



CHAPTER 5

COASTAL AND MARINE ENVIRONMENTS

Lead Authors: Russell Arthurton, Kwame Korateng

Contributing Authors: Ticky Forbes, Maria Snoussi, Johnson Kitheka, Jan Robinson, Nirmal Shah, Susan Taljaard, Pedro Monteiro

REGIONAL SYNTHESIS

As coastal populations in Africa continue to grow, and pressures on the environment from land-based and marine human activities increase, coastal and marine living resources and their habitats are being lost or damaged in ways that are diminishing biodiversity and thus decreasing livelihood opportunities and aggravating poverty. Degradation has become increasingly acute within the last 50 years (Crossland and others 2005). Arresting further losses of coastal and marine resources, and building on opportunities to manage the resources that remain in a sustainable way, are urgent objectives.

The main causes of this degradation, apart from natural disasters, are poverty and the pressures of economic development at local to global scales. Economic gains, many bringing only short-term benefits, are being made at the expense of the integrity of ecosystems and the vulnerable communities that they support. The overexploitation of offshore fisheries impacts on the food security of coastal populations. Another key concern is the modification of river flows to the coast by damming and irrigation, and pollution from land, marine and atmospheric sources (Crossland and others 2005).

Africa's coastal and marine areas also have important non-living resources. There are offshore commercial oil and natural gas reserves in some 20 countries and many of these are being developed to supply the global energy market as well as domestic needs (EIA 2005). Many countries in Western Africa, for example, are oil producers, with Cameroon, Gabon and Nigeria being net exporters. Alluvial diamond- and heavy mineral-bearing sands have long been worked from the coastal sediments of Southern Africa. Exploitation of these non-living resources has damaged

the coastal environment and, in the case of oil production in the Niger delta, caused civil conflict.

Africa's coastal environment is becoming an increasingly attractive destination for global tourism. In some countries, especially the small island developing states (SIDS), tourism, and its related services, is a main contributor to national economies (WTTC 2005).

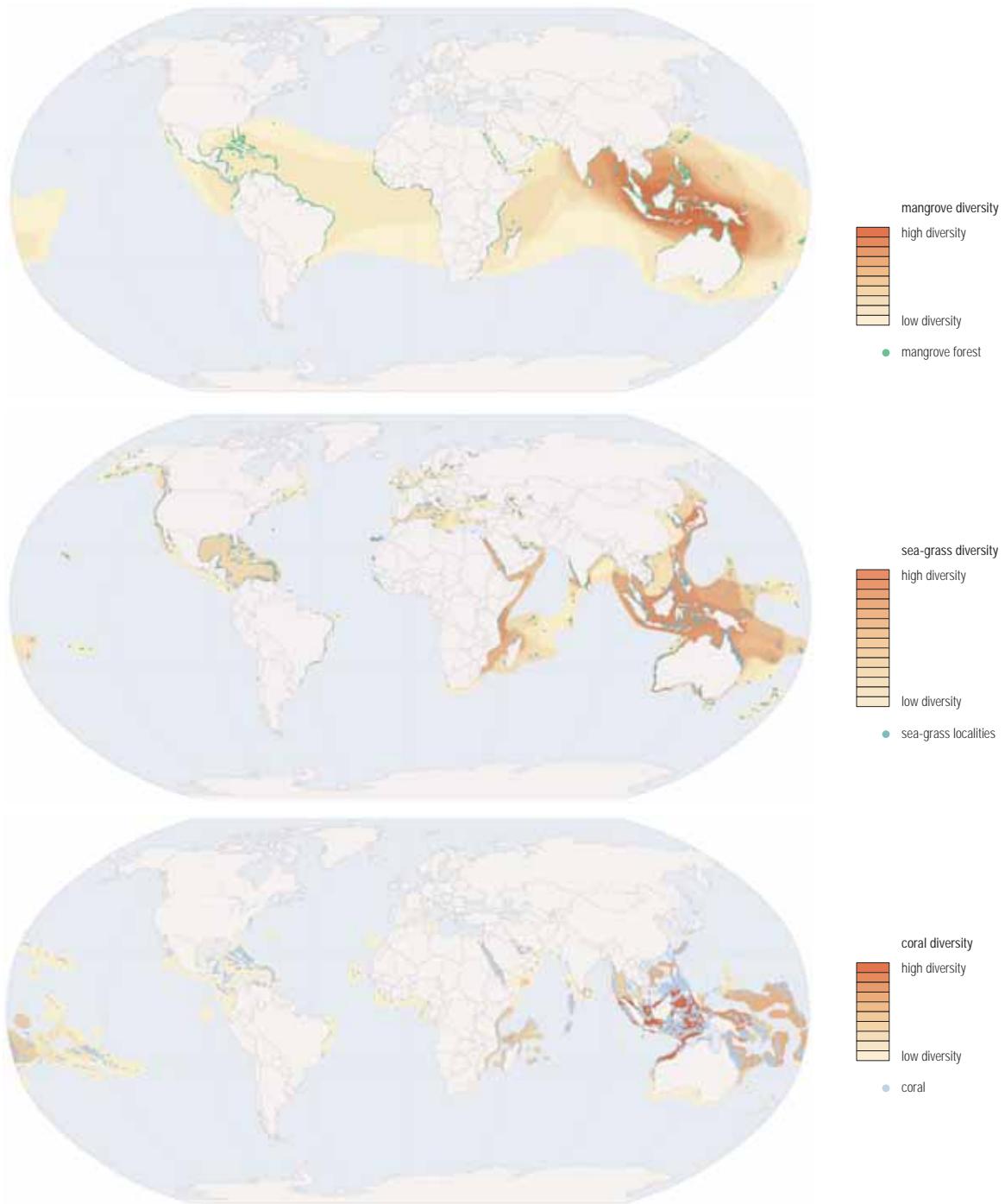
Most countries recognize the value of their coastal and marine biodiversity and have gazetted marine and wetland protected areas to ensure their sustainability (UNEP-WCMC 2000). The protection and restoration of Africa's coastal and marine ecosystems and their services are long-term objectives for local to global communities. These objectives must be achieved in the face of the pressures from land-use change, including urbanization, and climate change, including the rising sea level, coastal erosion and lowland flooding (IPCC 2001). This demands policy approaches that are multisectoral and occur at multiple levels; such approaches are discussed in Chapter 8: *Interlinkages: The Environment and Policy Web*.

OVERVIEW OF RESOURCES

Africa's mainland and island states have rich and varied coastal and marine resources, both living and non-living. The coasts range from deserts to fertile plains to rain forest, from coral reefs to lagoons, and from high-relief, rocky shores to deeply indented estuaries and deltas. Their marine environments include the open Atlantic and Indian oceans and the almost landlocked Mediterranean and Red seas. Continental shelves, where waters are less than 200 m deep, in some places extend more than 200 km offshore, while elsewhere they are almost absent.

The biodiversity of the coastal zone is an important resource and there are many designated protected areas, both wetland and marine. The coral reefs, sea-

Figure 1: Global distribution of mangrove, sea-grass and coral diversity



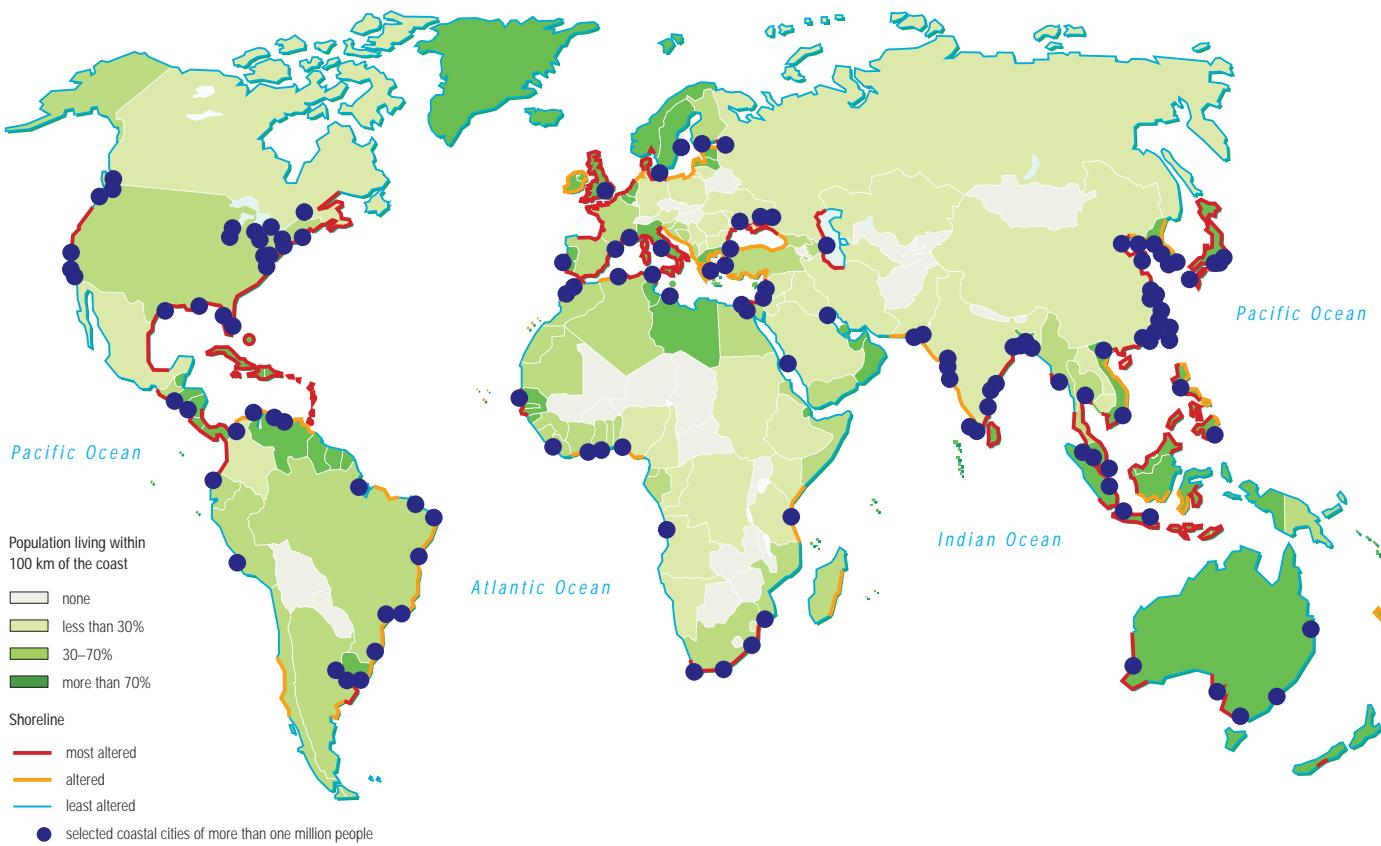
Source: Groombridge and Jenkins 2002; Maps prepared by UNEP WCMC

grass beds, sand dunes, estuaries, mangrove forests and other wetlands that occur around many shores provide valuable services for humanity, as well as crucial nursery habitats for marine animals and sanctuaries for endangered species. The coral reefs, sea-grass beds, sand dunes, estuaries, mangrove forests and other wetlands that occur around many shores provide valuable services for humanity, as well as crucial nursery habitats for marine animals and sanctuaries for endangered species (Figure 1). LMEs are relatively large

regions, in the order of 200 000 km² or greater, characterized by distinct bathymetry, hydrography, productivity, and trophically dependent populations (Sherman and Alexander 1986). Many of these LMEs are characterized by seasonal or permanent coastal upwellings of cold, nutrient-rich oceanic water (where water is forced upwards from the ocean depths to the surface) supporting important fisheries.

During the last decade or so, substantial oil and natural gas resources have been discovered offshore,

Figure 2: Coastal populations and shoreline degradation



Source: UNEP 2002c; data from Burke and others 2001, and Harrison and Pearce 2001

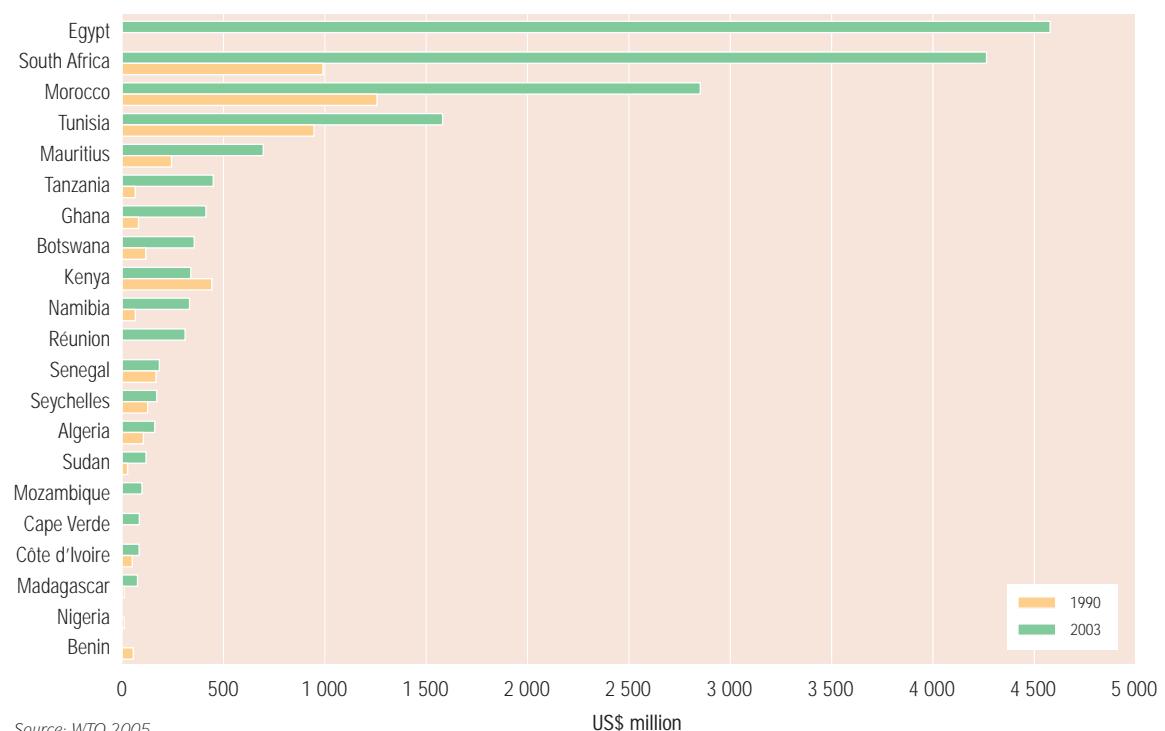
some of them in deep or ultra-deep water on the continental slope, as in Western Africa (EIA 2005) (Figure 2). Many offshore areas remain unexplored. The largest of the new oil reserves are those off the Niger delta, itself a globally important, established production area. Other major oil reserves have been discovered and are being developed within the Exclusive Economic Zones (EEZs) of Cameroon, Equatorial Guinea and Angola. Many oil reserves are associated with natural gas. Large reserves of non-associated gas have been discovered offshore around the Gulf of Guinea – notably in Nigeria – and off Namibia and South Africa; also in the Mediterranean in the Gulf of Gabès and off the Nile delta. Natural gas is in production off the Tanzanian mainland.

Many of the coastal sediments of Southern and Eastern Africa yield mineral resources. The coastal sand dunes and seabed sediments along the Atlantic shores of South Africa and Namibia contain commercially valuable alluvial diamonds, while coastal sediments on South Africa's Indian Ocean shores and in Mozambique contain commercial titanium and zirconium minerals. Coastal sands in Kenya are also a source of titanium.

ENDOWMENTS AND OPPORTUNITIES

Africa's marine and coastal resources have traditionally supported livelihoods through subsistence fisheries, agriculture and trading. Nowadays, the coastal areas are the locus of rapid urban and industrial growth, oil and gas development, industrial-scale fisheries and tourism (Figure 2). While there is a general trend of population increase in the coastal areas, the coastal cities are the principal growth nodes. It has been estimated that by 2025 the coastal zone from Accra to the Niger delta could be an unbroken chain of cities, with a total population of 50 million along 500 km of coastline (Hatzios and others 1996, Figure 2). Much of the region's heavy industry, including most refineries and gas liquefaction plants, is sited at coastal locations, along with terminal facilities for tankers and undersea pipelines, and bases for offshore engineering services.

The natural coastal assets have supported a growth in tourism, with substantial economic benefits including the creation of many jobs for men and women. Tourism has become a big employer and source of income, notably in Morocco, Tunisia, Egypt, Mauritius and South Africa (Figure 3). Many countries are set to further develop their coastal tourism, with an increasing market for eco- and

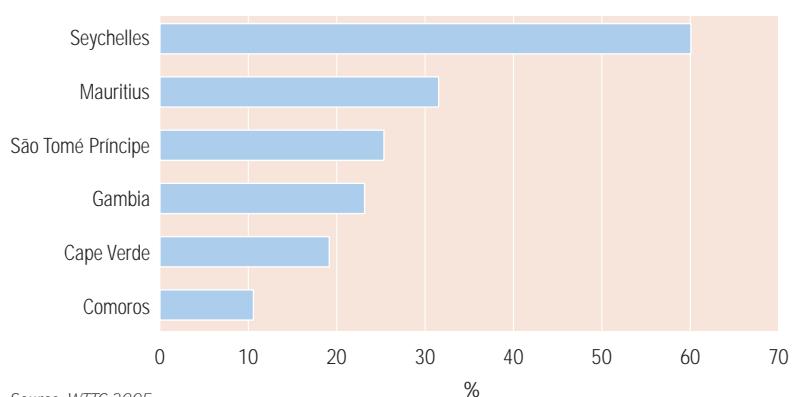
Figure 3: International tourism receipts in African coastal countries, 1990 and 2003

cultural tourism. Tourism revenues were expected to grow by 5 to 10 per cent in 2005, and annually, in real terms, by about 5 per cent between 2006 and 2015 (WTTC 2005). Much of this growth is likely to be coastal. Coral reefs are a major ecotourism attraction. There are opportunities for involving indigenous coastal communities in ecotourism, improving their well-being as well as contributing to national economies. In some countries – particularly some SIDS – tourism with its related services is already the largest employer and the tourism economy makes the largest contribution to Gross National Product (GNP) (Figure 4).

Artisanal fisheries are the mainstay of coastal communities' livelihoods around much of Africa's

coastline, employing mostly men operating in small, undocked boats. Some countries, such as Morocco, Egypt, South Africa, Ghana and Senegal, have offshore industrial fishing fleets which employ mostly men, while men and women are engaged in the preparation of fish products onshore, as in the tuna canneries of Ghana, Seychelles and Mauritius. Intertidal harvesting for shellfish or maricultured seaweed, as in Tanzania, is carried out by women.

The extent to which coastal communities, and their countries, benefit from fisheries resources varies greatly, as shown in Figure 5. The resources are exploited by industrial as well as artisanal fleets, the former comprising local and foreign-flag vessels. Where the artisanal sector is strong, as on the Atlantic coast, all vessels operate in about the same areas, targeting similar species, and this often leads to conflict between artisanal and industrial fleets. Cases of poaching and illegal, unregulated and unreported (IUU) fishing by vessels from outside the region are common, the latter jeopardizing the catches of local, small-scale fishers with serious consequences for food security and income. Increases in industrial-scale fishing over the last decade or so have impacted adversely on artisanal fisheries, already stressed through population pressure by overharvesting and the use of unsustainable fishing methods. Generally, artisanal fisheries are showing decreasing returns per fishing effort and reductions in the sizes of fish caught.

Figure 4: Travel and tourism economies as percentages of Gross Domestic Product 2005 for selected SIDS and Gambia

Chapter 5 • Coastal and Marine Environments

Countries whose EEZs extend into the areas of oceanic upwelling in the Atlantic LMEs tend to be major, industrial producers of marine fish, much of it taken by foreign fleets under access agreements. In Eastern Africa, Somalia could benefit from the rich fisheries of the Somali Current upwelling, but much of its production is captured illegally (Coffen-Smout 1988). In the Western Indian Ocean, fisheries contribute significantly to all national economies, with stocks including tuna exploited under licence by foreign fleets. Fish processing and transhipment provides additional employment and revenue (UNEP 2004). In Mozambique and Tanzania, estuarine prawn fisheries make an important economic contribution (UNEP 2001). In the Mediterranean, where foreign industrial fleets are becoming prevalent, there may still be some scope for increased production, but at the expense of the size of fish caught (Alm 2002). Total reported marine fish capture continues to increase, with nearly 5 million t recorded in 2003 (Figure 5, FAO 2005). In the last three decades, imports of fish and fishery products by African countries exceeded the exports of the same in quantity, although the gap is gradually decreasing. Conversely, export values were far in excess of import values. This is because many African countries import large quantities of low-grade species, like mackerel and sardinellas, and export high-grade species like shrimps and snappers, and other demersal species.

Aquaculture makes important contributions to the livelihoods of coastal dwellers in Egypt, particularly fish from the brackish water lagoons of the Nile delta. In Zanzibar, Tanzania, seaweed farming has become



Essaouira is a bustling coastal city in Morocco supporting the film industry, the arts, tourism and thriving fisheries. Here, a view of Essaouira through an old city gate.

