blue millennium

Biodiversity and Fisheries

CHAPTER 2: CASE STUDIES

Summaries

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Reservoir fisheries in the UPPER Paraná River basin, Brazil

Case study: The Itaipu Reservoir

Angelo Antonio Agostinho and Luiz Carlos Gomes

Principles: 1) Fisheries are indicators of environmental change, 2) management without monitoring or knowledge of fish biology will fail.

Experience: Management of reservoir fishery created by construction of the world's largest hydropower installation.

Most important lessons learned: 1) Preservation of critical habitat, especially upstream floodplain, 2) participation of communities in management.

Best practice: Consultation with fishing communities and preservation of three new park areas.

The Paraná River is the tenth longest river in the world and flows into the La Plata River in northern Argentina. It drainage area includes most of south central South America. Surveys in the upper Paraná River remain incomplete, but so far indicate at least 250 species of fish.

The most conspicuous man-made impact is the construction of dams, which have compartmentalized the river and regulated its flow. These changes affect migratory fish, the largest and most commercially important in the basin. These endangered species use several compartments of the basin, for spawning (upper part of tributaries), nursery (lagoons and secondary floodplain channels) and feeding (tributaries, main channel and reservoirs). The preservation of the remaining floodplain is essential for diversity and production of these stocks.

There are three kinds of fishery in the Upper Paraná basin: artisanal *(*fishers who live in small towns along the river); subsistence *(*small farmers or day workers); and recreational *(*inhabitants of major cities).

Fisheries management measures in Brazil

In 1938 a new law stated that dams must allow for the preservation of fish fauna, either by the use of fish ladders or hatcheries. Until the1950s, the main goal of Brazilian management programs became to ensure fish migration around small power plants. More than a dozen fish ladders were constructed in Brazilian small rivers before the 1960s, but rarely evaluated. Recently, as a result of public pressure, fish ladders were constructed close to large dams. Studies conducted on these facilities have, so far, been restricted to determining the efficiency of the ladders at transporting fish, and have not considered their effectiveness at conserving fish stocks.

The inefficiency of fish ladders prompted hydroelectric companies to build hatcheries, and in 1971 it became mandatory that one hatchery be built in every sub-basin containing a dam. The goal became to increase fishery yield through stocking, and to regulate fishing. The importance of biodiversity was not explicitly considered during this period.

Stocking of native and non-native species, especially in reservoirs, resulted in the widespread construction of hatcheries. Aquaculture is also promoted by Brazilian environmental agencies and hydro companies as a management alternative that may reduce the pressure on natural fish stocks and generate jobs for artisanal fishers impoverished by stock depletion.

In addition to hatcheries and fish passages, licensing, equipment and net mesh size restrictions, length limits and seasonal restrictions are used to control the fisheries.

The low yield of artisanal fisheries in South-southeast Brazilian reservoirs and the virtual absence of large fish species in the high parts of the upper Paraná River basin indicate that management results have not been satisfactory. In general, this is because management actions lack a clear purpose and are based on poor technical and scientific information. Regulations for protecting juveniles, spawning grounds and spawning season have not been efficient and have been compromised by a lack of information on fish populations, financial resources, and limited enforcement.

Case study: Itaipu Reservoir

The filling of the Itaipu reservoir in the main channel of the Paraná River was completed in 1982. Although the Itaipu dam itself is the world’s largest hydroelectric power plant, the reservoir itself is modest in size and retains some river-like qualities. The fish fauna of the Itaipu reservoir is the richest of the upper Paraná River and the reservoir has the largest number of exploited species. This great diversity seems to be a result of a large un-dammed stretch of river upstream.

Before the construction of the reservoir, artisanal fisheries were based on a more specialized and more profitable catch of large migratory piscivores. The lake-like conditions in the reservoir have caused a depletion of large piscivores and an increased density of piranhas. This compels the fishers to use gillnets, increasing both the number of species exploited and the amount of by-catch.

The fishery in the Itaipu Reservoir is characterized by low profitability and over exploitation. Habitat changes (especially damming) are the most important factor effecting biodiversity. Among the species considered endangered or threatened in the upper Paraná River several, continue to be exploited, potentially worsening their situation. Approximately 40 non-target species are caught in the reservoir and about 30% of them are of no commercial value. However, stock assessment surveys indicate that there are no problems with the stocks of these species.

The Itaipu authorities decided on a management approach different to the prevailing Brazilian model, especially regarding stocking. Stocking with exotic species was not allowed in the Itaipu Reservoir, although efforts to stock the reservoir with the native fish *Piaractus mesopotamicus* failed. In 1983, collection of biological, limnological and social information began, as a way to better understand the fishery. Collection of data relating to landings and social-economic aspects began in 1986. Surveys have registered more than a hundred species, over 60 of which are exploited in the fishery. Six out of the ten principal species in the artisanal fishery use the upstream floodplain for spawning and nurturing.

The first management action taken in the Itaipu Reservoir was construction of a hatchery on the Paraguayan side. Initially, the main goal of the hatchery was to produce fry of native species for stocking.

Due to the ease of access to the fishing grounds, especially in the upper half of the reservoir, and increased unemployment during the last decade, the number of fishers in the Itaipu Reservoir has increased, resulting in a level of fishing effort that exceeds the optimal level.

Mesh size restrictions have been attempted and refined in discussion with fishers, fishery control agencies and scientists.

The reservoir fishery was not seasonally restricted until 1997, when the need to reduce effort and protect the exit of migratory fishes to spawning grounds was considered. Fisheries were forbidden between November 01 and January 31. Positive impacts on reservoir stocks cannot, as yet, be evaluated. This decision has, however, caused many social and economic problems.

Results of management actions

Fishery management actions in Brazil are not usually evaluated or monitored. Unfortunately, many of the management actions taken in the Itaipu Reservoir have not had the desired results. For example, attempts to increase yield by decreasing minimum mesh size to exploit new species were problematic and taught fisheries management the need to consider the human dimensions when making management decisions. Today, in order to minimize possible weak points in management plans, all stakeholders are consulted before any actions are taken related to the management of the reservoir.

Management actions related to the maintenance of biodiversity have been, on the other hand, very successful. Fish life history studies have indicated that protection of critical habitats is the most important management consideration. So far, the first step toward this goal has been taken - the legal creation of three conservation areas: the Area of Environmental Protection of the Islands and Várzeas of the Paraná River; the Ilha Grande National Park; and the State Park of Ivinheima River. The effective conservation of the upper Paraná River floodplain and its biological diversity will depend on the prompt and effective management of these conservation areas.

Traditionally, management actions in the Paraná River basin, and in Brazil as a whole, have not been properly evaluated or followed by appropriate monitoring. This, in large part, explains why many unsuccessful management techniques (i.e. stocking and fish passages) were not abandoned or corrected sooner. Important lessons learned from the Itaipu experience are:

- Fishery management in reservoirs needs to give equal weight to both fish production (social reasons) and the maintenance of biodiversity.
- The focus of management actions must be on the integrity of the critical areas upstream of the reservoir, including the flood regime.
- Fishery regulation needs to be defined with the participation of the fisher community.
- No management action should be carried out without monitoring.

Fisheries legislation and control requires realism and clarity of objective, efficient communication, and the involvement of fisher organizations. It must be made clear to the public and all groups involved in the fishery that the fishery is an indicator of environmental change and plays an important role in conservation of biodiversity.

Marine Protected Areas

Tools for fishery management and biodiversity conservation in the Philippines

A.C. Alcala

Principle: Marine protected areas, conceived and managed with local participation, conserve biodiversity and sustain local fisheries and tourism.

Experience: Establishment and management of Sumilon and Apo Island marine protected areas in the Central Philippines, with contrasting results for marine biodiversity.

Most important lesson learned: Potential of protected areas realized only when local communities participate in the set up and management.

Best practice: Apo Island Marine Reserve a global model.

