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メタデータ	言語: eng
	出版者:
	公開日: 2009-04-28
	キーワード (Ja):
	キーワード (En):
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URL	https://doi.org/10.15021/00002668

SENRI ETHNOLOGICAL STUDIES 67: 197-214 ©2005
Indigenous Use and Management of Marine Resources
Edited by Nobuhiro Kishigami and James M. Savelle

Coastal Fisheries Co-Management in Okinawa, Samoa and the Philippines with Fish Aggregating Devices as Sources of Alternative Income

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1. INTRODUCTION

The alleviation of poverty was one of the most important themes discussed at the Environment and Development Summit held in Johannesburg in August 2002. The majority of the poor in the Asia Pacific region live in coastal areas, and depend on marine and coastal resources for food, employment and income [ADEEL et al. 2002]. In most of the tropical and sub-tropical areas, however, coastal fisheries resources have decreased due to over-harvesting, and coral and mangrove eco-systems supporting the resources are also threatened. Accordingly, the timely and effective management of the fisheries resources and the eco-system are important. Management regimes that have evolved in developed Western countries, or top-down management methods, have seldom worked in the tropics. Therefore, the resources should be managed primarily by involving local communities or through partnerships between the government and the communities (e.g. co-management: POMEROY and WILLIAMS [1994]).

Alternative income for the fishers is essential because often, in the management process, an initial reduction of the harvest is required. While aquaculture seems the simplest remedy, it is controversial in terms of its effects on the environment, especially in mangrove-rich areas. Fish Aggregating Devices (FADs) may play an important role as an alternative. FADs are artificial floating objects that attract pelagic fish such as tuna and skipjack. These devices are important for large-scale industrial fisheries (e.g. purse seine fleets), as well as small-scale artisanal fisheries. They are popular worldwide, and one million out of a total of four million metric tons of tuna are harvested worldwide using FADs. In Okinawa about 150 FADs are presently employed, and produces 2500–4000 metric tons of fish annually [KAKUMA 1999].

2. COASTAL FISHERIES CO-MANAGEMENT IN OKINAWA AS COMPARED TO SAMOA AND THE PHILIPPINES

2.1. An Overview of Okinawa

Okinawa prefecture is located southwest of mainland Japan and forms an archipelago between Kyushu and Taiwan (Fig.1). It consists of 160 islands running northeast to southwest. About 1.3 million people inhabit the 42 islands. Twenty to thirty kilometres to the southeast of the archipelago, the ocean floor drops rapidly to over 1,000 m. The "*Kuroshio*", a strong warm current, flows west of the archipelago along the continental shelf. The offshore surface water temperature is between 21° and 29°C. North to northeast monsoon winds dominate in the winter, causing rough sea conditions, while typhoons may occur during summer and autumn.

2.2. State of the Coastal Fisheries Resources in Tropical and Subtropical Regions

Fisheries statistics from the Okinawa Development Agency indicate catches of bottom fish have decreased drastically since 1982. On the other hand, the FAD fishery and diamond-back squid (*Thysanoteuthis rhombus*) fishery production has increased (Fig. 2), while sedentary species production, such as shellfish and sea urchin, has also decreased (Fig. 3).

In the Pacific Islands, bottom fish, such as groupers and snappers, and sedentary species such as black pearl oyster, giant clams, trochus and beche-de-mer (sea-cucumbers) have reportedly been over-harvested. However, this is difficult to confirm statistically, even, for example, in Fiji which has the most sophisticated fisheries statistics in the South Pacific.

In the Philippines, destructive fishing practices such as the use of dynamite and cyanide was common in the past. Also in some areas, bottom trawl fisheries have damaged the fisheries stocks and associated habitats [FLORES and MARTE 1996]. In addition, there has been a trend towards decreasing the catches among municipal fisheries (small-scale fisheries using fishing boats less than three gross ton).

In the Pacific Islands, recent human population increase (one of the causes of the stock decrease) has been 2.5–3.5 % annually [UNITED NATIONS 1997], while in the Philippines the

