Synthesis on moored FADs in the North West Pacific region

Shinichiro Kakuma

Okinawa Fisheries Experimental Station, 1-3-1 Nishizaki Itoman, Okinawa, Japan
skakuma@fish.pref.okinawa.jp

Abstract

In early 1980s, FAD fisheries were introduced from the Philippines to Japan, mainly to Okinawa. The fisheries have well developed becoming one of the main fisheries in Okinawa where 210 FADs are approved to deploy in 1999. The annual catch by roughly 1 000 boats (most of them are small) is 2500-4000 mt; average catch from one FAD is about 20 mt; average catch by one boat on one day is 73 kilogrammes. FADs are also important for easing the fishing pressures on bottom fish stocks. Most of the FADs were deployed and managed by local fishermen's groups that have improved the structures of the system to withstand typhoons. The catches are strongly depending on the sites, usually the farther off-shore, the better the catches. A variety of fishing methods are devised targeting each species and the size of the fish. Being most abundant and having relatively higher prices, yellowfin tuna is the most important and consists 68% of the total production. There have been conflicts among fishermen on the use of FADs since the early stage of the fisheries development. Now, the number of FADs is regulated by a management committee. Conflicts between fishermen and sport fishermen have become problems; on the other hand, the sport fishing could lead to further development of the fisheries. Degraded fish meat caused by high meat temperature and occasional oversupply have been major marketing problems since prices are strongly related to the meat quality and the fish supply.

Area and existing FAD programme

Geographic zone concerned and States in the zone

The geographic zone concerned: North West Pacific.
States in the zone: Japan.
The Philippines are excluded from this regional synthesis. I focused on Okinawa where the majority of FADs in Japan are deployed.

Outline of Okinawa

Okinawa prefecture is located south-west of mainland Japan forming an archipelago between Kyushu and Taiwan (fig. 1). It consists of 160 islands running north-east to south-west; 1.3 million people inhabit the 42 islands.

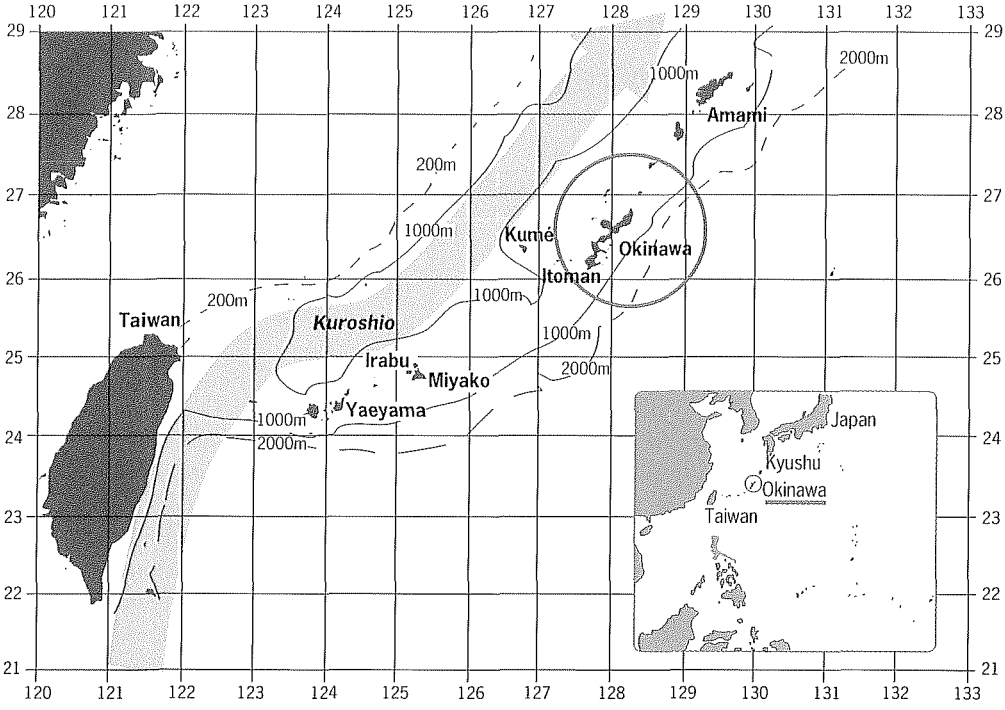


Figure 1
Location of Okinawa.

Ten to fifteen nautical miles to the south-east off the archipelago, the ocean depth drops rapidly to over 1,000 metres. The "Kuroshio", a warm and strong current, flows west of the archipelago along the continental shelf. Surface water temperature in the area of the FADs is between 21 and 29 degrees Celsius. North to north-east monsoon winds dominate in winter causing rough sea conditions, while some typhoons attack Okinawa during summer and autumn.