Rationale for protected areas

Coastal dwellers have traditionally depended on coral reefs and associated shallow-water ecosystems for their fish protein. Coral reef fishers in the Philippines have used a variety of traditional fishing gears, including fish traps, hook and line, set gill nets, and spears. With the exception of fish traps, these gears are generally not destructive to the coral reef environment. However, other methods cause great damage, including blast fishing, poisons and muro-ami.

Philippine capture fisheries as a whole had declined by the late 1970s. Trawl grounds showed signs of depletion as early as 1949. The fisheries of reefs and other shallow-water marine environments have been on the decline since the late 1970s.

Sumilon Marine Reserve and the Apo Island Marine Reserve were established to allow the build-up of fish abundance and biomass in order to export fish to the areas outside reserves and to protect biodiversity.

Sumilon Marine Reserve

The Sumilon Marine Reserve was protected and managed by the Silliman Marine Laboratory from April 1974 to 1984. In 1980, new mayors were elected in Santander and Oslob towns, and were not known for any commitment to marine conservation. In 1984, Silliman University asked the Bureau of Fisheries and Aquatic Resources to assume legal responsibility for the reserve. The next three years saw heavy fishing of the reserve and the non-reserve by local fishermen, devastating the large fish biomass built up during the 10 years of protection. Not only was the fish standing stock wiped out, but the high cover of live coral in the reserve was also reduced to rubble. The other marine species that constituted the high biodiversity of the reserve disappeared, and Sumilon reserve ceased to be attractive to tourists. The succeeding years have been characterized by unstable management. Fishing in the reserve was observed in 1995, 1997, 1998, and 1999-2001. Overall, the management objectives of Sumilon Island have only been partly achieved during its 26-year history and the benefits of protection have been eliminated. However, Sumilon provided some of the best early examples of build-up of fish abundance and fish biomass and increase of fish yield to local fishers following the establishment of the no-take marine reserve.

Apo Island Reserve

The Marine Management Committee of the Apo Island community managed Apo Island marine reserve from the early 1980s to 1994. Beginning in 1994, the Protected Area Management Board under the Department of Environment and Natural Resources took over management. The PAMB is composed of representatives from national, provincial, municipal and local levels.

The reserve is strictly a no-take reserve and fishing is restricted to the neighboring non-reserve. When asked about the effects of the sanctuary on their fish catch, most fishermen responded positively, claiming that their catch doubled because of the presence of the fish sanctuary. In the 1990s, two resorts with dive shops were built to serve the diving needs of tourists. Income from tourism appears substantial for a small island with 106 ha of coral reef.

Apo Island is a classic example of a highly successful community-based coral reef fishery resource project. This success is due to the collaborative partnership among a non-government organization, an organized local community, and local government units. Apo Marine Reserve has emerged as the model for marine resource management for the country and even for the world

Lessons learned

Marine reserves appear to be the most viable fishery management tool for developing nations because of their simplicity and the relative ease with which they can be established. They are likely to be most effective if local government units and local communities are fully involved in their management. Several human generations are required to ensure the attainment of the carrying capacity of these reserves, underscoring the usefulness of community-based management approaches.

Politics has a role in the management and protection of marine resources, and political issues must be faced early in the initiation of projects. Apo Island exemplifies full participation of local communities and local government units, along with academia and non-government agencies. The Apo community has become a model learning site for the communities on nearby islands in the Bohol (Mindanao) Sea. The existence of several hundred marine reserves subsequently established by local government units, non-government organizations and local communities, some of which are apparently working even though they have not been scientifically monitored, attests to the success of the community-based approaches in coastal resource management.

Marine reserves at Sumilon and Apo export adult fish biomass to adjacent areas after a varying period of protection. The abundance, biomass and species richness of fishes increased when the marine reserves were protected, but these biological attributes decreased when protection was lifted. The biomass of predatory target fish was still rising exponentially after 9-18 years of protection, implying that the carrying capacity of the reserves takes decades to level off and that protection must be long-term.

The Philippine Congress, recognizing the value of marine reserves and the role of communities in fisheries conservation, has included marine reserves and community participation in recent legislation, including the Agriculture and Fisheries Modernization Act of 1997 and the Philippine Fisheries Code of 1998.

Fisheries in the Mekong River

David Coates

Principles: 1) Environmental degradation, not capture fisheries, is the major threat to biodiversity in rivers, 2) fisheries are the best catalysts for preserving biodiversity.

Experience: Six-nation, heavy utilization of high biodiversity, primarily in small-scale fisheries.

Most important lesson learned: Cross-sectoral management, especially of habitat effects, is imperative where fisheries do not pose the major threat to biodiversity.

Best practices: 1) 1995 Mekong River Agreement, 2) World Commission on Dams review, 3) the fishing "lot" system.

The Mekong River is an integral part of the life of almost the entire population of the basin, which includes China, Myanmar, Lao PDR, Thailand, Cambodia and Viet Nam. Its freshwater fishery is arguably the most productive in the world. Fish diversity of the Mekong, per unit area of catchment, is roughly three times that recorded for the Amazon River basin, and is well in excess of that normally associated with coral reefs. The number of fish species in the Mekong basin is current estimated at 1200, and there is probably a high degree of within species diversity.

Much of the industrial/commercial fishery is based upon exploitation of fishes migrating in response to receding floodplain waters. Practically all species are targeted in the Mekong fishery. River fisheries are exploited largely by local communities and true "open access" fisheries rarely occur. Traditional systems for managing access and effort are widespread. Consequently, community-based management systems are better developed. Part-time fishing is the norm and is invariably mixed with agricultural activities. Average catches per fisher tend to be low, but participation is very high. There are no known direct or indirect economic government subsidies provided for the Mekong fishery.

The Mekong fishery is still dominated by smaller gears operated by individuals. At least 80 categories of gear have been identified in Cambodia alone. The net result is a very high participation in the fishery, with recorded involvement ranging from 64 to 93% of households. Survey findings indicate that, contrary to the common myth, the fishery can not be easily divided into its "commercial" and "subsistence" elements. Catches, especially of the higher value fish, are usually preferentially sold, but catches of smaller lower value fish significantly support household food security.

The "dai" fishery, prominent in Cambodia and Viet Nam, is based on a form of static trawl fixed by stakes in the river. During peak times a single gear in these "bagnet" fisheries can land up to 0.5 tons of fish per 15-minute haul. Other spectacular gears include the large barrage systems, in which fish are directed towards various forms of capture devices.

In the Cambodia and Thai Mekong a fishing "lot" system operates whereby most of the best fishing grounds are allocated through auction. Lot "owners" possess not only the fishing rights to their area, but also act as stewards. The owners protect their lots and enforce their regulations by the use of small local militia.

Although it is more prominent in some areas than others, aquaculture is currently dwarfed by the capture fisheries sector. The motivation for aquaculture, as with the fishery, tends to be profit rather than food.

The role of fisheries in conserving biodiversity

Development in the basin usually results in the simplification or obliteration of ecosystem diversity. Only by considering fisheries is there any realistic hope that these impacts can be moderated. Without the fisheries, managers across sectors have limited incentive to sustain the aquatic habitats upon which fisheries, and hence biodiversity, depend. Since the fishery exploits most of the available aquatic biodiversity, threats to fisheries and biodiversity are largely inseparable.

The Mekong fishery demonstrates that it is not necessary to use elaborate hypothetical arguments for sustaining biodiversity, because that diversity is demonstrably of immense immediate and tangible importance. Promotion of the concept that fisheries are generally damaging to biodiversity will reduce motivation to support the very sector that provides the clearest justification for improved management.

In general, individuals, communities, and government agencies in the fisheries sector in the Mekong do not distinguish between the management of biodiversity and fisheries. The direct impacts of the fisheries sector on biodiversity include the use of destructive fishing gears, exploitation of vulnerable life history stages and fishing activities in sensitive areas or times. Introductions and transfers of living aquatic organisms also affect biodiversity, through aquaculture and the inter and intra-drainage transfer of water. The movement of exotic species and strains for aquaculture is perhaps the major threat to biodiversity in the Mekong originating within the fisheries sector.

