as a Special Area under Annex V of the International Convention for the Prevention of Pollution from Ships (MARPOL). In 2007, the UN General Assembly adopted a resolution entitled: "Towards the Sustainable Development of the Caribbean Sea for Present and Future Generations" (UN General Assembly 61/197). This resolution is a further step in a process known as the "Caribbean Sea Initiative" by the Association of Caribbean States and the Caribbean Community (CARICOM) to secure the recognition by the international community of the Caribbean Sea as a special area in the context of sustainable development. The most significant regional agreement is the Cartagena Convention and its Protocols, the Specially Protected Areas and Wildlife (SPAW) Protocol, the Cooperation in Combating Oil Spills Protocol and the Land-Based Sources of Pollution (LBS) Protocol.

Within the Wider Caribbean Region, numerous organizations undertake assessments. Providing profiles of all these organizations would be a major task and beyond the scope of this summary. Even profiles of those conducting the assessments which were reviewed as part of this Assessment of Assessments (AoA) initiative would be extensive. These organizations include:

a. National and local government departments and non-governmental organizations (NGOs);
b. National/regional universities and other tertiary learning institutions;
c. Regional intergovernmental organizations (IGOs);
d. UN organizations and their regional bodies; and
e. International NGOs.

Several national level government departments, including those responsible for fisheries, agriculture, environment, tourism, health and planning, conduct assessments which are relevant to the marine environment. Given the 45

entities in the region, the number of national government bodies which may be generating data and information on the marine environment is likely to be more than 200. Many national and local level NGOs within the region also conduct assessments of one type or another.

Most countries have a university or tertiary learning institution which conducts research with some having more than 20 such institutions. There are also many marine laboratories within the region. The Association of Marine Laboratories of the Caribbean is a confederation of more than 30 marine research, education and resource management institutions as well as more than 200 individual members from around the region. A number of entities are associated with institutions and universities from outside the region, such as the Smithsonian Institute station in Panama and the McGill University station in Barbados. These universities and research institutions conduct numerous research programmes and projects, such as the Caribbean Coastal Marine Productivity Programme (CARICOMP) and the Caribbean LME project.

Many regional IGOs undertake a diversity of assessments primarily as projects. Key among these are the Association of Caribbean States (ACS), Caribbean Alliance for Sustainable Tourism (CAST), Caribbean Environmental Health Institute (CEHI), Caribbean Institute for Meteorology and Hydrology (CIMH), Caribbean Tourism Association, CARICOM Caribbean Regional Fisheries Mechanism (CRFM), Environment and Sustainable Development Unit of the Organization of Eastern Caribbean States (OECS), Latin American Organization for Fishery Development (OLDEPESCA) and Organización del Sector Pesquero y Acuícola del Istmo Centroamericano (OSPESCA). International IGOs such as the International Commission for the Conservation of Atlantic Tunas (ICCAT) also conduct assessments which are relevant to the Wider Caribbean Region.

UN organizations with regional bodies which carry out or facilitate assessments include the Western Central Atlantic Fisheries Commission (WECAFC) of the Food and Agriculture Organization (FAO), the United Nations Environment Programme (UNEP) Caribbean Environmental Programme, the Caribbean Sub-Commission (IOCARIBE) of IOC-UNESCO, the UN Economic Commission for Latin America and the Caribbean (UNECLAC), the United Nations Development Programme (UNDP) and the UNEP Regional Office for Latin America and the Caribbean (GEO global and Small Island Developing States outlook reports). The Global Environment Facility (GEF) has funded a variety of projects in the region.

Several large international NGOs, have programmes within the region that include assessments such as the World Wildlife Fund for Nature (WWF), The Nature Conservancy (TNC), the World Resources Institute (WRI), the International Union for Conservation of Nature (IUCN) and the Census of Marine Life, all of which bring financial resources and expertise from outside the Wider Caribbean Region. There are regional organizations also, such as the Wider Caribbean Sea Turtle Conservation Network (WIDECAST), which completed an assessment recently on the status of sea turtles. The Gulf and Caribbean Fisheries Institute (GCFI) plays a significant role in networking at the technical level.

National assessments are a regular process in some of the more developed Caribbean states and are used to monitor progress on national and regional programmes, or to fulfil the requirements of international conventions which have been signed by particular countries. Each government has at least one department for research, but it usually does not cover all aspects of the marine environment. Linking assessments to decision making is weak at regional levels and there is uncertainty regarding appropriate modes for governance of marine resources in the Wider Caribbean Region (Chakalall and others 2007; Fanning and others 2007).

