Multi-objective Management of Inshore Fisheries in Barbados: A Biodiversity Perspective

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Abstract

Barbados, like many small island developing states (SIDS), is concerned with maintaining its marine biological diversity. In the case of commercial fisheries this is so as to achieve several different social and economic development objectives. The recently introduced system of fisheries management planning, guided by the Code of Conduct for Responsible Fisheries, seeks to incorporate the maintenance of biodiversity into these objectives. How this is done is best illustrated by reference to the more vulnerable inshore resources such as reef fish, sea urchins and sea turtles. For these resources the need to address biodiversity is especially urgent. The formulation of management plans and legislation, management of fishing operations and conduct of research all assist to address issues including over-exploitation, destructive fishing, definition of fish stocks and determination of feasible management units. Also crucial to success is progress on integrating fisheries into coastal area management to ensure responsible physical development, reduction or prevention of habitat degradation and a genuinely participatory environment for engaging diverse stakeholders in dialogue and decision-making. Critical among factors that shape these initiatives are linkages and relationships between different components of the economy, such as tourism, that share the coastal area and depend on marine biodiversity almost to the same extent as the commercial fisheries. This case study examines challenges in Barbados for multi-objective management of inshore fisheries from a biodiversity perspective.

Introduction

It is somewhat ironic that almost as soon as the term was coined in the mid-1980s is when we began to fully appreciate the extent to which marine biodiversity had already been lost, and the cost of the continuing losses, much due to human intervention (Norse 1993, Pullin *et al.* 1999). The Convention on Biological Diversity (CBD), which opened for signature at the United Nations Conference on the Environment and Development (UNCED) in Rio de Janeiro in June 1992, brought biodiversity problems and possible solutions sharply into focus on a global scale. The 1994 United Nations Conference on Small Island Developing States, which was held in Barbados, identified the vulnerability of small islands to loss of biodiversity as a major concern.

Around this time, fisheries management was being introduced to Barbados (McConney and Mahon 1998), and elsewhere in the wider Caribbean (Chakalall *et al.* 1998), in reforms of fisheries governance. Over time, Barbados has moved to fully incorporate the principles of the Code of Conduct for Responsible Fisheries into its fisheries policy and management regimes, with attention being paid to biodiversity as prescribed by the Code. The relatively small inshore fisheries of Barbados illustrate some of the issues that confront small island developing states (SIDS) and the answers that may be presented in response, to deal with the challenges of incorporating biodiversity into fisheries management within a multiple use coastal zone.

Biodiversity conservation is not an explicit stated objective for any of these fisheries, but it is embedded in each of them. This is because maintaining biodiversity is seen as a means to an

end, but not a parameter routinely measured or monitored along the way by fisheries managers. For this reason lessons learnt are not confined to biological diversity alone, they are also embedded within larger considerations. One of these key considerations is that fisheries management must articulate with other coastal uses and abuses, especially due to tourism or agriculture or other sectors of the economy, in order to be successful. The many varied objectives of these sectors make the situation particularly complex.

The next section of this study describes the fisheries of Barbados, and focuses on the status of selected inshore resources: reef fish, sea urchins and sea turtles. The history, successes and failures of management measures are examined after introducing the biodiversity perspective. How this perspective has been incorporated into fisheries management is then described, ending in lessons learnt and recommendations for future action to improve the integration of biodiversity.

The Fishery Resources and their Exploitation

Political and fisheries oceanography

Barbados is the most eastern of the Caribbean islands (Figure 1), being entirely surrounded by the Atlantic Ocean, located at latitude 13° 10' N by longitude 59° 35' W. The mainly low relief and coralline island has a total land area of about 432 square kilometres encompassed by a coastline 95 kilometres long. The island shelf is small, only 320 square kilometres, and deep water is found close to shore. No marine boundaries have been negotiated, but Barbados' potential extended marine jurisdiction has been estimated to cover around 48,800 square kilometres of ocean.

These oceanic surface waters are relatively low in nutrients, thermally stable and of low productivity. Surface currents off Barbados are complex but generally directed towards the northwest, sometimes bringing water lenses of lower salinity containing debris from the Amazon and Orinoco Rivers of South America. Closer to shore, systems of gyres and eddies tend to entrain and shed near-shore water for periods that vary according to a number of factors.

Current patterns are key factors in the context of the biological diversity of most living marine resources in small island multi-jurisdictional systems, especially with active fisheries. Currents transport eggs and larvae, and influence the movements of some adult fisheries resources and the small-scale or artisanal fishing fleets that prey upon them. Inter-connections among areas under different marine jurisdictions are inevitable, and determine applicable and practical management units for many fisheries. The consequences of this connectivity for maintenance of biodiversity are several, but centred around an inescapable interdependence unless it can be shown that fisheries resources are retained within national political boundaries for all or most of their life cycles. This would be an ideal situation for relative autonomy in fisheries management. Yet, lack of congruence between ecological and political units must be considered. Figure 2 illustrates the potential mosaic of marine jurisdictions in the wider Caribbean.

Few of these are actual negotiated boundaries, and the management regimes for shared resources have generally not been formalised between countries. Until the degree of ecological and political congruence is sorted out we must conclude that local or national initiatives to maintain biodiversity through fisheries management may provide benefits elsewhere rather than locally, especially if aimed at early life history stages. The precautionary approach would be to assume connectivity, until proven otherwise, and manage the fisheries resources on this basis. Roberts (1997) provides a vivid illustration of some consequences of connectivity for coral reef resources based on passive dispersal and typical current patterns. This is reproduced in Figure 3.

Barbados' fishing industry

Vessels and gear

There are 4 main types of fishing boats in the Barbados fleet based on physical features and fishing methods. Moses, of which there are approximately 400, are open boats 3-6 metres in length with 10-40 horsepower gasoline outboard engines. They are used primarily as fishing and diving platforms for reef and coastal fisheries. The fishing gear commonly used includes hand and trolling lines, fish traps and cast nets.

Launches or dayboats, of which there are approximately 300, are mostly wooden vessels 6-12 metres in length, propelled by inboard diesel engines from 40-180 horsepower. However, fibreglass construction and outboard engines are fairly common. They primarily land flyingfish and large pelagics from same-day trips. Gear commonly used includes hand and trolling lines, gill nets and hoop nets, but some are also used for tending set nets and for inshore diving areas. Very few are fitted with machinery for hauling or retrieving gear.

Iceboats, approximately 150, are usually greater than 12 metres in length, propelled by inboard diesel engines and used primarily for harvesting flyingfish and large pelagics on trips of 5-10 days. The gear is the same as for dayboats. Size, trip duration and insulated hold are the main distinguishing features.

Longliners, approximately 30, often exceed 12 metres in length, are propelled by inboard diesel engines, and are often either converted iceboats or used vessels imported from the USA. They are used primarily for harvesting tunas and swordfish, with a by-catch of large other pelagics, on trips usually of 12-28 days. Pelagic longline gear (Florida-style) is mainly used, but some carry all of the other gear associated with iceboats and switch between fisheries.

Catches

Since the small island shelf cannot support a large demersal fishery, a multifleet, multispecies fishery for offshore pelagics is predominant (Table 1). All of these species appear to be seasonal, some more than others, but in most cases the main season runs from November to July when over 90% of the annual catch is landed. Figure 4 shows the locations of fish landing sites. Within the season there are usually peaks of abundance which shift from year

to year. The annual seasonality and absence of a clear growth or declining multi-year trend in total catches are evident in Figure 5.

Commercially, the most important species is the small pelagic fourwing flyingfish (*Hirundichthys affinis*) which usually comprises about 55% of total annual landings. Dolphin (*Coryphaena hippurus*, the fish, not the mammal) is the second most commercially important pelagic species in Barbados, usually comprising about 30% of the total annual landings. Besides sharks, which are not target species, the remaining pelagics of commercial importance are kingfish – mainly wahoo (*Acanthocybium solanderi*), tunas – mainly yellowfin (*Thunnus albacares*), billfish – mainly blue marlin (*Makira nigricans*) and Atlantic sailfish (*Istiophorus albicans*), and swordfish (*Xiphias gladius*). Most of these highly migratory species fall under the jurisdiction of the International Commission for the Conservation of Atlantic Tunas (ICCAT).

Demersal slope and bank species such as snappers (Lutjanidae) and the wider variety of shallow shelf reef species are more important during the hurricane season (June-October) when large pelagics and flyingfish are less abundant, and a large portion of the offshore fleet is hauled out for annual maintenance. There are currently inshore fisheries for spiny lobster (*Panulirus argus* with some *P. guttatus*) and a small fishery for conch (*Strombus gigas* and some helmets). The sea urchin (*Tripneustes ventricosus*) and sea turtle fisheries were closed, temporarily and indefinitely respectively, as part of the 1997-2000 Fisheries Management Plan. Catches in all of the inshore fisheries are generally small in terms of weight, but some such as lobster and sea urchin are valuable due to high unit price, relatively low investment for entry into the fisheries and the opportunity to earn alternative income from fishing for those in the pelagic fisheries or other industries. These inshore fisheries also experience the most varied interaction with other coastal uses and impacts such as of tourism and agriculture.