The major threat to biodiversity in river fisheries is environmental degradation. Development-related impacts from outside the fisheries sector include destruction of local spawning grounds or dry season refuges by habitat alteration, local changes in the quality and quantity of water in sensitive habitats and the timing of local hydrologic events, and the construction of barriers (dams, weirs, diversions etc.).

Status of fisheries

There is no evidence to support the widely held view that the fisheries, in terms of gross production, are actually declining. The limited data available, in fact, support the view that total catches have been maintained and are quite possibly increasing. What is generally accepted is that there are serious declines in the stocks of certain species. There are signs that this is already happening to the Tonle Sap fishery where the larger migratory species have declined significantly. Generally, though, species like the giant fishes are still fairly regularly caught. This suggests that the Mekong fishery is still in reasonably good shape, and that it is worth investing in its proper management.

Nevertheless, adverse changes in Mekong fish biodiversity are undeniable. The underlying cause, however, is far from clear. Fishing pressure is certainly increasing but environmental changes are occurring even more rapidly. Even where the effects of fishing are more obvious, it is not known if other factors have exacerbated the situation. Whatever the theoretical limits of fishing pressure, it is obvious that the resource cannot withstand both the current exploitation levels and environmental degradation combined.

Management

Biodiversity as such is still not firmly on the agenda of most fisheries management agencies, although there area number of examples where fisheries management is essentially aimed at biodiversity concerns. These include a recent ban on the use of dais for juvenile catfishes; widespread bans on the use of destructive gears; restrictions on fishing effort by gear type, location, season, method of deployment etc. and, rarely, restrictions on harvesting certain species, notably giant catfish. By and large, experiences with these government-imposed restrictions suggest they do not work effectively, except for the larger, easily monitored gears.

Community based management initiatives are relatively widespread in the Mekong Many are aimed at migratory species. However, there are few case studies showing whether these initiatives, actually succeed in sustaining biodiversity.

In terms of fisheries regulations and legislation, the picture in the Mekong is much the same as elsewhere. Top-down, government centered approaches generally fail to be effective. Management in the Mekong has generally failed to take on the greatest need of all – a cross-sectoral approach. Unless communities can manage influences from other sectors, these important fisheries can be considered highly vulnerable, if not doomed At the level of environmental management, activities in the basin are conspicuous for their absence of examples of good practice.

Best practice

In 1995 the four countries of the lower Mekong Basin (Cambodia, Lao PDR, Thailand and Viet Nam) signed a comprehensive water and related resources sharing agreement based on the principles of sustainable development. Conserving biodiversity is implicit within the concepts adopted. The Agreement present an opportunity to implement existing international agreements, guidelines or codes including the Convention on Biological Diversity, Convention on Migratory Species and the FAO Guidelines for Fisheries.

One of the World Commission on Dams study sites was in the Thai part of the Mekong where impacts of the dam upon local fisheries were particularly apparent. Recommendations of the commission included a sustainable livelihoods approach, as opposed to the more usual formal economic “cost-benefit analysis” criteria applied to investment decisions. This is considered to be a major leap forward in natural resources management, especially as the World Bank endorses the report.

Perhaps the most interesting example of “best practice” in the Mekong is the fishing lot system of Cambodia and Thailand. The extent to which “owners” manage their operations for sustainability is debatable, but a move towards longer-term, perhaps transferable, leases should promote moves in that direction. The social problems that the system may cause, such as the exclusion of the poor from resource use, need to be addressed.

A final example of progress in management approaches in the Mekong is the relatively successful use of local ecological knowledge in research and policy formulation.

Community-based protected areas in the Small Island States of the Pacific

Kenneth T. MacKay

Principle: Traditional social mechanisms form an excellent basis for lasting protection of aquatic biodiversity.

Experience: Community-based management of marine reserves in the Cook Islands, Samoa and Fiji.

Most important lesson learned: Communities are willing to modify traditional systems to effect long term conservation and sustainable use.

Best practice: Incorporation of traditional Cook Islands concept of Ra'ui, based on respect of social leaders.

Pacific Island fisheries and their management

There are twenty-one Pacific Island Countries and territories in the tropical west and central Pacific Ocean. All of the Pacific Island Countries rely heavily on their marine resources for food and income. Most of the islands have a barrier or fringing outer reef with an inner lagoon, often with associated seagrass beds and mangroves. It is primarily within this coral reef and lagoon environment that the inshore fishery is carried out. The annual inshore fishery production in Pacific Island Countries is estimated at 108,000 tons, with about 80 per cent of that accounted for by the subsistence fishery. Home fish consumption of marine products is among the highest in the world.

The coral reef and lagoon habitats contain a large number of species of fish, invertebrates, and algae. There has been extinction in some countries or Islands of a number of high value and vulnerable species, including coconut crab, giant clam, trochus, green snail, black-lipped pearl oyster and gold-lip pearl oyster. In addition, a number of sea cucumber species used in the production of bêche-de-mer have been driven to commercial extinction by overfishing. There is also recent evidence that some of the large, slow-growing reef fishes are becoming locally extinct, even around isolated islands. Marine turtles are considered endangered throughout the Pacific.

The inshore fishery in the Pacific uses a large number of species and families. Invertebrates are very important in the catch in most countries. There is often a gender difference in the harvesting. Men generally harvest the fish while women and children harvest the shellfish and seaweed. Enforcement, even where it is possible, is normally only applied to the commercial catch. The subsistence fishery is subject to very little formal regulation. It is safe to say that most inshore coastal fisheries in the Pacific are not under any formal management.

Using traditional management to conserve biodiversity

Pacific island communities have practiced traditional management systems for centuries. Recent experiences using traditional management methods indicate that social strictures can be powerful agents in conservation. These experiences include the Ra'ui system from Rarotonga, Cook Islands, a Marine Protected Area from Ono, Fiji, and village reserves in Samoa. These fish reserves have been effective in increasing biomass and biodiversity. Community or traditional leaders may select management areas using different criteria than those used by managers and conservationists, and traditional approaches need to be modified to incorporate long term conservation. Nevertheless, local communities have implemented the reserves, and decided their location, rules and management. NGOs and fisheries departments have acted as facilitators. The reserves allow harvest flexibility to match socio-cultural concerns and are evolving from short-term food banks to longer term closed areas. The village reserves are small but the network of reserves is significant and increasing.

An approach based on a traditional system has been successful where government management efforts were not. Success depends on the strong support of the traditional leaders and strong community involvement and community enforcement. Compliance is high, and the societal basis for protection varies. Village by-laws are used in Samoa and a simple legal instrument is being developed in Fiji, while in the Cook Islands traditional respect is sufficient.

There appear to be lasting social effects as well as biological ones. In the Cook Islands, for example, there is a now a much greater awareness of marine conservation and the role that ra'ui can play. A new fishery act is being developed and while not specifically aimed at legalizing ra'ui it will legally recognize management plans. These plans can include ra'ui as part of the plan. The national biodiversity plan is currently being developed as a bottom-up process with community consultation in problem and solution identification. Ra'ui is being identified as a potential tool for solving some conservation problems.

Biodiversity concerns in the management of inshore fisheries in Barbados

Patrick McConney

Principle: Connectivity of island marine jurisdictions influences national and regional management strategies for conserving biodiversity.

Experience: Management of inshore fisheries for sea urchins, reef fish and sea turtles.

Barbados is the most eastern of the Caribbean islands, part of a mosaic of marine jurisdictions in the wider Caribbean. Few marine boundaries have been negotiated, and the management regimes for shared resources have generally not been formalized. The precautionary approach would be to assume connectivity, until proven otherwise, and manage the fisheries resources on this basis. Local or national initiatives to maintain biodiversity through fisheries management may provide benefits elsewhere in the region rather than locally, especially if aimed at early life history stages.