Origin of Japanese FADs

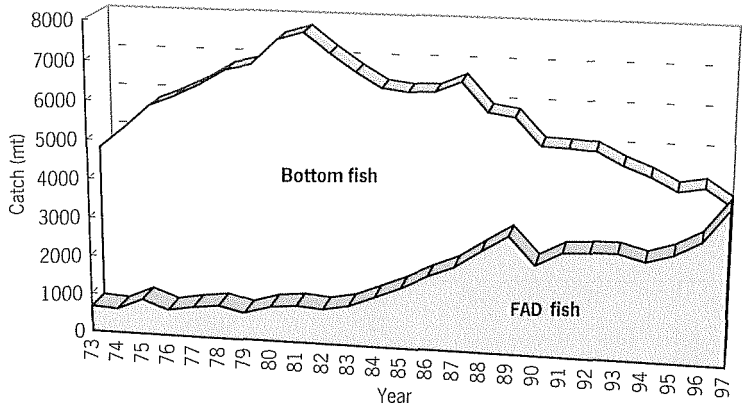
Simple FADs targeting dolphinfish *(Coryphaena hippurus)* have been deployed in various places in Japan for more than a hundred years. Offshore deeper (>1,000 m) FADs, targeting tuna species, were introduced from the Philippines to the southern parts of Japan.

Background and fisheries development

In early 1980s, prefectures such as Okinawa, Kagoshima, Miyazaki, and Kochi developed FAD fisheries. These prefectures are located on the south Pacific side of Japan and the Kuroshio flows along their shores. In those days, bottom fish stocks were decreasing due to overfishing, and one of the reasons that Okinawa tried to develop FAD fisheries was to improve income and divert fishing effort from these bottom fish species.

Fisheries statistics from the Okinawa Development Agency (ODA) show catches of bottom fish have decreased drastically since 1982 (fig. 2), while FAD fisheries production has increased. This has helped to compensate for the reduced demersal fisheries.

Figure 2
Catches of bottom fish and FAD fish.



Dynamics of deployments

Introduction, improvement and status

The offshore (>1,000 m depth) FAD projects started in 1982 when Okinawa Fisheries Experimental Station and two fisheries cooperatives (FCs) in Miyako examined the effects of 14 experimental FADs. Because the results were very good, the use of FADs spread rapidly and FADs were deployed by other FCs in Okinawa.

I have listed the number and the types of offshore FADs in Okinawa, Amami, the other prefectures and Taiwan in tables 1 and 2. At first, commercially manufactured FADs were popular in Okinawa but soon cheaper handmade FADs prevailed. A typical handmade FAD system (consisting of several small connected buoys) is similar to the Indian Ocean FAD systems (Cusack, 1996). The advantages of these FADs are, cheaper, easier maintenance and durability in strong currents. Another popular FAD type is the so-called "vertical type" that has larger underwater structures. Figures 3 and 4 show the configuration of Okinawan FADs.

Deployment constraints and considerations

Losses of FADs by typhoons have been a serious problem, especially in the early stages. Most FADs were lost within 1 to 1.5 year, with some lost less than a year after deployment. Despite this, the catch rates from FADs were sufficient to warrant new deployments. Besides, the fishermen tried to devise measures to make their FADs last longer.

First, the mooring system was improved. Some FCs changed the single-anchor system to a double-anchor system. Because the upper part of the mooring rope was sometimes damaged by fishing gear, it was replaced by stronger material. Today, shackles are almost never used in the upper part of the mooring system because they sometimes become the breaking points.

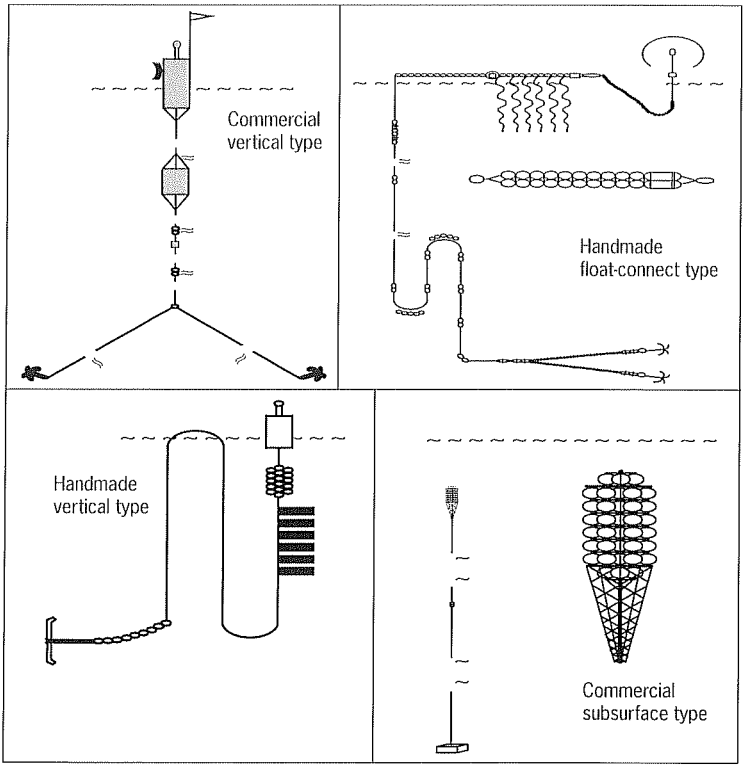
Table 1 - Number and types of FADs by fisheries cooperative in Okinawa.

