DEVELOPMENT OF SUBSURFACE FADS IN THE PACIFIC ISLANDS REGION, INCLUDING DEPLOYMENT OF TWO SUBSURFACE FADS IN NEW CALEDONIA

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Introduction

The introduction of fish aggregating devices (FADs) to the Pacific Islands region through the pole-and-line tuna fishery has, in some Pacific Island countries, improved the operational costs for small-scale offshore fishermen.

The commercial use of FADs, or *payaos*, originated in the Philippines, but the FAD concept is not new to the Pacific. In earlier days, some Pacific Islanders used bunches of bamboo, palm fronds, or mature coconuts anchored by large rocks in lagoons or on the ocean side of reef drop-offs to make it easier for canoe fisherman to catch the family's meal for the day; especially when the fisherman preferred one of the common pelagic fish normally found around drifting logs or debris. These types of basic FADs worked very well for subsistence fishermen. However, nowadays, with the increased number of powered craft found throughout the Pacific, particularly near major population areas, these basic types of FADs are now very rarely seen, except in remote areas.

The commercial use of FADs came about when their potential to aggregate pelagic fish proved effective for small-scale, offshore fishing operations, and subsequently, large-scale operations. On the other hand, the costs of maintaining sustainable FAD programmes in the Pacific Islands region can be expensive as some FADs must be replaced almost annually, due mainly to the effects of adverse weather conditions that place significant strains on the middle mooring and anchor systems.

Ever since this problem was identified, FAD designs in the Pacific have undergone a transition from weather-resistant flotation buoys, to surface flotation sections less resistant to the forces of nature. While in most cases this has improved the longevity of FADs in the water, there is still room for improvement in order to justify the cost of putting FADs in place. Other major problems that reduce the lifespan of FADs are vandalism and collision accidents.

FADs are also important to local fishermen in Japan. FAD problems there were similar to those in the Pacific Islands. To address these issues, several subsurface FAD programmes were implemented in Japan's fisheries prefectures. These programmes tested the performance of subsurface FADs, and determined their overall longevity. These trials proved to be very successful, with some FADs lasting up to 10 years and still functional. Now, more subsurface FADs are being deployed around Japan.

The Okinawa subsurface FAD programme is a good model to base subsurface FAD ideas on. Even though their subsurface FADs are too expensive for most Pacific Island programmes, the concepts and results of these subsurface FADs can be made simpler and cheaper for practical use in the region. Two cheaper versions of subsurface FAD designs were developed and trialed in Nauru and Fiji by SPC and the Japan International Cooperation Agency (JICA) on separate programmes.

Subsurface FAD activity in the Pacific Islands region

Two subsurface FADs were deployed off Suva, Fiji in 2006 by JICA adviser Takayuki Kai, working with the Fiji School of Maritime and Fisheries (FSMF). Another subsurface inshore FAD (of a simpler design) was deployed off Nauru by SPC's William Sokimi in early 2007, and two more subsurface FADs, similar to the FSMF design, were deployed off Suva in late 2007 with SPC's assistance under a JICA course for Pacific Islands Fisheries Officers. This project was coordinated jointly by Takayuki Kai and William Sokimi (Fig. 1).

Inconclusive data were obtained from the Nauru and FSMF subsurface FADs due to incomplete data feedback, although one of the two FADs deployed during the JICA course in 2007 had accumulated several large schools of skipjack tuna, frigate mackerel and yellowfin tuna. These schools were successfully fished during a FAD fishing methods workshop in July 2008, conducted by the Fiji Department of Fisheries with assistance from SPC's Nearshore Fisheries Development and Training Section.

The other subsurface FAD was not submerged when it was initially deployed. Although the deployment depth matched the scope of rope needed for the

FAD to be submerged at 20 m depth, the rope's stretching capacity was miscalculated, resulting in the FAD being stretched to the surface. During FAD preparation at the workshop, a forklift was used to stretch the rope for this FAD. The other FADs were manually stretched by workshop participants. The force exerted on the mooring ropes by the buoyant section was around 240 kg, so the ropes should have been stretched to this limit instead of being stretched greater than this by the forklift.