Selected inshore fisheries

The remainder of this case study examines the inshore fisheries for shallow shelf reef fish, sea urchins and sea turtles in the context of multi-objective fisheries management in Barbados. It focuses on some of the processes employed and trade-offs faced when managing complex small-scale fisheries. The analysis is from a biodiversity perspective, although it must be appreciated that biodiversity conservation is not necessarily an explicit or driving force behind management decisions and processes. The table below presents an overview of the selected fisheries, details of which are developed in subsequent sections before elaborating on the biodiversity perspective.

Status and Trends of the Fisheries

The case study draws heavily on the previous and present FMPs. These sections briefly describe each fishery ending with their status and trends. Much of the material is taken from the 2001-2003 Fisheries Management Plan.

Reef fish

A classic general introduction to Caribbean coral reef fisheries is Munro (1983). For Barbados the following descriptions profile the local fishery.

Target species - Hinds (Serranidae); Parrotfishes (Scaridae); Grunts (Haemulidae); Surgeonfishes (Acanthuridae); Triggerfishes (Balistidae)

By-catch - Squirrelfishes (Holocentridae) and other reef fish species; Lobsters (Palinuridae); Moray eels (Muraenidae)

Distribution - Seagrass beds (many juveniles); coral reefs (adults).

Growth - Up to 50 cm (many species).

Life span – Longevity is 4-6 years (most species).

Reproduction - Varies by species, but most broadcast eggs into the plankton that drifts with currents locally or regionally.

Economic importance - Economic links to tourism are perhaps as, or more, important than the dollar value of the food fishery. However, the distribution of these benefits is an issue.

Vessel type - Mainly small, open, outboard-powered boats (moses) are used.

Fishing gear and methods - Fishing is most intense during the period July - October when pelagics are scarce, but reef fishes are captured year round at some sites. Mainly fished using traps of various shapes (Z, A, S, and rectangular) and of various sizes. S-traps and rectangular traps are not common. Z-traps are prevalent on the south coast, and A-traps on the west. Hexagonal wire mesh 1.25 inch (3.18 cm) is most commonly used to make traps, and the 1 inch (2.5 cm) mesh previously in limited use has been illegal since 1998. These mesh sizes retain juveniles of several species. The traps are often baited with macerated fish or black sea urchins (*Diadema antillarum*) and hauled every 2-3 days. Reef fishes are also taken by traps and handlines fished at various depths down to about 50 m.

Landing sites - Rough seas limit reef fishing activity along the east coast at most times.

Employment - Important to part-time fishers year-round and full-time fishers upon conclusion of flyingfish season.

Resource status - Areas of reef are believed to be overfished, particularly on the south and west coasts, where fishermen have reported reduced catch per unit effort and fish size. The potential yield is unknown due to lack of accurate local catch and effort data over time, or reasonable estimates of production extrapolated from similarly fished and ecologically comparable reef areas elsewhere.

Catch and effort trends - Estimated annual landings of reef fish ranged 14 - 60 metric tons for 1990-1999. Information on effort is available only as numbers of vessels, not by gear type.

Recent research – In evaluating escape panels for fish traps Selliah *et al*. (in press) found that the commercially valuable finfish catch comprised 73 species from 26 families. Parrotfishes (Scaridae) were the most common species by weight (24%) and number (26%). Conventional traps caught on average 4 kg of fish per haul with a mean weight per fish of 181g.

Sea urchins

Mahon and Parker (1999) provide a simple overview of the local fishery for sea urchins.

Target species - White sea urchin or sea egg (*Tripneustes ventricosus*)

By-catch - None

Distribution - Adults live on sea grass beds and coral rubble. Juveniles appear to settle in same areas as adults. The sea urchin is particularly vulnerable to overfishing because it occurs close to shore, is virtually immobile, and is harvested for its gonads. Natural or man-made changes in marine habitats are concerns.

Growth - Varies according to environmental conditions. Gonads ripen seasonally.

Life span - 2-3 years (max).

Reproduction - Sexually mature by one year; eggs and larvae are planktonic for several weeks. The gonads of both sexes are considered a delicacy.

Economic importance - Revenue from the sea urchin fishery is an important part of some fishermen's income. Based on estimated catch rates (approximately 6 million urchins in the open season alone), an urchin fisherman can earn more than US$300 per week if fishing daily.

Vessel type - When vessels are used, the launch is common, but the moses is also used. The occasional ice-boat is observed. Alternatively, fishers who swim out to the sea urchin ground will often carry a floating log from which bags of harvested urchins will be suspended until returning to shore

Fishing gear and methods - Sea urchins were harvested close to shore by skin divers using mask, snorkel and fins, and previously also by SCUBA divers. The sea urchins are removed from the bottom by hand or metal scraper and are collected in a net bag.

Landing sites - Sea eggs occur all around Barbados. However, the main landing sites are located on the east and south east coasts. Oistin's, Silver Sands, Conset, Crane, Foul Bay, Long Bay, Martin's Bay, Sam Lord's, Skeete's Bay, Tent Bay and Bath. Stroud Bay on the northwest coast is also used.

Employment - There are about 220 fishermen in this fishery. In addition, other people crack, clean and sell sea eggs.

Resource status - High demand has led to over-exploitation of the resource despite a two-year moratorium on harvesting between 1987 and 1989. Sea urchins are scarce and potential yield is unknown. Landings have been estimated at 6 million urchins during the open season alone in some years (1980's).

Catch and effort trends - No regularly recorded landings statistics are available. Catch and effort fluctuate with highly variable abundance. No clear trends.

Recent research – A vitally important preliminary finding by Pena Rey (1998) is that populations of *T. ventricosus* may be genetically differentiated by island. This implies that management on a national level may be appropriate, using the waters of the island countries as management units. While this was suspected for Barbados, if confirmed by the ongoing more rigorous analyses, these findings suggest that connectivity is not an issue that creates obligations for Barbados in respect of management in the downstream eastern Caribbean.

Sea turtles

Horrocks (2000) provides general background information while the Sea Turtle Recovery Plan for Barbados (Horrocks 1992) address several key conservation issues in more detail.

Target species - Hawksbill turtle (*Eretmochelys imbricata*); Green turtle (*Chelonia mydas*); Leatherback turtle (*Dermochelys coriacea*); Loggerhead turtle (*Caretta caretta*)

By-catch - None known.

Distribution - Atlantic Ocean.

Growth - Relatively slow growing.

Life span - Sea turtles are long-lived and very late maturing relative to most other exploited marine resources in this region. Some species may take 20-30 years to mature.

Reproduction - Most species nest 3-5 times in a season, with each mature female nesting in 2-3 year intervals. At each nesting, a turtle lays 80-200 eggs. Horrocks (pers. com.) estimates 75-100 hawksbills nesting annually at present.

Economic importance - A minor fishery of little economic importance as a food source, but consumption and use of products for handicraft has been traditional.

Vessel type - Nets tended by moses, incidental catches by dayboats.

Fishing gear and methods - Nets at sea, but eggs and nesting females removed by hand.

Landing sites - Usually caught by entangling nets set close to shore off nesting beaches. Females are taken on the beach when they attempt to nest, and eggs are also taken from the beach. Loggerheads are an occasional by-catch of the pelagic fishery.

Employment - A few people engaged in the fishery part-time before closure and some still poach.

Resource status - Stocks are severely overexploited, and in some cases threatened with extinction. All require conservation.

Catch and effort trends - No commercial catch and effort data are available. Anecdotal historical evidence suggests turtles were more abundant.

Recent research – It has been demonstrated through satellite tagging that female hawksbills nesting in Barbados migrate to and forage in the waters of other countries in the region, highlighting the urgent need for collaboration in management and conservation (Horrocks *et al*. in press). Regarding inter-sectoral interactions, Horrocks *et al*. (2000) found that poaching was reduced on beaches where tourism was prevalent, but that this must be weighed against the possible harmful effects of tourism, due to physical development and beach lighting for example.

Biodiversity Perspective

The principle international instrument for the conservation of biodiversity is the Convention on Biological Diversity (CBD) that was opened for signature at the United Nations Conference on the Environment and Development (UNCED) in Rio de Janeiro in June 1992. The government of Barbados ratified the CBD on 10 December 1993. The State is therefore responsible for carrying out the provisions of the CBD to the extent that it has the capacity to do so. The box below extracts some of the key terms and general measures that appear in the Convention.

Initiatives to address biodiversity

Since UNCED and ratification of the CBD, the government of Barbados, local non-governmental organisations (NGOs) and civil society have engaged in several initiatives to assess and protect biodiversity. Biodiversity featured prominently at the 1994 United Nations Conference on Small Island Developing States that was held in Barbados. Small island developing states (SIDS) emphasised the extreme vulnerability of their biological diversity and included this issue in the Barbados Programme of Action produced by the conference. A multi-stakeholder National Commission on Sustainable Development (NCSD) was set up in Barbados and a project for the preparation of a National Biodiversity Strategy and Action Plan (NBSAP) was implemented.

Fishing industry stakeholders actively participated in workshops used to assist the drafting of the NBSAP. The resulting and related documents (Simmons and Associates 1999 and 2000) contain descriptions of the fisheries resources and the issues related to conserving their biodiversity. The NBSAP process is presently at the point of formulating details of the action plans. However, this exercise has largely been subsumed in the existing FMPs of 1997-2000 and 2001-2003 given the prior recognition of the importance of fisheries biodiversity by fisheries managers.