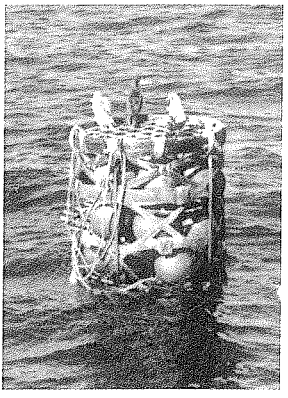
FC	Approved Nb in 1999	At sea in August	FAD type	Nb	Costs *1 (1000 yen)	Avg. years at sea	Nb of boats	Size of boats	Subsidy *3 (1000 yen)
Itoman	12	11	A	10	1700	2.5-3	91	<4 t	4350
			B	1	1000	?			
Minatogawa	9	9	B	9	1700	2-3	48	<4 t	1600
Chinen	7	7	B	7	1000	1.5	75	2-7 t	1000
Okinawashi	10	8	B	8	1500	2	36	4-7 t	1200
Kumejima	11	11	B	6	750	1-2	139	<5 t	2000
			B	5	900	3			
Irabu	7	7	C	6	400	>3	34	<5 t 10-20 t	4000
			D	1	4000	?			
Yaeyama	18	18	B	7	400	2-3	20	<5 t	3400
			C	11	1000	2-4			
Kin	8	8	A	2	5000	2	35	5 t	2500
			D	6	3000	?			
Motobu	4	4	D	4	1100	>3	6	<5 t 10-50	3000
Kunigami	6	6	B	3	1250	1	75	3-10 t	3000
			D	3	3500	>3			
Nago	4	4	B	4	1250	1-2	25	3-9 t	625
Haneji	3	0							
Ie	4	1	C	1	650	>2	4	3-5 t	0
Onna	5	5	C	5	1200	>3	30	<5 t	600
Yomitan	4	1	B	1	500	<2	2	<5	50%
Iheya	1	0							
Nakijin	2	1	B	1	600	2	2	3 t	50%
Chatan	6	0							
Urasoe	5	2	A	2	4500	>2	6	4 t	50%
Nahaengan	9	2	B	1	1500	<1	13	<5 t	2000
			B	1	2500				
Tokashiki	5	2	B	2	1500	3-5	10	3-5 t	0
Tonaki	4	3	C	3	3500	2	10	1-3 t	30%
Zamami	3	1	B	1	650	>3	23	<5 t	0
Ishikawa	3	2	B	2	1500	1	25	5-6 t	400
Yonashiro	3	0							
Katsuren	3	1	A	1	2000	1	3	<5 t	0
Yonabaru	6	2	B	2	430	1-2	2	3-5 t	0
Sashiki	4	2	B	2	850	<1	21	<3 t	500
Ginoza	3	3	B	3	800	1-1.5	10	3-5 t	600
Gushikawa	5	2	B	2	900	<1	20	3-5 t	1200
Hirara	13	6	C	5	550	2	4	<5 t	1000
			D	1	?	5			
Yonaguni	3	2	B	2	800	<2	35	3 t	600
Other	10	10	?	10	?	?	?	?	?
Nirai	10	10	A	10	>100000	>10			
Sum	210	151					840 *2		

FAD type
A: Commercial
B: Handmade vertical
C: Float-connect
D: Subsurface

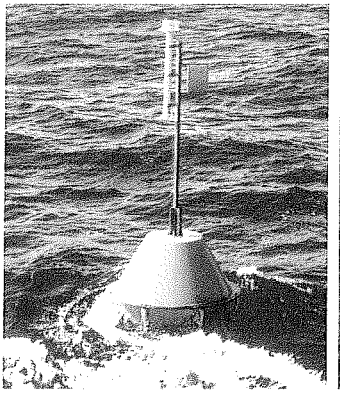
*1 Rough costs including buoys, anchors, ropes and deployment cost
*2 The total number of boats in the prefecture is greater than this.
*3 Annual average subsidy

Figure 3
Configurations
of Okinawan FADs.

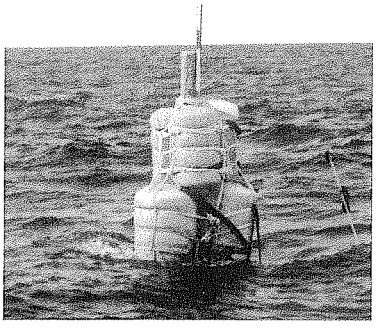




Commercial subsurface type

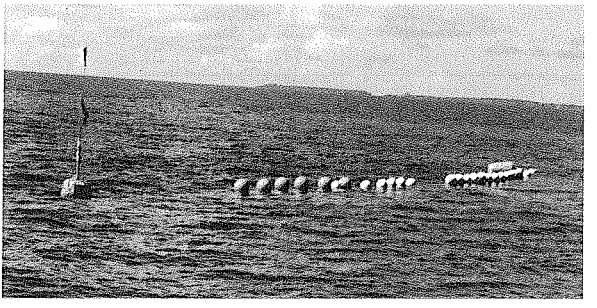


Commercial vertical type



Handmade vertical type

Figure 4
Pictures
of Okinawan FADs.



Handmade float-connect type

Table 2 - Number of FADs in Amami, the other prefectures and Taiwan.

