6.1 Introduction

The Barbados coastline measures 92 kilometres. It is surrounded by a narrow, insular shelf, with the 200m isobath lying between two and three kilometres offshore (Map 6.1). This shelf supports a variety of living reef systems and a great diversity of species.

The coastline and near-shore areas are important to the lives of many Barbadians. They depend on it for their livelihood, making it central to their existence. As a result, this environment is under stress from the many competing demands on its fragile ecosystems.

This section will address the subject in two parts. The first part will examine the coastal area, which is defined as the area extending two kilometres inland and offshore on the Atlantic coast, and the area encompassing the main coastal highway and the one-in-one- hundred-year flood inundation line on the Caribbean coast. The second part will examine the state of fisheries resources.

6.2 The Barbados Coastline: An Overview[1]

The west coast of Barbados is bounded by the Caribbean Sea - the Caribbean coast. This coastline is backed by inland limestone cliffs and is the focal point of the island's tourism industry as well as a large residential population. The Atlantic coast lies on the eastern side of the island and largely encompasses the Scotland District. It has extremely undulating topographic features. As a result, this coast is the least developed segment of Barbados.

Due to the presence of sustained strong wave and wind energy, as well as to high levels of sedimentation derived from soil erosion in the Scotland District, the Atlantic coast has less reef development than the Caribbean coast. It is, however, characterised by large areas of limestone pavements, which are dominated by gorgonian growth.

For more detailed analysis the coastline is further subdivided in to eight sub-area classifications as shown on Map 6.2. The southeast coast, Sub-Area 1, which extends from South Point to Kitridge Point, is fully exposed to Atlantic swells. There are no actively growing fringing reefs in this area, but there is a flat, shallow bank reef that extends 400-800 metres from the shore and runs parallel to the shore.

Sub-Area 2 runs from Kitridge Point to Consett Point, where near-shore marine habitats include coral rubble, algal and gorgonian pavement. Sub-Area 3 extends from Consett Point to The Choyce, falling entirely within the exclusively non-carbonate Scotland District. In Sub-Area 4, from the Choyce to North Point, the near-shore environment comprises mainly coral rubble, algal and gorgonian pavement. Sub-Area 5, from North Point to Maycock's Bay, contains the richest marine faunal communities including hard coral.

