WESTERN
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FISHERY
MANAGEMENT
COUNCIL

Pacific Islands Region
FAD Issues and Priorities Workshop
NOAA Fisheries – Honolulu Service Center – Pier 38
February 13 - 14, 2013

Workshop Report[1]

A. WELCOME AND INTRODUCTIONS

Kitty Simonds, Executive Director of the Western Pacific Regional Fishery Management Council (Council)[2] opened the meeting, welcoming delegates from the Pacific Islands Region (PIR) and invited FAD experts from the western Pacific. The importance of coastal FADs to small island communities was noted and the need to improve and streamline FAD programs was emphasized. Meeting participants introduced themselves around the room. David Itano, Recreational Fisheries Specialist for the PIR described the major intent of the meeting as an opportunity to review existing PIR FAD programs, to learn about new developments and technology in anchored FAD design and to examine ways to minimize costs while increasing longevity of FAD deployments. Issues of collecting FAD catch/effort data and FAD associated research would also be covered. Eric Kingma, Council staff chaired the meeting and directed discussion in collaboration with Itano. The agenda was reviewed and approved (**Appendix I).** A participants list with contact details is provided as **Appendix II**.

B. DESCRIPTION OF EXISTING US FAD PROGRAMS

B.1 ***American Samoa – FAD Program***

Tee Jay Letalie, FAD Program Supervisor provided a presentation on the American Samoa FAD program, which was established in 1979 and has gone through several design generations and different float types. A report detailing the American Samoa FAD Program from 1979 – 1987 was brought to the attention of the meeting (Itano and Buckley 1987) and two copies provided to Letalie. The program has been supported by the American Samoa government through the Office of Marine Resources (originally) which is now the Department of Marine and Wildlife Resources (DMWR). FADs are assembled by staff on the DMWR site next to the bay in Fagatogo and supported by US federal Sport Fish Restoration Act funding administered by the US Fish and Wildlife Service. FADs were proven to increase CPUE of pelagic species in American Samoa through an analysis of test fishing in open-water areas, around FADs and offshore seamounts during the mid 1980s (Buckey et al. 1989). The study provided scientific evidence that FADs had the potential to “create” target fishing areas that were more accessible than offshore banks while producing catches of the same relative magnitude.

Five deepwater FAD sites were maintained through the 1980s with only one or two FADs on station until recently. Deployment depths for deep-water FADs range from about 840 – 1650 m. The mooring system follows the well known deep-water FAD mooring design recommended by the Secretariat of the Pacific Community (SPC) incorporating the inverse/catenary combination of floating polypropylene line below sinking nylon line with chain sections at the top and bottom (Gates et al, 1996)[3]. Currently, the program is using locally constructed cylindrical spar-type FAD floats with a vertical mast and radar reflector.

[1] Version 1; 4/10/13
[2] http://www.wpcouncil.org/
[3] http://www.spc.int/coastfish/en/publications/technical-manuals/fads.html

The DMWR no longer has a vessel capable of deploying FADs, which are now being deployed by the inter-island ferry (M/V Sili) at a significant cost per trip ($8,000). **Figure 1** shows the charted position of current or possible deepwater FAD locations in American Samoa. Currently, FADs A, B and C are on station. Proposed locations of shallow water coastal FADs are shown in **Figure 2**.

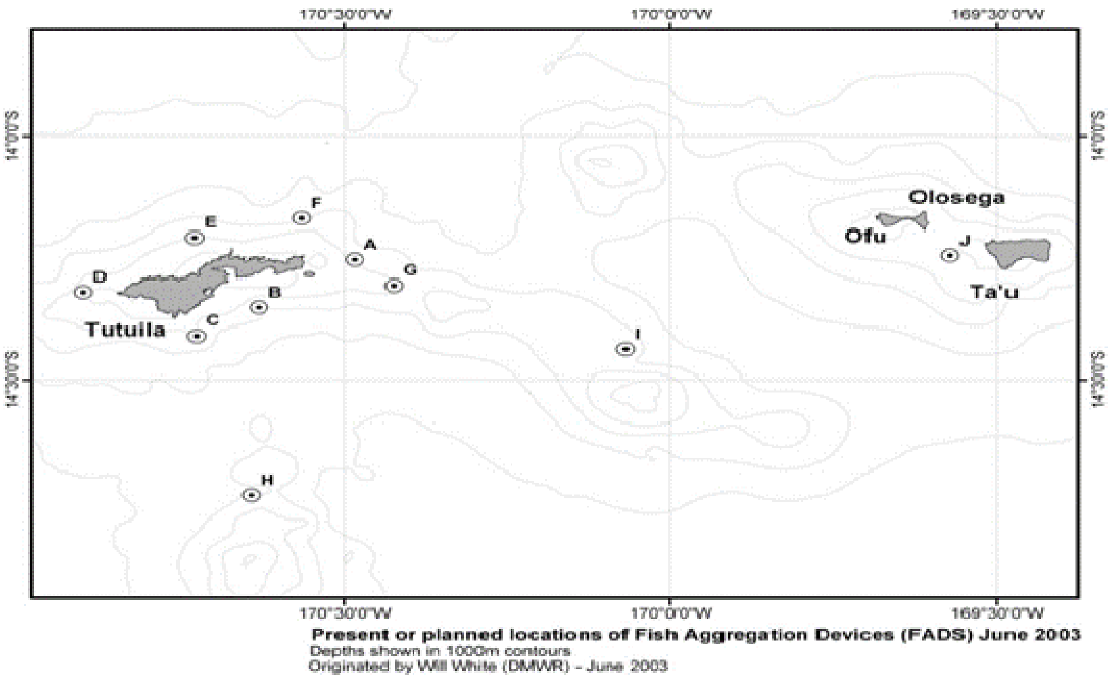

Figure 1. Permitted FAD locations in American Samoa.

A FAD training workshop was conducted in American Samoa by William Sokimi (SPC) from April 29 – May 4, 2012 that revitalized the program. The department has plans is to deploy and maintain five deep-water and seven shallow-water FADs. Additional FAD training and training in FAD-based fishing techniques has been requested. Additional plans are to monitor FAD catch using experimental fishing surveys and video gear and to improve data collection. Major constraints to the AS FAD Program were noted as funding levels and the lack of a suitable fisheries vessel for deployments.

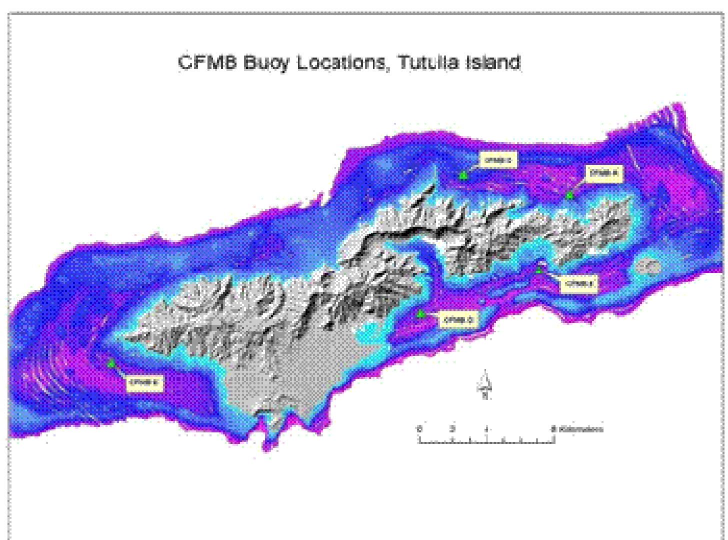

Figure 2. Proposed locations for shallow water coastal FADs in Tutuila, American Samoa.

B.2 ***Commonwealth of the Northern Mariana Islands – FAD Program***

Frank Villagomez, FAD manager for the CNMI, Division of Fish & Wildlife (DFW) provided description of their FAD Program. A detailed FAD Program report by Villagomez, Tenorio and Dunn is attached as **Appendix III**. A synopsis of key points is provided here:

The CNMI FAD program began in 1980 with funding from the Pacific Tuna Development Foundation, but has since been funded by Sportfish Restoration Act grants administered by the US Fish and Wildlife Service. Ten FAD site permits exist around Saipan, Tinian and Rota with two FADs currently on station off Saipan. FAD depths range from 316 to 1854 m. Since 1980, float types have ranged from drums, bell buoys, nun buoys, steel spheres and spar buoys. Currently, stream-lined fiberglass spar buoys have been adopted to reduce the high drag observed from previous designs. The spar buoys are locally constructed, have a keel to prevent twisting and can be deployed with a lighter anchor due to low drag characteristics.

The basic mooring system is based on the SPC inverse catenary design as outlined in Gates et al. (1996) with a few exceptions due to local availability of hardware and to improve efficiency. Notably, the size and diameter of swivels and shackles in the upper mooring system were increased while the overall chain length was decreased to reduce weight/drag on the buoy. The current mooring system and components are shown in **Figure 3** with all components described in detail in the DFW report in Appendix III.

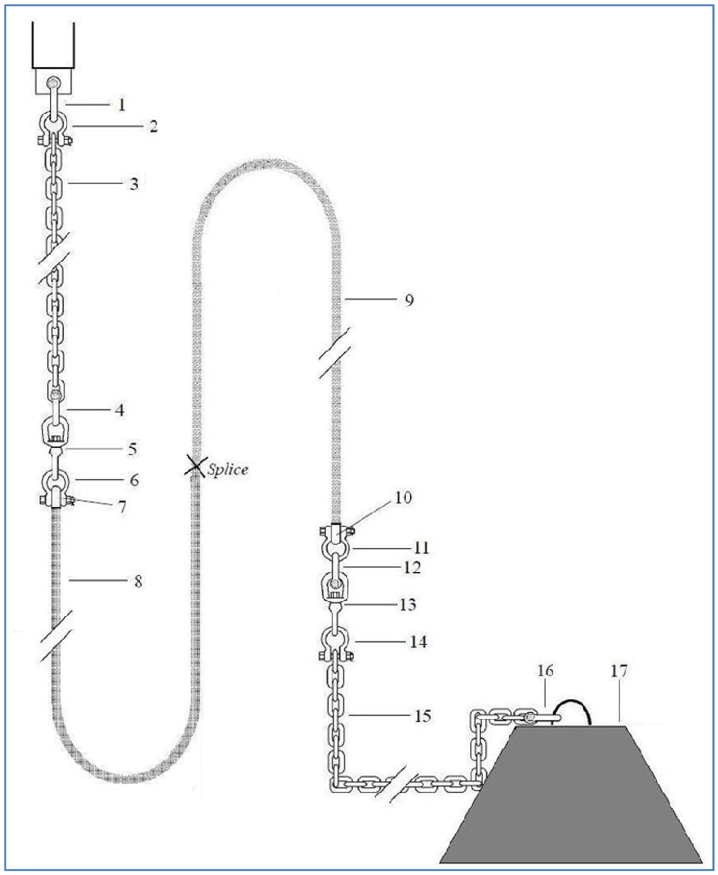

Figure 3. CNMI FAD mooring system.

The FAD Program is supported by the CNMI Division of Fish & Wildlife (DFW) under the Department of Lands and Natural Resource. The FAD buoys and anchors are fabricated by contractors with components assembled by DFW technicians. Total estimated cost (2013) for one complete anchored FAD system (components only) is USD $ 7775 per FAD with $5900 of the total for rope and $2580 for the FAD float. FAD aggregators have been used in the past but are not currently attached to the mooring system. The use of natural aggregators may be investigated in the future.

FAD deployments are carried out by contracted vessels at approximately $3800 - $6026 per FAD. Aerial surveys using helicopter have been used to locate free drifting FADs when mooring systems fail. Following identification of the targeted anchor site the FADs are deployed anchor last.

Data collection is restricted to small amounts of troll data collected prior to in-water visual surveys of FAD systems and boat-based intercept creel surveys of fishers.

Constraints to the CNMI FAD Program include budgetary and operational issues, such as: the locally high costs of goods and services, high shipping/import costs and lengthy government payment system that discourages vendor options. The high cost of deployments and the need to bid deployment jobs to the lowest (often least experienced) bidder was also noted as a significant issue facing the program. Details on the CNMI FAD Program are provided in **Appendix III**.

B.3 ***Guam – FAD Program***

Jay Gutierrez, FAD Manager for the Guam Division of Aquatic and Wildlife Resources (DAWR) provided description of the GUAM FAD Program. A detailed report by Gutierrez and Bass is attached as **Appendix IV**. A synopsis of key points is provided here:

The Guam FAD program began in 1979 with initial funding from the Pacific Tuna Development Foundation, but now supported by Sportfish Restoration Act funds administered by the US Fish and Wildlife Service.

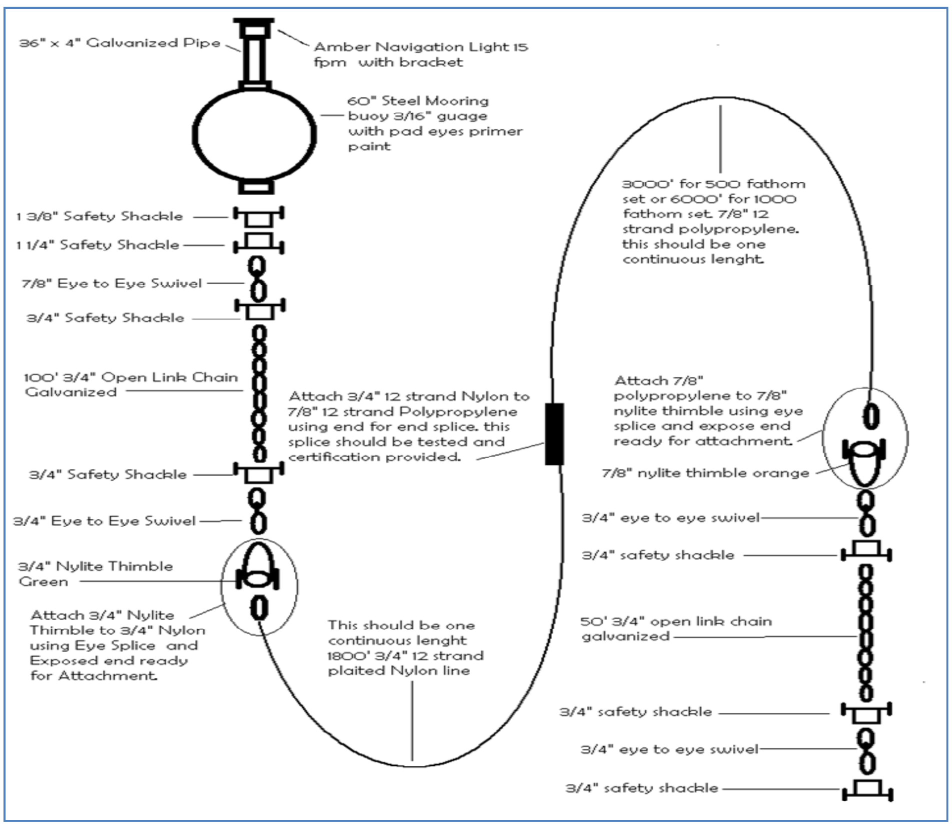

Figure 4. Guam FAD mooring system.

The current mooring system and components are shown in **Figure 4** with all components described in detail in the DAWR report in **Appendix IV.**

Fourteen permitted FAD sites surround Guam at depths from 400 – 1000 fathoms (732 – 1829 m). Spherical steel mooring buoys (60" dia) fitted with a light and radar reflector support the SPC type inverse catenary mooring system described earlier. Improvements to the system recommended by SPC have also been incorporated into the program in an attempt to increase FAD longevity. Aggregators have been used in the past but are no longer attached to mooring systems.

The construction of the FAD system is contracted to a private firm where two employees can construct one system in one to two days. Private vessels of 55' – 65' capable of transporting two FAD systems per trip have been contracted for deployments. Following identification of the targeted anchor site the FADs are deployed anchor last.

FAD fishing surveys have been conducted in the past but are not currently part of DMWR procedures. Creel survey data was discontinued in the 1990s due to uncertainty as to what distance from the FAD constituted "FAD fishing" effort.

The cost for one FAD and mooring system deployed in 1000 fathoms was given at $18,000 plus $2,000 per anchor or $20,000 which includes hardware, assembly and transfer to the deployment vessel. Deployment costs were estimated at $22,000 per FAD. At over $40,000 per FAD for construction and deployment, Guam is paying the most per FAD in the US Pacific Islands region.

The major constraints to the Guam FAD Program were noted as high costs of fabrication and deployment, inadequate longevity, procurement issues and issues related to federal permitting requirements.

B.4 *Hawaii – FAD Program*

Warren Cortez, FAD Program Manager provided a presentation covering the State of Hawaii FAD Program. FAD deployments began in 1979 with funding from the Hawaii State legislature but has since operated on an annual basis with funds from the Sport Fish Restoration Act with matching support from the University of Hawaii. The project is administered by the University of Hawaii, Hawaii Institute of Marine Biology (Dr. Kim Holland) and maintained on a day to day basis by UH personnel.

The program has used three basic float and mooring designs, settling on the use of spherical steel buoys (58# dia) fitted with a solar powered light, supporting an inverse catenary mooring system similar to that described by Gates et al. (1996). The program includes 55 mooring sites that surround the populated main Hawaiian Islands. Deployment depths range from around 110 to over 1300 fathoms but most FADs are deeper than 500 fathoms. Plastic strapping aggregators have been used in the past but are no longer attached, at least in part due to US Coast Guard concerns over marine debris issues. Sub-surface FADs have been deployed in the past, but currently all FADs utilize a surface float. **Figure 5** shows the approximate FAD locations surrounding the inhabited main Hawaiian Islands.

A description of the program, mooring system and deployment sites can be found at http://www.hawaii.edu/HIMB/FADS/.

FAD systems are assembled at the University of Hawaii Marine Center in Honolulu by UH personnel and deployed by independent vessel owners selected through a competitive bidding process. Following identification of the targeted anchor site the FADs are deployed anchor last. FAD longevity is in excess of 30 months with significantly longer deployment durations noted on leeward coasts.