	Amami	Kagoshima	Miyazaki	Kochi	Shizuoka	Kanagawa	Chiba	Jamarc *1	Taiwan
Type A	4	1	4	9	1	1	1		
Type B	53								3
Type D	7	6					9	64	3
Sum	64	7	4	9	1	1	10	64	6

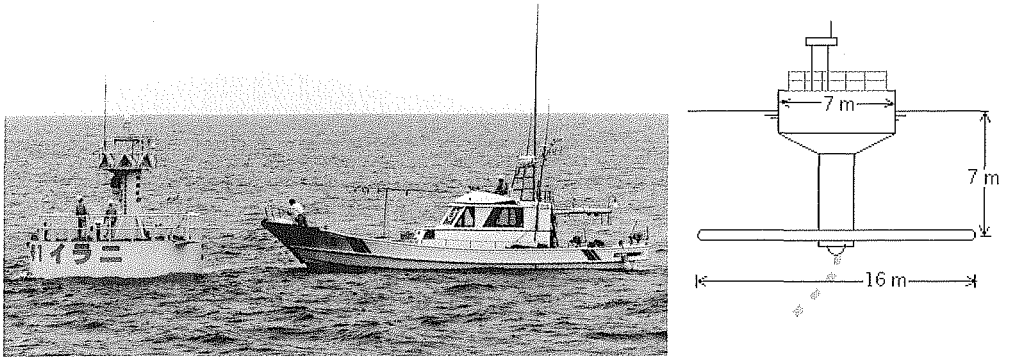
FAD type A: Surface large, similar to nirai
B: Surface small
D: Subsurface

*1 Jamarc: Japan Marine Fishery Resource Research Center
Jamarc FADs are located in Okinawa and Amami.

Second, for smaller handmade FADs, damaged floats or upper mooring ropes are repaired every two to three months. Large ships sometimes broke the FADs and so installing lights on FADs is now carried out. Replacement of batteries for the lights is a normal maintenance task. Recently, huge durable steel FADs (nirai) have been deployed with national and prefectural government subsidy. The diameters of the components of the nirai steel raft are 7 m for the surface part and 16 m for the underwater part (fig. 5). It is designed to last at least 10 years, is moored with huge chains and reinforced wires. The cost is over 100 million yen (equivalent to one million US$). Ten nirai were deployed in Okinawan waters in 1999. Although the cost seems very expensive, the average annual catch in 1996 and 1997 from one nirai was about 40 mt (25 million yen). So, if a nirai FAD lasts more than 10 years, it would yield much more than its cost.

It is thought that subsurface FADs might greatly decrease the losses of FADs. The Japan Marine Fishery Resource Research Center (Jamarc) deployed 56 subsurface FADs through 1996. To date, only one has been lost. In addition, some fishermen believe that the subsurface FADs aggregate more fish than the surface FADs. Nevertheless, subsurface FADs have encountered two drawbacks. First, it is difficult for fishermen to find the FADs. Second, it is difficult to deploy the subsurface rafts exactly at the desired depths. At deeper locations (>1,000 m), even getting an accurate sound of the ocean bottom was difficult. However, recently, it has become easier to find subsurface FADs with widespread use of GPS (Geographic Positioning System). Also, techniques

Figure 5
Nirai.



for deploying the subsurface raft have advanced greatly. Although the number of subsurface FADs is limited to date, it might increase rapidly.

Location of FADs

The locations of FADs around Okinawa Island and Miyako-Yaeyama are plotted in figure 6 and figure 7 respectively.

In 1999, 210 FAD sites were approved for deployment. Some of them have already been lost in recent typhoons and some have not yet been deployed. So the actual number of the FADs at sea at this time is unknown, though is thought to be between 140 and 160 (tab. 1). The actual location of the each FAD slightly diverges from its plotted point because

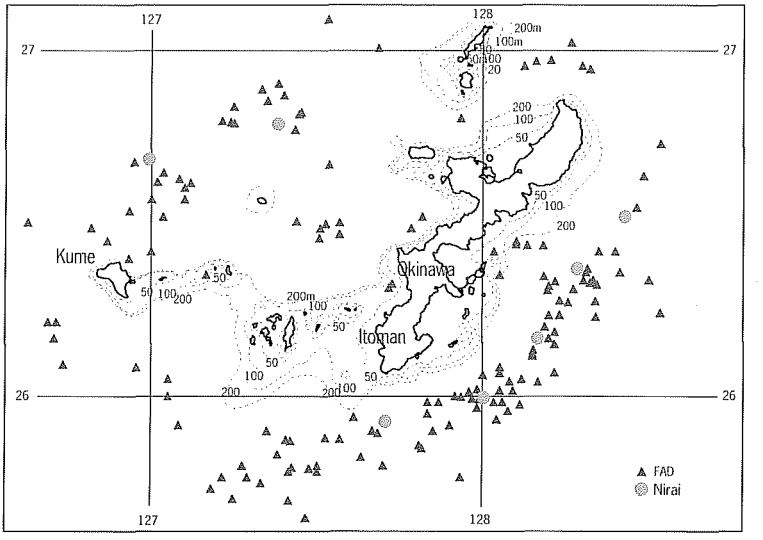


Figure 6
Locations of FADs around Okinawa Island.