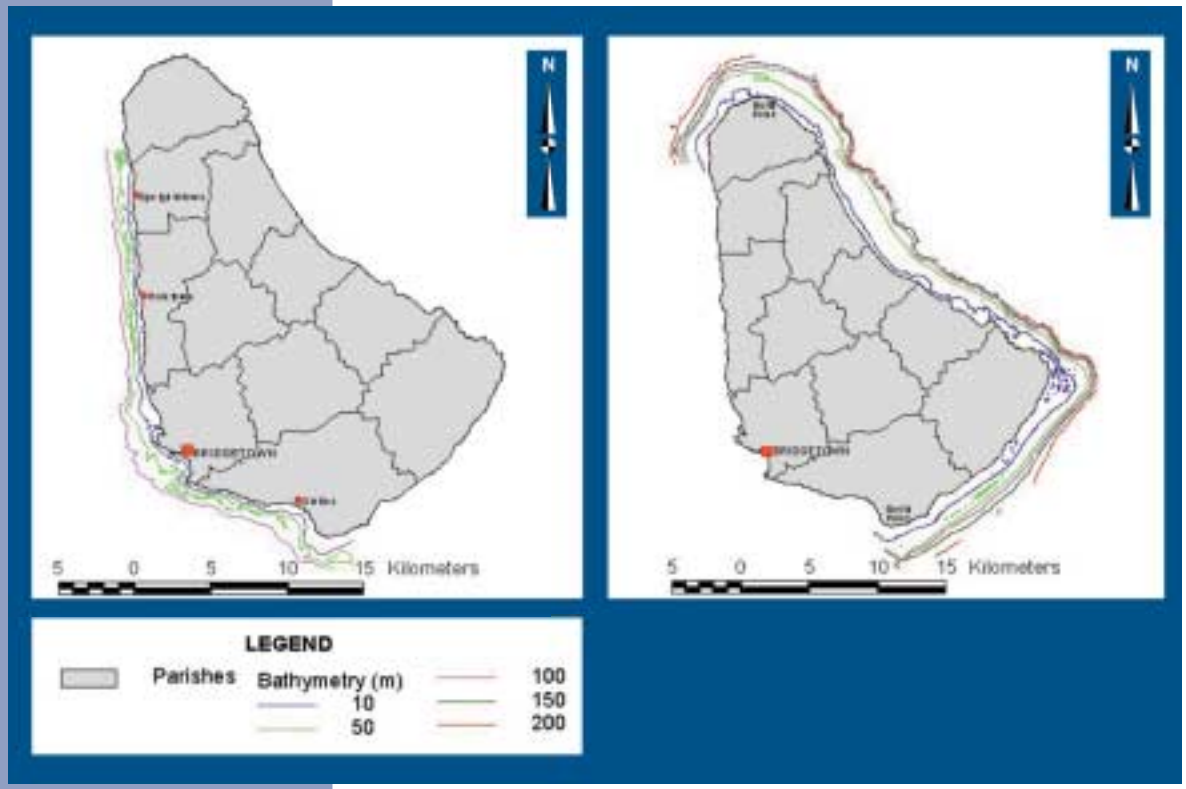
Sub-Area 6, from Maycock's Bay to Batt's Rock, has as its most distinctive immediate near-shore feature the bank barrier reef, which lies parallel to the coast between 800 and 1000m offshore. Sub-Area 7, Batt's Rock to Needham's Point, contains generally relic fringing reefs that extend to a gently sloping shelf, and extensive patch reefs in depths of 6-15m. Lastly Sub-Area 8, which extends from Needham's Point to South Point, contains one of the last remaining coastal wetlands in Barbados, consisting of an extensive inland swamp, a large beach area, sea grass beds and an offshore reef complex.

6.3 Pressures on Coastal Areas

The majority of the island's population and infrastructure is concentrated in the southwest urban corridor, and the Caribbean coast is the focal point of the island's tourism sector, as well as a large residential population. Development along this coast, which corresponds closely with coastal Sub Areas 6, 7 and 8, has occurred at some environmental cost including:

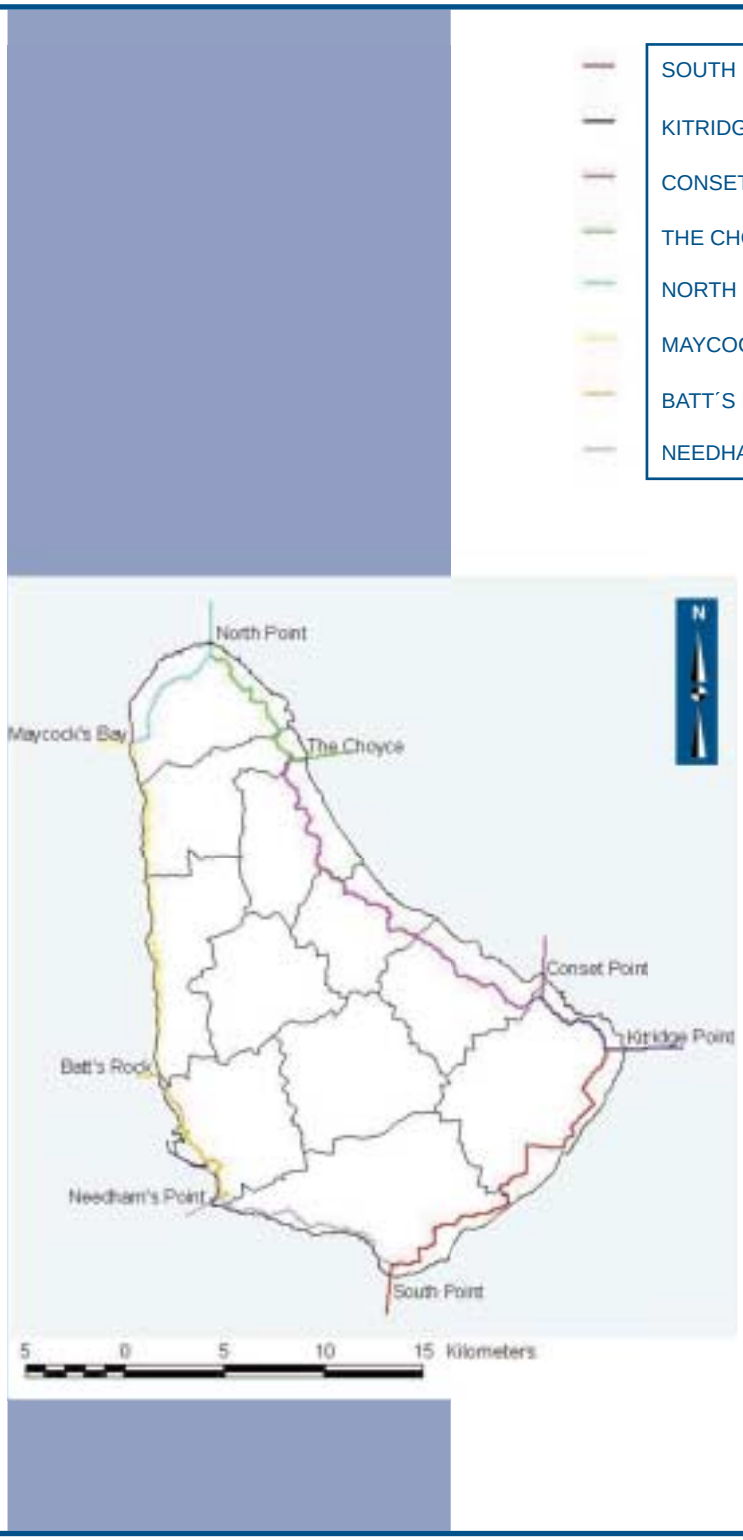
- Encroachment of buildings into the active beach zone;
- Loss and degradation of wetlands;
- Degradation of reefs and coastal water quality, and
- Loss of beach access.

Map 6.1: Coastal Bathymetry



Source: Coastal Zone Management Unit, Barbados 2001.

Map 6.2: Coastal Zone Management Sub-Areas



Source: Coastal Zone Management Unit.

With respect to the south-west urban corridor the major issues are:

- The spread of the urban corridor as a continuous coastal perimeter ribbon development with the four major towns acting as nodes. Along the west and south corridor are also found the major infrastructure and utilities, and

- Loss of economically viable agricultural/arable lands to tourism, residential and other infrastructural development.

It has been the land use policy, as articulated in successive Physical Development Plans, to encourage growth along this section of the coastline in order to allow for concentration of agriculture and water supply protection in the interior. As a result of the increasing pressure which this development has placed on the west and south coasts, the need has arisen for protective policies and guidelines.

6.4 Impacts of Coastal Land Use

In assessing the impacts of human activity on the state of coastal resources, it should be noted that several factors complicate the establishment of causal linkages. For example, the collapse of the black sea urchin population in 1983 due to disease resulted in increased growth in algae. Since this urchin grazes on algae that is harmful to coral, the increased algal abundance may be linked to coral reef deterioration and decline. Another contributing factor may be the decline in herbivorous reef fish, resulting in increased algal growth. While this is believed to be due to the human factor of over-fishing, it helps to highlight the difficulty in attributing coral reef deterioration to a single cause or to human activities[2].

Sub-Areas 1, 3, 7 and 8 show evidence of varying degrees of environmental impact. In Sub-Area 1, analysis of ground water, surface water and coastal waters revealed that wastewater discharges along the south east coast causes nitrate concentrations to rise by 0.25mg/l (milligrams per litre). There are also indications that this level will rise further due to agricultural changes. In Sub-Area 3 the main impact is the deposit of non-carbonate sediments in a north-westerly direction, derived from the Scotland District.

