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Coastal Zone Management and Environmental Assessment

Coastal areas are rich sources of food, energy and minerals and therefore a primary source of livelihood for a large part of the world's population. They also produce biological resources and sustain functions that are crucially important to the local, regional and global environment. However, economic development, rapid population growth and migration from inland to coastal areas exert increasing pressure on coastal resources. Today there are troubling signs that large coastal areas in the developing world have surpassed or come close to the point at which productivity falls and ecological functions collapse. Improved environmental and natural resource management and better integration with overall development planning from the national level down to the project and local levels are needed to reverse this trend.

This EA Sourcebook Update *focuses on the use of environmental assessment as a coastal zone management tool in Bank-funded projects and programs. Important subsystems of the coastal zone are described and examples given of relevant approaches in EA work. This* Update *belongs in Chapter 2 of the Update Binder and expands on pp. 87–91, Vol. I, of the* EA Sourcebook.

Definition and importance of coastal zones

There is no precise definition of "the coastal zone." It might refer to watershed areas which drain directly to the sea and the entire water area out to the continental shelf. However, it is more common and usually more practical to consider the coastal zone only a relatively narrow band of water and land along a marine shoreline. Natural features include beaches, wetlands, estuaries, lagoons, coral reefs, rocky coasts and dunes. Manmade features include ports, commercial fisheries and aquaculture operations, industries, tourism and recreation developments, archeological sites, and some of the largest and most densely populated urban areas in the world.

The coastal zone is, therefore, both ecologically and economically significant. It provides habitat for nearly all shellfish and finfish used for human consumption and in commercial fisheries. Important functions the coastal zone provides at no cost include shoreline stabilization, fish nurture, recreation and flood control. In many countries, coastlines are also convenient locations for industrial and commercial operations and attractive for tourism. Coastal areas in developing countries are increasingly subject to high population pressure and multiple economic activities across several sectors. This frequently results in cumulative and complex impacts on the environment, depletion of resources, and intensified conflict between competing user groups such as those relying on the coastal resources for livelihood and source of income and those interested in recreational uses of coastal areas.

Exploitation of fisheries and coastal vegetation has already exceeded sustainable levels in large parts of the world, and in many areas has irreversibly transformed ecological systems. Continued destruction and deterioration would cause significant losses of marine biodiversity and weaken the potential for long-term sustainable development. Reversing these trends will require, besides population stabilization, regional management to repair, mitigate and minimize damages and improve planning for sustainable development. Environmental assessment (EA) can be one of the most important planning tools for meeting these goals.

Box 1. Sector operations with potentially high impact on the coastal and marine environment

Agriculture	coastal and upland cultivation; conversion of coastal wetlands; large irrigation schemes
Aquaculture	fish farming; shrimp production
Fisheries	coastal and deep-sea fisheries
Forestry	mangrove forest products harvesting; large-scale uplands forestry
Energy	coastal and offshore oil and gas exploration and operation; coastal power generation; large inland hydroelectric dams
Transportation	ports and harbors; channel construction and maintenance dredging; dredge spoil disposal, coastal roads, railroads and bridges
Urbanization	shoreline modification; waste disposal (e.g., landfills); water and sewerage development; urbanization of coastal areas in natural or semi-natural state, and of upland watersheds; filling (reclamation)
Industry	coastal industrial plants; coastal and marine mining (e.g., sand); salt extraction; industrial waste disposal
Tourism	coastal hotels and recreation facilities; sewage and waste disposal

Coastal zone management and EA options

Certain types of activities in the coastal zone raise particular concerns, and it is important to recognize these issues at the earliest possible stages of project planning, during identification and environmental screening *(see Update* No. 2: *Environmental Screening).* Box 1 lists several sector operations that can have strong impact on the coastal and marine environment, especially when taking place in or adjacent to environmentally sensitive, productive, or otherwise important areas.

The location of an investment relative to the coastal area may be of greater concern than the type of investment, as location frequently determines the types and magnitude of impacts. The section on Natural Subsystems *(see* below) describes some sensitive coastal systems in terms of their importance and vulnerability.