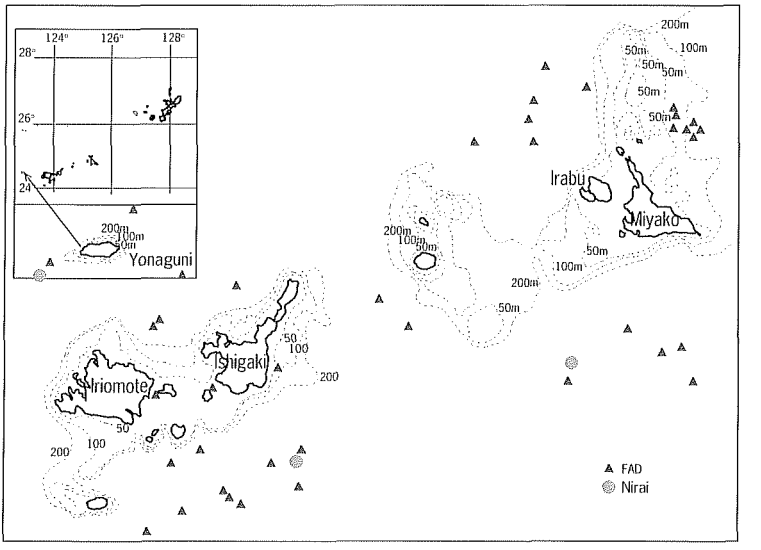
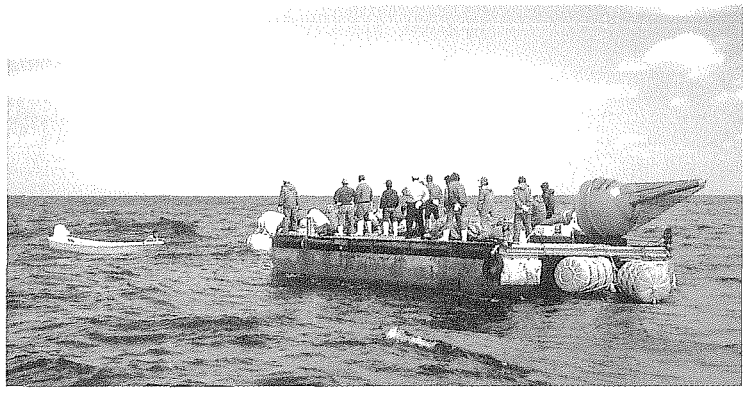


Figure 7
Locations of FADs around Miyako-Yaeyama.

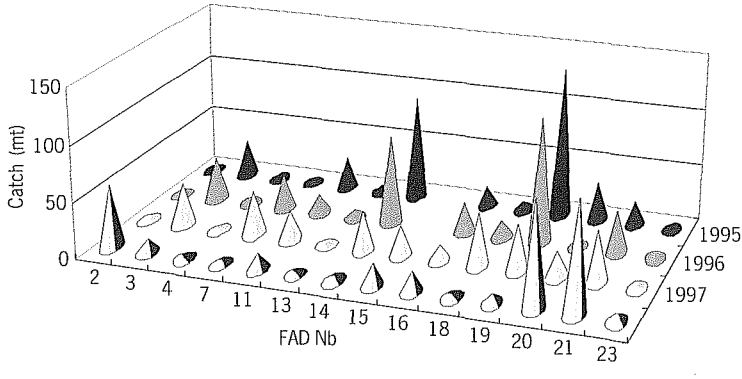
of the difficulty of deployment operations. The FADs owned by FCs were mostly deployed by fishermen. The fishermen in one FC constructed a large barge exclusively for FAD deployment. The barge was towed to the deployment site with FAD components and many fishermen on it, and then the FAD was deployed with manpower (fig. 8).

Figure 8
Deployment operation of FADs by fishermen.



Catch depends greatly on the FADs locations. Figure 9 shows catches from 14 FADs of one FC for 1995, 1996 and 1997. The better FAD catches are about 50 times greater than worse FAD catches and best three FAD catches together cover about 60% of the total catch. If the types of FADs are the same, it is reasonable to presume that the difference in catches comes from the difference of the locations of the FADs. Consequently, location selection is very important. The fishermen determine the FAD location by depth, currents, bottom topography, and distance from the ports. Reportedly, the further the location, the better the catch and catch statistics confirm this. Hence, the depth of the FAD locations has shifted to deeper places recently. However, if the location is too deep and too far from the port, it costs more for deployment and fuel, and smaller boats do not have access to the FAD.
There has not been any analysis carried out to look at the relationship between catch and proximity to other FADs. Often, due to lack of communication between FCs, FADs are unintentionally placed close together.

Figure 9
Catches by FADs belonging to Itoman FC in 1995-1997.

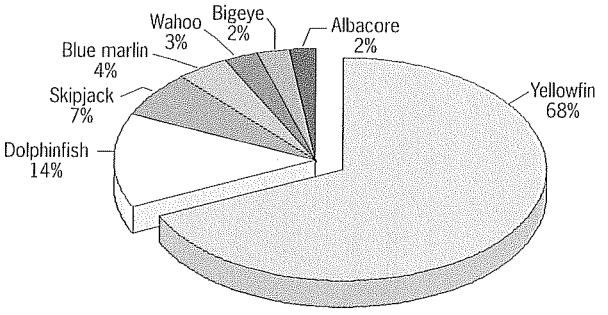


Survey results

Target species and catch data

Target species of the FAD fisheries are yellowfin *(Thunnus albacares)*, skipjack *(Katsuwonus pelamis)*, blue marlin *(Makaira mazara)*, dolphinfish *(Coryphaena hippurus)*, wahoo *(Acanthocybium solandri)*, bigeye *(T. obesus)*, albacore *(T. alalunga)*. Yellowfin constitutes 68% of the total catch (fig. 10). Most of these species, seemingly, migrate north-south along Okinawa.

Figure 10
The composition of species.



