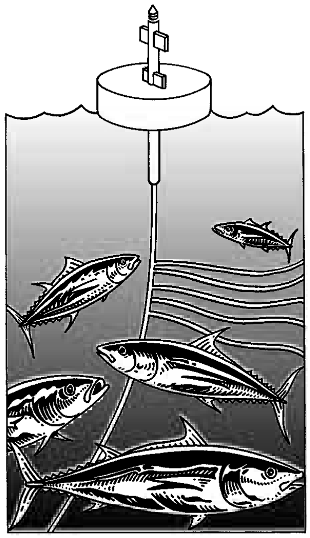
FISHERIES PROGRAMME
INFORMATION SECTION

FAD

Fish Aggregating Device

Number 1 — March 1996

INFORMATION BULLETIN



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EDITORIAL

Welcome to the first edition of the Fish Aggregating Device (FAD) Bulletin. This is the eighth special interest group (SIG) bulletin published by the Information Section of the SPC Coastal Fisheries Programme. Other bulletins concern: ciguatera, pearl oyster, beche-de-mer, trochus, traditional marine resource management and knowledge, fisheries education and training, and live reef fish.

First, we should clearly identify the field that will be covered by this bulletin. To quote our new SPC colleague Magnus Bergstrom: 'A fish aggregating device is any method, object or construction used for the purpose of facilitating the harvesting of fish by attracting and thus aggregating them'. In fact, the expression FAD has become more restricted, to mean a man-made floating object, anchored or not, set up to aggregate fish (mostly pelagic species). This bulletin will first concentrate on subjects related to these types of FADs but may, if members show interest, extend its coverage to other aggregating structures such as artificial reefs (ARs).

A questionnaire (of which you will find a copy on the last page of this issue) has been widely distributed since August 1995 to identify the most important topics for our future SIG members, and the ones on which we could expect contributions.

Up to now, we have received almost a hundred replies. The five following subjects were the most often cited:

1. FADs for small-scale commercial and subsistence use
2. Fish behaviour in association with FADs
3. Social and economic effects of FADs
4. FAD fishing techniques
5. Developments in FAD technology / materials

(cont'd page 2)

Inside this issue

This publication is organised in three main sections:

The first will present original contributions on general matters.

In this issue, one article by F. Conand and E. Tessier (page) presents the FAD programme of La Réunion Island in the Indian Ocean. Another by K. Kikutani (page.) explains the way fishermen have set up and run their own FAD programme through their cooperative on the Japanese Okunoshima Island. It is very interesting to note that in both cases FADs have created an important new source of income for artisanal fishermen and, in both cases also, fishermen have taken up themselves the management of the FAD programme. In the next issue we hope to publish an article by K. Holland and F. Marsac on the behaviour of fish related to FADs.

The second section will will be dedicated to the technical side of FADs, including FAD design and construction, and fishing techniques.

We begin this section with an article by Peter Cusack, SPC's Fisheries Development Adviser, who presents the two FAD systems recommended in the handbook: 'Rigging deep-water FAD moorings' (in press). Knowing how critical design and construction are for the success of a FAD programme, we hope that the comparison of the different designs will offer enough information and provoke sufficient debate to create the 'perfect FAD' ('the one that cost almost nothing and last forever'). In the next issue we will present the FAD designs used in French Polynesia and La Réunion.

F. Leproux and G. Moarii discuss on page... the latest developments of the ancestral 'dropstone' fishing technique that is commonly used around FADs by artisanal fishermen of French Polynesia.

The last section will be reserved for abstracts and reviews. For this first issue I have tried to present a wide spectrum of subjects related to FADs in order to allow you to evaluate the richness of the subject.

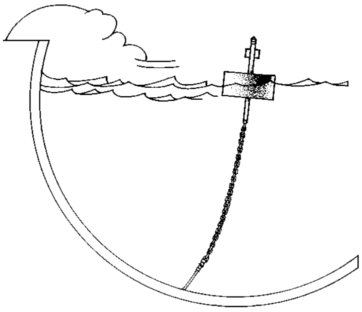
However, as a newsletter, the bulletin should stay informal and informative, and this initial plan is expected to be 'shaken-up'. It is a co-operative venture: you are encouraged (and as the actual co-ordinator, I should probably say: begged, beseeched, compelled or obliged, whatever works) to share what you are doing with all of us, and thereby become part of the wider network of FAD people. Any and all contributions are welcome, whether they be news, reports of recent progress, formal announcements, recent publications, reviews or abstracts.

As an information service, we also hope to include in each issue a regular listing of recent publications. We will start in the next issue with the list of publications related to FADs that are held by the SPC library. If you have published recently, please let us know.We hope to publish reviews of the most relevant literature, to help make it more accessible.

I would like to emphasise one point for the would-be contributors: SPC has an excellent translation section, and this bulletin will be published in English and in French. Thus, this publication provides a unique (and free!) opportunity to reach new readers and increase your sphere of influence . . .

I will end this editorial by saying that articles for all other SIG Bulletins are prepared for publication by an editor external to the SPC. I am convinced that there must be someone with hidden editorial talents amongst you. Although being a little time-consuming, the editor's role gives the opportunity to be directly in contact with fisheries workers and scientists from all over the world. If you are interested, don't hesitate to contact us for more information.

Aymeric Desurmont



NEWS and VIEWS

FAD deployments around Reunion Island: background, development and influence on catches and activity in the coastal fishery

by François Conand[1] and Emmanuel Tessier[2]

FADs have been used in the waters of Reunion Island since 1988 (Biais & Taquet, 1991). Mauritius was the location for the first FADs to be deployed in the South-West Indian Ocean, in 1985 (Roullot & Venkatasami, 1987), as part of a UNDP-funded project; their success prompted the Reunion Island fisheries authorities to set a series of FADs around the island.

Various factors make FADs particularly beneficial for the Reunion fishery. The island is a young volcanic structure with a very steep undersea slope, where only limited areas are accessible for bottom fishing. Significant depths are encountered a short distance out to sea, and, beyond a distance of five miles offshore, it is unusual to record depths under 1,000 metres.

It has been established, however, that FADs are more effective when they are moored in deep water (Prado, 1991). This topographical feature also places FADs within easy reach of fishermen, who do not need large boats and who can operate without high fuel costs.

Reunion Island is virtually circular, and, at the time of writing (October 1995), a total of 28 FADs were moored around its 200 kilometres of coastline (Figure 1). Most of these have been set to the west and north of the island, because very rough seas often occur to the east and south; and also because there are only a few places in these areas where landing is possible, and even these are often dangerous.

Table 1, which has been prepared from information provided by the Marine Apprenticeship School (EAM), shows the FADs deployed off Reunion Island since 1988. Two separate periods may be discerned. The first, from 1988 to 1991, was used to test and adapt the device designed by IFREMER and further developed by EAM, which had a suitable boat for setting FADs. The design and technology have been considered fairly satisfactory since 1992.

Management of the FADs was handed over to an association of professional fishermen known as APROPECHE, and subsequently to the Regional

Table 1: Number of FADs around Reunion Island and annual funding support

Year	No. of FADs deployed	No. on station as at 31 December	No. of FADs lost	Public funding support (FF)*
1988	11	9	2	?
1989	6	10	5	366,000
1990	9	14	6	276,000
1991	6	13	8	318,000
1992	16	23	6	318,000
1993	16	22	17	300,000
1994	11	26	5	300,000

* 1 FF ≈ US$0.20

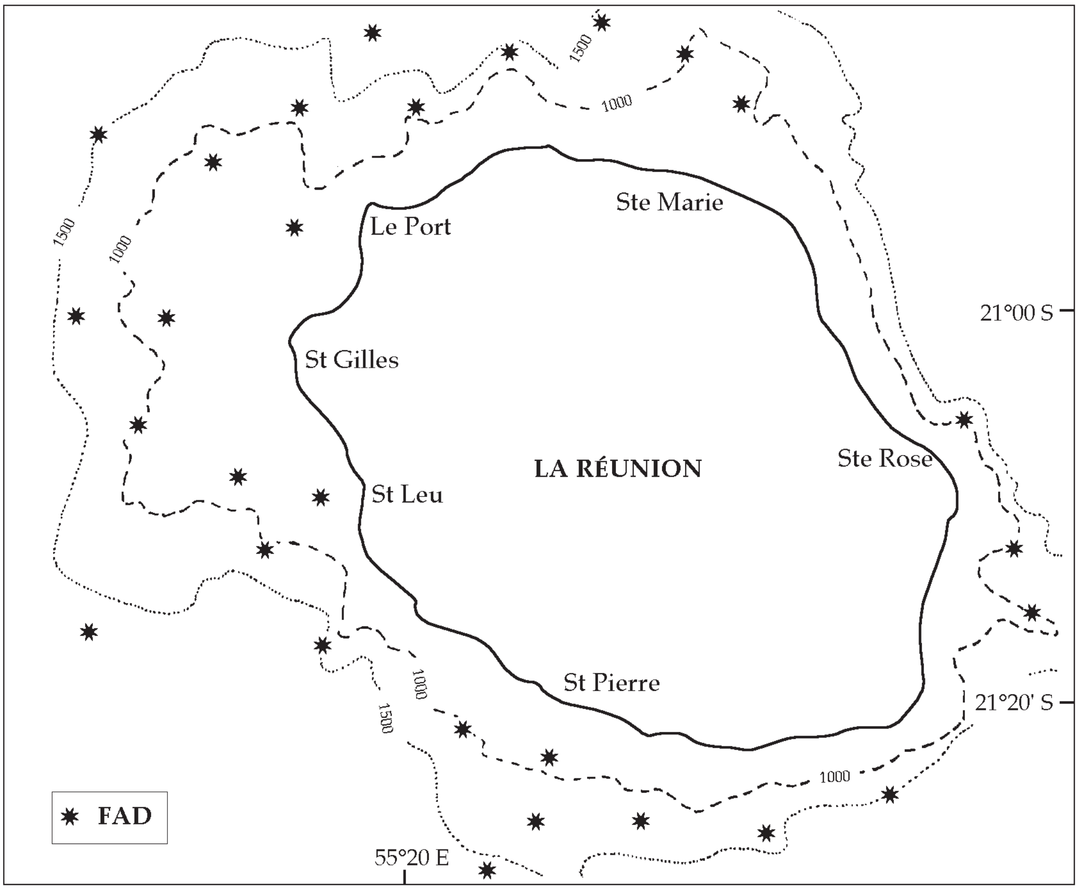


Figure 1: Reunion Island and locations of FADs in place on October 1995

Maritime Fisheries Committee (CRPM) when the latter took over from APROPECHE. This series of events is an illustration of the action of a research institute in introducing professional fishermen to a new technology, which they then adopted.

Reunion fishermen adapted to FADs very quickly and have developed increasingly efficient techniques, such as live-bait drift fishing, vertical longlining and a trolling technique involving constantly jerking the line. In 1994, the increasing popularity of FADs with professional and recreational fishermen resulted in regulations applying certain FAD access restrictions to recreational fishermen (see Appendix I).

The influence of FADs on catches is illustrated in Table 2. It is now evident that FADs playa determining role in the coastal artisanal fishery around Reunion Island. Catches of large pelagics have quadrupled in seven years and more and more fishermen are using the FADs.

The main species caught *are Thunnus albacares, Coryphaena hippurus, Katsuwonus pelamis* and *Acanthocybium solandri*, which are taken at the surface by drifting or by trolling, while *Thunnus alalunga* is caught using a drifting technique with the bait lowered to depths of between 60 and 200 metres (*T. albacares* is also often caught by the deep-drift method). Tagging and sonic tracking experiments on yellowfin tuna caught around FADs off Reunion Island (Marsac et al., 1995), demonstrated the close link between this fish and FADs, to and from which they migrate. Development of the pelagic fishery has brought about a reduction in fishing effort on demersal species (from 40,000 trips to less than 30,000 trips per year), a limited resource because of the bottom topography.

According to Tessier (1995), the fishery of Reunion Island, with its population of 600,000, accounts for 430 professionals, to whom should be added 700 informal-sector fisherfolk, while FAD activity is estimated at approximately 30,000 fishing trips per year. All fishing boats are motorised and approximately 700 skiffs, five to six metres in length, have been registered (Figure 2a), along with 200 larger boats with cabins, six to ten metres long. The larger category, which in 1988 consisted of sport-fishing cruisers, has been replaced by boats which are more suitable for

Table 2: **Influence of FADs on catches of large pelagics**

Year	Average no. of FADs on station	Total catches of large pelagics by the coastal fishery (t)	Estimate of percentage of catches made around FADs
1986	0.0	161	0
1987	0.0	159	0
1988	3.2	223	28
1989	7.5	167	50
1990	11.9	371	70
1991	11.2	382	75
1992	16.0	495	80
1993	19.9	574	85
1994	25.7	635	85

FAD fishing because they are more robust and cost less in maintenance (Figure 2b). Fish caught around FADs are purchased from fishermen at an average price of 25 FF (= US$ 5.00) per kg, which is low in comparison with bottom fish (60 FF per kg or = US$ 12.00). However, average yields from FAD fishing (75 kg per trip for the larger boats and 50 kg per trip for the smaller ones) are more financially rewarding than those recorded with bottom fishing (10 to 15 kg per trip). It may also be noted that public funding support for the deployment and maintenance of FADs has remained fairly constant (Table 1).

