

1 Introduction

The Okinawa region supports the predominant coral reef-associated fishery in Japan. This chapter describes the sustainable exploitation of this fishery, the features of coastal fishery management in the tropics and subtropics, and the state of fishery management in Okinawa.

2 Coral reef fishery off Okinawa

The Department of Agriculture, Forestry, and Fisheries of the Okinawa General Bureau issued the 31st Annual Report on Agriculture, Forestry, and Fisheries Statistics for Okinawa. This report states that the fishery and aquaculture in the waters off Okinawa produced a total of ~40,000 tons of marine products in 2001. Specifically, offshore fisheries contributed ~7,000 tons; coastal fisheries, ~13,000 tons; and marine aquaculture, ~20,000 tons. The production of deep-sea fisheries and inland aquaculture

was relatively low; coastal fisheries and marine aquaculture accounted for more than 80% of the total harvest. The statistics for coastal fisheries include catches by small fishing boats (10 tons or less) with fixed nets, and thus include the semi-offshore fisheries catch by fish aggregating device (called *Payao*) fishery and *Thysanoteuthis rhombus* (a large deep-sea squid) fishery. The catch accounts for most of the 5,000 tons of both fisheries caught in 2001. Coral reef fishery includes the use of hook-and-line, bottom long lines, gill nets, fixed nets, drive-in nets, and SCUBA fishery, as well as shellfish gathering.

3 Coral reef fishery management

The differences between coral reef and temperate fisheries must be taken into consideration during the formulation of management strategies. The unique properties of coral reef fisheries include: 1) many fish species, 2) numerous remote islands, 3) high ratio of subsistence

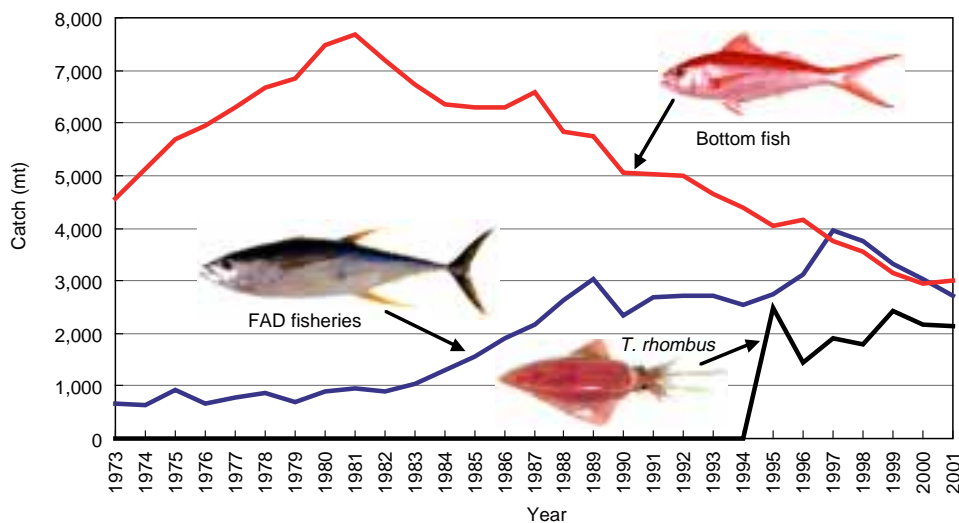


Fig. 1. shows the trends in the coastal fisheries catch for Okinawa. Until 1981, catches of bottom fish such as snappers, emperors, and groupers increased in proportion to increased fishing effort (number of fishing boats, operational days). However, catches of bottom fish sharply declined after 1981, partly because of over-fishing. Instead, the harvests from the fish aggregating device fishery and the *Thysanoteuthis rhombus* fishery increased rapidly, sustaining the coastal fishers.

fishers, 4) a lack of research, and 5) strong community spirit (Kakuma 2000a). Subsistence fishery is lower and recreational fishery is higher on Okinawa than on other islands, but the other four conditions apply to fisheries on Okinawa.

Temperate zones have limited numbers of economically important fish species, while a typical coral reef fishery can yield more than 100 valuable species. Western-type management, characterized by government-controlled management based on surveys of individual stocks, cannot readily be applied to reef fisheries because resources are assessed and managed as separate species. The Okinawa Prefectural Fisheries Experiment Station conducted a multi-year research project on a single fish species; the effect of a management plan was assessed using large amounts of data from length measurements, otolith aging, reproductive organs, and detailed fishing statistics for each region, and a computer simulation of the management model was developed. Without the effort and expense of obtaining this type of scientific information, it is difficult to establish management plans that are supported by the local fishers. For a multi-species fishery, however, the time required to gather information may prevent the timely implementation of suitable management plans.