Sub Area 7 comprises the most extensive and concentrated area of coastal development in Barbados, and is dominated by the conurbation of Bridgetown. Land in the northern part of this area is important in industry, with the Harbour, Pine and Spring Garden areas comprising nearly 50 per cent of the total area of the industrial estates of the Barbados Industrial Development Corporation. The shoreline in this area has been substantially altered within the last four decades by the creation of a deep-water harbour.

Finally, Sub-Area 8 is an extensively developed urban corridor running from the outskirts of Bridgetown to the regional centre of Oistins and further westward to Atlantic Shores. Graeme Hall Swamp, the largest remaining area of natural vegetation in the coastal zone, occurs here. Significant deterioration of the patch reefs in this area over the last ten years has been reported, as well as decreases in the number of fish species.

6.5 Impacts on Ecosystems

6.5.1 Coral Reefs

Repeated quantitative surveys have been carried out on Barbados' coral reefs since 1982. Initial surveys were concentrated on the west coast, with the south coast surveys being included in 1987. Surveys are conducted every five years, the most recent having been repeated in 1992 and 1997. Health of the reef is generally indicated by live coral cover and coral species diversity.

Studies have revealed that both the west-coast fringing reefs and the patch reefs on the south-west coast have deteriorated considerably. During the ten-year period 1982-1992, coral abundance on the west coast was found to have decreased by an average of 34 per cent, and the number of coral species decreased by an average of 24 per cent. This is linked to the increase in the abundance of benthic algae by an average of 151.3 per cent over the period[3]. An underlying cause of algal growth may be eutrophication, and increased levels of suspended particulate matter (SPM) may also affect coral health. It is reported that about half of the west coast fringing reefs are exposed to levels of SPM that are considered stressful to corals[4]. Some improvement in the abundance and diversity of the fringing reefs was

observed, however, during the 1997 survey episode. The bank reefs are in relatively good health, although some deterioration has been observed. The planned west coast sewerage system should signal further improvement in reef condition in the future.

Studies conducted on nine south coast fringing reefs over the five-year period 1987-1992 showed a decrease in hard corals by an average of 14 per cent, a decrease in the number of species by an average of 35 per cent, and a decrease in the number of soft coral colonies by an average of 14 per cent[5]. Since then the impact of the Bridgetown sewerage system should have manifested itself, and the more recently installed south coast sewerage system is expected to have a positive impact on coastal systems in that area as well.

From initial surveys carried out on the east coast, it appears that the reefs there are healthy and support a rich and diverse community of marine flora in particular. The north coast marine systems are believed to be in near pristine condition.

6.5.2 Sea-grass Beds

Patches of sea-grasses are reported in Sub - Area 8 as an integral part of the mangrove and offshore reef complex, particularly at Hastings, Maxwell and St. Lawrence. The latter site is located in a shallow lagoon that is protected from high-energy waves by a reef rubble bank, and turtle and manatee grasses predominate[6]. This lagoon is the only area with significant sea-grass cover on the west, southwest and southeast coasts of the island. It is also the only location in Barbados where mangrove swamps, sea-grass beds, and deep hard coral reefs can be found in close association.

It is reported[7] that the area of sea-grass coverage in this lagoon has decreased and the beach area has increased over the 27 years from 1964 to 1991. In fact, in the last few years the beach has accreted so rapidly that sea-grass on the western end of the lagoon has been smothered by sand and replaced by a beach exposed at low tide.

6.5.3 Mangroves

Coastal and near-shore development has modified the littoral vegetation communities to the extent that these sites now have low species diversity. On the north and east coasts, wetlands and estuaries remain relatively intact, suffering more indirect impacts from upstream point and non-point pollution rather than direct physical encroachment or reclamation impacts.

The Graeme Hall Swamp is the most significant wetland remaining on the island. The swamp covers an area of 32 ha in one of the most densely populated areas of the island. Residential development surrounds it along the southern, eastern, western and north-western boundaries, a main coastal road runs between the swamp and the sea on the south side, and agricultural lands border the north-eastern side[8].