The relatively small inshore fisheries of Barbados illustrate some of the issues that confront small island developing states (SIDS) and the challenges of incorporating biodiversity into fisheries management within a multiple use coastal zone.

A multifleet, multispecies fishery for offshore pelagics is predominant. Commercially, the most important species is the small pelagic fourwing flyingfish, which usually comprises about 55% of total annual landings. Dolphinfish is next, usually comprising about 30% of the total annual landings. The main inshore fisheries have been for reef fish, coastal pelagics, sea urchins, sea turtles, spiny lobster and a small fishery for conch. Catches in the inshore fisheries are small in terms of weight, but some 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 interaction with other coastal uses and impacts

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. However, 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.

Biodiversity conservation is not an explicit stated objective for any of the fisheries of Barbados, but it is embedded in each of them. This is because maintaining biodiversity is seen as a means to an end, not a parameter routinely measured or monitored along the way by fisheries managers.

The inshore fisheries for shallow shelf reef fish, sea urchins and sea turtles exemplify the position of biodiversity in fisheries management in Barbados today. The sea urchin and sea turtle fisheries were closed, temporarily and indefinitely respectively, as part of the 1997-2000 Fisheries Management Plan. Some important principles emerging from the experience of managing inshore fisheries include:

- The need for multi-stakeholder participation in fisheries management planning.
- Marine protected areas and ecosystem approaches to management.
- The use of genetic research to determine stocks and management units.
- Acknowledging the cultural context and importance of fisheries biodiversity to fishers.
- Highlighting conservation of biodiversity in environmental education.
- Incrementally increasing the severity of conservation legislation in order to facilitate learning by experience, especially if fishers first oppose it.
- Encouraging environmental NGOs to facilitate co-management.
- Protecting all stages of life history, taking trans-boundary connectivity into account.

Since UNCED and ratification of the CBD, the government of Barbados, local non-governmental organizations (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, held in Barbados. Delegates emphasized the extreme vulnerability of their countries' 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 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 Fisheries Management Plans of 1997-2000 and 2001-2003, reflecting recognition of the importance of fisheries biodiversity.

The fisheries of Lake Victoria

Harvesting biomass at the expense of biodiversity

Richard Ogutu-Ohwayo

Principle: Introduced species can stimulate fisheries but eliminate native biodiversity, with unknown long-term ecosystem effects.

Experience: Chronic overfishing in lake Victoria followed by shift to single-species fishery.

Most important lesson learned: Poverty can be a powerful stimulus to overfishing, so that a crisis is necessary before action is taken.

Best practices: 1) Proposed protected areas and refugia, 2) research on genetic population structure.

Lake Victoria in East Africa is the second largest freshwater body in the world, and is shared by Kenya, Uganda and Tanzania. Its watershed extends to Rwanda and Burundi.

Most of the fisheries in Kenya, Uganda and Tanzania are in Lake Victoria. In Uganda, the fishing industry employs between 500,000 and one million people. Fish is currently the second most important Ugandan export commodity (after coffee). These lakes are in one of the poorest regions of the world, and fish provide employment and food.

Lake Victoria and two other African Great Lakes (Malawi and Tanganyika) once had very high fish species diversity. They represented a spectacular example of rapid speciation, best demonstrated by the haplochromine group of fishes. There used to be over 500 species of haplochromines in Lake Victoria alone, more than 99% of which were endemic.

A history of the fishery

The lakes originally had a multi-species fishery in which two tilapiine species, (*Oreochromis esculentus* and *O. variabilis)*, were the most important. Overall, there was equity in access to the resources. Fishing was dominated by men, while fish processing and marketing were done by women. Fishing craft were small, restricting fishing to shallow inshore areas.

Pressure on the fisheries started to increase with the introduction of more efficient gill nets in 1905 and the expansion of markets following extension of the railway. Catch of the important *O. esculentus* decreased, even with increasing effort. A 1928 survey showed that *O. esculentus* was over-fished and recommended gill net mesh size restriction, effected in 1931. A lake-wide institution, the Lake Victoria Fisheries Service (LVFS), was set up to manage the fishery, and a fisheries research organization, the East African Freshwater Fisheries Organization (EAFFRO) was formed.

There were however, no limits put on fishing effort, and catches of *O. esculentus* continued to fall. Fishermen shifted to smaller mesh nets, and the mesh size limit was repealed. Fishing pressure continued to increase and catch rates decreased, due to the open access policy and the dependency of lakeside communities on the fisheries. Finally the fishery collapsed. *O. esculentus* became an endangered species in the Victoria and Kyoga lake basins. The LVFS was disbanded in 1960 and its role transferred to the individual national fisheries departments of Kenya, Uganda and Tanzania. There was no longer a regional mechanism to manage or coordinate management of this shared resource. Stocks of *Labeo victorianus*, which formed the most important fishery along the rivers of the Victoria and Kyoga Lake basins, were also depleted through intensive exploitation of gravid females during migration. *L. victorianus* became endangered in the Lake Victoria basin.

As the larger species became scarce, fishermen shifted to smaller species. A fish stock assessment in 1967 determined the magnitude of haplochromine fish stocks and options for processing and marketing. This survey showed at least 650,000 metric tones of fish of which 80% were haplochromines. Trawling started in the Tanzanian waters of Lake Victoria, and it was not long before catch rates started declining rapidly.

One of the most significant events in the fisheries of Lake Victoria was introduction of new fish species. *Lates. niloticus* (Nile perch) and four tilapiine species were introduced in the 1950s and early 1960s. Nile perch was introduced to feed on haplochromines and convert them into a larger fish of higher commercial value. The tilapiine species were introduced to augment stocks of native tilapiines which had declined due to over-fishing. Stocks of the introduced species increased rapidly between 1971 and 1983, accompanied by a decline and in some cases total disappearance of some of the native species. About 200 out of an estimated 300+ species of haplochromines are believed to have disappeared as a result of forming the main diet of Nile perch.

Nevertheless, overall fish catches increased five fold between 1975 and 1990, making Lake Victoria the single most important source of freshwater fish in the world. This increase of fish catches led to establishment of processing plants for Nile perch, mainly for export, and stimulated fishing. This rapid increase in fishing effort is a major threat to the perch fishery, and there are indications that the maximum sustainable yield (MSY) has been exceeded

Effects on ecosystems

When haplochromines were abundant, there was high trophic diversity of fishes. Feeding by the different trophic groups played an important role in the flow of energy in the lake. During the mid-1980s, major ecosystem changes started manifesting themselves in Lake Victoria. Algal blooms and mass fish kills became frequent. The concentration of phosphorus in the lake doubled between 1960 and 1990 while that of silicon decreased by a factor of 10. Algal species composition changed from dominance of diatoms to nitrogen fixing bacteria. Phytoplankton production doubled and algal biomass increased four to five times, causing a decrease in water transparency. Changes in biotic communities also occurred among invertebrates.

The depletion of the complex haplochromine community and the changes in zooplankton reduced grazing pressure, leaving much of the organic matter unconsumed. Decomposition of this organic matter depleted the water column of oxygen and led to anoxia, driving haplochromines to shallower waters where they fell easy prey to Nile perch. The water hyacinth invaded Lake Kyoga in 1988 and Lake Victoria in 1989. Water hyacinth occupied the shallow, sheltered bays, which are breeding, nursery and feeding grounds for fish.

Efforts to manage for biodiversity

The riparian states of Lake Victoria are now implementing measures for conservation and sustainable use of biodiversity as stipulated in Article 6 of the CBD. Some of the key areas of intervention include: Biodiversity identification and monitoring (*Article 7*); *In-situ* conservation *(Article 8*); *Ex-situ* conservation; *(Article 9)*; Sustainable use *(Article 10)*; Public education *(Article 13)*; and Exchange of information *(Article 17)*. Some examples of key efforts follow.