Incorporation of biodiversity into fisheries management

Fishing is under the jurisdiction of the Fisheries Division of the Ministry of Agriculture and Rural Development in Barbados. It is not a major contributor to the economy based on the official statistics which suggest fishing provides 0.5-1.0% of Gross Domestic Product (GDP) annually. But, as for the eastern Caribbean in general, the true value of the fishing industry is seldom accurately estimated due to deficiencies in available information on catches and prices. Other, "green" or ecological/environmental, values such as biodiversity are totally ignored in the national system of economic accounting.

The Fisheries Act provides legal authority for the Fisheries Division's jurisdiction, and makes a Fisheries Management Plan (FMP) mandatory in terms of "schemes for the management and development of fisheries in the waters of Barbados" (Fisheries Act section 4). The Chief Fisheries Officer is responsible for developing and keeping such schemes under review. The Act sets out the mandatory content, urges consultation in preparation and review, and requires that approval for implementation be obtained from the Minister. The FMP is expected to cover a 3 year period during which it forms the basis for fisheries policy, management (both conservation and development), administration and the formulation or implementation of fisheries-related legislation. It may be reviewed at any time during the plan period, but an annual review is encouraged to ensure the document remains relevant and dynamic (Fisheries Division 1997). The first plan was implemented in 1997 (McConney and Mahon 1998), and the 2001-2003 plan is just commencing following an extended process of consultation (Williams *et al.* in press).

The "objective of fisheries management and development shall be to ensure the optimum utilization of the fisheries resources in the waters of Barbados for the benefit of the people of Barbados" (Fisheries Act section 3(3)). This is also the mission of the Fisheries Division for the Barbados fishing industry, and optimum utilisation has been interpreted to include non-commercial and non-food uses of "fish". The latter term is very broadly defined in the legislation to include most harvestable aquatic fauna and flora. The FMP was first operationalized by the Fisheries (Management) Regulations of 1998.

Also relevant to some aspects of fisheries management, particularly of the inshore fisheries, are the Coastal Zone Management Act and plans under the jurisdiction of the Coastal Zone Management Unit (CZMU) of the Ministry of the Environment, Energy and Natural Resources. The CZMU has authority over virtually all inshore areas and resources except those under the Fisheries Act or Fisheries Management Plans. Although still in a phase of administrative transition, the CZMU has legal authority over marine protected areas (MPAs), the rules of which override normal fisheries management provisions within the boundaries of MPAs.

The primary mechanism for incorporating biodiversity into fisheries management has been through the fisheries management planning process and implementation of the product as illustrated by the two FMPs that have been approved between 1997 and 2001. The 2001-2003 FMP sets out guiding principles for the management of fisheries in Barbados summarised from the Code of Conduct for Responsible Fisheries (Box 2).

The Code was developed under the leadership of the FAO from a series of international conferences and instruments following UNCED. The Introduction to the Code states that:

> This Code sets out principles and international standards of behaviour for responsible practices with a view to ensuring the effective conservation, management and development of living aquatic resources, with due respect for the ecosystem and biodiversity. The Code recognises the nutritional, economic, social, environmental and cultural importance of fisheries, and the interests of all those concerned with the fishery sector. The Code takes into account the biological characteristics of the resources and their environment and the interests of consumers and other users.

The Code occupies a position of prominence among international fisheries instruments. It promotes the adoption of practices for the sustainable use, management, development, and conservation of all fisheries and aquaculture through the voluntary compliance of governments, fishing industries, non-governmental organisations and other entities associated with fisheries. The very first guiding principle for Barbados concerns the maintenance of biodiversity and the remainder strongly support and facilitate the achievement of this principle.

However, the Code also goes on to mention biodiversity in the contexts of fisheries management, fishing operations and fisheries research as shown in Box 3. Much of the research undertaken on the selected fisheries resources has been relevant to assessing issues related to biodiversity. The management measures for these fisheries also facilitate the maintenance of biodiversity.

Moving from policy into practice, the fisheries management planning process employed in Barbados provides ample opportunity for factors related to biodiversity to be incorporated from a number of sources and stakeholders. As illustrated below (Figure 6), and described in McConney and Mahon (1998), the participation of fishing industry stakeholders is critical to the success of fisheries management. Although stakeholders may be unfamiliar with the technical terms and concepts of biodiversity, among resource users there is a fundamental cultural and ecological understanding of what it means and the consequences of its loss. This appreciation found its way into the issues and actions identified by stakeholders during a comprehensive participatory process to encourage fishing industry stakeholders to contribute to the formulation of the 2001-2003 FMP (Williams *et al.* in press).

Importance of target and non-target species biodiversity

In the course of executing a project on fisheries biodiversity the Fisheries Division discovered that the biological diversity reported for freshwater and marine areas in Barbados was typically underestimated (Willoughby pers. com.). A recent NBSAP report suggests that the most valued components of marine biodiversity in Barbados are the fishery resources (Simmons and Associates 1999). The measurement of this value may differ between resources and include both consumptive and non-consumptive uses. This section briefly describes what makes the biological diversity of target and non-target species important in the three selected fisheries, within the context of fisheries management in Barbados and the

eastern Caribbean sub-region. Sustainable use is a prime consideration including inter-sectoral factors such as with tourism (UNEP 1998).

Reef fish

Of the three fisheries, reef fish represent the most complicated case due to the numerous and various uses of their habitat. Some examples of their importance locally include:

- Additional employment, food and income for full-time fishers and their households.
- Income or food supplement for part-time fishers after the main fishing season.
- Attraction for tourism based activities such as submarine tours, diving and snorkelling.
- Maintenance of potential to develop public aquaria and aquarium fisheries in the future.
- Obligation to support the sustainability of the downstream fisheries in other countries.
- Maintaining the resilience of reef ecosystems as a means of coastal protection.
- Utilising easily accessible and attractive reef resources for environmental education.

Sea urchins

Although sea urchin harvest has been regulated for a longer period than the other fisheries it is in the worst shape through overfishing. Ensuring the recovery and sustainability of the fishery is important for maintaining the biodiversity of fisheries resources in Barbados for several reasons.

- Potentially very lucrative fishery for supplementing income for full-time fishers.
- Income alternative or supplement for part-time fishers after the main fishing season.
- May assist in reducing the impacts of seasonality in other sectors such as agriculture
- Cultural importance of maintaining supplies of sea egg as a traditional food supply.
- Potential for export and foreign exchange earning if sustainable populations exist.
- Urchins perform important ecological functions through grazing algae and seagrass.

Sea turtles

The sea turtle is the inshore resource with most charisma and appeal to public conservation efforts. Global communication has made its plight well-known and the response has been encouraging because people perceive these animals as important for reasons including these.

- Barbados has a global conservation responsibility for sea turtles.
- Recovery and resumption of a viable traditional fishery is possible.
- Turtle viewing and feeding can be a profitable tourism-based activity.
- Maintenance of turtle biodiversity can be used to promote eco-tourism.
- Resumption of the handicraft industries that used turtles is possible.

Management History, Successes and Failures

In the case of sea urchins, legal conservation regulation dates back to the 19th century. Sea turtles and reef fish were regulated more recently. However, fisheries management, as we understand the practice today, was introduced only in the 1980's and legislated in the 1990's. This initiative is described in McConney and Mahon (1998), with some aspects mentioned previously.

A critical point is that no formal conventional stock assessments informed the management of these fisheries but this does not prevent fishery management objectives from being formulated and operationalized (Mahon 1997, McConney 1998). This precautionary approach appears to be particularly appropriate for the small-scale fisheries resources of the eastern Caribbean about which so little is definitively known, and should be vital for the maintenance of biodiversity.

Management units and objectives

As alluded to earlier, many of the fisheries resources in the eastern Caribbean are shared, particularly the pelagic resources. It is therefore important to conceptualise the management unit in order to know which countries need to have shared or complementary management objectives and to harmonise their regulations and regimes. This concerns boundaries (Fabres 1998).

The 1997 and 2001 3-year FMPs identify the same management units and objectives for the selected inshore fisheries. These are set out below.

Reef fish

The management unit for reef fish is thought to be the island shelf for juveniles and adults. However, the distribution may be wider for early life stages due to egg and larval drift in ocean and coastal currents. This issue of connectivity in early life stages is of serious concern

to fisheries and marine protected area managers since the effects of events in one marine jurisdiction on another are often less obvious than with the more conspicuous adults. It is especially in these vulnerable stages that non-fishery factors such as water quality and habitat degradation can have influence on recruitment to a fishery in the same, or another, country.

Also, coastal waters and coral reefs in the eastern Caribbean are heavily used by an increasing variety of activities due to the growth and diversification of tourism that has lead to a wide range of watersports. Management of the reef fishery, in order to optimise economic returns from the resource, has to take into account multiple objectives and the different needs of stakeholders. Some of these include non-consumptive uses of the resources.

The objective for this fishery in Barbados is to: "Rebuild reef fish populations to levels capable of satisfying the requirements of both the commercial fishery, and recreational or tourism non-harvest uses, in order to obtain the optimum social and economic benefits from the resource" (Fisheries Division 2001).

Sea urchins

Discrete stocks of sea urchins probably exist on the Barbados shelf given its relative isolation from other island shelves, and therefore the appropriate management unit may be the waters of the country. This assumption has been reinforced by the research results of Pena Rey (1998) as described before.

Historically, this used to be an extremely important fishery for Barbados for income and employment (Mahon and Parker 1999). There is a cultural attachment to sea egg consumption. In some other Caribbean countries this resource is ignored or only lightly exploited, but wherever a fishery has developed, overexploitation is evident.

