Guam Fish Aggregating Device programme

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Abstract

Installation and maintenance of FADs by the Government of Guam began in 1979, initially with funding from the Salstonstall-Kennedy Act through the Pacific Tuna Development Foundation. Current funding for the Guam FAD project is provided through the Dingell-Johnson/Wallop-Breaux Sport Fish Restoration programme, a Federal Aid Project funded by taxes collected on the purchase of fishing equipment and motorboat fuels nationwide. There are now sixteen operational FAD sites in Guam's waters. At a cost of approximately US$ 10,000 per system, concern for the rising costs of replacing and maintaining FAD systems has prompted the Department of Agriculture's Division of Aquatic and Wildlife Resources (DAWR) to investigate alternative FAD maintenance strategies and system design. Several cost-cutting measures being considered include the use of reliable solar-powered navigation lights to reduce the number of maintenance trips required, and switching to a newer generation of lighter, more durable buoys and mooring systems. Average time on station for a DAWR FAD system is nearing two years. Interestingly, in most cases where an errant system is recovered, the failure in the mooring system was observed to occur at a depth from 35 to 500 metres. These observations have led to speculation that additional protection of the mooring line down to 500 m may result in doubling the average time on station of most FAD systems.

Background

Strategically located at 13°28'N-144°47'E, Guam is the westernmost territory of the United States and the largest and southernmost island of the Mariana Archipelago in the Western Pacific Ocean. Shaped like a footprint, the island is about 48 km length with a width ranging from 6 to 19 kilometres. It has a total area of 451 sq. km and a population of approximately 133,000 people (1990 census), the highest densities being concentrated in the northern and central sections. The climate is tropical marine, generally warm and humid with little temperature variation, moderated by northeast tradewinds. There are two distinct seasonal patterns: a dry season that usually occurs from January to June, and a rainy season from July to December. Offshore fishing activity typically peaks during the summer doldrums when sea conditions are calmest.

Centrally situated on the western leeward coast, the Agana Boat Basin serves as the island's primary small-boat launch to fishing areas off the central and northern leeward coast, as well as the northern banks such as Rota and Icebox banks. Situated to the south, the Merizo Pier, Umatac Boat Ramp and Agat Marina serve as launch points to the southern shores and banks like Mile, Galvez, Stu, Baby, Santa Rosa, and White Tuna banks. The Agat Marina in particular, located between the Agana Boat Basin and the Merizo Pier, provides trailered boats from the northern and central portions of the island a closer and more convenient launch site to southern fishing grounds. Plans to construct two additional boat ramps at presently undeveloped eastern launch sites such as Ylig River and Inarajan Bay are currently being considered. If completed, the new boat launches are expected to lead to a significant increase in fishing effort on the eastern windward side of the island.

The estimated number of vessels participating in the pelagic troll fishery has steadily increased from 119 in 1980 to 438 in 1998. A wide majority of the fleet is comprised of vessels less than 8 metres in length and typically owned by recreational-subsistence fishermen who fish part-time and occasionally sell their catch. A smaller segment of the fleet, approximately 6%, consists of charter vessels that are berthed primarily at the Agana and Agat marinas (Anon., 1998).

Annual pelagic landings have varied widely over the years, ranging between 158 and 393 metric tons for the period between 1980 and 1998. Landings consist almost entirely of "mahi-mahi" (*Coryphaena hippurus*), wahoo (*Acanthocybium solandri*), skipjack tuna (*Katsuwonus pelamis*), yellowfin tuna (*Thunnus albacares*), and Pacific blue marlin (*Makaira mazara*). Other landings, to a much lesser extent, include rainbow runner (*Elagatis bipinnulata*), barracuda (*Sphyraena barracuda*), "kawa-kawa" (*Euthynnus affinis*), dogtooth tuna (*Gymnosarda unicolor*), and shortbill spearfish (*Tetrapterus angustirostris*) (Anon., 1998).