Many non-Caribbean researchers either participate in regional assessments through either contracted or voluntarily services, or conduct work of their own. The government of a particular country in the Wider Caribbean Region may not be aware of research being done locally by external institutions which makes controlling and quantifying available data difficult. Much of the work by non-Caribbean researchers is encountered only in the primary literature and is disconnected from governance.

3. DATA

3.1 Ecosystem data

A significant amount of marine data is collected within the Wider Caribbean Region. Each year, numerous assessments are carried out at the national, sub-regional, regional and international levels and it would take a considerable amount of effort to assess all of what has been done in the Wider Caribbean Region to date. However, there is a large pool of information at the regional and sub-regional levels. At present, data are available in the following areas in varying levels of detail and on varying geographic scales:

a. Offshore pelagic and near-shore fisheries;
b. Coastal habitats, with an emphasis on coral reefs;

c. Watersheds/hydrology;
d. Pollution, particularly land-based sources;
e. Endangered species such as sea turtles and manatees;
f. Oil and gas deposits;
g. Climate;
h. Physical oceanography through field and remote sensing data on atmospheric processes, bathymetry and currents; and
i. Litter.

A substantial amount of data is available in global databases such as the FAO Fishstat, the World Resources Institute (WRI) Earthtrends, the UNEP World Conservation Monitoring Centre, the Global Environment Outlook (GEO) data portal and ICCAT. Data are collected also during oceanographic and fisheries surveys such as the Fridtjof Nansen surveys on the northeastern South American continental shelf and in global observing programmes such as the Global Ocean Observing System (GOOS).

Many countries in the Wider Caribbean Region are engaged in developing environmental indicators and related databases, including those for the marine environment. For instance, under the GEF-supported Integrated Watershed and Coastal Areas Management Project in Caribbean SIDS, a template of the environmental state (including that for marine and coastal areas), stress reduction and process indicators, has been developed for use by Wider Caribbean Region countries. Environmental indicators are also being developed or have been proposed by the Organisation of Eastern Caribbean States (OECS) under the St. George's Declaration as well as by CARICOM. In addition, countries are developing or using indicators for state of the environment assessment and reporting and for reporting to environmental conventions and international donors. Some of the countries have produced national compendia of environmental indicators and statistics. Among the indicators are those related to fisheries (e.g., annual catch levels), marine biodiversity and water quality although the availability and use of indicators varies among countries. There is a need to develop a standard suite of robust indicators which can be applied at national/regional levels for the assessment of the state of the marine environment as well as human and natural driving forces.

Various regional organizations, such as CARICOM, OECS, UNECLAC and the Secretaries-General of the Central American Integration System (SICA) collect socio-economic and environmental statistics from their member countries. A Caribbean marine atlas is under development by IOC-

International Oceanographic Data and Information Exchange (IODE) and will include geo-spatial data and environmental indicators.

3.2 Socio-economic data

There has been a recent surge in socio-economic assessments in the Wider Caribbean Region as managers and policy-makers recognize the importance of this information. However, there are major gaps still, especially in the less developed countries. The majority of socio-economic assessments have had coastal resource usage as their focus resulting in fishermen and beach users being the most assessed user groups and providing data related to fisher demographics, income, marine protected area (MPA) usage and other aspects. With the recognition of the impacts on coastal and marine environments from upstream processes in watersheds, their management has led to assessment of users in the watershed through projects such as the MBRS. The IWCAM project is also beginning to carry out socio-economic studies in the watersheds.

4. ASSESSMENTS

Many assessments are executed in response to the requirements of the regional and international agreements and conventions adopted by countries in the Wider Caribbean Region. Some have also been done to guide the development of policy in areas such as regional agreements. In the AoA for the Wider Caribbean Region, 16 assessments were reviewed. These included only the most prominent assessments which have been conducted at regional and sub-regional levels. Although the list is by no means exhaustive, it provides an indication of the diversity of assessments which have been conducted (see the section on Data for a non-exhaustive list on assessment work in the region). Topics include pelagic fisheries, coral reefs and associated coastal ecosystems, marine pollution and watershed management, ecotourism, climate change and endangered species in the areas of exploitation, trade and management.

Although these assessments do include considerable information, there are numerous gaps remaining at all levels. Furthermore, the economic, social, linguistic and cultural diversity in the Wider Caribbean Region makes it difficult to transfer lessons learned from one place to another within the Wider Caribbean Region without considerable adaptation.

