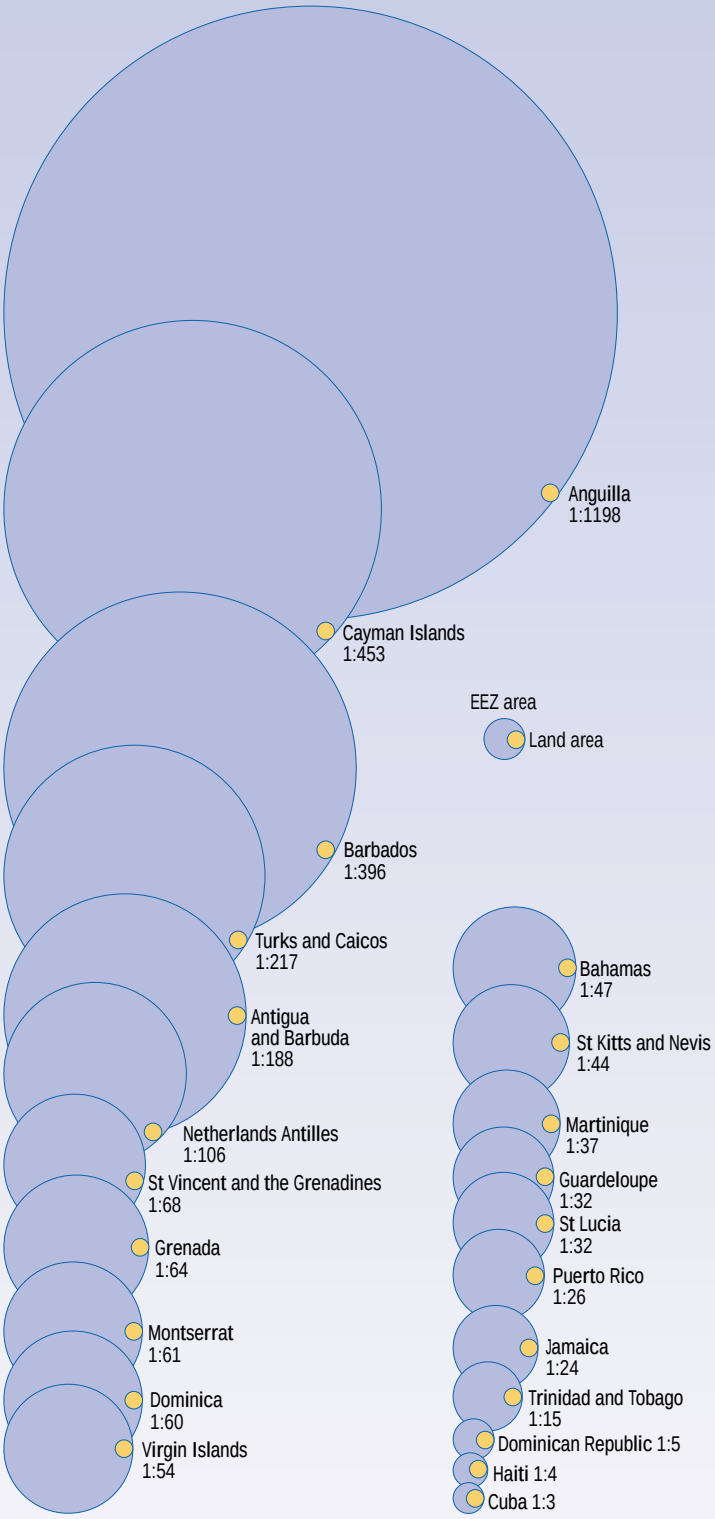
## Marine and coastal areas

The marine and coastal environments in the Caribbean represent an important natural resource: they provide the region with food and materials for new medicines, protect coastal settlements from storm damage, and generate income from tourism. This coastal ecosystem with its high level of biodiversity is extremely fragile, and therefore vulnerable to human interventions.