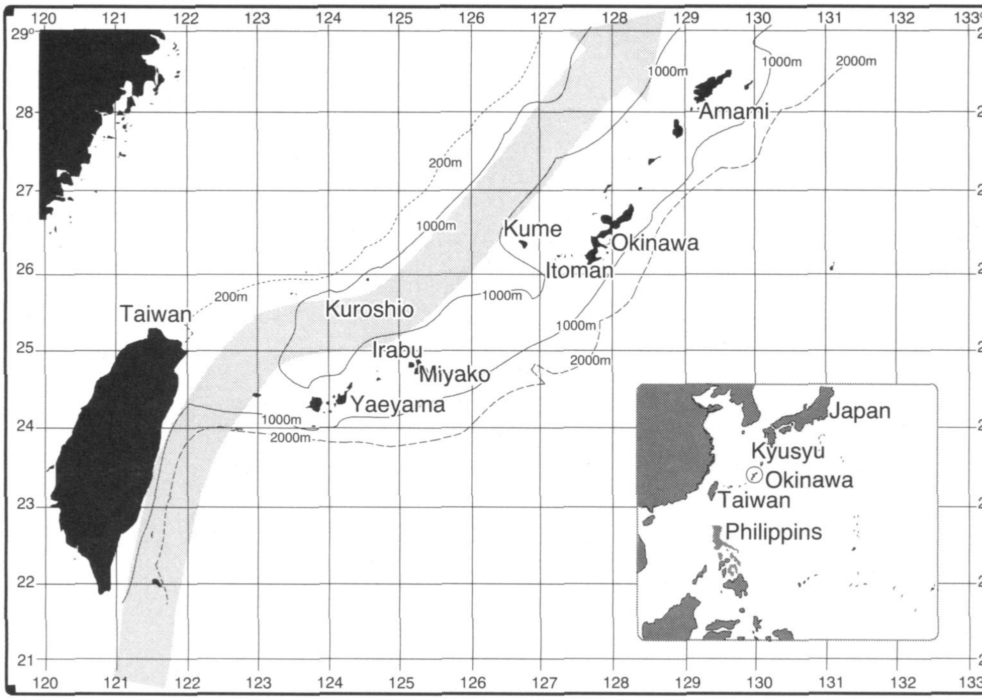

Figure. 1 Location of Okinawa

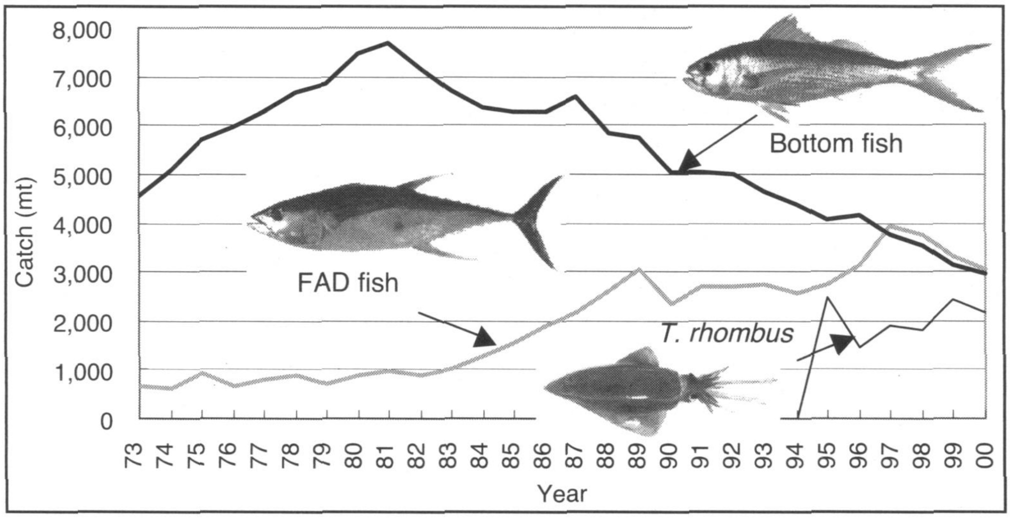

Figure. 2 Changes in catches of bottom fish, FAD fish and *T. rhombus*. Bottom fish: snappers, emperors, groupers, parrotfish, rabbitfish, fusiliers and jacks. FAD fish: yellowfin tuna, bigeye tuna, skipjack, dolphin fish, wahoo, blue marlin and albacore.

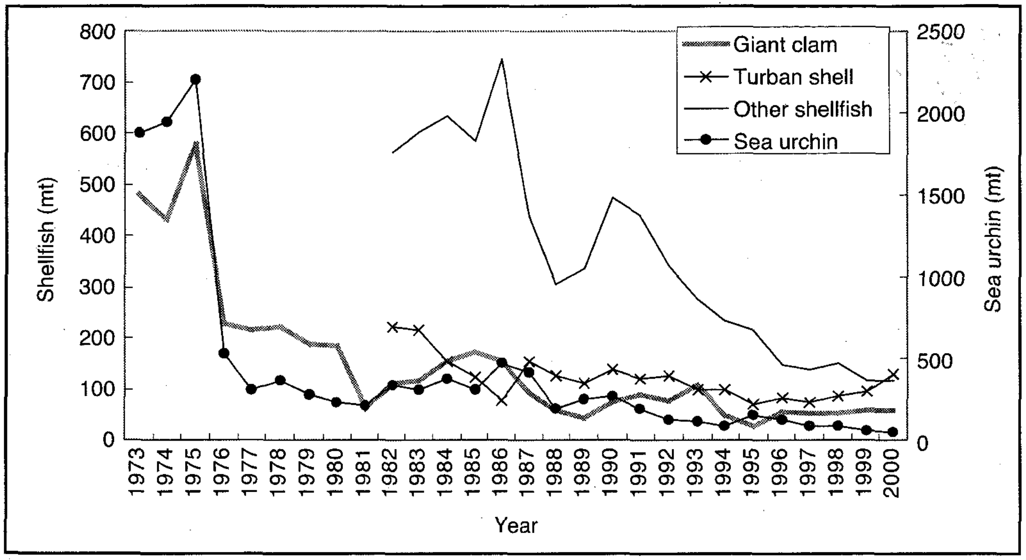

Figure. 3 Changes in catches of shellfish and sea urchin. Giant clam: mostly *Tridacna crocea*. Turban shell: *Turbo argyrostomus*. Other shellfish: trochus, strawberry conch, etc. Sea urchin: *Tripneustes gratilla*

rate of annual increase was 2 % from 1995 to 2000. A higher demand for fish than animal meat resulted in over-fishing. The demand exceeded local production and the Pacific Islanders had to import canned fish (amounting to more than 50% of the local production). The introduction of underwater torches and SCUBA, which dramatically increased fishing efficiency, and the destruction of nursery areas resulted in a decrease in fisheries resources [King and Fa'asili 1997]. As in the Philippines, the use of explosives and chemicals such as cyanide in fish harvesting [Johannes and Riepen 1995] severely affected nearshore ecosystems. Soil erosion and the resulting increase in sedimentation rates in coastal area also seriously threaten the coastal ecosystems. In Okinawa, for example, red soil runoff caused severe damage not only to coastal fisheries and aquaculture but also to tourism, the leading industry there. All these factors have resulted in substantial decreases in coastal fisheries resources.

The fisheries resources, in essence, need proper management because the resources are renewable resources, and they are considered common property. Unlike fossil resources, renewable resources can be used in a sustainable manner when properly managed, and the growth rates of fisheries resources are usually quite rapid. While "wild" fish are considered to belong collectively to a society, it is the individual fisher that utilizes these resources. He or she may strive to harvest as many fish as possible, even though there must be an optimum harvest level for the society as a whole. As a result, overfishing is very common. In open access fisheries, it has been estimated that a 60% reduction in effort (e.g. in the number of fishing boats) would ensure the maximum benefit [McManus 1996].