Amami district, which belongs to the Kagoshima prefecture, is located close to the north of Okinawa and has many FADs. The catches in Amami and in some of the other prefectures in Japan are listed in table 3. The FAD fisheries in Taiwan are still in experimental stages and yet they attained good results (J. Lin, Kaohsiung Branch of Taiwan Fisheries Research Institute, Taiwan, pers. comm.).

Table 3 - Annual catches in Amami and other prefectures in Japan (mt).

	Yellowfin	Dolphinfish	Skipjack	Blue marlin	Wahoo	Albacore	Bigeye	Total
Amami	697	174	517	12	91	7	-	1,499
Miyazaki	123	77	250	-	16	16	-	481
Kochi	283	-	525	-	-	-	-	808

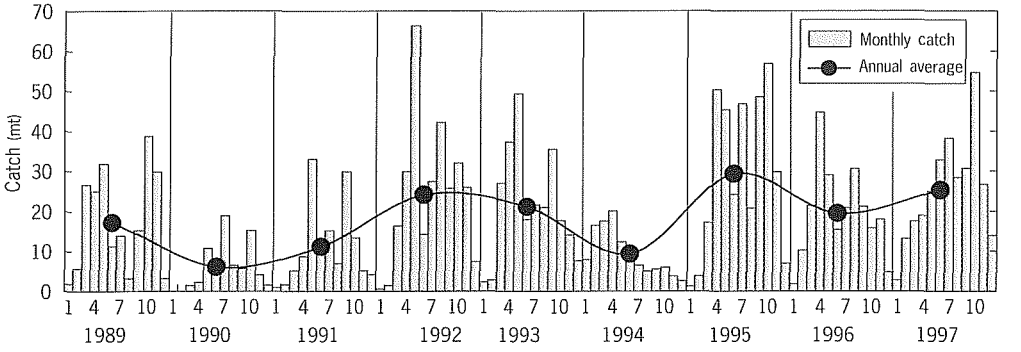
Table 4 shows the catch by species for 12 of the major fisheries cooperatives. This data does not include catch for other smaller FCs, but indicates most of total production of Okinawa.

Table 4 - Catch by species for 12 FCs (mt).

Fish species	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Yellowfin >10 kg	338	117	270	387	371	209	515	314	498	391
Yellowfin <10 kg	943	513	540	699	645	502	474	818	798	594
Dolphinfish	210	255	404	461	234	144	237	171	208	351
Skipjack	127	112	98	60	73	80	163	117	201	161
Blue marlin	207	118	120	84	95	56	91	107	112	103
Wahoo	44	51	59	92	65	60	54	30	45	65
Albacore	0	0	0	1	5	12	24	48	140	116
Bigeye	10	3	7	4	24	20	72	31	98	64
Total	1,881	1,173	1,501	1,789	1,514	1,085	1,631	1,638	2,103	1,846

The catch from FADs had increased rapidly since early 1980s in proportion to the increase of FADs. However, since 1989, the catches have fluctuated greatly. The numbers of FADs, FAD fishermen and fishing days have been relatively stable during this period. Figure 11 indicates the variation in yellowfin (> 10 kg) catch at four south Okinawa's FCs. The yellowfin catch, which dominates the catch from Okinawan FADs, was about 600 to 1,300 mt/year. This is pretty small compared with the total yellowfin catch (mostly by purse seining and longlining) of 312,000-460,000 mt/year in the Western and Central Pacific (Lawson, 1999).

Figure 11
Monthly catch of yellowfin (>10 kg) in south Okinawa.



Economic impact

Fleet characteristics and technological impact

There are two types of FAD fishing boats: "Wasen" (fig. 12) and "Sabani" (fig. 13). It has been more than 15 years since FAD fisheries have become widespread, so the fishermen in every FC have had a chance to devise a variety of fishing methods. The major fishing methods are: a) trolling; b) jumbo trolling (Désurmont, 1996); c) marlin trolling (with live baits); d) drift-line; e) drop-stone; f) drift-flag; g) pole-and-line; h) underwater-torch-fishing. Method "a" is mainly targeting smaller yellowfin, wahoo and dolphinfish, "b, d, e, f" are mainly for larger yellowfin, "c" is for blue marlin, "g" is mainly for skipjack, and "h" is mainly for bigeye. Some of the methods are illustrated in figure 14.

Scale of the fisheries

The FAD fisheries have developed into one of the major fisheries in Okinawa. According to the statistics from the ODA, annual production is 2,500 to 4,000 mt, which is 17-27% of the total coastal fisheries production. The economic value is around 1.2 to 2.0 billion yen (10-18% of the total). If we assume annual FAD catch as 3,000 mt and average number of FADs at sea as 150, then average annual catch per FAD is around 20 metric tons. The number of the FAD fishing boats is about 1,000, which is 25% of the total coastal fleet of 4,000 (including vessels involved in aquaculture). Most of the FAD fishing boats are small, less

Figure 12
"Wasen"

Figure 13
"Sabani"

than 5 t (about 10 m), and are usually operated by one person. So, the number of FAD fishermen is slightly greater than the number of the fishing boats.

We observed a maximum of 24 boats fishing at one FAD. The more fish aggregate at a FAD, the more fishing boats gather there. However, too many fishing boats can cause difficulties of fishing operations. In FAD fisheries, the catch per boat per day (CPUE) does not always reflect the abundance of fish schools because a FAD with good fish aggregation attracts more fishing boats. Nevertheless, the CPUE is still good information for the fishery's development. The combined CPUE of five FCs (for 389 fishing boats) in 1994 (a bad catch year) and in 1995 (a good catch year) was 73 kg/day per boat (tab. 5).