Figure 1.5: Water to land area ratios in the Caribbean




Based on a proprietary geographic information system (GIS) calculation of EEZ and island land areas developed by CAPMap for the Island Resources Foundation. Actual EEZ boundaries or areas claimed or being negotiated by any Caribbean island may not bear any relationship to this calculation: land areas are approximate and conditioned by the accuracy of islands depicted by the Digital Chart of the World.

## Marine resources

Figure 1.5 illustrates the importance of the marine environment to the smaller islands of the Caribbean, where the ratio of water to land area exceeds 30:1, and which averages over 200:1 for the quartile of smallest islands of the region. This illustration does not automatically mean that countries at the top of the list should count on marine and coastal environments for over 90 per cent of their GDP, but it should answer the question of why marine issues should be near the top of the development planning agenda.

Stresses in the Caribbean may be occurring at a regional scale in addition to site-specific coastal and marine pollution from nearby watersheds. For example, the 1979 satellite image presented in Figure 1.6 shows regional-level impacts of sediment from Venezuela. While conclusive studies relating these levels of increased opacity to impaired coral growth have not been concluded, it is prudent to assume that such effects are likely, given our knowledge of the light dependence of coral growth and the additional stresses being put on coral as a result of increased temperatures. (See also in the section 'Climate Change' below.) This picture of continental-scale sediment movement makes it clear that all the Caribbean countries have a direct and immediate interest in issues such as deforestation, agricultural practices, soil loss and fertilizer and pesticides use occurring hundreds or even thousands of kilometres away.

Figure 1.6: Large-scale sediment flows into the Caribbean


An analysis of chlorophyll in the water column (used as an indicator of sediment load and increased opacity), as seen from a satellite in 1979, shows a large plume of material flowing into the Caribbean from waters adjacent to the South American coast. Although most of this material might be assumed to be from the Orinoco watershed, other analyses have shown apparent sediment movements along the South American coast all the way from the mouth of the Amazon River.

*Source*: University of South Florida (USF) http://usfweb.usf.edu/

### Box 1.2: Integrated coastal zone management and legislation in the anglophone Caribbean

Coastal zone management is assuming increasing importance in the Caribbean. Management systems are being developed to deal with the growing problems of coastal deterioration caused by rapidly expanding levels of beach tourism, urbanization of coastal lands, and coastal sand mining to support the construction industry. Exposure of coastal areas to the risk of maritime oil pollution has also stimulated pollution control legislation.

Traditionally, Caribbean coastal zone management was carried out under a fragmented administrative and legal system. However, in the last ten years there have been significant improvements in management approaches, and today Caribbean countries present multiple management frameworks:

- Independent stand-alone coastal management units, authorized by coastal zone legislation.
- Coastal zone divisions of larger, comprehensive environmental management agencies, established by umbrella legislation regulating coastal resources as a component within an overall environmental strategy.
- Fragmented management systems reflecting piecemeal coastal zone regulation and legislation, arising on an ad hoc basis in response to specific problems.

In every instance, recognition of the vulnerability of the coastal zone to sea level rise, and the requirement for regulation of pollutants that cause climate change, tends to be implied and not expressed.

The existence of improved coastal management practices in some Caribbean countries provides important lessons for the regional management of coastal resources.

*Source*: Caribbean Law Institute Center 1998

In addition to looking ahead to improved, integrated management of the coastal zone, the Caribbean must also address two critical issues:

1) the protection and restoration of shallow-water ecosystems, including reefs; and
2) the improvement of fisheries management, including that of virtually all harvested species.

The functions of shoreline stabilization, fish nurseries, recreation and flood control provided by the coastal zone are being drastically curtailed by degradation of coastal and near-shore environments. A number of sectors (agriculture, aquaculture, fisheries, forestry, energy, transportation, urbanization, industry and tourism) have operations with potentially high impacts on the coastal and marine environment. Caribbean shorelines provide a logistically convenient location for industrial and commercial activities, and are critical for successful tourism. Coastal environments are subject to the pressures of high population and multiple economic activities across several sectors. Additionally, conflicts among competing user groups are intense in the coastal zone.