4.1 Thematic/sectoral assessments

Many assessments focused directly on specific resources and sectors. Examples of those focused on fisheries include:

a. The FAO/UNDP exploratory fishing (1969–1973), the Eastern Caribbean Flyingfish Project (Oxenford and other 1993);
b. The Lesser Antilles Pelagic Ecosystem Project (FAO);
c. The FAO-CARICOM Large Pelagic Fisheries Project (Mahon and McConney 2004);
d. The Western Central Atlantic aspect of the FAO State of Fisheries and Aquaculture (SOFIA) reports;
e. The annual assessments of ICCAT (Singh-Renton 2007); and
f. The Significant Trade Review assessments of queen conch required by the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES).

Other assessments focus on coral reefs and related habitats, some from a strictly ecological perspective, such as the CARICOMP (UNESCO 1998), Reef Check, Status of Caribbean Coral Reefs after Bleaching and Hurricanes in 2005 and the Atlantic and Gulf Rapid Reef Assessment (AGRRA) programme. Others take a multidisciplinary approach, including the Reefs at Risk in the Caribbean conducted by WRI (Burke and Maidens 2004) and the Rapid Assessment of Anthropogenic Impacts on Selected Transboundary Watersheds of the Mesoamerican Barrier Reef Systems Region, which is a part of the GEF MBRS Project that carried out a wide range of assessments, planning and implementation activities for the Wider Caribbean Region. Still others focus narrowly on specific resources such as the Regional Management Plan for the West Indian Manatee, *Trichechus manatus* and Exploitation, Trade and Management of Caribbean Sea Turtles required by CITES and conducted by the wildlife trade monitoring network TRAFFIC. WIDECAST has been instrumental also in initiating a number of national assessments of sea turtles leading to National Sea Turtle Recovery Action Plans in sufficient numbers that they can be collectively considered a regional programme. Regional assessments such as the Atlas of Sea Turtle Nesting Habitat for the Wider Caribbean Region also have been carried out. The UNEP Caribbean Environmental Program Regional Coordinating Unit under the SPAW protocol, collaborates with WIDECAST and supports monitoring sites for endangered hawksbill sea turtles. Sectoral assessments include those for tourism, such as the Assessment of the Competitiveness of Ecotourism in the Wider Caribbean Region.

Assessment of primary productivity in areas such as coral reefs and mangroves is undertaken by CARICOMP, which has a number of monitoring stations in the Wider Caribbean Region. Coastal primary productivity and the occurrence of harmful algal blooms are monitored in some of the Wider Caribbean Region countries.

4.2 Integrated assessments

Some of the assessments reviewed were highly inter-disciplinary and broad, such as the Caribbean Sea Ecosystem Assessment (CARSEA) (Agard and others 2007), a sub-regional assessment of the Millennium Ecosystem Assessment and the Preliminary Transboundary Diagnostic Analysis (TDA) of the Caribbean Large Marine Ecosystem (CLME) Project (CLME Project Implementation Unit 2007). Others were narrower such as the assessment of Marine World Heritage Sites in the wider Caribbean: how research data on biological connectivity can document the "outstanding universal value" of new nominations.

Some integrative assessments not reviewed include the Biodiversity Conservation Assessment of the Insular Caribbean (Huggins and others 2007) of TNC and the Caribbean Census of Marine Life-Ocean Biogeographic Information System (CoML-OBIS) and the variety of assessments carried out by the Caribbean Programme for Adaptation to Climate Change (CPACC) and its follow-on activities under the Mainstreaming Adaptation to Climate Change (MACC) through the CARICOM Centre for Climate Change in Belize. A range of integrative assessments has also been carried out by the IOC-UNESCO/UNEP-Caribbean Environment Programme for Marine Pollution Assessment and Control (CEPPOL), which evolved into the current Assessment and Management of Environmental Pollution Sub-Programme (AMEP) at the UNEP RCU (UNEP/CEP 1999). The objectives of AMEP relate to the obligations of the LBS and Oil Spills Protocols, which include the need for ongoing and periodic assessments of the state of the environment.

5. PRIORITIZED ISSUES

As identified in the TDA of the CLME project, the three foremost priority issues within the Wider Caribbean Region are unsustainable exploitation of fish and other living resources, coastal habitat and community modification and pollution. The full-sized CLME project will address these issues with a focus on

living marine resource governance. These issues have been the focus of almost all of the assessments reviewed in the AoA for the Wider Caribbean Region.