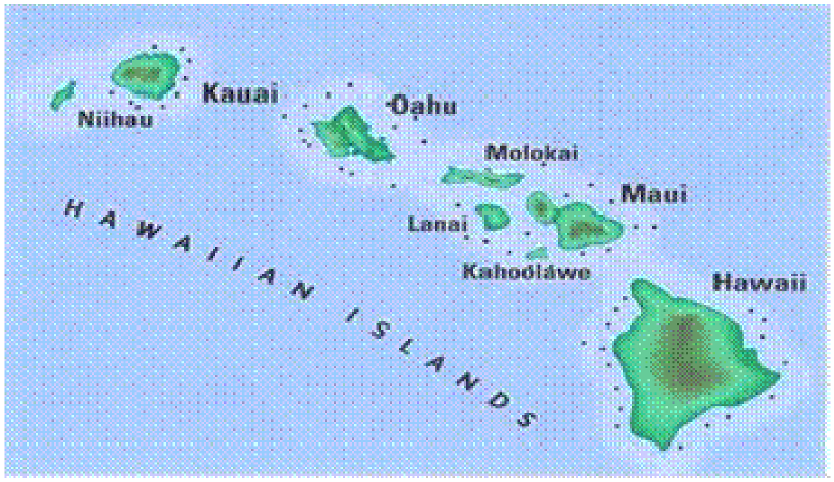

Figure 5. Permitted locations of Hawaii State FADs.

Specific FAD fishing surveys are not conducted. The Hawaii State in conjunction with the NMFS collects and compiles FAD –specific catch and effort data from small-boat commercial fishermen, but the reliability of the location data is unverified. No data collection is required of non-commercial fishers. University of Hawaii researchers utilize the FAD network to study the behavior of tuna, billfish and shark species using FAD-mounted acoustic receivers and sonic tags.

The cost for one FAD and mooring system deployed in 1000 fathoms (1829 m) was estimated at approximately $8600/FAD with solar light pack as of January 2013. FADs are deployed in a cluster of three concrete and steel anchors chained together that are made from waste (excess) concrete at a cost $75 per anchor. FADs cost approximately $8500/FAD.

Major constraints or potential threats to the Hawaii FAD Program were noted as increasing hardware costs with level funding for many years, limited options for deployment vessels and increasing oversight and issues related to the issuance of necessary permits and documentation by federal agencies.

C. REGIONAL PERSPECTIVES ON ANCHORED FADS

*C.1 **Secretariat of the Pacific Community (SPC)***

William Sokimi, Fisheries Development Officer for the Secretariat of the Pacific Community (SPC) provided an overview of FAD issues in the SPC region in the western and central equatorial Pacific. The SPC has been engaged in the development of artisanal FAD technology and fisheries for several decades. William conducts fishery development work and has conducted many FAD workshops and overseen many FAD deployments using a variety of vessel types. The SPC has produced several manuals and information papers related to FADs that include documents on planning, deploying, maintaining, monitoring and improving FAD programs and designs. They also have several manuals that describe FAD fishing techniques and seafood handling. These documents are available at: http://www.spc.int/coastfish/en/publications/technical-manuals/fads.html. Meeting participants were strongly encouraged to consult these resources.

Non-commercial anchored FAD types were categorized as offshore, nearshore sub-surface, nearshore surface, or lagoon-type FADs (**Figure 6**). Most surface offshore FADs in the SPC region are either metal spar buoys or of the Indian Ocean style, consisting of a series of purse seine type floats (**Figure 7**). Natural aggregators are sometimes used consisting of coconut tree fronds or other palm materials.

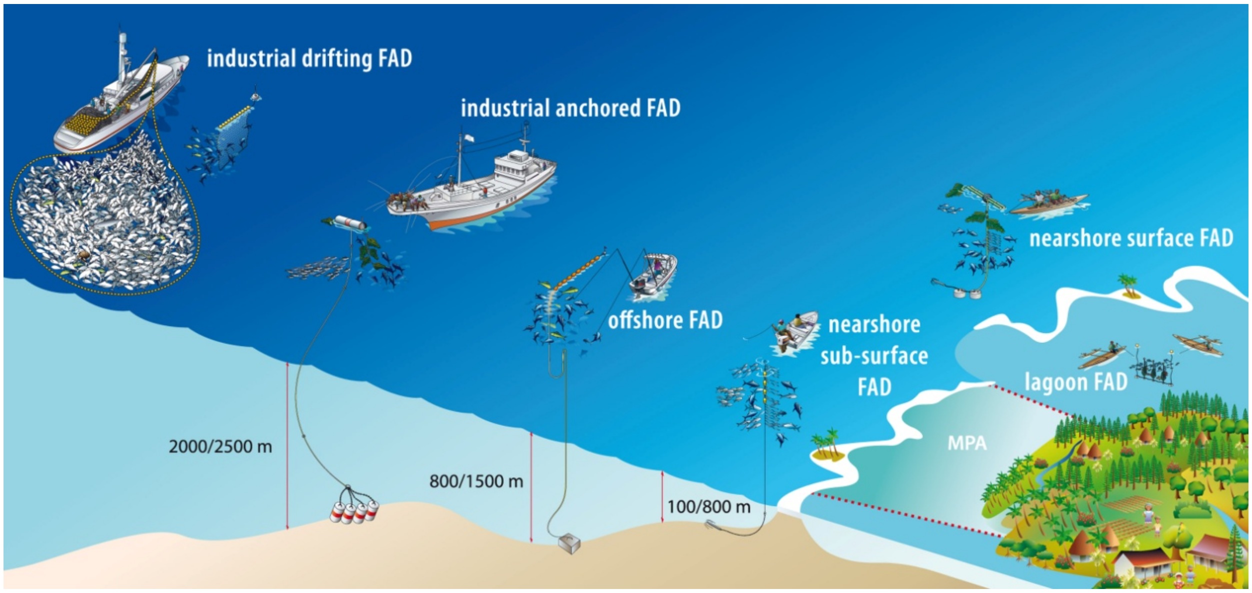

Figure 6, FAD types used to support commercial, recreational and subsistence uses.

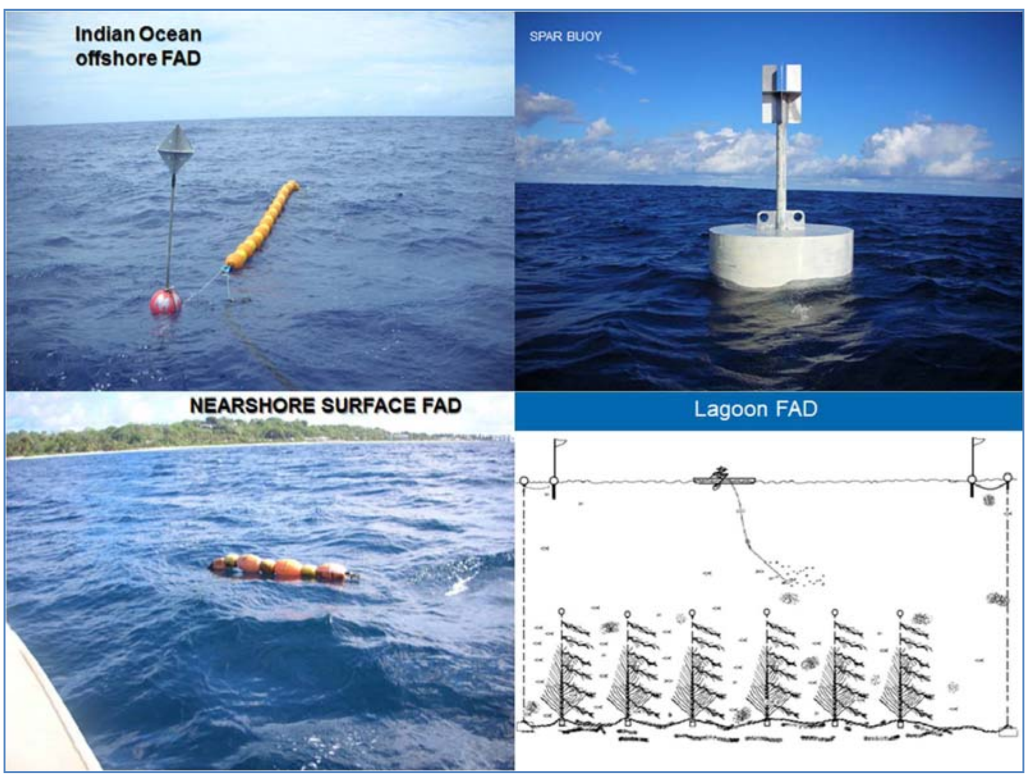

Figure 7. Anchored Fad types promoted by SPC.

C.1.1 ***<u>Traditional “SPAR”type FAD system</u>***

The spar buoy style FAD describes the anchored FAD style that was originally promoted for artisanal fisheries development in the SPC region and what is still deployed American Samoa, CNMI, Guam and Hawaii. The system is characterized by a large concrete anchor, poly/nylon rope catenary loop mooring line and a large steel or fiberglass float stabilized by a length of chain attached to the poly/nylon mooring line with galvanized shackles and swivels (**Figure 8**).

Steel spar buoy FAD system mooring arrangement and components

Components	Description and material	Size
1	Safety shackle with stainless steel (SS) cotter pin; Hdg-lcs*	25 mm 1 in
2	Safety shackle with SS cotter pin; Hdg-lcs*	16 mm or 19 mm 5/8 in or 3/4 in
3	Long-link chain; Hdg-lcs*	15 m of 13 mm 50 ft of 1/2 in
4	Safety shackle with SS cotter pin; Hdg-lcs*	16 mm or 19 mm 5/8 in or 3/4 in
5	Forged swivel (eye and eye); Hdg-lcs*	22 mm 7/8 in
6	Safety shackle with SS cotter pin; Hdg-lcs*	22 mm 7/8 in
7	Rope connector; *Samson* Nylite, size 3	22 mm 7/8 in
8	Sinking rope, nylon 8–12 strand plaited or 3-strand twisted nylon or lead-core polypropylene	20 mm 13/16 in
9	Buoyant rope, 8–12 strand plaited or 3-strand twisted polypropylene	20 mm 13/16 in
10	Rope connector; *Samson* Nylite, size 3	22 mm 7/8 in
11	Safety shackle with SS cotter pin; Hdg-lcs*	22 mm 7/8 in
12	Forged swivel (eye and eye); Hdg-lcs*	22 mm 7/8 in
13	Safety shackle with SS cotter pin; Hdg-lcs*	22 mm 7/8 in
14	Long-link chain; Hdg-lcs*	6–10 m of 20 mm 18–30 ft of 3/4 in
15	Safety shackle with SS cotter pin; Hdg-lcs*	25 mm 1 in
16	Anchor; concrete block	2000 kg 4400 lb

* Hdg-lcs: Hot-dip galvanised low-carbon steel

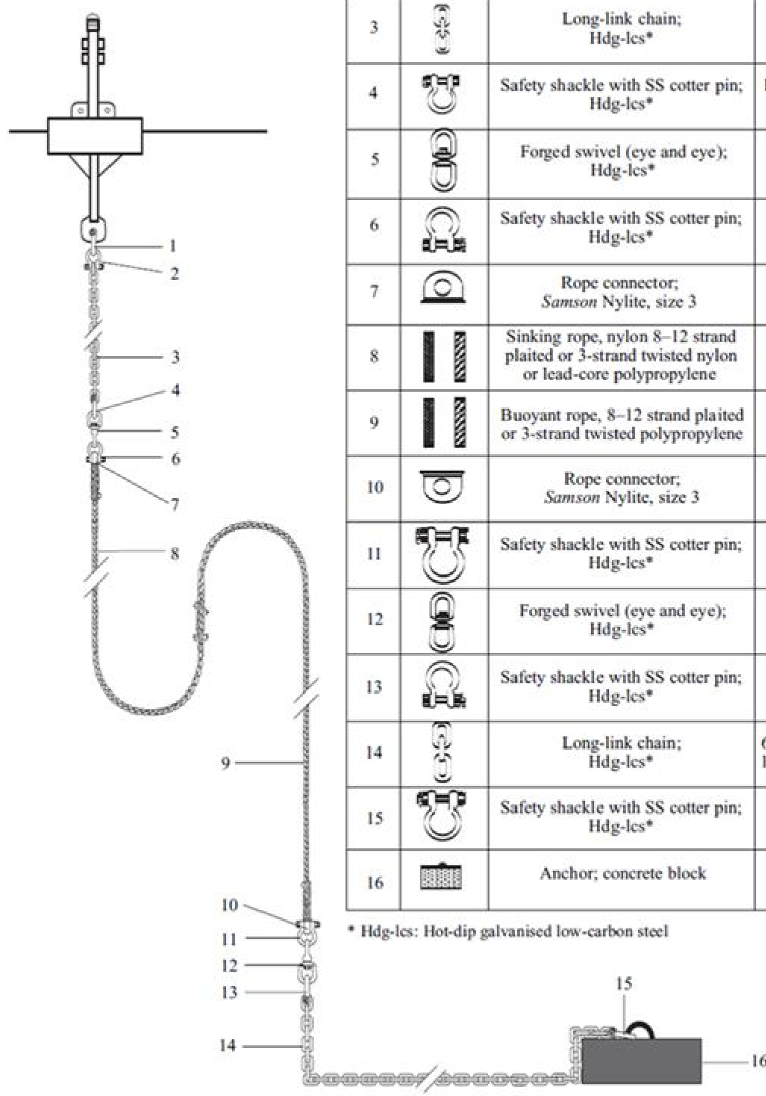

Figure 8. Spar type FAD and mooring system.

C.1.2 ***Indian Ocean style FAD system***

The Indian Ocean style FAD design has become very popular in many regions due to low cost, ease of construction and low drag characteristics. Significant savings are realized by the lack of a large surface float or buoy with flotation supplied by a series of oval floats. In many areas of the western Pacific, purse seine floats can be found at little or no cost where net repairs are conducted (**Figure 9**). Mooring systems are constructed of 3 strand poly/nylon mooring systems attached with shackles and swivels to an upper section of 3 strand nylon line strung with a series of oval floats. Another advantage is that smaller concrete anchors can be used due to the low drag characteristics of the system.

The low profile and visibility of this style FAD should be marked with the addition of a vertical flag buoy with light and radar reflector. The low drag characteristics result from the fact that more floats will submerge during storm events or large swells. For this reason, an adequate number of floats that will not lose buoyancy if submerged should be used.

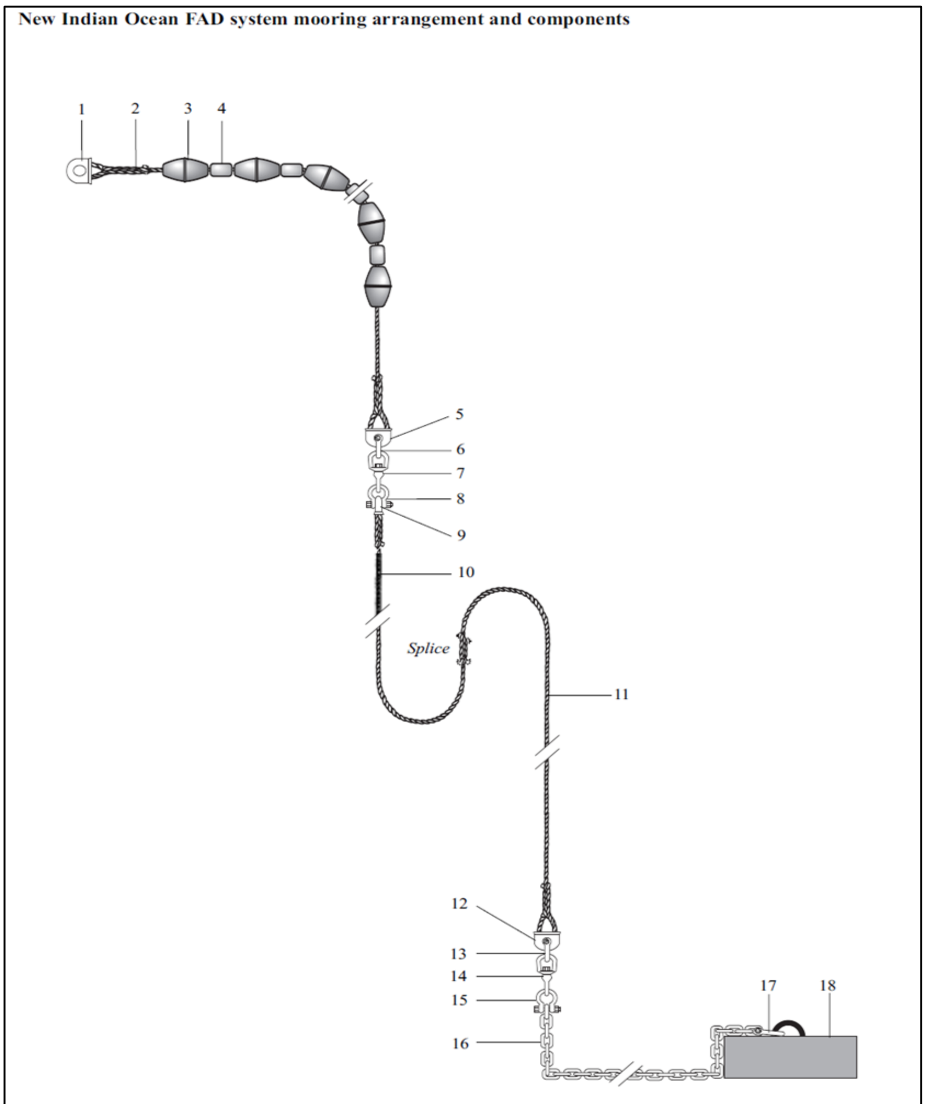

Figure 9. Indian Ocean style offshore FAD mooring system.

C.1.3 ***Improved Indian Ocean style FADs***

The SPC has been evaluating FAD and mooring designs for several years and a number of problem areas and solutions have been identified. Most problems that result in FAD loss occur in the surface waters within 150 m of the surface. Problems identified with Spar and Indian Ocean style FADs and mooring systems include:

- Corrosion of surface hardware
- Breakage at flexing areas (Indian Ocean style)
- Breakage due to chaffing
- Breakage at upper splice
- Hooks and fishing gear in mooring line
- Shark damage
- Use of wire in some mooring designs
- Tangling and fouling of swivels

In order to address these problem areas, the Indian Ocean FAD has been redesigned with the following characteristics:

- Use of multi-strand plaited line for mooring system
- Removal of all metal hardware from upper system
- Nylon line put directly through the surface floats to eliminate multiple splices and connections
- Insulation hose used inside floats to minimize wear
- Use of insulation hose on upper mooring system to protect mooring line from hooking and shark damage

Figure 10(a) shows an Indian Ocean style FAD with concrete anchor (13) with 12 strand plaited rope (6) and the removal of all galvanized steel hardware from the upper mooring system. This eliminates wear, corrosion and tangling of shackles and swivels. The use of small purse seine floats (4) between hard plastic pressure floats (3) also helps to reduce wear and friction. **Figure 10(b)** shows a similar system with a lighter grapnel hook and pipe anchor (13, 12) with the addition of a plastic hose sheathing (3) used to protect the upper mooring from hooks and shark bite and the line from abrasion by the floats. A surface flag and light mast is not shown but should be added to the system.