The swamp is divided into a western and eastern quadrant by a wide man-made track or roadway. The western quadrant comprises a brackish lake surrounded by a dense fringe of red mangroves *(Rhizophora mangle)* and white mangroves *(Laguncularia racemosa)*. The eastern quadrant contains a freshwater lake, in which there is a large stand of mature white mangroves and a network of man-made drainage canals.

This swamp is home to the widest variety of resident and migratory birds including the red seal coot *(Gallinula chloropus barbadensis)* and the yellow warbler *(Dendroica petechia)*, and it is the oldest nesting site in the island for the cattle egret *(Bulbulcus ibis)*. In addition, over 20 species of fresh and brackish water fish reside there, including the unique killifish *(Rivulus marmoratus)*[9].

Apart from the Graeme Hall swamp, there are other small patches of coastal wetlands remaining, generally on the seaward edge of watercourses. These include Heywoods Swamp, which is an estuarine mangrove swamp in healthy condition, and Brandon's Beach, a strand-wooded and basin mangrove forest with low species diversity, also in a healthy condition. Another area is the Chancery Lane Swamp, which has a significant variety of terrestrial vegetation. This site is threatened to be lost to development in the near future.

All available data conclusively indicate that mangroves and wetlands continue to suffer significant human impact, and areal coverage has declined substantively. The Graeme Hall Swamp, for exam-

ple, which has been heavily impacted over the last 150 years, is now the site of a mosquito control programme. This involves periodic clearing of vegetation from the freshwater dykes, cutting of mangroves that overhang the roadway and block the exit canal to the sea, intensive thermal fogging with Malathion, periodic opening of the sluice gate, and maintenance of the channel over the beach with heavy digging machinery. It has recently been privately developed as a bird sanctuary and interpretive centre, and the sewage treatment plant for the south coast has been constructed immediately east of the swamp.

Wetland systems continue to be threatened daily by proposed development, particularly for in-fill development within the urban southern and western coastlines, and from non-point sources of pollution.

6.5.4 Beaches

Beaches are a valuable resource, particularly on the sheltered west (Caribbean) and south coasts, which are the focus of the tourism industry. Most of the beach monitoring sites of the Coastal Zone Management Unit (CZMU) are concentrated on these coasts: approximately 35 along the west coast, 20 on the relatively short south coast, and 21 distributed on the remaining south-east, east and north coasts.

Records have shown increasing trends in beach width and beach volume in some places, such as at Welches on the south coast, and decreasing trends in others such as at Rumshop on the west coast. There is circumstantial evidence of beach gains on the south coast due directly to human activity. For example, the Oistins Fisheries Complex landfill advanced the shoreline and induced some growth of Oistins Beach immediately updrift of the landfill. Similarly Enterprise beach, popularly known as Miami Beach, was inadvertently created in 1973/1974 when the jetty that retains the beach was constructed to protect the now abandoned Oistins Coast Guard Station[10].

Notably, however, it is difficult, to attribute some trends to specific sources of impact, due to the complex interactions of natural beach dynamics and human activity.

6.6 Policy Response

Responsibility for coastal zone management lies with the CZMU of the Ministry of Physical Development and Environment. This unit, which was established as the result of an in-depth study of coastal issues and the institutional arrangements needed for effective management of the coastal zone, is a manifestation of the high priority placed on this subject by the Government of Barbados.

Two additional important products of that study were the Coastal Zone Management Act and the Marine Pollution Control Act, both to be administered by the CZMU in collaboration with other relevant agencies. These two sets of legislation, along with the Town and Country Planning Act, provide the legal basis for routine management and regulation of the coastal zone, including the implementation of policies such as:

- Planning for management of relevant resources and publication of the management plan;
- Requiring consultation by other government agencies in taking decisions that may affect coastal resources;
- Protection of linked ecologically sensitive coastal and marine areas and establishing regulations for governing activities in these areas, and
- Enforcement of the provisions of any legislation when breaches threaten coastal resources.

The proposed Environmental Management Act, which provides for the integrated and comprehensive management of the Barbados environment, incorporates the Coastal Zone Management Act and Pollution Control Act. This draft legislation is designed to be implemented jointly by the Director of Coastal Zone Management and the agencies responsible for environmental management and the Marine pollution control.