Before the Bank decides to support preparation of a project or program that could affect the coastal environment, a decision must be made regarding the appropriate type and scope of environmental analysis. This is done through environmental screening into one of three categories according to the degree of potential impacts (category A for significant impacts; category B for limited impacts; and category C for minimal or no impacts).

Category A

Projects located in or near sensitive coastal areas and involving activities such as those listed in Box 1 should normally be classified as EA category A. If a project is screened in category A, the appropriate option is normally project-specific EA *(see* Box 2). However, if the project is part of an investment program within a coastal area, or if several independent investments are being considered at the same time, a more comprehensive, regional analysis may be the better option. This can be accomplished through a *regional EA (see EA Sourcebook Vol. I, pp. 12–14);* or a coastal zone management (CZM) plan (a forthcoming *Update* will provide more detailed guidance and information on regional EA).

The Bank often recommends that borrowers prepare a CZM plan that provides a framework for subsequent policies, plans and investments in the coastal zone. Such a plan might be a spinoff from a national environmental action plan, national legislation or developed independently. Once a CZM plan has been implemented, project-specific EAs are usually the most appropriate instrument for assessing environmental impacts. Project-specific EA is normally also the most relevant approach when the Bank gets involved at a relatively advanced stage in regional or sectoral planning, where definition and preparation of concrete investments are the main concern. Box 3 illustrates an innovative approach to incorporating EA and CZM planning in coastal tourism development.

EA terms of reference (TORS) should encourage economic analysis of environmental costs and benefits of a project. Examples of such analyses for projects in coastal areas are shown in Boxes 4 and 5.

The best window of opportunity for regional EA is provided where the borrower is engaged in regional development planning in a coastal area at a stage when alternative development strategies can still be considered. However, regional EA can also be undertaken more downstream in the planning and investment process, as a tool to assess cumulative impacts and relationships between multiple activities. Similar to CZM plans, regional EAs provide a good base for project-specific EAs for individual investments.

Sectoral EA is normally not an appropriate instrument for analyzing environmental issues within a geographically defined area like a coastal zone. Normally, multiple sector activities are influencing the coastal envi-

Box 2. Madagascar: Minerals project

The objectives of the Madagascar Minerals Project (not funded by the Bank) include establishing an economically viable heavy mineral sands mining operation along Madagascar's southeastern coast and making a positive contribution to the general conservation and economic development objectives of the region. The major project activities that may impact the coastal and aquatic environment are: (1) construction of the weir between the lake and the estuary; (2) harbor development; (3) the mining operation; and (4) any possible new settlement. Early in project planning, the Malagasy mining companies initiated environmental studies of the proposed mining areas. The area is covered by a range of coastal vegetation types (littoral forests, swamps, mangroves) that support a variety of animals, including some endangered and threatened species such as the loggerhead turtle, Nil crocodile, and lemurs. The natural resources of the mining areas are utilized by the indigenous people who live nearby.

A preliminary EA covered the physical, biological, social and economic conditions in the affected area and identified types and locations of potential impacts. For instance, construction of the harbor would change the estuary from a predominantly fresh water system to a marine system with resulting changes to vegetation and aquatic communities. The weir would alter salinity distribution patterns both upstream and downstream. Water upstream of the weir would become more fresh and some species of plants and animals would disappear. The World Bank and other interested parties helped review the EA and also suggested mitigation measures.

Recommendations following the EA studies thus far include: a program of reforestation to ensure survival of forest species before they are threatened by the mineral exploits; establishment of reserves to ensure conservation of essential features of littoral forests and protection of threatened fauna in the region; and formulation—in advance of the mining operation—of policies governing the harvesting and management of natural resources. The findings of the EA process provides valuable input for an environmental management plan for the region, to be integrated into the country's National Biodiversity and Environmental Action Plans.

ronment, while sector-specific activities often have a national or multi-regional scope. However, sectoral EA may be useful where sectors or subsectors are confined to the coast by definition, such as coastal fisheries, marine aquaculture, off-shore petroleum activities, coastal tourism, and port and harbor development *(see Update* No. 4: *Sectoral Environmental Assessment).*

Category B

For category B projects, full EA in accordance with OD 4.01 is not required. The appropriate type and scope of a more limited environmental analysis will depend greatly on the type of project and its location. If a CZM plan or a regional EA has been prepared, the environmental analysis should determine whether the proposed category B project is consistent.