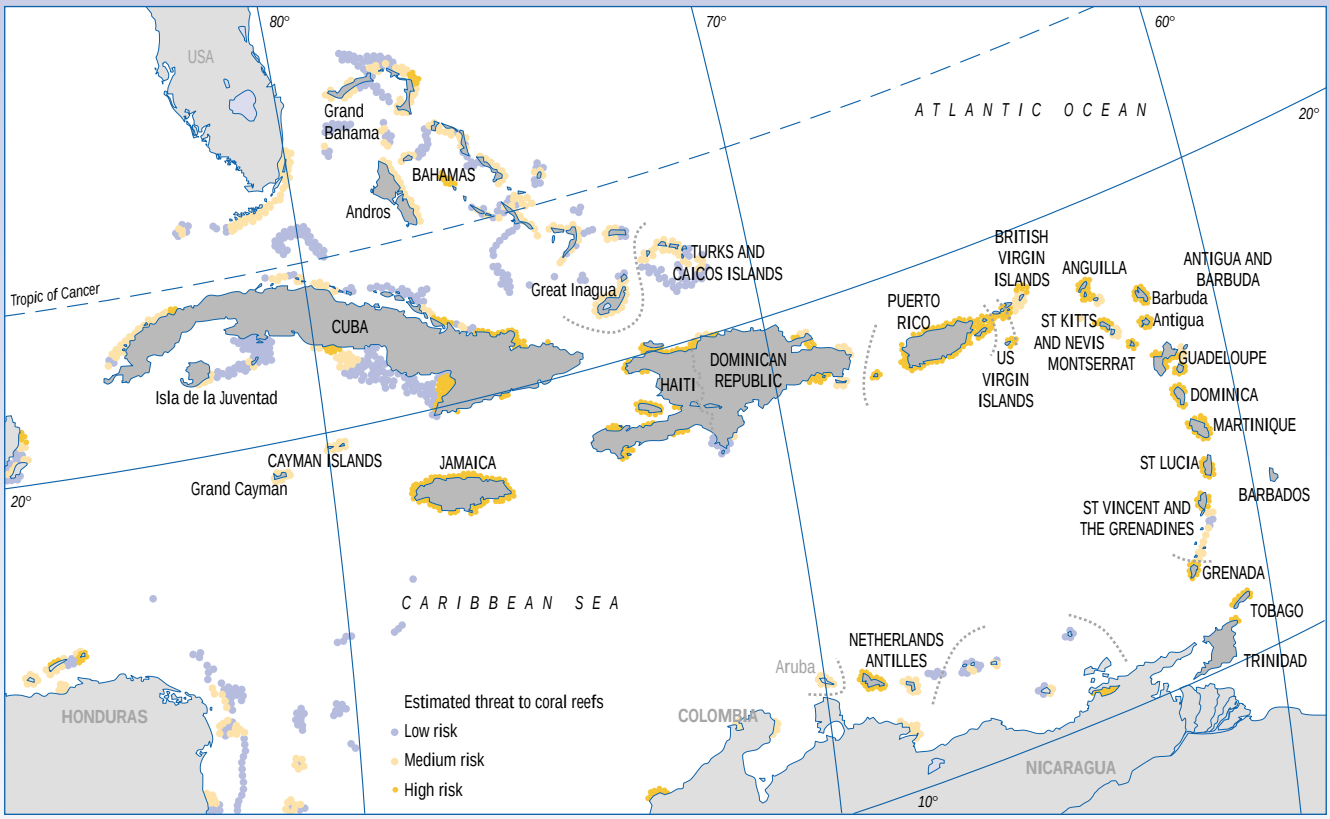
## Shallow-water ecosystems

The Caribbean has 20 000 km$^2$ of reefs (Figure 1.7), and probably ten times that area in shallow-water systems such as sand banks, sea grass beds and sponge beds at depths of less than 100 metres. A combination of near-shore pollution and offshore over-harvesting places the whole of this vast ecosystem at risk of collapsing. The WRI/ICLARM/WCMC/WB report *Reefs at Risk* (Bryant *et al*. 1998) estimates that two-thirds of the reefs in the region are at medium or high risk. The unexamined side of that conclusion, however, is how much of the adjacent non-coral-reef areas are equally damaged. Harvesting technologies for both fish and shellfish are in danger of depopulating vast areas of the Caribbean as more fishers use subsidized vessels and equipment to pursue shrinking fisheries resources.

While pollution from outside the Caribbean plays a part, the reality is that most of the pollution problems faced by the Caribbean can be ascribed to local impacts. Satellite images have revealed large amounts of sediment along the southern coast of the island of Cuba, probably as a result of forest removal and agricultural practices, possibly combined with severe rains. Similar pictures could be developed for the coastal areas of most islands in the region if imagery of sufficiently fine resolution was available. Such data, which would permit near real-time monitoring of many elements of coastal pollution for Caribbean islands, may become available when products from the new generations of 1m and 3m resolution satellite sensors become widely available.

The coastal zone contains some of the Caribbean's most productive ecosystems, including seagrass meadows, mangrove swamps and wetlands, all of which have rich biodiversity reserves. The coast also supports the majority of the region's human population and, as elsewhere, is integral to the region's social and economic life. Major population centres, agricultural areas, ports and other major sites for industrial and commercial activity are located in the coastal zone. In addition, tourism is to a great extent concentrated in the coastal areas. Combined, these activities and uses have

Figure 1.7: The reef areas of the Caribbean




*Source*: Bryant *et al.* (1998)

contributed towards the deteriorating quality of many coastal habitats in the Caribbean.