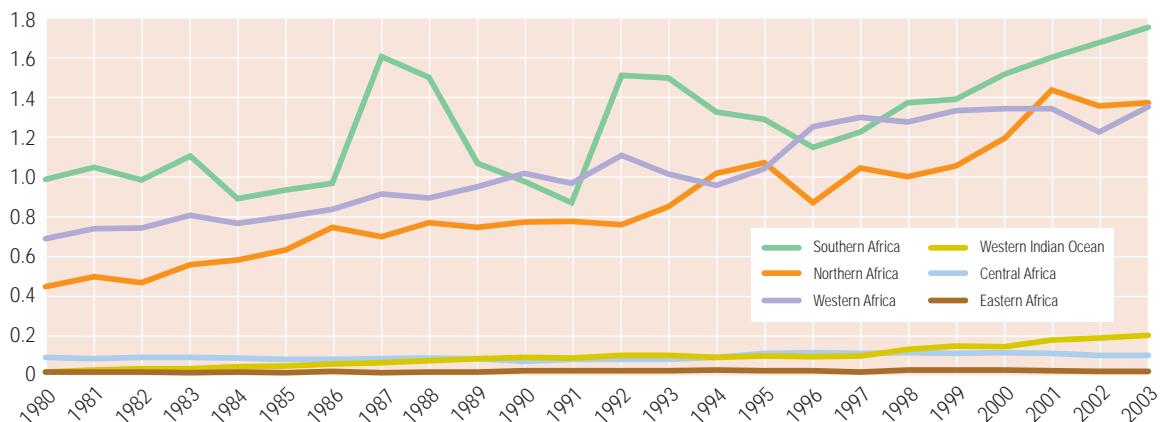
Source: J.C. Mohamed-Katerere

important, improving livelihoods particularly of women. Few countries have seized the opportunities of aquaculture, although considerable potential exists across the region (MA 2005). For sub-Saharan Africa (SSA), it is estimated that less than 5 per cent of the potential has been utilized, contributing less than 0.2 per cent to world aquaculture production.

In addition to fishery resources, coastal and marine ecosystems provide important services. Coral reefs and their associated sea-grass meadows and mangrove forests,

Figure 5: Reported marine fish capture in African sub-regions since 1980

million metric tonnes



Fishery production relates to catch of aquatic organisms, taken for commercial, industrial, recreational and subsistence purposes from inland, brackish and marine waters. The harvest from mariculture, aquaculture and other kinds of fish farming is also included. Catches of fish, crustaceans and molluscs are expressed in live weight, that is the nominal weight of the aquatic organisms at the time of capture. To assign nationality to catches, the flag of the fishing vessel is used, unless the wording of chartering and joint operation contracts indicates otherwise.

Source: FAO Fisheries Department, Fishery Information, Data and Statistics Units

and other coastal wetlands, provide nursery areas and shelter for a host of animals, both marine and terrestrial, as well as protection against inundation and erosion by marine storm surges and extreme waves (Figure 1). Mangrove forests act as chemical cleansing buffers, absorbing land-sourced pollutants, and they also have cultural and medicinal values. Beaches and dune systems provide coast protection as well as sites for nesting and breeding.

Offshore oil and gas development is making substantial contributions to national economies, providing jobs for men, though many of these are short-term. With the engagement of industry and effective national governance, the benefits to coastal communities and the protection of coastal and marine ecosystems could be substantially improved. In many countries, hydrocarbon development is supplying growing domestic and transnational energy markets. The value of the resources to national economies is difficult to estimate because of the volatile nature of the global energy market and the nature of specific licensing arrangements. The sums involved are potentially huge. But these resources are finite and the income generated from their production cannot be sustainable over the long term. The alluvial mineral resources of Southern Africa are similarly finite, and these too make substantial economic contributions.

CHALLENGES FACED IN REALIZING OPPORTUNITIES FOR DEVELOPMENT

The capacity of most coastal nations to utilize their coastal and marine assets, while simultaneously protecting them from degradation, is lacking.

Although the success of coastal tourism is subject to local security issues as well as global economic pressures, its sustainability depends, above all, on the protection and beneficial management of those assets. The region's fisheries have scope for restoration and continuing to be major contributors to coastal livelihoods, and the national economy, but only if the pressures leading to overexploitation and pollution can be controlled. Oil and natural gas development and mineral extraction have a potential for increasing the general levels of economic security and human well-being in the short to medium term, but these resources are finite and there is a need to diversify into sustainable ventures.

The overexploitation of fisheries at artisanal and industrial scales using unsustainable fishing methods, and the introduction to coastal ecosystems of invasive alien species from marine sources, are further concerns. Coastal ecosystems, especially estuaries and lagoonal wetlands, are becoming increasingly impacted by activities within river catchment, with deforestation, intensive agriculture, damming and irrigation all changing the nature of material fluxes (water, sediment, nutrients and pesticides) (Arthurton and others 2002, Crossland and others 2005). At the global scale, human-induced atmospheric warming has been contributing to a slow but persistent eustatic sea-level rise and significant climatic changes in the region (IPCC 2001). In the last decade, episodes of unusually high sea temperatures have caused widespread mortality of reef coral.

A summary of the principal issues faced in realizing development opportunities is given in Table 1.



Fishermen preparing their nets, Cape Town, South Africa.

Source: A. Mohamed

Table 1: Issues, threats and constraints related to regional development opportunities and goals

Opportunities for development	Issues, threats and constraints related to development NEPAD issues in <i>italics</i>
Oil and gas production	<i>Resource sustainability</i> <i>Marine and coastal pollution, water- and airborne</i> <i>Coastal habitat loss</i> <i>Invasive species from tanker ballast waters</i>
Coastal mineral extraction	<i>Habitat loss through excavation, siltation, pan construction</i> <i>Restoration of industrial mining sites</i> <i>Coastal erosion from beach sand mining</i>
Urban, industrial and port development	<i>Urban sprawl and habitat loss through construction, siltation</i> <i>Solid waste, sewage discharge and industrial effluents; hazardous waste</i> <i>Pollution of coastal wetlands and seas</i> <i>Invasive species especially from shipping ballast waters</i> <i>Coastal erosion</i> <i>Inundation due to sea-level rise; extreme wave events</i>
Tourism growth	<i>Urban sprawl and habitat loss from construction and tourist pressures</i> <i>Solid waste and sewage discharge; chemical effluents</i> <i>Loss of amenity value</i> <i>Coral bleaching</i> <i>Coastal erosion, beach loss</i> <i>Sea-level rise; extreme wave events</i>
Marine fisheries growth and sustainability	<i>Overharvesting and use of destructive methods</i> <i>By-catch and endangered species</i> <i>Regulation and enforcement; illegal fishing</i> <i>Protection of nursery areas</i> <i>Land-sourced pollution of coastal waters</i> <i>Reduced freshwater discharge from rivers (prawn fisheries)</i>
Coastal aquaculture growth	<i>Wetland drainage and reclamation for agriculture and urban growth</i> <i>Habitat and biodiversity loss, especially from pond construction</i> <i>Urban, industrial and agricultural pollution; pollution from aquaculture</i> <i>Lack of freshwater input</i> <i>Institutional constraints</i> <i>Coastal erosion; sea-level rise</i>
Coastal agriculture sustainability	<i>Habitat and biodiversity loss</i> <i>Coastal siltation from increased run-off</i> <i>Reduced freshwater discharge from rivers through irrigation</i> <i>Reduced flooding and sedimentation through damming</i> <i>Salinization of groundwater</i> <i>Control of fertilizers and pesticides</i> <i>Impact of urban sprawl</i> <i>Coastal erosion; sea-level rise</i>

Empowerment and capacity

The will and capacity of countries to manage their coastal and marine resources in ways that promote human well-being, for present populations and for future generations, are important issues. Effective governance at community to global levels is a prerequisite for environmental stewardship, while the development and maintenance of

that stewardship depends on a sustained commitment to human and technical capacity-building. Such capacity-building encompasses scientific data collection and monitoring, the construction of appropriate legal frameworks, and improving capabilities in surveillance and the enforcement of legislation. Capacity-building in monitoring and enforcement at community level offers

Table 2: Priority areas for promoting best practice in governance and management

Priority areas	Means
Fisheries: regulation and practice	Laws, licensing, surveillance, health and safety, education and training
Coastal and marine conservation (including Marine Protected Areas (MPAs) and wetlands programme, public awareness	Management, community benefits
ICZM	Establish and improve planning and management institutions (especially urban, industrial and tourism-related)
Waste management and pollution control	Improve local waste services, sewage systems, industrial and agricultural effluent control; international action on marine waste, litter and illegal dumping; oil spill management; protection against invasive species
Coastal protection	Vulnerability assessment, adaptive land-use planning, shoreline maintenance; participatory 'Blue Flag' schemes
Inter-sector cooperation	Consultation and engagement between stakeholders, locally, at the catchment scale, nationally and internationally
Information systems, monitoring, R & D	Ground-truthing and remote sensing techniques, standards for monitoring, establishing performance indicators, improving evidence base including community reporting, costing
Human and operational capacity	Develop professional, technical and managerial resources; equipment and physical infrastructure investment and maintenance

Sources: Alm 2002, Francis and Torell 2004, Hatzios and others 1996, UNEP and EEA 1999, UNEP 2002a, UNEP 2004

important opportunities. Community-based or participatory monitoring has been very effective in increasing the manpower available for monitoring (thus cost-effective) and at the same time enhancing environmental awareness and ownership among community members. This has been effective in mangrove and coral reef monitoring in Tanzania (Wagner 2004).

In order to develop and maintain environmental stewardship, there must be sustained commitment to finance, human and operational capacity-building, as well as to the promotion of public awareness. Capacity-building should include the development of appropriate institutions and legal frameworks, scientific data collection and monitoring, and capabilities in surveillance, as well as the monitoring and enforcement of legislation. There is a clear need for the development of professional, technical and managerial staff in each of the priority areas and activities identified in Table 2.

Collaboration and cooperation

Most coastal countries are signatories to one or more multilateral environmental agreement (MEA) that deals with marine and coastal management issues. These MEAs include the Barcelona Convention, the Jeddah Convention, the Nairobi Convention and the

Abidjan Convention, as well as the International Convention for the Prevention of Pollution from Ships (MARPOL) relating to the control of pollution from ships, and the United Nations Convention on the Law of the Sea (UNCLOS). These conventions lay the foundations for coastal states to develop legislation and management plans relating to their coastal and marine environments, integrating the various sectoral policies and, increasingly, taking account of river catchment that discharge to those environments (UNEP/MAP/PAP 1999). Under Article 76 of UNCLOS, a state may submit proposals to extend its defined continental shelf beyond the 200-nautical mile limit of its EEZ for the purposes of mineral extraction and harvesting benthic organisms (UNEP/GRID-Arendal, 2004). Some countries have introduced legislation for coastal management.

Recognizing the transnational issues involved in an ecosystem-wide approach to catchment, coastal and marine resource management, national legislation and management plans should place a priority on the coordination of sector interests, with the involvement of all resource users. Policies should reflect the marked increase in environmental degradation over the last 50 years or so, as well as acknowledge the priorities for taking action.

Partnerships with global actors are increasingly important in addressing coastal and marine management issues. Initiatives for improving resource management and related capacity-building are in place through organizations such as the Intergovernmental Oceanographic Commission of UNESCO (IOC), the World Bank, The Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden (PERSCA), LOICZ (Land-Ocean Interactions in the Coastal Zone), WWF – the World Wide Fund For Nature (WWF), IUCN- the World Conservation Union (IUCN) and UNEP. These initiatives, along with many bilateral agreements, commonly have overlapping objectives and there would be merit in improved coordination and cooperation amongst the various organizations and donors.

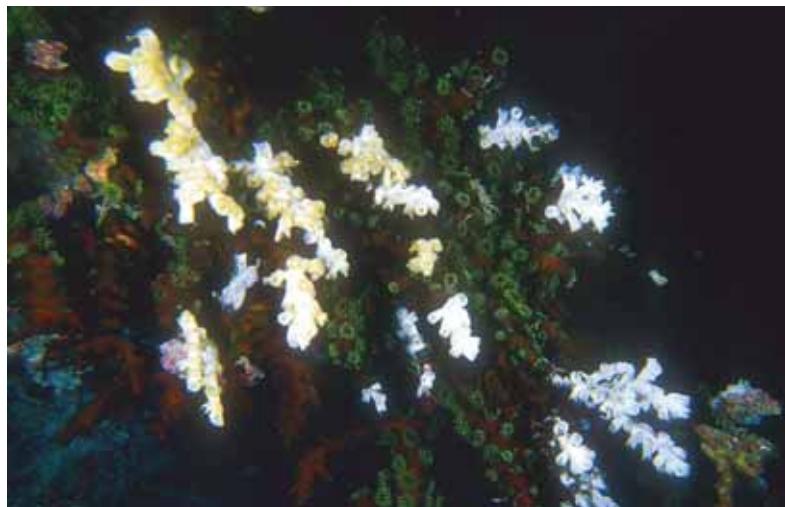
Destruction and pollution

Key issues in the management of the coastal zone and offshore waters include the loss of biodiversity and habitats through human-related pressures, the impacts of which have become increasingly acute within the last 50 years or so. Physical destruction and pollution of habitats from land-based and marine sources as a consequence of economic development is rife. For example, the clearance of mangroves for local consumption and export, as well as land clearance for agriculture and fuelwood leading to siltation, threaten marine life (UNEP 2004).

Competition for space is intense around developing cities, where urban sprawl is making inroads into coastal wetlands and disturbing them through land-filling, pollution and eutrophication. Elsewhere, agriculture is impinging on wetlands, with drainage schemes and pollution from fertilizers and pesticides. Mangrove forests, which provide an invaluable range of ecological services and products, including pollution filtering and coastal defence, are especially vulnerable to development pressure from overharvesting (eg for construction poles) and clearance for agriculture, prawn ponds and salt pans. They are also being stressed by reduced freshwater supply due to damming. Protected area status provides little assurance from the impacts of these competing economic activities. One challenge is how to deal with oil and gas exploration in or adjacent to marine protected areas (MPAs).

Unsustainable fisheries

Overexploitation of fisheries has two main drivers – at the artisanal scale, poverty and population growth (including the inward migration of fishers) amongst coastal communities (an added difficulty is that many fishers will



Bleached coral caused by ocean warming, Maldives.

Source: P. Kobeh/Still Pictures

not easily accept alternative means of livelihood) and, at the industrial scale, commercial incentives and subsidies available to foreign fleets operating under licence, or in some cases illegally, in EEZs.

Economic and social benefits accruing to western coastal countries, in particular those arising from access agreements with distant water fleets, have generally not been realized (though the case of Namibia is an exception) and few coastal people benefit directly from access fees in terms of direct or indirect employment or in improved standards of living (Alder and Sumaila 2004). There will be serious consequences for rural coastal populations if the degradation of fisheries, through overharvesting (inshore and offshore) and the use of damaging methods, continues unchecked. Fishing access agreements in the coastal states are signed by various ministries, each with their own development agenda and no common goal. Although the extent of stocks may be poorly known, countries continue to sign agreements with foreign fleets who may take advantage of the lack of surveillance and fish beyond their agreed quotas (Alder and Sumaila 2004).

The fish stocks in most of the LMEs around Africa, as in the rest of the world's oceans, are overexploited (Pauly and others 2002), and where catch tonnages are increasing, as in the Mediterranean, there are reductions in the sizes of fish caught (Alm 2002). The resulting by-catch (non-target species) also poses a threat to biodiversity. Effective enforcement of regulations concerning fishing methods, such as the minimum allowable net mesh sizes, is needed if stocks are to attain maturity. Without the recognition by the international community of the precarious state of most

of the offshore fisheries, there is a real danger that stocks will collapse. There is an urgent need for international agreement on fisheries regulation, as well as for financial support for monitoring, control and surveillance, and for enforcement of regulation. Most countries do not yet have the management and operational capacity to fully develop their EEZs to their own long-term economic advantage, although those of the Western Indian Ocean have recently come together (with the help of WWF) to set up minimum terms and conditions for fishing access. With this capacity in place, there should be opportunities to restore the fisheries resources to a sustainable level. There is also a great need for capacity-building in the area of negotiations.

Data collection and the development of inventories remain a challenge. In the region as a whole, the quality of reported statistics for fisheries, especially for fish catches, numbers of fishers and fishing boats, is varied and in some cases unreliable.

Tourism

Coastal tourism development has the potential for long-term benefits to coastal communities and national economies, but it also raises important issues of sustainability. For sites of mass tourism, the construction of hotels and transport infrastructure involves habitat loss, while the pressures of tourist numbers – through physical disturbance, high demand

for freshwater, pollution and eutrophication – impact adversely on the living resources, especially those of coral reef ecosystems. The short-term aspirations of developers must be appraised in the longer-term contexts of the sustainability of the amenity that has attracted those developers in the first place and of the implications of climate change. In particular, tourism development should aim to avoid the sidelining and alienation of indigenous communities by involving them in ecotourism.

Coastal accretion and erosion

Much of Africa's coastal zone is vulnerable to physical shoreline change, in some places from accretion, but mostly from erosion. Most of the change is due to, or exacerbated by, human activities. Locally, it is caused by coastal engineering, such as port development interrupting the longshore transport of protective beach sediment. More widely, it is due to the retention (by damming) of river-borne sediments formerly discharged at the coast (WCD 2000, Crossland and others 2005), as in the case of the Nile delta. Short of dismantling existing dams, there is little that can be done in mitigation other than installing expensive coastal defences. Coastal erosion and the progressive flooding of coastal lowlands are likely to increase, largely as a consequence of the rise in sea level produced by global warming (IPCC 2001). Apart from catastrophic temporary inundations caused by tsunamis or climate-driven marine surges, physical shoreline change is usually a slow process, and the most cost-effective solutions for threatened communities will be those involving adaptation by planned relocation. The long-term impact of sea-temperature rise (resulting from climate change) on the integrity of the region's coral reefs is likely to be profound (Lindeboom 2002).

Incentives and empowerment for coastal communities to sustainably manage and develop the resources upon which they depend should be considered at the national level. Payments for the use of ecosystem services by developers and harvesters of all sorts may provide a pathway for this. The valuation of ecological services is not simple, but global knowledge in this field is fast developing. "Cap and trade" schemes, similar to those being applied to the production of gases such as carbon dioxide, can be applied to fisheries, for example, with quotas being tradable between countries or smaller stakeholders. With or without such incentives, the promotion of public awareness is important if Africa and its coastal communities are going to benefit from their coastal and marine resources over the long term.



Coastal tourism threatens coral reefs and coastal ecosystems

Tourism development at Hurghada on Egypt's Red Sea coast.

Source: Google Earth



Two children playing in the sea, Cameroon. Offshore is a big tanker.

Source: A. Buck/Still Pictures

SUB-REGIONAL OVERVIEWS

CENTRAL AFRICA

The principal concerns are the loss and degradation of coastal habitats and the modification of marine ecosystems due to pollution from land-based urban and industrial sources (including oil and natural gas development) and from the overharvesting of marine fish stocks. Pressures from continuing population growth, notably in the coastal cities, such as Douala in Cameroon and Libreville in Gabon, are having increasing impacts on the coastal environment. These impacts may be exacerbated by global climate change and sea-level rise, particularly with regard to coastal erosion – already a serious problem locally – and the inundation of low-lying coasts such as those of Cameroon and Gabon (IPCC 2001, UNEP 2002a).

OVERVIEW OF RESOURCES

Except for Chad and the Central African Republic, all the countries of Central Africa – Cameroon, Congo, the Democratic Republic of the Congo, Gabon, Equatorial Guinea and São Tomé and Príncipe – border the Atlantic Ocean. The mainland shores are mostly low-lying, with estuaries and mangrove swamps, especially in Cameroon and Gabon, and lagoons protected by sandy beaches. Rivers, including the Kouilou, Ogooué, Sanaga and, notably, the Congo, drain a hinterland of rainforest. The EEZs of these countries form part of the Guinea Current LME (NOAA 2003a) and have substantial fisheries resources. Total marine fish production in 2001 for all Central African countries was 113 000 t, with Cameroon

being the main producer (Figure 8, FAO 2005). Abundant oil and natural gas resources occur offshore, notably off Cameroon and Equatorial Guinea.

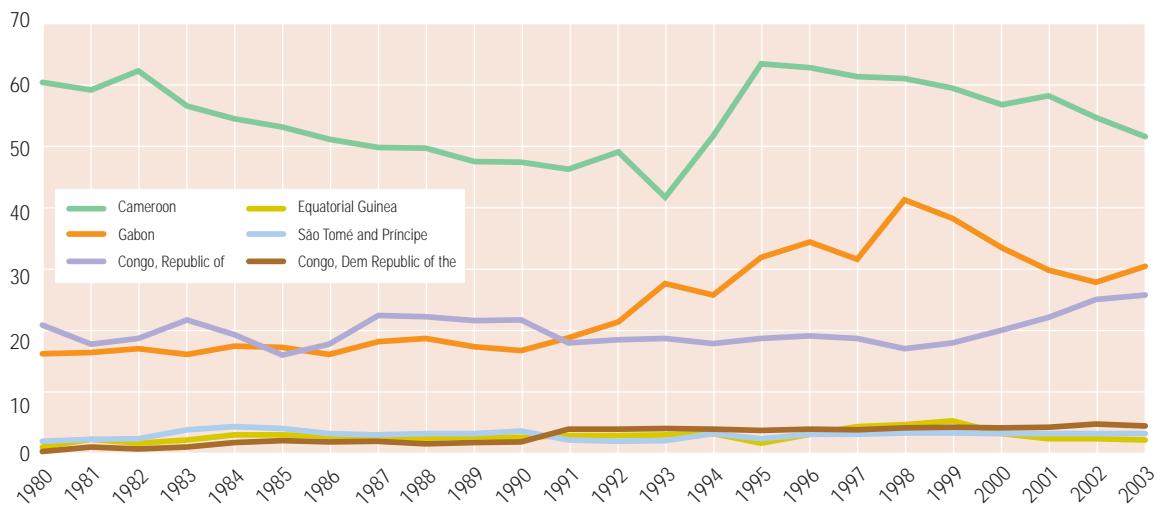
The Guinea Current LME is characterized by its tropical climate. It is considered to be highly productive, with climate being the primary driving force and intensive fishing the secondary force. The living marine resources include commercially valuable fish which are exploited at artisanal and industrial scales. The major pelagic species on the Gabon shelf is the sardinella. The demersal communities include croakers and the threadfin in nearshore waters, and sea bream and driftfish in deeper waters (NOAA 2003a).