In many cases, a pinpointed assessment of the effects of planned small-scale construction activities and a mitigation plan may be the most relevant category B environmental analysis. In other cases, preparation of guidelines, criteria or standards may be better (for example, for the construction or operation of small-to-medium scale aquaculture facilities). In some circumstances, a limited regional analysis of the administrative framework for the coastal area, in terms of institutional responsibilities, capacity, training and resource needs, may be the more appropriate solution. Developing an environmental monitoring plan (for example, using a geographic information system) may also be part of category B environmental analysis.

Addressing cumulative impacts from upstream activities

Adverse water quality or ecosystem impacts often occur in the coastal zone as a result of cumulative effects of upstream activities in river basins. For example, municipal and industrial pollution may cause little impact in rivers but very serious impacts in slow moving estuarine systems of the coastal zone. In particular, excessive amounts of nitrogen and phosphorus from human sewage or agricultural activities can result in over-fertilization or eutrophication of coastal zone waters with devastating impacts on finfish and shellfish. Reduced river flows from excessive upstream diversions of water cause cumulative downstream impacts in river deltas and estuaries as salinity conditions change and coastal ecosystems become degraded. Saltwater intrusion into groundwater supplies can also occur from these flow diversions.

Water development projects associated with irrigation, hydropower, flood control, or water supply uses may contribute to these adverse impacts. Category A or B water development projects should contain an element of the EA to determine downstream coastal zone impacts. Likewise, agricultural and municipal sewage projects that would increase nutrient loading to eutrophic coastal waters should include an

Box 3. Egypt: Complementary reef conservation and tourism in the Red **Sea**

The nearly-enclosed Red Sea supports a unique combination of tropical marine habitats surrounded by magnificent coastal deserts, mountains and wadis. The associated wildlife includes dugongs, turtles, terns and tunicates, but the natural conditions also support extensive coral reef communities, whose beauty and rarity attract great numbers of tourists. Without effective CZM and planning, tourism could threaten the coral reefs and other coastal habitats, as appears to be happening along a 40 km stretch of Egypt's Red Sea coast known as Hurgada-Safaga.

Until the late 1980s Egypt did not fully exploit its rich cultural and natural heritage, favorable climate, and easy access from European and Middle Eastern markets for purposes of tourism. However, by 1991, tourism was the second largest foreign exchange earner, thanks in large part to a liberalization of prices, reforms in the aviation industry, and a new policy of attracting private sector investment in high-density tourism along the coast.

As a result, Hurgada-Safaga is host to numerous "holiday villages" that are growing considerably faster than the Government of Egypt's (GOE) capacity to provide infrastructure. Consequently, resorts must provide their own water, electricity, solid-waste disposal and wastewater facilities. These tend to be poorly regulated and sited. For example, pipelines are placed over live coral, excess effluent is dumped into the sea causing eutrophication, airborne and insect disease is spreading, drinking water is polluted, generator lubricants leak into the ground and sea, and entire reef flats are being filled in to construct additional tourism resorts. These impacts are causing extensive degradation to the coastal and marine habitats, especially to the coral reefs.

The Tourism Development Authority (TDA) was created in 1991 with jurisdictional and promotional responsibility to support environmentally sound, master-planned tourism. However, action toward this goal has been stalled by conflicting authority within and between private and public-sector entities, competing resource groups (e.g., oil, tourism, fisheries), poorly defined laws and little enforcement. The failure of execution has been especially apparent in coastal areas, where the need for integrated zoning, rational resource allocation and cooperation between stakeholders is needed. In an attempt to rectify the present situation in Hurgada-Safaga, the GOE and the World Bank approved two interdependent and innovative initiatives: 1) a loan of US$130 million to the TDA to improve private-sector policies of the tourism industry, support infrastructure for two model integrated master-plan developments in the Hurgada-Safaga area, and upgrade water supply, sewerage and solid waste for the existing resorts; and 2) a complementary three-year, CEF joint grant of US$4.5 million to the TDA, Egyptian Environmental Affairs Agency and the Red Sea Governorate to work together to protect the coral reef resource base. This entails: 1) CZM planning with multi-disciplinary resource management inventories and GIS; 2) development of EA capability; 3) private sector reef recreation management in the Hurgada-Safaga area; and 4) establishment of a multi-zoned and multi-purpose marine protected area in the undeveloped southern coast. Both the loan and grant initiatives are scheduled to be effective in 1994.