2.3. Characteristics of Tropical and Subtropical Coastal Fisheries Management

Any attempt at coastal fisheries management in the South Pacific must take into account the following characteristics that are discussed in detail below: 1) a large variety of marine species, 2) many remote islands, 3) few researchers, 4) many individual subsistence fisheries, and 5) a strong sense of community [KAKUMA 2000].

1) Many more species than temperate regions: In temperate countries like Japan, for example, ten species accounted for 40% of the total production in 1996. In contrast, 200–300 species are typically harvested in the tropical islands [MUNRO 1996]. In the sub-tropical islands of Okinawa, the combined production of species for which individual catch percentages are less than 3% accounted for 70% of the total production in 1997 (from the Okinawa Fisheries Experimental Station Statistics). Fisheries management in temperate waters was undertaken under conditions in which there are few target species. The greater the number of target species, the more difficult management becomes.
2) Many small islands and remote areas: "Regulations are almost useless if they cannot be enforced" [ADAMS 1996]. Enforcement or policing is difficult in tropical countries as they comprise many remote areas and islands.
3) Fewer researchers: In most developing tropical countries, there are few scientific researchers who deal with fisheries management.
4) Large percentage of small scale, subsistence fisheries: The tropical fisheries can be divided into "commercial", "artisanal" (small-scale) and "subsistence" fisheries [DALZELL et al 1996]. Subsistence fisheries in the South Pacific account for 80% of the total production [DALZELL et al 1996]. These subsistence fisheries are rarely monitored, making management difficult.
5) A strong sense of community: In South Pacific countries, people traditionally have a strong sense of community and usually manage the local resources though community-based decision-making systems [RUDDLE 1994; 1996; JOHANNES et al. 1993]. These differ substantially from those of Western, government-based systems.

In the Philippines and Okinawa these five characteristics or conditions for coastal fisheries management are very similar to those of the South Pacific, although commercial fisheries in the Philippines form a substantial part of the production, as do recreational fisheries in Okinawa.

2.4. Co-Management and the Retrospective Approach

While biological and economic approaches have traditionally formed the basis of nearshore resource management, society-based approaches are becoming increasingly important. These nearshore resources might be managed more effectively through co-management than through centralized management. The merits of co-management are that under it, compliance from fishers is easy to obtain, enforcement is effective and cheaper, and it is flexible and can incorporate fishers' knowledge. Often, for example, fishers have more detailed knowledge about when and where target species spawn than do researchers. The potential problems are that restrictions determined by the local communities often do not have a firm legal basis, and the restrictions are often not effective for species that migrate beyond the community's management zone. A system of by-laws could alleviate the former problem [FA'ASHILI and KELEKOLO 1999], while all concerned local communities and governments could collaborate in the management regimes for migratory species, thus addressing the latter problem.

There is another difference in management approaches between "pre-emptive" and "retrospective" management. According to Adams, "Pre-emptive management requires detailed knowledge of the target organisms and fishing community. By contrast, retrospective management is a form of adaptive management in which rules are developed on the basis of experience of their effects on stocks" [1996]. Although neither extreme would be suitable, the retrospective approach would appear to be more suitable for the tropics, given the five characteristics of fisheries in these areas. In implementing retrospective management systems, however, it should be kept in mind that:

1) sufficient information for management might not be available to properly manage the resources. Thus, precautionary approaches should be taken [FAO 1996];
2) feedback mechanisms should be incorporated so that the management systems can be effectively modified [ADAMS 1996]; and
3) the management plans should be sufficiently flexible to be modified as required.

In Okinawa, the management of an emperor fish (*Lethrinus atkinsoni*) provides an example of pre-emptive management. Length, otoliths, age, growth, mortality, and catch statistics of the fish were intensively studied, and after assessing the stock, the government suggested several management measures [EBISAWA 1998]. However, the study was time-consuming, and involved only one of eight economically important species of emperor fish. It would take many years to complete similar research for the other species (we have at least fifty important fish species in Okinawa), and the stocks may not be sustained during that period. On the other hand, the management of a newly discovered giant squid stock [*T. rhombus*, KAWASAKI and KAKUMA 1998] and co-management of sedentary species in Onna village [KAKUMA and HIGA 1995] are examples of retrospective management, because in both cases experience and feedback processes have been incorporated in the management systems, with the result that the systems have been amended on a number of occasions.

2.5. Marine Protected Areas (MPAs)

Among the various management tools (e.g. seasonal closures, size limits, gear restrictions, catch quotas, licenses, etc.), MPA seems to be the most effective in the tropics [MUNRO 1996; KING and FA'ASILI 1999; BOHNSACK 1996]. MPA is effective because it can be implemented retrospectively without intensive biological research; it can assist in the preservation of coral, sea-grass and mangrove areas; and it works for multiple fish species. MPA is especially useful if concerned local communities are involved from the initial design stage [CROSBY et al. 2000]. This participatory approach enables the community to participate meaningfully in the resource management.

In this regard, the concept of "source and sink" should be clearly recognized. The larvae, juveniles or adults of the target species would ideally leave, or spill out, of the MPAs (sources) and migrate outside the MPAs (to the fishing grounds or "sinks"). The size and number of MPAs, and the distance between the MPAs would be based on this concept.

To date, Okinawa has two legal fish reserves (MPAs): Nagura Bay and Kabira Bay, Ishigaki

Island. They were designated as such by the Minister of Agriculture, Forestry and Fishery and a series of procedures are necessary to modify the restrictions. These procedures are not appropriate for community-owned small-scale MPAs, and the regulations should be flexible enough to modify the location, size or number of the MPAs. Pollnac et al. [2001] studied 45 community-based MPAs in Visayas, the Philippines. They found that factors influencing the success of these systems are: community population; a perceived crisis in terms of reduced fish population; successful alternative income projects; high levels of participation in community decision making; continuing advice from the implementing organization; and input from the local government.