This subsurface FAD is suspected to have totally submerged after attempts by the Fiji Department of Fisheries technicians to sink it to around 20 m; instead of settling at 20 m or so the FAD likely sank to the bottom. The added weights must have been more than the upward pressure on the floats could withstand.

Following on from the deployment of these two subsurface FADs in Fiji, JICA will be deploying another two in Tonga, while completing the third component of the JICA Community-Based Fisheries Diversification in Small Island States Course for Pacific Islands Fisheries Officers. The decision to carry out this subsurface FAD deployment in Tonga was the result of an action plan proposed by the Tongan participant on the course, which was acknowledged by JICA as a constructive FAD development programme for the country.

Noumea subsurface FAD

Two subsurface FADs were constructed in Noumea by SPC's Nearshore Fisheries Development and Training Section (NFDTS) in August. The intention was to have these FADs deployed at strategic locations so that they could be periodically monitored by the Section's officers to ascertain their fish aggregating capabilities, longevity, fishing response, catch rate, and any other impacts that may be beneficial or otherwise to small-scale fishermen.

One of the subsurface FADs was deployed off Dumbea passage on 18 September, while the second one will be deployed off Passe Saint-Vincent at Tenia once sea conditions improve and NFDTS officers are back from duty travel.

Pre-construction calculations

The structure of the two Noumea subsurface FADs was based on the design that was used in Nauru in early 2007, where pressure floats, stainless steel wire, chain, and grapnel anchor were used. This design focused on being:

- easy to construct,
- easy to transport and deploy,
- durable with minimal resistance to the weather and sea forces, and
- not as expensive to produce as other subsurface FAD designs.

An Excel table listed all of the FAD components in the sequence the FAD was rigged, and the formulas used to calculate:

- Number of 30G-2 oval pressure floats required to support the middle mooring and a minimum of 10 m of chain off the bottom.
- Total weight of the anchor and connecting shackle.

Figure 1: Subsurface FAD deployed in 2007 off of Suva, Fiji.

- Total weight of the mooring section, including the middle mooring.
- Number of 30G-2 floats required to lift the anchor and total mooring completely off the bottom.
- Actual length of chain lifted off the bottom (in metres).
- Actual length of chain remaining on the bottom (in metres).
- Holding weight remaining on the bottom.

With this information, the weight of the full anchor system could be determined so that it would not be necessary to use an overly heavy anchor for the job but at the same time be sufficient to securely anchor the FAD in position (Fig. 2).

Emphasis was placed on using the chain as the principal anchor weight with a grapnel anchor at the end to prevent the chain from sliding along the bottom. With hindsight, the grapnel anchor that was used in this project was too bulky but this could be improved on in future FAD work to make transportation of the full FAD rig to the deployment site less cumbersome.

Dumbea FAD buoyancy section

The buoyancy section consisted of four 30G-2 oval pressure floats buffered by a halved piece of Polytech M700 purse-seine float between each 30G-2 float; three pieces were used in the mooring (Fig. 3). These were connected together with a 20-mm three-strand Polypropylene rope rove through a 22 mm clear flexible tube then through the 40-mm centre holes of the floats. An eye loop was spliced at the top end of the flotation system with a Turks head directly below the splice to prevent the floats from riding up on the splice. The end leading to the anchor mooring was spliced directly on to a #4 Nylite rope connector. This was shackled to a 16-mm stainless steel swivel with a 16-mm stainless steel shackle.

The total flotation buoyancy was calculated to be 90.5 kg, which should lift the chain 21.3 m off the sea floor. It is expected that the three halved pieces of M700 purse-seine floats will eventually be squeezed out to become a liability to the flotation section, thus reducing the buoyancy to 80 kg, and eventually dropping the chain to be lifted off the bottom from 21 m to 15 m.

Middle mooring

The middle mooring section for the subsurface FAD was constructed with 360 m x 5 mm x 7 x 7 (6x1) stainless steel wire.