(a)

(b)

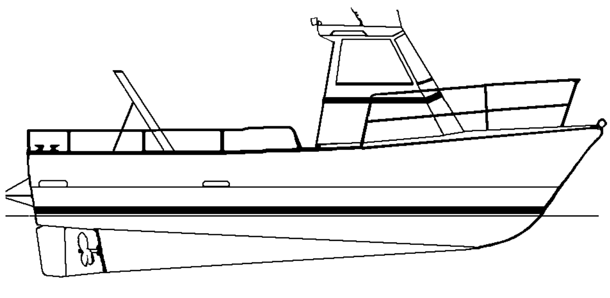


Figure 2: **Typical Reunion Island artisanal fishing boats**
(a) 'loup de mer' (sea-wolf), a 5.5 m skiff
(b) Professional fishing boat, 6.75 m in length

References

BIAIS, G. & M. TAQUET. (1991). La pêche locale réunionnaise. Rap. Int. DRV / RH, IFREMER, La Réunion. 68p.

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ROULLOT, J. & A. VENKATASAMI. (1986). Dispositifs de concentration des poissons (DCP), l'experience Mauricienne. In: Collective Volume of Working Documents Presented at the Expert Consultation on the Stock Assessment of Tunas in the Indian Ocean, Colombo, Sri Lanka, 4-8 December 1986. Doc. no. TWS/86/26. FAO/IPTP, Colombo, Sri Lanka. 226-238.

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Appendix I

The following extract comes from local legislation set up in 1995 (Arrete no. 10-167 du 11 Juillet 1995) in order to try to minimise conflicts between FAD users.

Nothing is said on the way these rules are enforced. As one can see, FADs bring all types of sources of conflict, mostly between professional and pleasure craft but also between professionals themselves.

In Reunion Island, FADs are, de facto, forbidden to industrial fishing boats by a law that obliges them to operate at least 15 miles from the coast.

. . . Fishing in a radius of half a nautical mile around the FADs is regulated in the following manner:

- It is forbidden to tie to the FAD.
- It is forbidden for professional fishermen to set up more than two longlines per boat in the area.
- It is forbidden for professional fishermen to set up longlines in the area when they have paying customers on-board.
- Longlining and drifting with live bait are forbidden to all pleasure craft in the area.
- Fishing from a pleasure craft is forbidden when a minimum of two professional fishing boats are fishing in the area (except on weekends and statutory holidays). Exceptional authorisations may be given for fishing tournaments by the local Director of Maritime Affairs.
- Dive-fishing is forbidden. Occasionally, authorisations for scientific purposes may be given by the local Director of Maritime Affairs.

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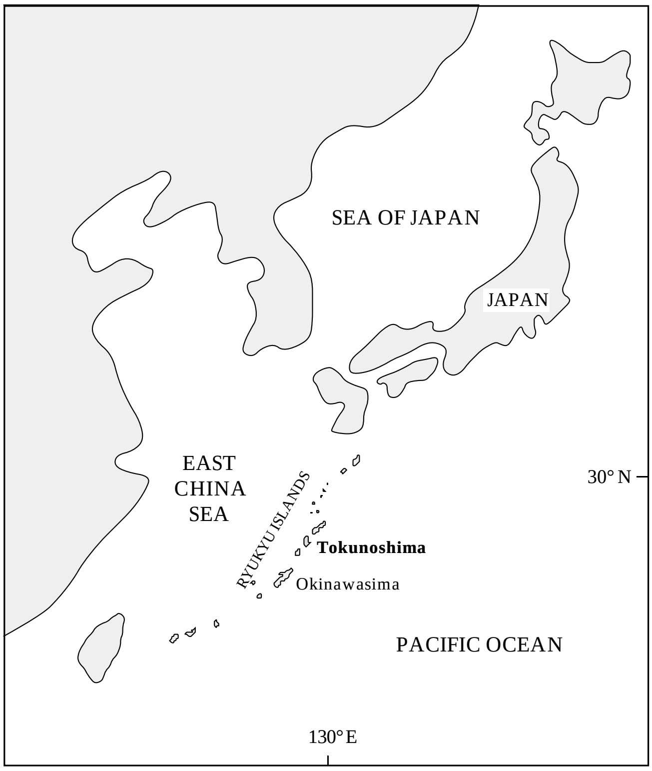
The FAD project of Tokunoshima Fishery Cooperative (TFC)

by Kenichi Kikutani, Taeko Toyoshima and Ichiro Tokuda

The FAD fishery within the Tokunoshima fishery cooperative

The Tokunoshima Fishery Cooperative (TFC) is a small fishery cooperative located in the southern and sub-tropical area of Japan (Figure 1). In 1995 TFC had 144 members (44 regular members and 110 associate members). TFC's fish landing income ranges from US$ 1.5 million to US$ 2 million a year.



Many fishery cooperatives in the Ryukyu Islands introduced FADs (called 'Ukigyoshyo' in Japanese) in the 1980s. In 1987, three FADs were introduced for trial at TFC. During the same year, fish caught around these FADs generated a total income of 13,569,552 yen (Table 1). This accounted for 8 per cent of the total income from fish landed and was considered a good result. Since then, TFC has set a FAD programme.

As of June 1995, ten FADs are moored on the eastern side of Tokunoshima Island

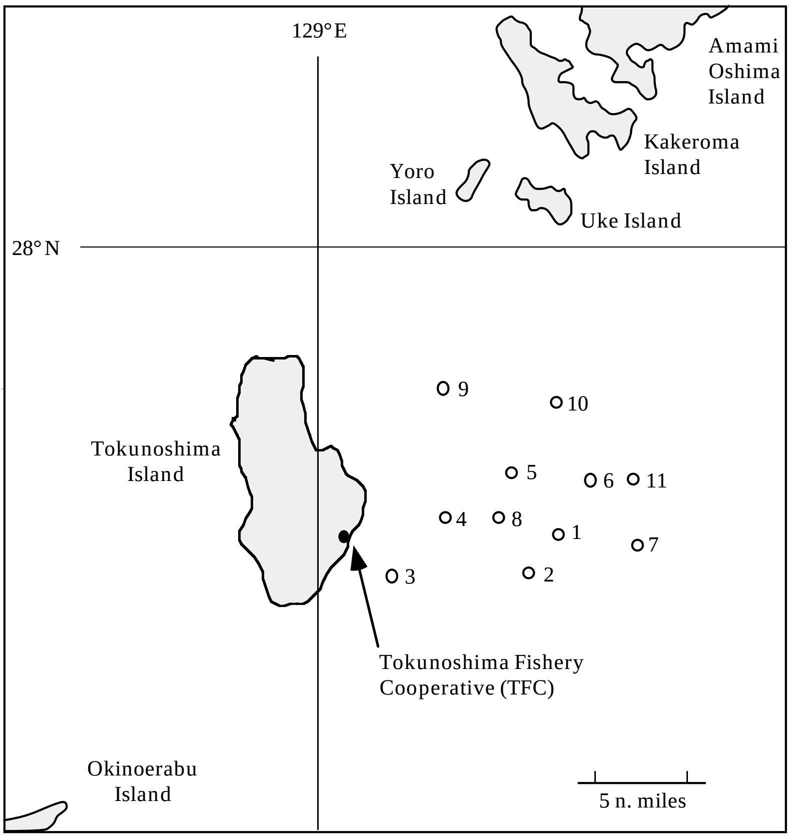


Figure 2: Location of FADs

Table 1: Details about TFC fish landings

Fiscal year	Total landings (t)	Total landings in value (yen)	Landings from FADs (t)	Landings from FADs in value (yen)	Landings from FADs as % of value	Total landings of pelagic species (t)				
						Wahoo	Small tuna & skipja.	Bigeye & yel.-fin	Mahi mahi	Blue marlin
1979[(1)]	118.2	137,864,621				10.9			3.3	
1980	120.5	152,574,824				15.8			2.5	
1981	100.0	126,513,242				18.6			3.0	
1982	102.6	139,747,330								
1983	106.7	141,211,847				12.4	2.5		6.2	
1984	81.8	113,671,025				2.0	1.9		1.3	
1985	123.3	155,110,705								
1986	149.1	169,983,141								
1987[(2)]	146.0	172,985,445	25.6	13,569,552	7.8 %	18.2	18.2		10.3	1.8
1988	154.2	182,694,252	39.4	26,633,783	14.6 %	15.6	27.4	3.8	14.0	1.5
1989	172.6	211,787,001	52.3	35,299,602	16.7 %	15.5	33.9	12.8	10.2	9.2
1990	209.9	249,187,032	57.9	47,899,876	19.2 %	23.5	28.2	20.8	28.3	6.1
1991	166.0	201,846,481	47.8	36,323,014	18.0 %	21.6	11.1	21.3	22.8	7.2
1992	251.5	260,988,770	50.9	31,474,895	12.1 %	32.7	12.8	79.0	22.7	3.9
1993	195.9	204,657,042	35.3	27,029,094	13.2 %	16.0	19.3	56.9		
1994	179.4	185,619,738	34.5	28,887,533	15.6 %	20.0	14.1	26.6		

(1) Establishment of TFC's fishmarket
(2) Introduction of FADs

(Figure 2 and Table 2). The total amount of fish landed from these FADs during the fiscal year 1994 (1 April 1993 to 31 March 1994) was 28,887,533 yen, accounting for 15.6 per cent of the total annual income generated by fish landed (Table 1).

Table 2: Location of FADs as of June 1995

FAD no.	Latitude (N)	Longitude (E)	Depth (m)
1	27° 42' 87	129° 15' 69	
2	27° 38' 46	129° 12' 52	
3 [(1)]	27° 40' 80	129° 04' 85	
4	27° 42' 06	129° 08' 00	
5	27° 46' 21	129° 11' 41	
6	27° 44' 44	129° 16' 03	
7	27° 42' 01	129° 21' 16	1100
8	27° 43' 26	129° 10' 75	750
9	27° 49' 07	129° 07' 56	
10	27° 47' 90	129° 15' 64	800
11	27° 45' 33	129° 18' 53	

[(1)] lost

The main species fished from FADs are wahoo (*Acanthocybium solandri*), *skipjack (Katsuwonus pelamis*), yellowfin tuna (*Thunnus albacares*), bigeye tuna (*Thunnus obesus*), mahi mahi (*Coryphaena hippurus*) and blue marlin (*Makaira mazara*).

Large (more than 20 kg) and high-quality tuna are sent to Kagoshima Central Market for auction. Smaller tuna and other species are sold at TFC's fish market. At present, the FAD fishery is vital to TFC fishermen.

Management of the FAD fishery by TFC

Two sources of funding are used by TFC to run their FAD programme:

- An income of 1,140,000 yen generated by licence fees (Table 3), used mostly to maintain FADs on station and incidentally to help purchase new ones; and

- A 3,000,000 yen subsidy from the Tokunoshima City, used to buy new FADs.

Table 3: Income generated by licence fees (1994)

	No. of members	Licence fee (yen)	Income (yen)
Regularmembers	52	20,000	1,040,000
Newmembers	2	50,000	100,000
Total (yen)			**1,140,000**

TFC fishermen can only fish from FADs if they pay a fishing licence fee. This fee costs 20,000 Yen (~ US$ 200.00) per year for regular members and 50,000 yen (~US$ 500.00) per year for fishermen entering the fishery for the first time.

Two specimens of a sticker (Fig. 3) are given to each boat-owner after payment of his licence fee. He must affix them on each side of his boat where they can easily be seen from other boats. The price of the licence is decided by the directors of TFC at a meeting held at the end of every fiscal year. The fees are calculated to cover the FADs' maintenance costs.

Figure 3: Sticker used for the FAD fishing license

Table 4 shows details of the cost of maintenance for the FAD fishery in 1994. Table 5 gives a summary of the TFC's budget for its 1994 FAD programme.