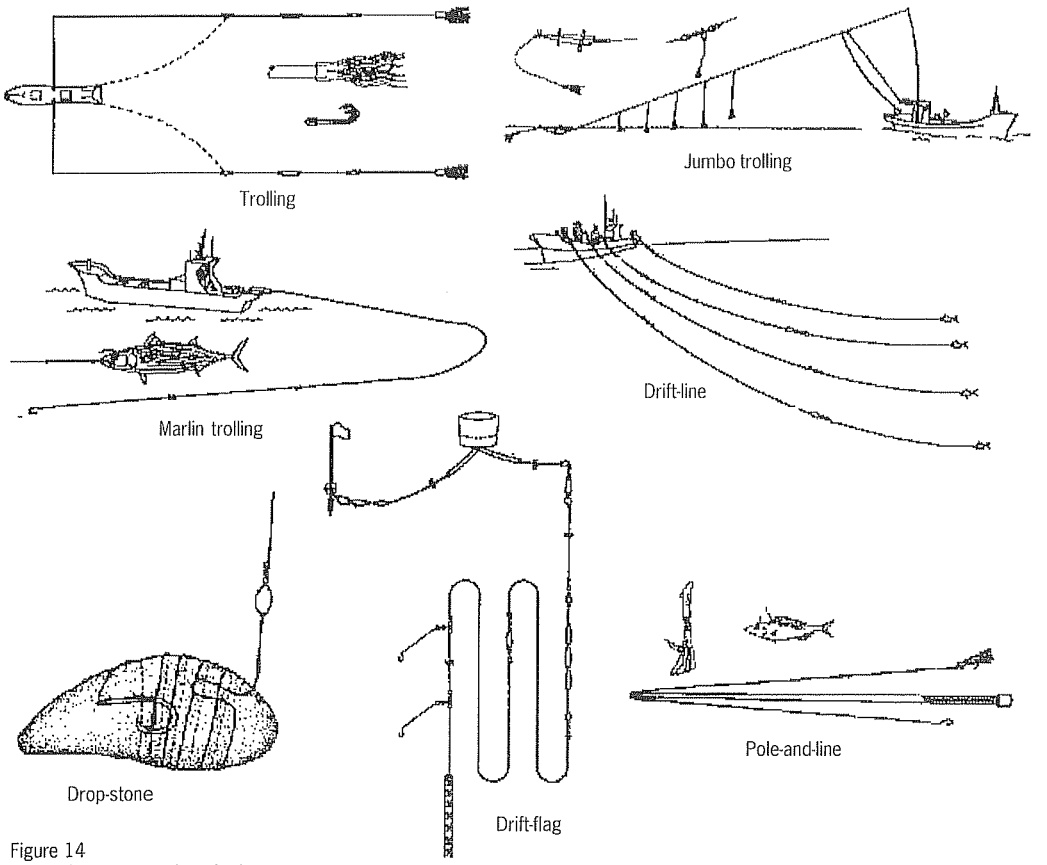


Figure 14
FAD fishing gears and methods.
Source: Fishing gear and methods of coastal fishery in the southern waters. Fishing gear and methods in Okinawa Prefecture. Overseas Fisheries Cooperation Foundation, 1988.

Table 5 - CPUE at five FCs in 1994 and 1995. CPUE: Catch (kg)/day/boat.

FC	Itoman		Minatogawa		Chinen		Okinawa-shi		Kumejima		Total
Nb of boats	91		48		75		36		139		389
Year	1994	1995	1994	1995	1994	1995	1994	1995	1994	1995	
CPUE	119	150	65	92	60	91	72	74	30	30	73

Fishing practices in terms of distance, transit times

Most of the FADs are within 2 or 3 hours from the home ports. Consequently, FAD fishing is usually one-day fishing. However, Nirai and Jamarc FADs are often quite far away. The fishermen occasionally visit these FADs with 2 or 3-day trips when their own FADs do not aggregate much fish.

Conflict management and sport fishing

Conflict management

Because the FADs aggregate a lot of fishes, there were conflicts among FAD fishermen about the deployment and the use of the FADs since the

early stages of the FAD projects. Consequently, the Okinawa Marine Zone Fisheries Regulation Committee (OMZFRC) divided Okinawan waters into four zones, namely North, Southwest, Southeast, and Miyako-Yaeyama. This agency now annually regulates the number of the FADs in each zone.

Longline fishermen and FAD fishermen also had conflicts on the use of offshore fishing grounds. Therefore, after negotiations, FAD fishermen agreed to deploy FADs within about 20 nautical miles off the coasts. More serious conflicts were the ones between Okinawan fishermen and the other prefectures' pole-and-line fishermen who traditionally caught skipjack and small yellowfin in Okinawan waters, prior to the FAD fisheries. The fishing boats of the other prefectures are far bigger than Okinawan boats and could catch most of the fish aggregated with FADs when sea condition is too rough for Okinawan small boats.

The Japanese fisheries law does not have explicit regulations regarding these conflicts. Therefore, representatives of both groups talked about this problem and agreed that both groups deploy their own FADs separately and use them separately. The conflicts seemed to calm down but many Okinawan fishermen still have complaints about the fishing activities at their FADs by boats from other prefectures.