Attempts to establish reliable annual estimates of the percentage of the total harvest of pelagic fish attributed to FADs, as well as the percentage of total trolling effort spent working FADs, have been made in the past. However, the results are not conclusive due in part to varying survey methodologies and the inherent difficulties in establishing when a vessel is, or is not, actually working a FAD. There is also the concern of whether a fish caught in the vicinity of a FAD was truly affected by the presence of that system or purely coincidental. This may be the case given the number of FAD sites in the Guam programme today, the area they affect, and the close proximity of the sites. In general, DAWR remains satisfied with the effectiveness of its FADs and does not depend on yearly creel survey results to justify continuation of the programme. For this reason, collection of harvest and effort data around FADs during offshore creel surveys was discontinued in 1993.

Guam's involvement with FADs began in 1979 after the Guam Department of Agriculture's Division of Aquatic and Wildlife Resources (DAWR) received a US$ 21,500 grant from the Salstonstall-Kennedy Act through the Pacific Tuna Development Foundation (PTDF) to construct and deploy several FAD systems. From 1980 to 1982, development of the DAWR FAD project continued utilizing Dingell-Johnson (DJ) Sportfish Restoration funding after the initial PTDF award was depleted. The project then went through a period of relative inactivity between 1983 and 1985 as no new FADs were constructed or deployed after the last of the first generation FADs came off station in 1983. In 1986, the project was reactivated and became permanently funded through the DJ-funded Fisheries Development programme.

Funding

DAWR's ability to continue to operate an extensive FAD programme over the years with little to no local funding has been made possible with federal grants through the Dingle-Johnson/Wallop-Breaux Sportfish Restoration Act. Enacted in 1950 and amended in 1984, this federal legislation captures a percentage of the annual excise taxes collected nationwide on the manufacture, importation and sale of fishing equipment and motorboat fuels. The funds generated are then apportioned to eligible State and Territorial fish and wildlife agencies to strengthen their ability to restore and manage fish and wildlife resources to effectively meet the consumptive and non-consumptive needs of the public for these fish and wildlife resources. Approximately US$ 2.8 billion has been apportioned to State and Territorial fish and wildlife agencies since 1952 (US Fish and Wildlife Services Basic Grants Management Course, Oct. 19-22, 1998). Guam and other insular US territories receive 1/3 of 1% of the total amount of money collected annually, which has yielded approximately US$ 700,000 for Guam each year for the last several years. Of the US$ 700,000 Guam receives annually, approximately US$ 50,000 (7%) is appropriated each year to the DAWR FAD project. From 1986 to 1998, over US$ 620,000 have been spent to establish and maintain the sixteen-site FAD programme that exists today.