Estuaries and coastal lagoons make a major contribution to fish diversity. Mangrove forests are extensive on the sheltered coasts of Cameroon (3 060 km²) and Gabon (2 500 km²) (UNEP-WCMC 2000, Figure 1). While some coral species are recorded, there are no coral reefs. Gabon has a number of coastal protected areas, including three sites protected under the Ramsar Convention on Wetlands (Ramsar) with rare and endangered mammals and birds.

The coastal areas of Central Africa have substantial hydrocarbon resources (EIA 2005). Gabon, Equatorial Guinea and Cameroon are all significant producers and exporters of crude oil. Much of the production now comes from offshore wells. In Equatorial Guinea, production has increased from 17 000 barrels per day (bbl/d) in 1996 to an average of 350 000 bbl/d for the first half of 2004 (EIA 2005). The Democratic Republic of the Congo is now a minor producer from a well on its continental shelf. While there is concern

Figure 6: Reported marine fish catches in Central African countries since 1950

thousand metric tonnes



Fishery production relates to catch of aquatic organisms, taken for commercial, industrial, recreational and subsistence purposes from inland, brackish and marine waters. The harvest from mariculture, aquaculture and other kinds of fish farming is also included. Catches of fish, crustaceans and molluscs are expressed in live weight, that is the nominal weight of the aquatic organisms at the time of capture. To assign nationality to catches, the flag of the fishing vessel is used, unless the wording of chartering and joint operation contracts indicates otherwise.

Source: FAO Fisheries Department, Fishery Information, Data and Statistics Units

over the longevity of the reserves in Gabon, a country almost wholly dependent on oil revenues to fund its economy, Cameroon and Equatorial Guinea are thought to have major reserves. Equatorial Guinea also has huge natural gas reserves, located off Bioko Island. Natural gas and condensate production in Equatorial Guinea has expanded rapidly in the last five years. Alba, the country's largest natural gas field, contains 1.3×10^{12} cubic feet of discovered reserves, with probable reserves estimated to be at least at 4.4×10^{12} cubic feet.

ENDOWMENTS AND OPPORTUNITIES

Hydrocarbon resources are making an increasingly strong contribution to the economies of Central African countries (EIA 2005) and have been a key factor in improved economic growth, as discussed in Chapter 1: *The Human Dimension*. Over the last decade or so, the focus of exploration has shifted from onshore to the coastal waters, where there are now many successful production ventures. The offshore Joint Development Zone, shared by São Tomé and neighbouring Nigeria, is reported to hold reserves of 11 000 million barrels and could potentially yield up to 3 million bbl/d when fully operational (EIA 2005). If successful, this development could have an immense impact on the economy of this otherwise impoverished SIDS. Hydrocarbon resources development and production present considerable local employment opportunities.

The natural beauty, biodiversity and socio-cultural aspects of the coastal areas provide strong potential for fishery and tourism, and in particular ecotourism. Total marine fish production in 2001 for all Central African countries was 113 000 t, with Cameroon being the main producer (Figure 6, FAO 2005). However, the LME shows evidence of ecosystem stress and there are major fluctuations of commercially valuable species (NOAA 2003a).

CHALLENGES FACED IN REALIZING DEVELOPMENT

Marine pollution and coastal erosion continue to disturb and destroy habitats, disrupt ecosystem functioning, cause loss of biodiversity, and affect human health and well-being. The main pollution problems are the discharge of industrial effluents and sewage, solid waste including marine-transported debris, and beach pollution. Coastal erosion has a serious impact on the low-lying coasts. Contributing causes include mangrove clearance and the reduction in sediment discharge through the damming of rivers draining the hinterland. Further entrapment of sediment in the Sanaga River basin, where Cameroon is set to construct another dam, may exacerbate erosion. Erosion can be expected to increase with sea-level rise associated with global climate change (IPCC 2001). In São Tomé, coastal erosion, exacerbated by beach sand mining (now largely banned), has been reported to be threatening infrastructure in the southern part of the main island (UNEP 1999).

Chapter 5 • Coastal and Marine Environments

The risk of offshore oil spills from wells, terminals and tankers is a serious threat (UNEP 1999, UNEP 2002a). These problems affect the islands of São Tomé and Príncipe as well as the mainland shores and their coastal waters. This risk of oil pollution comes not only from Central Africa's offshore development but also from the huge hydrocarbon developments off neighbouring Nigeria and, to a lesser extent, Angola. As well as water-borne oil pollution, air quality is affected by the flaring of natural gas associated with oil production.

Population growth and poverty are the major factors in coastal degradation. The coastal population continues to expand, in part by inward migration. Much of this expansion is in the coastal cities of Douala in Cameroon and Libreville in Gabon, accompanied by urban sprawl and the consequent loss of formerly rich habitats (Figure 2).

There is strong evidence of serious degradation in the Guinea Current coastal environment (NOAA 2003a). Primary productivity surveys in coastal waters have revealed an increasing occurrence of harmful algal blooms, indicating intense eutrophication and therefore excessive nutrient loading from anthropogenic sources. Agricultural run-off contributes to increased eutrophication in the estuaries and coastal environments. The restoration of lagoons, mangroves, estuaries, deltas and tidal wetlands will benefit local communities. Not only are these habitats rich in natural resources but they are also effective filters for pollution.

The overfishing and overexploitation of transboundary and migratory fish by industrialized foreign fleets is having a detrimental effect on artisanal fishermen, and in particular on coastal communities that depend on the nearshore fisheries resource for food (NOAA 2003a). This becomes particularly serious in a context of exploding demographics in the coastal areas.

EASTERN AFRICA

The main concerns are the loss of biodiversity, habitat degradation and the modification of mangrove and coral reef ecosystems. Human-related pressures come from overfishing and fishing-related damage, from urbanization and tourism development, from agriculture and industry, and from damming for hydropower. Other important concerns are the reported dumping of hazardous wastes on Somalia's shores and coastal waters (UNEP 2005a) and climate change, contributing to coral bleaching and sea-level rise, which in turn leads to coastal erosion and inundation of coastal lowlands. Another issue is the sporadic infestation of coral reefs by the invasive crown-of-thorns starfish (COTS). The shores facing the Indian Ocean were impacted by the catastrophic tsunami of

26 December 2004, and in Somalia, some 300 people are reported to have died (UNEP 2005a).

OVERVIEW OF RESOURCES

The sub-region's long coastline stretches from the Red Sea, which flanks Eritrea, through the Gulf of Aden, off Djibouti, to the Indian Ocean, off Somalia and Kenya. Most of the coastal zone is arid and, outside the few coastal cities, sparsely populated, except in Kenya where the coast has a monsoonal climate and supports a large and growing population.

Most countries have important marine fisheries resources, as well as the inshore and reef fisheries which are traditionally exploited by artisanal fishers. There are prolific fisheries associated with the upwelling of the Somali Current off the north-eastern coast of Somalia, and seasonally rich resources off Djibouti and Eritrea.

Coral reefs occur extensively, except where there is upwelling or sediment is discharged. Surveys of reefs in the late 1990s, here, and on the shores of the Gulf of Aden, reported reef health to be generally good, and the diversity of coral and reef-associated fauna to be globally significant, with a high level of endemism and species diversity (PERSGA/GEF 2003, Kotb and others 2004). Reefs occur as an interrupted barrier on Somalia's southern coast (UNEP-WCMC 2000), and in Kenya they fringe a cliff-bounded, intertidal platform extending over some 150 km of the Mombasa shore. Kenya's coral reefs suffered severe mortality in the 1998 bleaching event, but recovery of coral cover is now at 50–100 per cent levels (Obura and others 2004).



Coral reefs occur extensively along Africa's east coast

In southern Somalia coral reefs form a barrier along the coast.

Source: NASA 2001

Mangroves colonize some sheltered inlets on the Red Sea and in southern Somalia, and in Kenya exist as extensive, lush forests, in the Lamu district, and as linings to tidal creeks, further south; they have a total estimated area of 610 km² (Taylor and others 2003). The coral reefs, sea-grass beds and mangroves of the Somali Current LME (NOAA 2000) form a productive and diverse ecosystem of great ecological and socioeconomic importance; the mangroves also providing sanctuary to a wide variety of terrestrial fauna (UNEP/GPA and WIOMSA 2004). For the Red Sea, several MPAs have been declared or proposed – notably the Dahlak Archipelago marine park (2 000 km²) in Eritrea – but these are mostly lacking effective management plans and enforcement (Koth and others 2004). In Kenya, MPAs, such as the Watamu and Kisite marine national parks, are well established and generally well managed (IUCN and others 2004, Obura and others 2004). No effective protection exists on the Somali coast.

Oil and gas exploration is continuing along the Eritrean and Kenyan coasts (EIA 2005). The Pleistocene reef limestones provide raw materials for an established cement industry near Mombasa, and in Somalia similar limestones are quarried for aggregate and building stone. In a new coastal development venture in Kenya, mineral sands have been identified as a source of titanium ore.

The coastal zone has a rich archaeological and cultural heritage which includes the UNESCO World Heritage site of Lamu Old Town in Kenya, the oldest and best-preserved Swahili settlement in East Africa (UNESCO 2005). Other significant heritage sites in Kenya include Mombasa's Old Town and Fort Jesus. The Gedi ruins near Malindi, gazetted as a monument in 1927 and now a National Museum, mark an Islamic civilization city (National Museums of Kenya undated).

ENDOWMENTS AND OPPORTUNITIES

Inshore and reef-related fisheries have been a mainstay of the coastal populations and continue to be an essential resource for their livelihoods (FAO 2004b, FAO 2002a, PERSGA/GEF 2003, UNEP 1998). The Red Sea coasts of Eritrea and Djibouti support extensive reef-based artisanal fisheries; there are also productive offshore fisheries due to the seasonal upwelling in the Gulf of Aden.

Fisheries are dominated by foreign fleets, with production far outstripping that of artisanal fishers (FAO 2002a). Most commercial operations in the prolific fisheries of the Somali Current upwelling are carried out by foreign vessels, many of them illegally (UNEP 2002a). In Kenya, most fishing activity takes place along the reef, with mainly reef- and sea-grass-associated fish species being exploited; a few freezer trawlers fish for shrimp in the shallow waters of



Lamu – a UNESCO World Heritage site on the Kenyan coast, is a highly acclaimed tourist destination.

Chapter 5 • Coastal and Marine Environments

Ungwana Bay (FAO 2001a). Little is known of the potential of the offshore fisheries resource in southern Somali and Kenyan waters.

While artisanal and inshore fisheries are generally overharvested, some countries have not yet developed the capacity to fully exploit, or enforce regulation of, their offshore fisheries. But this is changing. Eritrea now places a high priority on the development of commercial fisheries (Kotb and others 2004), aiming to increase production three- to four-fold, up to between 50 000 and 60 000 t per year. Some 80 to 85 per cent of this production is expected to be generated by the foreign industrial fleet, especially trawlers, but the contribution from artisanal fisheries may also be increased (FAO 2002a). In Djibouti, pelagic and small tuna species are considered to be significantly underexploited (FAO 2004b). Djibouti is aiming for an annual maximum sustainable yield (MSY) of 5 000 t, compared with a 2001 level of 350 t.

In Kenya, coastal tourism is a major foreign exchange earner, with its beach and coral reef resources, coastal heritage sites and forest reserves being major assets. Coastal tourism is starting to develop in Djibouti and has shown a moderate growth in Eritrea (Kotb and others 2004). In Somalia, ecotourism offers promise, but promise that cannot be realized until stability and effective governance is re-established (Coffen-Smout 1998).

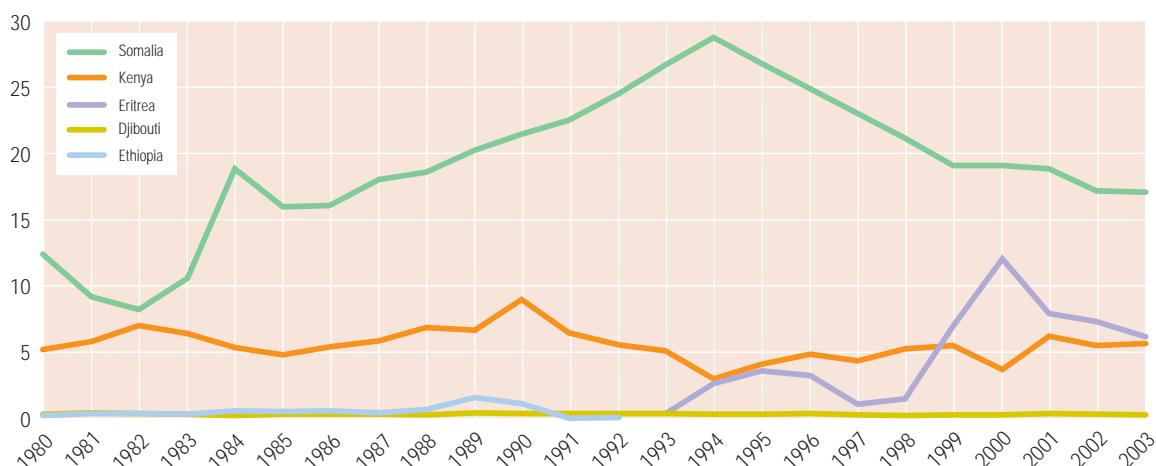
CHALLENGES FACED IN REALIZING DEVELOPMENT**OPPORTUNITIES**

Adopting transboundary approaches to manage marine and coastal resources is essential if their sustainability is to be ensured. The main transboundary cooperation is within the framework of the Nairobi (involving Kenya and Somalia) and Jeddah (involving Djibouti and Somalia) conventions. For the Red Sea and Gulf of Aden, PERSGA implements the Jeddah Convention. Priority actions have been identified in the Regional Action Plan coordinated by PERSGA in 2003. The Nairobi Convention is administered by UNEP. Land-based activities impacting the coastal and marine resources in Kenya are addressed through UNEP as part of the GEF-funded WIO-LaB project (WIO-LaB 2005).

The loss of biodiversity, degradation of habitats, and the modification of mangrove and coral reef ecosystems have widespread consequences. Direct human pressures on the coastal and marine environment come from increasing coastal populations, pollution and the growth of tourism. Indirect pressures come from the consequences of climate change – rising sea level and high sea temperatures leading to coral bleaching. Urbanization and industrial growth, and the development of mass tourism are contributing to the loss of habitats and the degradation of living resources. Tourism development tends to be poorly controlled and is contributing to reef deterioration, pollution, inappropriate construction of sea defences, and the loss of the natural tourism value

Figure 7: Reported marine fish catches in Eastern African countries since 1980

thousand metric tonnes



Fishery production relates to catch of aquatic organisms, taken for commercial, industrial, recreational and subsistence purposes from inland, brackish and marine waters. The harvest from mariculture, aquaculture and other kinds of fish farming is also included. Catches of fish, crustaceans and molluscs are expressed in live weight, that is the nominal weight of the aquatic organisms at the time of capture. To assign nationality to catches, the flag of the fishing vessel is used, unless the wording of chartering and joint operation contracts indicates otherwise.

Box 1: The socioeconomic context of small-scale marine fisheries in Kenya

Small-scale marine fisheries in Kenya are multispecies and use multigear. These are economically valuable, generating in excess of US\$3.2 million per year for local fishers, which would represent significantly more for the wider community if the income for traders was known. The small-scale fishers land at least 95 per cent of the marine catch. It is estimated that more than 60 000 coastal people depend on these fisheries. In some coastal communities, over 70 per cent of households depend on fisheries, but an estimated average for the coast as a whole is 45 per cent of households.

Although very few coastal households depend solely on fishing for their livelihood, many depend only on fisheries resources for income. Fishing and trading fish is one activity amongst a range of livelihood activities (both subsistence and income earning) carried out by coastal households. Fish is an important source of animal protein for coastal

communities, 70 per cent of fisheries-dependent households and 50 per cent of non-fisheries-dependent households eat fish more than once a week. Fisheries-dependent households in Kenya are poor: this is the perception of fishers and is confirmed by food security and quality of life indicators. The high levels of dependence reflect the paucity of alternative income earning options. This situation makes coastal communities highly vulnerable to mismanagement or loss of fisheries resources. The lack of effective management, by both formal and informal institutions, and the high dependence on these resources have been identified by fisheries stakeholders as important contributors to poverty in coastal communities. The prevalence of destructive fishing gear, primarily small meshed nets, coupled with growing numbers of fishers, are key management issues to tackle.

Source: UN 2005

(UNEP/GPA and WIOMSA 2004). Population increase and migration to coastal areas are putting resources under increasing pressure, and people are resorting to practices to cater for their needs which are increasingly environmentally damaging (Francis and Torell 2004). Other human-related pressures come from overfishing and fishing-related damage, from urbanization and tourism development, pollution from agriculture and industry and, in Kenya, the damming of rivers for hydropower. Another key issue is the reported use of Somali shores and coastal waters as dumping grounds for hazardous wastes (UNEP 2005a).

The principal threats to the continuing health of the coral reefs come from recurrences of bleaching events similar to that of 1998, overfishing and the use of destructive gear (Obura and others 2004). Another issue is the sporadic infestation of coral reefs by the invasive COTS. In the absence of efficient regulatory mechanisms and because it is an open access resource, marine fishery often provides a refuge of last resort for impoverished coastal dwellers (Ochiewo 2004) as shown in Box 1. In Kenya, there are indications that the degradation of reef fisheries and ecosystems has been checked or at least slowed down along those stretches of coast where MPAs have been established (FAO 2001a).

There is a lack of public and government awareness of the issues, poor enforcement of the legal framework relating to reef conservation and, in the case of Somalia, a lack of effective governance (Kotb and others 2004,

Obura and others 2004). Mangroves are also under threat. Increasing land-based pollution, decreasing freshwater discharge from rivers and overharvesting are having adverse effects on the health of mangroves – the nursery areas for many marine fish species. In Kenya, there has been overharvesting to meet an increased demand from tourism developments for construction timber, as well as mangrove clearance from the expansion of agriculture and solar salt pans (UNEP/GPA and WIOMSA 2004). Seepage of saline groundwater from the salt pans has killed neighbouring mangroves (Taylor and others 2003).

Damming on the Tana River in Kenya for hydropower (Box 2) has led to a reduction in the frequency and extent of seasonal flooding events, with negative impacts on agriculture and fisheries in the lower floodplains and coastal wetlands (IUCN 2003b, Crossland and others 2005) and on the prawn fishery in the adjoining Ungwana Bay. The introduction of short-term, high flow releases to simulate the natural flooding regime is under consideration in the design of the Mutonga-Grand Falls dam planned for the Upper Tana (Acreman 2005).

Physical shoreline change including coastal erosion is another common issue. It is caused by natural phenomena, such as the Indian Ocean tsunami of December 2004, as well as human pressures (Kairu and Nyandwi 2000, UNEP/GPA 2004, Crossland and others 2005, UNEP 2005a). Shoreline change impacts on

Box 2: Management of the downstream and coastal impacts of damming in the Tana basin, Kenya

Tana and Athi Rivers Development Authority (TARDA) plans to construct a high dam at Mutonga-Grand Falls, downstream of the existing Seven Forks dams. The dam will provide hydroelectricity as well as water storage for irrigation projects and urban/rural water supply schemes. The dam has the potential to exacerbate the changes in downstream flow caused by the present dams. Although the base flow is expected to increase by continuous release, the peak flood flows are expected to reduce considerably both in frequency and severity. Increased base flow is important for sustaining livelihood systems in the lower Tana basin during the dry seasons.

Reduced peak flows due to the existing damming have already impacted on the livelihoods of the riverine communities in the lower Tana basin, downstream of Garissa, who depend on seasonal flooding to cultivate the fertile floodplain soils, and on the maintenance of the rich biodiversity of the extensive delta, with its mangrove forests and productive fisheries. The coastal prawn fishery of Ungwana Bay has become stressed through reduced nutrient discharge from the delta distributaries and there is concern that the intrusion of saline waters into the delta will be enhanced. The delta front is formed of prominent sand dunes, the sand redistributed from the discharged river bedload by tidal and wave currents and wind. The expected reductions in peak flows are likely to further reduce the amount of sand discharged, aggravating the erosion already affecting the delta shore.

The need for integration of downstream values into hydropower planning in the Tana system has been highlighted in a case study (IUCN 2003b), based on research in the early 1990s into the economic valuation of the costs and benefits in the lower Tana resulting from dam construction (Emerton in Nippon Koei 1994). The resource value of the Tana's floodplain and its floods has been recognized by the dam's designers and developers (Acreman 2005). The dam is expected to



Mouth of the Tana River on Kenya's Indian Ocean coast.

Source: Altitude/Still Pictures

store enough water to produce short-term, high releases to simulate natural floods, as well as meeting the target for power generation. The possibility of releasing silt together with the floodwater is also being examined. Modelling studies have been undertaken in order to determine the optimum release required to maintain or improve the integrity of the riverine and coastal-marine ecosystems.

The determination of the optimum environmental flow is a challenging scientific assignment, requiring input from ecologists and socioeconomists as well as hydrologists. Integrated management of the Tana River system, taking into consideration the downstream and coastal impacts of damming, is a priority objective, so that development activities upstream are initiated with full awareness of the potential consequences for its floodplain and delta, and its adjoining coastal waters in Ungwana Bay.