The objective for this fishery is to: "Rebuild populations and establish a co-management arrangement with fishers to maintain populations at levels which can sustain long term optimum yields for social and economic purposes" (Fisheries Division 2001).

Sea turtles

For sea turtles the appropriate unit for management may vary with species, but in all cases it should be at least the wider Caribbean through which these animals roam, as illustrated by research (Bass *et al.* 1996, Horrocks *et al.* in press).

The objective for this fishery is to: "To promote the protection, conservation and recovery of sea turtle populations" (Fisheries Division 2001). This is the one fishery in Barbados where the objective does not contemplate even restricted consumptive use. It should be noted, however, that non-consumptive use such as viewing or swimming with turtles has the potential for generating economic returns under this strict conservation regime.

Management measures

Only when the objective and area of management is decided is it possible to realistically determine what sorts of management measures are feasible. Measures may be legal or non-legal, the former being found in regulations and the latter in the operations of the fisheries management authority that are not governed by law. Operational measures often centre on education, training, technological innovations and livelihood alternatives.

Reef fish

The provisions covering reef fish under both the fisheries and coastal zone management legislation are summarized below.

Fisheries Act:

- Use of dynamite, poisons and noxious substances is prohibited.

Fisheries (Management) Regulations:

- Minimum mesh size 1.25 inches (3.18 cm) in traps.
- Trap fitted with escape panel of approves size and design to reduce ghost fishing.
- Trap marked for identification in an approved manner.
- Prohibition of trammel and any other entangling nets.
- Declaring closed areas and seasons for species and fishing methods is provided for.
- Minimum mesh size for seines 1.50 inches (3.81 cm) to reduce reef fish by-catch.
- Permission required for coral harvesting or damage.
- Permission required for aquarium fish harvesting.

Although these provisions are on the books, they have not been fully implemented or enforced. For example, the design of escape panel is still being researched (Selliah *et al*. in press) and this has not yet been introduced to the fishing industry. The same is the case for trap marking. On the positive side there have been successful actions against persons damaging coral and the harvest of aquarium fish has not become a threat to reef system biodiversity. Fishermen, acknowledging declining catches and changes in species composition, generally support the management measures (Williams *et al.* in press).

Coastal Zone Management Act:

- Use of dynamite, poisons and noxious substances is prohibited.
- Coral harvesting or damage prohibited.

- Fishing will be prohibited in no-take marine reserves.

In addition to the above, other approaches being considered are described in the management plan. Minimum mesh size in traps was introduced at 1.25 inches (3.18 cm) in 1998 and was to be increased to 1.5 inches (3.8 cm) within 2 years, continuing incrementally up to 2 inches (5.1 cm) if necessary. Increase in mesh size was postponed due to the 1999 fish kill event, but must take place before 2002 in order for recovery to commence. Furthermore, effort control may be introduced, perhaps with reduction through attrition, through licensing vessels, fishermen and traps. A permit may be required for the use of spear guns, but authorities recognise that this would be difficult to enforce. Other islands have completely banned spear fishing, but the practice continues. There is strong support from some stakeholders to prohibit SCUBA-assisted spear fishing in order to reduce effort and the depth range of harvesting.

The Folkestone Park and Marine Reserve, a no-take MPA by law but not practice, has been studied with a view to re-zoning, expansion and changes in management. No-take, or fully protected, MPAs are favoured in general (Roberts and Hawkins 2000), and have some degree of success in Barbados although not necessarily enhancing fish catches (Rakitin and Kramer 1996). Another MPA is planned for Carlisle Bay with emphasis on enhancing tourism while accommodating customary fishing practices. The Coastal Zone Management Unit (CZMU 1998) has identified locations for biodiversity conservation and environmental education.

Co-management arrangements in the context of integrated coastal area management are also being vigorously promoted. This requires an integrated, participatory approach to reef fish management, involving all of the stakeholders and most of the management approaches above to deal with the complex issues surrounding this fishery. It is essential for marine protected areas. For these approaches to succeed, habitat protection through the Coastal Zone Management Unit (CZMU) and associated agencies is essential.

Sea urchins

The regulation of the sea urchin fishery has a long history beginning with the Sea Egg Preservation Act of 1879 that established a closed season encompassing what was observed to be the peak spawning period. The closed season has been the main regulatory measure. Mahon and Parker (1999) provide a detailed chronology on changes to the regulations influenced both by conservation concerns and the government responsibility to ensure food security. The latter was a factor in the war years that precipitated relaxation of conservation measures on a few occasions. Price control was also introduced at one point to ensure that poor people could afford this important source of protein.

In more recent times there was a moratorium from 1987 to 1989 when harvesting sea eggs was not allowed. Since 1989, the closed season has been from 1 January to 31 August. During the open season from, 1 September to 31 December, it was against the law to:

- Leave the shell or offal of sea eggs on any bank or in shallow water.

- Willfully or wantonly destroy or injure any sea egg.

Due to inadequate enforcement and absence of social sanctions, illegal harvesting often started as early as July. The 1998 regulations imposed additional restrictions and closed the fishery for 3 years in order to facilitate recovery and establish comanagement arrangements for the future of the fishery.

Fisheries (Management) Regulations:

- Provision for closed seasons and areas.
- Prohibition of harvest with the assistance of SCUBA.
- Illegal to have, sell, expose for sale or purchase sea eggs during the closed season unless the sea eggs were obtained with the permission of the Chief Fisheries Officer.
- Cannot wantonly injure or destroy any sea eggs.

Fisheries (Sea Eggs Closed Season) Notice, 1998:

Instituted a closed season from 1 August 1998 to 31 July 2001. The 2001-2003 FMP contemplates an additional period of closure (minimum 1 year) for rebuilding stocks.

Co-management measures still to be considered include:

- Licensing harvesters.
- Closed areas and seasons.
- Minimum size of urchin.
- Total, individual or area quotas of allowable catches.
- Monitoring and management information systems involving harvesters.

A project to introduce comanagement to the sea egg fishery was jointly executed by the Fisheries Division and Coastal Zone Management Unit. This went as far as the formation of a fisherfolk organisation with plans to adopt a proactive role prior to the re-opening of the fishery. However, the organisation became dormant shortly after formation. The establishment of arrangements for comanagement, thought necessary to ensure the sustainability of the fishery, have not materialised but the quest for them continues through new initiatives spearheaded by an NGO.

One of the activities being considered by the fishermen was transplanting local sea urchins from plentiful to sparse areas around Barbados, perhaps by importation for neighbouring islands (Mahon and Parker 1999). However, given the preliminary genetic findings of Pena Rey (1998) of separate stocks, the introduction of urchins from other places needs to be re-examined.

Sea turtles

Sea turtles also have a relatively long history of regulation. It has been against the law to:

- Take turtle eggs.
- Capture and set gear to capture turtles of any size on shore or within 100 yards from shore.
- Buy, sell or possess any turtle less than 30 lbs in weight.

Barbados is party to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), requiring commercial trade in turtles and turtle products to be restricted or prohibited.

Fisheries (Management) Regulations:

- Illegal to possess, sell, expose for sale or purchase any turtle or part or turtle eggs.
- Fishing for or ensnaring turtles is prohibited.
- Illegal to disturb or endanger any turtle nest or remove from a nest any turtle eggs.
- Prohibition of selling turtle products under the provisions of CITES.
- Public education, monitoring and rescue under the Barbados Sea Turtle Project.
- Conservation oriented changes to coastal development and recreation.

This indefinite closure of the turtle fishery has generally been well received, but some highly publicised poaching persists, especially at the more remote beaches where regular monitoring by volunteers of the Barbados Sea Turtle Project (BSTP) is difficult. Hotels have responded well to awareness building through brochures and workshops, as have the schools. In general, public support for turtle conservation is the highest among the fisheries in the FMP. With the harvest moratorium in place, the BSTP now focuses more attention on supportive measures such as conservation-oriented educational material, beachfront lighting and other coastal development.

Lessons Learned

The preceding sections illustrate some the lessons learnt from the incorporation of biodiversity into multi-objective fisheries management in the Barbados inshore fisheries. These lessons range from the national policy level to the practices of individuals and households. This case study concludes by briefly reiterating and summarising the main lessons and then outlining possible future biodiversity initiatives n fisheries management.

Best practices, guidelines, policies, legislation

This section lists, in no particular order, some of the best practices, guidelines, policies and legislation that can be derived as lessons from the failures and successes with these fisheries.

- Multi-stakeholder participation in fisheries management planning is essential.
- Use marine protected areas and ecosystem approaches to management if possible.
- The use of genetic research to determine stocks and management units should be encouraged.
- Use genetic research results and sub-regional dialogue to determine management units.
- Acknowledge the cultural context and importance of fisheries biodiversity to fishers.
- Recognize the importance fisheries resources have for the general public of non-fishers.
- Appreciate that fisheries management must encompass non-consumptive resource uses.
- Note the positive and negative links between fisheries and other economic activities.
- Promote non-consumptive alternative livelihood resource uses for income generation.
- Conservation of biodiversity should be highlighted within environmental education.
- Determine what threats to biodiversity lie outside the scope of fisheries management.
- Incrementally increase the severity of conservation legislation if fishers first oppose it.
- Encourage environmental NGOs to facilitate the introduction of co-management.
- Consider co-management or community-based management for sustainability.
- Include non-fishery stakeholders in seeking support for biodiversity conservation.
- Consider positive and negative inter-sectoral linkages that affect fisheries management.
- Protect all stages of life history taking trans-boundary connectivity into account.