2.6. Case Studies

2.6.1. Okinawa

In Okinawa, the Onna village fisheries cooperative (FC) has practiced management of sedentary resources since a fisheries extension program was introduced there in 1988. The target species are trochus, giant clams, turban shells, strawberry conchs, sea urchins, spiny lobsters and damselfish. Among them, the giant clam (*Tridacna crocea*) is the most important and the management initially involved re-stocking hatchery-produced juveniles to enhance the reduced stock. The Okinawa prefectural government provided the juvenile giant clams and sent extension officers to instruct the local community in restocking techniques, which included the use of

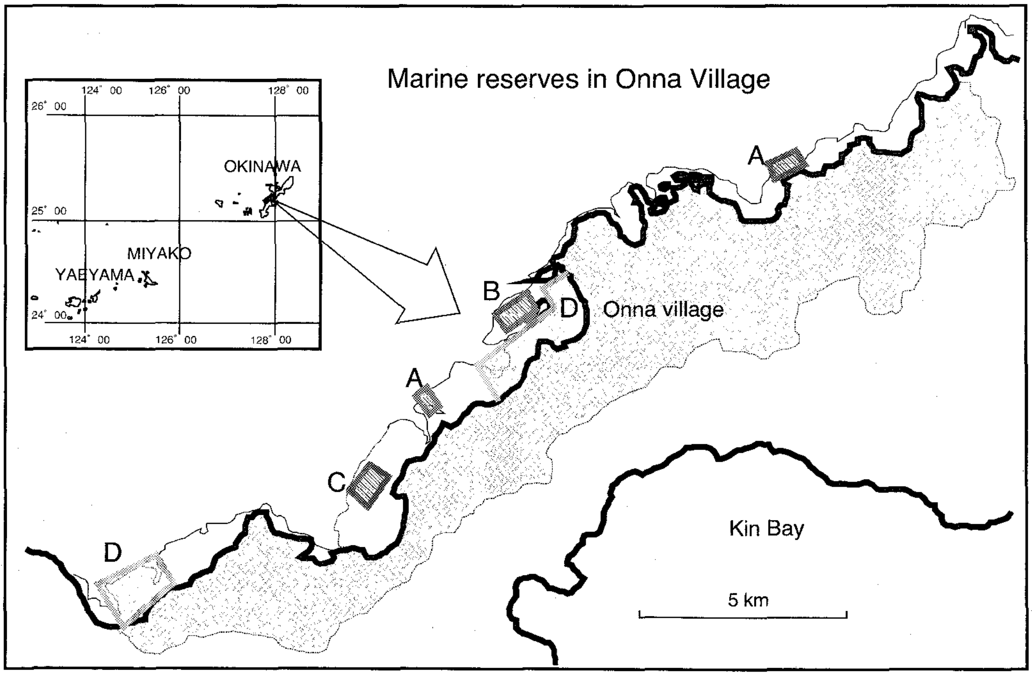

Figure. 4 MPAs in Onna Village. A: for trochus, B: for trochus, giant clams and turban shell, C: for giant clams, D: for sea urchin.

air-powered drills and sections of net to protect against predators [KAKUMA and HIGA 1995]. This type of "sea farming project" is useful for stock enhancement, and also for increasing public awareness of resource conservation. In this project, MPAs for sedentary species were established (Fig. 4) and prefectural regulations were strengthened with regard to allowable harvesting procedures (e.g. the minimum shell diameter of harvestable trochus shells increased from 6 to 8 cm). These restrictions are community-based management tools, and thus flexible, and the management plans have been amended four times since inception [ONNA FC 2000]. The community-based rules have been strongly adhered to and the management has been successful thus far, except for sea urchin. One of the reasons for this success is that the largest share of the income of fishers in Onna derives from sea-weed *Cladosiphon okamuranus* aquaculture. Accordingly, the initial harvest reduction of the sedentary species did not adversely affect the local economy.

2.6.2. Samoa

In Samoa, 44 fishing villages have implemented coastal resources management, which includes the protection of critical habitats such as mangroves, under a community-based fisheries extension program [KING and FA'ASILI 1997]. A large number (38) of the villages chose to establish small village fish reserves in their traditional fishing areas.

The process, especially the extensive involvement of the communities in management decisions, was quite similar to that of Onna village. Fig. 5 compares the processes in Samoa and Onna village. The governments primarily provided scientific information and rarely forced the fishers to restrict the harvest.

In the Samoan case, government support involved: 1) introducing medium-sized low-cost boats for use in outer reef areas, thus decreasing pressure on near-shore reef areas; 2) promoting village-level aquaculture; and 3) re-introducing depleted species. Initially, the government trained extension officers, who in turn played an important role in leading the many community meetings. Although public awareness-raising activities may be required, the prime need is not for education, but for motivation and support. [See KING, "Problems with Centralised Fisheries

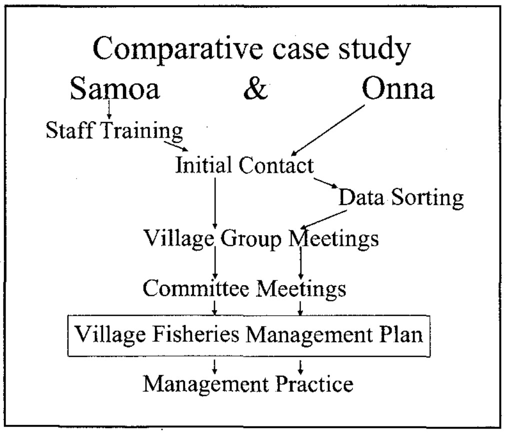

Figure. 5 Fisheries extension processes in Samoa and Onna

Management in Pacific Islands", this volume]. The prospects for continuing compliance and commitment to the management by the communities appear high [KING and FA'ASILI 1999], and it is likely that other fishing villages in the South Pacific will follow the lead of the Samoan communities [KING 2000].