Ideally CZM and EA tools, such as those to be developed through the GEF project, would provide a framework for a planned approach to tourism before development takes place, thus balancing the socioeconomic demands with the ecological carrying capacity. Yet in the case of Hurgada-Safaga, the tourism development took place in large part before any CZM plan was prepared and the loan was several years in design before GEF was an option. The Bank, realizing that Hurgada-Safaga urgently needed environmentally sound infrastructure and that resort development needed to be done within the context of an effective CZM and EA capability, supported Egypt's request for a GEF grant in 1991 to develop broad-based CZM and EA methodologies for Egypt's entire Red Sea region. Hence the two projects were redesigned to be mutually supportive and interactive, providing a CZM and EA capacity to remedy the problems of Hurgada-Safaga as well as provide a sound basis for complementary reef conservation and tourism for all the rest of the Red Sea coast. In addition, the Bank's EA procedures strengthened the loan's environmental mandate resulting in cross conditionality between the loan and the GEF project.

EA component analyzing potential impacts and nutrient mitigation alternatives. For consistency with the Bank's Water Resources Management Policy issued in 1993, these agricultural projects should employ best management practices to reduce water pollution, and the municipal sewerage projects should avoid downstream pollution impacts. In addition, water development projects that might affect the coastal zone should utilize appropriate structural modifications and operational flow regimes to have no adverse impact on the coastal zone or downstream riverine aquatic ecosystems.

Natural subsystems of the coastal zone: Issues of special concern

Familiarity with the various subsystems of the coastal zone and their functions and values can help select development alternatives that minimize impacts to the coastal environment. The following ecological sub-systems—coral reefs, coastal wetlands, muddy and sandy bottoms, and rocky coasts—are found throughout the developing world and are increasingly subject to intense pressures from human activities.

Box 4. Considering economic and environmental benefits of mangroves

Valuation of mangrove forests has typically considered only limited functions provided by these ecosystems—primarily the marketable goods and services they produce, which is just a fraction of their total goods and services. As a result, total values and benefits have been underestimated and conversion has become the most attractive alternative. However, with increasing knowledge of both the economic and environmental values of mangrove ecosystems, economic analysis can serve as a useful tool in analyzing development alternatives for mangrove forests. EA provides an excellent framework for such analysis whenever a project is considered which proposes or implies conversion of mangroves.

Comprehensive economic analysis has shown that mangroves often yield greater social net benefits if they remain as natural ecosystems. When conversion of mangroves is clearly justified, a physical-social-economic analysis can help plan conversions that will minimize the loss of the mangrove forest benefits. The analysis should consider the following: costs of conversion (direct and indirect); possible employment generating potential; benefits of conversion (large and sustainable); and a valuation of the mangroves' marketed and non-marketed goods and services, both within and outside the area covered by mangroves (see figure 1).

While collecting complete data for the economic analysis may not always be possible, several points should be taken into account when development options are considered: (1) a natural mangrove is a self-sustaining, productive ecosystem, whereas many conversion-based alternative uses have proved to be expensive to construct and maintain, or have produced disappointing economic results due to low and declining productivity; (2) the land-ocean linkages of mangrove ecosystems are important as they produce an extensive variety of goods and services, such as coastline stabilization, protection against erosion, and function as traps for pollutants; (3) subsistence production of many non-marketed goods and services are culturally important; and (4) mangroves are valuable wildlife habitats.

Figure 1. Relationship between location and valuation of mangrove goods and services

Quadrants 1–4 reveal important ecosystem interactions that together contribute to the total values and benefits produced by the mangrove system. They include goods and services that do not have market prices or monetary value, and have seldom been included in traditional economic analysis.