Table 4: FADs maintenance costs (1994)

Details	Expenditure (yen)
Alkaline batteries	100,320
Batteries' replacement work	412,000
FAD reinforcement	30,000
Radar reflecting boards	13,500
Beacon lights	50,000
Licence stickers (1)	72,000
Total	**677,820**

(1) 2 stickers x 60 boats x 600 yen

Table 5: TFC's FAD budget (1994)

Income (yen)	
Subsidies from Tokunoshima Town	3,000,000
Licence fees	1,140,000
Total	**4,140,000**
Expenditure (yen)	
Purchase of 4 new FADs	3,090,000
FAD deployments	120,000
FAD maintenance	677,820
Total	**3,887,820**

To run the FAD programme on a permanent basis, TFC has to organise the following:

1. *Deployment of new FADs and replacement of missing ones*

TFC decides on any expenditure concerning FADs. Decisions about the number of FADs to be set and their location are taken by all members of TFC. Construction and deployment of new FADs are carried out by the fishermen on a voluntary basis.

2. *Maintenance of FADs*

Decisions about the normal maintenance of the FADs are taken by the fishermen themselves, without necessarily referring them to TFC. When important actions must be undertaken (such as changing the top part of the mooring), fishermen warn TFC. However, the work is still carried out by the fishermen themselves.

3. *Clear definition of FAD ownership and fishing rights*

It is important to clearly identify each FAD, because TFC fishermen exclude other cooperatives' fishing boats, as well as leisure boats, from fishing around their FADs. Any boat that is not carrying the stickers is chased away from the FAD fishing grounds by the TFC fishermen themselves.

Future directions

TFC and their fishermen aim to:

- Purchase FADs with TFC's own funds;
- Introduce stronger and more economical FADs to expand their life expectancy and thus reduce their cost; and
- Keep encouraging multi-fisheries for regular income purposes, including the FAD fishery (many fishermen already combine FAD fishing with bottom fishing).

It is also interesting to note that some fishermen talk about deploying their own private FAD. . .

Latest news on TFC's FAD fishery (1995)

Fishing boats (approximately 5 tons) with large fish holds have landed 650 kg of fish on average per two-day trip. Smaller boats (1-3 tons) have landed 140-150 kg of fish per one-day trip. Good catches of big eye tuna (10-30 kg) and yellowfin tuna (over 30 kg) were recorded around FAD No.8 in July and August.

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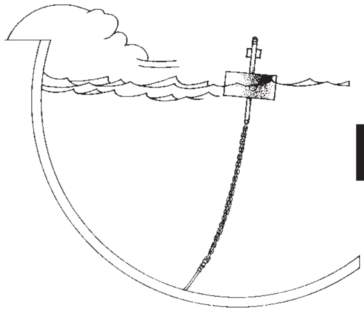
1. Tokunoshima Fishery Cooperative, Kametu Tokuno, shima-cho, Oshima-gun, Kagoshima, Japan



HANDS-ON FADs

Two FAD systems recommended by SPC

by Peter Cusack

Introduction

In the region served by the South Pacific Commission the use of fish aggregating devices, or FADs, is widespread. Twenty of the Commission's twenty-two member countries and territories, are known to have made use of these devices at one time or another, and the majority maintain ongoing FAD programmes.

Since the introduction of FADs into the Pacific from the Philippines in the late 1970s, regional FAD experience has passed through several distinct phases. Between 1979 and 1983, FAD effort centered on modifying the traditional Filipino payao system to withstand the harsher, deeper-water, high-energy ocean environments typical of the Pacific. The second period, from 1984 through 1990, saw the introduction and widespread adoption of the inverse catenary curve mooring system*. Since that time development efforts have focused on refinement of the inverse catenary curve mooring, the development of strict material specification, improvement of buoy technology, and establishment of sound procedures for FAD-site surveys and deployments. The SPC has maintained an active FAD research and development programme since the early 1980s.

In early 1996, SPC will publish the first two volumes of its *Fish Aggregating Device (FAD) manual*. *Volume I, Planning FAD programmes* is designed to help fisheries managers decide whether FADs are likely to be worthwhile investments in particular fisheries, while *Volume II, Rigging deep-water FAD moorings*, provides a practical guide to rigging two mooring systems field-tested and recommended by SPC: the SPC steel spar buoy FAD and the SPC Indian Ocean FAD. These FAD systems are considered suitable for the majority of deep-water deployments in the region and both make use of the inverse catenary curve mooring, differing only in the raft, or floating surface part, and the uppermost part of the subsurface mooring. Each system has advantages of cost or ease of construction in particular circumstances.

Volume II is presented in sections, describing in turn: FAD rafts, FAD mooring components, ropes, mooring calculations and anchors. Detailed specification of materials and components are given, as well as descriptions of the way in which materials are used to rig both systems. Numerous drawings and tables are included which clarify each step of raft construction and rigging of moorings.

The two raft designs, and the associated variations in the standard catenary curve mooring, have been widely deployed in the Pacific Islands. The systems are not the cheapest that can be deployed, but when rigged properly (and barring vandalism, fish bite and severe cyclonic storms) are considered likely to provide two years or more of service.

An overview of both FAD system designs is given here. It is important to note that the successful use of these designs is dependent on the strict use of the materials recommended and, in the case of deployments in less than 1100 metres, the use of supplementary buoyancy in the way described in the *SPC FAD manual*.

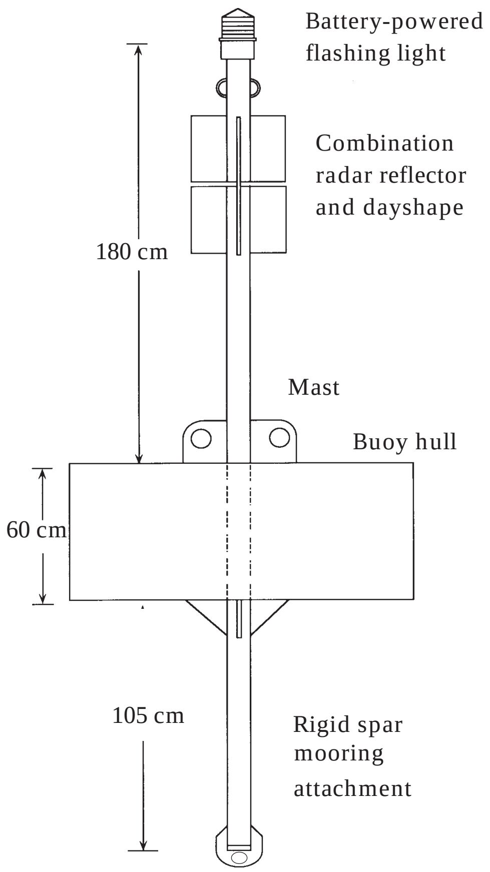
Readers interested in receiving a copy of Volumes I and II of the SPC FAD manual are invited to contact: Peter Cusack, Fisheries Development Adviser, South Pacific Commission, BP D5, Noumea, New Caledonia.

*The essential feature of the inverse catenary curve mooring is the use of sinking rope in the upper part of the mooring combined with floating rope in the lower part to form a reserve of rope that is held at a specified depth below the surface. This provides scope, or slack, in the mooring to cope with the stresses of currents and wave action. The floating rope in the lower mooring also serves to buoy up the bottom chain and hardware and so ensure that the rope does not contact the sea floor and so come in danger of abrasion. The SPC-recommended mooring system uses the following proportions:

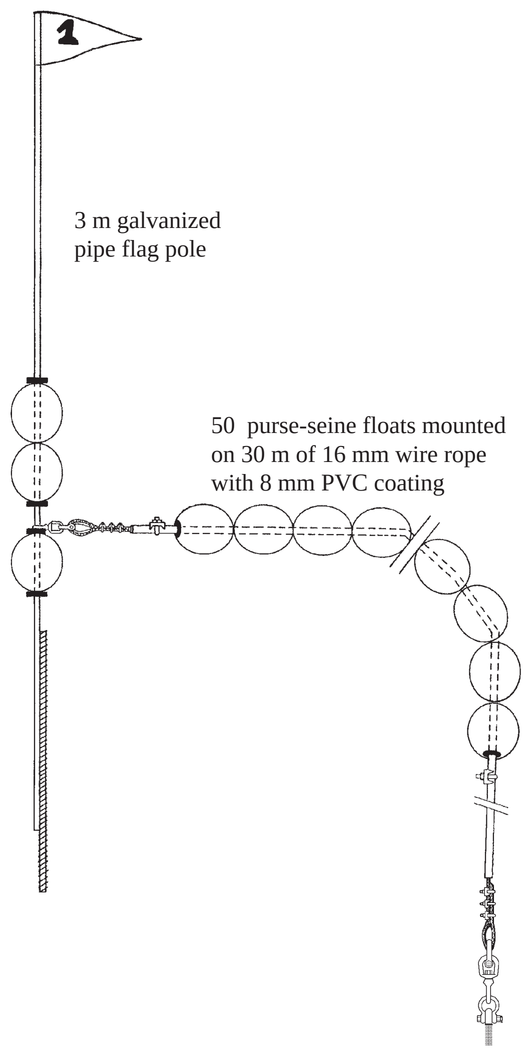
- Length of slack line (scope): 25 % of depth (of which 3/4 is nylon rope and 1/4 polypro. rope)
- Length of nylon rope: 150 m + 3/4 of scope
- Length of polypro. rope: depth – 150 m + 1/4 of scope

Some construction details for the flotation devices

Steel spar buoy

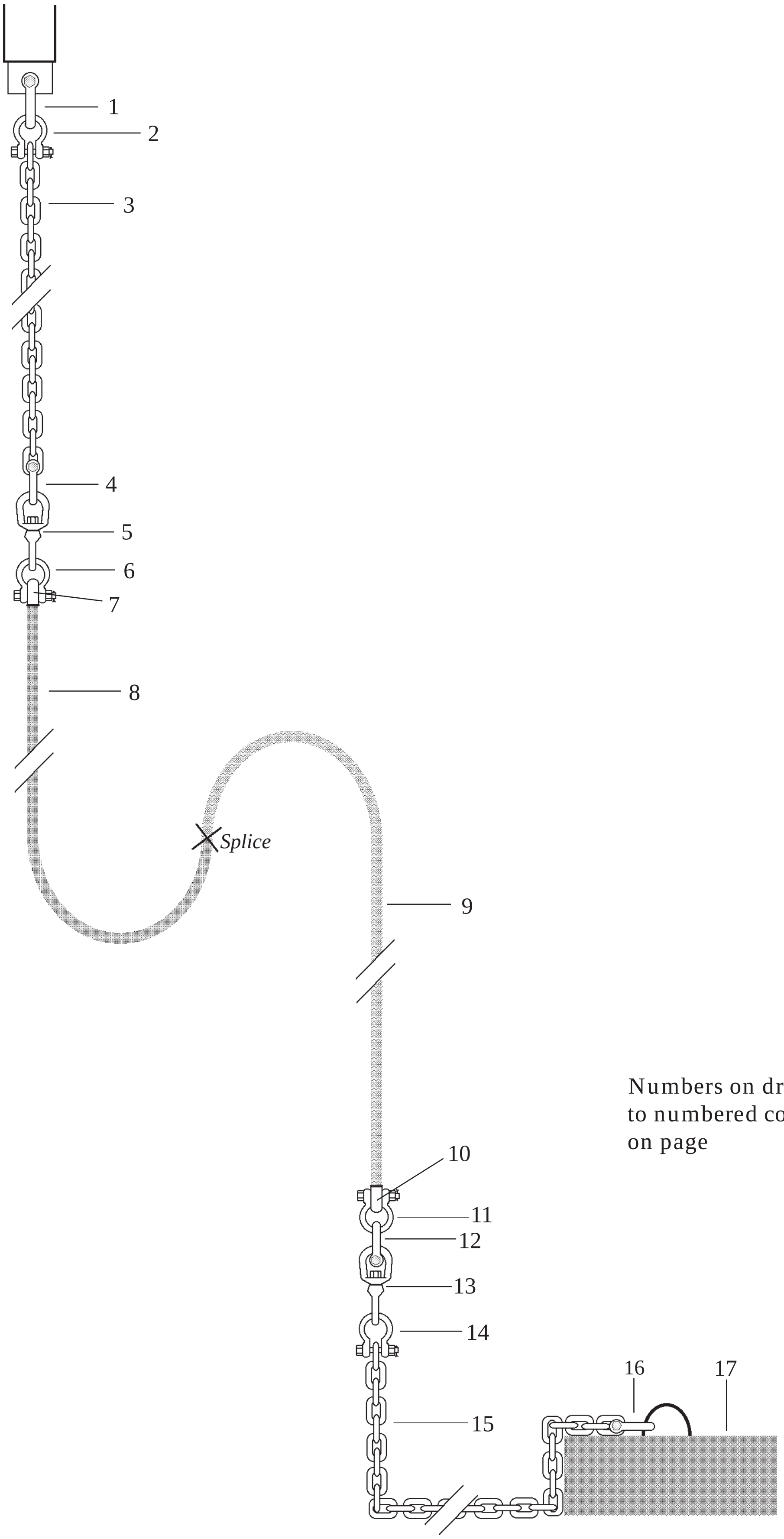


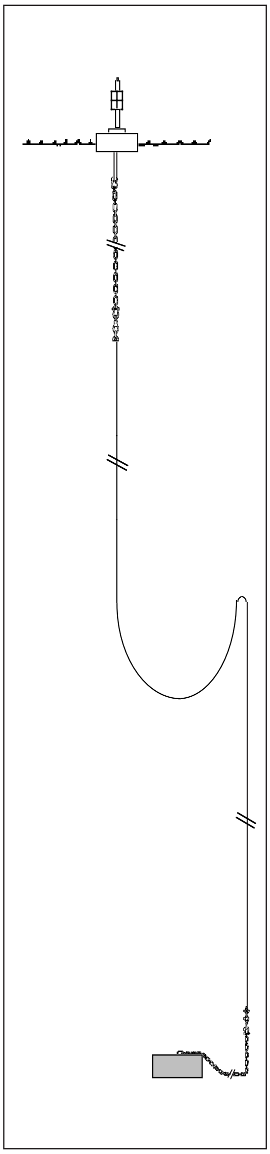
Indian Ocean FAD flotation device



Notes:
- Both flotation devices have a minimum reserve buoyancy of 300 litres.
- The handbook recommends the use of plastic strapping attached to the top part of the mooring as appendages (‘attractors’). It is interesting to note that the effectiveness of these appendages seem to vary with the locations of FADs: French Polynesia, American Samoa and Cook Islands don’t use them, while Vanuatu and Fiji think they are absolutely necessary . . .