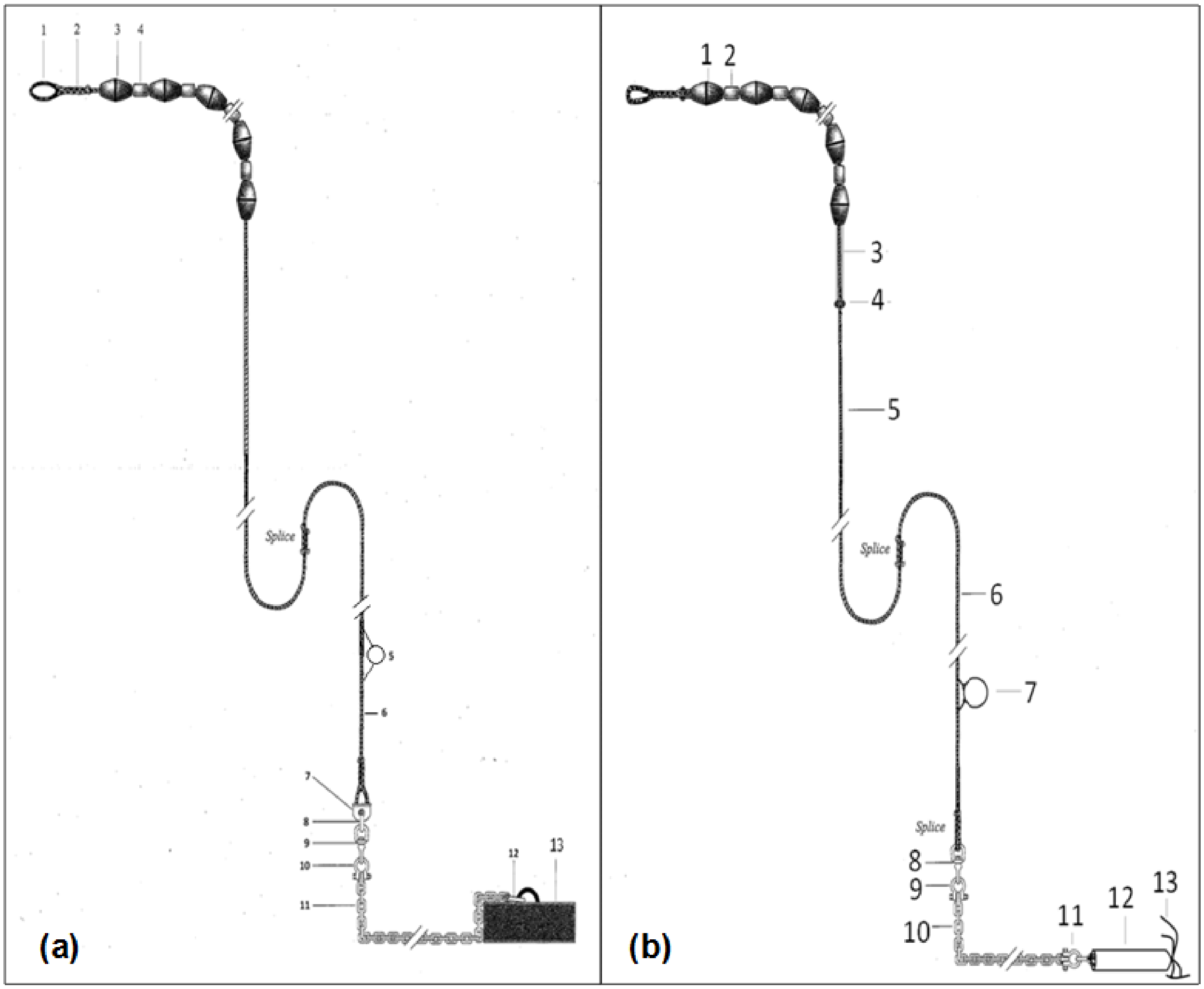

Figure 10. Recent improvements to the Indian Ocean style FAD

C.1.4 ***Subsurface FAD designs***

Subsurface FADs are known to have increased longevity due to low impact or wear of surface components but are difficult to deploy at the desired depth below the surface. Also, they can be difficult to locate without GPS and can be subject to movement and submersion in strong current situations. Deployment position, mooring line length, stretch or shrinkage of the mooring line and the anchor weight/float buoyancy ratio must be calculated precisely for a successful deployment. However, they have proved to be very successful aggregators of pelagic and lagoon fish in certain situations, particularly at shallow to medium depths (<~500m). It was recommended that subsurface FADs be deployed so that surface FADs end up around 20 m below the surface with floats pressure rated to 300 m. However, it was noted that subsurface FADs with the float at 60 m still aggregate successfully.

SPC is now promoting a combination surface/subsurface FAD that has floatation added to the mooring system below an Indian Ocean style float that provides added buoyancy and security in the event that the surface floats lose buoyancy over time or are lost.

SPC has been working on the development of useful subsurface FAD designs, recognizing that subsurface FADs eliminate three major problems:

- Vandalism
- Risk of collision and entanglement
- Stress on mooring line due to wave action and storm events

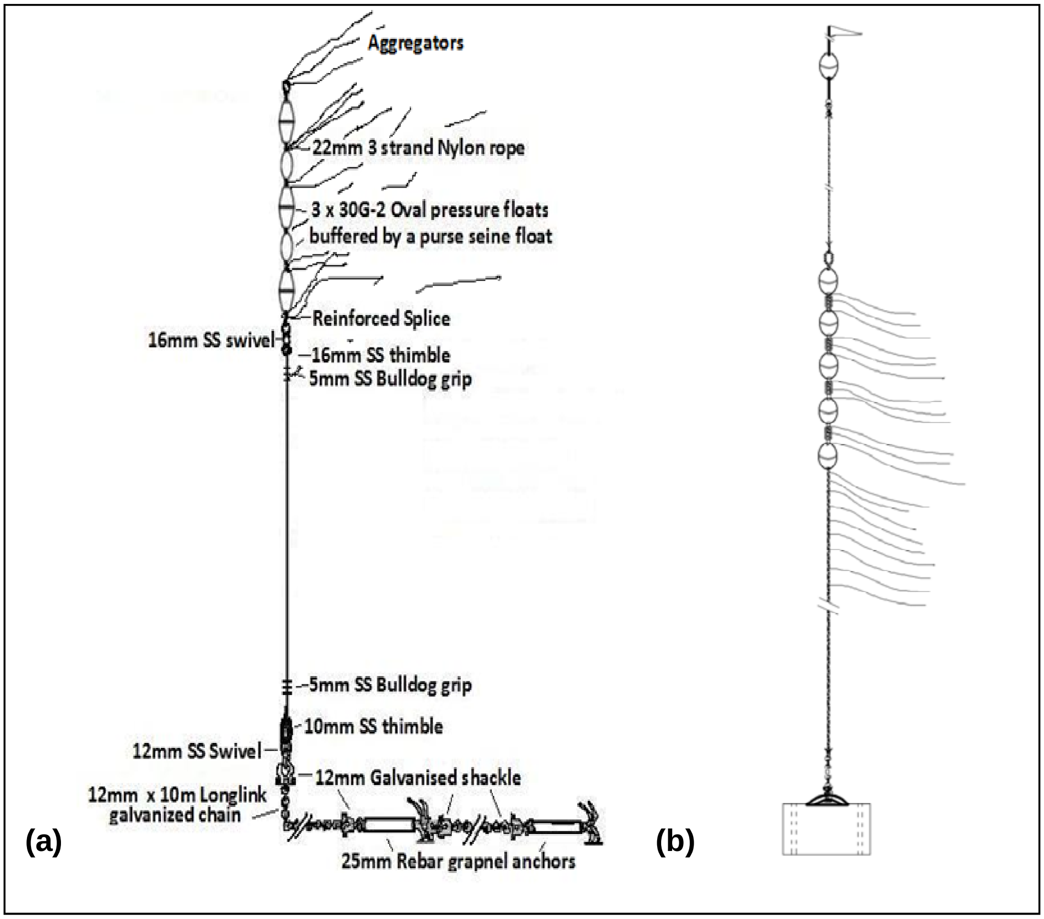

Figure 11. Subsurface FAD components (a) and subsurface FAD with a surface marker (b).

Figure 11 shows two SPC subsurface FAD designs used for nearshore and lagoon style FAD applications. **Figure 11(a)** has no surface indicator while **Figure 11(b)** has a surface flag buoy to assist fishermen in locating the FAD. There may be additional aggregation benefits of having a surface float. Aggregators are shown attached to the main mooring line and between floats.

Figure 12 shows another style of subsurface FAD modified from a Japanese design. The flotation consists of pressure floats that are readily available wherever tuna longline vessels unload and a steel and mesh framework to hold the floats. Rope aggregators can be added. The SPC and other organizations have tested subsurface FADs in Pohnpei, Fiji, Tonga, Samoa and New Caledonia. They have proved to be very effective at aggregating pelagic fish at a relatively low cost.

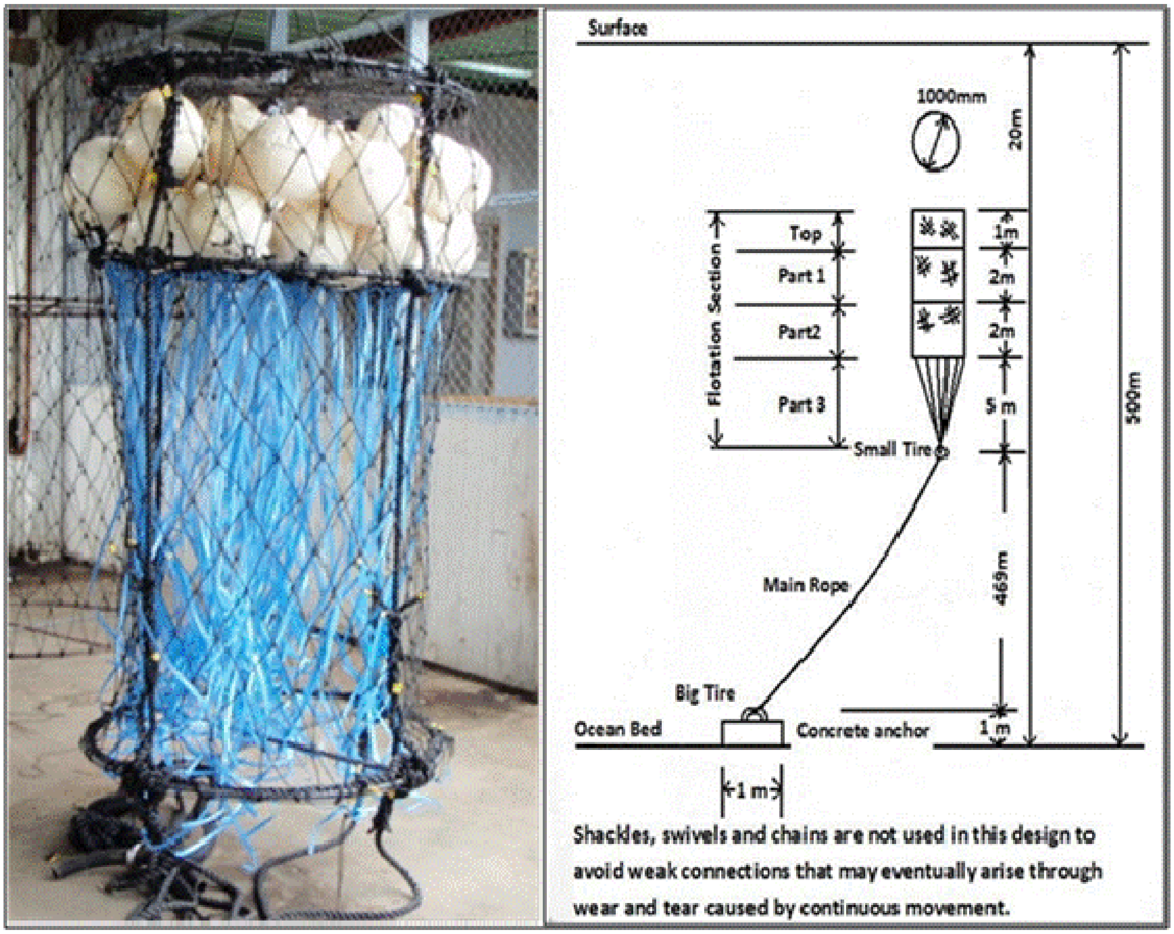

Figure 12. Experimental subsurface FAD modified from a Japanese design.

C.1.5 ***Modifications to Spar buoys and anchors***

Spherical steel floats as are used in Guam and Hawaii have a high positive buoyancy but also have strong resistance and drag in situations of large swells and high current. Some areas are now using tear or oval shaped floats that reduce drag but also risk submersion if currents are exceptionally strong (**Figure 13(a)**).

Massive weight concrete anchors have also been modified with the addition of holes that speed the descent of anchors during deployment (**Figure 13(b)**).. It is thought that an anchor that descends quickly can be more accurately deployed. This is important in areas of high relief and steep terrain as is common throughout Oceania. The holes are thought to help to lock the block in place on the bottom.

The group discussed the merits of steel anchors, noting that steel retains .87 of its weight in seawater while concrete retains only .43 of its weight in air. Steel danforth, workboat or navy type stockless anchors have much greater holding power if combined with adequate lengths of chain. Steel anchors also take up less space making them easier to deploy from small vessels and some can be disassembled for easier handling and transport to the deployment site. Grapnel anchors with adequate amounts of chain were also suggested as being useful for some situations.

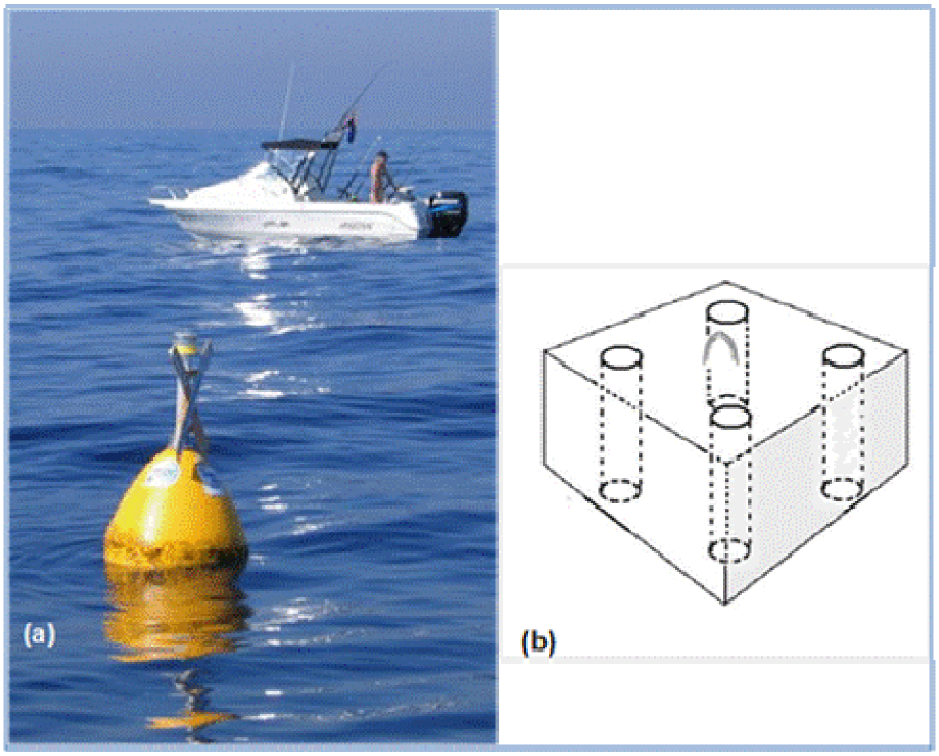

Figure 13. Oval shaped FAD for reduced current drag and holes placed in cement anchor to speed descent

C.1.6 __Aggregators beneath FADs__

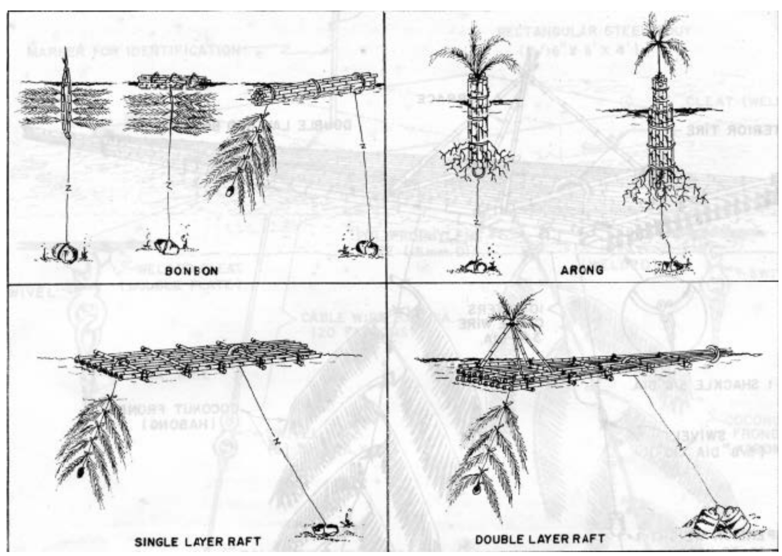

Figure 14. Philippine anchored payaos with coconut frond appendages (DeJesus 1982)

Suspending coconut fronds beneath anchored payaos has been standard practice in the Philippines where anchored FADs were first developed on a large scale to assist coastal and pelagic fisheries (**Figure 14**). Many natural or synthetic materials have been used by FAD programs in the belief that they can enhance the attraction of baitfish, tuna and other gamefish to FADs. There is no quantitative scientific proof that aggregators enhance FAD production but many FAD programs continue to deploy aggregators beneath FADs. Despite the lack of statistical verification of their efficacy, the SPC FAD program and experts feel that aggregators are beneficial to the aggregation process, particularly during the initial recruitment phase and continue to include them in FAD systems.