Many FCs have their own rules on FAD use. For example, one FC restricts mooring to FADs, controls trolling operations (you should always move around a FAD clockwise), restricts the use of wire fishing gears, etc. In this FC, FAD fishermen have to pay a 20,000 yen annual fee and two percent of their catch sales to maintain their FADs.

Sport fishing

Generally, FADs belonging to FCs are supposed to be fished only by the members of the FCs. Recently, however, sport fishing at FADs has become popular. The majority of the FAD fishermen probably have some complaints about the sport fishermen. For instance, they do not follow the rules on FAD use; they use too much chum; they use better fishing gears; they cause an oversupply of fish resulting cheaper fish prices at the markets. (They seldom sell fish. They, however, provide fish for potential customers.)

Sport fishing may have great potential to influence the further development of FADs and FAD fisheries. To date, the total number of Okinawan commercial fishermen is about 5,000 while the number of sport fishermen is reportedly about 150,000. And, since the charter fee that can be charged for sport fishing at FADs can be quite high, a fisherman could receive greater income if he takes sport fishermen to FADs than he could from selling the average daily commercial catch.

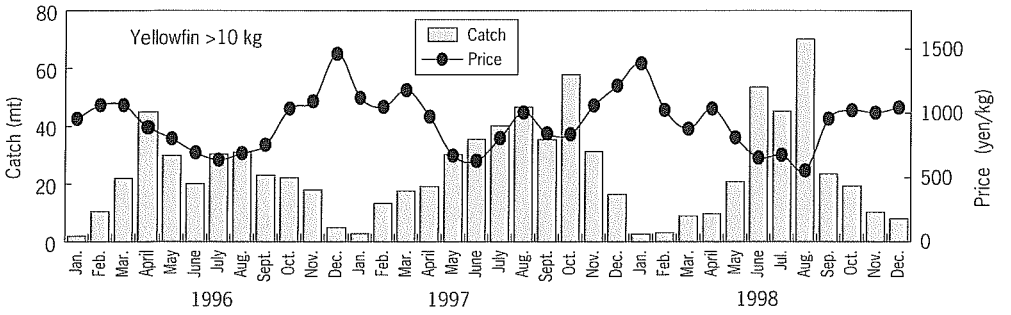
Game fishing targeting blue marlin has also become popular (Kakuma, 1998). The availability and size of blue marlin is said to be as good or better than in Hawaii. Consequently, the sport fishing could make a contribution to tourism, the biggest industry in Okinawa.

Marketing considerations

The most serious problem with marketing FAD fish is, probably, "yake" (burned meat). The yake is degraded fish meat caused by high meat temperature and low meat pH incurred during fishing operations. Because of this, the fish may be auctioned at very low prices (often one third to one fifth of normal prices). Tuna caught by longline tend to be free from yake. This suggests that the deeper, cooler water temperature or longer cooling period before hauling could reduce the yake phenomenon. A variety of methods to avoid yake, such as bleeding, cooling, or quick killing have been tried. According to some fishermen, some of the methods actually worked well. Nonetheless, there has been no method that works well in all occasions.

Low prices caused by occasional oversupply are another major problem. Middle to large-size yellowfin command higher prices. The annual average prices in southern Okinawa's four markets between 1989 and 1998 ranged between 660 to 1,100 yen per kilogramme. These prices are correlated to the catches; the greater the catches, the lower the prices. Figure 15 shows the monthly catches and prices of yellowfin.

Figure 15
Monthly catches and prices of yellowfin (>10 kg).



The marketing of small tuna is a serious problem. The price for yellowfin (>10 kg) in 1998 averaged 700 yen/kg, smaller (<10 kg) yellowfin was 280, skipjack was 320, blue marlin was 630, dolphinfish was 220, wahoo was 290, and albacore was 280. In Irabu, a small remote island, the prices were about 70% of the prices of south Okinawa.

Better quality, larger-size tuna often go to mainland Japan markets, while lesser quality, smaller size tuna are consumed locally. Consequently, the fishermen do not intentionally target these cheaper fishes. If larger yellowfin are not abundant at the FADs, the fishermen will catch the cheaper fishes.

Prospects

We will monitor the catch of FAD fisheries at 23 FC's markets in Okinawa.
According to a recent prefectural fisheries development plan, a total of 14 nirai will be deployed and maintained by 2001. The other, smaller FADs, will be maintained by the FCs with or without local government subsidies.
We will soon be included within a regional management system for the Western and Central Pacific tuna stocks. A task of great importance for the future will be how to incorporate the Okinawa's FAD fisheries into this international system.

Bibliographic references

Cusack P., 1996. Two FAD systems recommended by SPC. SPC Fish Aggreg. Device Inf. Bull., 1, 10-15.

Désurmont A. (ed.), 1996. Jumbo trolling. SPC Fish Aggreg. Device Inf. Bull., 2, 16-18.

Kakuma S., 1998. Gamefish tournaments and FAD fisheries in Okinawa, Japan. A paper presented at the Symposium on Pacific Island Gamefish Tournaments, Kailua-Kona, Hawaii, 29 July-1 August 1998, 4 p.

Lawson T.A. (ed.), 1999. Secretariat of the Pacific Community Tuna Fishery Yearbook 1998. Oceanic Fisheries Programme, SPC, Noumea, New Caledonia, 155 p.