The costs of rapid population growth, the human disturbance of coastal areas and overexploitation of marine resources are becoming more and more evident. According to a WRI/ICLARM/WCMC/WB report (Bryant *et al.* 1998), 29 per cent of the region's reefs are considered to be at high risk from human development, 32 per cent are considered to be at medium risk and 37 per cent at low risk. Most reefs off Haiti, the Dominican Republic, Puerto Rico, Dominica and Barbados are under high potential threat. Virtually all the reefs of the Lesser Antilles are at risk. These figures are a matter of concern, especially when combined with the documented degradation of coral reefs throughout the Caribbean.

The *Reefs at Risk* report (Bryant *et al.* 1998) identifies four major threats to reefs:

- sediment and land-based pollution;
- exploitation;
- marine sources of pollution, and
- coastal development.

The progressive degradation of reefs throughout the Caribbean is due to a combination of human and natural causes (Table 1.6), which often compound each other. The massive die-off of the grazing long-spined sea urchin

## Box 1.3: Jamaica's reefs

Jamaica is completely surrounded by reefs, although those of the north coast once contained the most extensive coral cover and are the most diverse. Reefs are an integral part of the Jamaican economy, supporting fishing and tourism, the country's most important industries.

Virtually all reef communities here have been affected by human and natural impacts. Overfishing in particular, and pollution from sewage disposal, industrial effluents and agricultural runoff, siltation due to poor land use practices, and tourism-related activities, have seriously degraded Jamaica's reefs. Storm damage from hurricanes, coral reef bleaching (see also Box 1.6) due to periodic high sea water temperatures, and – with the decline of sea urchins and other algae grazers – the unchecked algal overgrowth of corals, have all compounded the problem. The reefs surrounding Montego Bay are perhaps the most seriously degraded, even though they are protected, in part, by a marine park. The original park, established in 1966, was too small and was completely unmanaged. Although re-established and expanded in 1990, with a financial base and a staff that works closely with town authorities, reefs in the park continue to be affected by poaching, pollution for the nearby city and airport, and runoff from inland agricultural activity.