The first plan to conserve the biodiversity of threatened species of Lake Victoria cichlids was to breed them in North American aquaria and zoos with the hope of reintroducing them. However, there is no hope of completely removing Nile perch from Lake Victoria and the other lakes. Besides, this would be economically undesirable because of the large economic benefits that had been realized from Nile perch catches. There is also a limit to the number of species which can be protected by this approach. This method is therefore of limited value. A related option is to conserve some of the threatened food fishes through fish farming. Technologies are being developed to introduce *O. esculentus* and *L. victorianus* in aquaculture. Because some aquatic flora and fauna will be lost despite protection, representative samples are being kept as preserved or live specimens in museums and aquaria.

A more promising way of addressing biodiversity concerns is to identify and conserve the diversity of ecosystems. Generally, lakes which are protected from human encroachment, such as Lake Agu (among the Kyoga satellite lakes), are very valuable in biodiversity conservation. Almost all the native non-cichlids which occurred in the main lakes Victoria and Kyoga before the Nile perch upsurge have been encountered in satellite lakes. Those with high biodiversity values have been recommended as protected areas.

Refugia that take advantage of natural fish tendencies are also useful. Nile perch cannot survive under low oxygen conditions such as those in papyrus swamps. Papyrus swamps and fringing wetlands have been observed to provide refuge from Nile perch. They also serve as barriers to movement of Nile perch between adjacent water bodies. It has therefore been recommended that papyrus swamps and vegetation along and between affected lakes should not be cleared. One of the wetlands in the Victoria lake basin (the Nabugabo wetlands) is also being developed into a Ramsar site whose role will include conservation of some of the fish species lost from Lake Victoria, such as *O. esculentus*.

The genetic variability of native and introduced species has been used to guide conservation efforts. Results of research suggest that conserving genetic diversity of *L. victorianus* and *O. esculentus* will require protecting many individual populations. Some of the satellite lakes within the Victoria and Kyoga Lake basins contain the only populations of native tilapiines which have not been contaminated by *O. niloticus*. It has been recommended that measures should be undertaken to safeguard against entry *O. niloticus* into these lakes.

Changes in fishing patterns have also been considered. Recovery or improvement in stocks of endangered species would depend upon reduction in Nile perch stocks. Selective exploitation of Nile perch, especially at the time when it feeds heavily on other fishes, could reduce predation pressure on those fishes and help improving their stocks. However, the economic importance of Nile perch makes this an unlikely option.

Participatory management of fisheries in the Brazilian Amazon

Mauro Luis Ruffino

Principle: Centralized management of widely spread Amazon fisheries is ineffective.

Experience: Project IARA increased local participation in management of middle Amazon fisheries.

Most important lessons learned: 1) Cross-sectoral management of floodplain habitat effects is vital, 2) government and communities can cooperate at local level.

Best practice: Formalization of existing, community-developed "Fishing Agreements".

South America is home to a great number of fish species, the total of which has yet to be established. The largest diversity has been found in the Amazon Basin, with more than 1,300 species so far described. The ecosystem that sustains Amazon fisheries has three components: the flood plains, the river channels and the estuary. Each one supports hundreds of fish species with diverse habitats, the destruction of which would result in loss of biodiversity. The most immediate concern for Amazonian commercial fish is the loss of floodplain (várzea) forest and herbaceous plants, which supply fruits, seeds, leaves, terrestrial arthropods and other food sources for fish. The trophic chain is extremely complex.

Impacts on Amazon habitat include deforestation, ranching, pollution, mining, urban and agricultural expansion, and hydroelectric development. Territorial extension, complexity of the environment and the diversity of economic activity also present enormous management challenges for the government. The current management system, which is centralized and non-participatory, has proved to be incapable of regulating the use of natural resource in the Amazon.

The fishery for human consumption is considered one of the most productive traditional activities in the Amazon and generates at least $100 million US per year with no subsidy from either State or Federal Government. The fishery provides the principal source of protein for the Amazon population and supports several related industries. Exports of ornamental fish are also an important source of revenue for the region, and the sport fishery has great potential. Piramutaba (*Brachyplatystoma vaillantii*) has been the main fish, by weight, caught in the Amazon since the 1970s. Other important species include tambaqui, surubim, mapara and pirarucu. Due to the fact that classical methods of stock assessment and catch estimation are difficult to apply in multi-species fisheries of this type, all of the above mentioned species except mapara appear to be over-fished. The species under threat grow to relatively large sizes and have low growth rates, making them extremely sensitive to heavy exploitation.

Fisheries management in the Brazilian Amazon has until recently been conducted in the conventional centralized manner. The federal government instituted decrees, regulating fishing activities by classic methods such as closures during spawning migrations, limits on mesh size, minimum sizes and gear prohibitions. Such decrees were not always based on scientific evidence, and enforcement was not effective. Commercial fisheries were, therefore, largely developed in a regulatory vacuum, and conflicts between riverine communities and outside commercial fisherfolk proliferated in the last two decades. Many riverine communities began to implement their own management regulations, referred to as "fishing agreements". These agreements were developed to protect the fishing rights of community members and were not linked to environmental considerations.

The IARA Project

The IARA Project (Administration of the Middle Amazon Fisheries Resources) began in 1995 to develop strategies for environmental management that would guarantee sustainable exploitation of the fisheries resources. IARA used a participatory approach to integrate fisherfolk and riverine communities into the fisheries administration system and included the gathering of basic information on the fishery and the socio-economic situation of the riverine populations, and monitoring of fish landings at the major ports. It soon became obvious that the sustainable use of várzea resources could only be feasible by treating the ecosystem as a whole, and that management should include all the relevant sectoral administrations in a single system. The basic problems were insufficient socio-political organization of local rural and urban society and large gaps in social communication systems, which limited representation for those seeking sustainable natural resources management. Thus, most action in the project was directed toward institutional strengthening and encouraging a communication network. Participation of users in the management process was recognized as fundamental to its success. The project initiated a program to train community leaders as stimulators, motivators, coordinators and representatives with links to the management process and in the organization and maintenance of community groups. A comprehensive discussion process also began with all sectors involved in the fisheries, which resulted in a series of municipal fisheries forums.

Monitoring showed a progressive maturing of attitudes amongst those involved in the "fishing agreements", and as a result these agreements began to be formalized by government decrees. Nevertheless, enforcement remained a key element in the implementation of "fishing agreements". Therefore, as part of the process of co-management, the community's participation in the enforcement process was formalized by creating "environmental agents." The success achieved by these voluntary agents has created a huge demand of their use from communities in other regions.

The IARA project, funded under international technical cooperation terms, was completed at the end of 1998. A new project, the Floodplain Natural Resources Management Project (ProVárzea) was initiated in July 2000 to establish scientific, technical and policy basis for the environmentally and socially sustainable conservation of natural resources of the Várzea floodplains of the central Amazon Basin region, with emphasis on fisheries resources. ProVárzea was designed to consolidate, replicate and expand IARA's experiences over the full length of the Amazon/Solimões, with increased political and social emphasis and to adapt it to regional needs.

Products of IARA

Some measures adopted by the government and the communities are unintentionally incorporating biodiversity conservation strategies, whether through regulation of the fisheries or conservation of habitats.

IARA carried out various studies, which led to a revision of existing regulations. As far as the fishing accords are concerned, IARA reviewed the management practices of the "fishing agreements" already in place in riverine communities and adapted them for use by the government as a viable form of fisheries regulation.

Field experiences have demonstrated the importance of decentralized, participatory management. However, discussions have tended to concentrate on communities, ignoring large landowners and companies. In some regions many of the water bodies covered by fishing agreements are situated in large privately owned properties.

Based on the experiences of the project IARA, a new type of democratic and decentralized regulatory system has been introduced by the Brazilian Institute for Environment and Natural Resources (IBAMA). Decree 07/96 delegated responsibilities for regulating the fishery, through coordinated season and area closures, to State representatives of IBAMA. Decree 08/96 set out regulations concerning fishing gears and methods, and set minimum sizes for four species throughout the Amazon basin, correcting various problems. IBAMA also published "Participatory Management, a Challenge for Environmental Management" which outlined strategic directives for the fisheries and established management criteria to regularize the informal practices used for many years by riverine community "fishing agreements". In addition, a decentralized surveillance system was set up with the participation of the voluntary environmental agents.