History

1979-1983

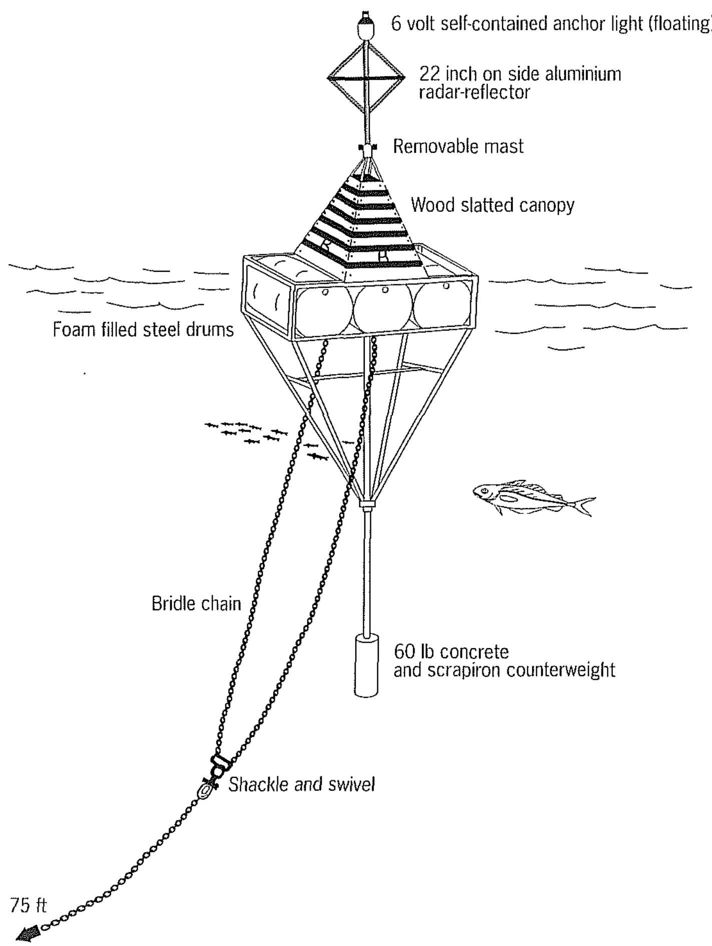
Type I raft design

The earliest DAWR FAD system utilized a first-generation Type I raft design that consisted of three foam-filled 200-liter drums held together inside a welded steel frame (fig. 1). The upper exposed portion supported a small tower with a radar-reflector and navigation light. A 30-kg concrete counterweight extended directly beneath the raft. The mooring system began with a bridle chain attached to the raft that allowed the counterweight to swing through freely. The bridle chains joined together below the counterweight and continued down on a single length of chain another 18 metres. Sixteen-millimetre polypropylene line then extended down from the end of the bridle chain to the seafloor where it was attached to another 18-m section of chain. This last section of chain was then shackled to a 900-kg cement block anchor.

In 1979, three Type I FAD systems were constructed at a cost of approximately US$ 3,000 each. One system was deployed off Facpi Point, another off Haputo Point, and the third held as a replacement system. Several deployments were conducted using a Coast Guard vessel at no cost to the Government of Guam.

The average lifespan of the Type I system was 66 days. Actual time on station ranged from a minimum of 7 days to a maximum of 94 days.

Figure 1
Type I FAD.