	On-site	Off-site
Marketed	1 Poles, charcoal, woodchips and mangrove crabs are usually included in an economic analysis.	2 Fish or shellfish caught in adjacent waters may be included.
Non-marketed	3 Medicinal uses of mangrove, domestic fuelwood, food in times of famine, nursery area for juvenile fish, feeding ground for estuarine fish and shrimp, viewing and study of wildlife are seldom included.	4 Nutrient flows to estuaries and buffer to storm damage are usually ignored.

Source: Dixon, J.A. 1989. Valuation of Mangroves in *Tropical Coastal Area Management,* Vol. 4, No. 3.

Coral reefs

Definition. Coral reefs are tropical, shallow water ecosystems. These ecosystems consist principally of hard bottom, typically carbonate rock, where corals are prominent, with some interspersion of rubble and sand. Growth of corals requires clear, warm, aerated and nutrient-poor conditions; these are only met in suitable tropical and sub-tropical shallow waters.

Functions. Coral reefs offer many environmental benefits. (1) Their structure allows them to withstand and dissipate strong wave action, thus protecting land, islands, and beaches from wave damage and shoreline erosion. By naturally replenishing sand lost through natural erosion and sand movements they help preserve the integrity of thousands of miles of coastline throughout the tropics and subtropics. (2) Coral reefs are important in food production. They provide habitat for animals and plants thereby accumulating nutrients for rather complex food webs. Fish, invertebrates, and other animals are collected directly from the reefs for human food in many developing countries. (3) Coral reefs have the highest reported species diversity of any marine ecosystem, thus their role in global biodiversity is substantial. (4) There are some medicinal drug and marine natural products being produced from coral reef organisms.

Issues. Coral reefs are sensitive biological systems that are threatened by human activities and are therefore more threatened by high population density in coastal areas. An IUCN / UNEP study indicates that large parts of coral reefs around the world are severely stressed or already destroyed *(Coral Reefs of the World, Vol. 1–3,1989,* Cambridge: IUCN). The main, direct threats are generally sedimentation, (e.g., from agriculture and deforestation—*see* Box 5), eutrophication (e.g., from agriculture, sewage, and certain industries), and destructive fishing practices (e.g., blasting). In areas with intensive agriculture, run-off from agricultural chemicals pose a particular threat through increases in nutrient levels. In coastal zone areas of South-East Asia (particularly the Philippines) and Africa, dynamite fishing and other fishing techniques (such, as releasing toxics into the water) destroy many reefs, thus eliminating habitat for unique and often endemic species of fish and other organisms.

Coral reefs can also be damaged by development activities such as dredge and fill operations for port development and construction and operation of tourist resorts. Construction of hotels and other facilities near the shoreline typically cause sedimentation from land clearing, coastal erosion, and generation of solid and liquid wastes unless proper treatment is in place. Tourism activities such as spearfishing, souvenir hunting and mechanical damage due to anchoring also threaten coral reefs. These activities can result in a decline in productivity of the harvestable reef resources and adversely affect the physical buffering capacity of the reefs. Studies in the Red Sea and on Australia's Great Barrier Reef have shown that oil pollution and spills from off-shore petroleum development sometimes affect coral reefs.

Due to the critical condition of many coral reef systems and their environmental and economic importance, a full EA is normally needed for proposed development projects. Projects can also be designed partly or wholly to protect coral reef systems. Technology is available to help prevent damage to reefs. For example, sewerage outfalls can be placed below the level of coral growth and thermal effluent can be discharged in deep water with carefully engineered diffuser systems. Projects in areas where coral reefs have been destroyed should consider the construction of artificial reefs (materials may consist of cement and stone blocks and newly developed PVC structures). While not providing all characteristics of reef ecosystems, artificial reefs quickly replace some of the important reef functions to marine life and restore beach protection.

Coastal wetlands

Definition. Wetlands are transitional areas between terrestrial and marine systems in which the water table is usually at or near the surface or the land is covered by shallow water. The marine wetlands of most concern in the developing world include: (l) mangrove swamps found on the tropical Atlantic and Pacific and Indian Ocean coasts, with a large concentration in the Indian Ocean / West Pacific region; (2) submerged seagrass meadows predominant in shallow coastal areas in both tropical and temperate environments; and (3) coastal lagoons and estuaries.