*Source*: Bryant *et al.* (1998)

Table 1.6: Summary of threats to coral reefs in the eastern Caribbean states

| | Sediments | Exploitation | Marine pollution | Coastal development | Composite threat |
|---|---|---|---|---|---|
| Antigua and Barbuda | | ● | | ○ | ● |
| Barbados | ○ | ● | | ○ | ● |
| Dominica | | ● | | | ● |
| Grenada | ○ | ● | | | ● |
| St. Kitts and and Nevis | | ● | | ○ | ○ |
| St. Lucia | ○ | ● | ● | ○ | ● |
| St. Vincent and the Grenadines | ● | ● | | ○ | ○ |
| Trinidad and Tobago | ○ | ● | ○ | ○ | ● |

● = high threat ○ = medium threat

*Diadema antillarum* in 1983 has resulted in dramatic increases in macroalgae, which are smothering coral colonies and reducing coral recruitment and survival. In many areas the sea urchin populations have still not recovered to their pre-1983 levels. The effects of the urchin die-off have, in many locations, been made more severe by added stress from nutrient pollution and overfishing, contributing to a decrease in coral cover (Woodley *et al*. 1998).

Islands with fewer people and little fishing pressure (Bonaire, Cayman, Turks and Caicos, and parts of the Bahamas, for example) have reefs that are in good shape. In these and several other areas the growing economic importance of diving tourism has helped promote awareness of reef conservation. Other areas, such as the north coast of Jamaica, have reefs that show a large amount of damage. Steep-sided islands with reefs on narrow shelves are particularly vulnerable to the heavy runoff of sediments and nutrients that result from the clearing of hillsides due to increased population pressure. Where shelf and reef areas are larger (the south coast of Jamaica, Cayman Islands), reef fish are larger and more abundant, and help prevent algal overgrowth of corals.

Hurricanes are the main source of natural impacts on coral reefs, and their effect is especially severe on shallow and exposed reefs. For example, hurricanes Allen and David (1980), Hugo (1989), Luis and Marilyn (1995) and Georges (1998) had major impacts in the Lesser Antilles, in addition to Hurricane Gilbert (1988) – probably the largest hurricane in the Caribbean in the twentieth century – in Jamaica. Hurricanes often trigger major changes in coral reef ecosystems because chronic human disturbances have altered the natural conditions and prevent normal recovery.

Diseases are another important, apparently natural factor. White band disease (affecting especially the branching corals such as *Acropora* spp.) has reduced live coral cover on many reefs during the last two decades. Diseases, together with storms, boat groundings, and the direct and indirect effects of pollution have contributed to severe losses in the abundance of the three species of *Acropora* (*Acropora palmata*, *Acropora cervicornis* and the rare *Acropora proliferata*). Dead colonies have been found in locations ranging from relatively pristine reefs in the central–eastern Bahamas, Turks and Caicos Islands and Cuba, to impacted reefs in the Dominican Republic and Jamaica. *Acropora palmata*, once luxuriant, has disappeared from the reefs flats of Barbados since the start of intensive sugar cane cultivation over a century ago, while on the US Virgin Islands reefs, the same species – previously the primary reef builder on many shallow reefs – has been severely affected by white band disease and shows little sign of recovery. New colonies have been destroyed by major storms, along with the other major reef builder, *Montastrea annularis* (Lang *et al*. 1988; Smith, Rogers and Bouchon 1988; Woodley *et al*. 1998).

Several episodes of coral bleaching (see Box 1.6) in the Caribbean have resulted in partial mortality. The most recent event took place during the summer and autumn of 1998. Prior to this, the most notable coral bleaching events occurred in 1983 and 1995. Mass bleaching can happen when sea surface temperatures rise well above the average summer temperatures in an area, stressing the corals. Frequently corals recover from bleaching, but death may result if the stress is extreme or prolonged (Wilkinson 1998).