Sources: Acreman 2005, Emerton in Nippon Koei 1994, IUCN 2003b

tourism infrastructure and on the attractiveness of the coastal environment upon which coastal tourism largely depends. The loss of beach sands and the erosion of low-lying beach plains, much favoured as sites for hotel development, are particular concerns in Kenya. In many instances, beach erosion has been exacerbated by the installation of inappropriate, hard-engineered sea defences. Beach sand erosion also endangers the nesting sites of the sea turtle, an endangered species. It is anticipated that coastal erosion will increase with sea-level rise associated with global climate change (IPCC 2001). Shoreline accretion can also be a problem. During the last 40 years or so, changes in the regime of sediment discharge from the Sabaki River have led to major siltation and beach progradation in the vicinity of

the resort town of Malindi (Kairu and Nyandwi 2000, UNEP/GPA 2004).

NORTHERN AFRICA

Loss of habitats and the modification of ecosystems, due primarily to the pressures of land-based and marine human activities, are the main environmental challenges. The pressures include urbanization and industrialization resulting in pollution and eutrophication, damming and irrigation leading to saline intrusion and coastal erosion, and the overexploitation of marine fisheries (Figure 2). There is concern over the potential impacts of climate change and associated, anticipated sea-level rise, particularly coastal erosion and the inundation of coastal lowlands.

OVERVIEW OF RESOURCES

The bordering seas – the Atlantic Ocean and the almost landlocked Mediterranean and Red seas connected by the Straits of Gibraltar and the Suez Canal – are endowed with biodiverse coastal and marine ecosystems, including wetlands on the Atlantic and Mediterranean coasts, coral reefs and mangroves around the Red Sea, and a wide variety of fisheries (Figure 1). The coastal climate is mostly semi-arid to arid and the few significant rivers, notably the Nile, are now dammed so that there is little freshwater and sediment discharge to the sea. Substantial oil and gas resources occur offshore, mainly in the Mediterranean and Red seas. The coasts have a wealth of cultural heritage sites.

The Mediterranean shores are mainly sandy and host a variety of turtles, as well as cetaceans and the monk seal. Their many protected areas include marine and coastal wetland national parks such as Kouf and Karabelli in Libya, and Ichkeul, a UNESCO World Heritage site in Tunisia, of importance for migratory birds. Another key ornithological site (with Ramsar status) is the intertidal wetland of Moulay Boussemham on Morocco's Atlantic coast. The biodiversity of the Red Sea coasts of Egypt and Sudan is globally significant. Corals occur extensively, primarily on mainland-fringing and barrier reefs, around islands and, in Sudan, on an atoll. Mangroves occur in sheltered mainland inlets. Besides hosting several varieties of sea-grass, these coasts are home to three turtle species, inshore

cetaceans and dugongs. Reef health in the late 1990s was considered generally good, and the coral diversity and reef-associated fauna amongst the highest in the Indian Ocean region (PERSGA/GEF 2003). Protected areas in the Red Sea include the marine national parks of Ras Mohammed on the Egyptian Sinai peninsula and the Sanganeb Atoll off the Sudan shore (Abdellatif 1993), where 124 coral species are recorded.

Morocco has a productive, nutrient-rich upwelling area off its Atlantic coast – part of the Canary Current LME. The Mediterranean Sea is considered to be a low productivity ecosystem with intensive fishing its primary driving force (NOAA 2003b). It is relatively poor in marine resources except around the Nile delta, where high nutrient outflows increase productivity (FAO 2003b). The reefs of the Red Sea provide some of the most productive coastal fisheries.

Offshore hydrocarbon resources are especially important (EIA 2005). Huge offshore gas reserves have been discovered in the Gulf of Gabès, where a transboundary field is being developed jointly by Tunisia and Libya. The majority of Egypt's oil reserves are also situated offshore, with the main production in the Gulf of Suez, while some of its largest gas resources have recently been proved off the Nile delta. Morocco has limited resources of natural gas and oil in its coastal Essaouira basin.

The coastal zone has a rich archaeological and cultural heritage, including UNESCO World Heritage sites in Morocco, Algeria, Tunisia and Libya (UNESCO 2005) and the now submerged archaeological heritage of the city of Alexandria in Egypt.

ENDOWMENTS AND OPPORTUNITIES

The development of oil and natural gas resources underpins most national economies, with considerable local employment opportunities, though mostly for men. During the last decade or so, much of the development has focused on offshore acreage (EIA 2005) and this is likely to continue. Algeria, Tunisia, Libya and Egypt are all set to substantially increase gas production, feeding growing demand mostly from Europe, as well as satisfying the national and transnational needs of the electricity sector, along with industry and domestic consumers. Natural gas, largely from off the Nile delta, is likely to drive Egypt's energy sector for the foreseeable future.

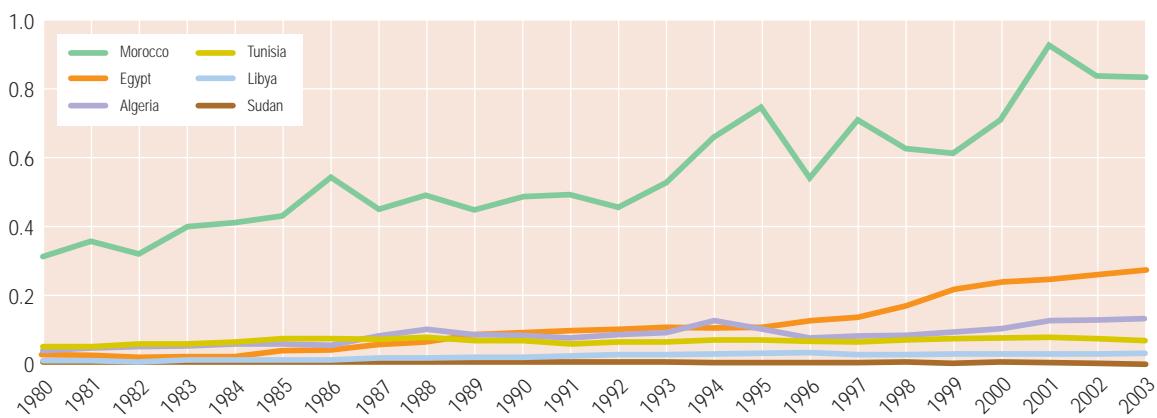
Reported marine fish production has increased overall during the period 1980-2003, totalling about 1.4 million t in 2001 (Figure 11, FAO 2005). Morocco (Atlantic and Mediterranean) is by far the largest producer. In 2001, its total marine fish production was 933 197 t – a six-fold



The UNESCO World Heritage site of Leptis Magna in Libya. The city was originally a Phoenician trading port developed by Septimius Severus, emperor of the Roman Empire from AD 193. Such sites may support the growth of tourism.

Figure 8: Reported marine fish catches in Northern African countries since 1980

million metric tonnes



Fishery production relates to catch of aquatic organisms, taken for commercial, industrial, recreational and subsistence purposes from inland, brackish and marine waters. The harvest from mariculture, aquaculture and other kinds of fish farming is also included. Catches of fish, crustaceans and molluscs are expressed in live weight, that is the nominal weight of the aquatic organisms at the time of capture. To assign nationality to catches, the flag of the fishing vessel is used, unless the wording of chartering and joint operation contracts indicates otherwise.

Source: FAO Fisheries Department, Fishery Information, Data and Statistics Units

increase since 1961. Egypt (Mediterranean and Red Sea) is the second largest producer (FAO 2005). Generally in the Mediterranean, total fish landings have increased steadily, not only due to greater fishing pressure, but also to higher nutrient input into a formerly low-nutrient sea (Alm 2002). In the Red Sea, where the total fish landings amount to about 22 800 t per year, 44 per cent of the landings are coral reef-based (PERSGA/GEF 2003). Artisanal fisheries are still important in the Mediterranean and Red seas, but industrial fishing including foreign fleets is becoming prevalent.

Further development of marine fisheries will depend on the success of regulation at national and international levels. The principal fishing grounds on the continental shelf off the Nile delta are fairly heavily exploited (FAO 2003b), but elsewhere there is potential for increased catches. Algeria's five-year fisheries plan aims to increase production to 230 000 t per year, with the creation of 100 000 new jobs (FAO 2003a). Egypt aims to increase Red Sea catches to 70 000 t per year (PERSGA/GEF 2003). Sudan also has potential for increased production, notably of finfish, doubling its present yield of 5 000 t per year (FAO 2002b). Aquaculture in coastal wetlands makes a significant contribution to total fish production, particularly in Egypt, by far the largest producer of farmed fish, with rapid development mostly in semi-intensive, brackish water farms (El Gamal 2001, FAO 2003b). According to Egypt's General Authority of Fish Resources Development (GAFRD), the total production from fish farms in 2003 was 445 200 t (GAFRD 2003).

Tourism is a major foreign exchange earner, much of it generated in coastal areas (Figure 3). The cultural heritage sites are major assets with significant development potential over the long term. Statistics and forecasts indicate steady growth in this sector (WTTC 2005). Demand overall in Northern African countries, excluding Sudan, is expected to grow by 9 per cent in 2005 and by 5.5 per cent per year, in real terms, between 2006 and 2015. It is Egypt's most dynamic industry and the largest earner of foreign



Inshore fishers at the mouth of the Sebou River, Morocco. Moroccan fisheries are among the most productive of all Northern African countries.

Source: R. Arthurton

exchange. Its annual increase of tourist inflows from 1982 to 1999 averaged 9.7 per cent and is expected to account for 15.4 per cent of GDP in 2005. Much of its tourism economy is sustained by its Red Sea coral reef coasts, where activity is locally intense.

CHALLENGES FACED IN REALIZING DEVELOPMENT OPPORTUNITIES

The environmental issues and threats relating to the realization of development opportunities are being addressed locally to globally, within the framework of integrated management of coastal resources. All countries are party to either the Convention for the Protection of the Mediterranean Sea against Pollution (the Barcelona Convention) or the Jeddah Convention (Red Sea and Gulf of Aden) – in Egypt's case, both. These MEAs focus on cooperation for a coordinated approach to protection and enhancement of the marine environment and coastal zones. Tunisia has passed specific coastal zone legislation and has established the Tunisian Agency of Coastal Protection and Management (UNEP/MAP/PAP 2001). Algeria is drafting such legislation and creating an agency. Support for capacity-building for the sustainable management of coastal and marine resources is offered by the World Bank's Mediterranean Environmental Technical Assistance Programme, focused on water

quality, municipal and hazardous waste, and policy and legislation tools (METAP 2004). A Strategic Action Programme for land-based sources of marine pollution has been adopted by all 20 Mediterranean countries under the Barcelona Convention. Initiatives exist for strengthening the management of Mediterranean coastal wetlands through MedWet and its programmes such as MedWetCoast and the North African Wetland Network (Box 3).

Population growth in the southern Mediterranean countries will present major challenges in physical planning and policy formation to protect coastal areas (Alm 2002). Urban sprawl is a priority issue. In Algeria, coastal cities have more than tripled their surface area in 30 years. Much prime agricultural land is being lost to urban expansion and coastal wetland lost to both peri-urban landfill and agricultural reclamation. In this competition for space, semi-intensive brackish water fish farms are increasingly vulnerable (El Gamal 2001). As well as suffering population pressures, parts of coastal Morocco and Algeria are prone to damaging earthquakes.

Coastal pollution is a serious concern. In Egypt, the discharge of untreated municipal waste and industrial and agricultural pollutants has been commonplace, leading to eutrophication and related public health risks (UNEP/MAP 1999, EEAA 2002, Crossland and others

Box 3: Environmental degradation of Lake Maryout, Egypt

Lake Maryout covers 60 km², the remains of a once much more extensive coastal lake separating Alexandria's Mediterranean shoreline from the Egyptian hinterland. It has high salinity and is fed by agricultural drainage waters (though formerly by a branch of the River Nile). Historically it has provided a rich fisheries resource, but is now identified by Egypt's National Environmental Action Plan as the country's most polluted lake. In the decade 1980-1990, annual fish production there fell from more than 10 000 t to less than 2 000 t.

The current phase of the lake's decline stemmed from the 1950s, when its southern parts were reclaimed for agriculture. In 1986, the lake became the receptacle for Alexandria's sewage, which had earlier been discharged untreated to the sea. Additional contemporary pressures come from urban expansion and industrial development, the discharge of industrial liquid and solid waste, and agricultural effluent, which is heavily polluted with

pesticides. In 1994, sewage and industrial waste became subject to treatment, and some of the drainage canals that used to flood the lake with industrial waste were closed.

While some of the environmentally damaging activities have now been curtailed, land reclamation for urban project development continues to threaten the capacity of the lake to function as a fishery. The multiplicity of government bodies controlling the lake is the source of most of the environmental problems. Major factors which have led to the current deterioration in the state of the lake are the conflicts between different stakeholders (urban developers, fishermen and farmers) and the lack of an integrated policy between the many institutional bodies at the national and local scale, who have responsibilities in managing the lake resource. Environmental sustainability of the lake resource is a choice, but it requires a collective understanding to see beyond destructive environmental conflict which is leading to its deterioration.

Chapter 5 • Coastal and Marine Environments

2005) (Box 3), though the situation is improving with many of the polluting sources now stopped. For example, in Tunisia, 65 per cent of wastewater is now treated (METAP 2004).

Overexploitation of fisheries is another key factor determining the health of the marine ecosystem. Foreign fleets and new technology are contributing to the problem, reflected in a decrease in the mean size of fish caught (Alm 2002). The issues of by-catch and discards, as well as the damage to seabed habitats from trawling, are problems for biodiversity. Another factor affecting biodiversity is the introduction of invasive species, especially from ships' ballast water discharge. In the Mediterranean, more than 240 non-indigenous species have been identified, much of the introduction attributed to migration and transport by shipping through the Suez Canal (Lindeboom 2002).

Oil and gas development is another contributor to habitat disturbance and loss, notably seabed disturbance around platforms and submarine pipelines, and pollution from drilling compounds. Accidental pollution from oil wells and oil transportation remains a risk.

Much of the development of tourism on Egypt's Red Sea coast is poorly controlled, leading to an overall decline in coral cover and the loss of the natural tourism attraction (PERSGA 2005). The construction of hotels and transport infrastructure inevitably involves habitat loss, while the pressures of tourist numbers – physical disturbance, high demand for freshwater, pollution and eutrophication – impact adversely on the living resources, especially those of coral reef ecosystems. The reefs also suffer from destructive fishing methods, including the use of explosives. Considering the importance of coral reefs in the development of tourism on the Red Sea coasts, there is a worrying lack of public and government awareness, as well as poor enforcement of the legal framework relating to reef conservation (Kotb and others 2004). Human-induced global warming is likely to be responsible for the coral bleaching in 1998 which caused the extensive coral mortality in the northern-central Red Sea (Kotb and others 2004).

The discharge of freshwater and sediment from rivers into the Mediterranean has been drastically reduced over the last few decades as a result of damming and agricultural irrigation (UNEP/MAP/PAP 2001), leading to coastal erosion and to the saline intrusion of deltaic wetlands. Freshwater discharge from the River Nile became insignificant with the commissioning in 1968 of the Aswan High Dam. The reductions in sediment discharge, as a consequence of damming, have caused a major retreat of the

Box 4: Tourism and water resources in Tunisia

Tunisia is a relatively water-scarce country, especially in the tourism zones along the eastern seaboard and the offshore islands. Water must be transferred to some of the best known tourist resort areas such as Sfax and the island of Kerkenna. Within perhaps ten years, it may also be necessary to do so to Djerba. While in absolute terms tourists in Tunisia consume only 1 per cent of national water resources, per head they consume nine times as much as nationals, partly because the use of water by tourists in hotels and resorts is typically very wasteful. Extensive treatment of this water is required before it can be re-used. In Tunisia, it is predicted that, even without the effects of climate change, water rationing may ultimately be required because of the regional water demand conflicts to which tourism contributes.

Source: WTO 2003

(formerly prograding) distributary mouths at Damietta and Rosetta (Milliman 1997, NEAP 2002, Crossland and others 2005), where coastal defences have been installed in an attempt to arrest the retreat. Similar impacts of damming have been reported from the delta of the Moulouya River in Morocco (Snoussi and others 2002), as shown in

**Climate change may threaten coastal development**

The city of Alexandria on Egypt's Mediterranean coast is vulnerable to sea-level rise.

Source: TerraServer 2004

Box 5: Multiple uses and conflicts on the Moulouya coastal wetland, Morocco

The Moulouya deltaic zone, with its complex marshes, is a 3 000 ha Moroccan Site of Biological and Ecological Interest. It is a refuge for many birds of worldwide or national interest.

The main human activities in the area are agriculture and grazing. National tourism at the adjoining Saïdia beach provides an important summer income for the local population. In 1992, a 230-ha aquaculture farm was established close to the estuary, but closed in 1996 because it caused accelerated salinization of the aquifer. This had a negative impact on the vegetation and generated conflicts between agriculture, aquaculture and wetland conservation. A multidisciplinary analysis of the state of the Moulouya coastal wetland has been carried out as part of the MedWetCoast Project. This has shown that, in terms of biodiversity, among the 67 globally threatened taxa present on the Mediterranean coast of Morocco, 13 are present on the delta site. This and previous studies have revealed impacts including: erosion of the delta

coastline related mainly to water and sediment abstraction by damming (Snoussi, Haida and Imassi 2002, Imassi and Snoussi 2003); water pollution and salinization related to agricultural practices (Benkaddour 1997); wetland reclamation and gradual encroachment of agriculture on wetlands; saltwater intrusion in connection with overpumping of freshwater and aquaculture activities (Sadki 1996); losses of the ecological and economic values of the wetlands (Khattabi 2002); and problems of water management between the different users and wetland conservation (Snoussi, 2004).

The overall initiative of MedWetCoast aims at ensuring the sustainable management of the biological diversity of the coastal areas and wetlands in six Mediterranean countries, through the development of adequate legal and regulatory frameworks, the creation of institutional organizations adapted to the complexity of the issues at stake, capacity-building and the development of an exchange network at the regional level.

Sources: Benkaddour 1997, Khattabi 2002, Sadki 1996, Snoussi, Haida and Imassi 2002, Imassi and Snoussi 2003, Snoussi 2004

Box 5. Coastal erosion and saline intrusion are some of the expected impacts of climate change and its anticipated, associated sea-level rise (IPCC 2001). Coastal erosion is already widely reported, with major beach loss in Algeria and Tunisia necessitating costly renourishment (Alm 2002). Sea-level rise poses particular problems for the Nile delta and the city of Alexandria, much of which would be inundated by a rise in sea level of only a metre or so (El Raey and others 1999).

SOUTHERN AFRICA

The main challenges facing the sustainable use of coastal and marine resources are the loss of natural habitat and biodiversity, and the consequent loss of any opportunity of exploitation of renewable living resources. Other concerns include the long-term effects of climatic change and sea-level rise, and the interruption of coastal processes such as sediment supply, beach dynamics, and degradation of water quality due to human activities in catchment and estuaries. There are difficulties in managing human activities impacting on the environment because of inadequate legislation and compliance, the lack of capacity for detection, and inadequate education and environmental awareness. All these factors are

exacerbated by poverty and disease, and, in some countries, conflict and migration.

OVERVIEW OF RESOURCES

The coastal and marine areas, which extend along the 10 000 km of coastline from Angola on the Atlantic Ocean side to Tanzania on the Indian Ocean side and offshore to the limit of the EEZ, encompass diverse living and non-living resources. The west coast is characterized largely by desert conditions and sparse human populations, but with rain forest established towards the mouth of the Congo River. Its seas are influenced by the cold, northward flowing Benguela Current, with highly productive upwellings supporting industrial-scale fisheries. The east coast, under the influence of the East African Coast Current which flows northward along the coast of Tanzania and the warm, southward flowing Mozambique and Agulhas currents, is sub-tropical in South Africa, becoming tropical and wetter northwards. Marine diversity increases towards the warmer zones. Much of the hinterland drains to this coast through rivers including the Rufiji, Zambezi, Limpopo and Incomati. In Mozambique and Tanzania, there are extensive coral reefs and sea-grass beds, and mangrove forests, especially around the Rufiji and Zambezi deltas (Figure 1), which are largely protected by barrier beaches. Parts of

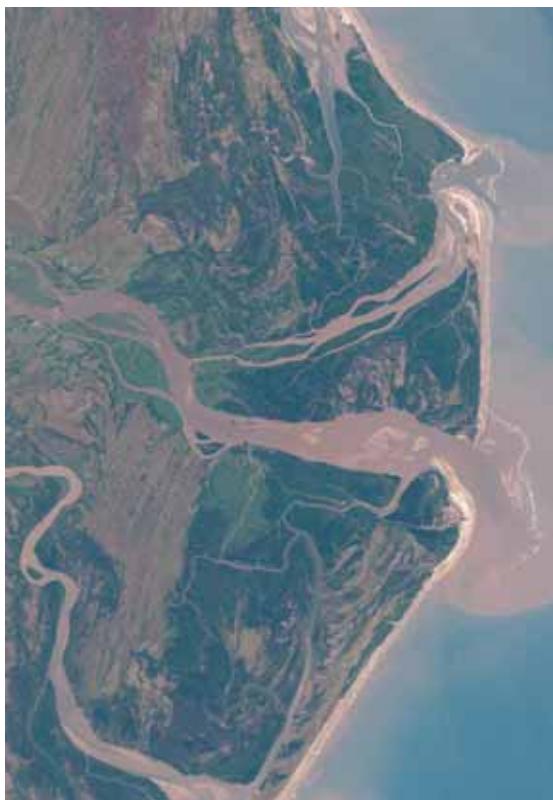
Chapter 5 • Coastal and Marine Environments

the South African coast are heavily urbanized and have associated industrial development (Figure 2).