Functions. Coastal wetlands act as a buffer between land and sea in a number of ways, such as protecting the land from sea storms. Wetlands are nutrient-rich, provide protective habitat, and are productive nursery areas. For example, many fish and shrimp species depend on estuaries for spawning and early juvenile stages.

Issues. Coastal wetlands are often destroyed by industrial and agricultural development (roads, dams and irrigation systems) and urbanization. Development activities such as dredging, filling, paving, and flooding of coastal wetlands result in habitat destruction. These activities often lead to accidental spills and water pollution from industrial operations, run-off from agricultural land and changes in environmental conditions.

EA is required where a proposed development may result in conversion, degradation or destruction of a significant part of a country's coastal wetlands, or where species of flora and fauna are threatened. Special consideration is needed for mangrove forests, for which the Bank's policy on forestry (OP 4.36) applies.

Mangroves: Coastal wetland of special concern. In many countries of South and Southeast Asia, there is considerable destruction of the coastal vegetation, including the mangroves. The word "mangroves" refers either to the constituent plants of a tropical intertidal forest community or to the community itself. Many mangrove trees can grow in both saltwater and brackish environments.

Mangroves provide habitat to many terrestrial and aquatic animals and serve as temporary habitat for spawning, nursery and feeding. They are important in the preservation of biological diversity for many species of plants and animals. Mangrove forests protect coastal areas against erosion and mangrove vegetation filters and purifies water.

Over the past 30 years, about 50–80% of the mangroves have been eliminated in Indonesia, the Philip-

Box 5. Logging versus coral reefs—applying economic analysis to assess alternatives

Coastal development is rapidly expanding in the Bacuit Bay on the Philippine island of Palawan, leading to conflicts over resources among the tourism, fisheries and logging industries. A one-year study on sediment input from logging into the main river and bay and the effects of sediment pollution on coral reefs and fisheries showed that logging caused accelerated erosion resulting in high sediment deposition into the bay and onto the coral reefs. This killed the corals and lead to a subsequent decline in fish populations. It also threatened the touristic value of the bay that had attracted foreign visitors for some time.

In view of these results an analysis of two development options was considered: (1) a logging ban, which meant that the major economic activities in the bay area would continue to be fishing and tourism, and (2) continued logging in addition to the ongoing tourism and fisheries. For purposes of this analysis, it was assumed that (1) the fish catch was proportional to fish biomass (to estimate the impact of sedimentation on the value of fisheries production) and (2) expenditures for foreign goods were equal in all 3 industries. The analysis covered only a 10-year period due to the difficulty of predicting future values of fish stocks, commodity prices and growth in tourism. Cost/benefit analysis was not possible as financial records of the companies were not available, however, gross and present values of revenues from each industry were computed for both options for a 10-year period, taking into account estimated sedimentation increases resulting from logging.

Under option 1, (logging ban) gross revenue was approximately $75 million and under option 2, (continued logging) some $34 million. Calculations for present value of gross revenue which included discount rates of 10–15% showed that the logging ban produced the greatest revenue over a 10-year period. For example, gross revenue with the 10% discount rate was roughly $42 million under option 1 and $25 million under option 2. Even when externalities such as increased risk of flooding and loss of wildlife (via habitat loss) or employment were taken into account, the analysis indicated that the tourism and fisheries industries allow for more sustainable development than continued logging.

pines and in the Caribbean. In the Philippines less than 25% of original mangrove forests remain. In many developing countries, mangroves are over-harvested for fuelwood in densely populated areas. Moreover, mangrove areas are often favorite sites for dumping solid waste (both illegal and established garbage dumps). Leaching and run-off from these dumpsites lead to degradation in water quality. Forestry projects, road construction, and conversion into rice paddies have also lead to the disappearance of mangroves. Often mangroves are destroyed because they are converted for shrimp ponds and brackish water fish culture. In Southeast Asia this is a leading cause of declining mangrove habitats.

Seagrasses

Definition. Seagrasses are a group of vascular plants adapted to the marine environment. Some species are also able to live in freshwater. They are widely distributed throughout the shallow coastal seas in all oceans.