- Beware the introduction of invasive or alien species through re-stocking programs.
- Encourage regional and sub-regional fisheries management arrangements.
- Draw upon other international instruments to supplement obligations under the CBD.
- Incorporate the provisions of conservation instruments into formal fisheries policy.

Future action recommended

Annexes A, B and C reproduce the implementation plans for the three selected fisheries as they appear in the 2001-2003 Barbados Fisheries Management Plan. They set out what should be accomplished by government and the other fishing industry stakeholders within the plan period. To elaborate and add to these lists, the following could also be recommended to strengthen the incorporation of biodiversity into fisheries management n Barbados for these resources:

- Further investigation into the application of marine protected areas.
- Determine how biodiversity can be used to provide economic benefits.
- Additional education on the terms and concepts related to biodiversity.
- More attention to fisheries externalities such as habitat degradation.
- Promotion of voluntary compliance and strengthen enforcement.
- Encourage university research on the consequences of conservation.
- Further assist fishing organisations to institutionalise co-management.
- Emphasize the importance of determining appropriate management units.

References

Bass, A. L., D. A. Good, K. A. Bjorndal, J. I. Richardson, Z-M. Hillis, J. A. Horrocks, and B. W. Bowen. 1996. Testing models of female reproductive migratory behaviour and population structure in the Caribbean hawksbill turtle, *Eretmochelys imbricata*, with MtDNA sequences. Molecular Ecology 5:271-281.

Chakalall, B., R. Mahon, and P. McConney. 1998. Current issues in fisheries governance in the Caribbean Community (CARICOM). Marine Policy 22:29-44.

CZMU. 1998. The Atlantic coast. Integrated coastal management plan for the southeast, east, and northwest coasts of Barbados. Ministry of Health and the Environment, Government of Barbados. 92 p.

Fabres, B. 1998. Beyond boundaries: fisheries and marine biodiversity in Caribbean SIDS. EC Cooperation Bulletin 11(3-4):48.

Fisheries Act. Chapter 391 of the Laws of Barbados.

Fisheries Division. 1997. Barbados fisheries management plan 1997-2000. Ministry of Agriculture and Rural Development, Government of Barbados. 69 p.

Fisheries Division. 2001. Barbados fisheries management plan 2001-2003. Ministry of Agriculture and Rural Development, Government of Barbados. 72 p.

Horrocks, J. A. 1992. WIDECAST Sea Turtle Recovery Action Plan for Barbados. *in* K. L. Eckert (Ed.). CEP Technical Report No. 12. UNEP Caribbean Environment Programme, Kingston, Jamaica. 61 p.

Horrocks, J. A. 2000. The sea turtles of Barbados. Journal of the Barbados Museum & Historical Society 46:66-74.

Horrocks, J., S. Hertzlieb, and V. Copeman. 2000. Mortality rates of nesting hawksbill turtles in Barbados; a positive impact of tourism on sea turtle conservation. Pages 138-139, *in* F. A. Abreu-Grobois, R. Briseno-Duenas, R. Marquez, and L. Sarti (Compilers). Proceedings of the Eighteenth Eighteenth International Sea Turtle Symposium. US. Dep. Commer. NOAA Tech. Memo. NMFS-SEFSC-436. 293 p.

Horrocks, J. A., L. A. Vermeer, B. Krueger, M. Coyne, B. A. Schroeder, and G. Balazs. In press. Migration routes and destination characteristics of post-nesting hawksbill turtles satellite-tracked from Barbados, West Indies. Chelonian Conservation and Biology, July 2001.

Mahon, R. 1996. Fisheries and research for tunas and tuna-like species in the Western Central Atlantic: implications of the Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks. FAO Technical Paper No. 357. Rome, FAO. 62p.

Mahon, R. 1997. Does fisheries science serve the needs of managers of small stocks in developing countries? Can. J. Fish. Aquat. Sci. 54:2207-2213

Mahon, R., and C. Parker. 1999. Barbados sea eggs, past, present, future. Fisheries Division, Ministry of Agriculture and Rural Development. Fisheries Management Plan Public Information Document No. 1. 15 p.

McConney, P., and R. Mahon. 1998. Introducing fishery management planning to Barbados. Ocean and Coastal Management 39:189-195.

McConney, P. A. 1998. Using "common science' in co-management. Proc. Gulf Carib. Fish. Inst. 50:1115-1121.

Munro, J. L. (Ed.). 1983. Caribbean coral reef fishery resources. ICLARM Studies and Reviews 7, ICLARM, Manila, Philippines.

Norse, E. (Ed.). 1993. Global marine biological diversity: a strategy for building conservation into decision making. Island Press. 383 p.

Pena Rey, M. 1998. The application of randomly amplified polymorphic DNA (RAPD) markers to stock structure discrimination of the white sea urchin, *Tripneustes ventricosus*, in the eastern Caribbean. Master's thesis. University of the West Indies. 125p.

Pullin, R. S. V., R. Froese, and C. M. V. Casal (Eds.). 1999. ACP-EU fisheries research initiative. Proceedings of the conference on sustainable use of aquatic biodiversity: data, tools and cooperation, 3-5 September, 1998. Lisbon, Portugal. ACP-EU Fish. Res. Rep. 6. 70 p.

Rakitin, A., and D. L. Kramer. 1996. Effect of a marine reserve on the distribution of coral reef fishes in Barbados. Marine Ecology Progress Series 131:97-113.

Roberts, C. M. 1997. Connectivity and management of Caribbean coral reefs. Science 278:1454-1457.

Roberts, C. M., and J. P. Hawkins. 2000. Fully-protected marine reserves: a guide. WWF Endangered Seas Campaign, 1250 24th Street, NW, Washington, DC 20037, USA and Environment Department, University of York, York, UK.

Selliah, N., H. Oxenford, and C. Parker. In press. Selecting biodegradable fasteners and testing the effects of escape panels on catch rates of fish traps. Proceedings of the Gulf and Caribbean Fisheries Institute 52.

Simmons and Associates. 1999. A national biodiversity strategy and action plan for Barbados. Draft report to the Ministry of Environment, Energy and Natural Resources. Government of Barbados.

Simmons and Associates. 2000. First national report to the Conference of Parties to the Convention on Biological Diversity. Draft report to the Ministry of Environment, Energy and Natural Resources. Government of Barbados.

UNEP. 1998. UNEP's Caribbean environment programme and coral reef conservation in the wider Caribbean region through integrated coastal area management, marine protected areas and partnerships with the tourism sector. UNEP. 6 p.

Williams, E., P. McConney, and A. Kinch. In press. Participatory processes for involving fisherfolk in Barbados fisheries management planning. Proc. Gulf Carib. Fish. Inst. 53.

Figures and Tables

Figure 1. Location of Barbados.