The implementation of 'top-down', or government-controlled, resource management is difficult when fishers are distributed among remote islands. Management plans, even those with strong biological merit, are not effective without compliance from fishers and regulation enforcement by local authorities (Adams 1996). An effective policing and enforcement system is crucial; however, in developing countries with many remote islands, it is difficult to deploy sufficient law enforcement personnel. Few researchers and a high ratio of subsistence fishers also pose challenges to government-led management. A study by Dalzell *et al.* (1996) showed that subsistence fisheries accounted for greater than 80% of the coastal catches of Pacific island countries. Subsistence fisheries are not usually monitored, making resource management by quotas difficult to implement. The resources of coral reef fisheries are therefore more appropriately managed with a community-based, co-management approach that involves both the community and the government (Pomeroy and Williams 1994). Co-management arrangements vary in terms of the relative influence of the community versus the government; the role of the government in research and management is greater in Okinawa than in other

countries and regions engaged in coral reef fishery.

In addition to being classified according to the distribution of responsibility between government and community, resource management can also be considered in terms of 'pre-emptive management' versus 'retrospective management' (Adams 1996). Pre-emptive management is initiated only after extensive research into the ecology and catch statistics of the species of interest and the creation of a model to predict the management outcome. Alternatively, retrospective management involves management modifications based on the results of the current management plan as assessed by existing data and information from fishers. This method is similar to 'adaptive management' (LMMA Network Web site: <http://www.lmmanetwork.org>), whereby the resource management plan is improved during a cycle of monitoring, analysis, discussion, planning, implementation, and more monitoring. Given the unique conditions of the coral reef fishery mentioned above, the retrospective approach would seem to be more effective, depending on the location and target species.

4 Resource management tools and Marine Protected Areas

Resource management tools include closed seasons, size limits, restriction of fishing gear and methods, restricted fishing areas, limitation of entry into the fishing areas, and catch limitations. Chapter 3 of the Fishery Regulation of the Okinawa Prefecture (Fisheries Division of the Department of Agriculture, Forestry, and Fisheries, Okinawa Prefecture 2002) describes species-specific regulations such as closed seasons and prohibited sizes. For example, it is prohibited to harvest spiny lobsters during their spawning season, from April 1 to June 30 (Fig. 2), and to collect *Tridacna crocea* with a shell length of 8 cm or less (Fig. 3). In addition, the use of 28-mm or smaller mesh in drive-in nets, and trammel gill nets is prohibited between June 1 and September 30 to prevent the degradation of the catch during the hot summer. The collection of reef-building corals is also prohibited. Fishery restrictions and management plans are currently designated and implemented by the government. In the future, it may be advantageous to shift to a co-management plan in which local communities participate more actively.

The Common Fishery Rights system also limits the harvesting of marine products from coral reefs. It is some-



Fig. 2. An example of a closed season for giant clams and lobsters in Okinawa region according to the Fishery Regulation of Okinawa Prefecture. (From the Web site, <http://www.pref.okinawa.jp/suisan/sangogakkou/sangogakkou5.htm>)



Fig. 3. An example of the size limitations on important benthic fishery resources in Okinawa region, according to the Fishery Regulation of Okinawa Prefecture. (From the Web site, <http://www.pref.okinawa.jp/suisan/sangogakkou/sangogakkou5.htm>).

times considered a violation of fishery rights for a person who is not a union member of the managing fishery cooperative to collect benthic resources in the designated common fishery rights district.

The Total Allowable Catch (TAC) system began in 1997 in Japan. This common Western-style management method controls fisheries by output, or catch, rather than by inputs such as fishing effort. The harvesting of eight important species in Japan is currently regulated by TAC; however, these species are rarely caught in the waters off Okinawa, so TAC limits have not yet been set in Okinawa.