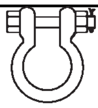
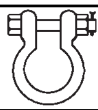
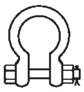
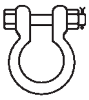
Steel spar buoy FAD system mooring arrangement



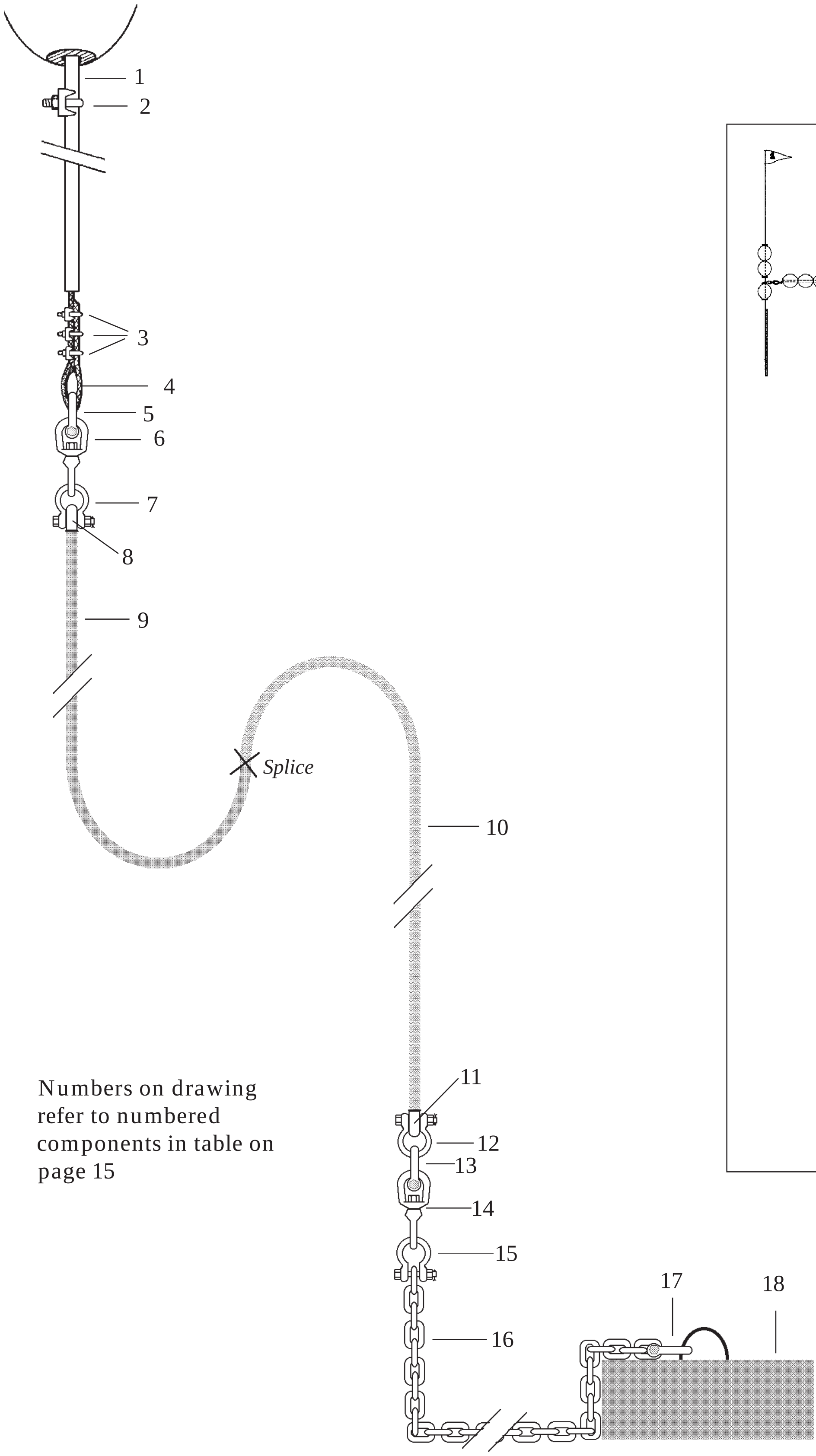


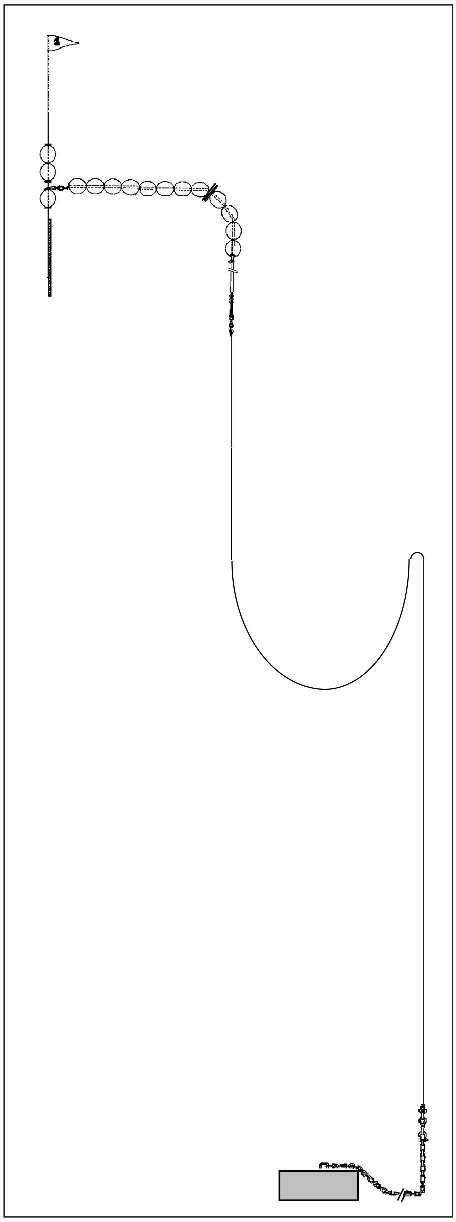
Numbers on drawing refer to numbered components on page

Steel spar buoy system components

Components		Description	Size	Material	Minimum breaking strength
1		Safety shackle with stainless steel (SS) cotter pin	25 mm 1 in	Hot-dip galvanised low-carbon steel (Hdg-lcs)	25,000 kg 56,000 lb
2		Safety shackle with SS cotter pin	16 mm 5/8 in	Hdg-lcs	10,000 kg 22,000 lb
3		Long-link chain	15 m of 13 mm 50 ft of 1/2 in	Hdg-lcs	9,000 kg 19,000 lb
4		Safety shackle with SS cotter pin	16 mm 5/8 in	Hdg-lcs	10,000 kg 22,000 lb
5		Forged swivel (eye and eye)	22 mm 7/8 in	Hdg-lcs	22,700 kg 50,000 lb
6		Safety shackle with SS cotter pin	22 mm 7/8 in	Hdg-lcs	19,500 kg 49,000 lb
7		Rope connector (*Samson*; size 3)	19 mm 3/4 in	Nylite	
8		Sinking rope, 8–12 strand, plaited	19 mm 3/4 in 47 kg/220 m 14.3 lb/100 ft	Nylon	6,400 kg 14,200 lb
9		Buoyant rope, 8–12 strand, plaited	22 mm 7/8 in 45 kg/220 m 13.7 lb/100 ft	Polypropylene	5,200 kg 11,500 lb
10		Rope connector (*Samson*; size 4)	22 mm 7/8 in	*Nylite*	
11		Safety shackle with SS cotter pin	25 mm 1 in	Hdg-lcs	25,000 kg 56,000 lb
12		Safety shackle with SS cotter pin	19 mm 3/4 in	Hdg-lcs	14,000 kg 31,000 lb
13		Forged swivel (eye and eye)	19 mm 3/4 in	Hdg-lcs	16,200 kg 40,000 lb
14		Safety shackle with SS cotter pin	19 mm 3/4 in	Hdg-lcs	14,000 kg 31,000 lb
15		Long-link chain	15 m of 19 mm 45 ft of 3/4 in	Hdg-lcs	14,000 kg 31,000 lb
16		Safety shackle with SS cotter pin	22 mm 7/8 in	Hdg-lcs	19,500 kg 49,000 lb
17		Anchor	900 kg 2000 lb	Concrete block	Compress. strength 3,000 psi

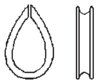
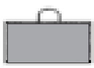
Indian Ocean FAD system mooring arrangement





Numbers on drawing refer to numbered components in table on page 15

Indian Ocean FAD system components

Component		Description	Size	Material	Minimum breaking strength
1		Float cable	30 m of 32 mm 100 ft of 1 1/4 in	Steel wire rope with PVC coating	5,000 kg 11,000 lb
2		Cable clamp	32 mm 1 1/4 in	Hot-dip galvanised low-carbon steel (Hdg-lcs)	
3		Cable clamp (6 pieces)	16 mm 5/8 in	Hdg-lcs	
4		Thimble (2 pieces)	16 mm 5/8 in	Hdg-lcs	
5		Safety shackle with SS cotter pin	19 mm 3/4 in	Hdg-lcs	14,000 kg 31,000 lb
6		Forged swivel (eye and eye)	19 mm 3/4 in	Hdg-lcs	16,200 kg 40,000 lb
7		Safety shackle with SS cotter pin	19 mm 3/4 in	Hdg-lcs	14,000 kg 31,000 lb
8		Rope connector (*Samson*: size 3)	19 mm 3/4 in	*Nylite*	
9		Sinking rope, 8–12 strand, plaited	19 mm 3/4 in 47 kg/220 m 14.3 lb/100 ft	Nylon	6,400 kg 14,200 lb
10		Buoyant rope, 8–12 strand, plaited	22 mm 7/8 in 45 kg/220 m 13.7 lb/100 ft	Polypropylene	5,200 kg 11,500 lb
11		Rope connector (*Samson*: size 4)	22 mm 7/8 in	*Nylite*	
12		Safety shackle with SS cotter pin	25 mm 1 in	Hdg-lcs	25,000 kg 56,000 lb
13		Safety shackle with SS cotter pin	19 mm 3/4 in	Hdg-lcs	14,000 kg 31,000 lb
14		Forged swivel (eye and eye)	19 mm 3/4 in	Hdg-lcs	16,200 kg 40,000 lb
15		Safety shackle with SS cotter pin	19 mm 3/4 in	Hdg-lcs	14,000 kg 31,000 lb
16		Long-link chain	15 m of 19 mm 45 ft of 3/4 in	Hdg-lcs	14,000 kg 31,000 lb
17		Safety shackle with SS cotter pin	22 mm 7/8 in	Hdg-lcs	19,500 kg 49,000 lb
18		Anchor	900 kg 2,000 lb	Concrete block	Compressive strength 3,000 psi

The drop-stone technique used by artisanal fishermen in French Polynesia

by G. Moarii and F. Leproux

Introduction

In French Polynesia, the main technique used around FADs by small artisanal boats (poti-marara) is a modem version of the ancestral drop-stone technique. Fishermen used this technique around 'tuna-holes', keeping the fishing line in hand and waiting for the strike. Nowadays, the line is attached to a buoy and left to drift, so one fisherman can operate several lines simultaneously.