There are few long-term studies that would help determine the status and trends of coral reef community dynamics in the Caribbean. However,

monitoring programmes for coral reefs and other marine resources have now been put in place in most countries. Some standardized regional or global efforts include ReefCheck, the Caribbean Coastal Marine Productivity Programme (CARICOMP) and the Atlantic and Gulf Rapid Reef Assessment (AGRRA). These programmes – some using volunteers, some trained personnel – monitor the status and health of reef areas and promote sustainable management. CARICOMP is an environmental monitoring programme that includes reefs, seagrass beds and mangroves, as well as some physical measurements, and is implemented at participating stations throughout the Caribbean using common methodology. AGRRA was launched by scientists at the University of Miami in Florida in 1998, to map reef health. ReefCheck is a global monitoring programme with many Caribbean participants, using volunteers to monitor reefs, and has a major goal in raising awareness among the public and governments about the need for coral reef conservation. ReefCheck is sometimes portrayed as a step towards community-based management.

## Fisheries resources

Table 1.7 shows the rise and fall of marine fisheries in the Caribbean between 1975 and 1995. Marine fish harvests peaked at around 280 million tonnes for the region in 1985, and have since dropped to a little over half that level. Detailed figures by type of fishery or type of fish show that this trend is not limited to specific areas or species, but in fact is a general collapse throughout the region.

It should be understood that these fishery data are not presented for their economic and development implications, which are themselves significant, but as indicators of potentially catastrophic damage occurring to the marine and coastal environments of the Caribbean as a result of stress and overfishing.

Knowledge of the status of the stocks being harvested is generally poor, and sustainable levels of fishing harvests are essentially unknown for most species in most areas. There is a prevalent assumption that many stocks are being fully or over-exploited and there is concern for the status of species such as the Nassau grouper (*Epinephelus striatus*) and jewfish (*Einephelus itajara*), the spiny lobster (*Panulirus argus*) in some regions, and the queen conch (*Strombus gigas*). The greatest need in the region is for improved knowledge of the status and potential productivity of the stocks and of the fisheries harvesting them, in order to put in place appropriate management action (FAO 1997a).

Depletion of reef fish stocks ranges from relatively small (for example, parts of the Bahamas, Turks and Caicos) to severe (for example Haiti and many areas of the eastern Caribbean). Manatee (*Trichechus manatus*) and jewfish are commercially extinct throughout the Caribbean. The main crustacean fisheries are those for spiny lobster and penaeid shrimps. The spiny lobster fishery is dominated by Cuba and the Bahamas (FAO 1997a). Populations of spiny lobster as well as queen conch, the most important commercially exploited mollusc, are greatly reduced in some areas. Fishing pressure has been so intense in Haiti that many of the edible fish and invertebrates caught by artisanal fisheries are below sexual maturity (Lang *et al*. 1998). Marine turtles are still taken in many countries, both for their meat and for their shells which are used in crafting jewellery and ornaments.

The pelagic fishery includes such large internationally distributed oceanic species as billfishes, tunas and swordfish. Most of these species are assessed by the International Commission for the Conservation of Atlantic Tunas (ICCAT) and are considered to be either fully exploited or over-exploited (FAO 1997a). Using catch per unit effort (CPUE) as a measure of relative abundance, declines in Atlantic yellowfin tuna in the Caribbean were recorded by the Japanese longline fleet around the mid-1960s. These observations have been reinforced by recent stock assessments which indicate an overall decline in Atlantic yellowfin tuna (Singh-Renton 1997).