Since 1996, based on the results of biological studies and conventional single-stock assessment, the legislation regulating fisheries has begun to be simplified and systematized, correcting inconsistencies and eliminating unnecessary measures.

Seamount fisheries in New Zealand

Effects on high-value target fish species and non-target invertebrates

Peter Smith

Principles: 1) Life history of target species is crucial to sustainable management, 2) trawling can have large effects on non-target biodiversity

Experience: Technologically advanced trawl-fisheries for slow-growing, long-lived species can severely reduce standing stock and non-target invertebrate species on seamounts.

Most important lessons learned: 1) Allowable catch must reflect life history and appropriate management units, 2) non-target species are little-known.

Best practices: 1) Closure of individual seamounts, 2) catch-limits on individual seamounts, 3) increased investment in research.

Seamount fisheries

The deepwater trawl fishery for orange roughy and oreos in New Zealand illustrates the effects of a high-technology fishery on target and non-target species.

Seamounts are steep-sided undersea mountains that are widely distributed in the world's oceans. This unique and vulnerable habitat is often characterized by slow-growing, long-lived, high value fish species that aggregate to spawn and are vulnerable to exploitation. The wide distribution of seamounts increases the risk of overexploitation through unregulated fishing in high seas.

Seamounts are fished by trawling, which poses a major threat to biodiversity and the sustainability of bottom-living species. Seamounts are the focus of very deep (600-1200m) trawl fisheries for orange roughy, black oreo, and smooth oreo. The fish are slow-growing, reaching maturity at 20-30 years of age, and may live for more than 100 years.

Management

An Individual Transferable Quota (ITQ) management system was introduced in 1986 for coastal and deepwater New Zealand fisheries. ITQs provide individuals with a transferable or tradable right to harvest a specific proportion of the total allocated surplus production of a stock.

The New Zealand Ministry of Fisheries sets an annual Total Allowable Commercial Catch (TACC) based on stock assessments produced by fishery working groups made up of representatives from the seafood industry, government agencies, and non-government organizations.

Reductions in catch on seamounts

Stock assessment results have indicated that previous catch levels were not sustainable. During the 1990s more than 50% of the orange roughy catch in the New Zealand EEZ has come from seamount complexes and all have shown a significant decline in catch rate. The TAC on the Chatham Rise was reduced from 21,300 t to 12,700 t in 1995-96 and further reduced to 7,200 t in 2000-01. The TAC for the Challenger Plateau fishery, which has been fished to only 3% of virgin biomass, has been reduced from 1425 to 1 t, effectively closing the fishery. Additional orange roughy fisheries have been developed outside the EEZ. In all fisheries, catches have declined rapidly within a few years of exploitation.

Effects of seamount fisheries on non-target biodiversity

While there are few data on the impacts of trawling in deepwater environments, the indications are that impacts will be more severe and longer-term than in coastal waters. Once depleted, seamount species may take decades, or even centuries, to regenerate. Concerns about loss of biodiversity are amplified when there is limited information on the taxonomy and biology of the seamount invertebrates.

There is anecdotal evidence for reduction in invertebrate by-catch in orange roughy trawls in the New Zealand fisheries. On Tasmanian seamounts major impacts were recorded on biodiversity within a few years of the development of the orange roughy fishery. On heavily fished seamounts, reef aggregate had been removed or reduced to rubble, the invertebrate biomass was 83% lower and the number of species 59% lower than on lightly fished seamounts.

Responses to concerns about seamount fisheries

In 1999, the New Zealand Ministry of Fisheries developed a draft strategy to manage the adverse effects of commercial fishing on seamounts. Key seamounts are identified and become eligible for a limited range of measure to reduce the impact of bottom trawling, including sub-area and/or depth restrictions on specific seamounts, restricting fishing within 50 m of the seabed, closure to trawling and closure to all fishing methods. Nineteen seamounts around New Zealand were closed to bottom trawling in September 2000.

The closed seamounts represent a small proportion of the known seamounts (19 out of 800 in or near the EEZ) and far less than the proportion of land protected in National Parks or coastal reserves. . They may represent too little too late; key seamounts have been heavily exploited, and these productive seamounts, with high fish densities, could maintain the highest densities of invertebrates. The fishing industry is actively surveying unfished seamounts for potential new fish stocks. Nevertheless, the closures represent a first step in protecting biodiversity on seamounts and comply with the precautionary principle of taking action with limited data

The draft New Zealand strategy is designed to evolve, as new data become available. In this respect the Ministry of Fisheries allocated just over NZ$14 million over five years from June 2000 for research and management of marine biodiversity. Projects include database development, analysis and research on threats to biodiversity, and research on three key communities.

Mineral extraction in a pristine tropical watershed

Impacts of the Ok Tedi Mine on fish and fisheries in the Fly River basin, Papua New Guinea

Stephen Swales

Principle: Habitat alteration in tropical aquatic freshwater ecosystems has profound effects on biodiversity and livelihoods.

Experience: Sixteen years of monitoring fish abundance and distribution following construction of a large mine on an undamaged tropical river.

Most important lessons learned: 1) Prediction and mitigation of development effects in tropical aquatic ecosystems is impossible without a long-term research and monitoring program, 2) mining operations carried out within the boundaries of a river catchment without adequate environmental safeguards may have serious adverse effects on tropical river fisheries.

The Fly River system and its fisheries

The Fly River system in Western Province, Papua New Guinea, has the highest water flow of any river in Australasia. Because of the very high rainfall in the region, the Fly outranks all the world's major rivers in terms of runoff per unit catchment area. The river catchment consists mainly of primary tropical rainforest and open savannah grasslands, while the river itself is completely unregulated by dams, water diversions or other abstractions. The river system also has a large, intact floodplain system of lakes and other wetlands, with a network of channels linking the river to its floodplain. There are few such river systems remaining intact in the world.

The Fly River system supports the most diverse freshwater fish fauna in the Australasian region, with 128 recorded native species representing 33 families. Seventeen species are known only from the Fly basin.

The primary human use of the aquatic ecosystem is the subsistence fishery, which forms part of the traditional way of life of villagers living along the river. Most fish are consumed by the villagers, with catfish being the preferred species, compared to barramundi and black bass in a limited commercial fishery.

The inland and marine fisheries of Papua New Guinea are under the jurisdiction of the P.N.G. Department of Fisheries, which manages and regulates the fisheries. The commercial and artisanal fisheries of the Fly River system have generally been characterized by a non-interventionist approach to management. As a result, there are very little data available on these fisheries. The main approach to fish and fishery restoration in the Fly River system is currently one of investigating environmental management through mitigation of mining impacts rather than through active management of the fishery itself.

The Ok Tedi Mine

The only other significant impacts on the fish resource of the Fly River system, besides fisheries, arises through mining activities in the headwaters of the Fly and Strickland Rivers. The Ok Tedi copper and gold mine is situated in the upper catchment of the Fly River and is one of the largest copper mines in the world. Because of the high rainfall and geological instability of the region, construction of a tailings dam was not feasible, and the mine has been operating without waste retention since its opening in 1984. The Ok Tedi mine discharges up to 80,000 tons per day of waste rock and 120,000 tons per day of tailings directly into the Ok Tedi/Fly River system.

At the outset of mining operations, it was a statutory requirement that the environmental impacts of mining be monitored and that the effects of mine waste discharges not lead to unacceptable damage to fish and fisheries. As a result, environmental monitoring of mine impacts began in 1981, with long-term hydrological, chemical and biological monitoring programs being established in 1983. The extensive monitoring program means that the Fly River system is one of the most intensively studied tropical river systems in the world. Since the early 1980s, the OTML biological monitoring program has formed the only routine sampling in the Ok Tedi, Fly River and its delta. A variety of faunal groups are routinely monitored, but the main emphasis of the monitoring program is on freshwater fish populations.