There is a rich coastal and marine biodiversity associated with the fringing and patch coral reefs and mangrove forests in Tanzania and Mozambique (Figure 1). Mangrove areas in those countries total 6 483 km² (Taylor and others 2003) while, in Tanzania, fringing reef platforms and patch reefs occur on over 80 per cent of the coast (UNEP-WCMC 2000). Coral communities also occur on the Maputoland Reef in KwaZulu Natal, South Africa (Obura and others 2004). Most reefs were severely affected by the coral bleaching event of 1998 and there was further mortality in 2002. Patchy infestation by COTS has also been reported (Obura and others 2004). The Agulhas Current LME has an enhancing effect on biodiversity which extends from Tanzania to well along the South African coast. The estuaries of Tanzania and Mozambique support penaeid prawn fisheries while, on the reef shores, artisanal and subsistence fishing are major activities. In Tanzania, areas of coastal forest with high levels of endemism occur over about 350 km² as fragments of a formerly extensive lowland forest (UNEP 2001). The west coast has no

significant coral reef development, with only a few coral species reported from Angola (UNEP-WCMC 2000, Figure 1). Mangrove is confined to Angola where 1 100 km² are recorded. It is characterized by productive upwelling systems between Cape Agulhas in South Africa and southern Angola – the Benguela Current LME (Box 6). It has relatively low diversity but makes an important contribution to the total African, and global, fish catch, with epipelagic species including the South African pilchard and the Cape anchovy.

There are significant coastal and offshore hydrocarbon resources (EIA 2005). Angola has by far the majority of Southern Africa's estimated crude reserves – 5.4 thousand million barrels, mostly located in deep water. Reserves of natural gas, also largely offshore, make up about 2.5 per cent of Africa's total. Reserves have been discovered in Angola (1.6×10^{12} cubic feet); Mozambique (4.5×10^{12} cubic feet); Namibia (2.2×10^{12} cubic feet); South Africa (780×10^9 cubic feet) and Tanzania (800×10^9 cubic feet), where there are commercial reserves under production around the island of Songo-Songo (EIA 2005).



Mangrove forests provide valuable ecosystem services

The Zambezi delta, Mozambique, showing the extensive development of mangrove (dark green) between the distributary's channels. The mangrove is subject to overharvesting and clearance.

Source: NASA 2000



Rivers may transport large amounts of sediment to the sea

Plumes of suspended sediment discharged to the Atlantic Ocean from the Gariep (formerly Orange) River at the boundary of Namibia and South Africa. The river has been the conduit for alluvial diamonds that are being dredged and mined in this coastal zone.

Source: NASA 2000

Box 6: The Benguela Current Large Marine Ecosystem (BCLME) Programme: joint cooperative management of shared resources

The Benguela Current LME is one of the world's most productive marine environments. In 2000, the total fish catch of the region was 1 166 000 t. The fishing industry has become an economic mainstay, contributing 10 per cent of GDP in Namibia, 4 per cent in Angola and 0.37 per cent in South Africa. The continental shelf is also rich in oil, natural gas and diamonds. Oil production contributes 70 per cent of Angolan GDP, and the Kudu gas fields in Namibia hold some of the largest reserves in western Africa. The marine diamond mining industry in Namibia and South Africa yields close to a million carats of diamonds each year. The exceptional natural beauty, biodiversity and cultural attributes of the BCLME already attract large numbers of tourists, particularly in South Africa, and tourism has the potential to grow substantially.

The ecosystem faces accelerating threats which, if left unchecked, could threaten vital economic and ecological values. The primary threats include habitat loss and pollution – particularly in areas adjacent to urban centres – and increasing exploitation of straddling fish stocks, concerns exacerbated by the lack of a coordinated regional management framework. There is also the recognition that oil and gas exploration and production, and diamond mining in and around critical marine habitats, will have to be undertaken in an environmentally safe manner to minimize impacts. In addition, the BCLME is characterized by a high degree of environmental variability,

manifest in fluctuations in the abundance and distribution of marine living resources. Global climate change has the potential to influence this variability. The transboundary nature of these issues demands regional cooperation for their effective management.

In 1999, Angola, Namibia and South Africa signed a Strategic Action Programme, identifying strategies and priority actions required to protect the BCLME. In 2002, the Benguela Current Large Marine Ecosystem (BCLME) Programme was officially launched. The Programme aims to integrate management, sustain development and protect and conserve the ecosystem. The regional initiative is funded by the Global Environment Facility (GEF), which is contributing US\$15.2 million, complementing an investment of approximately US\$16 million by the three countries. The initiative aims to lay the foundation for a long-term collaborative management system, overseen by a regional management organization, to be known as the Benguela Current Commission.

From its inception in March 2002 to the end of 2004, the Programme had instituted 60 projects worth US\$4.7 million. These were designed to address transboundary environmental problems and contribute to the integrated and sustainable management of the BCLME. The Programme is regarded as a concrete and constructive initiative towards the New Partnership for Africa's Development (NEPAD).

Sources: Benkaddour 1997, Khattabi 2002, Sadki 1996, Snoussi, Haida and Imassi 2002, Imassi and Snoussi 2003, Snoussi 2004

Diamond mining from coastal sand dunes and by dredging inshore seabed sediments is a major industry in Namibia and western South Africa. The minerals have been derived over time from the diamond-bearing volcanic rocks exposed in the catchment of the Gariep (formerly Orange) River. In coastal sediments on the Indian Ocean shores of South Africa and Mozambique, there are commercially viable titanium and zirconium minerals, also derived from the hinterland.

There are three coastal UNESCO World Heritage sites in South Africa (UNESCO 2005). The Greater St Lucia Wetland Park has critical habitats for species from marine, wetland and savannah environments, and has exceptional species diversity.

ENDOWMENTS AND OPPORTUNITIES

The combination of coastal attractions and unique wildlife

presents a powerful resource for the long term if utilized with care. Nearly all of the coastline holds some sort of attraction. With careful management, the value of the assets underpinning such attractions can increase. Travel and tourism are already major foreign exchange earners in Southern Africa and much of the income is generated in coastal areas, providing substantial employment opportunities for women as well as men. In South Africa, travel and tourism in 2005 is expected to generate US\$30.3 thousand million of economic activity (total demand), in Namibia, US\$1 004.4 million and in Tanzania, US\$1 858.4 million, accounting for 9.7 per cent of its GDP and 7.7 per cent of total employment (WTTC 2005).

The mangrove forests present opportunities for improving the livelihoods of coastal people and contributing to the alleviation of poverty (Taylor and others 2003). They are a rich source of fuel, building

Chapter 5 • Coastal and Marine Environments

poles, and materials for boat making, and provide nectar for large populations of bees. With effective conservation and replanting programmes, perhaps supported by ecotourism, these resources could be harvested on a sustainable basis, maintaining supplies while preserving their important ecological functions.

Total marine fisheries production declined from 1 556 000 t in 1988 to 1 289 000 t in 2000, the contribution to the world total declining from 11.0 to 7.2 per cent (FAO 2002c). However, despite this trend some countries have increased their production (Figure 9). The overall declining trend is a continuation of that reported for the period 1972-97 (UNEP 2002a) and is part of the global trend (Pauly and others). Approximately half the finfish catch is taken by South Africa, and more than half the crustacean catch is taken by Mozambique, where catch value is dominated by the shallow-water penaeid prawns. Despite the declining trends in marine fish production, fishery commodity exports over the period 1988-2000 rose in value from US\$200 million to US\$892 million, while imports declined from US\$224 million to US\$195 million (FAO 2004b). In South Africa, coastal goods-and-services in 1998 were estimated to be worth about US\$29 000 million (Government of South Africa 1998) or 37 per cent of the GDP; this figure incorporated about US\$175 million in terms of benefits to subsistence fishermen. The commercial fishery was worth about US\$270 million and the recreational fishery US\$200 million.

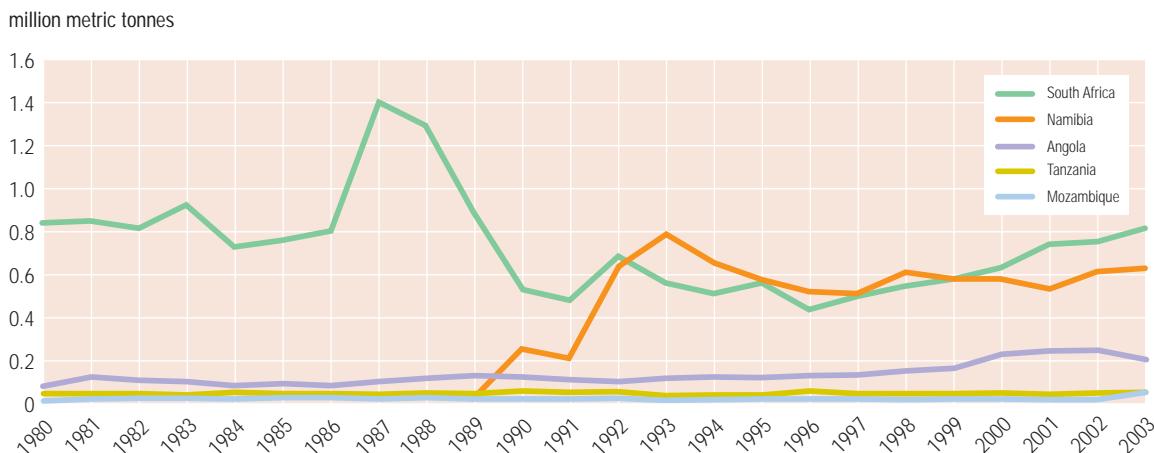
**Coastal wetlands maybe important reservoirs of biodiversity**

The Greater St Lucia Wetland Park is a United Nations World Heritage site located on the Indian Ocean coast of South Africa. A colony of coelacanth was discovered in the shallow waters of the park in 2000.

Source: Google Earth

Combined freshwater and marine aquaculture production rose from 4 000 t in 1988 to 11 000 t in 2000 (FAO 2002c). The seaweed *Eucheuma* is cultivated, mainly by women, on intertidal platforms mainly in Zanzibar, Tanzania, with a production of 7 000 t in 2002 (Figure 9). Cultivation is slowly spreading to mainland Tanzania and Mozambique. Seaweed farming represents an opportunity for coastal villagers, and especially women, to improve their incomes.

Figure 9: Reported marine fish catches in Southern African countries



Fishery production relates to catch of aquatic organisms, taken for commercial, industrial, recreational and subsistence purposes from inland, brackish and marine waters. The harvest from mariculture, aquaculture and other kinds of fish farming is also included. Catches of fish, crustaceans and molluscs are expressed in live weight, that is the nominal weight of the aquatic organisms at the time of capture. To assign nationality to catches, the flag of the fishing vessel is used, unless the wording of chartering and joint operation contracts indicates otherwise.

Source: FAO Fisheries Department, Fishery Information, Data and Statistics Units



Bundles of seaweed harvested from an intertidal reef platform awaiting shipment on Pemba Island, Tanzania.

Source: R. Arthurton

Hydrocarbon resources are making an increasingly strong contribution to the economy. Over the last decade or so, the focus of oil and gas exploration has shifted offshore to the coastal waters, where there are now many successful production ventures (EIA 2005).

Angola is the only significant oil producer. Overall, by early 2004, Angola's production reached nearly 950 000 bbl/d and this is expected to double by early 2008, with new deep-water production sites. South Africa's production is also from offshore fields which, by late 2003, yielded more than 60 000 bbl/d. Much of the gas associated with oil production is currently flared or reinjected. In Tanzania, production on the island of Songo-Songo is gathered from on and around the island and transported via a 225-km pipeline to Dar es Salaam where it provides fuel for electricity generation. Development and production present considerable local employment opportunities, though mostly for men.

The value of the alluvial diamond industry in Namibia and western South Africa was estimated at US\$625 million in 1998 (Government of South Africa 1998).

CHALLENGES FACED IN REALIZING DEVELOPMENT

The environmental issues and threats relating to the realization of development opportunities are addressed within the framework of the Nairobi Convention (by Tanzania, Mozambique and South Africa) and the Abidjan Convention (by Angola, Namibia and South

Box 7: Pollution management in South Africa through private-public consensus

The Saldanha Bay Water Quality Forum Trust was set up in 1996 to promote water quality and ecosystems for the benefit of the local community and is funded by the implementation of a management approach based on the polluter pays principle.

Saldanha Bay is a coastal embayment located in the southern Benguela upwelling system, approximately 100 km north of Cape Town, South Africa (Monteiro and Largier, 1999). It provides one of the few naturally sheltered areas for in-water mariculture operations in South Africa (Probyn and others 2001).

The environmental problem: For many decades, the bay has been subject to the discharge of wastewater from land-based fish processing industries (Stenton-Dozey, Jackson and Busy 1999). This pollution poses a continual threat to shellfish culture operations and recreational harvest in the area. Wastewater discharges, mainly from the fish processing industries, introduce nutrients (ammonia) into the system. This condition is favoured by opportunistic species (including harmful algal blooms) and therefore enhances the risk of *in situ* growth of toxic algal blooms. Consequently, the deposition of organic matter and hypoxia (eg those introduced through port operations) creates an environment that favours high rates of build-up of toxic substances.

Management and finance: In the 1990s, individuals with an interest in the area started to create awareness for the need to address these

conflicting issues and this led to the establishment of the Trust. The Trust is a voluntary organization comprising officials from local, regional and national authorities, representative of all major industries in the area, and other groups who have a common interest in maintaining water quality and ecosystem functioning in order to keep Saldanha Bay fit for all its designated uses. It also acts as an advisory body to legislative authorities such as the Department of Water Affairs and Forestry and Department of Environmental Affairs and Tourism. The Trust collects funding by applying the polluter pays principle, and financial resources are utilized to commission joint scientific investigations and monitoring programmes to make informed decisions on the management of the area (Taljaard and Monteiro 2002, Monteiro and Kemp 2004).

A quote from *Bay Watch*, the publication of the Saldanha Bay Water Quality Forum Trust (2004) probably explains this best:

"This is a most unique forum in that, as far as I am aware, it is the only non-government body (in South Africa) that is totally successful in melting the private sector with their contributions and the government with their overseeing capacity, to form a unit that is ultimately functional and effective."

Chapter 5 • Coastal and Marine Environments

Africa). These MEAs focus on coordinated protection and enhancement of the marine environment and coastal zones. Land-based activities impacting the coastal and marine resources in the countries flanking the Indian Ocean are being addressed through the Nairobi Convention as part of the GEF-funded WIO-LaB project (WIO-LaB 2005).

The coastal environment is vulnerable and is being degraded by the current levels of development. Critical ecological functions are being undermined, including those provided by mangrove swamps, coral reefs, rivers and estuaries, which protect and stabilize coastlines, and provide sediments for beaches and nursery areas for fish and prawns. These changes, ironically brought about by development activity, are increasing the vulnerability of human populations, particularly those in low-lying coastal areas. Such vulnerability will be exacerbated by sea-level rise, storm surges and tsunamis.

Population growth, combined with migration to large coastal cities, will form one of the major challenges for physical planning and policy formation to protect coastal areas. On the eastern coasts, the population is growing at 5 to 6 per cent annually, due to births and migration from inland rural areas, and coastal poverty levels are high (Obura and others 2004). The traditional cultural and religious beliefs of the indigenous communities relating to the marine environment and its resources are being lost as population densities increase and people move in from other areas, thus diminishing a vital management resource.

In Tanzania and Mozambique, the degradation of the coral reef resources due to increasing population pressures and coral bleaching is one of the most important management issues (Obura 2004, Obura and others 2004). Bleaching has caused the decline of 30 per cent of the reefs, and the threats posed by a growing population are probably slowing their recovery. In Mozambique and southern Tanzania, there have been increased rates of reef erosion, due in part to the bio-erosion of dead coral tables and plates. A patchy but widespread increase in COTS infestation was recorded in 2003 and 2004 in Tanzania. Much of the damage to the reef ecosystems is coming from fisheries exploitation. Specific threats include excess harvesting (in part by migrant fishers), the use of destructive gears such as beach seines and gill nets, and bomb fishing that damages juvenile fish populations and vulnerable species. In Tanzania, by far the most destructive type of fishing is dynamiting, which has been practised since the 1960s (Wagner 2004). In the 1980s and 1990s, dynamite blasts reached epidemic rates. Recent management initiatives there have already had a

Box 8: Catchment2Coast Transboundary Ecosystem Programme

One challenge in the sustainable management of the tropical coastal ecosystems of southern and eastern Africa is their dependence on large transboundary river inputs. The magnitude of human needs for water resources in large river basins is decreasing the socioeconomic value of coastal ecosystem services. There is a need to focus on increasing socioeconomic value at the system level, rather than at either the river basin or coastal level, to avoid future conflict. The Catchment2Coast Programme (2002–2005) has been able to show that the success of integrated freshwater and coastal ecosystem management lies in understanding the river-coastal linkages. The programme used the Maputo Bay catchment (shared by South Africa, Swaziland and Mozambique) as a pilot study, and was able to hindcast the ecosystem production for a nine-year period (1996–2004). This study was used to explain variability in CPUE (Catch per Unit Effort) for the prawn fishery in Maputo Bay. The findings can be used to inform environmental management and planning in other river-coastal systems.

Source: Monteiro and Mathews (2003)

significant positive impact on the coral reef environment (Wagner 2004). Resource users, particularly fishing communities, have been increasingly involved, enhancing their environmental awareness. Mangrove areas continue to be under threat from pollution and coastal development, notably aquaculture and the construction of salt pans. The overall rate of deforestation in Mozambique is estimated at 18 km² per year (Taylor and others 2003).

In South Africa, the once abundant, easily accessible, shallow sub-tidal invertebrate resources, such as the southern rock lobster and the abalone, have been reduced by heavy commercial and in part illegal exploitation. High prices obtainable for abalone in eastern Asia have exacerbated the pressure on this species and increased poaching. The shallow-water prawns of Mozambique have long been the targets of artisanal fisheries and a major tourist attraction in local restaurants (Box 8). With the possible exception of sea cucumbers in Mozambique, there are few, if any, other large invertebrate stocks which remain to be profitably exploited. In contrast to most western African countries, Namibia's policy of fisheries management since independence has generated economic and social benefits to the country (Alder and Sumaila 2004).

Constraints to coastal aquaculture development include the lack of sheltered waters and the environmental degradation of coastal environments, such as mangrove forests. It should also be realized that aquaculture and mariculture are energy-consuming, rather than energy-producing, processes. While there

Box 9: The Cape Verde Islands and the West African Marine Eco-region

The West African Marine Eco-region spans 3 500 km of coast in Western Africa and includes six countries:

Mauritania, Senegal, Gambia, Cape Verde, Guinea-Bissau and Guinea. This coastline presents a wide variety of habitats, from rocky cliffs and broad sandy beaches, to extensive sea-grass prairies in the north, and dense mangrove forests and well-developed estuaries in the south.

Among its most striking features are the unique coral reefs of Cape Verde and the powerful coastal upwellings of cold water that support one of the most diverse, and economically important, fishing zones in the world. The upwellings are primarily the result of the year-round trade winds that push surface waters away from the coast and draw cold, nutrient-rich waters from deep in the ocean up to the surface. These rich waters meet the tropical sun to provide a perfect environment for plankton – the foundation

of a tremendously productive food chain that supports incredible biodiversity.

Over 1 000 species of fish have been identified, as have several species of cetaceans including dolphins and whales, five species of endangered marine turtles, and a colony of 100 monk seals – the largest breeding colony left on Earth. While the continental upwellings support their characteristic floral and faunal diversity, the offshore archipelago of Cape Verde harbours one of the most important coral reefs in the world. Recently published studies have identified Cape Verde as both a centre of endemism, because of its unique and rare species, and as a top 10 global hot spot for coral communities, where conservation action is most needed and could have the greatest benefits.

Source: WWF 2005

might be employment opportunities, the products, whether they be mussels, prawns, abalone or fish, tend to be beyond the means of poor communities.

Mineral extraction from dunes and the seabed is controversial, given the environmental degradation to which it can lead. On the east coast of South Africa, the mitigation of these impacts constitutes a sub-industry. The exploitation of mineral resources is a comparatively short-term operation and one which needs to be carefully managed in order to mitigate any short- or long-term environmental impacts. There is also a need for responsible management in order to maximize the benefits to the people of the country and to allow investment of profits in longer-term sustainable developments. In Tanzania, the extraction of live coral for lime burning is a widespread activity which can have highly destructive effects on reef habitats (see Obura 2004).

Physical shoreline change, including coastal erosion, is another common issue, though its causes include natural forcing as well as human interventions and pressures. In Tanzania, shoreline change – accretion as well as erosion – impacts particularly on tourism infrastructure. Erosion has led to the demolition of beach hotels on low-lying beach plains at Kunduchi, near Dar es Salaam. Attempts have been made to stabilize shorelines by the installation of groynes (Kairu and Nyandwi 2000, UNEP/GPA 2004). It is anticipated that coastal erosion will increase with sea-level rise associated with global climate change (IPCC 2001).

WESTERN AFRICA

The main concerns of the mainland states are the degradation of their coastal habitats and biodiversity through pollution, saline intrusion and erosion, and the overexploitation of their fisheries resources. The coastal degradation has contributing causes in the pressures generated by an expanding coastal population, urbanization and industrial development. This includes the development of coastal and offshore oil and gas resources. In some countries, these pressures have been exacerbated in recent years by human conflict and political instability. The damming of rivers, reducing the amount of freshwater and sandy sediment being discharged at the coast, contributes to the degradation of coastal wetlands and coastal erosion. The potential impacts of climate change and sea-level rise, particularly with regard to coastal erosion and the inundation of coastal lowlands, are important issues in coastal land use and planning.

OVERVIEW OF RESOURCES

Western Africa's varied coastal zone extends for some 4 400 km, from the desert sandy shores of Mauritania in the north, through deeply indented, estuarine and island coasts (eg Guinea-Bissau with its Bijagos archipelago), to the lagoonal coasts with their extensive barrier beaches on the Gulf of Guinea. The huge delta of the Niger and Cross rivers forms its eastern end. Major rivers – Senegal, Volta, Niger – drain the hinterland, each dammed

variously for agricultural irrigation and hydropower, altering the nature of water and sediment discharge to the coast. The volcanic, mountainous SIDS of the Cape Verde Islands lie some 600 km west of Dakar, Senegal.