Functions. Seagrasses offer many important goods and services. (1) They are biologically productive and serve as food to species such as dugongs, manatees, sea turtles and certain waterfowl. (2) Seagrass beds function as nurseries for some commercially exploited fish. (3) They protect coast lines from erosion by slowing wave movements and also stabilize bottom sediment which keeps the water clear.

Issues. Seagrass beds can be destroyed by any significant changes in the physical and chemical characteristics of coastal waters. Increased siltation, effluents, thermal pollution and run-off water from industrial and agricultural operations have harmful effects on seagrasses. Projects involving the construction of harbors, channels or dams increase silt loads which can eliminate seagrasses from an area and have drastic effects on the entire coastal ecosystem.

Muddy and sandy bottoms

Definition. These ecosystems are constituted by fine muddy or coarser sandy sediment overlain permanently or temporarily by water. The sediment is derived from rivers, bedrock and reefs by erosion, transport and deposition and can be further modified by inputs of organic matter from adjacent coastal wetlands.

Functions. Sandy and muddy areas (1) act as nursery grounds for rapidly-growing juveniles of many valuable fishery stocks, particularly in shallow water by offering conditions such as reduced predation and greater food availability, and (2) provide permanent or temporary habitat for some rare, endangered or protected species including marine mammals and sea-birds.

Issues. Muddy and sandy bottoms in many areas are widely subject to modification or conversion which have negative effects on the environment. Development for housing and runways requires activities such as in-filling to increase land area. Other activities such as sand-mining lead to coastal erosion. Muddy and sandy bottoms are modified through accelerated nutrient inputs and increased loading with organic matter from domestic sewage and industrial sources. Although these threats are not of global concern because of the extent of this ecosystem type, they can be of considerable local significance. EA work would be needed where projects affecting this habitat could result in loss of species, large-scale disruption of internationally important feeding or breeding grounds for mammals and sea-birds, or significant reduction in fishery or other economically important activates.

Rocky coasts

Definition. Rock commonly forms the coast where there is little sediment input, the relief of the shore is high and water movement is strong. Bedrock and boulders may be made of various materials including basalt and granite which can be heavily colonized by large algae. Rocky coasts occur in all geographic zones of the world.

Functions. Rocky coasts provide environmental goods and services and perform important biological functions. (1) They provide for attachment of productive marine algae and filter-feeding invertebrates such as oysters, support food-webs and provide suitable habitat for finfish and shellfish fisheries for subsistence or commercial purposes. (2) They offer feeding or breeding sites for many rare, endangered or protected species such as seals and sea-birds as well as sustain many species which are not found in other ecosystems. (3) They also help dissipate wave energy and thus protect associated sediments and soils from erosion by the sea.

Issues. Development activities such as mining and quarrying and associated pollutants (sewage, industrial effluents, heavy-metal loading) can have a negative impact on rocky coasts as habitats for wildlife. The pollutants may lead to significant increases in turbidity and changes in water temperature. Moreover, the aesthetic value of rocky coasts can be easily undermined by unsightly development, potentially reducing the touristic value of such areas. When projects potentially threaten species of wildlife living in rocky coast areas, EA is required.

Recommended for further reading

Chua, T.E., and L.F. Scura (eds). 1992. *Integrative Framework and Methods for Coastal Area Management, Manila:* ICLARM.

OECD. 1993. *Coastal Zone Management: Integrated Policies and Selected Case Studies,* Paris: OECD.

UNEP. 1990. *An Approach to Environmental Impact Assessment for Projects Affecting the Coastal and Marine Environment*, UNEP Regional Seas Report and Studies No. 122, Nairobi: UNEP.

This *Update* was prepared by Elena Pappas in collaboration with Jan Post and Carl G. Lundin. The *EA Sourcebook Updates* provide guidance for conducting environmental assessments (EAs) of proposed projects and should be used as a supplement to the *Environmental Assessment Sourcebook.* The Bank is thankful to the Government of Norway for financing the production of the *Updates.* Please address comments and inquiries to Colin Rees and Aidan Davy, Managing Editors, EA Sourcebook Update, Environment Department, The World Bank, 1818 H St. NW, Washington, D.C., 20433, Room MC-5-105, (202) 458-2715.