2.6.3. The Philippines

As noted previously, destructive fishing practices (the use of blasting, cyanide and trawl fisheries) prevailed in the Philippines in the past, but there are now many successful cases of co-management there, achieved with the assistance of non-government organizations (NGOs) and international research organizations [POMEROY and CARLOS 1997]. The co-management cases cover not only fisheries resources but also entire eco-systems such as coral reefs and mangroves, and often include tourism promoting "Integrated Coastal Resource Management."

Co-management at Banate Bay involves four local government units (LGUs), which cooperate to manage coastal resources in the bay with minimal external funding. According to the program brief of the Banate Bay Coastal Resource Management Program, the program components are: institutional development; mangrove and land-use; livelihood development; law enforcement; and research and data banking. The main activities of the co-management are: inter-community organization which involves trainings and awareness development; mangrove conservation and reforestation; and law enforcement, which includes the zoning of the fishing grounds, establishing unified fishery ordinances, and regular patrolling and

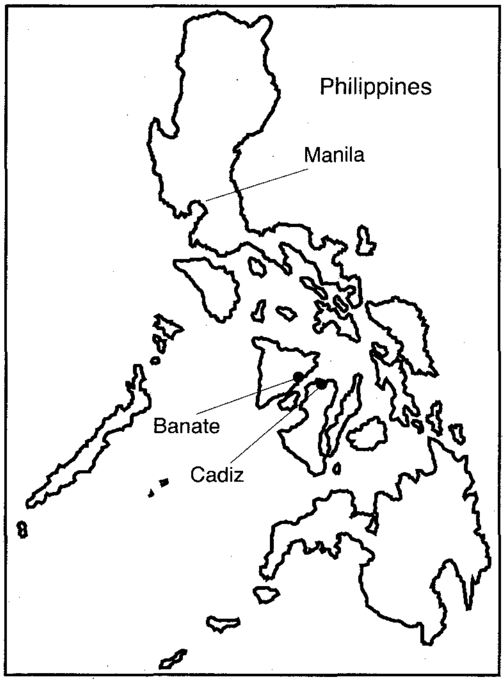

Figure. 6 Philippines

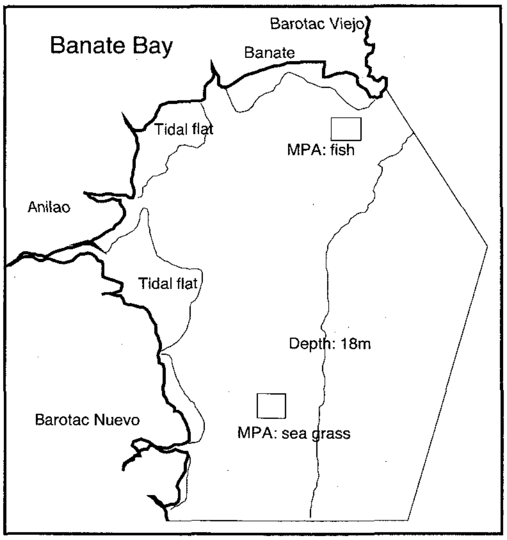

Figure. 7 Banate Bay

surveillance.

The Japan Bank for International Cooperation (JBIC) and the Philippine government started a fishing port construction project at Cadiz, northern Negros with Official Development Assistance (ODA). Accordingly, preliminary research was conducted on coastal fisheries management in 2002. Some of the resulting recommendations are: the establishment of clearly-determined zones for active gear (such as bottom trawls) and for passive gear (such as hook and line); the enlargement of a marine sanctuary; the strict enforcement of the use of fine mesh nets; basic data gathering; the formation of Barangay (village) Fisheries and Aquatic Resources Management Councils; and the invitation of NGOs that deal with fisheries co-management.

Photo 1 Banate Bay and a patrol boat

Photo 2 A gill net fishery in Cadiz

3. FISH AGGREGATING DEVICES (FADS) AS SOURCES OF ALTERNATIVE INCOME

3.1. Background

It is well known that pelagic fishes tend to aggregate around floating objects. Based on this knowledge, fishers have placed man-made objects called Fish Aggregating Devices (FADs) and caught the fish associated with them, especially in the tropics. In the early 1980s, Okinawa developed FAD fisheries in conjunction with other prefectures located on Japan's south Pacific coastal areas where the *Kuroshio* flows along their shores. At that time, as bottom fish stocks had decreased due to overfishing, Okinawa tried to divert the fishing effort from these stocks to offshore pelagic species in an attempt to improve the fishers' income. In 1982 the Okinawa Fisheries Experimental Station and two Fisheries Cooperatives (FCs) in Miyako examined the effects of 14 experimental FADs. Because of the excellent results, the use of FADs spread quickly and they were deployed by other FCs throughout Okinawa. The catch of bottom fish continues to decrease, while FAD fisheries production has increased rapidly, helping to compensate for the reduced demersal fisheries.

FADs originated in the Philippines. The number of FADs (both *payao* and *arong*) was about 4000 in 1999 and they produced more than 300,000mt of tuna [Dickson and Natividad 1999]. In the South Pacific, FADs have been deployed in 21 countries and territories, and more than 600 FADs were estimated to be in use in 1984, attracting offshore pelagic fish such as tuna, skipjack and wahoo [DESURMONT and CHAPMAN 1999]. Samoa was one of the pioneer countries that commenced the FAD projects in the South Pacific in the early 1980s. However, no FADs were used in Samoa in 1999 because small-scale, long-line tuna fishery without FADs has spread there.

3.2. FAD Losses Due to Typhoons

During the early development stages, losses of FADs due to typhoons was a serious problem. Most FADs were lost within 1 to 1.5 years, with some lost less than a year after deployment. Despite this, the catch rates from the FADs were sufficient to warrant new deployments. In addition, the fishers devised several measures to reduce loss rates.

The mooring system was improved, with some FCs changing from using a single anchor to a double anchor. In addition, because the upper part of the mooring rope was sometimes damaged by fishing gear, it was replaced with stronger material. Today, shackles are almost never used in the upper part of the mooring system because they break easily. Furthermore, for smaller hand-made FADs, damaged floats or upper mooring ropes are now repaired every two to three months. Finally, because large ships sometimes broke the FADs, all FADs are now equipped with lights, and the replacement of batteries for the lights has become a routine maintenance task.