The seas off Mauritania, Senegal and Gambia form part of the Canary Current LME, sustained by the cold, southward flowing Canary Current, with its nutrient-rich coastal upwellings (URI 2003). Countries from Guinea-Bissau to Nigeria flank the Guinea Current LME which is sustained by the eastward-flowing Guinea Current. Seasonal upwelling of cold, nutrient-rich water occurs off the coasts of Ghana and Côte d'Ivoire. Both LMEs have substantial fisheries resources. Both are driven by climate, with intensive fishing as their secondary force. Commercially valuable fish in the Canary Current LME include cephalopods, tuna and hake. In both LMEs, more than half of the commercial catch comprises small pelagic clupeoids (herring, sardines and anchovies). Many coastal wetlands support important fisheries.

Mangroves are abundant in the Niger delta, covering many thousand square kilometres, and also in Guinea-Bissau (2 366 km²) and Senegal (1 690 km²) (UNEP-WCMC 2000). Coral reefs occur only in the Cape Verde Islands (Box 9). The coastal waters are home to endangered species including marine turtles, inshore cetaceans and the West African manatee. There are many designated coastal wetland protected areas, with some twenty Ramsar sites, notably in Mauritania, Senegal, Gambia, Guinea, Côte d'Ivoire, Ghana and Benin (IUCN 2003a, Wetlands International 2005). Banc d'Arguin, in Mauritania, is a UNESCO World Heritage site (UNESCO 2005) where the desert environment is juxtaposed with biodiverse coastal habitats over more than 180 km of shoreline. Many of the coastal wetlands support important fisheries. Cultural World Heritage sites include the island of Gorée off the Senegal coast at Dakar. From the 15th to the 19th century, this was the largest slave-trading centre on the African coast.

Western Africa has important hydrocarbon resources (EIA 2005). Oil and gas have long been developed in the Niger delta, but now there is increasing exploration and development in most countries, mainly in offshore sites in water depths ranging from shallow to ultra-deep, beyond the continental shelf. Organization of Petroleum Exporting Countries (OPEC) statistics list Nigeria's estimated crude reserves at 31 000.5 million barrels. Smaller oil (and significant gas) reserves are located offshore in the Gulf of Guinea in Benin, Ghana and Côte d'Ivoire, also offshore Senegal and Mauritania, where the Chinguetti

Box 10: Diawling National Park, Mauritania – an area of important biodiversity

The wetlands of the Senegal delta are recognized to be among the richest and most extensive in West Africa. They have provided an interface between the freshwater of the Senegal River with its seasonal floods and the marine waters that intrude the estuary. This interface has favoured the development of rich botanical variety. In addition, this zone has served as a fish spawning ground and constitutes important feeding and nesting sites for numerous species of fish-eating birds.

Source: IUCN 2002



Source: IUCN

field, located in deep water near the capital, Nouakchott, was proved in 2001 to be commercial. There are also significant reserves of natural gas, which amount to approximately 32 per cent of Africa's natural gas reserves (EIA 2005). Nigeria's gas reserves are the ninth-largest in the world. The West African Pipeline



Mangrove forests (dark green) fringe estuaries and tidal creeks in Guinea-Bissau.

Source: NASA Earth Observatory

project, carrying gas from Nigeria to Benin, Togo and Ghana is set to proceed. While Nigeria is likely to remain by far the largest producer of oil and gas, nearly every country has attracted exploration interest.

ENDOWMENTS AND OPPORTUNITIES

The coastal areas of Western African countries have dense and growing populations and developing commerce. This is where most of the industrial infrastructure is located, historically because of access to port facilities. In Nigeria, about 10 per cent of the total population of over 120 million live in the coastal city of Lagos, which is also the centre for 85 per cent of the country's formal industry. Coastal cities are likely to continue to be nodes of population growth for the foreseeable future, with opportunities over the longer term for people to improve their economic well-being. As well as the intrinsic attractions of coastal areas for growing populations, rich biodiversity and marine fisheries, and the extensive coastal and offshore oil and gas fields, are key assets with potential for boosting economic development and alleviating poverty.

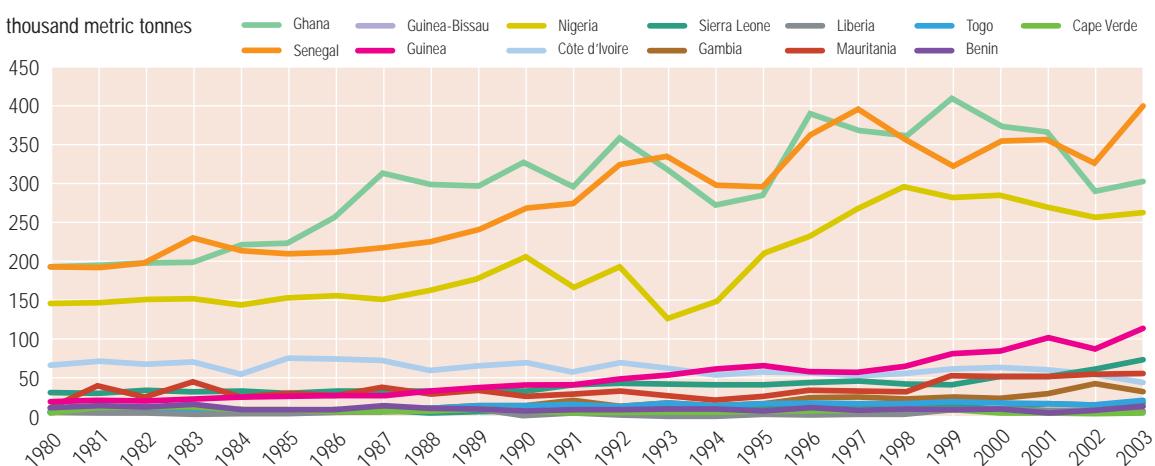
Oil and gas development offers most countries a prospect of economic growth as well as a contribution to their energy needs (EIA 2005). Nigeria is the only significant oil producer, with production exceeding 2 million bbl/d in 2003. It ranks as the sixth-largest oil producer in the world, with exports accounting for 95 per cent of the country's foreign income. Nigeria has the potential to maintain its already substantial crude oil production as recent discoveries in new deep-water

projects come on stream. The offshore Joint Development Zone, shared by Nigeria with neighbouring São Tomé (Central Africa), could soon potentially yield up to 3 million bbl/d. Nigeria is developing several projects to utilize its vast reserves of natural gas. Much of the present gas production from oilfields is flared. The projects involve the reinjection of gas into oilfields to maintain pumping pressure, and processing to produce liquefied natural gas (LNG). There are also schemes being planned to distribute gas for domestic and transboundary consumption.

Marine fisheries make an important contribution to food security, employment and national income, with Ghana, Senegal and Nigeria the main producers. In the Cape Verde Islands, fishery products represent 63 per cent of the state's exports (FAO 2005). Significant changes in species composition and fishery patterns have occurred, apparently partly due to overfishing, as shown by a decline in CPUE and the taking of immature fish by artisanal fishers (NOAA 2003a).

Tourism has potential for substantial growth, with the biodiversity and socio-cultural heritage aspects of many coastal areas providing a strong attraction. Ecotourism in particular should thrive with improved management of national parks. Individual countries show wide variations in their overall travel and tourism statistics and forecasts (WTTC 2005). Given trends elsewhere, it is plausible that coastal areas make a significant contribution to tourism. Ghana's travel and tourism economy in 2005 was expected to account for 10.8 per cent of GDP and 11.5 per cent of total employment (WTTC 2005).

Figure 10: Reported marine fish catches in Western African countries since 1980



Fishery production relates to catch of aquatic organisms, taken for commercial, industrial, recreational and subsistence purposes from inland, brackish and marine waters. The harvest from mariculture, aquaculture and other kinds of fish farming is also included. Catches of fish, crustaceans and molluscs are expressed in live weight, that is the nominal weight of the aquatic organisms at the time of capture. To assign nationality to catches, the flag of the fishing vessel is used, unless the wording of chartering and joint operation contracts indicates otherwise.

Chapter 5 • Coastal and Marine Environments

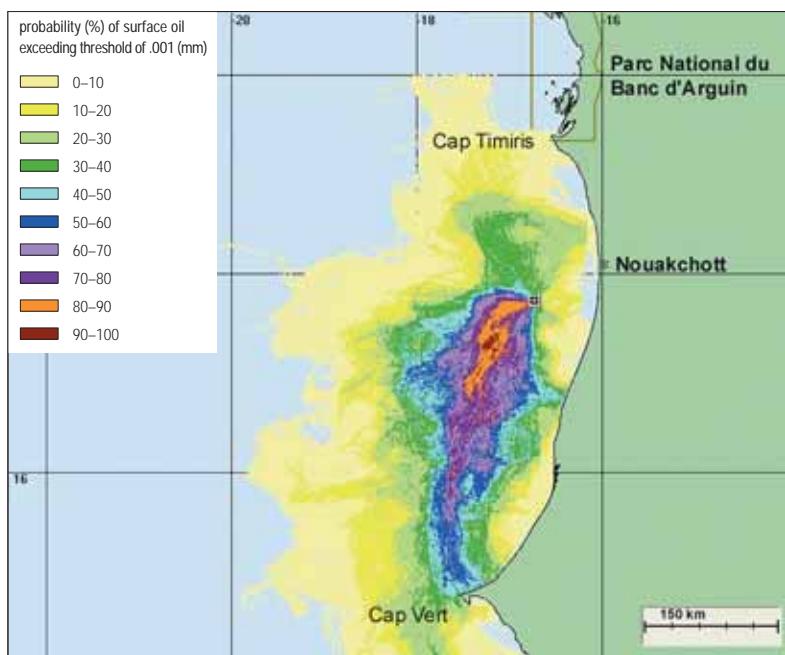
CHALLENGES FACED IN REALIZING DEVELOPMENT OPPORTUNITIES

All countries are signatories to the UNEP-administered Abidjan Convention. The environmental issues and challenges faced in the realization of development opportunities are being addressed at local to global levels within this framework. Important initiatives in the control and reduction of pollution are already in progress, with the member countries committed to reducing and controlling land-based sources of pollution.

The continuing growth of coastal populations, and in particular the increasing urbanization along the coast, is placing severe stress on the living resources through physical disruption and pollution, resulting in the degradation or loss of habitats that have crucial value in ecosystem services and biodiversity. One such example is the Diawling National Park (Box 10) on the estuary of the Senegal River, where damming has led to restricted freshwater flow in the dry season (Hamerlynck 1999). Aquatic weeds, such as the *Nypa* palm, infest many estuaries (Crossland and others 2005).

The intensity of industrial-scale marine fishing, notably by foreign fleets operating under licensed agreements, also continues to increase, with serious impacts on fish stocks. Despite increasing catches by foreign fishing fleets, the economic growth and social benefits from marine resources have not been realized in many Western African countries that host these fleets (Alder and Sumaila 2004). Alongside the impacts on living resources, there has been a rapid expansion in seabed and marine engineering for the development of oil and gas resources, with accompanying air pollution and the ever-present risk of extensive oil pollution. The

Figure 11: Modelling oil spills in Chinguetti field, Mauritania



Conditional probability of exposure from a 140 000 barrels (22 260 m³) sea-floor release of crude oil over 14 days from the Chinguetti field, in winter (assuming no intervention).

Source: APASA 2004

scale of environmental destruction and accompanying civil unrest arising from oil production operations in the Niger delta over the last few decades serves as a shocking indictment of the industry.

Coastal erosion by wave action has long been an important issue on the high-energy coasts of Western Africa (UNEP 1999). Reductions in the discharge of sand, due to damming and the disruption of longshore



Coastal erosion caused by the interruption of beach sand supply by longshore drift due to nearby port construction at Cotonou, Benin.

Source: R. Arthurton

sand transport by coastal engineering such as port development, have exacerbated this process. Some shorelines, such as the sand spit of Langue de Barbarie at the mouth of the Senegal River, have shown periodic erosion and accretion, mostly without obvious human influence.

The issue of climate change and its anticipated, associated sea-level rise (IPCC 2001) has important implications. As well as the increasing desertification of the Sahel (which may lead to further increases in coastal populations), there is likely to be an increase in coastal erosion and inundation of what are now densely populated low-lying areas, such as the Victoria Island beaches in Lagos, Nigeria, and the Greater Banjul Area in Gambia (Jallow and others 1996, UNEP 1999).

WESTERN INDIAN OCEAN ISLANDS

Pollution and the impacts of climate change, including coastal erosion and coral bleaching, are the main concerns (UNEP 2004). The potential impact of anticipated sea-level rise is also a major issue (IPCC 2001, UNEP 2002a). Southern areas, including Mauritius, Réunion and Madagascar, are subject to frequent tropical cyclones, causing loss of life and widespread devastation and destruction of coastal infrastructure (UNEP 2005b).

OVERVIEW OF RESOURCES

The islands form a heterogeneous group, reflecting their contrasting geological origins – micro-continental (Madagascar and the granitic islands of the Seychelles Bank), volcanic (Mauritius and the Comoros) or low-

lying coralline (eg Aldabra in western Seychelles) (UNEP 2004). The Seychelles Bank and Mauritius form the ends of the crescentic Mascarene Plateau where the ocean shoals to less than 200 m. All countries except Madagascar are classified as SIDS, acknowledged to be especially dependent on their coastal and marine resources. All have large EEZs in relation to their land areas. The combined EEZs cover an ocean area of approximately 3.8 million km², while the total land cover is only 586 250 km², of which Madagascar constitutes about 99 per cent (UNEP 2004).

The seas are endowed with rich and varied coastal and marine ecosystems, including parts of the Somali Current and Agulhas Current LMEs. There are extensive coral reefs, covering some 5 000 km², with 320 species of hard corals (UNEP-WCMC 2000, Ahamada, and others 2004, Figure 1) and, notably on Madagascar, coastal wetlands. The reefs constitute an important resource for fishing, tourism and recreation, as well as providing protection to vulnerable shores against potentially damaging waves. There are many endemic species, as well as endangered species including turtles, dugongs and cetaceans.

Coral reefs collectively cover an area of more than 5 000 km², with 320 species of hard corals. They constitute an important resource for fishing, tourism and recreation, as well as providing protection to vulnerable shores against potentially damaging waves (Ahamada, and others 2004). Fringing reef almost completely surrounds the islands of Mauritius (including Rodrigues) and the Comoros islands, while many fringing and patch reefs occur around the granitic islands of the Seychelles. The island of Aldabra, a designated World Heritage site (UNESCO 2005) in the western Seychelles, is a classic atoll. In Madagascar there are extensive coral reefs in the south-western and northern parts of the island (UNEP-WCMC 2000), all affected by the bleaching event of 1998 as a result of unusually high sea-surface temperatures. Live coral cover was reduced to less than 10 per cent around some of the Seychelles' granitic islands, while Mauritius was relatively lightly affected (Linden and Sporrong 1999).

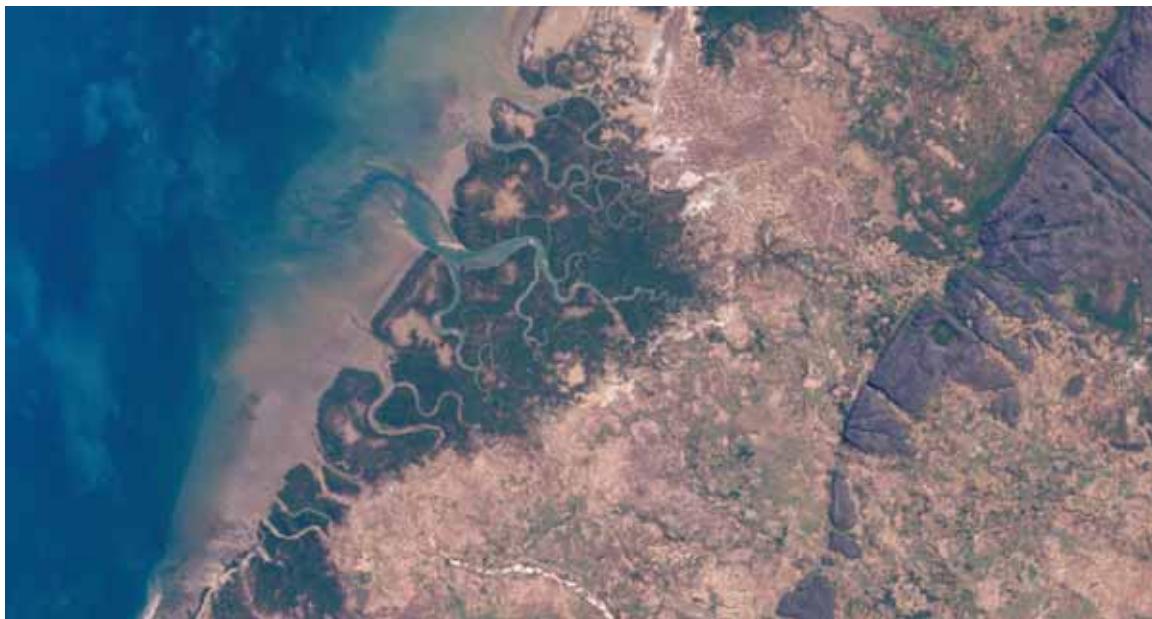
The deep waters surrounding the Comoros are home to the coelacanth, a living representative of a family of fish known to have existed 370 million years ago (UNEP 2002b). Coelacanths have also been reported in the adjoining waters of Southern Africa and are the subject of a regional project, the African Coelacanth Ecosystem Programme (ACEP 2004). Coastal wetlands are extensive in Madagascar where mangroves cover an estimated 340 000 ha. More than 30 km² of mangrove stands are present in the Comoros (UNEP 2004). In the



Coastal reef formations

Coral reefs form the fringes of extensive lagoonal platforms at Tanjoni'i Masoala, south-eastern Madagascar.

Source: NASA 2001



Northern Madagascar

Mangrove forest (dark green) cut by tidal creeks. River discharges into the sea carry a high suspended sediment load.

Source: NASA 2000

Seychelles, remaining mangrove totals only 29 km², the largest areas being on the western islands, including Aldabra (Taylor and others 2003). In the sub-region as a whole, there are 15, mostly coastal, MPAs, established for different purposes and with different styles of management (Francis and others 2002, UNEP 2004).

All the countries have important marine fisheries resources. In addition to the inshore and reef fisheries traditionally exploited by artisanal fishers, the fisheries resources include the offshore demersal fishery of the banks of the Mascarene Plateau and the Chagos Archipelago, as well as extensive oceanic tuna fisheries that support commercial industries in Mauritius and the Seychelles.

Offshore geophysical and geological exploration for oil has taken place on the Seychelles Bank since the 1970s, with minor exploration drilling (SNOC 2000). The geochemical analyses and exploration data from its offshore acreage indicate potential for commercial production (MBendi 2005b). In 2005, an agreement was signed for exploration rights around Constant, Topaz, Farquhar and Coetivy islands (EIA 2005). There are no known oil and gas reserves in Mauritius. In Madagascar, the existence of oil and gas reserves has been confirmed; Bemolanga and Tsimiroro are exhumed oil fields, while numerous other wells include oil shows (MBendi 2005a). It has a modest production of crude and gas (MBendi 2005a), with reserves of 70 x 10⁹ cubic feet of natural gas (EIA 2005). A field off the

west coast containing heavy oil was proved in 2003, but deemed to lie too deep and to be too heavy to be commercially viable. Offshore exploration has continued over the last decade in the Majunga basin, off the west coast (EIA 2005).

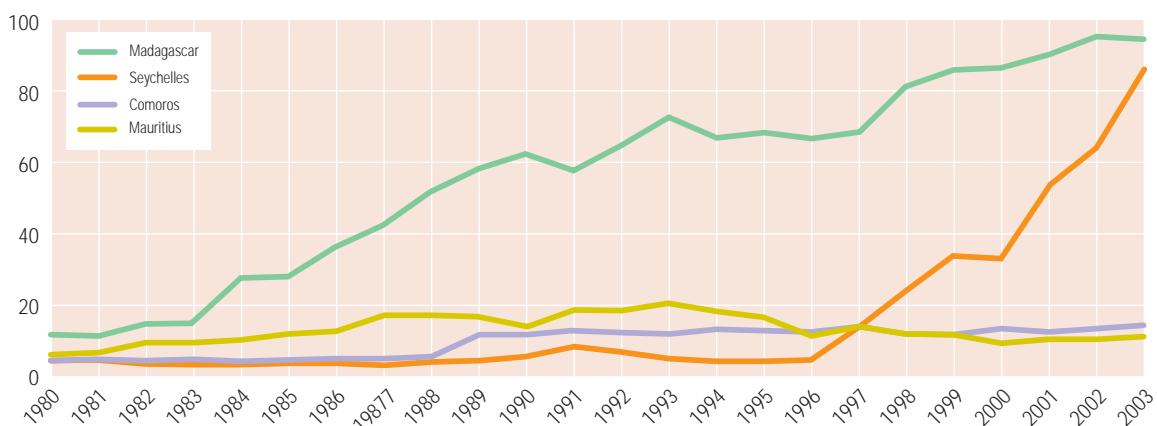
Box 11: Tourism benefits local people and conservation

One way of promoting conservation at community level is to ensure that local people benefit financially from protected areas. In addition, those who may have become poachers or who would have opposed the management of the protected area receive legitimate livelihoods. Cousin, a small island in the Seychelles, is a good example. This sea-and-island reserve was established by law in 1968, and run by an NGO, Nature Seychelles, who developed an ecotourism initiative in 1972. It has grown to become a modern practice run under internationally accepted principles. It has won numerous accolades, including the Condé Nast Ecotourism Award for 1994. A wholly Seychellois team runs the Reserve and only local people are involved in ecotourism there, ranging from small boat operators to larger tour organizations. Other small businesses on the neighbouring island of Praslin, such as shops, cargo service, mechanics, small contractors and boatyards, also benefit from business associated with Cousin. Poaching is virtually zero. Ecotourism brings sufficient revenues to run the Reserve and also for implementation of other conservation and educational programmes including the Local Environment Action Program (LEAP) and the Special Program on Learning and Awareness on Species and Habitats (SPLASH).