The main purpose of this technique is to bring the baited hook deep down where the big fish are supposed to be.

Materials used (Figure 1)

Float:

One longline float (0 200 mm), pressure-resistant, with a longline clip (120 mm length) attached to it by a short loop of nylon rope;

Mainline:

A reel of 400 m of nylon monofilament (250 lb) marked every 10 fathoms (= 18 m) with twine of different colours to be able to estimate the fishing depth of the baited hook;

Swivel:

A leaded swivel (same type as the ones used by the horizontal tuna longline fishermen) placed at approximately six metres from the hook; if the current is strong, leads (0.2 to 0.5 kg) may be added between the mainline and the swivel;

Snood:

6 metres of nylon monofilament (180 to 220 lb);

Hook:

Tuna circle hook (Mustad or equivalent) of a minimum size of 16/0;

Bait:

With the development of the tuna longline fishery, imported bait (Japanese mackerel, herrings from the Baltic, etc.) is now available and is commonly used by artisanal fishermen around Tahiti. Several types of local baits may also be used, depending onavaibility: 'operu' (*Decapterus macarellus*); 'ature' (*Selar crumenophtalmus*); 'numa' (*Mulloidichthys samoensis*); 'marara' (*Cypselurus simus*); and skipjack fillet (*Katsuwonus pelamis*).

Method

The bait is fixed to the hook (Figure 2) and attached, together with some pieces of skipjack, to the stone (Figure 3).

Several methods may be used to fix the bait to the hook and attach it to the stone. The methods described in Figures 2 and 3 are the most commonly used. The choice of the stone is essential. It must have a roundish shape, no sharp edges and be a little bigger than the baitfish. River stones are the best.

When everything is ready, the boat is placed upcurrent from the FAD. The fisherman wants his fishing line to drift in the vicinity of the FAD but not too close as it could' catch' the FAD (this fishing technique has created a real problem. EVAAM estimates that 70 per cent of their FADs' premature losses are due to fishermen battling to recover their tangled fishing lines and thus severing the FAD's mooring line).

The stone with the bait attached is dropped and the line is carefully paid out, watching the length marks, until the desired depth is reached (80 to 200 m during the 'high season' [October to May], 200 to 300 m during the 'low season' [June to September]). A good jerk is then given to the line to release the knot that kept the bait, the chum and the stone together. The chum sinks slowly, with the current creating a 'smelling path' that will help the fish to find the bait. The stone sinks and is lost.

The remaining mainline is left on the spool. The fisherman makes a knot with a big loop to make sure the remaining line stays tightly coiled on the spool. The buoy is 'clipped' to the loop and left to drift. Two to five lines may be used simultaneously by one fishing boat. The buoys are then carefully monitored to watch for a strike. Since the lines are retrieved by hand, big fishes are left to fight the buoy before they are hauled aboard.

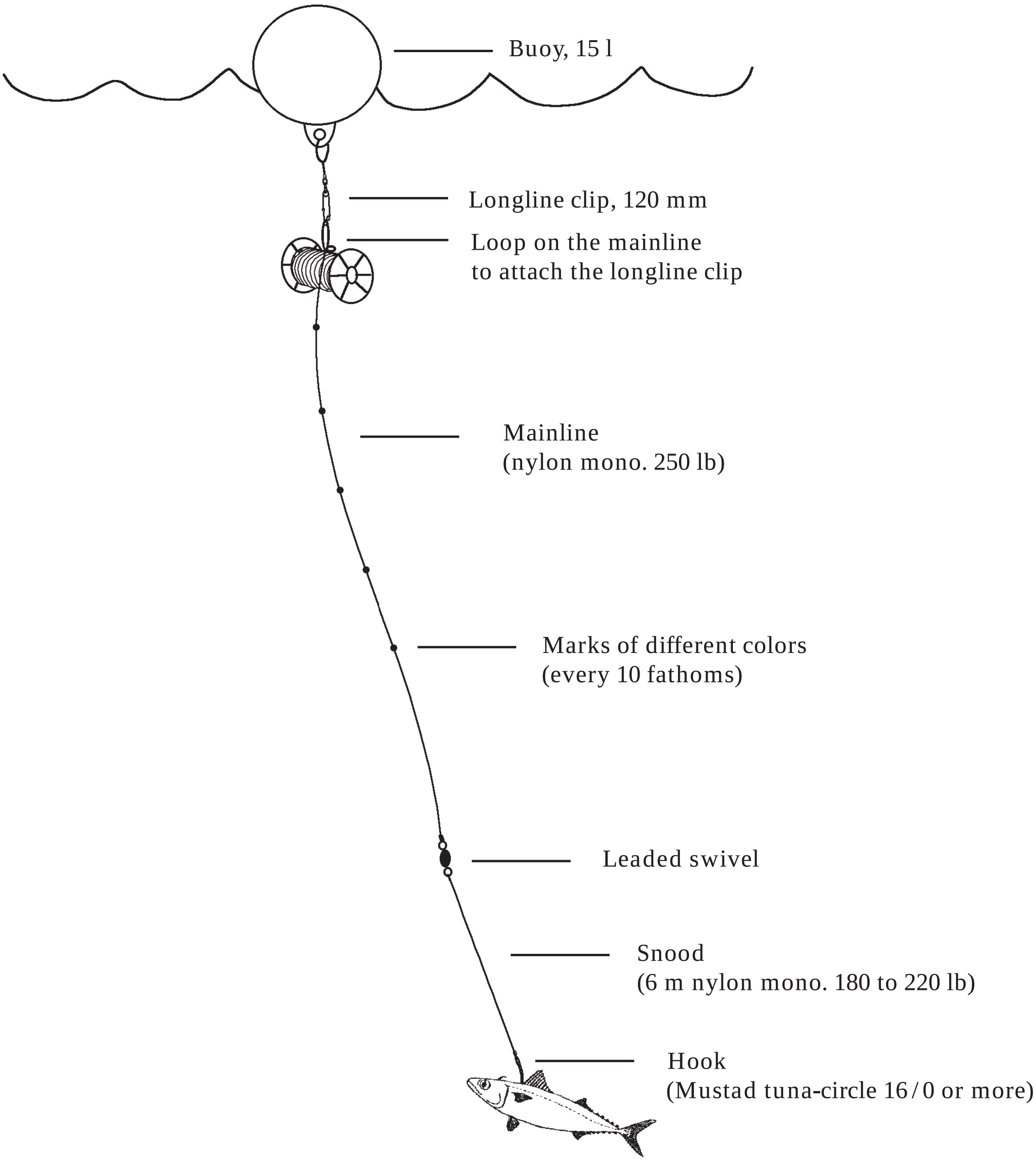


Figure 1: The fishing line

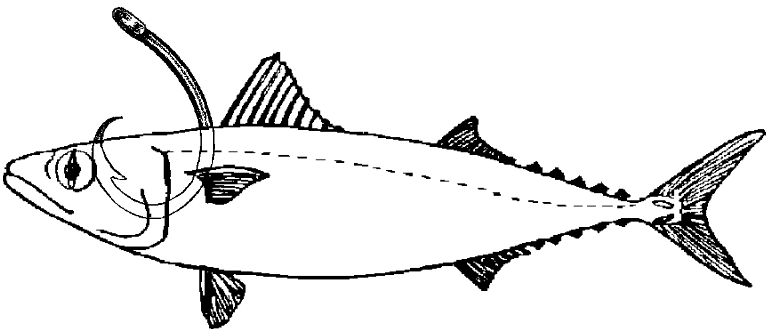
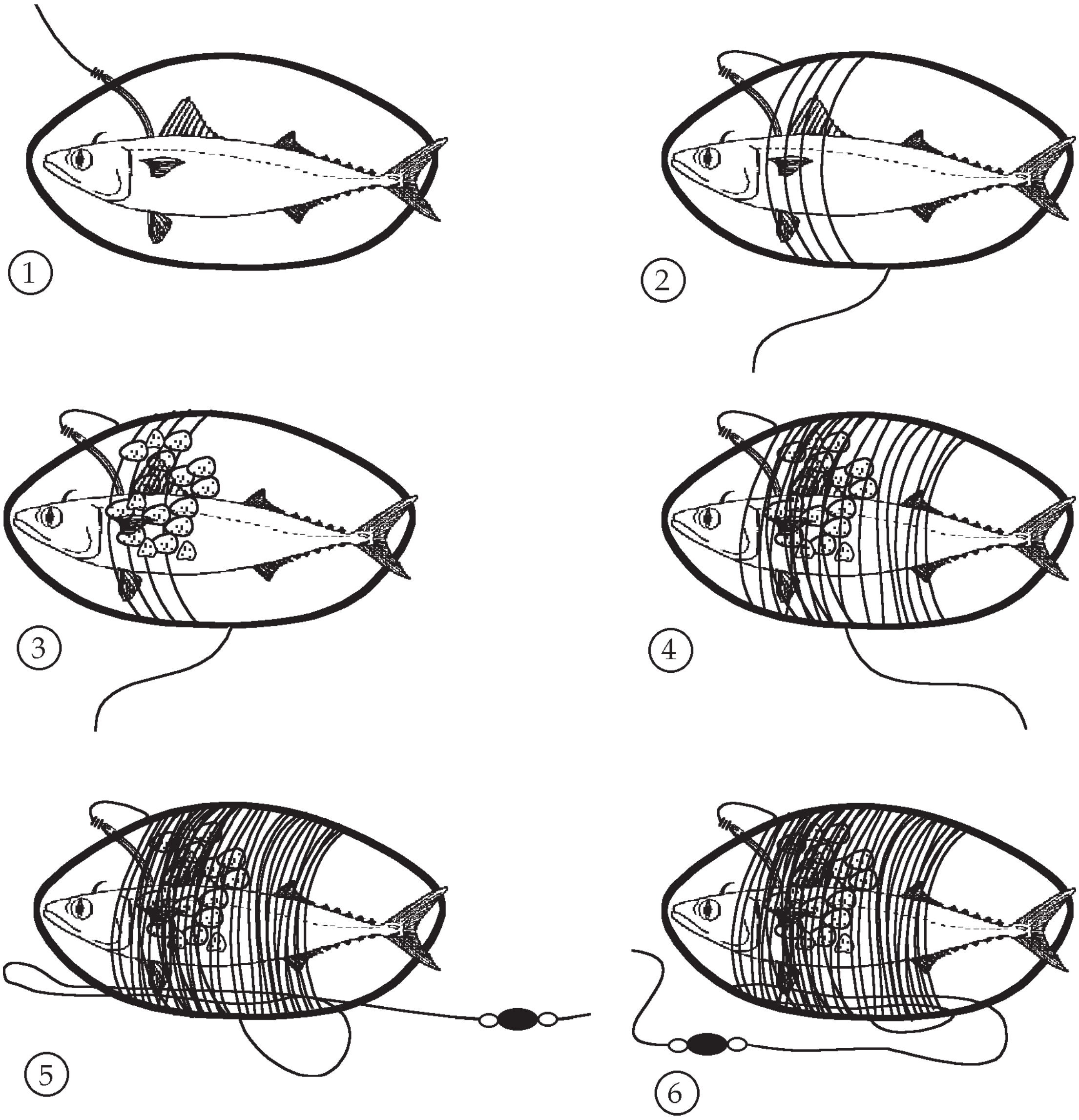


Figure 2: One way to rig the bait



1 Put the bait-fish on the stone lengthwise. Stone must be roundish and slightly bigger than the bait-fish.

2 Bring the nylon line to the middle of the stone, make 3 or 4 turns to join the bait-fish to the stone.

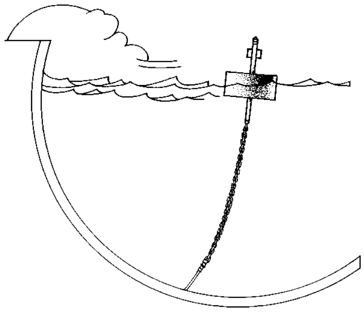
3 Sprinkle a few pieces of bait (skipjack, mackerel or any bait available).

4 Make many tight turns around the stone and add a few pieces of bait through the process. Leave about 40 cm of line between the stone and the swivel.

5 Make a loop and slide it between the stone and the wrapped line.

6 Bring the loop down to the side angle of the stone where the line is tightly wrapped against the stone. The stone is ready to be thrown in the water. When it will have reached the desired depth, a strong pull to the line will free the loop and release the stone and the baits.

Figure 3: Preparing the stone



READINGS

The assessment of the interaction between fish aggregating devices and artisanal fisheries

by Jim Anderson

In 1992 , Jim Anderson undertook an in-depth study, through the United Kingdom Overseas Development Administration (ODA) Fisheries Management Science Programme, on the interaction between FADs and artisanal fisheries. Most of his fieldwork was done in Fiji and Vanuatu. The following summary describes the different stages of his work.