The status of the stocks of the more common locally distributed large pelagics, such as mackerel (*Scomberomorus* spp.), blackfin tuna and common dolphinfish is unknown. The round sardinella and Atlantic thread herring are generally caught close to the continental mainland, and large islands such as Trinidad and Jamaica. Fisheries for small pelagics on the smaller islands of the Lesser Antilles generally make use of beach seine nets. These fisheries are locally important providers of employment and food. They tend to be based on jacks and scads, such as *Selar crumenophthalmus*, *Decaotyrys* spp. and halfbeaks (*Hemiramphus* spp.). The flying fish (*Hirundichthys affinis*) makes up only a small portion of landings of small pelagics, but is important in the south-eastern Caribbean states (FAO 1997a).

## Marine and coastal summary

In addition to overfishing, the loss of important coastal

Table 1.7: Caribbean marine fish catch by country (thousand tonnes per year)

| | 1975 | 1980 | 1985 | 1990 | 1995 |
|---|---|---|---|---|---|
| Antigua and Barbuda | 1 601 | 1 171 | 2 407 | 2 200 | 2 400 |
| Bahamas | 2 772 | 4 997 | 7 589 | 7 492 | 9 636 |
| Barbados | 4 412 | 3 735 | 3 915 | 2 967 | 3 284 |
| British Virgin Islands | 318 | 670 | 1 148 | 1 377 | 1 300 |
| Cayman Islands | | 1 391 | 396 | 837 | 625 |
| Dominica | 1 001 | 1 445 | 640 | 448 | 797 |
| Dominican Republic | 5 243 | 8 032 | 15 721 | 18 240 | 16 542 |
| Grenada | 1 700 | 1 419 | 1 731 | 1 784 | 2 093 |
| Guadeloupe | 4 740 | 8 000 | 8 421 | 8 642 | 7 990 |
| Haiti | 3 700 | 4 700 | 6 100 | 4 800 | 5 000 |
| Jamaica | 10 100 | 9 000 | 9 438 | 7 912 | 9 847 |
| Martinique | 3 631 | 4 842 | 4 559 | 3 474 | 5 292 |
| Montserrat | 89 | 109 | 110 | 150 | 110 |
| Netherlands Antilles | 887 | 1 090 | 030 | 1 200 | 1 200 |
| Puerto Rico | 2 264 | 2 557 | 1 496 | 1 949 | 2 516 |
| Saint Kitts and Nevis | 1 218 | 1 935 | 1 595 | 1 720 | 1 700 |
| Saint Lucia | 2 000 | 969 | 1 052 | 927 | 1 114 |
| Trinidad and Tobago | 4 417 | 4 461 | 5 509 | 8419 | 13 000 |
| Turks and Caicos Islands | 1 132 | 1 190 | 1 349 | 941 | 1 459 |
| United States Virgin Islands | 503 | 669 | 607 | 684 | 890 |

*Sources*: Food and Agriculture Organization of the United Nations (FAO); FISHSTAT 97.

nursery areas such as mangroves and seagrass beds may have contributed to the decline in stocks. The status of the region's seagrasses is not well known. Mangrove swamps are often regarded as marginal land and are being systematically degraded and destroyed as land is cleared for human settlements, or for the creation of beaches for tourism purposes. Mangroves and coastal wetlands are also frequently used as sites for landfills and the dumping of garbage, further degrading these important habitats. The decline of coral reefs, detailed above, has implications for reef fisheries. The successful management of marine and coastal resources of the Caribbean requires a solid understanding of how ecosystems function. Incorporated in this understanding is knowledge of the distribution of habitats and of the species that inhabit them. The interaction of species and their responses to the activities of man are of great importance for coastal resource management. The conservation of a particular resource requires a comprehensive, integrated framework for policy, planning and management.

The current state and importance of the marine and coastal environment demands action, and because of the dynamism of much of that environment, action will require international agreement and co-operation. Tentative beginnings of such activities are seen in regional investigations of stocks such as conch and lobster, and in the growing pressure to do something about the disappearing pelagic and wide-ranging species which are important for commercial, recreational and tourist fishers. In order for these regional efforts to be successful, however, Caribbean governments themselves must be empowered and encouraged to design, monitor and assess progress in coastal and marine activities.