Source: Shah 2002

Figure 12: Reported marine fish catches in the Western Indian Ocean Island countries since 1980

thousand metric tonnes



Fishery production relates to catch of aquatic organisms, taken for commercial, industrial, recreational and subsistence purposes from inland, brackish and marine waters. The harvest from mariculture, aquaculture and other kinds of fish farming is also included. Catches of fish, crustaceans and molluscs are expressed in live weight, that is the nominal weight of the aquatic organisms at the time of capture. To assign nationality to catches, the flag of the fishing vessel is used, unless the wording of chartering and joint operation contracts indicates otherwise.

Source: FAO Fisheries Department, *Fishery Information, Data and Statistics Units*

ENDOWMENTS AND OPPORTUNITIES

The island states are valued for their outstanding natural beauty and tropical biodiversity, but are under pressure from land-based pollution and degradation of coastal wetlands and beaches. Tourism is already a major foreign exchange earner and is becoming increasingly important, particularly in the Seychelles and Mauritius. Directly and indirectly, tourism accounts for much of the employment in the SIDS, for women as well as men. The Seychelles already has a buoyant tourist industry, currently with a maximum of about 130 000 tourists per year. It is planned to increase arrivals to 200 000 by 2010 (UNEP 2004). The

Seychelles' tourism economy (direct and indirect impact) in 2005 was expected to account for 60.2 per cent of GDP and 76.7 per cent of total employment (WTTC 2005) and was expected to grow by 14.0 per cent in 2005. Mauritius' tourism in 2005 was expected to account for 31.6 per cent of GDP and 33.9 per cent of total employment. It was expected to grow by 12.7 per cent in 2005. Tourism in Madagascar and the Comoros is less developed, but both countries have a great development potential, with tourism the primary foreign exchange earner in Madagascar (UNEP 2004).

Fisheries contribute significantly to all the national economies. Stocks within EEZs are exploited under licence by foreign fleets and licence fees form a significant proportion of national revenue (FAO 2004a). The fisheries are known to be nearly fully exploited and overfishing may have already occurred in many coastal areas, with most of the largely artisanal coastal fisheries being exploited beyond their MSY (UNEP 2004). Overall catches have increased over the past three decades to a level that has been more or less stable in recent years, but with a decline in Mauritius and the Comoros (Figure 12, FAO 2004b). There is scope for improvement in the quality of fisheries catch data for the purposes of policy making and management. Some marine fisheries may have scope for development, subject to enforcement of regulation at national and international levels. In the Seychelles, where there is now a highly developed tuna industry, including a canning factory employing 1 800 workers (FAO 2001b), fishing has become the largest earner after tourism,

Box 12: Science in support of management

Complex decision-making processes are required for managing coastal and marine environments. In the WIO region these are generally weakened by inadequate information and research inputs. Therefore, it is essential that appropriate scientific information is available for the assessment of impacts, and that a sound scientific base exists which can accommodate the changing needs of management institutions, as well as society at large, and upon which policies and practices of resource management can be built. Consequently, input from the scientific community needs to be developed in collaboration with relevant stakeholders. In addition to the information needs, it is necessary that research capacity-building is continued to meet long-term scientific development and the environmental needs of the region.

Source: WIOMSA 2005

contributing 12-15 per cent to GDP (Seychelles Fishing Authority, unpublished data). Licence fees of US\$8 million are collected every year, with income from indirect expenditure (port dues, food supplies, services, etc.) amounting to over US\$2 million. The Seychelles particularly, but also Mauritius, have important canning and transhipment facilities for tuna.

Aquaculture is a developing industry in all countries except the Comoros. The islands' coastlines are well suited for several types of aquaculture development (Rönnbäck and others 2002). Such developments present scope for increasing food security, in particular for coastal populations, and provide new sources of income for local economies and export markets. In Madagascar, there has been extensive conversion of coastal wetlands and mangrove areas to pond culture (UNEP 2004). In Mauritius, commercial aquaculture, mostly in freshwater ponds, consists of the production of giant freshwater prawns and red tilapia (FAO 2000).

CHALLENGES FACED IN REALIZING DEVELOPMENT OPPORTUNITIES

All countries are signatories to the UNEP-administered Nairobi Convention, which has a cooperative and coordinated approach to protection and enhancement of the marine and coastal environment. Similar resource development objectives are iterated specifically for SIDS in the Mauritius Strategy for the Implementation of the Programme of Action for the Sustainable Development of Small Island Developing States (UNEP 2005b).

Major efforts are needed to regulate the pressures that are now leading to extensive habitat loss and degradation (UNEP/GPA and WIOMSA 2004). The tasks involve sea-use and catchment management as well as the management of coastal resources. The island states have made considerable strides in establishing effective resource management (Ahamada and others 2004). In Mauritius, new MPAs have been proclaimed, with supporting regulations and long-term monitoring of coral and fish communities, and in the Comoros, management of the environment and coastal zone has become a priority. Madagascar has adopted regulations to protect the natural environment, including marine areas, while the Seychelles has a national environmental management plan as well as a national biodiversity action plan that guides marine and terrestrial biodiversity conservation.

Concerns over the impacts of tourism development on the environment in some countries, including Mauritius and the Seychelles, are to be addressed through UNEP in a major GEF-funded project entitled



North-western Madagascar

Suspended sediment run-off discharged to the sea reflects high levels of soil erosion in the hinterland.

Source: NASA 2001

Reduction of Environmental Impact from Coastal Tourism through Introduction of Policy Changes and Strengthening Public-Private Partnerships. This initiative recognizes the importance of protecting the attractiveness of the coastal resources in order to sustain the tourism market in the long term. The development of tourism is creating new coastal nodes, as at Grande Baie in Mauritius. However, this type of development is often poorly controlled and is leading to the deterioration of coral reefs and the loss of the natural tourism attraction. Much of the original coastline has been physically altered, and habitats destroyed by dredging and filling operations and the sediment plumes which they generate. Pollution due to the improper disposal of solid waste and eutrophication, due to poor sewage treatment, were identified as severe concerns in the Indian Ocean Islands GIWA assessment (UNEP 2004). In Mauritius, preliminary surveys indicate damaging nutrient levels in many areas, which may have caused the development of six red tides in 1996 in the Trou-aux-Biches area. The coastal impacts of the widespread use of nitrate fertilizers and pesticides in the island's agriculture raise particular concerns. Two major GEF-funded projects relate to pollution in the coastal and marine environment. Land-based activities impacting on coastal and marine resources are being addressed through UNEP under the Western Indian Ocean Land-based Activities Project (WIO-LaB) (WIO-LaB 2005), and the problems of oil spills are being covered by the Western Indian Ocean Islands Oil Spill Contingency Planning project.

Coral reefs continue to suffer pressures from increasing populations, coastal development and marine-transported litter (Ahamada and others 2004, UNEP 2004). Mining of coral and sand for use in construction is also damaging habitats, with most states implementing stricter legislation and licensing. Intensive tourism is thought to be damaging to reef habitats by pollution from boats, hotels and other facilities, and by anchor damage, trampling and removal of coral as souvenirs. Degradation of coral reefs is especially detrimental to the dive tourism industry. Fishing with dynamite, a common practice in the Comoros despite awareness campaigns, threatens coastal ecosystems. Stresses on reefs have been exacerbated by coral bleaching events (Ahamada and others 2004). Since the 1998 event, which reduced live hard coral cover on many reefs to less than 5 per cent, there have been further, though smaller, damaging episodes. Some reefs are showing recovery. Further pressures come from agriculture, where nutrients and sediments are discharged at the coast, particularly during cyclones. In Madagascar, deforestation is exacerbating soil erosion and sediment run-off (UNEP 2004, UNEP 2005a).

Overexploitation of the inshore and reef artisanal fisheries, including the non-selective and destructive practices of dynamite fishing, purse-seining and dragnetting, is a serious issue (UNEP 2004). The offshore fisheries have provided strong growth in production

over the last two decades. However, there is an urgent need to develop institutional capacity in the region to address the problems facing fisheries, with an emphasis on regional institutions to deal with transboundary and highly migratory stocks, and to cope with high seas issues. The major challenges to productivity and biodiversity in the region's fisheries stem from a lack of regional cooperation and political will, poor monitoring and scientific capacity, and inadequate compliance structures. Biodiversity issues include concern over the large catches of non-target, endangered species, especially turtles, dolphins and dugongs. In the Seychelles, by-catch in the industrial tuna fishery constitutes 25-30 per cent of the catch. The unregulated development of coastal aquaculture could pose serious environmental threats and cause conflict amongst coastal communities. The practice of mangrove clearance for the construction of prawn ponds is a particular issue in Madagascar (UNEP 2004).

Improving management demands investing in and building local capacity in all sectors of the fishing industry, to reduce the reliance on distant water fleets and to adopt regional approaches to fisheries management. A long-term project due to begin in 2006 – the GEF-World Bank-supported South West Indian Ocean Fisheries Project (SWIOFP), designed to interface with a GEF-UNDP initiative to study the Agulhas Current and Somali Current LMEs – should bring an unprecedented level of scientific and management cooperation. In another project, a framework for regional fisheries management of non-tuna species is being developed, through the establishment of the South West Indian Ocean Fisheries Commission (SWIOFC). A non-binding coastal arrangement is in place within this framework, and negotiations are under way for a binding high seas arrangement.

Coastal erosion due to the impact of large waves is a major issue and has serious implications for tourism development. The extent to which upward reef growth and platform sedimentation might keep pace with sea-level rise is unknown, but it is likely that the protection from large waves offered by reefs will become less effective. In the extreme case of the Indian Ocean tsunami impact of 26 December 2004, damage in the Seychelles was estimated at US\$30 million (UNEP 2005a). Even where shores are fringed by extensive reef platforms and lagoons, as around Mauritius, they may be susceptible to erosion. The most critical coasts are those formed by low-lying beach plains, where former beach sands have accreted on rock platforms (the so-called "plateau" sands of the Seychelles islands such as Praslin and La Digue) (Kairu and Nyandwi 2000,

Box 13: Ecological restoration of islands in the Seychelles

The environment of most of the islands of the Western Indian Ocean has been severely degraded. An island restoration programme, initiated in 1999 in the Seychelles, points the way to sustainable mechanisms of island restoration. A collaborative effort between an NGO, Nature Seychelles, private island owners and the Seychelles government, the programme is ongoing. Components include biological assessment of islands, socioeconomic valuation of restored ecosystems and ecotourism, cost analysis of restoration and maintenance, education and awareness, island management plans, removal of alien predators and other invasive alien species, establishment or rehabilitation of native coastal habitats and translocation of globally threatened endemic species. Islands in the programme include Frégate, North and Denis islands, private 5-star hotel resorts. Establishment of new populations of endangered species will not only lead to the downgrading of the threat status of these species on the IUCN Red List, but also to enhancing ecotourism potential, thus inducing hotel owners to contribute to conservation efforts. The programme has been financed by the GEF, the Seychelles government and island owners, and has involved international partners such as BirdLife International.

Sources: Shah 2001, Henri and others 2004

UNEP/GPA 2004). Attempts have been made to stabilize shorelines in the Seychelles by the installation of groynes, and in Mauritius by the use of rock-filled wire gabions. The erosion of beaches and non-rocky beachhead materials is likely to be aggravated by rising eustatic sea level and an increasing frequency of storm surge events arising from global climate change (IPCC 2001). In the Seychelles, a national beach monitoring programme was launched in 2003.

CONCLUSION

The continuing capacity of the region's coastal and marine ecosystems to provide the goods-and-services that are essential to human well-being will depend on the effectiveness of ecosystem management in response to the pressures of global change. Such management requires reliable monitoring information gathered from community to global levels and needs to be supported by nationally and internationally relevant legislation. Robust governance and institutional capacity, and the cooperative integration of sectoral interests at all scales, are essential. Response and compliance mechanisms should involve education as well as local and cultural knowledge. The enforcement of international agreements need to be strengthened, along with the promotion of public awareness and the enhancement of capacity for implementation, surveillance and enforcement, using remote sensing techniques as appropriate. Key research aims are to improve understanding of the causal linkages within, and affecting, the coastal and marine ecosystems, and of the value of the ecosystem's services to humanity in order to appropriately inform policymakers and to provide the information that resource managers need to act effectively within policy frameworks (Crossland and others 2005).

The development and application of integrated coastal management (ICZM or ICAM) plans should be promoted, with strong inter-sectoral and international linkages, including those with catchment management authorities with responsibilities for Integrated Water Resource Management (IWRM). The impacts of reduced freshwater and sediment discharge from rivers on coastal ecosystems and stability are a particular concern.

Action in terms of consultation, coordination and the implementation of relevant legislation, at various levels, is urgently needed to halt the degradation of coastal and marine fisheries (industrial, subsistence and artisanal) and to restore their sustainability for the



Nature protection programme in the Seychelles. Sea turtle nests are registered and hatched turtle young are escorted to the sea.

Source: J. Tack/Still Pictures

benefit of coastal communities and national economies. Effective monitoring and surveillance capacity will be needed to achieve this goal. Remedial measures need to be agreed at the international and ecosystem levels, with a clear understanding of the long-term negative consequences for human well-being of non-compliance. Regional cooperation, such as the BCLME programme (Box 6), in the management of widespread or shared migratory stocks should be seen as essential rather than only an opportunity. Protection of artisanal fisheries in the face of population pressure and industrial-scale fishing is an urgent issue and directly impacts on well-being and the ability of countries to meet the income and nutritional targets of the MDGs. Recognizing the potential for aquaculture development, appropriate regulations are needed to protect coastal ecosystems, and to promote sustainable production practices.

Management of existing protected areas requires increased public awareness, financial support and political will, with stronger enforcement of national and international laws. Coral reefs and coastal wetlands must be rigorously protected within an integrated management framework, involving local fishermen in monitoring where feasible.

Water- and airborne pollution control measures, including coastal and catchment point and diffuse sources, as well as offshore oil and gas fields, should be obligatory, with financial incentives for compliance and penalties for non-compliance. The issues of solid waste management and of marine-transported litter impacting shores need urgent attention, particularly as they affect SIDS. The latter requires international cooperation, with a strengthening of adherence to MARPOL – the Convention for the Prevention of Pollution from Ships.

The management of coastal erosion and marine inundation in the context of global climate change is a particularly difficult challenge, involving cooperation at local to global levels, as well as the adoption of interlinkages approaches as discussed in Chapter 8: *Interlinkages: The Environment and Policy Web*. Long-term planning for adaptation to sea-level rise and increased storminess should be instituted by all coastal managers, especially urban authorities. Coastal development, including tourism infrastructure, should reflect a shoreline's susceptibility to change, with appropriate setback regimes and the relocation of vulnerable communities.

Much of the region's coastline is exposed to extreme tsunami waves and to storm-driven marine surges that generate unusually high sea levels. Learning from the lessons of the Indian Ocean tsunami of December 2004, the development of an early warning system for these extreme marine hazards should be a priority, as well as the promotion of public awareness and emergency procedures.

References

- Abdellatif, E. M. (1993). A Call for Attention: Factors Threatening the Marine and Coastal Environment of the Red Sea in Sudan. Sudanese Environment Conservation Society, Khartoum.
- Abdelrehim, A. (2004). Developing a Decision Support System for Environmentally Sensitive Areas. Proceedings of the Expert Group Meeting on the Integrated Management of Coastal Areas of the Mediterranean Basin and the Black Sea. Trieste, Italy. 13-15 December.
- ACEP (2004). The African Coelacanth Ecosystem Programme (ACEP). <http://www.acep.co.za/>
- Acreman, M.C. (2005). Environmental flows: flood flows. In *Water Resources and Environment Technical Notes* (eds. Davis, R. and Hirji, R.), C.3. The World Bank, Washington, D.C. [http://lnweb18.worldbank.org/ESSD/ardext.nsf/18ByDocName/EnvironmentalFlowAssessment-NOTEC3EnvironmentalFlowsFloodFlows/\\$FILE>NoteC3EnvironmentalFlowAssessment2003.pdf](http://lnweb18.worldbank.org/ESSD/ardext.nsf/18ByDocName/EnvironmentalFlowAssessment-NOTEC3EnvironmentalFlowsFloodFlows/$FILE>NoteC3EnvironmentalFlowAssessment2003.pdf)
- Ahamada, S., Bijoux, J., Bigot, L., Cauvin, B., Koonjul, M., Maharavo, J., Meunier, S., Moine-Picard, M., Quod, J., and Pierre-Louis, R. (2004). Status of the coral reefs of the South West Indian Ocean Island States. In *Status of Coral Reefs of the World: 2004* (ed. Wilkinson, C.), Vol. 1. <http://www.aims.gov.au/pages/research/coral-bleaching/scr2004/pdf/scr2004v1-07.pdf>
- Alder, J. and Sumaila, U.R. (2004). Western Africa: A fish basket of Europe past and present. *Journal of Environment and Development*. 13(2), 156-78
- Alm, A. (2002). Integrated Coastal Zone Management in the Mediterranean: From Concept to Implementation – Towards a Strategy for Capacity Building in METAP Countries. Mediterranean Environmental Technical Assistance Program. [http://lnweb18.worldbank.org/mna/mena.nsf/Attachments/ICZM+Strategy/\\$File/ICZM+strategy.pdf](http://lnweb18.worldbank.org/mna/mena.nsf/Attachments/ICZM+Strategy/$File/ICZM+strategy.pdf)
- APASA (2004). Quantitative Oil Spill Risk Assessment for the Chinguetti production wells, offshore Mauritania, North West Africa. Asia-Pacific Applied Science Associates. <http://www.woodside.com.au/NR/rdonlyres/e45mv2l4fv7h2lsaezda7dansba3oycdyচhi4a245xabovbqjij03uzsz5k5fvcdas5bkohz5ipyphntnraegzrdzxaa/6D+-+Technical+Report++Oil+Spill+Modelling.pdf>
- Arthurton, R.S., Kremer, H.H., Odada, E., Salomons, W. and Marshall Crossland, J.I. (eds. 2002). African Basins: LOICZ Global Change Assessment and Synthesis of River Catchment – Coastal Sea Interaction and Human Dimensions. LOICZ Reports & Studies No. 25. Land-Ocean Interactions in the Coastal Zone, Texel. http://www.loicz.org/public/loicz/products/r_and_s/report25.pdf
- BCLME (2003). The Benguela Current Large Marine Ecosystem Programme (BCLME). <http://www.bclme.org>
- Benkaddour, R. (1997). Contribution à l'étude de la salinité et de la pollution par les nitrates des eaux souterraines de la plaine des Triffa (Basse Moulouya). Masters thesis, Univ. Mohamed 1^{er}, Oujda
- Burke, L., Kura, Y., Kassem, K., Revenga, C., Spalding, M.D. and McAllister, D. (2001). *Pilot Analysis of Global Ecosystems: Coastal Ecosystems*. World Resources Institute, Washington D.C.
- Carbone, F. and Accordi, G. (2000). The Indian Ocean Coast of Somalia. *Marine Pollution Bulletin*. 41 (1-6), 141-59
- Coffen-Smout, S. (1998). Pirates, Warlords and Rogue Fishing Vessels in Somalia's Unruly Seas. <http://www.chebucto.ns.ca/~ar120/somalia.html>
- Crossland, C.J., Kremer, H.H., Lindeboom, H.J., Marshall Crossland, J.I. and Le Tissier, M.D.A. (eds. 2005). *Coastal Fluxes in the Anthropocene – The Land-Ocean Interactions in the Coastal Zone Project of the International Geosphere-Biosphere Programme*. Global Change – the International Geosphere-Biosphere Program Series. Springer, Berlin.
- EEAA (2002). Annual Report on Water Quality Data from the Coastal Waters of the Mediterranean Sea, Year 2000. Egyptian Environmental Affairs Agency. http://www.eeaa.gov.eg/eimp/reports/EIMP%20Med_%20water%20rep_2.pdf
- EIA (2005). Country Analysis Briefs. Energy Information Administration. http://www.eia.doe.gov/emeu/cabs/Region_af.html
- El Gamal, A.R. (2001). Status and development trends of aquaculture in the Near East. In *Aquaculture in the Third Millennium*. Technical Proceedings of the Conference on Aquaculture in the Third Millennium, Bangkok, Thailand, 20-25 February 2000. (eds. Subasinghe, R.P., Bueno, P., Phillips, M.J., Hough, C., McGladdery, S.E. and Arthur, J.R.), pp. 357-76. Network of Aquaculture Centres in Asia Pacific. Bangkok and Food and Agriculture Organization of the United Nations, Rome. http://www.fao.org/documents/show_cdr.asp?url_file=/DOCREP/003/AB412E/ab412e22.htm