High coastal populations, ease of access and the limited land area in many small islands have made fishing an important source of food and an opportunity for creating a livelihood. With the increased demand, advanced technology and the presence of legal and illegal foreign fishing fleets, many fish stocks have become severely overexploited. Some coastal resources, such as the queen conch (*Strombus gigas*), are endangered. The Wider Caribbean Region also has one of the highest dependencies on tourism in the world. Demand for coastal tourism development (coupled with increasing coastal populations and associated impacts) has led to the modification and destruction of many nearshore habitats and has amplified the effects of land-based pollution.

Climate change is now recognized as a severe threat to the Wider Caribbean Region. The recent Global Coral Reef Monitoring Network (GCRMN) report highlighted the devastating impact on Caribbean coral reefs of bleaching in 2005. There is a suggestion by some that climate change, global warming, ocean acidification and over fishing have surpassed land-based pollution as the primary threat to reefs (McClanahan and others 2007). Climate change also poses other threats to the Wider Caribbean Region through influences ranging from sea level rise to acidification of the ocean and should be an integral part of future assessments.

6. SUPRA-REGIONAL ISSUES

The Caribbean Sea lies adjacent to the second largest ocean and between the two American continents, making it extremely susceptible to extra-regional natural and anthropogenic pressures.

Due to the presence of high-value pelagic species such as tuna and marlin, many international fishing fleets cross the oceans to exploit the mid-Atlantic fishery as well as the fisheries resources in the Exclusive Economic Zones (EEZ) of Wider Caribbean Region countries. As well as the abundance of these migratory species being affected, Caribbean based fleets are unable to compete with the advanced technology and capacity of the foreign fleets. There is also the issue of the vulnerability of Wider Caribbean Region states to illegal, unreported and unregulated fishing, mainly because of inadequate enforcement capacities to monitor their EEZs and territorial seas.

Climate change poses an increasing threat. Coral reefs, which provide more than US$3 billion in direct and indirect revenue for the Caribbean, are

extremely vulnerable to rising sea temperatures (Hoegh-Guldberg and others 2008). Rising sea levels can be expected to have an impact on many coastal habitats and increasing desertification in Africa will lead to an increase in suspended particulate matter dispersing across the Atlantic which may carry pathogens that cause reef diseases such as Aspergillosis in sea fans.

The drainage basins of the Wider Caribbean Region cover 7.5 million km^2 and encompass eight major river systems, from the Mississippi in the north to the Orinoco in the south, with influence also from the Amazon River, which is responsible for the highest rate of water discharge in the world. As a result, the area from which land-based sources of pollution could arise is enormous, but the states within the Wider Caribbean Region have little influence over the management of these watersheds.

The high volume of maritime traffic, including through the Panama Canal, presents a significant potential risk of introducing alien invasive species or of shipping accidents and spills of oil and hazardous material. In addition, the proximity of an entirely different biogeographic region through the Panama Canal presents a high potential for the introduction of alien invasive species in ship ballast water, although to this point, most alien species have been introduced through the aquarium trade.

7. CAPACITY OF THE REGION TO UNDERTAKE ASSESSMENTS

Almost all of the countries within the Wider Caribbean Region are developing countries and many are SIDS. Therefore, capacity to undertake assessment of any type is often deficient at the national level. In addition, economic growth is usually given priority over the marine environment and environmental sustainability on the whole. Even though there is considerable capacity for marine assessment within the Wider Caribbean Region, it is highly centralized in a few major institutions in some of the most developed countries. At the regional level, a number of organizations have capacity for various types of assessments.

For future assessments or for a global marine assessment to be more effective, comprehensive and of greater use in policy development and decision making, there is the need to focus on building local capacity for assessment and monitoring. In some instances where technological requirements exceed those that a small country can be reasonably expected to have, the distribution of capacity and responsibility between national and regional levels will be a critical issue for effective monitoring. Likewise, increased attention on

low-technology, indicator-based monitoring of a suite of indicators should be a priority. Nevertheless, wherever feasible and sustainable, national agencies in the Wider Caribbean Region should be equipped with the capacity for long-term monitoring of environmental indicators such as coral health, fish landings and nutrient loads, all of which have local implications and require a local response. They also need to possess the means for social and economic assessments in order to be best able to implement measures which are agreed to at the regional level, especially with regard to shared resources.

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