Mine effects

Declines in fish catches and biodiversity in main channel sites in the Ok Tedi, upper and middle Fly appear to be directly related to the environmental changes associated with waste discharges from the Ok Tedi copper mine. Fish catches in the Ok Tedi and middle Fly were the most badly affected, with catch reductions in the Ok Tedi of up to 95% and the elimination of most fish species. In contrast, changes in fish catches at floodplain sites in the middle Fly area (declines of up to 75%) appear to be related to hydrological changes associated with El Niño. Fish catches at sites in the lower Fly area remain high.

This case-study shows clearly that fish populations in this major tropical river system exhibited significant declines in abundance and diversity, almost to the point of extinction in some areas, associated with the long-term discharge of mine-waste. Although the Fly River system is by world standards a major river system, this has not prevented mine-waste pollution from a single point source from having devastating environmental effects over large stretches of river. The ability of the river system to assimilate waste materials has clearly been exceeded, causing major changes to the aquatic and terrestrial environments and large reductions in fish population abundance and diversity.

The importance of monitoring

One of the major findings from this case-history is the importance of a detailed, long-term biological monitoring program and the utility of fish populations as indicator organisms. Large tropical rivers are complex ecosystems, with many factors affecting biotic communities and an extensive data set is required to begin to assess environmental change due to anthropogenic disturbance.

This case-study shows the importance of undertaking not only a detailed long-term fish population monitoring program, but also of carrying out adequate research to identify the underlying environmental mechanisms behind the declines. The lack of such information has clearly impaired the ability to mitigate the effects of the Ok Tedi mine.

Perhaps the most important single lesson to be learned from this experience is the urgent need for more international cooperation amongst environment, conservation and fisheries agencies and the need to be more pro-actively involved in the protection and management of a country's resources. There is also an urgent need to implement legislation, which would not allow major resource developments to proceed without adequate protective measures.

Managing Namibia's marine fisheries

A decade of rebuilding

Ben J. van Zyl

Principle: Promoting national participation in offshore fisheries is compatible with sustainable management of resources.

Experience: Creating Namibian fisheries management expertise after heavy foreign exploitation followed by national Independence.

Most important lesson learned: Natural instability in marine systems demands conservative management measures and a shift to ecosystem based management.

Best practice: National fisheries Acts promote "Namibianization" of fisheries within a framework of conservative management.

The marine environment of Namibia falls within the Benguela Current system. The Benguela Current is one of the world's major eastern boundary current systems and is rich in pelagic and demersal fish populations, supported by plankton production driven by intense coastal upwelling. Such systems predictably support a low diversity of species, while at the same time being among the most productive habitats in the world

The Namibian coast is approximately 1500km long and is hyper-arid desert along its entire length. The coastal zone is sparsely populated and the desert is not suitable for agriculture. The marine environment is thus free from the level of pollution commonly associated with large urban communities, and is considered relatively pristine except for the deposition of sediment in the water column from diamond mining along the southern coast. On a local level these mining activities are highly destructive to biodiversity to the inter-tidal habitat.

Fishing is the third-largest sector of the Namibian economy, behind agriculture and mining. It is the second fastest growing industry in the Namibian economy (behind tourism) with the value of exports now being approximately six times greater than at independence. The demersal fishery is the most valuable fishery in Namibia, and almost the entire catch is exported. About 90% of the catch is hake, with monkfish making up most of the remainder. The mid-water fishery for horse mackerel is second in importance. Finally, there is a smaller pelagic fishery with canned sardine as the most valuable product.

History of fishing in Namibia

A large number of Distant Water Fishing Nations (DWFNs) used to fish off Namibia when the country was under South African rule and the 200-mile EEZ had not been declared. More than 300 mid-water and bottom trawl vessels operated off the coast. As soon as the independent government announced the EEZ regime in 1990, there was a more than 90 per cent drop in the number of unlicensed foreign vessels fishing in the area.

Most commercially exploited species are currently nowhere near as abundant as they have been in the past. Unfavourable environmental conditions have usually accompanied these reductions in numbers, and there is evidence of cyclical booms and crashes in pilchard and anchovy populations, which predate the commercial fisheries. However, exploitation of already declining populations has doubtless exacerbated the situation.

Present management

At independence, few Namibians had any experience in fisheries research. Through assistance from donor countries and exposure to the international research community Namibia has, a decade later, a core group of fisheries scientists able to conduct monitoring and assessment work at a level comparable to that found in many countries with a much longer history of fisheries research. At present, harvest levels are set to enable stocks to return to levels that will provide maximum sustainable yields. While adherence to constant proportion harvesting rates has worked well for several stocks during the past decade, more sophisticated procedures will be needed in the future. The formal incorporation of such concepts as reference points (either biological or economic) and the precautionary approach needs to be considered and long-term management strategies adopted. Currently, single species assessment is used to assess commercial species except for hake and seals. An improved, updated and dynamic ecosystem model of the trophic flows through the Northern Benguela is now being built to facilitate multi-species management for the marine resources of Namibia and possible for the entire Benguela region.

After several decades of over-exploitation, several of Namibia’s marine resources are showing signs of a recovery. The monkfish catches have increased since independence and this fishery is now an important component of the trawl industry. Similarly the hake fishery has grown since independence, although catches are still considerably below those of earlier years.

It has become clear to fisheries managers in Namibia that there is no universal recipe for good fisheries management. After independence, support for measures to rebuild the stocks made it easy to implement drastic conservation measures. The acute need to rebuild many of them was put into practice by introducing total allowable catches (TACs) for all major species. Namibia endeavored to adapt the modern trend in fisheries management to its own needs and develop a system based on the allocation of rights, quotas and vessel licenses. The system takes into account collective international wisdom on fisheries management, but it steers clear of blindly following other models.

The Fisheries Act of 1992 spells out a clear and transparent process through which the Minister responsible for fisheries allocates harvest rights based on criteria that ensure Namibians get a fair chance to enter the industry, and facilitates the empowerment of previously disadvantaged groups. The transferability of quotas as practiced in New Zealand and elsewhere is not regarded as the ideal system in Namibia. The Namibian fishing industry operates without subsidies. The industry pays a resource rent (quota levy) as well as a portion of the costs of research and the fisheries observers that monitor catches.

Various area restrictions are in effect to restrict fishing effort. A vessel observation system is being implemented for better control over area restrictions. Depth and gear restrictions, as well as experiments with selective fishing gear, are also parts of management.

Managing Namibian fish resources has required managers to deal with uncertainties brought about by the highly variable Benguela ecosystem. The only way that risk levels in managing resources can be reduced is to be conservative in harvesting. Of the three main resources - hake, sardine, and horse mackerel - only sardine has not performed well since independence. Some of the smaller, longer-lived species, e.g. rock lobster, red crab, and Cape fur seal, show either a steady recovery or stabilization. For most resources, a major environmental aberration in the northern Benguela in 1994/1995 caused biomass estimates to decrease, and a return to normal environmental conditions has underpinned the recoveries during 1997/1998. On the basis of these trends it is evident that, despite the adverse conditions of 1994/1995, the well-disciplined and conservative approach to setting TACs, allied to ensuring that landings do not exceed the set limits, is being rewarded by recovery of stocks.

International initiatives

BENEFIT (Benguela Environmental Fisheries Interaction & Training) is a regional marine science and training program involving Angola, Namibia and South Africa. Its goal it to promote optimal and sustainable utilization of the Benguela ecosystem's living resources.

The Benguela Current Large Marine Ecosystem Project (BCLME), another regional initiative between Angola, Namibia and South Africa, is aimed at sustainable integrated management of the Benguela Current ecosystem.

Namibia, together with approximately 50 other African, Caribbean and Pacific countries, is also part of the project "Strengthening Fisheries & Biodiversity Management in ACP Countries" that provides training to researchers and fishery managers. The objectives are to build up the aquatic resource management and scientific capacity of ACP institutions, to promote an enabling environment for research, and to improve the quality, completeness and usefulness of FishBase and other management tools.