Natural aggregators include coconut fronds, palm leaf, dried pandanus leaf and natural rope fibers. Synthetic materials have included polypropylene or polyethylene rope, plastic strapping, woven poly strapping and plastic sheeting.

A study was initiated in 1985 in American Samoa to evaluate the effectiveness and longevity of different drape materials uses in conjunction with catamaran style FADs and to conduct visual survey and test fishing on FADs with or without appendages (Itano and Buckley 1987). Fish abundance near the FAD was initially conducted on SCUBA gear with the support vessel tied directly to the FAD. This methodology was modified as it was found the SCUBA gear discouraged the approach of large pelagic species and the vessel disrupted the associated baitfish community. Visual census with the support vessel drifting away from the FAD using trained observers on snorkel gear were able to observe wahoo, mahimah, tuna and porpoise at close range and the baitfish appear to behave more naturally than when SCUBA divers were present.

Figure 15. Catamaran style FAD float in American Samoa, c. 1986. Note polyprolylene strapping appendages buckled to chain links.

Natural and synthetic materials were attached directly to the 50 ft (15m) stabilizing chain below the FAD float: polypropylene, nylon, sisal and manila rope, 2” wide woven poly strapping and ½” wide poly strapping. The ropes were tied to individual chain links while the poly straps were tightly buckled to chain links with poly buckles supplied by the manufacturer (see **Figure 15**).

All materials appeared attractive to the baitfish species in comparison to bare chain with an apparent preference for the poly rope material. Nineteen species of fish were regularly observed in association with American Samoa FADs with the highest biomass of “baitfish” consisting of juvenile jacks (*Caranx sexfasciatus*), bigeye scad (*Selar crumenophthalmus*), opelu (*Decapterus macarellus*), driftfish (*Psenes cyanophrys*) and rainbow runner (*Elagatis bipinnulata*).

It was not possible to statistically verify that appendages enhanced the aggregation of small baitfish species or improve troll or handline CPUE due to the experimental design and variability in the oceanic environment. FADs equipped with or without appendages were spatially separated and observations and test fishing were therefore confounded by variability in tuna and baitfsih abundance by area, season, the time of day and the loss of some test FADs during the experiment. Despite the fact that these studies could not statistically quantify enhanced aggregation, the fishermen lobbied strongly for their use. The program compromised by evaluating appendages to select materials with high retention and longevity with low drag characteristics.

Dive observations confirmed that manila and sisal rope became entangled tightly around the mooring chain after only 3 – 4 weeks and were missing after 1.5 – 2 months. Polypropylene appendages were made by unlaying 1" diameter rope to its three component strands. Two meter sections were tied to every other chain link in the 50' section. These eventually wore through due to the constant vertical motion of the FAD and broke loose after 6 – 7 months. Polypropylene strapping buckled to the chain links were observed to be in place and in good condition after 16 months but were mostly missing after 24 months. The material by then had become very brittle, presumably due to ultraviolet degradation. The strapping did not appear to create significant drag on the mooring system and this material was adopted for use by the American Samoa FAD Program.

Another appendage attachment method was developed by weaving 10 foot sections of poly strapping through a 50 foot piece of 1" diameter, 3-strand nylon rope with eye splices on both ends. This produced a section of line with 5 foot streamers similar to that pictured in **Figure 16**. This rope was shackled to one pontoon of the catamaran FAD float and bottom of the 50' chain that could be attached, replaced or removed by SCUBA equipped divers (Itano and Buckley 1987).

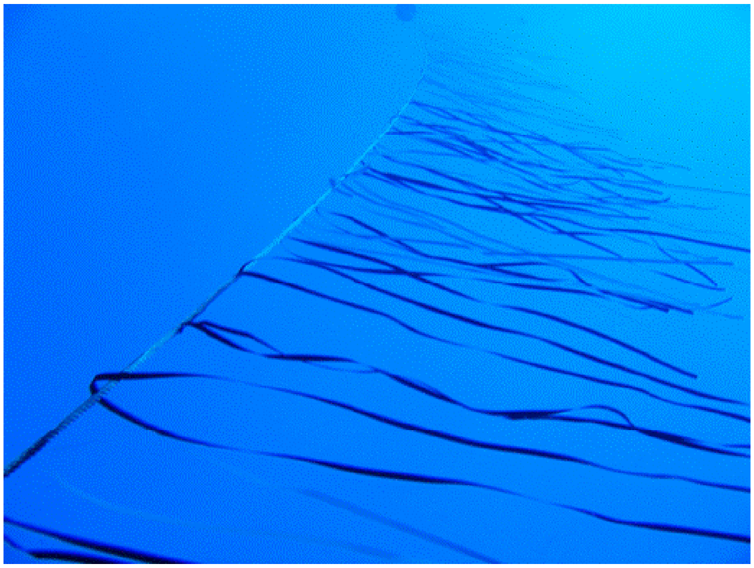

Figure 16. Poly straps woven into 3-strand rope to serve as aggregators on a sub-surface FAD.

The use of plastic or synthetic materials under FADs is difficult to obtain permits for in the US system due to marine debris and pollution issues. Natural materials are favored by the SPC programs such as coconut fronds tied underneath the FAD.

The SPC recommends attaching natural materials to a separate weighted rope that can be tied to the end float of an Indian Ocean style FAD. This system is used for Philippine style anchored payaos where dried palm leaves are tied in bundles and attached to a 20 – 40m weighted rope (**Figure 17**). These aggregator lines are attached to the back end of anchored payaos and are changed regularly. Tuna do aggregate to these lines as they are transferred to an auxiliary boat prior to the purse seine set to prevent tangling of the mooring line with the net.

Figure 17. Philippine style aggregator line that is suspended from anchored FADs.

C.2 French Polynesia FAD Program – Mainui Tanetoa

Mainui Tenetoa, FAD Coordinator for the Fisheries Department, French Polynesia provided an overview of their program and FAD issues in French Polynesia. The region includes 4 archipelagos with 118 islands where artisanal fishing and FADs are very important to food security and household income. The FAD Program maintains up to 70 anchored FADs in the four archipelagos as indicated in **Figure 14** for the benefit of a diverse commercial and recreational fishing communities.

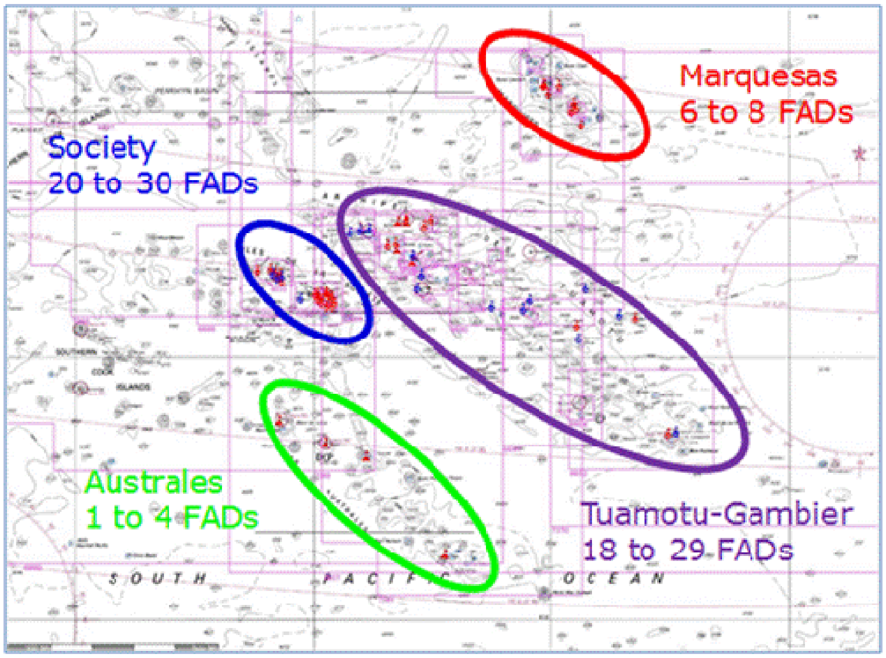

Figure 18. FAD deployment sites in French Polynesia.

C.2.1 ***FAD style and mooring systems***

The French Polynesia FAD deployments began in 1981 with government support, with 357 heavy spar type FADs deployed from 1981 – 2012 (**Figure 19**). Deployment depths range from 100 – 2700 m and 1 – 15 nmi from islands but most FADs would be considered the deepwater, offshore type. As of February 2013, 509 FADs have been set for the benefit of local fishers in a succession of 9 different models at a cost of USD $ 4.5 million since 1981.

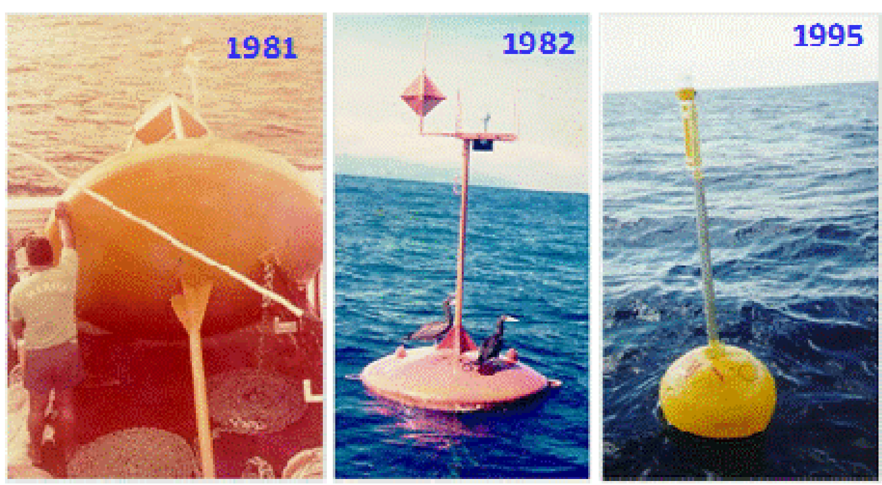

Figure 19. Heavy Spar type FAD floats used in the past in the French Polynesian FAD program.

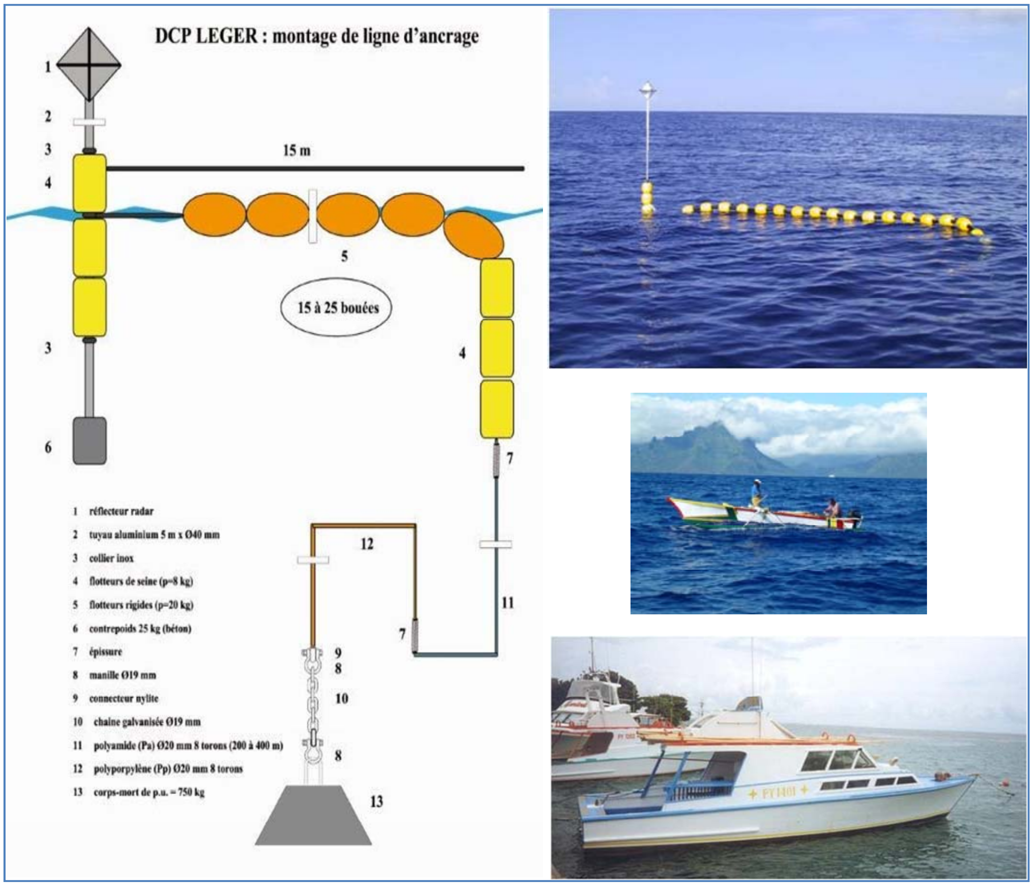

Figure 20. . Indian Ocean style FAD currently in use. An artisanal troll/handline vessel is pictured (right center) and a commercial skipjack pole and line boat (right bottom).

The FAD Program began experimenting with the Indian Ocean style FADs since 2000 <u>which are now used exclusively having replaced the earlier Spar type FAD due to low drag characteristics, extended longevity, ease of deployment and low cost.</u> **Figure 20** depicts the mooring system currently deployed by the program with an artisanal troll/handline vessel and a skipjack pole and line boat (*bonitier or poti auhopu*). These vessel types as well as motorized skiffs (*poti marara*) and a wide variety of recreational/subsistence fishing craft fish on these FADs. **A detailed description of the cost and specifications of all FAD components is listed in Appendix V.**

FAD aggregators are usually installed with the assistance from fishermen and fishing cooperatives.

C.2.2 <u>Fisheries Data Collection</u>

Commercial landings from FAD associated pelagic fisheries is significant but considered significantly under-reported and there is no data available from the recreational/non-commercial sector. The available FAD catch data indicates that 80 – 90% of landings by weight are yellowfin and albacore tuna with small contributions from landed skipjack, mahi mahi and billfish. Commercial deep-drop fishing with vertical longlining near FADs is common and explains the large-size yellowfin and abundance of albacore in the landings.

C.2.3 ***FAD Deployment – remote island situations***

The French Polynesia FAD Program has had to adapt to deployment strategies to accommodate their large EEZ that includes FAD placement in remote island situations where large vessels are not available. An innovative system has been developed that uses a purpose-built aluminum pontoon craft that is transports the concrete FAD anchor to the deployment site. The pontoon craft is transported to remote atolls and islands onboard inter-island ferries or cargo ships (**Figure 21(a)**). The pontoon and anchor are towed to the deployment site by a small fishing vessel that are common on the outer islands that also transports the rope and buoys for an Indian Ocean style FAD mooring (**Figure 21(b)**). It was noted that 5.5 m outboard powered fishing boats can tow the pontoon and anchor at 25 knots and have deployed FADs in 3 m swells. The FAD and line is deployed at the site and attached to the anchor chain. The anchor is deployed last by one person walking to the stern of the pontoon float which tips the craft and allows the anchor to slide off the stern (**Figure 21(c)**).

Figure 21. deployment in remote island situation using a portable pontoon barge that supports the FAD anchor.

C.2.4 ***FAD Maintenance Program***

The French Polynesia FAD Program has been able to extend FAD longevity by implementing a maintenance program of regular visual inspections, repair and replacement of the upper mooring system. Fisheries Department divers survey the floats and upper mooring system on SCUBA and remove tangled fishing lines from hardware and ropes. Tangling by fishing lines and hooking damage is significant in French Polynesia due to high fishing effort using heavy vertical longline and handline gear. Buildup of tangled gear can cause significant drag submerging the buoys and can contribute to FAD loss.

Divers also inspect and install aggregators, reinforce damaged rope and remove coral buildup on hardware and ropes. The upper mooring systems are thoroughly inspected, cleaned and replaced as necessary every 4 – 6 months in the Society Islands and annually in the western Tuamotu atolls and northern Marquesas. This is accomplished with a team of two scuba divers using lift bags to raise the upper mooring system to the surface.

C.2.5 ***Problems, issues and solutions***

Gear related problems include oxidation, wear, bio-fouling and entangling of shackles and swivels, loss of flotation and rope damage by hooks and tangled by large diameter fishing lines. These issues have been well addressed by regular maintenance programs as described earlier. The use of hard plastic pressure floats in place of foam purse seine floats and plastic sheathing for hook protection have also been adopted.

User group conflicts and problems have also been noted that include vandalism (cutting FADs loose), entanglement by horizontal longline gear and mooring of fishing boats to the FAD floats.

D. WESTERN PACIFIC REGIONAL FISHERY MANAGEMENT COUNCIL'S COMMUNITY FAD PROJECTS

Eric Kingma, Council staff member described the background to and current status of the Council's Community FAD projects. The program developed to address the needs of isolated fishing communities and growing conflicts over access to "private FADs". The state FAD system operates with Sport Fish Restoration Act funds and is primarily a program to assist small boat recreational access to pelagic stocks. This emphasis has created a network of coastal FADs within easy running distance from major ports and small boat ramps surrounding the main Hawaiian Islands.

During the past 25+ years, commercial fishermen have been setting their own privately funded FADs further offshore to aggregate commercial quantities of bigeye tuna which have proved very lucrative during some years. These "private" FADs have been set without federal permitting or Coast Guard approval and owners have attempted to exercise proprietary and exclusive rights on their visitation and use. These issues have lead to aggressive conflict, community unrest and market instability.

In 2006 the Council funded its first Community FAD project in Hana, Maui; an isolated community that is highly dependent on subsistence farming and fishing with limited commercial markets. The community later self-funded their own FADs that became a source of conflict with fishers from other communities. The Council funded two publicly accessible FADs off north Maui and southwest Hawaii Island to mitigate conflict and assist small boat commercial fishermen.

Community FADs were set further offshore and in deeper water than Hawaii State FADs. A voluntary catch reporting program was an integral part of the projects and confirmed that these offshore FADs aggregate higher concentrations of bigeye tuna and larger yellowfin compared to the Hawaii State FADs. Cooperative research with the University of Hawaii was also conducted on the north Maui FADs resulting in several bigeye and yellowfin tagged with sonic tags and one bigeye tagged with a satellite tag.