Marine Protected Areas (MPAs) have recently received attention as a valuable resource management tool. Often, the objective of an MPA is to conserve coral reef and mangrove areas. There are many reports on the qualitative effects of MPAs, and the quantitative impacts have recently been investigated as well. MPAs are an effective resource management technique in the tropics for several reasons. 1) Areas can be designated based on the knowledge of local fishers, especially as regards spawning grounds and the breeding seasons of important species, without detailed research. 2) MPAs can simultaneously

protect many species. 3) MPAs protect ecologically important habitats such as coral reef and mangrove areas. 4) The regulations within an MPA can be changed after its initial designation. 5) MPAs can provide hands-on management opportunities for local communities. 6) The participation of local communities in the MPA planning process can increase the awareness of local fishers (Crosby *et al.* 2000). There are two MPAs designated by the Ministry of Agriculture, Forestry and Fisheries in Okinawa on Ishigaki Island. One MPA covers Kabira Bay, which contains 275 ha of coral reefs, and the area outside the bay. This MPA is regulated by the Fishery Regulation of the Okinawa Prefecture, which prohibits the harvesting of seven kinds of marine flora and fauna, including the giant clams. The other MPA is in Nagura Bay; it protects 68 ha of coral reefs and sea-grass beds by prohibiting the collection of all marine flora and fauna. The Okinawa Prefectural Fisheries Experiment Station has compiled annual reports on the protected areas of Kabira and Nagura bays based on more than 25 years of research. The management of officially designated Marine Protected Areas reflects the character of government-led management systems, such as the inflexibility in regulation modification. However, local communities in Okinawa (for example, the Onna Village, Nakijin, Itoman, and Yaeyama Fishery Cooperatives) have established community-based MPAs based on discussions with fishers.

The 'stock enhancement projects' are part of coral reef fishery management in Japan. The projects mass-produce larvae of important fishery species in hatcheries, releases them to the sea as juveniles, and catches the adult fish. Stock enhancement projects do not include aquaculture in the strict sense. The stock enhancement projects in Okinawa deal with marine organisms such as Spangled Emperor (*Lethrinus nebulosus*), *Trochus niloticus*, *Portunus pelagicus*, and *Tripneustes gratilla*. The biggest challenge to the stock enhancement project is increasing the survival rate of juveniles after release.

5 Sources of alternative income

Fishery resource management regulations will limit harvests. It is therefore important to secure alternative or supplementary income and food sources for local fishers, especially during the initial stages of implementation. A few possibilities are discussed below.

1. Aquaculture

Aquaculture is usually initiated first for the alternatives. The cultivation of Mozuku (*Cladosiphon okamuranus* and *Nemacystus decipiens*), edible brown algae, is important in Okinawa. These algae can be cultivated with comparatively negligible impacts on adjacent ecosystems because no supplemental food and only simple facilities are required. Moreover, because there is no need for advanced techniques or a large amount of capital (as compared to aquaculture of fish and prawns), algae aquaculture provides a suitable alternative income source in the tropics and subtropics. The cultivation of an edible green alga *Caulerpa lentillifera* in land tanks has recently become an active venture. The cultivation of Kuruma prawn (*Penaeus japonicus*) and some fish species are also important in Okinawa. It should be noted, however, that the construction of prawn and fish aquaculture ponds became problems in Southeast Asia, owing to the associated deforestation of mangroves and the environmental impacts on reefs caused by the input of excessive nutrients.

2. Fish Aggregating Device (FAD)

The installation of FADs, or Payao (Photo 1), seems to be a promising alternative income source. The FAD fishery may also relieve fishing pressure in the overexploited coastal areas (Kakuma 2000b). More FADs are being installed now in tropical regions around the world. The FAD fishery in Okinawa is not managed by the government but by fishery cooperatives and fishers. The fishers are responsible for designing the floats, selecting the installation points, constructing and installing the floats, making repairs, improving fishing gear and methods, preventing fishery conflicts, and improving product distribution. The biggest concern associated with FADs is the loss of FADs caused by storms such as typhoons, but these losses are decreasing as the number of sub-surface (about 50 m depth) Payao in Okinawa increases. This technology may spread worldwide in the future.

3. Tourism fishery

In Okinawa, the diversification of income sources for fishers is also expanding through the development of a 'tourism fishery'. This includes fishing guides, diving guides, and experimental fishery by tourists. Marine ecotourism is also on the rise.