Chapter 5 • Coastal and Marine Environments

- El Raey, M., Dewidar, K. and El Hattab, M. (1999). Adaptation to the impacts of sea-level rise in Egypt. *Climate Research*. 12 (2-3), 117-28. <http://www.int-res.com/articles/cr/12/c012p117.pdf>
- FAO (2005). FAOSTAT Database. Fisheries Data. Food and Agriculture Organization of the United Nations. <http://faostat.fao.org/faostat/collections?version=ext&hasbulk=0&subset=fisheries>
- FAO (2004a). *FAO and SIDS: challenges and emerging issues in agriculture, forestry and fisheries*. Paper prepared by Food and Agriculture Organization of the United Nations on the occasion of the Inter-Regional Conference of Small Island Developing States. Bahamas, 26-30 January 2004. Food and Agriculture Organization of the United Nations, Rome. <ftp://ftp.fao.org/docrep/fao/006/y5203E/y5203E00.pdf>
- FAO (2004b). Djibouti profile – fishery country profile. Food and Agriculture Organization of the United Nations. <http://www.fao.org/fi/fcp/en/DJI/profile.htm>
- FAO (2003a). Algeria profile – fishery country profile. Food and Agriculture Organization of the United Nations. <http://www.fao.org/fi/fcp/fr/DZA/profile.htm>
- FAO (2003b). Egypt profile – fishery country profile. Food and Agriculture Organization of the United Nations. <http://www.fao.org/fi/fcp/en/EGY/profile.htm>
- FAO (2002a). Eritrea profile – fishery country profile. Food and Agriculture Organization of the United Nations. <http://www.fao.org/fi/fcp/en/ERI/profile.htm>
- FAO (2002b). Sudan profile – fishery country profile. Food and Agriculture Organization of the United Nations. <http://www.fao.org/fi/fcp/en/SDN/profile.htm>
- FAO (2002c). The State of World Fisheries and Aquaculture. Food and Agriculture Organization of the United Nations, Rome. <ftp://ftp.fao.org/docrep/fao/005/y7300e/y7300e00.pdf>
- FAO (2001a). Kenya profile – fishery country profile. Food and Agriculture Organization of the United Nations. <http://www.fao.org/fi/fcp/en/KEN/profile.htm>
- FAO (2001b). Seychelles profile – fishery country profile. Food and Agriculture Organization of the United Nations. <http://www.fao.org/fi/fcp/en/SYC/profile.htm>
- FAO (2000). Mauritius profile – fishery country profile. Food and Agriculture Organization of the United Nations. <http://www.fao.org/fi/fcp/en/MUS/profile.htm>
- Francis, J. and Torell, E. (2004). Human dimensions of coastal management in the Western Indian Ocean region. *Ocean and Coastal Management*. 47 (7-8), 299-307
- Francis, J., Nilsson, A. and Waruinge, D. (2002). Marine Protected Areas in the Eastern African Region: How Successful Are They? *Ambio*. 31 (7-8), 503-11
- GAFRD (2003). *Annual Statistical Report*. General Authority for Fishing Resources Development, Cairo
- Government of South Africa (1998). Coastal Policy Green Paper: Towards Sustainable Coastal Development in South Africa. <http://www.info.gov.za/greenpapers/1998/coastalpolicy.htm>
- Groombridge, B. and Jenkins, M. (2002). *World Atlas of Biodiversity: Earth's Living Resources in the 21st Century*. University of California Press, Berkeley
- Hamerlynck, O. (1999). Use and abuse of deltas. *World Conservation*. 2/99, 11-12. <http://www.iucn.org/bookstore/bulletin/1999/wc2/content/deltas.pdf>
- Harrison, P. and Pearce, F. (2001). *AAAS Atlas of Population and Environment*. American Association for the Advancement of Science. University of California Press, California <http://www.ourplanet.com/aaas/pages/about.html>
- Hatzilios, M., Lunden, C.G. and Alm, A. (1996). Africa: A Framework for Integrated Coastal Zone Management. Second edition. The World Bank, Washington, D.C.
- Henri, K., Milne, G.R. and Shah, N.J. (2004). Costs of ecosystem restoration on islands in Seychelles. *Ocean and Coastal Management*. 47 (7-8), 409-28
- Imassi, S. and Snoussi, M. (2003). Historical shoreline changes at the Moulouya deltaic coast in connection with land use effects. Proceedings of the International Conference on Studying Land Use Effects in Coastal Zones with Remote Sensing and GIS (eds. Gutman, G., Maktav, D., and Erbek, F.S.), Antalia/Kemer, Turkey. 13-16 August
- IOC (2002). ODINAFRICA Countries Reports. Intergovernmental Oceanographic Commission of UNESCO. http://ioc3.unesco.org/odinafrica/files.php?action=viewcat&fcat_id=116
- IPCC (2001). Technical Summary, *Climate Change 2001: Impacts, Adaptation and Vulnerability*. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Intergovernmental Panel on Climate Change. Cambridge University Press, New York. http://www.grida.no/climate/ipcc_tar/wg2/pdf/wg2TARtechsum.pdf
- IUCN (2003a). Regional Strategy for Marine Protected Areas in West Africa. IUCN – The World Conservation Union. <http://www.iucn.org/places/mauritania/PRCM/Trilangue/ENGLISH/STRATEGY.pdf>
- IUCN (2003b). TANA RIVER, KENYA: Integrating downstream values into hydropower planning. Case Studies in Wetland Valuation, No.6, May 2003. IUCN – The World Conservation Union. <http://www.iucn.org/themes/wani/econ/CaseStudy06Tana.pdf>
- IUCN (2002). Parc National de Diawling. IUCN – The World Conservation Union. <http://www.iucn.org/places/mauritania/pnd/zone-riche.html>
- IUCN, UNEP and ICAN (2004). Assessment of managed effectiveness in selected marine protected areas in the Western Indian Ocean: Final Report. IUCN – The World Conservation Union, United Nations Environment Programme and the International Coral Reef Action Network. http://www.icran.org/pdf/ICAN_IUCN_ME_study_Eastern_Africa.pdf
- Jallow, B.P., Barrow, M.K.A. and Leatherman, S.P. (1996). Vulnerability of the coastal zone of the Gambia to sea-level rise and development of response strategies and adaptation options. *Climate Research*. 6 (2), 165-77
- Kairu, K. and Nyandwi, N. (eds. 2000). *Guidelines for the Study of Shoreline Change in the Western Indian Ocean Region*. IOC Manuals and Guides No. 40. United Nations Educational, Scientific and Cultural, Paris. <http://unesdoc.unesco.org/images/0012/001219/121963Eb.pdf>
- Khattabi, A. (2002). Etude socioéconomique de l'embouchure de la Moulouya. Rapport provisoire, MedWetCoast, Maroc
- Kotb, M., Abdulaziz, M., Al-Agwan, Z., Alshaikh, K., Al-Yami, H., Banajah, A., Devantier, L., Eisinger, M., Eltayeb, M., Hassan, M., Heiss, G., Howe, S., Kemp, J., Klaus, R., Krupp, F., Mohamed, N., Roushail, T., Turner, J. and Zajonc, U. (2004). Status of the coral reefs in the Red Sea and Gulf of Aden. In *Status of Coral Reefs of the World: 2004* (ed. Wilkinson, C.), Vol. 1. <http://www.aims.gov.au/pages/research/coral-bleaching/scr2004/pdf/scr2004v1-04.pdf>
- Lindeboom, H. (2002). The Coastal Zone: An Ecosystem Under Pressure. In *Oceans 2020: Science, Trends and the Challenge of Sustainability* (eds. Field, J.G., Hempel, G., and Summerhayes, C.P.), pp. 49-84. Island Press, Washington

- Linden, O. and Sporrøgård, N. (eds. 1999). Coral Reef Degradation in the Indian Ocean – status report and project presentations 1999. Coral Reef Degradation in the Indian Ocean, Stockholm, Sweden.
http://www.cordio.org/reports/CORDIO_Status_Report_1999.pdf
- MA (2005). *Ecosystems and Human Well-being: Biodiversity Synthesis*. Millennium Ecosystem Assessment. Island Press, Washington, D.C.
<http://www.millenniumassessment.org/en/Products.Synthesis.aspx>
- Malleret-King, D., King, A., Mangubhai, S., Tunje, J., Mueni, E. and On'ganda, H. (2003). Review of Marine Fisheries Resources for Kenya. Understanding Fisheries Livelihoods and Constraints to their Development, Kenya & Tanzania (Annex 1.2). FMSP Project R8196: Understanding Fisheries Associated Livelihoods and the Constraints to their Development in Kenya and Tanzania. DFID.
- Malleret-King, D. (2003a). Livelihood Appraisal (Annex 2). In: FMSP Project R8196: Understanding Fisheries Associated Livelihoods and the Constraints to their Development in Kenya and Tanzania. DFID.
- Malleret-King, D. (2003b). Comparative Analysis (Annex 4). In: FMSP Project R8196: Understanding Fisheries Associated Livelihoods and the Constraints to their Development in Kenya and Tanzania. DFID.
- MBendi (2005b). An Mbendi Profile: Seychelles: Oil and Gas Industry – Overview. <http://mbendi.co.za/indy/oilg/af/se/p0005.htm>
- MBendi (2005a). An Mbendi Profile: Madagascar: Oil and Gas Industry – Overview. <http://mbendi.co.za/indy/oilg/af/md/p0005.htm>
- METAP (2004). Mediterranean Environmental Technical Assistance Programme. The World Bank, Washington, D.C. <http://www.metap.org>
- Milliman, J.D. (1997). The effect of terrestrial and human activities on river discharge and their impact on the coastal zone. In *Coastal Zone Management Imperative for Maritime Developing Nations* (eds. Haq, B.U., Haq, S.M., Kullenberg G., and Stel, J.H.), pp. 75-92. Kluwer Academic Publishers, Dordrecht/Boston
- Monteiro, P.M.S. and Kemp, A (2004). Water quality Management Plan for Saldanha Bay. Phase III: Setting of critical loads using a modelling-based ecosystem approach. CSIR Report ENV-C-S 2004-083. CSIR Environmentek, Stellenbosch, South Africa.
- Monteiro, P.M.S. and Largier, J.L. (1999). Thermal stratification in Saldanha Bay (South Africa) and subtidal, density-driven exchange with the coastal waters of the Benguela upwelling system. *Estuarine, Coastal and Shelf Science*. 49(6), 877-90
- Monteiro, P.M.S. and Mathews, S. (2003). Catchment2Coast: Making the link between coastal resource variability and river inputs. *South African Journal of Science*. 99, 299-301. <http://www.catchment2coast.org/upload/pub53.pdf>
- National Museums of Kenya (undated). Gede Museum.
<http://www.museums.or.ke/reggede.html>
- Nippon Koei (1994). Socio-economic baseline survey. Unpublished report prepared for Tana Delta Irrigation Project, Nairobi.
- NOAA (2004). Somali Current Large Marine Ecosystem, LME No.31. United States National Oceanic and Atmospheric Administration.
<http://na.nefsc.noaa.gov/lme/text/lme31.htm>
- NOAA (2003a). Guinea Current Large Marine Ecosystem, LME No.28. United States National Oceanic and Atmospheric Administration.
<http://na.nefsc.noaa.gov/lme/text/lme28.htm>
- NOAA (2003b). Mediterranean Sea Large Marine Ecosystem, LME No.26. United States National Oceanic and Atmospheric Administration.
<http://na.nefsc.noaa.gov/lme/text/lme26.htm>
- Obura, D. (2004). Biodiversity Surveys of the Coral Reefs of the Mnazi Bay Ruvuma Estuary Marine Park. IUCN – The World Conservation Union Eastern Africa Regional Office, Nairobi
- Obura, D., Church, J., Daniels, C., Kalombo, H., Schleyer, M. and Suleiman, M. (2004). Status of Coral Reefs in East Africa 2004: Kenya, Tanzania, Mozambique and South Africa. In *Status of Coral Reefs of the World: 2004* (ed. Wilkinson, C.), Vol. 1. <http://www.aims.gov.au/pages/research/coral-bleaching/scr2004/pdf/scr2004v1-06.pdf>
- Ochiwo J. (2004). Changing fisheries practices and their socioeconomic implications in South Coast Kenya. *Ocean & Coastal Management*. 47(7-8), 389-408
- Pauly, D., Christensen, V., Guénette, S., Pitcher, T.J., Rashid Sumaila, U., Walters, C.J., Watson, R. and Zeller, D. (2002). Towards sustainability in world fisheries. *Nature*. 418, 689-95
- PERSGA (2005). Country report overview for Egypt. The Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden <http://www.persga.org/about/tour/Egypt.asp>
- PERSGA/GEF (2003). *Coral Reefs in the Red Sea and Gulf of Aden Surveys 1990 to 2000 Summary and Recommendations*. The Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden Technical Series No. 7. The Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden and the Global Environment Facility. The Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden, Jeddah. <http://www.persga.org/publications/technical/pdf/4%20technical%20series/ts7%20coral%20reefs%20rsga%20surveys%201990.pdf>
- Probey, T., Pitcher, G., Pienaar, R. and Nuzzi, R. (2001). Brown Tides and Mariculture in Saldanha Bay, South Africa. *Marine Pollution Bulletin*. 42(5), 405-8
- Rönnbäck, P., Bryceson, I. and Kautsky, N. (2002). Coastal aquaculture development in Eastern Africa and the Western Indian Ocean: Prospects and problems for food security and local economies. *Ambio*. 31(7-8), 537-42
- Sadki, R. (1996). Evolution spatiale et temporelle de la salinisation dans la nappe cétière de Saidia. Thèse 3^{eme} Cycle, Université Mohamed Ier, Oujda.
- Saldanha Bay Water Quality Forum Trust (2004). Bay Watch, the publication of the Trust. September 2004. Saldanha Bay, South Africa
- Seychelles Fishing Authority (2004). Annual Report for 2003. Seychelles Fishing Authority, Victoria, Seychelles. <http://www.sfa.sc/SFA%20Reports/Annual%20Reports/annual03.pdf>
- Shah, N.J. (2002). Bikinis and biodiversity: tourism and conservation on Cousin Island, Seychelles. In *Tourism, Biodiversity and Information* (eds. Castri, F. di and Balaji, V.). Backhuys Publishers, Leiden
- Shah, N.J. (2001). Eradication of alien predators in the Seychelles: an example of conservation action on tropical islands. *Biodiversity and Conservation*. 10(7), 1219-20
- Sherman, K. and Alexander, L.M. (eds. 1986). *Variability and Management of Large Marine Ecosystems*. American Association for the Advancement of Science Selected Symposia Series, No. 99. Westview Press, Boulder
- SNOC (2000). Exploration history. Seychelles National Oil Company. <http://www.snoc.sc/petroframe.htm>
- Snoussi, M. (2004). Review of certain basic elements for the assessment of environmental flows in the Lower Moulouya – Mediterranean case study. Assessment and Provision of Environmental Flows in the Mediterranean Watercourses: Basic Concepts, Methodologies and Emerging Practice. http://www.medwetcoast.com/IMG/Review_of_certain_basic_elements_for_the_assessment_of_environmental_flows_in_the_Lower_Moulouya.pdf

Chapter 5 • Coastal and Marine Environments

- Soussi, M., Haida, S. and Imassi, S. (2002). Effects of the construction of dams on the Moulouya and the Sebou rivers, Morocco. *Regional Environmental Change*. 3(1-3), 5-12
- Stenton-Dozey, J.M.E., Jackson, L.F. and Busy, A.J. (1999). Impact of mussel culture on macrobenthic community structure in Saldanha Bay, South Africa. *Marine Pollution Bulletin*. 39 (1-12), 357-366
- Taljaard, S. and Monteiro, P.M.S. (2002). Saldanha Bay marine water quality management plan. Phase I: Situation Assessment. Report to the Saldanha Bay Water Quality Forum Trust. CSIR Report ENV-S-C 2002-115/1. CSIR Environmentek, Stellenbosch, South Africa
- Taylor, M., Ravilious, C. and Green, E.P. (2003). *Mangroves of East Africa*. UNEP-WCMC Biodiversity Series No. 13. http://www.unep-wcmc.org/resources/publications/UNEP_WCMC_bio_series/13/MangrovesHR.pdf
- UNEP (2005a). *After the Tsunami: Rapid Environmental Assessment*. United Nations Environment Programme, Nairobi. http://www.unep.org/tsunami/reports/TSUNAMI_report_complete.pdf
- UNEP (2005b). *Atlantic and Indian Oceans Environment Outlook*. United Nations Environment Programme, Nairobi
- UNEP (2004). Payet, R.A., Soogun, N., Ranaivoson, E., Payet, R. J. and Ali Abdallah, F. *Indian Ocean Islands. Global International Waters Assessment, Regional Assessment 45b*. University of Kalmar, Kalmar, Sweden. http://www.giwa.net/areas/reports/r45b/giwaRegionalAssessment_45b.pdf
- UNEP (2002a). *Africa Environment Outlook: Past, Present and Future Perspectives*. United Nations Environment Programme, Nairobi
- UNEP (2002b). *Atlas des Ressources Côtières de l'Afrique Orientale, République Fédérale Islamique des Comores*. United Nations Environment Programme, Nairobi
- UNEP (2002c). *Vital Water Graphics: An Overview of the State of the World's Fresh and Marine Waters*. United Nations Environment Programme, Nairobi. <http://www.unep.org/vitalwater>
- UNEP (2001). *Eastern Africa Atlas of Coastal resources, Tanzania*. United Nations Environment Programme, Nairobi. http://www.ims.udsm.ac.tz/download/TZ_book.pdf
- UNEP (1999). Overview of Land-based Sources and Activities Affecting the Marine, Coastal and Associated Freshwater Environment in the West and Central African Region. Regional Seas Reports and Studies, No.171. United Nations Environment Programme, Nairobi. http://www.gpa.unep.org/documents/technical/rseas_reports/171-eng.pdf
- UNEP (1998). *Eastern Africa Atlas of Coastal Resources, 1: Kenya*. United Nations Environment Programme, Nairobi. <http://www.unep.org/eaf/Docs/Kenya/KEeaf14.htm>
- UNEP and EEA (1999). *State and pressures of the marine and coastal Mediterranean environment*, Environmental Issues Series No.5. United Nations Environment Programme and the European Environment Agency. <http://reports.eea.eu.int/ENVSERIES05/en/envissue05.pdf>
- UNEP/GPA (2004). Shoreline Change in the Western Indian Ocean Region: An Overview. Report prepared by Western Indian Ocean Marine Science Association (WIOMSA) for United Nations Environment Programme / Global Programme of Action, The Hague
- UNEP/GPA and WIOMSA (2004). Regional Overview of Physical Alteration and Destruction of Habitats (PADH) in the Western Indian Ocean region. A report prepared by the Western Indian Ocean Marine Science Association for United Nations Environment Programme / Global Programme of Action, The Hague.
- UNEP/GRID-Arendal (2004). UNEP Shelf Programme. United Nation Environment Programme / Global Resource Information Database – Arendal. <http://www.continentalshelf.org/>
- UNEP/MAP (1999). Identification of priority pollution hot spots and sensitive areas in the Mediterranean. MAP Technical Reports Series No. 124. United Nations Environment Programme – Mediterranean Action Plan, Athens.
- UNEP/MAP/PAP (2001). White Paper: Coastal Zone Management in the Mediterranean. United Nations Environment Programme / Mediterranean Action Plan / Priority Actions Programme. <http://www.pap-thecoastcentre.org/pdfs/ICAM%20in%20Mediterranean%20-%20White%20Paper.pdf>
- UNEP/MAP/PAP (1999). Conceptual Framework and Planning Guidelines for Integrated Coastal Area and River Basins Management. United Nations Environment Programme / Mediterranean Action Plan / Priority Actions Programme. <http://www.ucc-water.org/freshco/Docs/ICARM-Guidelines.pdf>
- UNEP-WCMC (2000). Marine Information. United Nations Environment Programme's World Conservation Monitoring Centre. <http://www.wcmc.org.uk/marine/data/index.html>
- UNESCO (2005). United Nations Educational, Scientific and Cultural Organization – World Heritage Centre – World Heritage List. United Nations Educational, Scientific and Cultural Organization. <http://whc.unesco.org/en/list>
- URI (2003). Large Marine Ecosystems of the World – LME #27: Canary Current. University of Rhode Island. <http://www.edc.uri.edu/lme/Text/canary-current.htm>
- Wagner, G.M. (2004). Coral reefs and their management in Tanzania. *Western Indian Ocean Journal of Marine Science*. 3(2), pp. 227–243
- WCD (2000). *Dams and Development – A New Framework for Decision-Making: the Report of the World Commission on Dams*. World Commission on Dams. Earthscan Publications Ltd., London. <http://www.dams.org/report/contents.htm>
- Wetlands International (2005). Ramsar Sites Information Service. <http://www.wetlands.org/RSDB/default.htm>
- WIO-LaB (2005). Addressing Land-based Activities in the Western Indian Ocean. <http://www.wiolab.org>
- WIOMSA (2005). Strategic Plan 2005-2020. Western Indian Ocean Marine Science Association. Zanzibar
- WTO (2005). World Tourism Market Trends 2004: Africa. World Tourism Organisation, Madrid
- WTO (2003). Final Report of the 1st International Conference on Climate Change and Tourism. Djerba, Tunisia, 9-11 April 2003. World Tourism Organization, Madrid. <http://www.world-tourism.org/sustainable/climate/brochure.htm#main>
- WTTC (2005). Country League Tables – Travel and Tourism: Sowing the Seeds of Growth – The 2005 Travel & Tourism Economic Research. World Travel and Tourism Council, London. <http://www.wttc.org/2005tsa/pdf/League%20Tables%202005.pdf>
- WWF (2005). West African Marine Ecoregion (WAMER). WWF - World Wide Fund for Nature (Formerly World Wildlife Fund). http://www.panda.org/about_wwf/where_we_work/africa/where/western_africa/ecoregion/wamer/area/index.cfm
- WWF Eastern African Marine Ecoregion (2004). *Towards a Western Indian Ocean Dugong Conservation Strategy: The Status of Dugongs in the Western Indian Ocean Region and Priority Conservation Actions*. WWF - World Wide Fund for Nature (Formerly World Wildlife Fund), Dar es Salaam, Tanzania. <http://www.panda.org/downloads/africa/dugongpdffinal.pdf>