Maintaining biodiversity in mixed-stock salmon fisheries in the Skeena watershed

A 130-year history

Chris C. Wood

Principle: Mixed-stock transboundary fisheries impose special requirements on management of within-species and between-species genetic diversity.

Experience: 130 years of commercial and aboriginal fisheries on six species of Pacific salmon in one watershed.

Most important lesson learned: Artificial enhancement of stocks exploited by fisheries that also catch less productive species and wild stocks is incompatible with preservation and sustainable use of genetic diversity.

Best practices: 1) New government Wild Salmon Policy places priority on biodiversity, 2) by allowing selective release of non-target species, live capture fisheries help to conserve species diversity but typically fail to protect stock diversity within-species.

Pacific salmon biodiversity

Pacific salmon utilize virtually every freshwater environment accessible from the Pacific Ocean. Their ability to home to natal streams where they spawn and die results in partial or complete reproductive isolation of spawning sites. Most salmon are still harvested commercially in coastal waters before individual stocks have segregated to their natal streams. These “mixed-stock fisheries” remain entrenched because they are logistically expedient and because salmon are commercially most valuable before they enter the river. Fisheries managers are thus faced with a trade-off that remains unresolved – how to reap the benefits from commercially valuable stocks while maintaining the diversity essential for sustainability.

In some stocks, natural reproduction is supplemented by artificial propagation in hatcheries or spawning channels. Salmon “enhancement” has important implications for fisheries management. By increasing the abundance and productivity of target stocks, enhancement provides an opportunity for increased fishing effort but amplifies natural variations in productivity. Mixed-stock harvest of wild and enhanced salmon stocks greatly complicates the conservation of salmon diversity, Unless it is possible to selectively harvest productive populations, the overall harvest rate must be reduced to ensure the conservation of less productive stocks.

Skeena River salmon

In Canada, the Skeena River is second only to the Fraser River in its capacity to produce sockeye salmon. Six related species inhabit the Skeena River including four Pacific salmon (pink, chum, coho, and chinook) and two anadromous trout (steelhead and coastal cutthroat). Skeena sockeye salmon are harvested by Canadian aboriginal communities and in an extensive Canadian and Alaskan commercial fishery.

From a production perspective, Skeena sockeye appear to be in good shape. However, the diversity of the Skeena sockeye escapement has changed dramatically. Stocks that have not been "enhanced" have suffered an overall decline as they have been caught in the mixed stock fishery. Escapements of other salmon species have also declined dramatically during the history of the fishery for Skeena sockeye. Fishery management actions have restored species diversity, but have been less successful in restoring stock diversity within-species.

Management history

Skeena sockeye stocks had begun to be chronically overfished by 1925. As early as 1958, it was evident that non-Babine stocks had declined more than the Babine stock. During this period, Fisheries Research Board scientists began to recognize that there were significant differences in life history and run timing among runs ("stocks") rearing in different lakes. The Babine Lake Development Project was started in 1965 to enhance fry recruitment. This ambitious project involved building large artificial spawning channels as well as other structures. "Enhanced" sockeye began to return in 1970.

Overall sockeye abundance in the Skeena increased as production from spawning channels in Babine Lake increased, but escapements to other sockeye lakes continued to decrease. This trade-off was initially viewed as acceptable because managers had little flexibility to avoid harvesting non-target stocks. Abundance of other species, including chinook, coho and steelhead salmon, was affected by fisheries on enhanced sockeye, prompting impositions of catch ceilings and protracted international negotiations between Canada and the United States. The Canada-US Pacific Salmon Treaty was not always successful in limiting harvest pressure on non-enhanced stocks and non-target species due to interception in Alaskan waters.

Increasingly, mixed-stock fishery management issues became complicated by the demands of various fishing groups with highly divergent views on where, how, and by whom Skeena salmon should be caught. To help resolve these issues, the Canadian Department of Fisheries and Oceans (DFO) in 1993 encouraged a new public process for developing management strategies to protect weaker stocks while achieving sustainable fisheries ("Skeena Green Plan"). The Skeena Green Plan worked by a consensus-based process involving aboriginal people, commercial fishing groups, recreational fishing groups, DFO, and the Province of British Columbia. Significant new funding was committed to improve assessments of selected stocks and capability for in-season management. New research was supported to assess the productive potential of non-enhanced stocks of sockeye, coho and steelhead trout. Special emphasis was also given to evaluating more selective harvesting techniques and new opportunities for terminal harvest.

The Skeena Watershed Committee process was initially hailed as a great success because of renewed co-operation among stakeholders and significant progress on many issues. However, , the commercial fishing sector withdrew in 1996. Most research and monitoring activities were discontinued after 1997. The progressive spirit of the Green Plan languished in the Skeena but later became entrenched in broader policy.

In 1998, DFO released a *New Direction for Canada's Pacific Salmon Fisheries* which proclaimed the start of a "risk averse, conservation-based fishery". A draft *Wild Salmon Policy* (WSP) was released for public consultation in 2000. The primary goal of the draft WSP, consistent with the Convention on Biological Diversity, is "to ensure the long-term viability of Pacific salmon populations in natural surroundings and the maintenance of fish habitat for all life stages for the sustainable benefit of the people of Canada". It includes six principles, the first of which states that "wild Pacific salmon will be conserved by maintaining diversity of local populations and their habitats". DFO has pledged to implement the WSP pending revision to reflect public consultation.

Pacific salmon management has always involved finding acceptable trade-offs between extracting economic benefits from productive stocks while protecting unproductive stocks from extirpation. Although this trade-off remains unresolved, the WSP promises to provide explicit limits to these trade-offs based on stewardship ethics and conservation principles. Canada's proposed *Species At Risk Act* (SARA, scheduled for proclamation by early 2002) will also provide automatic protection for distinct biological populations listed as threatened or endangered. Thus, the WSP and SARA have been designed to play complementary roles in protecting Pacific salmon. If implemented effectively, the WSP should keep Pacific salmon off the endangered species list so that the heroic, salvage measures mandated by SARA will not be required.

Lessons

The Skeena sockeye fishery still depends on a monoculture of enhanced fish that has become visibly vulnerable. The Skeena case study has shown that enhancement within a mixed-stock fishery is incompatible with the conservation of wild salmon diversity. DFO has recognized this problem and has not authorized any new production enhancement facilities since 1983. New policies have shifted the focus towards more appropriately scaled shorter-term supplementation to rebuild wild stocks. The most important lesson from the last 30 years is that non-selective mixed-stock fishing in tidal waters must be reduced to conserve salmon diversity in the Skeena and elsewhere. The resulting increase in escapements should allow un-enhanced Skeena populations to rebuild, leading to increased total returns in the future.

Scientific research has played a crucial role in the evolution of Skeena salmon fisheries and in the protection of salmon diversity from commercial exploitation. Research helps identify diversity, monitor status against reference points to determine when special conservation actions are required, and provide options for reducing the social and economic cost of conservation actions. On the other hand, research alone is clearly not sufficient to ensure conservation. The decline of the non-Babine sockeye populations in the Skeena was identified as early as 1958, and the cause was understood by 1968. Yet the non-Babine populations continued to decline and remained at low abundance until the late 1980 and 1990s.

Conservation actions in the Skeena have been most successful in response to crises where DFO has had support from stakeholders, especially in response to declining abundance in highly-valued species rather than chronic declines in less-valued weak stocks within species. DFO has clearly had more difficulty reacting to conservation issues involving trade-offs between short-term and long-term economic interests, or conflicts between extraction and stewardship ethics. These decisions are complicated by considerations of catch allocation both internationally under the Pacific Salmon Treaty, and domestically in treaty negotiations with aboriginal people, and disputes among commercial and recreational fishery sectors. Conservation in these cases ultimately depends on a strong conservation ethic being defined in policy.