Executive summary

The proposition that fish aggregating devices (FADs) can provide a means to improve fisheries undertaken by artisanal fishermen in tropical marine environments has a relatively long history. Practical programmes for FAD deployment have been undertaken in numerous places with varying degrees of success.

If further use of FADs is to be considered it is clearly desirable to synthesise the reasons for their success or failure and to offer guidelines that will ensure that FAD deployments, whether by government departments or fishermen-function for the purposes intended: to enhance catchability of fish and improve production and economic performance of fishermen (a development issue) and/or to divert fishing effort away from fish stocks that are in need of conservation (a management issue).

This research project was designed to address biological, social and economic characteristics of FAD projects for artisanal fishermen. Because of the limited budget, and therefore scope, for detailed experimental work involving FAD placements and monitoring, this research project was undertaken in collaboration with FAD deployment programmes of the South Pacific Commission (SPC).

At the start of the project a series of FADs were deployed in Vanuatu and a monitoring programme was established by the Marine Resources Assessment Group Limited (MRAG) to measure the biological, social and economic consequences.

It became clear relatively quickly that a number of factors thought to be critical for successful FAD programmes had not been accounted for in site selection and that the FADs did not successfully aggregate fish or fishermen.

Nevertheless, confirmation of the importance of such factors was vital to the production of guidelines, an output for which the research project was primarily designed.

A similar SPC FAD programme followed in Fiji, to which MRAG supplied the monitoring and assessment component. Although results were mixed there were sufficient comparative successes, particularly on information collection, to offer some scope for an analytical approach.

This research report on the assessment of the interaction between fish aggregating devices and artisanal fisheries consists of a document series as follows:

Document 1 -Synthesis of research and recommendations;

Document 2 -Vanuatu country report;

Document 3 -Fiji country report;

Document 4 -A handbook for FAD programmes;

Document 5 -A review of bioeconomic and sociological FAD modelling.

Document 1 provides a synthesis of all research undertaken, both background and field, the results obtained and the conclusions and recommendations revealed.

Part 1 offers a general introduction to FADs, the techniques and costs of their placement, and their importance to both industrial and artisanal fisheries of the South Pacific.

Part II describes the objectives of the research to identify biological, economic and social attributes of artisanal FADs and the ways these can be used to plan for the future.

Part III provides some conclusions on the aggregating effect, the placement of FADs and their contribution to sector performance and goes on to offer general recommendations for further research work.

The case studies (Documents 2 and 3) for Vanuatu and Fiji provide detailed descriptions of the work undertaken and site-specific results achieved.

A comparison of these reveals clearly that social, cultural and, to some extent, economic characteristics of fishing communities are likely to be more important to FAD success or failure than the extent of the biological effect.

As a result of background research and these field case studies the nature of the direct practical output could be identified. This feature of the project was always meant to be an output of a practical nature to assist in meeting the wider objectives, as stated in the project document: to improve the socio-economic conditions of marine artisanal fishermen.

Since MRAG and SPC had collaborated on information and the research programme it was believed appropriate to take the practical output-the handbook for FAD Programmes-to the stage of publication and dissemination through both the ODA and the SPC.

Document 4 (to be published as Vol. I of the SPC FAD manual) is the result of that collaboration. It provides a complete guide to the assessment of the potential success a FAD programme might enjoy in any area, including economic and financial appraisal. It is hoped that the handbook (and spreadsheets that are available to undertake the calculations) will provide a useful tool for governments, fishing companies and fishermen in their assessment of the value of FADs to their particular needs.

Lastly, Document 5 takes a broad look at bioeconomic and sociological modelling of FADs. It reviews all the available scientific literature and suggests avenues for further research, both theoretical and experimental.

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In Document 1, Synthesis of research and recommendations, Jim Anderson gives a good overview of tuna aggregation theories.

Tuna aggregation theories

Exactly what prompts the aggregation of fish around FADs is not understood with certainty. In general terms, the reasons for aggregation would seem to depend on the type of FAD in question.
Shallow-water FADs tend to attract smaller species of fish, such as scads (*Decapturus* spp. and *Selar* spp.) and appear to provide some increased security from predators, the basis of this protection being that resident schools become used to the presence of the mooring-line and aggregator. In the event of a predator (e.g. *Acanthocybium solandri, Sphyraena* spp.) attacking the school, refuge is sought close to the mooring line. The predator is not used to the mooring line and thus takes avoiding action, facilitating the escape of the smaller fish.

For FADs deployed in depths of up to 1200 metres and located anywhere from three to twenty nautical miles off the coast, there are currently a number of theories:

1. That aggregation is driven by the need for a forage base

This theory is often argued from an anthropocentric viewpoint: that the ocean is a featureless, homogenous environment, which is certainly not the case. Tunas and many other species migrate through a complex environment of varying solenoids, magnetic fields, currents and temperatures; many species migrate thousands of kilometres annually across entire oceans.

It is unlikely, therefore, that these animals do not have an equally complex and sophisticated navigation system that allows them to 'know' exactly where they are at all times. The need to utilise a fixed navigation point would therefore be unnecessary.

However, the daylight dispersion and subsequent re-aggregation at night clearly lend credence to the forage-base theory. FADs are generally accepted (in the Pacific region at least) to have a radius of attraction of 4.5 nautical miles; if the mechanism that allows tunas to sense the location of a FAD is physical (perhaps though the lateral line), then the FAD could provide a static base from which tuna could radiate out while foraging.

There remains however the question whether the area in which the FAD is deployed has sufficient prey resources to hold the tuna in that area. FADs are usually deployed in areas that are known to have tuna and are therefore likely to be suitable feeding environments.

However, diffusion theories (e.g. Mullen, 1989) suggest that the tuna hold themselves in an area of high productivity by adjustment of the direction in which they swim (determined perhaps by some minimum prey density).

Tuna may therefore have to leave an area of high prey density to return to the forage-base (the FAD), the possible advantage of which remains unclear.

An interesting adjunct to the forage-base theory is that FADs act as centres of communication, in the same way bees return to their hives to pass on information on the location of suitable sources of nectar and pollen (Evans, pers. comm.).

2. That FADs assist in predator avoidance

Research suggests that several free-swimming schools aggregate around the FADs, probably forming a single large school at night which disperses into sub-schools during daylight when the fish feed (Preston, 1991). The size of individual fish and the size of schools typically aggregated make explanations based on the FADs themselves providing protection from predators, in the way suggested for shallow-water FADs, unlikely.

Clearly a large school would give more protection to individuals than a smaller one but this begs the question of why such large schools appear to only form around FADs (both natural and artificial). Given the distance over which FAD-associated tunas range, it is unlikely that this theory is valid; the tunas could not retreat sufficiently rapidly to the FAD to gain any protective advantage.

3. That FADs aggregate prey items for the tunas

Perhaps a useful insight into the phenomenon can be gained by looking at aggregation under natural circumstances. The effect of oceanic gyres and currents tends to lead to the formation of aggregations of natural FADs (such as floating logs). Such areas are also likely to be more productive than adjacent areas because of the meetings of currents, and may therefore explain why flotsam and jetsam act to aggregate tunas.

The size and age of logs appears to correlate with catches. However, artificial FADs are usually not placed with respect to considerations of local productivity, although they are often placed where tunas are found or on tuna migration paths. The FAD must therefore provide sufficiently attractive feeding opportunities to hold tuna schools.

Industrial fisheries utilise both inanimate floating objects and live whales as indicators of possible concentrations of tunas.

The purse-seine fishery operating north of Papua New Guinea targets live whales in the first and fourth quarter of the year and the presence of tunas is possibly related to the presence of prey species common to both whales and tunas (such as the ocean anchovy).

FADs therefore may enhance feeding by aggregating prey species; research does suggest that, for example, the pelagic larval stages of reef fish are aggregated by floating objects; stomach content analysis of smaller coastal yellowfin tuna (mean weight of 4.3 kg) have shown that post-larval and juvenile reef fish (Monocanthidae 12.9%; Chaetodontidae 9.9%; Acanthuridae 4.3%) comprised 27 per cent of the total food intake although these fish were not taken at FADs.

Alternatively, it may be that the innate aggregating behaviour that leads to aggregation around natural floating objects causes the tuna to school around FADs even though there may in fact be no energetic advantage. There is some evidence that large FAD-associated yellowfin change their target prey, which may explain how such a large biomass (up to 1500 t) can sustain itself in a relatively small volume of water.

Brock (1985) reported that yellowfin caught at some distance from FADs (>2 km) deployed off Hawaii, had a significantly greater volume of food ($p<0.0005$) in their stomachs than those caught around FADs and that dietary composition was dominated by fish (66% by volume). Those yellowfin caught around the FADs fed primarily on crustaceans (85% by volume) of which 78 per cent (by volume) was the mid-water shrimp, *Olophorus gracilirostris*.

The situation is far from uniform, however, with apparent significant regional variation; analysis of the stomach contents of yellowfin caught off FADs deployed in the North Celebes Sea indicated that 68 per cent of the weight of food comprised juvenile tunas (prey and chum) (Yesaki, 1983).

Sonar surveys do not suggest that the olophorid shrimps are aggregated by the FADs and they do not appear in the stomach contents of other FAD-associated predators. Brock suggested that although the large biomass found locally around FADs reduced overall prey availability, the switch of diet could imply that FADs actually enhance yellowfin production.

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YESAKI, M. (1983). Feeding habits of yellowfin tuna (Thunnus alba cares) captured by handlines under payaos in the North Celebes Sea. In: Proceedings of the 34th Annual Tuna Conference. Ed. R.J. Olsen. IATTC, La Jolla, CA. 2.

Observation report on tuna purse-seine fishing operations around Seychelles waters onboard *Nippon-Maru*, 8 November 1992 to 7 January 1993

by Aussanee Munprasit & Isara Chanrachkij

MUNPRASIT, A. & I. CHANRACHKIJ. (1993). Observation report on tuna purse seine fishing operation around Seychelles waters onboard Nippon-maru, 8 November 1992 to 7 January 1993. Training Department Research Paper 32. Southeast Asian Fisheries Development Center (SEAFDEC), Samutprakarn, Thailand. 39 p.

In this report, Aussanee Munprasit & Isara Chanrachkij (SEAFDEC, Olympia Building, 4th Fl, 956 Rama IV Rd., Bangkok 10500, Thailand) present in detail the way Nippon Maru, a Japanese tuna purse-seiner, uses 'home-made' drifting FADs. The following extract presents three different fishing operations in relation to the situation of the fish school: free-swimming, associated with drifting objects and associated with 'homemade' drifting FADs.

Fishing ground designation

Fishing masters designate fishing grounds according to their own experience, former fishing recorded, up-to-date information by radio communication from other vessels at the same fishing ground, and from their own equipment onboard, such as fishing-ground detectors (NOAA satellite system).

The fishing master on *Nippon Maru* designated the fishing ground not only in accordance with this information but also taking the research programme into consideration. According to five years-plus experience in the west Indian Ocean area, the fishing season for tuna purse seine around Seychelles waters is as follows:

January-March:
Southern area of Seychelles group;

February-April:
South-west area of Seychelles group up to the Exclusive Economic Zone (EEZ) boundary line of Kenya, Somalia, and northern Madagascar;

April-June:
Western area of Seychelles group and along EEZ boundary line of Somalia;

July-October:
Northern area of Seychelles up to Maldive waters; and

November-December:
Eastern area of the Seychelles group.

Spanish and French purse seiners conduct fishing by searching for schools and following seasonal variations, but Japanese purse seiners are different. They prefer 'payao' fishing, so their fishing season depends upon the oceanic currents.

When the current is too strong and its average direction is to the east, fishing is not good. The northern and southern areas of the Seychelles do not have such strong currents. Japanese purse seiners decide on fishing grounds by the current conditions.

So although the *Nippon-Maru* sailed around the waters of the Seychelles for this fishing trip, the main catch was in the eastern area.

Searching

While the vessel sails to the fishing ground during the day, bird radar is operated at a range of six and 12 nautical miles, to find-far distant flocks of birds. When found, the vessel proceeds in that direction.

Throughout the day, the fishing master, captain, officers and crew also search through binoculars from the high basket on the main mast and from the high bridge deck to find a flock of birds, jumping fish, drifting objects or other signs related to fish schools.

When the vessel is close to the area or object, careful observation is made through binoculars, and by sonar and echo-sounder, to confirm the fish school's condition. After this is confirmed the fishing master orders the net operation, or the luring method, and waits for a suitable time for a net operation.

Searching is one of the important steps of tuna purse-seine fishing. After searching, however, if a fish school is not found or the fish school is not suitable for net operations (scattered or not big enough), aggregating methods are used.