6 Examples of coral reef fishery management

1. Onna Village

The Onna Village Fishery Cooperative in the northern part of Okinawa Island created a Regional Fishing Plan through the Fishery Extension Project in fiscal year 1982 (Kakuma and Higa 1995). As part of this project, a management plan for benthic fishing resources was mapped out for the first time in Okinawa. The target species were shellfish, sea-urchin, and related species, and the establishment of MPAs was a foundation of the management plan. Support from the government included the dispatch of extension officers, the provision of hatchery-produced spat of shellfish, and guidance for spat-releasing techniques. As this was a community-based, self-imposed management plan, the regulations were flexible and had been revised three times by 2000 (Onna Village Fishery Cooperative 2000). This management plan appears to be successful partly because the fishers in Onna Village were obtaining most of their income from Mozuku aquaculture, rather than from benthic fishing resources. The self-imposed regulations also incorporated the confirmation and addition of the Fishery Regulation of the prefecture. Fishery regulations have already been enacted in almost all areas and countries in the Asia-Pacific region; however, the problem lies in the lack of effective operation and enforcement. Thus, the confirmation and addition of the government regulations by the communities as co-management seem to be an effective solution.

2. Yaeyama

The Okinawa prefectural government implemented the Comprehensive Project for the fisheries co-management of the Pacific Yellowtail Emperor (*Lethrinus atkinsoni*) around the district of Yaeyama in fiscal years 1995-1997. It was the most pre-emptive management in Okinawa, and the Okinawa Prefectural Fisheries Experiment Station conducted a variety of stock assessment research. The management plan called for a closed season within the MPAs that are located in four main spawning grounds. The fishery was closed for all fishing methods and fish species during the main spawning season in April and May. This plan was not easily determined, but a consensus was reached after many meetings of a fishers' study committee. The committee also asked recreational fishers for cooperation with the management regulations as a large quantity of *L. atkinsoni* is caught by the recre-

ational fishery. The Okinawa Prefectural Fisheries Experiment Station proposed that if the catches were cut by 10%, the fish stock would rise by 23% in five years (Ebisawa 1998). However, annual catches decreased to the targeted level in only three of the five years of restrictions. The catch per unit effort (CPUE), the most general indication of the resource status, also remained unchanged. The restricted areas were probably too few or too small; however, despite not achieving the target result, this resource management plan is considered a success. The rapidly decreasing trend in CPUE stabilized, fishers observed the regulations, the organization was strengthened, and the level of management awareness rose. Increasing fishers' awareness provides a foundation for future improvements in the *L. atkinsoni* management and for the expansion of the management to include other fish species and fishing methods.

3. Other regions

Prior to the management of *L. atkinsoni* in Yaeyama, *T. rhombus* was targeted for resource management throughout the Okinawa region. Although the fishery of *T. rhombus* occurs offshore, this project represented the beginning of co-management in which the government offered extensive scientific information and established management plans through frequent dialogue with fishers. The plan combined several elements such as license and zoning of the fishery, the restriction of fishing gear, and catch size limitations. However, the primary restriction was the closure of the fishery from July through October to protect small squid and to prevent the "growth overfishing" (Gulland 1983).



Photo 1. A fish aggregating device (*Payao*) established by the Ie Fisheries Cooperative off Iejima Island (photo taken by J. Maeda).

After the *L. atkinsoni* project, similar plans for *L. nebulosus* management were implemented off Nakijin Village and Haneji in the northern part of Okinawa Island. The project implemented a closed season in two MPAs from August to November to protect juvenile fish. Subsequently, projects implemented by the Haneji, Nakijin, Motobu, and Nago Fishery Cooperatives, in the same northern part of Okinawa Island, targeted Coral Trout (*Plectropomus leopardus*) and Black Spot Tuskfish (*Choerodon shoeneleini*) by the SCUBA diving fishery. Weight limits prohibited taking Coral Trout or Black Spot Tuskfish weighing 1 kg or less, and the fishery cooperative market would not accept fish smaller than this. The limits were applied year-round in all marine areas of the Common Fishery Rights districts. When the Okinawa Prefectural Fisheries Experiment Station proposed the size and weight limits, they presented fishers with extensive data on the length-weight of the fish, reproductive status and the ratio of the juvenile fish catch. In fiscal year 2004, management of the SCUBA diving fishery will be proposed for the Yaeyama district.

7 Postscript

Overfishing has been pointed out to be one of the disturbing factors on coral reefs (Russ 1991; McClanahan and Kaunda-Arara 1996; Horrill *et al.* 2000). Coral reef is a complex ecosystem composed of diverse organisms, and therefore, fishery resource management mentioned in this section also plays an important role in coral reef conservation. Further advancement of such integrated resource management and sustainable use of fishery resources are expected to be achieved as our future tasks.