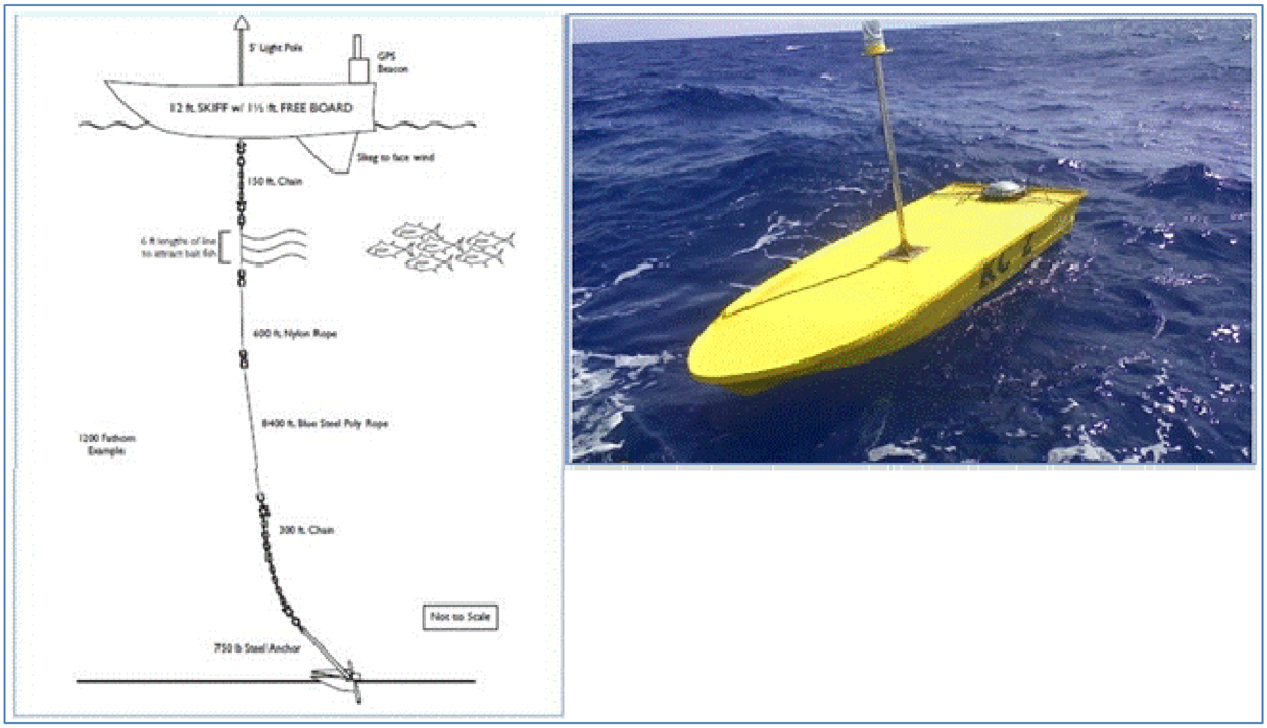

Figure 22, WPRFMC Community FAD mooring system and float. Note GPS buoy mounted in the stern of boat shaped float.

The Community FADs incorporated design elements from private FAD fishers using a foam-filled, boat-shaped fiberglass float with stabilizing keel, long streamers attached 10 – 150 ft from the surface and equipped with a GPS reporting buoy. The system is grounded with a 750 lb Danforth anchor that is easier to transport and deploy while having superior holding characteristics (see **Figure 22**). Approximate cost for one deepwater (>3000 m) Community FAD including deployment is $11,000/FAD.

The goals of the program were to supplement the Hawaii State FAD Program by providing FADs in different areas while allowing experimentation with new and different FAD designs. The objectives of the Community FAD program are to:

- Enhance fishing opportunities
- Reduce community conflicts over FADs
- Test and develop effective and innovative FAD design
- Support data collection
- Support cooperative research

E. FAD RELATED RESEARCH, SMART FADS AND SONAR BUOY TECHNOLOGY

E.1 *Smart FADs*

Jeff Muir, researcher with the University of Hawaii, Hawaii Institute for Marine Biology provided a presentation on FAD electronics and FAD related research. Small solar powered buoys that report precise Global Positioning System (GPS) position, SST and current speed/direction are used by purse seine fisheries to monitor drifting FADs and are now being attached to anchored FADs to assist small boat fisheries. GPS buoys on anchored FADs can reduce search time and fuel costs and assist in the retrieval of FAD that have broken free but are subject to vandalism or theft. A great advantage is the ability to remotely activate a powerful strobe light, allowing fishermen to locate their FAD before dawn.

More sophisticated models are equipped with "sonar" functionality that provides a crude display of biomass intensity by depth. These units can assist in the decision to visit and fish a FAD but are not as reliable as readings derived from consumer grade echo sounders. **Figure 23** shows GPS buoys and a display indicating the trajectories of several GPS marked FADs. The bottom display indicates more than two weeks of biomass estimates from beneath a single buoy. Dark bands indicate night time hours.

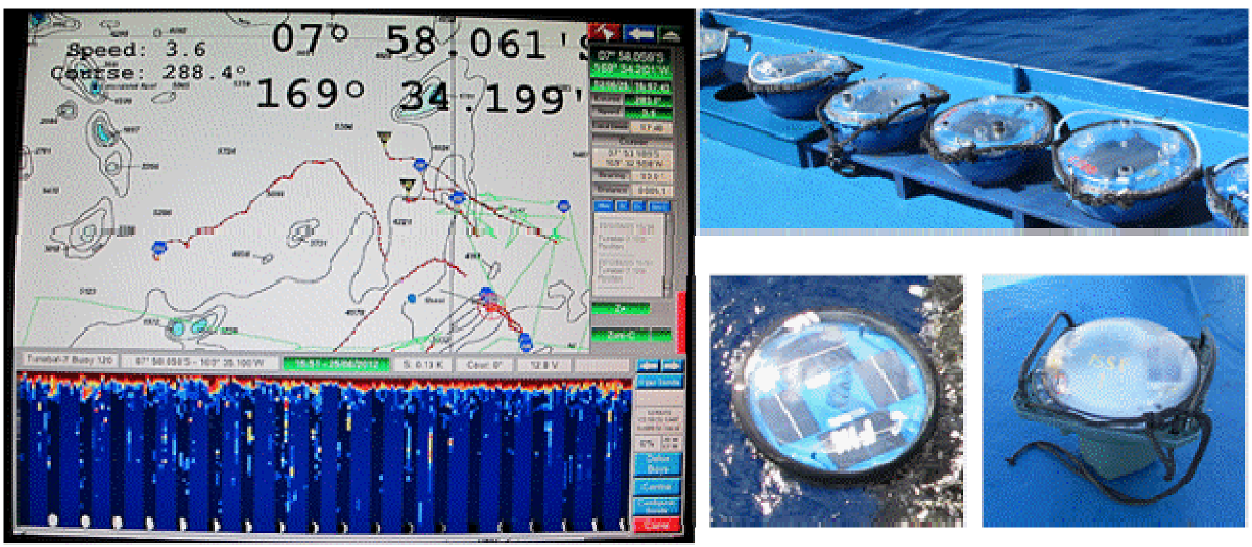

Figure 23. Three models of GPS buoys for FAD tracking and a typical display from a "sonar" buoy.

E.2 *FAD Research*

Researchers have used FADs as a proxy to study how drifting objects can affect behavior of tuna and other pelagic species that has important implications to their vulnerability to fisheries. Previous FAD research has examined questions like: 1) how long do tuna reside at FADs, 2) how vulnerable (to fishing) are tuna and other species at FADs throughout the day/night cycle 3) how does a pelagic fish's behavior change at a FAD, and 4) how does FAD association affect feeding success of different pelagic species?

Anchored FADs provide a fixed point for scientific monitoring equipment and allow an excellent opportunity to obtain time series data from tagged animals at a known location. This is a feature of the Hawaii State FAD program administered by Dr Kim Holland of the Hawaii Institute of Marine biology that has monitored the behavior of tagged tuna, sharks and billfish at Oahu FADs since 2002 using sonic tags and FAD-mounted acoustic receivers. Results from this work have demonstrated that residence time of yellowfin and bigeye tuna can vary between a few hours to several months with most residences averaging closer to one week. Schooling behavior and synchronicity in arrival/departure to a FAD has also been observed in both species, often linked to size specific groups. FAD aggregations appear to be a mix of different species specific schools, each with a different aggregation histories and motivations. Depth reporting sonic tags has verified that FADs have a strong influence on the vertical behavior of yellowfin and bigeye tuna making them easier to target and catch and that vertical behavior varies significantly by size. Yellowfin and bigeye tuna associate closely to a FAD seldom leaving it for more than 12 hours during continuous FAD association and appear to be capable of directed movement to the next closest FAD. **Figure 24** shows the 13 FADs monitored during these studies with insets showing: **(a)** an acoustic depth recording sonic tag and a conventional dart tag; **(b)** insertion of a sonic tag into a juvenile bigeye tuna, and **(c)** a diver changing out a FAD-mounted acoustic receiver 18 m below the surface.

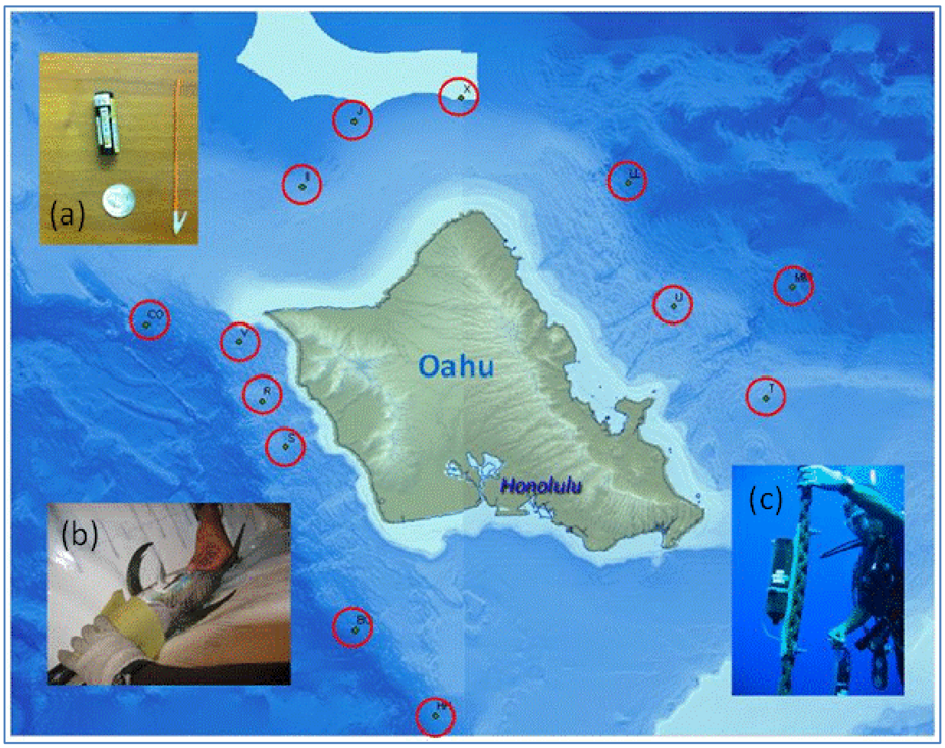

Figure 24. Sonic tag, dart tag and FAD mounted receiver used to monitor pelagic fish behavior around Oahu, Hawaii FADs (a,c). Inserting a sonic tag into a bigeye tuna prior to suturing (b). The red circles represent the area of detection of receivers.

The tagging and monitoring programs indicate high recapture rates of yellowfin and bigeye tuna tagged and released at FADs that provide access of pelagic fish to small boat fisheries. Cooperative research with the WPRFMC Community FAD Project has provided preliminary data from a satellite tagged BET and sonic tagged bigeye around a community FAD, which shows promise for additional cooperative work to assist management of large pelagic fish.

F. DATA COLLECTION AND RESOURCE MANAGEMENT ISSUES

Paul Dalzell, Chief Scientist for the WPRFMC presented an evaluation of the relative performance of the Council Community FAD Project and Hawaii State FADs. The study utilized CPUE and line hour data from the Hawaii State Commercial Marine License (CML) database, comparing catches around the top-ten producing State FADs, the area grids surrounding those FADs and the Community FADs. Despite data issues inherent in the database (under-reporting, attribution by area or FAD association), the results were striking. The catch composition at the top-10 producing State FADs indicated yellowfin, mahimahi and bigeye tuna accounted for 42, 24 and 8% of total catch. Areas with more open water (unassociated) effort were dominated by mahimahi landings (41%) with zero bigeye catch, suggesting that the data is reasonably accurate in relation to allocation of catch to area and FADs. Catches reported for the Community FADs indicated that bigeye tuna accounted for 42% of total catch with yellowfin (27%) and mahimahi (24%) contributing lesser but almost equal poundage. CPUE data indicated Community FAD CPUE in lbs/line hour was much higher than State FADs for these three species and higher overall in pounds/trip (**Figure 25**).

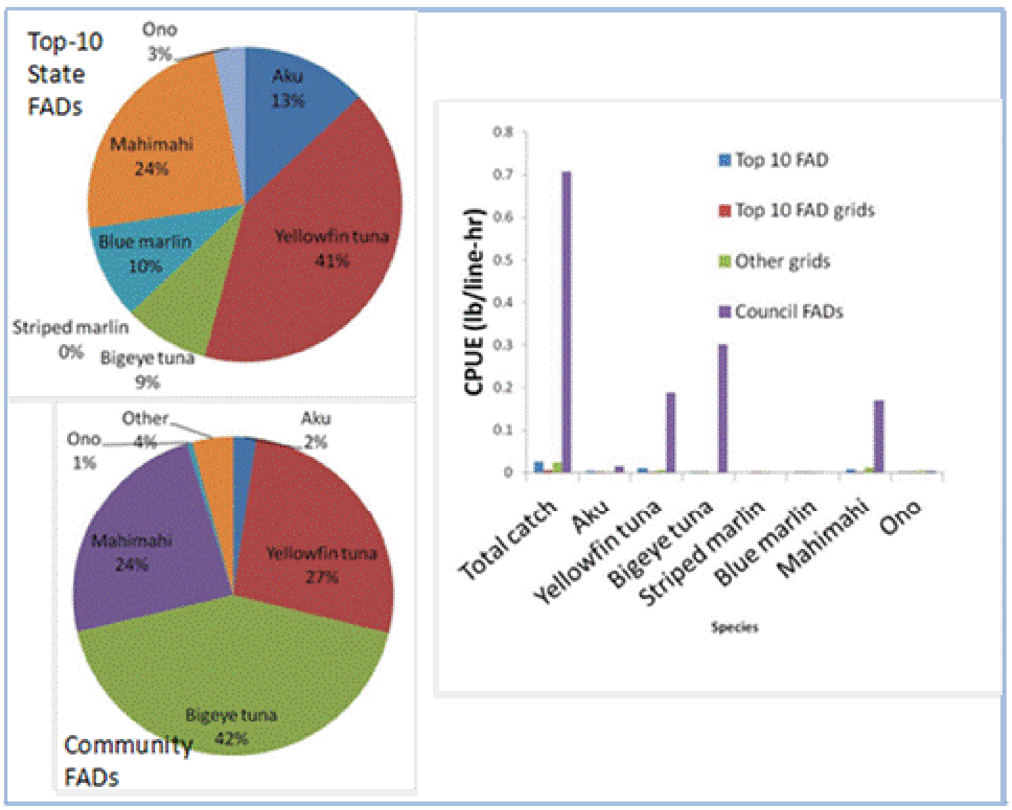

Figure 25. Species composition of catch from the top-10 producing Hawaii State FADs and Wespac Council Community FADs with CPUE data (lbs/line hour).

The conclusion of the study supported high catch rates on the Community FADs, particularly for bigeye tuna and very high total catch per trip realized through increases in catch of bigeye, yellowfin and mahimahi. This may be a function of the offshore location and deep areas of deployment for these FADs. These locations sometimes more than30 miles offshore may not be suitable for recreational fishers but supports the idea that the Community FAD program can augment the State FAD program by assisting commercial fishers and in providing food security for isolated fishing communities.

G. PACIFIC ISLANDS OCEAN OBSERVING SYSTEM, COOPERATION – PACIFIC BUOY PROGRAMS

Melissa Iwamoto, Outreach and Program Coordinator for the Pacific Islands Ocean Observing System (PacIOOS) described the program mission to generate and serve ocean data and information to address stakeholder needs. The program is based in the School of Ocean and Earth Science and Technology (SOEST) at the University of Hawaiʻi at Mānoa and serves the US Pacific Islands region, the US remote insular areas as well as the Marshall Islands, FSM and Palau and is part of the larger Integrated Ocean Observing System and the Global Ocean Observing System. PacIOOS focus areas include marine operations, coastal hazards, marine ecosystems, water quality, modeling, data management, and outreach.

One way PacIOOS generates data is through wave and water quality buoys. PacIOOS currently operates 11 Waverider II Directional Wave Buoys across the Pacific, with another to be deployed off Tutuila, American Samoa in 2013. These buoys measure wave height, direction, period, and water temperature every 15 minutes. PacIOOS also has several types of water quality buoys off Oʻahu and the Big Island that measure various parameters of water quality, such as salinity, temperature, pH, chlorophyll, turbidity, dissolved oxygen, and carbon dioxide.

PacIOOS buoys are supported through numerous partnerships, including the Coastal Data Information Program at SCRIPPS, U.S. Army Corps of Engineers, Joint Institute for Marine and Atmospheric Research, SOEST, National Science Foundation, Hawaiʻi Natural Energy Institute, NOAA National Data Buoy Center, and NOAA Pacific Marine Environmental Laboratory. There are many logistics to consider when deploying these buoys, including cost of buoys and sensors, data telemetry/ collection, maintenance, battery packs, biofouling, recovery, redeployment, and personnel.

PacIOOS serves the data from buoys and other platforms for free on the PacIOOS website. Indeed, data management and visualization services are the core of PacIOOS. One extremely useful tool is the PacIOOS Voyager (**Figure 22**). With Voyager, users can visually explore PacIOOS and partner data on an online map. Users can also download subsets of data directly from the interface and share their maps with others. Voyager contains a wide array of geospatial data, including recent, historical and forecast data, and new dynamic and static data layers are frequently added.