Aggregating

A long time ago, fishermen learned by experience that fish aggregate around a drifting object in the sea. So, they made floating objects and put them into the sea; the Philippine fishermen make a bamboo raft under which coconut fronds are attached, and set it in the sea fixed with an anchor. This is called a ‘payao’.

This is well known among purse-seine fishermen, especially tuna purse seiners. There are many types, designs and styles of ‘payaos’ in various parts of the world, where they are sometimes called ‘Fish Aggregating Devices’ (FADs).

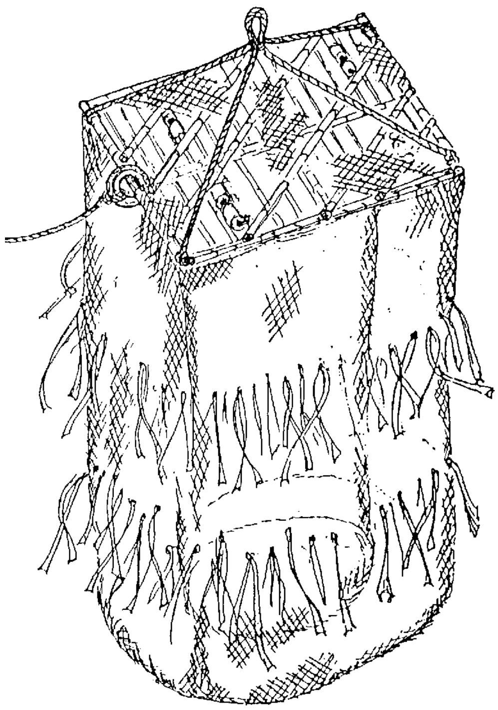
There are two different settings. For certain fishing grounds (not a wide area), anchored FADs are set, but on wider and oceanic waters, drifting FADs are used. Fishing grounds around the Seychelles are very wide, so drifting FADs are popular among Japanese purse seiners. Spanish, French and Russian purse seiners prefer searching for fish schools rather than using FAD fishing.

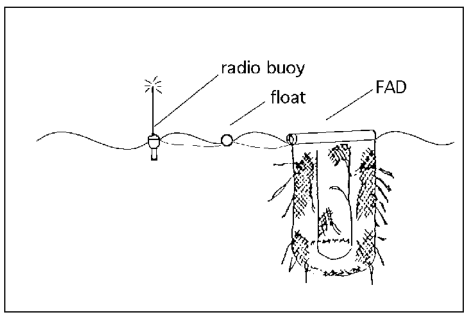
The FADs of the *Nippon Maru* were quite specially designed, made of used materials, iron frames, bamboo, net rope, plastic sheet and others (see Figure 1). Setting the FADs depends on the condition of the fish at the fishing ground. The fishing master decides to set FADs when he finds a lot of bait at the fishing ground but few fish, or when the location has yielded good catches in previous years, or when a small drifting object is found with a good number of fish around it.

Six to ten FADs, with a radio buoy attached to each one, are set near the drifting object with a distance of about 15 to 30 nautical miles between each. Usually, fishing conditions around FADs are good enough for net operations about two weeks after setting. At the fishing grounds in Seychelles waters it is sometimes quite difficult to use this method because there are a lot of fishing vessels after the same target, all using different methods, so a lot of FADs and radio buoys are lost.

Fishing operation

After a school or drifting objects are found, the condition of the school is confirmed by binoculars, sonar and echo-sounder, and then net operations will be designated. The fishing operation is carried out in three different fishing conditions-fish schooling, fish aggregating at a drifting object and fish gathering around FADsall of which require different fishing techniques.





Dimensions:
length: 3-5 m
width: 2-4 m
depth: 6-8 m

Materials:
bamboo, wood, iron frame, floats, ~20 mm nylon rope, used tyres, ~4 mm polyethylene net, wire, plastic sheets, etc.

Figure 1: ‘Home-made’ FAD used on the *Nippon Maru*

Fish schooling

This type of fishing condition involves the most difficult method, because fish schools usually move very fast in the daytime. There is only a very short time, about 30 to 50 seconds, to use the surrounding net while the fish feed on bait on the surface. The fishing master has to control the following of the school until the position of the vessel, direction of fish school movement, and direction of current and wind are fit to start surrounding the fish with the net. If all these factors are not ready at the same time, the fish escape from the surrounding net and the operation is in trouble.

After the surrounding by the net is complete, work boats must be released quickly to chase the fish into the net opening until it is closed, at the purse line too. Then the other steps of net operation continue until the operation is finished.

Fish school aggregated with a drifting object

When it is confirmed that fish are under the object or nearby and not moving much, net operations are started, usually around noon. If the school is still moving around and is far from the object, a radio buoy with a light will be attached to the object for net operations early the next morning. If the object is small, FADs will be set to accompany it. In the case of immediate net operation, two work boats are released to stay around the object with echo-sounders operating, in order to confirm the fish school condition.

The echo-sounding operation of these two boats is instantly sent to the purse seiner by telesounding. If conditions are right, the net surrounding is started and continues until the operation is completed.

Fish school gathering around FADs

Usually, fishing on FADs is designated for the early morning, starting before sunrise (0430-0530 a.m.). Purse-line hauling should be finished before sunrise. When the fishing vessel arrives at the FAD, a rough check and confirmation of fish conditions is conducted by sonar, binoculars and echo-sounder. Then a flashlight is attached to the radio buoy.

The vessel stays about three to five miles away from the FAD depending on wind conditions, and drifts at night with small lights on board. The next day, early in the morning, the vessel proceeds to the FADs and confirms fishing conditions again. If they are good, two work boats are sent to the FAD.

One stays there with the echo-sounder operating and, sometimes, two underwater lamps (2,000 wand 3,000 w) set at 10 and 20 metre depths, whilst the other work boat moves slowly around the FAD with the echo-sounder on (Fig. 2). The fishing master makes a last confirmation with the information received on the purse seiner from the two work boats by tele-sounder before starting the net operations.

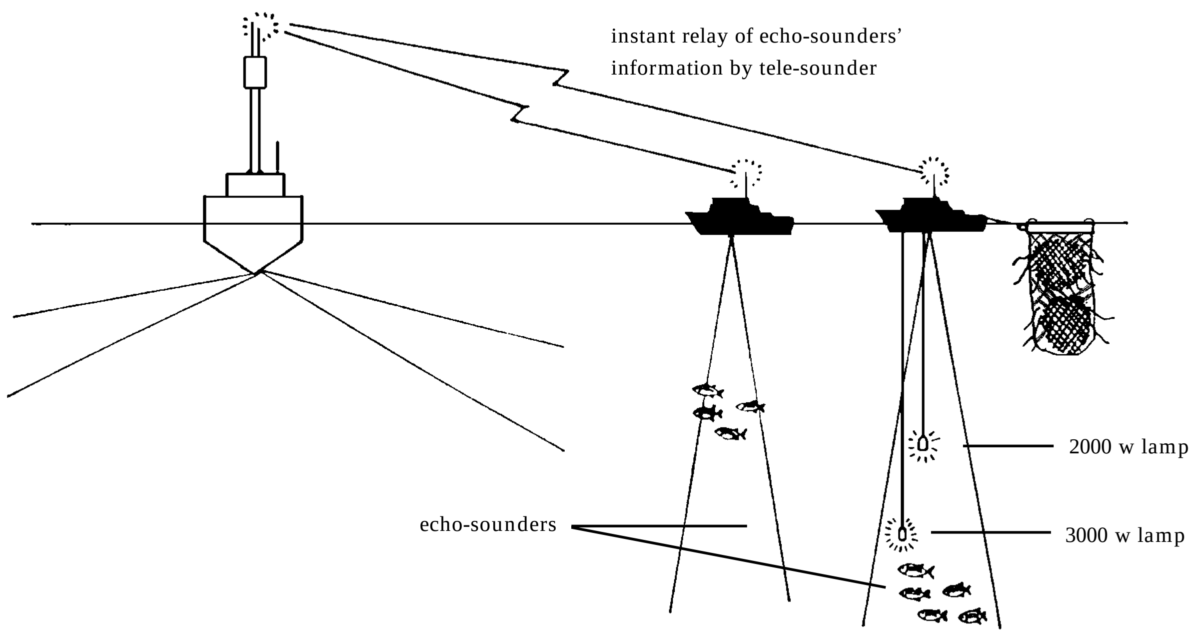


Figure 2: Estimating school density before net operations

Indo-Pacific Fishery Commission (IPFC) Report of the Symposium on Artificial Reefs and Fish Aggregating Devices as Tools for the Management and Enhancement of Marine Fishery Resources, Colombo, Sri Lanka, 14–17 May 1990

Indo-Pacific Fishery Commission (IPFC). (1991). Report of the Symposium on Artificial Reefs and Fish Aggregation Devices as Tools for the Management and Enhancement of Marine Fisheries Resources, Colombo, Sri Lanka, 14–17 May 1990. RAPA / Report 1991 / 10. FAO, Regional Office for Asia and the Pacific, Bangkok, Thailand. 27 p.

This symposium allowed more than 30 scientists, mostly from the Indo-Pacific region, to meet and share their experiences on artificial reefs (ARs) and FADs. The following abstract gives the recommendations that were issued from the symposium. Although being now six-years old, most of these recommendations are still valid today. . .

Recommendations

1. Since FADs (Fish Aggregation Devices) and Artificial Reefs (ARs) may produce relatively higher CPUEs and increase catchability, their application in situations where fishing effort is controlled can result in positive social and economic benefits. However, where effort is uncontrolled it may result in increased fishing mortality and further overfishing. It is therefore recommended that these structures should not be used except in situations where fishing mortality is controlled. Specifically, in situations where stocks are overfished, FADs and ARs are not recommended if these structures aggregate the overfished species, unless deployment is accompanied by substantial reduction in fishing effort. It is recommended that FADs and ARs which shift fishing effort from overfished to underutilised species be considered as long as overall fishing effort is effectively controlled.

2 FADs and ARs may offer opportunities for the strengthening of community-based fisheries management. It is recommended that the planning, deployment and management of such structures be done with the active participation of the fishing communities who, with adequate support, are ultimately given the responsibility for their rational use.

3. ARs and FADs have important effects on allocating space and resources which will result in desirable or undesirable distribution of benefits. It is therefore recommended that the issue of allocation and its socio-economic consequences be explicitly considered when planning a FAD and especially an AR programme, whether on a small or large scale.

4. Prior to the deployment of FADs, and especially ARs, on a large scale, it is recommended that their objectives be clearly stated and that their bio-economic effects, on the fishery and on the coastal zone activities, be thoroughly evaluated. Such evaluation should not be confined to the local level where the installations are to be sited but should also extend to the entire fishery.

5. The symposium recognised, the gross inadequacy of the available knowledge, relative to the size of the investments, and the necessity to facilitate and improve research on the potential biological, socio-economic and environmental impacts of FADs and Ars. It is therefore recommended that countries in cooperation with technical and financial agencies ensure coordination between the various deployment programmes in the region to improve knowledge through comparative studies. It was however recognised that successful experiences in one area may not always be replicable. It is also recommended that properly planned and coordinated pilot programmes be undertaken, with appropriate support, for research purposes.

6. Given the relative permanence of ARs, it is recommended that a) environmental impact assessments be undertaken, and b) FAO collect information on the potential problem of pollution from scrap-tyre reefs and, if resources permit, the potential environmental impact of other commonly used scrap materials (e.g. buses, tricycles, etc.) be thoroughly assessed.

7. It is recommended that a thorough study be conducted on the viability of using ARs on a

large scale, for the purpose of excluding active gears (such as trawlers and other related gears) before further deployments are undertaken with this objective. It is also recommended that the appropriate use of inexpensive FADs to aggregate underutilised species such as dolphin fish and rainbow runners be investigated;

8. It is recommended that countries consider the inclusion of a specific legal framework for the deployment and management of FADs and ARs in their fisheries legislation, with due regard to the problem of siting, access, access fees, liability and navigation safety.

Practical and legal aspects of fish aggregating devices (FADs) settlement and exploitation

P. Cayré, X. de Reviers & A. Venkatasami

CAYRÉ, P., X. DE REVIERS & A. VENKATASAMI (1991). Practical and legal aspects of settlement and exploitation of fish aggregation devices (FADs). **In:** Papers Presented at the Symposium on Artificial Reefs and Fish Aggregating Device as Tools for the Management and Enhancement of Marine Fishery Resources, Colombo, Sri Lanka, 14–17 May 1990. RAPA Report 1991/11. RAPA, FAO, Bangkok, Thailand. 75–82.