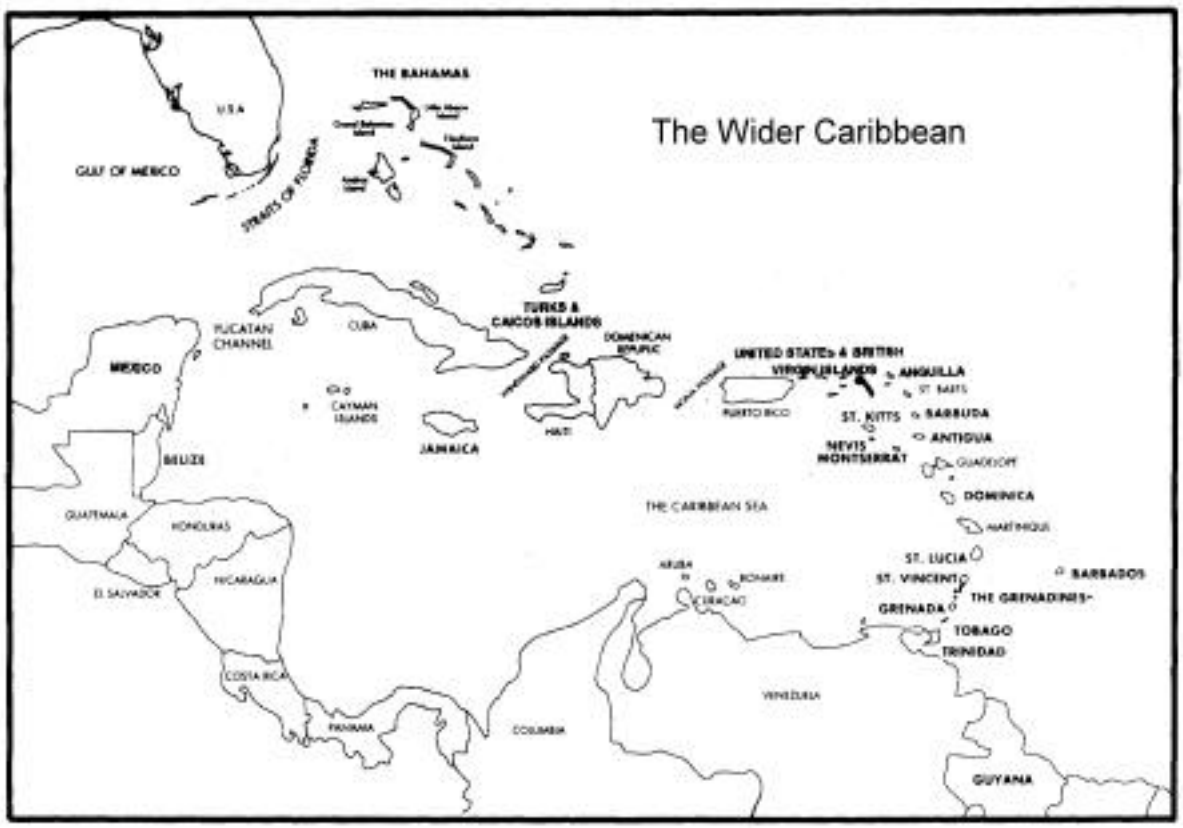
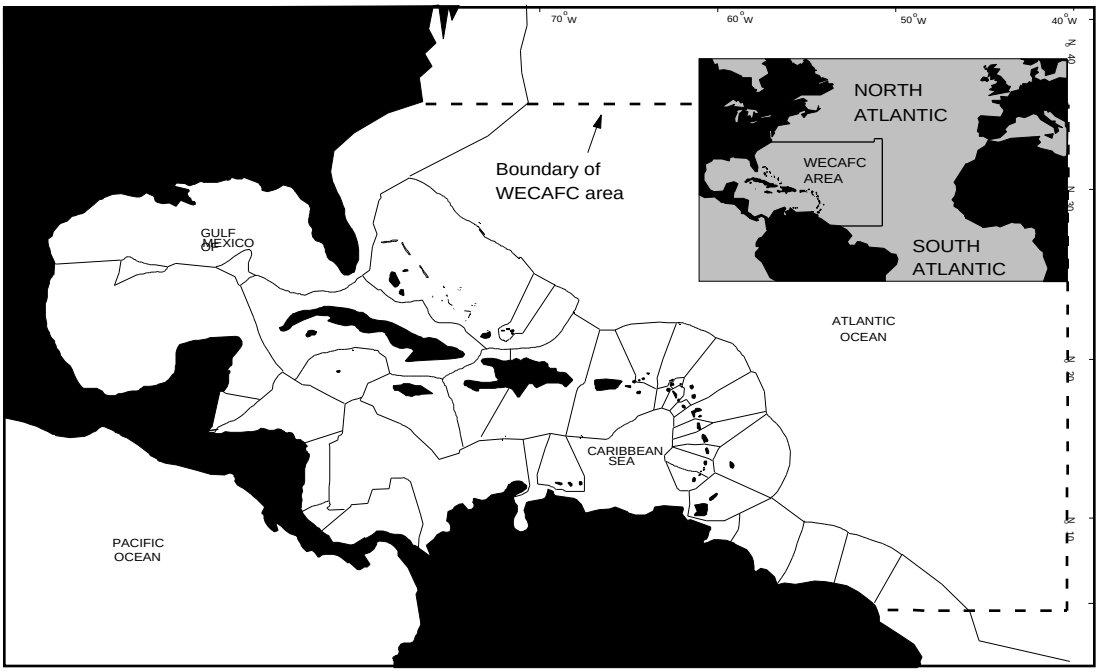
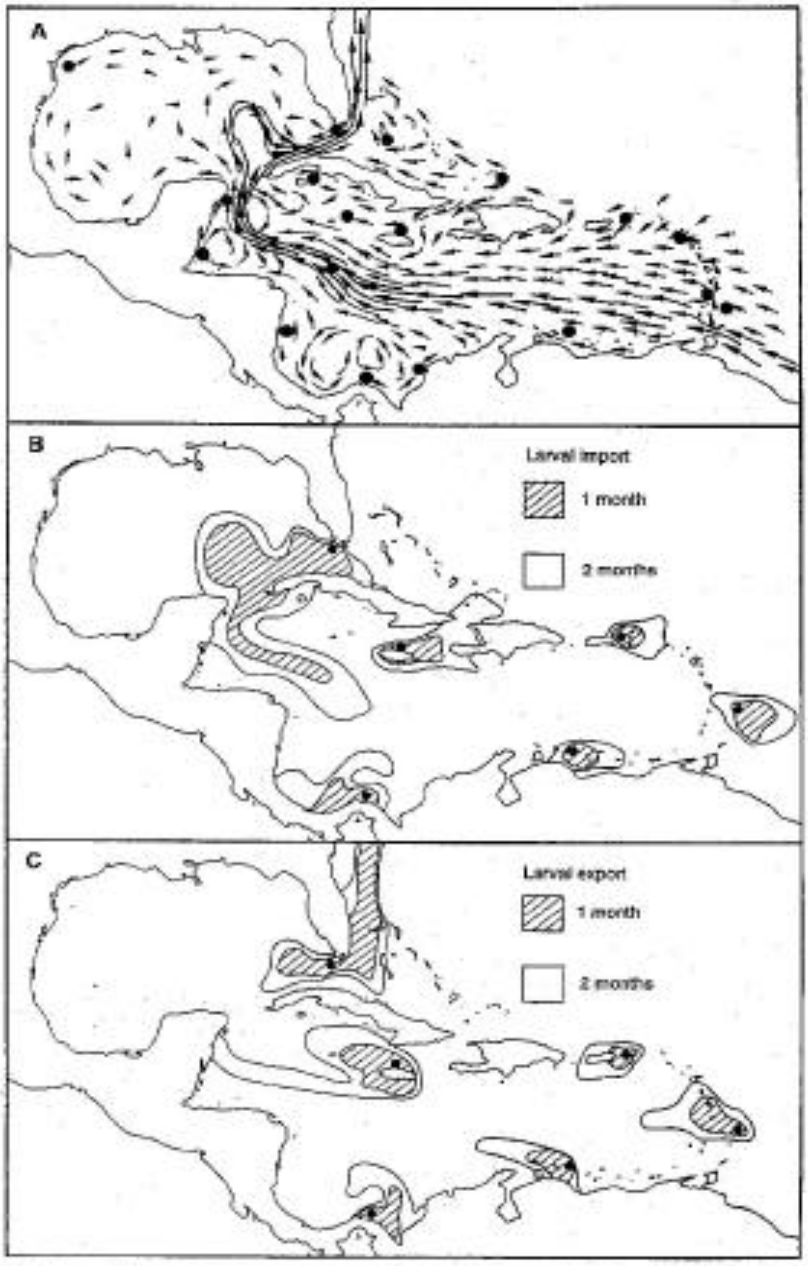


Figure 2. Potential marine boundaries in the wider Caribbean.[1]



[1] Source: Mahon, 1996.

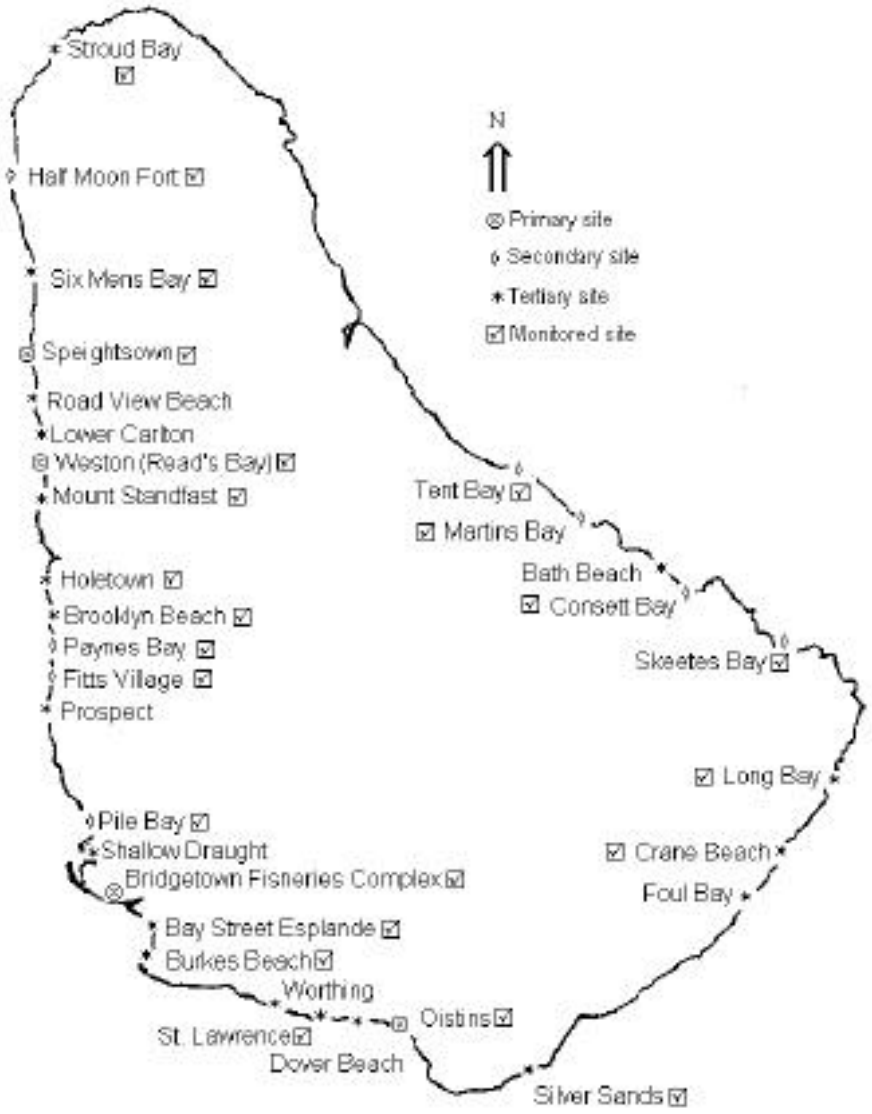
Figure 3. Caribbean coral reef connectivity taking currents into account.[2]



(A) Major surface current patterns in the wider Caribbean region (2). The tail length and thickness of arrows are approximately proportional to current strength. There are weak nearshore countercurrent flows along most coastlines, but owing to scale constraints they are only shown for a few areas on this map. The 16 study locations are shown by dots. (B) One- and 2-month envelopes of potential larval transport showing upstream areas from which larvae could be imported to six of the 16 locations studied. Transport envelopes were calculated with the use of detailed data on current patterns and strength (2) surrounding each location and the distances a passively transported larva could travel to or from that point, calculated for 12 different directions around the compass, using the current speeds and the areas over which they would be experienced within each sector. (C) One- and 2-month envelopes of potential larval transport showing downstream areas to which larvae could be exported from the same six of the 16 locations studied.