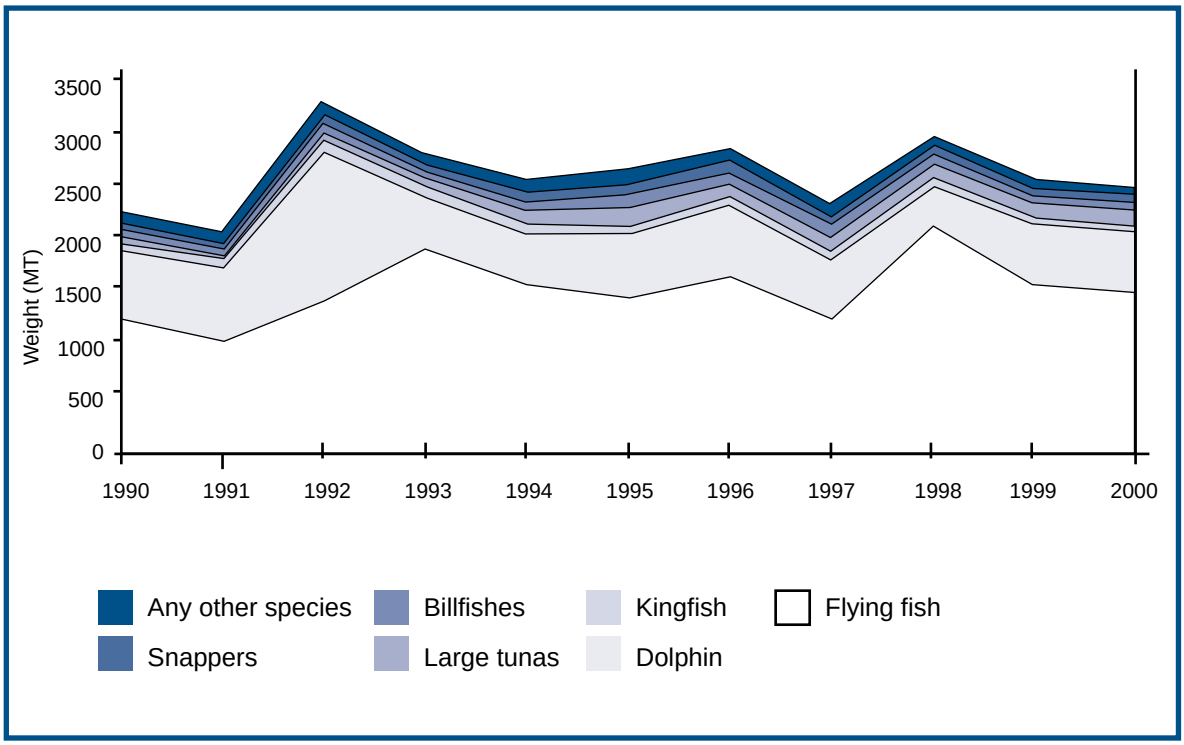
6.7 Fisheries Resources

Fishery resources are an important part of the local economy and culture, even though the total contribution of fisheries to GDP is relatively small (around one per cent annually). To facilitate

management, all local fisheries are divided into nine main categories. The status of a number of locally fished stocks is largely unknown. However, it is believed that presently, many local stocks of both near-shore piscine and shellfish species are either fully exploited or over-exploited. There is also international concern over the status of straddling stocks of large pelagic fishes such as tunas and billfishes that are also harvested by Barbadian fishers. The International Commission for the Conservation of Atlantic Tunas (ICCAT) is charged with the responsibilities of managing these stocks. Barbados became a member of ICCAT in December 2000 to facilitate a participatory role in the management of these valuable fisheries. Barbados continues to promote regional-wide fisheries management and to this end, actively participates in such regional organizations as the Caribbean Community (CARICOM) Fisheries Resource Assessment and Management Program (CFRAMP) and the Western Central Atlantic Fishery Commission (WECAFC). Table 6.1 provides a summary of the local fishery management categories and the status of the resources.