3.3. Types of FADs in Okinawa

One characteristic of Okinawa's FAD fisheries is that the whole operation is conducted primarily by fishers' groups, rather than by governments or large companies. These groups have designed their own FADs, resulting in a variety of types. The cost of deploying the FADs by FCs varies from US$4,000 to $50,000.

Recently, large durable steel FADs (*Nirai*) have been deployed by the Okinawa prefectural government, with national government subsidies. *Nirai* are steel rafts 7m in diameter on the exposed surface, and 16m on the submerged platform (Fig. 8B). They are moored with huge

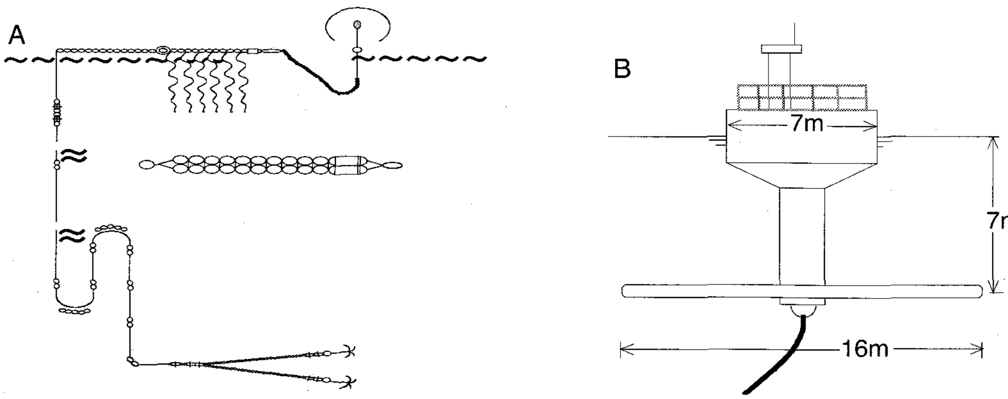

Figure. 8 The configurations of Okinawa FADs. A: The cheapest type. B: The most expensive type (Nirai).

chains and reinforced wires and designed to last at least 10 years. Although the total cost of deploying one *Nirai* is over one million US dollars, at some *Nirai* the total amount of fish catch has become more than the deployment costs. Fourteen *Nirai* had been deployed in waters around Okinawa by 2002. Fig. 8 illustrates the cheapest type of FAD and the *Nirai*, the most expensive type.

Subsurface FADs (Fig. 9) may greatly decrease the loss of these devices. The Japan Marine Fishery Resource Research Center (JAMARC) had deployed 56 subsurface FADs by 1996. To date, only one has been reported lost. In addition, some fishers believe that the subsurface FADs cause the aggregation of more fish than the surface FADs. Nevertheless, the subsurface FADs have two drawbacks. First, it is difficult for fishers to locate them once they are deployed. Second, it is difficult to deploy them at the exact desired depths. At deeper locations (>1000 m), even getting an accurate sounding of the ocean bottom is difficult.

However, recently it has become easier to locate subsurface FADs through the widespread use of GPS (Global Positioning System). Furthermore, techniques for deploying subsurface FADs, such as sounding techniques or calculations of rope elongation and anchor movement, have advanced greatly. Although the number of subsurface FADs is at present limited, their use could increase rapidly.

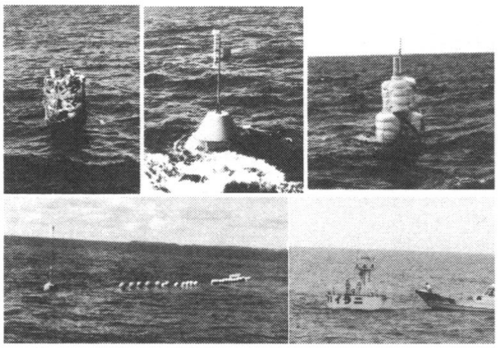

Photo 3 FADs in Okinawa

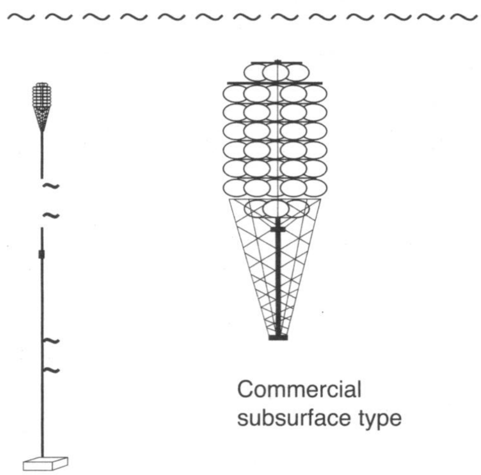

Figure. 9 Subsurface FAD

3.4. The Location of FADs

The locations of FADs around Okinawa Island are shown in Fig. 10.

In 2001, 203 sites were approved for FAD deployment, although some FADs have already been lost in typhoons and some have yet to be deployed. Thus, the actual number of FADs at sea is unknown, though it is probably between 140 and 160. The actual locations of the FADs differ slightly from their plotted points because of the difficulty of deployment operations. The FADs owned by FCs were deployed primarily by the fishers themselves.