It was suggested that the FAD programs and PacIOOS should explore avenues of collaboration such as to provide space under FADs for carrying data sensors in return for funding assistance for deployments. Fishers were also encouraged to operate with caution near data buoys due to the risk of entanglement and damage to expensive sensor arrays.

For more information on PacIOOS, go to http://pacioos.org or contact Melissa Iwamoto at (808) 956-6556 or melissa.iwamoto@hawaii.edu.

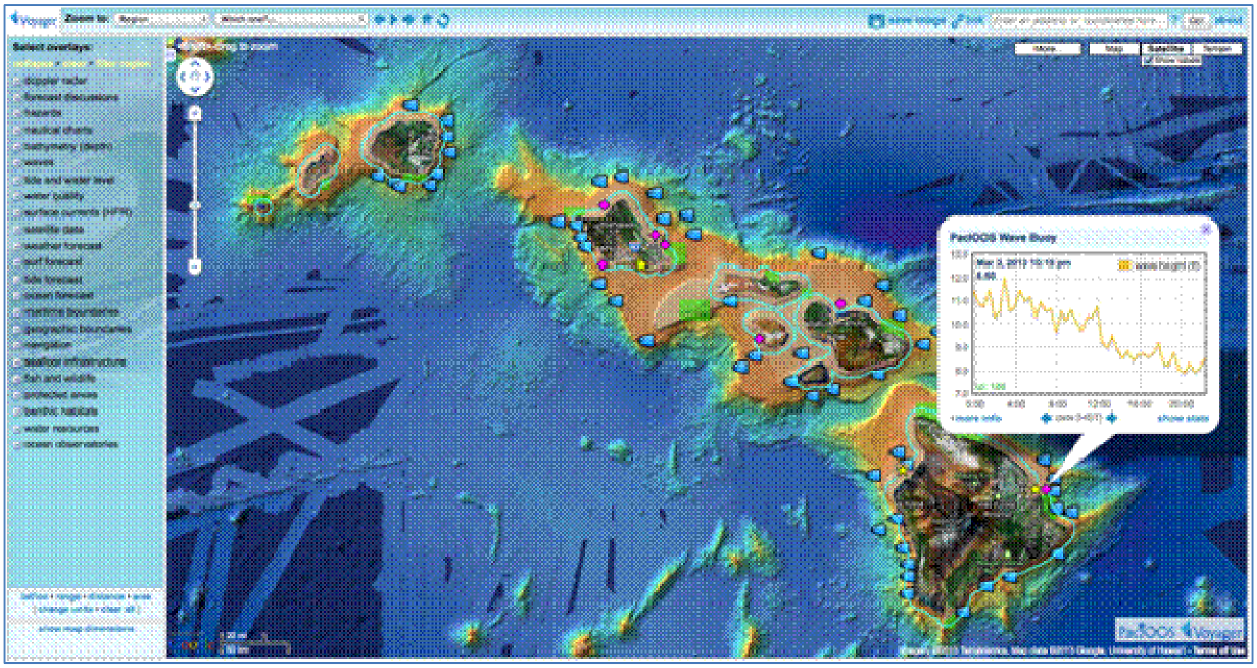

Figure 26. Screenshot from PacIOOS Voyager with several layers active, including high resolution bathymetry, PacIOOS wave buoys (purple diamonds), PacIOOS water quality buoys (yellow stars), bottomfish protected areas (green boxes), 3-mile line.

H. FAD DEPLOYMENT, DESIGN, MONITORING AND FUNDING – DISCUSSION AND RECOMMENDATIONS

The final sessions of the workshop concentrated on discussion and recommendations for adopting new mooring and design technology, reducing costs and improving FAD longevity while promoting the collection and analysis of catch/effort data and collaboration with other programs. A summary of recommendations by category arising from the presentations by FAD experts and group discussion are presented below. Note that the categories are not mutually exclusive as some recommendations may apply to more than one category of improvement. Also, some recommendations will require more expensive hardware which can counter cost-saving measures but may extend overall FAD longevity.
It should be noted that the SPC has published a FAD manual specific to improvements to FAD designs and low cost mooring systems (Chapman et al 2005).

H.1 FAD Design Improvements

1) Improvements to FAD Floats

a) Develop and test tapered float styles that reduce drag and shock load of wave action on upper mooring hardware (shackles, swivel, and chain).

b) Locally construct foam-filled fiberglass floats which are easier to transport and deploy with smaller vessels and avoid time and expense of importing steel buoys.

c) Design FAD floats with a stabilizing fin to reduce spin and twisting of upper mooring system

2) **Improvements to Mooring System**
   a) Use multi-strand nylon and poly ropes instead of 3 strand twisted rope for added strength and reduced problems with twisting and “hockling” of line.

   b) Attach pressure float to mooring system near anchor chain to assist in floating chain off the bottom to reduce wear and tangling on rocks. Tie float close to line to avoid tangling.

   c) Avoid the use of counter-weights in the middle of mooring line system that can contribute to tangling of mooring system.

   d) Experiment with shock absorbing device in upper mooring system to reduce strain and shock on swivels and shackles.
      i) Note: Philippine anchored FADs use automobile tires to attach the FAD float to the mooring line that provides some give and shock absorbing qualities.

3) **SPAR type FADs with stabilizing chain**
   a) lengthen upper chain section at top to 150 ft if/where vandalism is a problem (intentional cut-offs or theft)
   b) Install bypass or breakaway safety chain to areas prone to wear (suggested but not proven)

4) **INDIAN OCEAN type FADs**
   a) Eliminate chain, shackles and galvanized steel hardware from the upper mooring system below the float. Use nylon rope.
   b) Sheath upper rope section with plastic hose to reduce wear from floats and protect rope from hooking and shark damage
   c) Use hard plastic pressure floats at surface that will not lose buoyancy if the mooring system submerges during periods of heavy current and swell.
   d) Place foam purse seine floats between hard plastic pressure floats for padding and shock absorption.
   e) Install sub-surface floats in the mooring system in addition to surface floats to improve buoyancy and save the system if the surface floats are cut off or lose buoyancy **(see Figure 10**)

5) **FAD ANCHORS**
   a) Install holes in concrete anchors to reduce water resistance to improve deployment site accuracy.

   b) Avoid putting steel inside concrete block anchors as they will contribute to cracking and failure due to rust and expansion.

   c) Recommend using steel anchors which have higher holding power for less weight allowing deployments by smaller craft, such as Danforth, workboat or Navy type anchors.

      i) Note: concrete has only 43% of its weight in water while steel retains 87% in water.
      ii) Note: some danforth or workboat type anchors are easy to disassemble making each part easy to lift and transport to the deployment site using smaller vessels.
      iii) Try designing steel anchors with prongs on either side with low bulk, high holding power, and hinged to improve holding at higher different angles with less chain.

   - iv) Note: Steel anchors can be constructed of surplus scrap steel which is free and readily available in many islands areas.

6) SUBSURFACE FADS

- a) Advantages
   - i) Long deployments due to low stress and wear of surface components
   - ii) Vandalism-free
   - iii) No chance of mooring line entanglement due to taught line design.
   - iv) Should be set around 20 m below the surface

- b) Disadvantages
   - i) Difficult to set properly to settle at correct depth from surface
   - ii) Can lean over in current
   - iii) Can be difficult to locate without GPS or echo sounder

7) FAD Aggregators

- a) Use biodegradable and natural materials whenever possible.
- b) Utilize low drag designs that do not compromise mooring system
- c) Use systems that can be added, replaced or removed easily (see **Figures 16, 17**)

H.2 ***Increasing FAD longevity***

1) Evaluate drag and stress factors for FAD floats and system using test tanks and simulated current speeds.

2) Conduct thorough surveys of FAD deployment sites with high quality echo sounder to map out the surrounding area to avoid "holes" and identify areas with low relief with slope less than 30%.

3) Do not rush deployments. Wait for good weather and sea conditions.

4) Implement a FAD Maintenance Program
   - a) Develop a routine schedule to dive and visually inspect the condition of the upper mooring system and remove tangled fishing gear.

   - b) Replace the upper mooring system as necessary.
      - i) Can be accomplished using divers, slings and a large vessel equipped with winch, or
      - ii) Can be accomplished using divers and air lift bags to raise mooring system for changeout

5) Increase the size/thickness of galvanized steel hardware in the upper mooring system.
   - a) Note: most verified mooring system failures occur in the upper system close to the surface where shock loads occur from swell action.
   - b) If a maintenance program cannot be implemented, using larger shackles and swivels may be useful alternative.
   - c) Note: Need to devise or fabricate a strong connection between chain links and larger shackles.

6) Experiment with new materials or components
   a) Cover mooring lines with plastic hose or sheathing at vulnerable points to reduce wear and protect from hooking and shark damage.
   b) Try new synthetic fiber ropes like Dyneema for shallow water FADs or for components of FAD mooring systems.
   c) Note: avoid the use of stainless steel or galvanized cable in the upper mooring system that have been seen to kink, twist and contribute to galvanic corrosion of mooring systems.

H.3 ***<u>Improving FAD Deployment procedures – reduce expenses</u>***

1) Use portable, purpose built catamaran barge for anchor deployments
   a) Can be towed at high speed to deployment site at low cost using small vessels.
   b) One-time construction cost.
   c) Can be transported to remote locations on cargo vessels.

2) Use modular steel anchors that can be disassembled for easy lifting and transport and have higher holding power and weight in water than concrete anchors

3) Develop a sensible bidding process for awarding FAD deployment contracts on a competitive and cost-effective basis. Avoid single-source bidding.

4) Utilize free labor and expertise of Fishermen's Cooperatives and fishing clubs with vested interest in assisting the FAD fabrication and deployment process.

H.4 ***<u>Improving FAD Catch and Effort Data</u>***

1) Hawaii Commercial Marine License (CML) reporting requirements and design

   a) Reduce size of CML recording book to ease use and storage onboard vessels.
   b) Add data for weight categories by species to get better data from the fisheries.
   c) Assign a specific area code for each state FAD to avoid ambiguity with surrounding area code.
   d) Update gear type codes to better reflect the fishing methods taking place on FADs.
   e) Develop a smart phone APP to promote timely and accurate reporting.

2) Link continued support of FAD funding and programs to data reporting requirements.

H.5 ***Community FADs and collaboration with other buoy programs***

1) Pacific Islands Ocean Observing System (PacIOOS)
   a) Explore possibility of deploying PacIOOS data packages on existing FADs and securing funding for additional or replacement FAD systems.

2) Community FAD Programs
   a) Strong support for the development and funding of community FAD programs to enhance food security and provide sustenance and income to isolated coastal communities.
   b) Should supplement existing state/federal FAD programs, not to compete.
   c) Should be developed to evaluate new FAD types, mooring designs and technology.
   d) Communities should be encouraged to raise funds for Community FADs that can be assisted by state/federal agencies for ordering, fabrication and deployment.
   e) Community involvement will promote stewardship, maintenance and longevity of FADs.

The meeting was adjourned at 12:00 PM

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Chapman, L., B. Pasisi, I. Bertram, S. Beverly and W. Sokimi. 2005. MANUAL ON FISH AGGREGATING DEVICES (FADs): LOWER-COST MOORINGS AND PROGRAMME MANAGEMENT. Noumea, New Caledonia: Secretariat of the Pacific Community. 49 p.

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Volume II : Rigging deep water FAD moorings. Noumea: SPC Coastal Fisheries Programme. Capture Section. Fish aggregating device (FAD) manual, vii, 46 p.

Itano, D. and T. Buckley 1987. Report on the Fish Aggregation Device (FAD) program in American Samoa (1979 to November 1987). Department of Marine and Wildlife Resources. Pago Pago, American Samoa. 53 p plus appendices.

Appendix I. Agenda

FAD Issues and Priorities Workshop
NOAA Service Center, Pier 38, Honolulu, Hawaii
February 13 - 14, 2013
Wednesday, February 13th

1:00 – 1:20 Welcome & Introductions – *Kitty Simonds/David Itano*

- Meeting format and outcomes

1:20 – 3:00 Description of existing US FAD Programs

1:20 – 1:45 ***American Samoa*** – *Tee Jay Letalie*
1:45 – 2:10 ***CNMI*** – *Frank Villagomez*
2:10 – 2:35 ***Guam*** – *Jay Gutierrez*
2:35 – 3:00 ***Hawaii*** – *Warren Cortez*

3:00 – 3:15 Break

Regional perspectives on Anchored FADs

3:15 – 3:45 ***SPC*** – *William Sokimi*

3:45 – 4:15 ***French Polynesia*** – *Mainui Tanetoa*

4:15 – 4:35 Wespac Council's Community FAD projects – *Eric Kingma*

4:35 – 4:50 FAD related research, SMART FADs and sonar buoy technology – *Jeff Muir*

4:50 - 5:00 Wrap-up and Adjourn for the day

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Thursday, February 14th

8:30 – 8:50 Data collection and resource management issues – *Paul Dalzell*

8:50 – 9:15 Pacific Islands Ocean Observing System, cooperation and collaboration with other buoy programs – *Melissa Iwamoto*

9:15 – 10:15 FAD Deployment, Design, Monitoring and Funding – Discussion and Recommendations

10:15 – 10:30 Break

10:30 – 11:30 FAD Deployment, Design, Monitoring and Funding – Discussion and Recommendations cont'd

11:30 – 12:00 Other issues of concern – open discussion
12:00 Adjourn

Appendix II. Participants List – FAD Issues and Priorities Workshop (13 – 14 Feb 2013)

Participants List – Recreational (Non-Commercial) Fisheries Roundtable / PI FAD Issues and Priorities Workshop (12 – 14 Feb 2013)

Name	Affiliation	Archipelago, Island or State	E-mail contact	Comments/title
Kitty Simonds	WPRFMC	Oahu	Kitty.simonds@noaa.gov	Executive Director
Sam Pooley	NMFS/PIFSC	Oahu	Samuel.pooley@noaa.gov	NMFS/PIFSC, Science Director
Eric Kingma	WPRFMC	Oahu	Eric.Kingma@noaa.gov	Enforcement/NEPA/International/FADs
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Geoff Walker	fisherman	Hawaii island	geoffkona@hawaii.rr.com	Tuna, bottomfish, mixed gear
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Nathan Abe	Fisherman	Hawaii island		Big island fisherman, tuna
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Pat (Pepe) Conley	August 2013 Summit	Kauai	pepekauai@hotmail.com	troller, bottomfish, Garden Valley Trollers
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Clay Ching	August 2013 Summit	Molokai	hallelujahhoufishing@ hawaiiantel.net	fishing guide, charterboat, mixed fisheries
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Appendix III. CNMI DFW FAD Program Report

Pacific Islands Region
FAD Issues and Priorities Workshop
NOAA Service Center, Pier 38, Honolulu, Hawaii
February 13 - 14, 2013

Title: The Commonwealth of the Northern Mariana Islands' Division of Fish & Wildlife FAD Program
Author (s): Frank Villagomez, Mike Tenorio, and Trey Dunn
Date: February 13, 2013

A) Introduction

(Provide a brief history and status of your FAD program)

The Commonwealth of the Northern Mariana Islands (CNMI) consists of the 14 island archipelago including the 3 Southern islands—Saipan, Tinian, and Rota ranging from approximately 14°N to 20.5°N, 145°E. In 1980 the Pacific Tuna Development Foundation out of Honolulu, Hawaii deployed 5 FADs—2 near Saipan, 2 near Tinian, and 1 near Rota using a 3-drum NMFS design. Within months, all FADs were lost and the 3-drum design was replaced with a 1-drum design. FAD designs evolved over the years from bell buoys to spar buoys. Today the Division of Fish & Wildlife (DFW) Fisheries Research Section (FRS) uses a ~7 foot spar buoy that is tapered on the bottom for stream-lining and a 1 inch keel to keep the buoy from spinning. The keel and stream-lined buoy has improved the lifespan of the FAD significantly, however, more research into longevity is needed.

B) Program overview

Agency and manpower support

The Commonwealth of the Northern Mariana Islands' Division of Fish & Wildlife under the Department of Lands and Natural Resource
-4 Fisheries Biologists
-4 Fisheries Technicians

Funding source and funding level

US Fish & Wildlife Dingell-Johnson Sportfish Restoration Act Grant awarded the CNMI DFW approximately $102,000 for FY2012.

Number and location of FADs (include figures or maps)

There are currently 10 FAD sites with 2 active FADs near Saipan. DFW put out a bid to redeploy 10 FADs to replace inactive sites this year.

This map is not intended for navigational use.