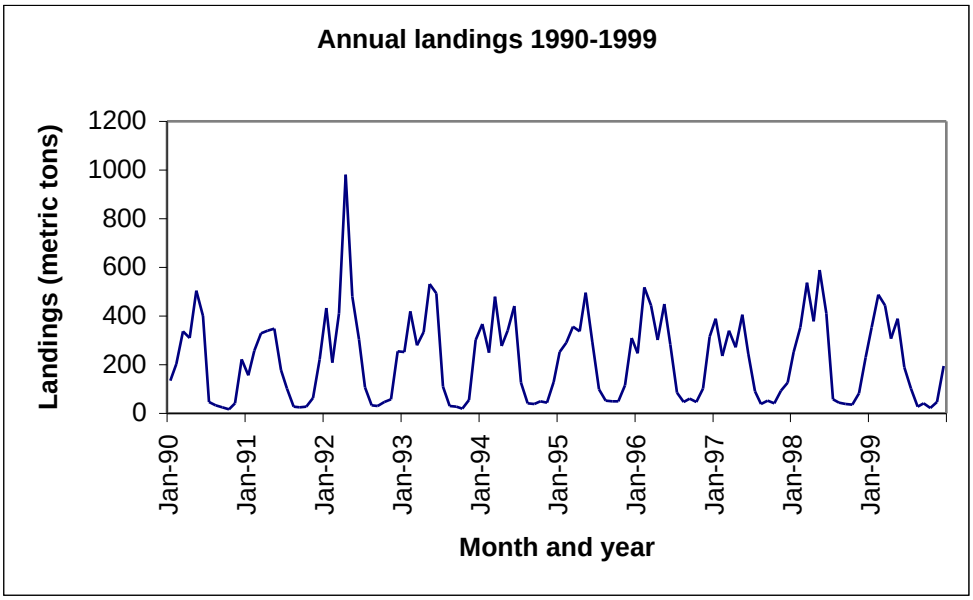
[2] Source: Roberts, 1997.

Figure 4. Fish landing and operating sites around Barbados.[3]



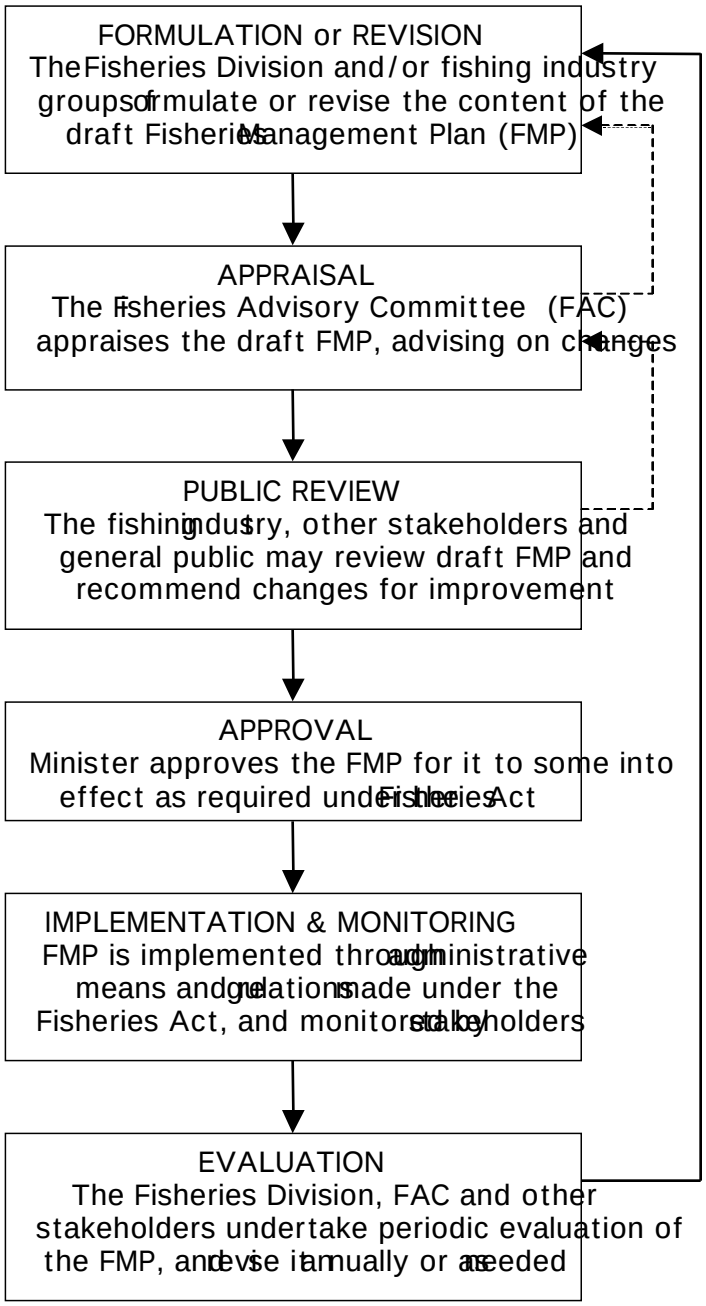
[3] Source: Fisheries Division, 2001.

Figure 5. Total estimated fish landings for Barbados, 1990-1999.[4]



[4] Source: Fisheries Division, 2001.

Figure 6. The fisheries management planning process used in Barbados.[5]

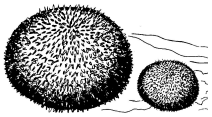


[5] Source: Fisheries Division, 2001.

Table 1. Provisional estimated total fish landings for Barbados in 2000.[6]

Local Catch by Species or Species Group	Estimated Landings (metric tons)	Percentage of total estimated landings (%)
Flyingfish	1915.6	61.8%
Dolphinfish	728.5	23.5%
Large Tunas	190.9	6.2%
Billfish	76.9	2.5%
Kingfish (wahoo)	36.1	1.1%
Carangids (jacks)	28.0	0.9%
Snappers	24.8	0.8%
Shark	13.8	0.4%
Reef Fish	11.8	0.4%
Swordfish	9.9	0.3%
Small Tunas	2.7	0.1%
Unspecified	60.8	2.0%
Total	**3099.8**	**100.0%**

Table 2. Overview of selected inshore fisheries.[7]

Fisheries	Fishing methods	Areas fished	Resource status
 shallow-shelf reef fish	Fish traps, set nets, lines, hand spears, spear guns with or without SCUBA, dynamite is illegal	Coastal coral reefs mainly along west and south coasts, but everywhere suitable habitat exists	Many south and west coast areas overfished. Status of east coast areas less well known. Trend of catch decline.
 sea urchins	By hand or manual rake, but SCUBA assistance banned since 1998	Coastal seagrass and reef rubble anywhere but mainly south, east and north coasts	Overfished now, as has happened several times in the past, perhaps exacerbated by natural population variability.
 sea turtles	Entangling nets at sea and by hand on the beach. Fishery closed until further notice since 1998.	Coastal for most, but oceanic incidental catches (fishery closed until further notice since 1998)	Considered by global standards to be under threat due to harvest and trade. Fishery had also declined locally.

[6] Source: Fisheries Division, 2001.
[7] Source: Fisheries Division, 2001.

Box 1. Terms and general measures from the Convention on Biological Diversity.

Article 2. Use of Terms

For the purposes of this Convention:

"*Biological diversity*" means the variability among living organisms from all sources including, *inter alia*, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.

"*Protected area*" means a geographically defined area which is designated or regulated and managed to achieve specific conservation objectives.

"*Sustainable use*" means the use of components of biological diversity in a way and at a rate that does not lead to the long-term decline of biological diversity, thereby maintaining its potential to meet the needs and aspirations of present and future generations.

Article 6. General Measures for Conservation and Sustainable Use

Each Contracting Party shall, in accordance with its particular conditions and capabilities:

(a) Develop national strategies, plans or programmes for the conservation and sustainable use of biological diversity or adapt for this purpose existing strategies, plans or programmes which shall reflect, *inter alia*, the measures set out in this Convention relevant to the Contracting Party concerned; and

(b) Integrate, as far as possible and as appropriate, the conservation and sustainable use of biological diversity into relevant sectoral or cross-sectoral plans, programmes and policies.