The main available indicators of resource status include data on overall fish landings and landings by species. Figure 6.1 shows the total annual landings of fish recorded at major landing sites on the island over the last eleven years. The graph shows that annual landings fluctuated over the period with the highest catch recorded during the period (31MT in 1992) immediately following the lowest recorded catch (21MT in 1991). The figure also indicates that that flyingfish continued to comprise the largest proportion of local annual fish catches (mean of 59 per cent) throughout the period. It should be noted that marked fluctuations in total fisheries landings over time, especially for multi-species fisheries, are not uncommon worldwide. Variations may result from myriad factors acting either singly or in concert including differences in fishing effort, fishing success and natural variations in the sizes of individual fish stocks.

Figure 6.1: Total Fish Landings Recorded at Major Landing Sites



Source: Fisheries Division, Ministry of Agriculture and Rural Development.

Table 6.1: Status of Fisheries Resources

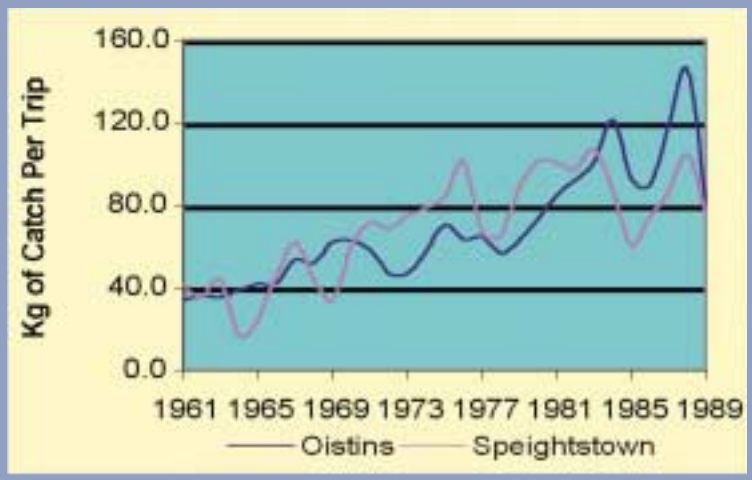
Fishery managed	Fishing methods	Area fished	Resource status
Shallow-shelf reef fishes (e.g. parrotfish, surgeonfish)	Fish traps, set nets, spear guns	Coastal coral reefs	Many south and west coast areas are considered overfished. Status of east coast resources is unknown.
Deep slope fishes (e.g. snappers, groupers)	Fish traps, handline	Deep slope bank reefs and shelf area	Unknown, but preliminary studies suggest that some areas may have potential for increased harvest.
Coastal pelagics (e.g. herrings, jacks, small tunas)	Handline, troll lines, cast net, seine net	Coastal	Unknown
Large pelagics (e.g. dolphin, tunas, kingfish, swordfish, shark)	Handline, troll lines, longline	Oceanic	Dolphin unknown. ICCAT assessment indicates some other species may be fully or over exploited.
Flyingfish	Gillnet, handline, dip net	Coastal, oceanic	Unknown. Preliminary evidence suggests potential for cautious expansion.
Sea urchins (i.e. sea egg)	Manual hand or rake	Coastal	Overfished.
Turtles (e.g. loggerhead, hawksbill, leatherback)	Entangling nets (fishery closed until further notice since 1998)	Coastal, oceanic (fishery closed until further notice since 1998)	Considered by international standards to be threatened.
Lobsters (e.g. spiny, spotted)	Fish traps, hand spears	Coastal	Unknown. Populations appear to be small.
Conch (e.g. Queen conch)	Manual	Coastal	Unknown. Populations appear to be small.

Source: Fisheries Division, Ministry of Agriculture and Rural Development, 2001.

Map 6.3: Fish Landing Sites

Source: Fisheries Division: Barbados Fisheries Management Plan, 2001.

Figure 6.2: Fishing Productivity, Speightstown & Oistins 1961 - 1989



Source: Mahon et al, 1990.