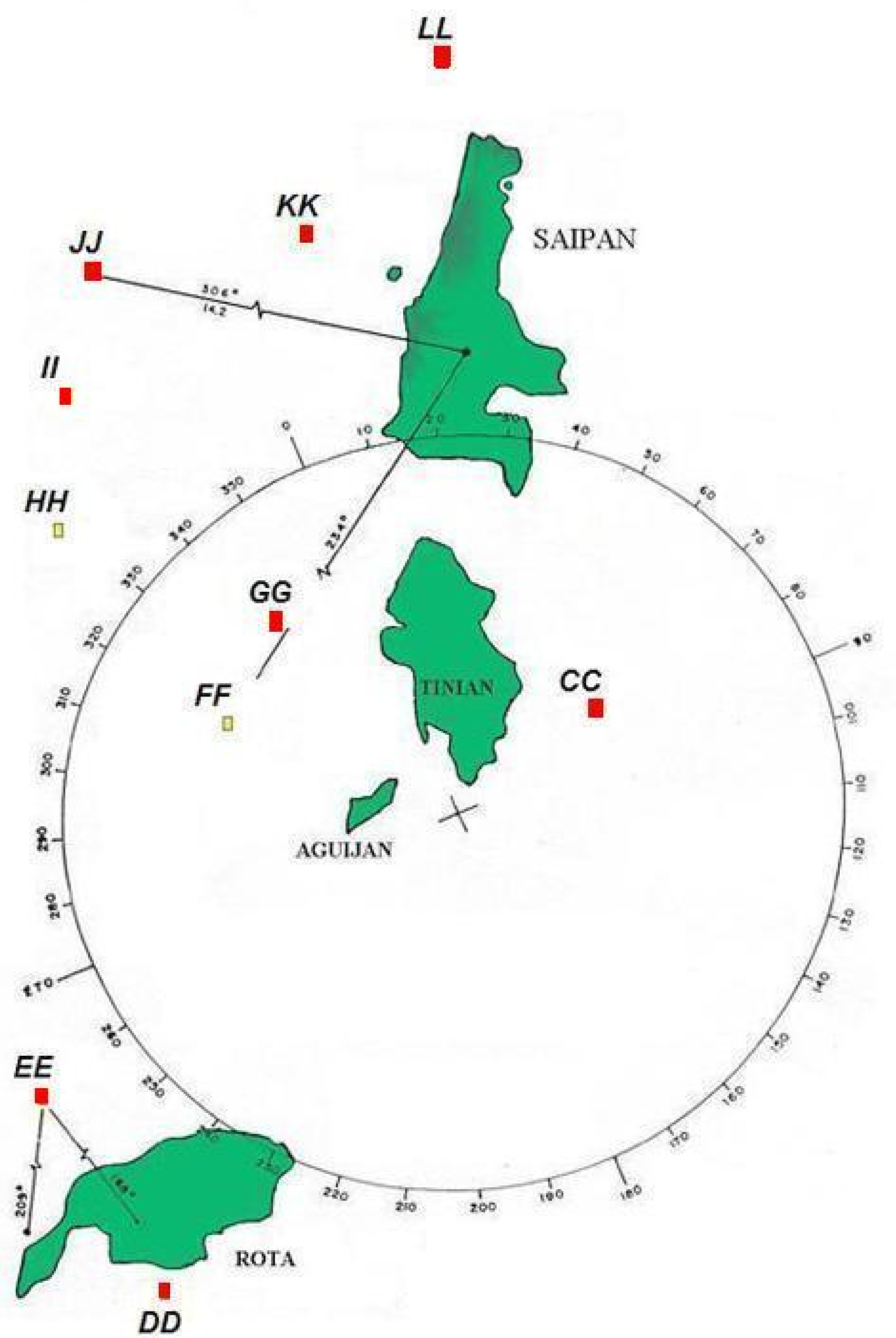


Figure 1: Illustrated positions of FADs with position markers as of February 11, 2013. Yellow represents active FADs. Red represents missing FADS.

Deployment depth range (ft/m)

Table 1: Bottom Depth of CNMI FAD Sites. Coordinates are set in WGS84 datum. Units are in Degrees, Minutes, and Seconds. Buoys have a drift range of 0.5 nautical miles from coordinates.

SITE	Latitude (D/M/S)	Longitude (D/M/S)	DEPTH (feet)	Depth (meters)
CC	14' 59 30N	145' 43 48E	1740	530.35
DD	14' 05 48N	145' 09 12E	1038	316.38
EE	14' 12 42N	145' 10 48E	1356	413.31
FF	14' 59 54N	145' 27 42E	4080	1243.58
GG	15' 04 36N	145' 32 56E	2646	806.50
HH	15' 09 51N	145' 28 15E	5556	1693.47
II	15' 14 54N	145' 29 47E	4302	1311.25
JJ	15' 19 19N	145' 32 20E	6084	1854.40
KK	15' 17 11N	145' 41 20E	1950	594.36
LL	15' 20 45N	145' 46 00E	1974	601.68

C) FAD Mooring System description

Overview

In the past the CNMI used 3-drum NMFS buoys, 1-drum buoys, bell buoys, nun buoys, spherical buoys, and spar buoys. Previous buoys had a lot of drag, thus prompting the Fisheries Research Section to develop a more stream-lined spar buoy that included a keel to prevent the mooring rope from twisting. The stream-lined FAD also suggested that a lighter anchor (2 tons to 1 ton) would be enough to keep the system in place. The anchor was originally cylindrical in shape, but later evolved to a square-based pyramid shaped anchor.

Float type and construction

(Provide a detailed description of any portion of your FAD system that is ABOVE water, i.e. light, radar reflector, mast, floats, metal buoy, fiberglass raft, etc.)

Figure 2 shows the current CNMI FAD design with keel. A contractor fabricated this buoy using 5-ply fiberglass filled with marine foam. The internal structure of the buoy includes a 9 foot, 3 inch diameter galvanized pipe with two angle bars welded and crossed to the galvanized pipe (figure 3). An 18 inch by 18 inch metal support plate is used to replace the 2 in by 2 in plate to fit inside the cylinder. An 8 in by 8 in plate is positioned on the top for the Carmanah marine navigational light model M650 white.

BUOY SPECIFICATIONS

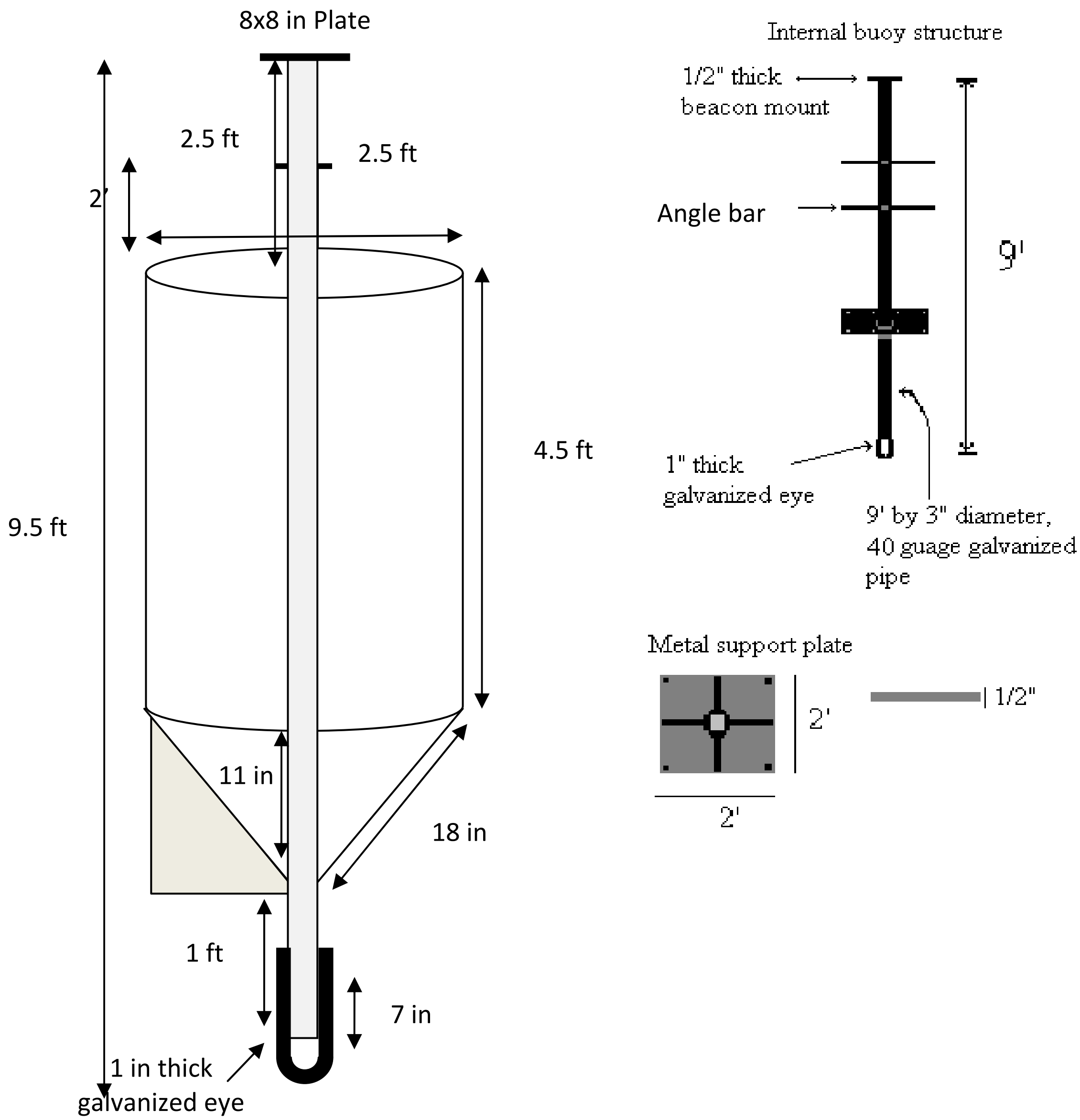


Figure 2: Galvanized pipe and foam filled 5-ply fiberglass buoy

Figure 3: Internal buoy structure with 9 foot, 3 inch diameter pipe and two angle bars for support. The yellow panel is the keel (

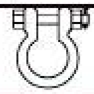
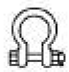
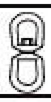
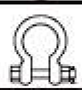
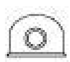
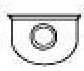
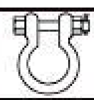
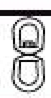
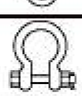
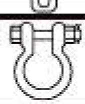
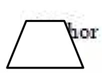
Mooring system description and fabrication

(Describe basic components of your FAD system, referring to a figure or diagram. Describe who constructs the FAD system, how many people are involved and approximately how long it takes to put a FAD system together)

The basic mooring components are adopted from the South Pacific Commission Fish Aggregating Device Manual Volume II Steel spar buoy system components table. Table 2 corresponds to the Figure 4 diagram with few exceptions. Long-link chains were recommended by the SPC FAD manual; however, procuring the recommended 19mm long-link chains proved to be a difficult task. The FRS continues to look for the long-link chains, but also uses a 20 mm open-link chain in replacement. After the improvement of the new FAD designs, the FRS decreased the length of the chain component to decrease the weight on the FAD buoy. Shackle and swivel sizes were increased from ¾ inch hardware to 7/8 inch and 1 inch hardware. Component #12 in Table 2 is eliminated if the shackle fits through the eye and eye swivel.

Two to three fisheries technicians work together in assembling the components and splicing the ropes. It could take half a day to one full day to splice, assemble, and spool one FAD system. FAD buoys are contracted for fabrication and can produce possibly 3 buoys a week, but because it is a contracted they sometimes take up to a month. FAD anchors are also contracted for fabrication and can be ready in 1-2 weeks. The anchors are 16 sq. ft. at the base, 4 sq. ft. at the top, and are 2 and ½ feet tall. They are reinforced with ½" rebar for strength. Each anchor weighs approximately 1 ton (2,000 lbs) and has a 1 ¼" thick anchor eye rebar.

Table 2: CNMI FAD components

Components		Description	Size	Material
1		Safety shackle with stainless steel (SS) cotter pin	25 mm 1 in	Hot-dip galvanised low-carbon steel (Hdg-lcs)
2		Safety shackle with SS cotter pin	22 mm 7/8 in	Hdg-lcs
3		Long-link chain		Hdg-lcs
4		Safety shackle with SS cotter pin	22 mm 7/8 in	Hdg-lcs
5		Forged swivel (eye and eye)	25 mm 1 in	Hdg-lcs
6		Safety shackle with SS cotter pin	25 mm 1 in	Hdg-lcs
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
9		Buoyant rope, 8–12 strand, plaited	22 mm 7/8 in 45 kg/220 m 13.7 lb/100 ft	Polypropylene
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
12				
13		Forged swivel (eye and eye)	25 mm 1 in	Hdg-lcs
14		Safety shackle with SS cotter pin	22 mm 7/8 in	Hdg-lcs
15		Long-link chain		Hdg-lcs
16		Safety shackle with SS cotter pin		Hdg-lcs
17		 hor	900 kg 2000 lb	Concrete block

Mooring system diagram

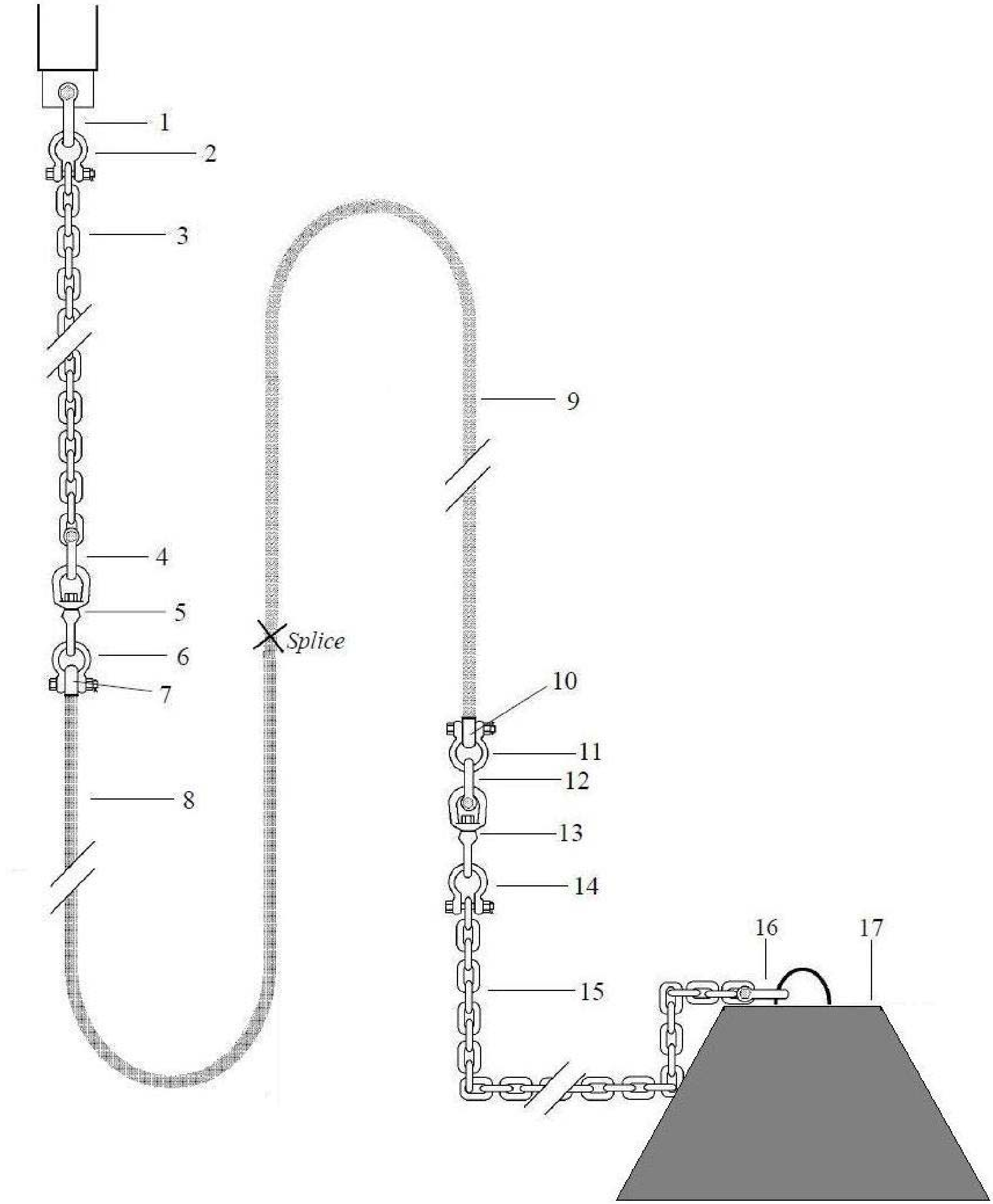


Figure 4: Illustrated mooring system

Component table (Excel Spreadsheet)

(Fill in the Excel spreadsheet supplied with the components necessary for an anchored FAD deployed at depth of 6000 feet (1829 m). Use whatever lines on the spreadsheet that are useful for your system or make your own. Include costs per item or category. For example, you can note total cost of rope, total costs of all hardware, cost of anchor, etc. Tally the total cost for FAD construction at bottom.)

Use of aggregators or other enhancements

(describe any streamers or other appendages that are attached to your mooring system, noting the material, time to apply, cost, longevity and if any studies have been done to determine their effectiveness)

Aggregators were used in the past; however, recent deployments did not include aggregators because of NOAA section 6 concerns. The Fisheries Research Section will look into using natural aggregators such as coconut palm leaves to be attached to the mooring chain.

D) Deployment of FADs

Vessel or anchor floating description

Various vessels have been used to deploy FADs over the years. Anchors are deployed off of large vessels to minimize danger. The most recent deployment contract was awarded to a 62 ft fishing vessel the Tenshou II capable of transporting over 6 tons. This vessel is able to deploy up to 2 systems at a time. Before the Tenshou II, the Micronesian Marine was used for deployment. This vessel has a cargo platform and is able to deploy 4-6 at a time. Deployment vessels are also required to have an equipped depth finder and GPS unit for accurate positioning and deployment.

FAD Gear, rope and anchor preparation and loading

The FRS prepares the rope onto spools to reduce entanglement and for safety issues. The contracted deployment company transports the FAD system from the FRS warehouse to the vessel. The Tenshou II had anchor platforms in the center of the boat, with the buoys secured in the lower deck (Fig. 5). The Micronesian Marine secured the anchors at the stern with the buoys and ropes secured on the deck (Fig. 6). Buoys and anchors are attached onboard the vessel.

Figure 5: The 2010 deployment on the Tenshou II

Figure 6: The 2006 deployment on the Micronesian Marine

<u>Site survey</u>

(Describe how FAD sites were selected and how the area is surveyed prior to deploying the anchor)

Sites were selected using bathymetric maps and areas were surveyed with a depth sounder prior to deployment. Current locations are not resurveyed when replacing FAD systems, but when a depth sounder is available the depth of the site is verified.

<u>Deployment system</u>

(Describe the actual process of deploying the FAD float, chain, line and anchor)

The FRS first confirms the site depth with the 27' Whaler. The FAD buoy is deployed first and towed until the 75% marker, which is tied to the mooring rope, reaches the deployment site. The FRS staff then radios the vessel to release the anchor into the water.

E) Expenses (not including hardware)

<u>Fabrication costs</u>

FAD anchor materials $530 each
FAD buoys net cost was $2580 per buoy

<u>Labor costs</u>

FAD anchor labor for 2 people at 168 hrs was $420 each and $840 total for labor.

<u>Deployment costs</u>

Average deployment cost is $3800-$6026 per buoy according to the 2013 deployment bid.

<u>Other expenses</u>

Include any additional FAD related costs not otherwise included, i.e. gear storage, maintenance, etc.)

Inspecting the FADs by boat can be costly especially if it is unable to be located or lost. Boat inspections are also dependent weather conditions. A contract for aerial surveys with the local helicopter company is in place to quickly locate FADs. $5000 is good for ~3-4 surveys.