Box 2. Guiding principles from the Code of Conduct for Responsible Fisheries.[8]

Article 6 of the Code of Conduct for Responsible Fisheries sets out general principles that are summarised below:

- Maintain *biodiversity* and use ecosystem approaches to management;
- Manage fishing capacity and fishing methods to facilitate resource sustainability;
- Use precautionary approaches to sustainable use, management and exploitation;
- Protect and rehabilitate critical fisheries habitats and the environment generally;
- Use post-harvest practices that maintain nutritional value and quality of products;
- Include fisheries interests in all aspects of management planning and development;
- Establish effective mechanisms for monitoring, control and surveillance;
- Collect and provide data including sharing, pooling and information exchange;
- Ensure that fisheries decision-making processes are transparent and that all stakeholders have the opportunity to participate;
- Conduct trade in fish and fishery products according to applicable agreements;
- Cooperate with States in order to prevent disputes or resolve them in a peaceful manner;
- Promote awareness of responsible fishing through education and training;
- Ensure safe, healthy and fair working and living conditions for fishery workers;
- Recognise the contribution of small-scale fisheries to employment, income and food security;
- Encourage aquaculture as a means to promote diversification of income and diet.

[8] Source: Fisheries Division, 2001.

Box 3. Biodiversity in the Code of Conduct for Responsible Fisheries.

6 - GENERAL PRINCIPLES

6.6 Selective and environmentally safe fishing gear and practices should be further developed and applied, to the extent practicable, in order to maintain *biodiversity* and to conserve the population structure and aquatic ecosystems and protect fish quality. Where proper selective and environmentally safe fishing gear and practices exist, they should be recognized and accorded a priority in establishing conservation and management measures for fisheries. States and users of aquatic ecosystems should minimize waste, catch of non-target species, both fish and non-fish species, and impacts on associated or dependent species.

7 - FISHERIES MANAGEMENT

7.2 Management objectives

7.2.1 Recognizing that long-term sustainable use of fisheries resources is the overriding objective of conservation and management, States and subregional or regional fisheries management organizations and arrangements should, inter alia, adopt appropriate measures, based on the best scientific evidence available, which are designed to maintain or restore stocks at levels capable of producing maximum sustainable yield, as qualified by relevant environmental and economic factors, including the special requirements of developing countries.

7.2.2 Such measures should provide inter alia that:

a. excess fishing capacity is avoided and exploitation of the stocks remains economically viable;

b. the economic conditions under which fishing industries operate promote responsible fisheries;

c. the interests of fishers, including those engaged in subsistence, small-scale and artisanal fisheries, are taken into account;

d. *biodiversity* of aquatic habitats and ecosystems is conserved and endangered species are protected;

e. depleted stocks are allowed to recover or, where appropriate, are actively restored;

f. adverse environmental impacts on the resources from human activities are assessed and, where appropriate, corrected; and

g. pollution, waste, discards, catch by lost or abandoned gear, catch of non-target species, both fish and non- fish species, and impacts on associated or dependent species are minimized, through measures including, to the extent practicable, the development and use of selective, environmentally safe and cost-effective fishing gear and techniques.

8 - FISHING OPERATIONS

8.4 Fishing activities

8.4.8 Research on the environmental and social impacts of fishing gear and, in particular, on the impact of such gear on *biodiversity* and coastal fishing communities should be promoted.

12 - FISHERIES RESEARCH

12.10 States should carry out studies on the selectivity of fishing gear, the environmental impact of fishing gear on target species and on the behaviour of target and non-target species in relation to such fishing gear as an aid for management decisions and with a view to minimizing non-utilized catches as well as safeguarding the *biodiversity* of ecosystems and the aquatic habitat.

Annex A. Shallow-shelf reef fishes FMP implementation plan 2001-2003.

Issues Identified	Action Strategy	Resources Required
Conflicts between the fishery and other activities in the coastal zone especially on the west and south coasts	- Formally integrate fishing into coastal zone planning and management - Establish means for fisherfolk and other coastal zone users to meaningfully participate in planning and management	- Time, personnel and funds for a review of studies, survey of zone users and uses, public meetings and a pilot project
Not enough attention to development of sustainable solutions to conflicts	- Conduct more research on stakeholder analysis and solutions to conflicts - Use GIS and facilitation to help identify and develop solutions	- Appropriate GIS technology and means to produce maps - Training and capacity in participatory methods
Overfishing due to high mortality of juvenile and adult reef fish	- Publicise the fishery regulations - Enforce minimum mesh sizes for traps and seines, escape panels and trap marking - Establish and enforce agreed upon marine protected areas - Research effects of mesh size increases and marine reserves - Increase minimum mesh size in traps to at least 3.8 cm (1_ in.) - Limit fishing effort through licensing fishermen and gear - Research feasibility of further gear and vessel restrictions	- Funds for public education programme - Equipment and personnel for increased enforcement - Equipment and SCUBA training for personnel to conduct underwater surveys - Laboratory upgrading - An additional fisheries biologist on Fisheries Division staff
Habitat degradation and destruction	- CZMU to implement legislation for coastal zone management - Prevent fishing with dynamite - Restrict use of spear guns, especially with SCUBA - Expand marine protected areas following consultation - Increase public information on coastal habitat conservation - Encourage and inform NGOs for environmental awareness and conservation activities	- Time for inter-agency and stakeholder forums - Funds and inputs for public education programme - Funds, equipment and personnel for increased enforcement and area management
Inadequate fishery information and statistics for planning and management	- Improve sampling scheme for catches and map their locations - Get better means of measuring fishing effort on reefs - Collect biological, economic and social data - Collaborate on data collection with fishers and students - Stock assessment	- Funds for public education programme on data collection - An additional Fisheries Biologist - Computing facilities for data analysis - Scientific literature - Stock assessment training for staff
Economic linkages with tourism not optimised for fishermen	- Research and develop linkages that provide more economic opportunities for fishermen in tourism-related activities on the inshore reefs	- Access to research partners and innovative entrepreneurial collaborators for pilot projects
The institutional arrangements for managing this fishery have not been fully developed	- Explore possible institutional arrangements in collaboration with all stakeholders - Implement the preferred arrangement(s) as pilot projects for trial, and evaluate to improve	- Access to institutional research partners, fishing industry cooperation and stakeholder collaborators for pilot projects

Annex B. Sea urchins FMP implementation plan for period 2001-2003.

Issues Identified	Action Strategy	Resources Required
Stocks usually low, highly variable, and extremely vulnerable to overfishing	- Rebuild and maintain stocks at a level which can sustain fishing - Establish co-management for monitoring and harvest - Perhaps extend the 1998-2001 harvest moratorium to 2002 - Eliminate illegal fishing during the closed season/moratorium	- Funds and personnel for monitoring and enforcement - Time, funds and personnel for working on arrangements for comanagement
Poor track record of compliance with and enforcement of conservation regulations	- Find more innovative ways to enforce fishery regulations - Public education on sea egg conservation and management - Implement a “coast watch” type of public surveillance system	- Funds for public education programme on conservation - Response capability for “coast watch” - Time for inter-agency and stakeholder forums
Inadequate fishery information and statistics for planning and management	- Improve estimation of catch and effort - Collect biological, economic and social data - Collaborate on data collection and monitoring with fishers - Stock assessment in collaboration with university	- Funds for public education programme on data collection - Additional Fisheries Biologist(s)
Possible habitat degradation and destruction and water pollution	- CZMU to implement legislation for coastal zone management - Collaborate closely with CZMU and environmental agencies on habitat surveys, pollution etc.	- Funds, equipment and SCUBA training for personnel to conduct underwater surveys
The institutional arrangements for managing this fishery have not been fully developed	- Explore possible institutional arrangements in collaboration with all stakeholders - Implement the preferred arrangement(s) as pilot projects for trial, and evaluate to improve	- Access to institutional research partners, fishing industry cooperation and stakeholder collaborators for pilot projects

Annex C. Sea turtles FMP implementation plan for period 2001-2003.

Issues Identified	Action Strategy	Resources Required
Habitat degradation and destruction	- CZMU to implement legislation for coastal zone management - Expand marine protected areas after consultation - Improve turtle conservation provisions in coastal physical development legislation	- Time for inter-agency and stakeholder forums - Equipment and personnel for increased enforcement and area management - Advice for legal review process
Vulnerability of stocks to overfishing	- Implement and strictly enforce indefinite harvest moratorium in the fishery regulations - Public education on conservation and management - Prohibit harvest and sale of turtle products	- Funds and personnel for enforcement - Funds for public education programme
Inadequate information and statistics for planning and management	- Collect data on nesting sites and forage areas - Estimate nesting population and seasonality - Participate in tagging and tracking programmes - Implement a “coast watch” type of public surveillance system with coastal residents to obtain information and compliance	- Funds and personnel for scientific programme - Response capability for “coast watch”
Sea turtles are subject to CITES trade restrictions	- Meet obligations under CITES - Inform vendors and visitors about trade restrictions	- Time for inter-agency and stakeholder forums
The institutional arrangements for managing this fishery have not been fully developed	- Explore possible institutional arrangements in collaboration with all stakeholders - Implement the preferred arrangement(s) as pilot projects for trial, and evaluate to improve	- Access to institutional research partners, fishing industry cooperation and stakeholder collaborators for pilot projects