Catch depends greatly on the location of the FADs. Among one particular FC's 13 FADs,

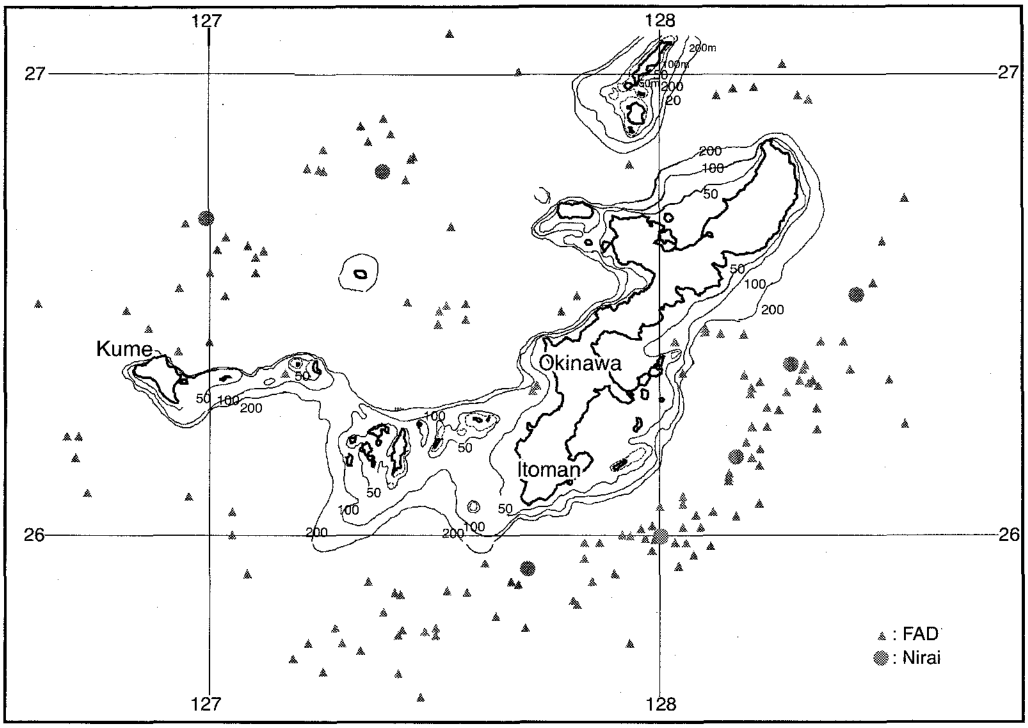

Figure. 10 Locations of FADs around Okinawa Island

the most productive catch was 50 times greater than the least productive FAD, and three FADs together produced 60% of the total catch. Since all the FADs were of the same type, it is reasonable to assume that the difference in productivity results from the difference in the location of the FADs. Consequently, FAD location is very important. The fishers select the FAD location according to depth, current, bottom topography, and distance from ports. Reportedly, the farther the location is from ports, the better the catch, and catch statistics confirm this. Hence, the FAD locations have recently shifted to deeper locations further offshore. However, if the location is too deep and too far from ports, deployment and fuel costs increase, and smaller boats do not have access to these locations.

3.5. Target Species

Target species of the FAD fisheries are yellowfin tuna (*Thunnus albacares*), skipjack (*Katswonus pelamis*), blue marlin (*Makaira mazara*), dolphin fish (*Coryphaena hippurus*), wahoo (*Acanthocybium solandri*), bigeye tuna (*T. obesus*), and albacore (*T. alalunga*). Yellowfin tuna constitutes 68% of the total catch (Fig. 11). Most of these species, apparently, migrate north-south along Okinawa. The yellowfin catch is about 1,000 to 2,000 mt/year. This is a low yield compared to the total yellowfin catch (mostly by purse-seining and long-lining) of 312,000–460,000 mt/year in the Western and Central Pacific [Lawson 1999].

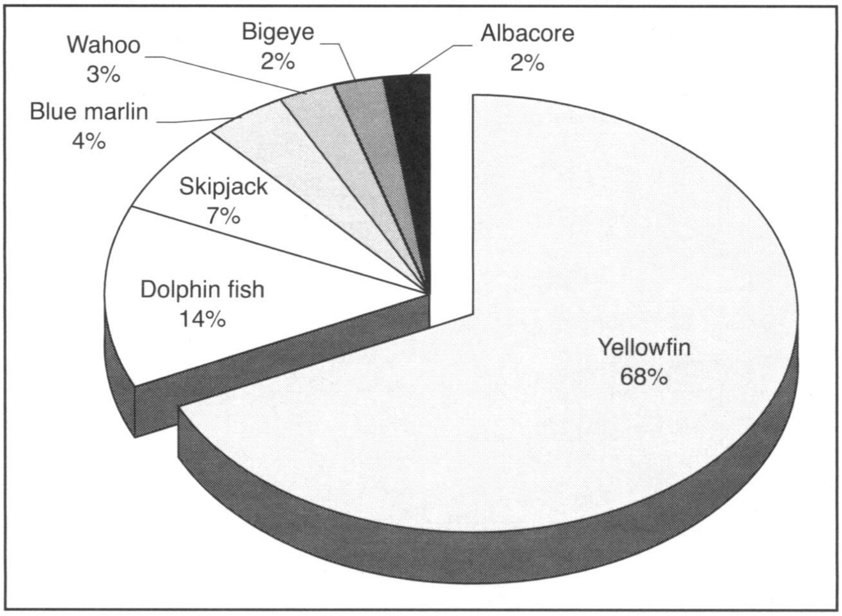

Figure. 11 The composition of FDA caught species

3.6. Fishing Methods

It has been more than 20 years since FAD fisheries became widespread, and a variety of fishing methods have been devised and employed to harvest the fish attracted by the FADs (Fig. 12). The major fishing methods are: trolling, jumbo trolling, marlin trolling, drift-line, drop-stone, drift-flag, pole-and-line, and underwater-torch-fishing.

3.7. Economic Impact

The FAD fishery has developed into one of the major fisheries in Okinawa. The annual production was 2500 to 4000mt in the past 10 years, which is 17–27 % of the total coastal fisheries production. The economic value was 1.2 to 2.0 billion yen (equivalent to US$10 to US$17 million). If we assume the annual FAD catch is 3000mt and the average number of FADs at sea is 150, the average annual catch per FAD is approximately 20mt. The number of FAD fishing boats is about 1000, which is 25 % of the total coastal fleet of 4000. Most of the FAD fishing boats are small, and are usually operated by one person. Thus, the number of FAD fishers is only slightly greater than the number of fishing boats.