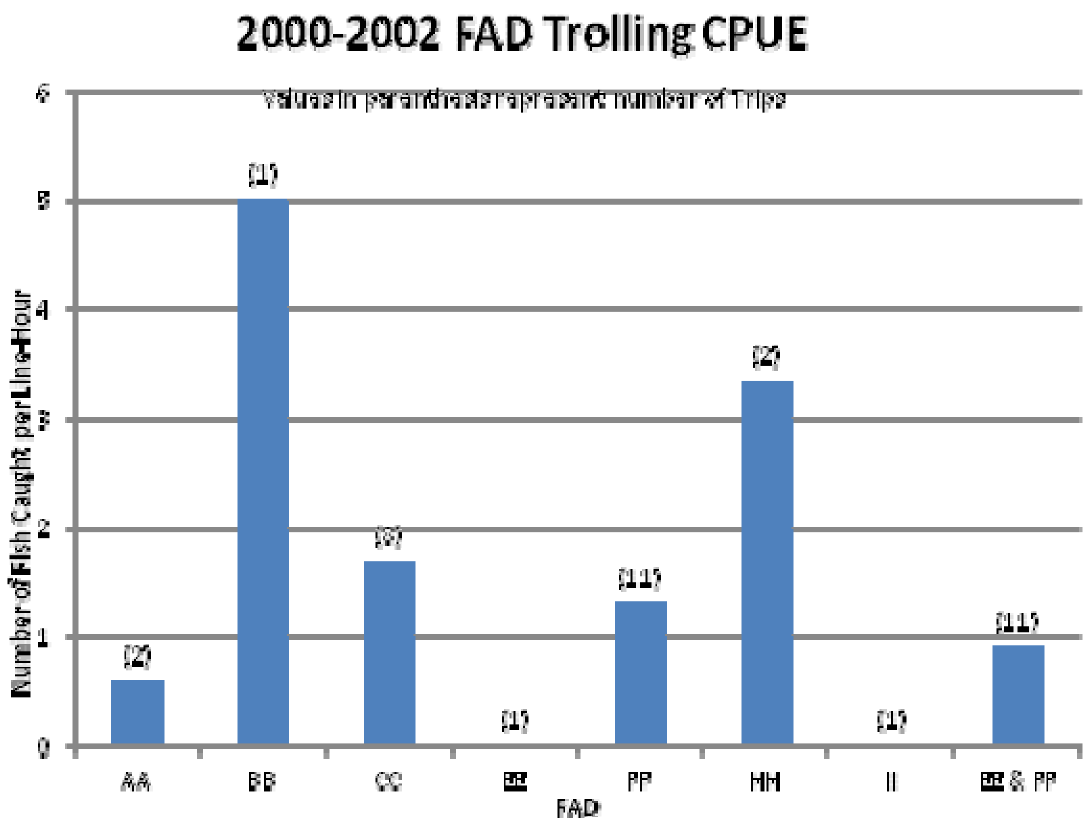
F) Data collection (Describe any past or present efforts to collect FAD specific catch and effort data. Discuss issues, problems, solutions)

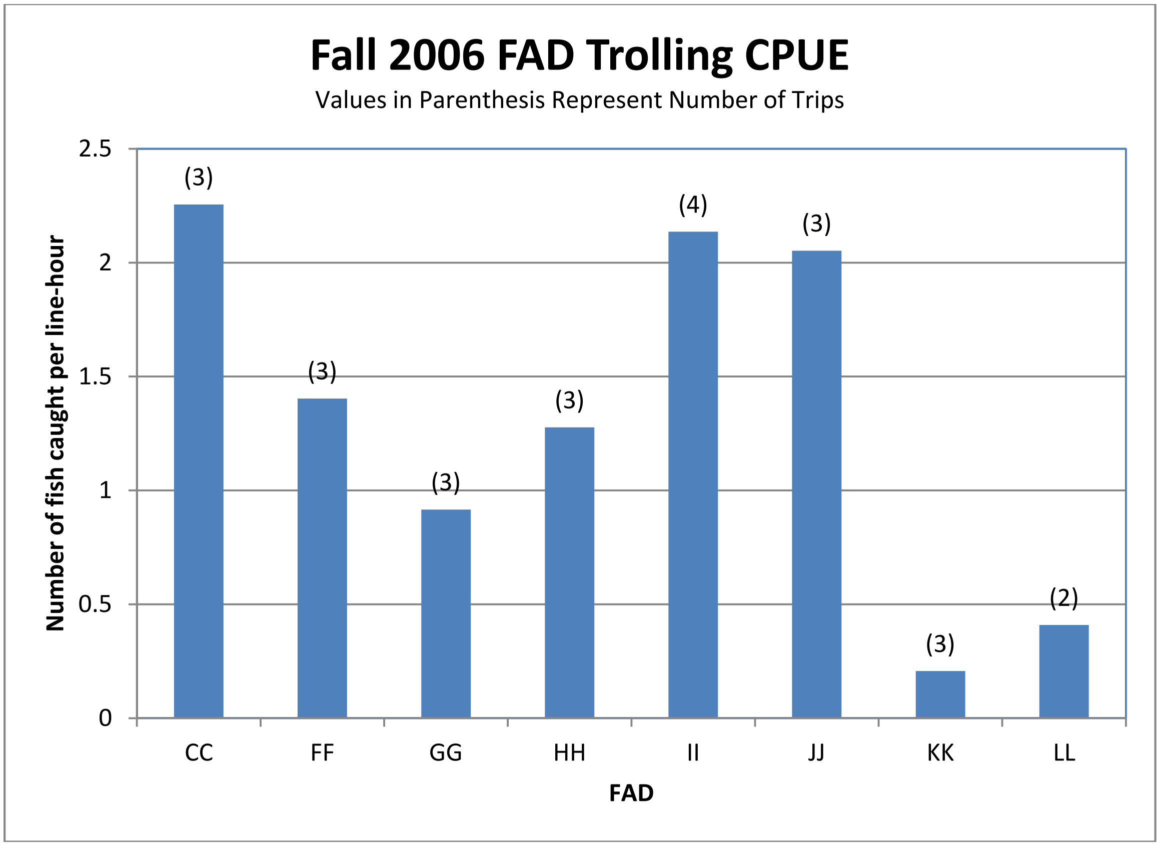
Minimal current effort is focused on data collection. Brief trolling of squid lures is conducted prior to in water visual surveys of FAD buoy and riggings. Catch is recorded. Also visual surveys yield species present in the immediate vicinity of FAD and rigging. Also the DFW boat-based creel survey includes questions about FAD use while fishing.

G) Catch Efficiency (Include available information on catch rates, species, etc.)

Recent data collection on catch efficiency has not been collected; however, effort and catch data was collected by the Fisheries Research Section and SPC personnel in 2001. The CPUE of the combined catches for the vertical long-line was 2.8 fish/100 hooks or 42 kg/100 hooks according to the 2001 Field Report by Steve Beverly, the Fisheries Development Officer.

There was CPUE data recorded in 2000, 2001, 2002 and 2006 (see graphs below). CPUE could also be calculated from the appropriate creel survey participants from 2005 on. This data has not been analyzed yet.





H) Issues, problems, concerns and future prospects (Describe any problems or particular concerns related to the conduct or future of your FAD Program)

The CNMI is dependent on external products, with a majority of its materials being imported. It's location within the region also contributes to the significantly high cost of services and products. Increases in shipping costs ultimately results in increased costs to the consumers. The construction of FADs requires materials that are not readily available in the CNMI. As a result, most of the materials needed for the construction of FADs are ordered from off-island. The CNMI has few vendors who are able to offer services for the procurement of FAD materials. Additionally a majority of them are limited in their abilities to perform the tasks required by the project. The services these vendors offer are usually costly, which consequently forces us to explore services outside the CNMI. A pressing issue in the CNMI is that government payments have been a sluggish, prolonged process which has resulted in many of the vendors being reluctant to offer services to government entities. Additionally, it has also led to the increase in service costs to cover the time it takes for the government to pay its obligations. (DFW Fisheries Research Section 2011-12 Report)

Another issue with our FADs program is that deployment costs continue to increase each year. Companies who are familiar with the deployment process increased their prices. In contrast newer companies who aren't familiar with the deployment process bid low which can force the program to award the cheaper, unskilled company; in the past this resulted in a few lost FADs.

To possibly help alleviate the increased costs of deployment, the FRS will continue to research for new buoy designs for prolonged lifespan of FAD systems and remote satellite tracking of FADs. The use of remote monitoring using GPS integrated technology could possibly cut costs for aerial or boat surveys.

Appendix IV. Guam DAWR FAD Program Report

Pacific Islands Region
FAD Issues and Priorities Workshop
NOAA Service Center, Pier 38, Honolulu, Hawaii
February 13 - 14, 2013

Title: Guam FAD Program
Author (s): Jay Gutierrez/Jamie Bass Department of Agriculture Division of Aquatic and Wildlife Resources (DAWR)
Date: February 13, 2013

A) Introduction
(provide a brief history and status of your FAD program)
Construction of the FADs in Guam began in 1979, initially under funding from the Pacific Tuna Development Foundation, and was later continued as part of D-J Sport Fish Restoration program. By the end of FY83, the 10 FAD systems deployed had been lost primarily due to problems involving mooring system design and materials. The FADs have proven successful throughout the Pacific as well in Guam. Reactivation of the program was seen in FY87. Information provided by the South Pacific Commission (SPC) regarding design improvements on the mooring systems and deployment procedures, have been incorporated to increase the longevity by decreasing premature loss of the FAD system. The design of the FADs changed over the years such to what it is today using a steel spherical buoy with the inverse catenary loop FAD design. The locations have changed over the years also with some locations modified and others added bringing the total to 14 FAD sites (See attached FAD location map – Figure 1)
.

B) Program overview
Agency and manpower support – Department of Agriculture Division of Aquatic and Wildlife Resources (DAWR), mainly two technicians with one technician acting as the program coordinator,
Funding source and funding level - Sport Fish Restoration Program, $204,000
Number and location of FADs (include figures or maps) – 14 FAD sites plus a NOAA wave buoy (See attached FAD location map – Figure 1)

Deployment depth range (ft/m) – 400 fathoms to 1000 fathoms
(a table with this information would be ideal)

C) FAD Mooring System description
Overview – Follow and use SPC Fish Aggregating Device Manual. Use inverse catenary loop FAD design using a spherical buoy deployed between 400 fathoms to 1000 fathoms
Float type and construction
(Provide a detailed description of any portion of your FAD system that is ABOVE water, i.e. light, radar reflector, mast, floats, metal buoy, fiberglass raft, etc.)
60” Spherical 3/16” Gauge Steel Mooring Buoy with PAD Eyes and Light Mast , 36” x 4” galvanized pipe, 2 nautical mile amber 15 FPM navigational light with bracket
Mooring system description and fabrication
(Describe basic components of your FAD system, referring to a figure or diagram. Describe who constructs the FAD system, how many people are involved and approximately how long it takes to put a FAD system together)

See Figures 2 and 3 for basic components. DAWR contracts out the construction of the FAD system to a local company who uses about 2 individuals to construct the FAD, which takes about a day or two. The company transports the FAD systems from the Department to its facility, prepares the FAD buoys by sand blasting, grinding, sanding, as necessary, prior to applying marine grade primer and marine grade epoxy paint, assembles, attaches/welds all components in their proper order and loads the system onto the vessel.

Mooring system diagram
(provide a diagram of your FAD system. This can be hand drawn if a graphic can not be produced)
See Figures 2 and 3.
Component table (Excel Spreadsheet)
(Fill in the Excel spreadsheet supplied with the components necessary for an anchored FAD deployed at depth of 6000 feet (1829 m). Use whatever lines on the spreadsheet that are useful for your system or make your own. Include costs per item or category. For example, you can note total cost of rope, total costs of all hardware, cost of anchor, etc . Tally the total cost for FAD construction at bottom.)
Use of aggregators or other enhancements
(describe any streamers or other appendages that are attached to your mooring system, noting the material, time to apply, cost, longevity and if any studies have been done to determine their effectiveness)
No aggregators or other enhancements are currently being used but have been in the past.

D) Deployment of FADs
Vessel or anchor floating description
Different vessels ranging from 55’ to 65’ are used depending on availability. United States Coast Guard (USCG) inspected vessel capable of transporting over six (6) tons and operate in moderate offshore seas with adequate deck area to safely hold up to two (2) FAD Systems and ropes, chain blocks and/or winches outfitted on vessel to lift and secure buoy.
FAD Gear, rope and anchor preparation and loading
The entire FAD system consisting of the buoy, mooring system (assembled), and anchor system are loaded on board the deployment vessel to allow easy deployment and maximize safety. The anchor system (concrete blocks, chain and connecting hardware) are assembled and connected to the mooring line prior to actual deployment. The 2 ton anchor is placed on the stern on top of metal supports and

positioned at an angle (30-45 degrees) for ease of release. It is secured with line and a quick release mechanism to facilitate a safe and easy release into the water.
The buoy is secured on the side of the boat near the stern. The crate containing the mooring lines is placed behind the anchors. The mooring system is prepacked with the polypropylene on bottom and the nylon on top. The FAD light is also installed prior to deployment. The same procedure for gear setup is used on the other side of the vessel when a second FAD is to be deployed on the same trip.
Site survey

(describe how FAD sites were selected and how the area is surveyed prior to deploying the anchor)
FAD sites were identified based on input from fishermen and if the bathymetry allowed for successful anchor placement, i.e., wide enough and not too close to steep drop-offs. DAWR against convention of having FADs spaced at least 5-6 miles apart to prevent fish from hopscotching from one to another, and opted instead to put more FADs out to spread fishermen around. FAD sites were standardizing to 500 and 1,000 fathoms to make it easier to maintain an inventory of replacement systems. (Andrew Torres per comm.)

Deployment system
Upon reaching the general vicinity of the deployment site, the vessel identifies the actual FAD placement site, buoy drift direction, and checks the depth at the designated site. The buoy (two thirds down current of the FAD site) and anchor (1/3 up current of the FAD site) drop points are determined and programmed into the GPS. Once the hardware connections are checked, the vessel starts deployment at the buoy drop point by releasing the FAD buoy. Once this is done the upper mooring chain and rope are placed in the water while the vessel moves slowly up current towards and past the FAD site. As the vessel reaches the anchor drop point, the chain is deployed and all crew members stand clear, except for the person pulling the quick release mechanism on the anchor blocks. The drag of the mooring line and the weight of the chain is usually enough to pull the anchors overboard from their angled position.

E) Expenses (not including hardware)
Fabrication costs – Included with deployment cost

Labor costs – Included with deployment cost
Deployment costs - $132,000 includes 5 FAD deployments and 2 errant buoy recovery
Other expenses
Include any additional FAD related costs not otherwise included, i.e. gear storage, maintenance, etc.)

F) Data collection
(Describe any past or present efforts to collect FAD specific catch and effort data. Discuss issues, problems, solutions)
Fishing surveys of FADs were conducted in the early 90s as part of an in-house effort to collect data on the effectiveness of each FAD, but were later temporarily discontinued due to a shortage of available man-hours. Fish caught during the survey were identified, measured, recorded, and then released. Compilation of the data collected from DAWR in-house FAD surveys was not expanded due to inconsistent and insufficient data collection.
Other FAD fishing information, usually collected via the offshore creel surveys, were also discontinued in the 90s because the data is now viewed by DAWR as unreliable. One of the major inconsistencies of the offshore creel survey concerns the distinction between when a boat is fishing, or not fishing, a FAD (i.e., upon visual contact, within 100 yards, 1 mile, 2 miles, 4 miles, etc.).
G) Catch Efficiency
(Include available information on catch rates, species, etc.)
NA

H) Issues, problems, concerns and future prospects
(describe any problems or particular concerns related to the conduct or future of your FAD Program)
Procurement, FAD longevity, one vendor deploying, high cost – prohibits restoring inventory on a timely basis, coast guard issues in regards potential discontinuance of permits in Hawaii and Guam.

Figure 2. FAD with Spherical Steel Buoy

Appendix V. Components and cost (US $) of French Polynesia FAD Program – Indian Ocean style FAD.

	1400m long FAD co-financed by the Fisheries and Fishing cooperative							
Component	**Description**	**Material or Type**	**Size**	**Length**	**Quantity**	**Cost each (US $)**	**Total Cost (US $)**	**Comments**
Light	**Solar CH-1 sea light**	**3 Nm**			**1**	**105**	**105**	**Waterproof to 200 feet**
Radar Reflector		**Aluminium**	**1'*1'**		**1**	**55**	**55**	**Locally made**
	Surface Flag Marker	**Aluminium tube**	**40mm**	**6m**	**1**	**140**	**140**	**Aluminium pole with at the top, the light and reflector radar and at the basis, 22 kg concrete block. The buoyancy is assured by 3 * M700 SHE 85 floats**
	Surface Float Raft type							
	Surface Float Indian Ocean Type	**#30G-2ABS**	**20kg buoyancy**		**10**	**45**	**450**	**Limited to 200m deep-**
	Polytech M700 Float	HSE 85	**8,5kg buoyancy**		7	30	210	Used as a buffer and at the curve of the surface float chain (4); 3 are used for the pole flag marker
	8 strands plaited rope	**Nylon**	**24mm**	**30m (100')**	**1**	**150**	**150**	**Spool of 200m long**
Rope Splice								

	8 strands plaited rope	**Nylon**	20 mm	200m	1	770	770	250m more appropiate, Splice directly on nylon of the surface floats chain and polypopylene ropes downunder
	3 strands plaited	**Polyethylene**	20mm	1200	6*200m	150	900	Splice required to connect end to end
	Sampson Nylite rope connector		22mm (7/8")		1	65	65	Used to connect Polypropylene rope to the anchor chain
	Safety shackle(s) w cotter pin	Galvanised	22mm		2	25	50	For connecting both chain extremities to the anchor and PP rope / Cotter pin encourages oxydation process and replaced by 4mm braided rope
	Galvanized chain		20mm	5m	5	62	310	
Cement anchors	**Concrete cement block with a steel rebar loop for connection**	Cement	750 kg (1500 lbs)	75cm*75cm*55cm	1	270	270	Resistance pressure ratio 140kg/cm² for avoiding implosion
					TOTAL COMPONENT COST		**3475**	