In the following abstract, the authors give a list of various steps to follow before implementing any FAD programme. This list was one of the tools used and developed in the first volume of the SPC FAD manual: Planning FAD programmes, written by Jim Anderson and Paul D. Gates (in press).

Proposed steps for setting up a rational FAD program

. . . There are several different fields or topics to be surveyed and explored before or during any FAD programme. A list of various steps to follow when elaborating a FAD programme can thus be proposed. A chronological order was adopted in the presentation of the questions and fields which should be investigated.

A. Gross evaluation of the overall abundance of the different species which could aggregate around FADs.

B. Do oceanographic conditions (i.e. current, wind, bottom of the sea . . .) permit FAD anchoring?

C. Gross evaluation of the local needs (nature and importance) in animal products whatever they are (i.e. fish, chicken . . .)

If the results or answers to steps 'A', 'B' and 'C' are negative, FAD programme should not be considered.

D. Estimate the relative importance of the exploitation of the different marine species actually harvested:

- which species are exploited?
- how are they exploited (methods, strategies, people exploiting, etc.)?
- intensity of the exploitation of each species or group of species (fishing statistics should be examined at least on a seasonal basis)
- organisation of the market (market prices should be examined on the same time scale as used for the fishing statistics)

If the exploitation of species (i.e. tunas) which could aggregate around FADs is relatively low, then proceed to step 'E'.

If the exploitation of species which could aggregate around FADs is of major importance then proceed to step 'F'.

E. Determine the reasons why tunas (or any other candidate species to aggregation around FADs) exploitation is of minor importance compared to the other exploited species.

E.a Low local market value

Tunas or related species, are not appreciated by the population which prefers other species for food.

In this case, before taking any decision to initiate a FAD programme, the two following points should be examined:

- is there any way to change the feeding habits (e.g. new processing methods)?
- is there any possibility to export the produce?

E.b High local market value but:

The catchability is low given the existing fishing methods; fishing techniques or gears are not efficient enough to harvest a scattered resource and/or high exploitation costs limits the fishing effort.

At this step 3 different options (with different needed means) can be adopted:

1. FADs anchoring alone

2. FADs anchoring and gear trials to improve the fishing efficiency

3. Programme to improve the fishing efficiency without FADs settlement (embarkations, fishing gears, fishing strategy, etc.)

F. The actual exploitation of tunas (or related species) is of major importance:

- can the local market absorb an increased production?
- can an export market absorb a potential surplus production?
- gross evaluation of the potential effect of decreasing exploitation costs

If a FAD programme is decided after step 'F', the reasons which triggered the decision and the benefits expected from a FAD programme would normally have been identified.

G. Census of the places and conditions for FAD settlements

Fishermen must be associated to this step in order to take into account the distance at which the actual fishing embarcations can operate; moreover the traditional habits and legislation regulating the exploitation of the marine area must be observed:

- which existing fisheries and communities could exploit FADs?
- determine a mooring policy in agreement with the local traditions and legislation.

H. During the FAD programme, a continuous and careful assessment should be conducted on:

- fisheries (catch, effort, cpue, etc.) in order to estimate the FAD impact on the activity and the impact of the exploitation on the resources;
- the economic sectors involved in the fisheries which do or do not exploit the FADs;
- the social impact of the FADs exploitation.

An efficient sampling strategy should have previously been planned for these 3 parts of the survey. As any decision to modify any practical aspect of the programme could have to be taken during the survey, the information collected has to be processed on a short time basis.

Fish aggregating devices and feeding habits of tuna in French Polynesia

by Patrick Lehodey

LEHODEY, P. (1990). Dispositifs de concentration des poissons et habitudes alimentaires des thonides en Polynesie Française. Document DCP no. 9. Programme DCP, EVAAM / ORSTOM / IFREMER. Établissement pour la Valorisation des Activites Aquacoles et Maritimes, Tahiti, French Polynesia. 61 p.

The following abstract is a summary of a DEAl 'mémoire' presented on 20 September 1990. The DEA is a French post-graduate diploma awarded after one or two years of study. Students awarded the diploma are eligible to enrol in Ph.D. courses.

The stomach contents and volumes of 106 tuna (yellowfin, albacore and skipjack) caught in French Polynesia were studied in relation to their capture locations, viz. around FADs, in tuna holes2 and in the open ocean. Analysis of these results revealed quantitative and qualitative variations in stomach contents according to species and location.

Skipjack caught by trolling in the open ocean differed quantitatively from the other sample groups due to a very large variability in stomach contents, a high proportion of empty stomachs and, indeed, a mean number of prey per stomach which was higher than that for yellowfin tuna in the open ocean and equal to that of tuna captured in a 'tuna hole'.

Qualitatively, prey composition was dominated by fish, almost all of which were reef fish. The specimens captured in deep water near FADs were bigger and consumed proportionately larger numbers of prey (chiefly fish and crustaceans) than those caught at the surface in the open ocean or in deep water near the reef.

Most of the fish consumed, therefore, were reef species. Were they captured near FADs or did the tuna migrate between the FAD and the reef? If so, how can we explain the difference observed, i.e. the lower number of fish consumed by tuna caught in the 'tuna hole'? It is certain that the reef's diversity and biomass richness are incommensurate with that occasionally recorded around FADs.

However, for the same reasons, competition around FADs is certainly much less fierce where pelagic or semi-pelagic fish are concerned. They can find additional food there, but may be compelled to modify their behaviour; unless it is the prey which modifies its behaviour due to the FAD's influence and environment, thereby making it easier to locate and catch it.

Large numbers of crustaceans were found in the stomachs of large tunas caught around FADs in the deep water several miles from the coast, and smaller numbers in tuna caught near the reef or at the surface in the open ocean. Among crustaceans consumed near FADs, a distinction must be made between the Stomatopoda and Euphausiacea.

The former are normal prey for tuna, but usually surface tuna. Even if they occurred here in greater numbers, they were consumed by fewer specimens. Could it be theorised that the environment of FADs modifies either the behaviour of the squills which drift through their surroundings (aggregation or beginning of the passage to the benthic lifestage and sinking in search of the bottom?) or the behaviour of the tunas which hunt more vertically than horizontally around the devices? Sonic tags have shown the existence of this type of movement near FADs (Cayre et al., 1986; Holland, 1990) as occurring much more frequently in the daytime and occasionally with very regular patterns.

The other distinguishing feature concerns the Euphausiacea, which, contrary to expectations, occurred quite regularly in the stomachs of tuna captured near FADs (F = 40%). In this case, a FAD effect must also be postulated concerning either the behaviour of tuna (going deeper in its vertical movements) or the behaviour of Euphausiacea (e.g. prolonged presence at the surface until the tuna begin to hunt).

These results would seem to indicate a trophic relationship between FADs and the tuna captured around them.

However, it must be emphasised that the scope of these results remains limited by the low number of samples analysed and by the restricted area covered by the study; Also, it must be kept in mind that a trophic relationship is not sufficient in many cases to explain the formation of large schools whose feeding needs can apparently not be satisfied by the biomass present around FADs.

It is, therefore necessary to seek other factors. Gregarious behaviour and the hypothesis of a gathering point are among the most plausible. It is conceivable that tunas, isolated in a universe which is empty in three dimensions, are instinctively attracted by the stimulus of FADs. In that event, the deployment of such devices would have a greater impact than the deployment of buoys, as the entire column of water is involved.

The following process could be imagined:

1. Detection of the log or FAD

   This would take place more rapidly when the chances of encounter are high (natural abundance, transit route, currents, etc.) and the FADs scope is large, as, depending on the fish's means of perception (olfactory, hearing, vision), the FADs scope increases as the biomass increases.

2. Attraction

   Once the device has been detected, it would become a centre of attraction, and it is at this point that a possible trophic link would appear. However, we have seen that other phenomena are likely to be involved, e.g. the search for fellow creatures in order to form a school.

   If the attraction disappeared (e.g. a reduced biomass which was rapidly consumed), the tuna would leave the FAD to go in search of food (towards the reefs?), and during this period of time, the school would be likely to break up. It is possible that they memorise the location of this 'meeting place' and regularly come to visit it, 'knowing' that there they have a greater chance of finding something to eat or satisfying their gregarious instincts.

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HOLLAND, K.N., R.W. BRILL & R.K.C. CHANG. (1990). Horizontal and vertical movements of yellowfin and bigeye tuna associated with fish aggregating devices. Fish. Bull. NOAANMFS 88(3): 483-507

1 Patrick Lehodey is now working for SPC as Senior Fisheries Scientist in the South Pacific Regional Tuna Resource Assessment and Monitoring Project (SPRTRAMP).

2 Name used in Tahiti for a deep-ocean fishing site favourable to the capture of tuna and which, in fact, corresponds to a submerged reef or a seamount.

Modelling effects of FADs and islands on movement of skipjack tuna (*Katsuwonus pelamis*): estimating parameters from tagging data

by P. Kleiber and J. Hampton

KLEIBER, P. & J. HAMPTON. (1994). Modelling effects of FADs and islands on movement of skipjack tuna (Katsuwonus pelamis): estimating parameters from tagging data. Can. J. Fish. Aquat. Sci. 51:2642-2653.

From an experiment with ordinary dart tags, we have found evidence of the effect of fish aggregating devices (FADs) and of islands on the movements of skipjack tuna (Katsuwonus pelamis) around the Solomon Islands.

By fitting a fish-movement model to the tag data, we were able to estimate mortality and movement parameters (including diffusivity), parameters of a function that models FAD attraction, and a separate parameter of island attraction.

Diffusivity was high enough to effectively distribute fish throughout the island archipelago (approximately 150,000 km2) within a few months.

Estimates of FAD parameters indicate that the presence of up to four or five FADs in an area approximately 50 x 50 km can reduce the propensity for skipjack to leave that area by approximately 50 per cent, but that deploying additional FADs in such an area does not significantly increase their effectiveness in holding skipjack.

Estimates of the island attraction parameter imply that the propensity of skipjack for movement away from the archipelago is less than half the propensity for movement within it.

Depending on the way FADs are placed in a cell, the radius of action of one FAD is 9 km (≈ 5 nmi), assuming FADs are placed in a linear array across cells, or 18 km (≈ 10 nmi), assuming FADs are placed throughout the cells. This range roughly agrees with estimates from tracking studies: 'several miles' (Cayre & Chabanne, 1986) and 'minimum 5 miles' (Holland et al., 1990).

References

CAYRE, P. & J. CHABANNE. (1986). Marquage acoustique et comportement de thons tropicaux (albacore: *Thunnus alabacares* et listao: *Katsuwonus pelamis*) au voisinage d'un dispositif concentrateur de poissons. Oceanogra. Trop. 21: 167-183.

HOLLAND, K.N., R.W. BRILL & R.K.C. CHANG. (1990). Horizontal and vertical movements of yellowfin and bigeye tuna associated with fish aggregating devices. Fish. Bull. (U.S.) 88: 493-507.

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2 Oceanic Fisheries Programme, South Pacific Commission, Noumea, New Caledonia

QUESTIONNAIRE ON THE ESTABLISHEMENT OF SPECIAL INTEREST GROUP ON FISH AGGREGATING DEVICES

Identify: please provide the following details about yourself:

Name (in full):
Organisation:
Postal adress (state whether home or work):
Position / Title:
How long have you held this post?:
Home telephone: Fax: e-mail:
Work telephone: Other:

Areas of interest: please select all the subject areas below according to their level of importance (1st, 2nd, 3rd etc..) and specify those on which you could produce an article:

- Developments in FAD technology / materials
- FAD fishing techniques
- FAD material specification and procurement
- FAD programme planning
- FAD site survey technique and equipment
- FADs and the law
- FADs for large-scale commercial fisheries
- FADs for small-scale commercial and subsistence fisheries
- Flsh behavior in association with FADs
- Improving FAD efficiency
- Social and economic effect of FADs
- Inshore and baitfish FADs
- Low-cost FADs for subsistence fisheries
- Paying for FAD programmes
- Other (please specify):

PIMRIS is a joint project of five international organisations concerned with fisheries and marine resource development in the Pacific Islands region. The project is executed by the Secretariat of the Pacific Community (SPC), the South Pacific Forum Fisheries Agency (FFA), the University of the South Pacific (USP), the South Pacific Applied Geoscience Commission (SOPAC), and the South Pacific Regional Environment Programme (SPREP). This bulletin is produced by SPC as part of its commitment to PIMRIS. The aim of PIMRIS is to improve the availability of information on marine resources to users in the region, so as to support their rational development and management. PIMRIS activities include: the active collection, cataloguing and archiving of technical documents, especially ephemera ('grey literature'); evaluation, repackaging and dissemination of information; provision of literature searches, question-and-answer services and bibliographic support; and assistance with the development of in-country reference collections and databases on marine resources.

PIMRIS
Pacific Islands Marine Resources Information System