The top end of the middle mooring was connected to the stainless steel swivel on the flotation section using a Flemish eye and three bulldog wire grips to clamp the dead end of the wire to the working end (Fig. 4).

Figure 2 (top). Grapnel anchor for mooring the FAD.

Figure 3 (bottom). Flotation section for the subsurface FAD.

The anchor end of the middle mooring was connected in the same way to a 22-mm forged swivel, which was then shackled to the 12-mm galvanized chain with a 12-mm galvanized bow shackle (Fig. 5). All the shackles and bulldog grips in the system were seized with wire to prevent the pins and nuts from unwinding and these were all wrapped in rubber tube to further strengthen the locking properties.

Anchor system

The anchor system consisted of 30 m x 12 mm galvanized chain and a grapnel anchor weighing 67 kg (58 kg in seawater). The initial weight of the anchor and chain remaining on the bottom immediately after deployment should have been around 84 kg. However, after the M700 floats were squeezed out, the FAD should have submerged an additional 6 m and more chain would have settled on the bottom, bringing the holding weight to around 103 kg.

Deployment of the Dumbea subsurface FAD

The Dumbea subsurface FAD was deployed in 390 m depth. The flotation section was first released at the deployment position, then the middle mooring wire was paid out as the vessel drifted downwind. At one stage there was a slight tangle in the wire as it was paid out. This occurred because of a lack of vigilance to ensure that the top wire loop flipped over and out and not slide under several coils while paying out. However, this problem was quickly rectified and the deployment finished without further disruptions.

An aggregator was tied on to the wire rope immediately beneath the flotation section to enhance and speed up the fish aggregating process. This aggre-

Figure 4 (top). Connection to flotation to the stainless wire in the middle mooring.

Figure 5 (middle). Connection of the middle mooring to the anchor chain.

Figure 6 (bottom). Tying on the aggregators while paying out the middle mooring wire.

gator was constructed from multiple 2-m lengths of plastic binding straps rove through the strands ofa 10-m green Polypropylene rop (Fig. 6).

A 2-mm twine was calibrated every 10 m and coiled onto a plastic bottle for checking the settling depth of the subsurface FAD. The twine was paid out as the vessel drifted downwind while releasing the middle mooring wire. After the anchor was deployed and the flotation section had submerged to its settling depth, this was measured by retrieving the twine and reading off the calibration.

After all the wire was paid out, the vessel was pushed ahead, away from the flotation section, so that the wire was at an angle to the boat. The anchor was then deployed after checking the depth again and ensuring that the wire angle was sufficient to prevent the anchor from being dropped on top of it and fouling the mooring.

When the anchor was finally deployed, the FAD settled at 60 m below the surface. This was deeper than initially intended but was still an effective depth for aggregating pelagic fish. Some of the subsurface FADs in Okinawa were at 100 m. There were two possible reasons why this subsurface FAD settled deeper than initially planned: the anchor settled at a deeper depth on the bottom slope, and the effects of the current on the FAD gave it a scope that settled the FAD deeper at its extreme stretch. After plotting the deployment position on the chart it was evident that the anchor had settled deeper than intended.

Subsurface FAD to be deployed at Tenia

Except for two minor changes, the Tenia subsurface FAD was constructed with the same procedures and components used for the Dumbea subsurface FAD. The changes included:

- A longer middle mooring section of 510 m to meet the depth at the deployment site of 540 m. The subsurface will FAD initially settle at around 10 m below the surface, and then sinking further to 17 m below the surface when the M700 floats get squeezed out.
- Instead of rigging a Flemish eye at both ends of the middle mooring wire, and then securing this with three bulldog grips, the ends were grommet spliced then secured with three bulldog grips (Figs. 7).

The rest of the subsurface FAD construction remained the same as for the Dumbea subsurface FAD. The shackle pins and bulldog grip nuts were secured with wire then wrapped in rubber tube as additional security.

Figures 7 (left and right). Middle mooring wire; grommet spliced then secured with bulldog grips, seizing wire and bound with a rubber strap.