We observed a maximum of 24 boats fishing at one FAD in 1986. The more fish that aggregate at a FAD, the more fishing boats that gather there. However, too many fishing boats can create difficulties in a fishing operation. In FAD fisheries, catch per unit of effort (CPUE, e.g. catch per boat per day) does not always reflect the abundance of fish stocks because a FAD with a greater fish aggregation will attract more fishing boats. Nevertheless, the CPUE is still a relatively reliable indicator of the fishery's productivity. The combined CPUE of five FCs (for 389 fishing boats) in 1994 (a low catch year) and in 1995 (a high catch year) was 73 kg/day per boat.

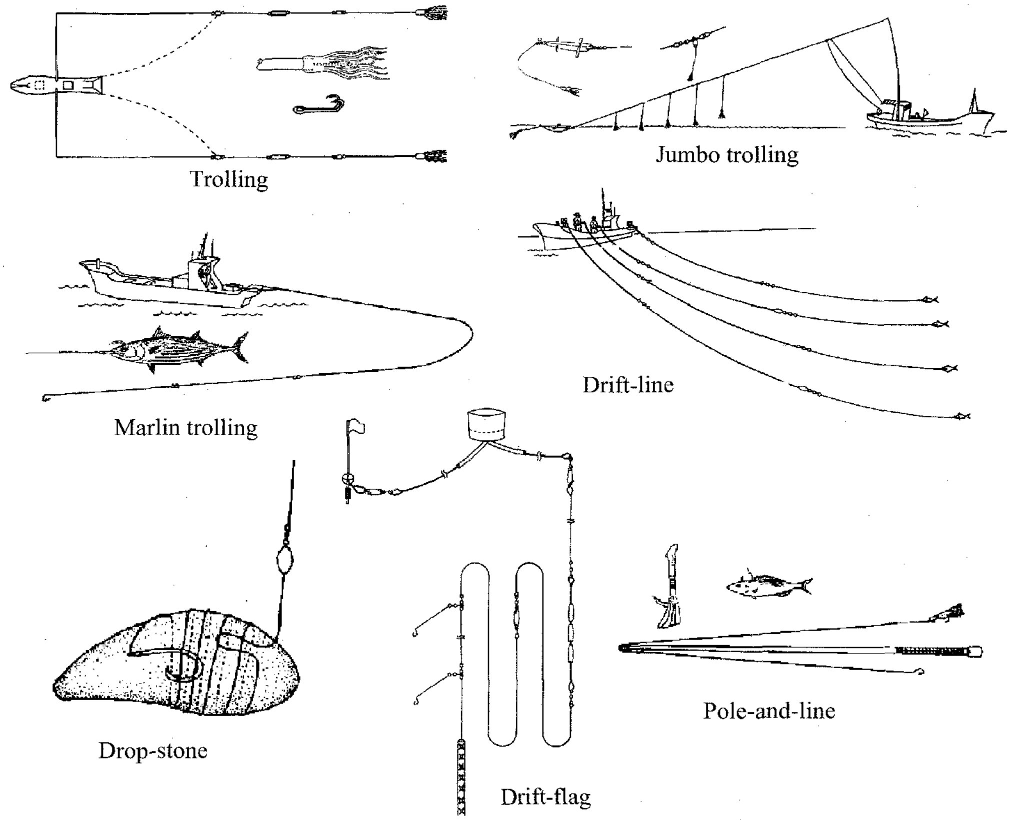

Figure. 12 FAD fishing gears and methods
Source: Fishing gear and methods of coastal fishery in the southern waters—Fishing gear and methods in Okinawa Prefecture, Overseas Fisheries Cooperation Foundation, 1988.

3.8. Conflicts

Conflicts within FAD fisheries are classified into four types: among FAD fishers; between FAD and tuna long-line fishers; between the fishers from Okinawa and from other prefectures; and between professional and sport fishers.

Because the FADs aggregate large numbers of fish, there have been conflicts among FAD fishers on the deployment and use of FADs since the early stages of the fisheries' development. Consequently, the Okinawa Marine Zone Fisheries Regulation Committee divided Okinawa waters into four zones (North, Southwest, Southeast, and Miyako-Yaeyama) and the committee now annually regulates the number of FADs in each zone.

Long-line fishers and FAD fishers also have been in conflict regarding the use of offshore fishing grounds. Therefore, after negotiations, FAD fishers agreed to deploy FADs within about 20 nautical miles of the coasts, while long-line fishers agreed to operate beyond that limit.

More serious conflicts have occurred between the fishers from Okinawa and pole-and-line fishers from other prefectures. The pole-and-line fishers traditionally caught skipjack and small yellowfin tuna in Okinawan waters prior to the FAD fisheries. The fishing boats of the other prefectures are far larger than Okinawa's boats and can catch most of the fish aggregated at a FAD when sea conditions are too rough for Okinawa's small boats. The Japanese fisheries law does not have explicit regulations regarding these conflicts. Therefore, representatives of both groups discussed the problem and agreed that both groups should deploy their own FADs separately and use them separately. The conflicts seemed to have been mediated through the intervention of the governments concerned.

Generally, FADs that belong to FCs are supposed to be fished only by the members of the FCs. However, sport fishing at FADs has become popular recently, and conflicts with professional fishers have increased substantially, causing serious problems for the fisheries. On the other hand, sport fishing has great potential to influence further developments in the FAD fisheries. Since the charter fee for sport fishing at FADs can be quite high, a fisher could receive greater income by taking sport fishers to FADs than from selling the average daily commercial catch. Game fishing targeting blue marlin has also become popular [KAKUMA 2001], and contributes substantially to tourism, which is already Okinawa's largest industry.

4. CONCLUSION

Coastal fisheries resources may be managed effectively through co-management between governments and communities in the tropical and sub-tropical regions, such as Okinawa, Samoa and the Philippines. Retrospective management using MPAs could also be of benefit there. Alternative income and seafood projects are crucial for fisheries management, and FADs may play an important role as an alternative.

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