With respect to productivity of the fisheries, information is not continuous, nor is the coverage island wide. There are about 31 fish landing sites on the island, which are classified by the Fisheries Division as Primary, secondary and tertiary[11] (Map 6.3). Productivity of the resources was studied using catch landed by pelagic fishing fleets out of two of the primary sites - Speightstown and Oistins - between 1961 and 1989. The results, which are presented in Figure 6.2, suggest an overall increase in productivity at these sites over the period. It is not clear, however, whether the increased landings are due to increased stocks or improved fishing capacity.

6.8 Fisheries Policy

Owing to the important role that fisheries play in the local economy and culture, attention has been paid to the management of these resources for some time. Previously existing management regulations for the sea-egg, turtle and whale fisheries were consolidated in the Fisheries Regulation Act of 1904. This Act was repealed in its entirety and replaced by the more extensive Fisheries Act of 1993. In addition to these acts several other pieces of legislation relevant to fisheries have been put into force.

The Barbados Territorial Waters Act 1979 (cap 386), for example, contains provisions relevant to the protection of marine life, including the prohibition of fishing or extraction of living resources by foreign ships under "innocent passage", and empowers the Minister of Foreign Affairs to provide for the "regulation of fishing". The Marine Boundaries and Jurisdiction Act, 1979 (cap 387) provides a definition of fish, prohibits fishing within the 200 mile EEZ without the permission of, or an agreement with, the government of Barbados, and establishes penalties for illegal fishing[12].

The Fisheries Act 1993 consolidates the above provisions, and further provides for the Management and Development of Fisheries in accordance with statutory schemes. It also contains specifies conservation measures with respect to fishing gear and methods and provides for the protection of internationally endangered species such as marine turtles. The Act also gives the Minister responsible for fisheries the authority to create new regulations for the management of local fisheries when necessary.

The first Fisheries Management Plan (FMP) was published in 1997. A revised version was published in 2001. The FMP is developed in accordance with the requirements of the 1993 Act, "to ensure the optimum utilization of the fisheries resources in the waters of Barbados for the benefit of the people of Barbados"[13]. The document contains plans for the

continuous study, monitoring and assessment of fisheries resources in general, as well as strategies that focus on specific species. Its development and implementation is done, as required by the Fisheries Act, in collaboration with relevant agencies, interest groups and the fishing community, and is subject to public review.

6.9 Conclusion

Coastal and marine resources are vital to the Barbados economy and culture. In the past these resources have been negatively impacted by policies and practices that did not take into account their vulnerability and finiteness. In recognition of the importance of the resources, recent years have seen considerable attention paid to their protection and management. The challenge, currently and for the future, is to engage in careful monitoring and recording of the impacts of the existing policies to measure their effectiveness, and to implement changes where necessary, so as to effect the sustainable use of coastal and marine resources.

Notes

1. Most of this information on the state of the coast was obtained from the CZMU via the Ministry of Physical Development and Environment. Additional sources are cited where used.
2. Ibid.
3. Crowards (1997), citing the Bellairs Research Institute (1997), in *Environmental Indictors for Barbados: a Pilot Study for 1996*. This is a draft report prepared by the Caribbean Development Bank in collaboration with the Ministry of the Environment, under the Sustainable Development Indicators programme.
4. Ibid.
5. Ibid.
6. This site is studied as part of the CARICOMP (Caribbean Coastal Marine Productivity) network of monitoring projects, the other in Barbados being the Graeme Hall Swamp. Information was obtained from the following publication: UNESCO, 1998. CARICOMP – Caribbean coral reef, seagrass and mangrove sites. Coastal region and small island papers 3, UNESCO, Paris. Available at: http://www.unesco.org/csi/pub/papers/papers3.htm.
7. Ibid.
8. Ibid.
9. Ibid.
10. Coastal Zone Management Unit
11. Fisheries Division, Ministry of Agriculture and Rural Development, 2000. *Barbados Fisheries Management Plan*
12. Willms & Shier, 1997b, Working Paper on Environmental Laws of Barbados; prepared as part of the project on Environmental Management and Land Use Planning for Sustainable Development.
13. See 11 above.