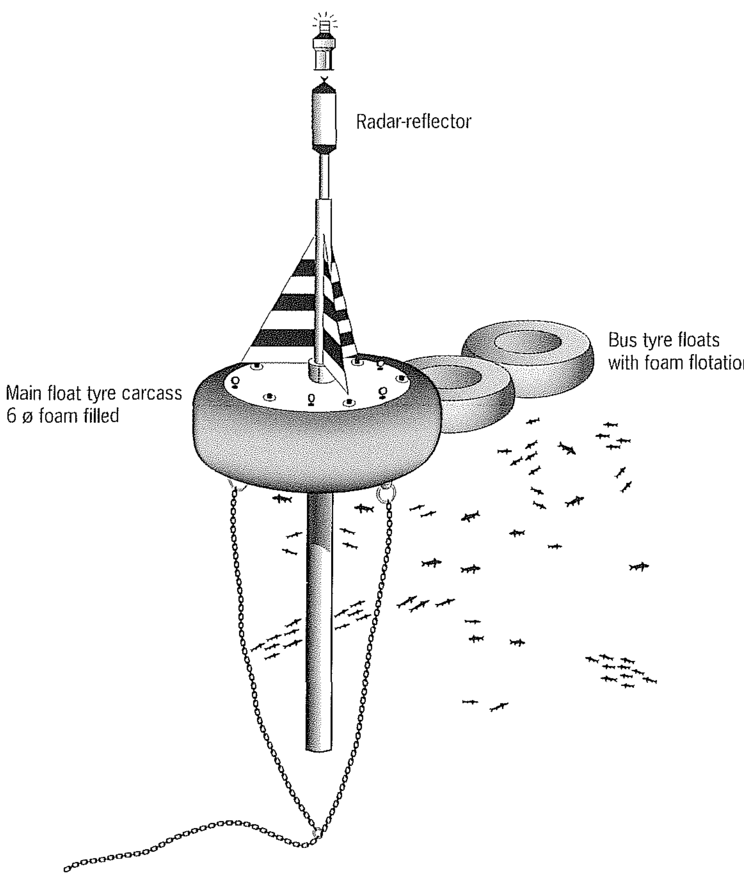


Type II tyre raft design

In 1980, the Type II foam-filled tyre buoy was incorporated into the FAD programme (fig. 2). This raft design was comprised of one large-diameter (1.6-m) foam-filled tyre with two smaller foam-filled tyres attached. The same mooring tackle and navigational configuration were utilized as the Type I. Five of the Type II systems were constructed in 1980 at a cost of approximately US$ 2,500 each.

The average lifespan of the Type II FAD was approximately 79 days. Actual time on station ranged from a minimum of 15 days to a maximum of 142 days.

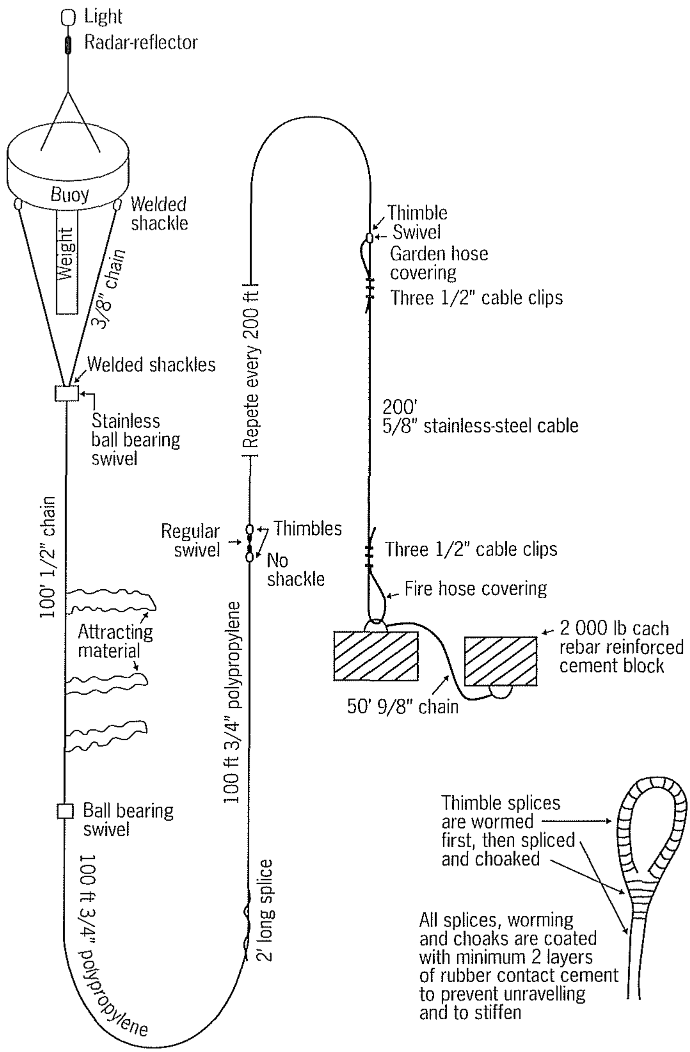
Figure 2
Type II FAD.



Type III "small-tyre" raft design

Four Type III rafts were constructed and deployed in 1981 (fig. 3). This raft design used a smaller tyre casing (1.2-m) in the construction of the raft and thus was referred to as the "small-tyre" FAD raft. Additional modifications included use of 19-mm three-strand polypropylene line, a 1:1.13 scope ratio, 12-mm chain below the raft, stainless-steel cable to

Figure 3
Type III FAD.



attach to the mooring block, fiberglassed or welded shackles, stainless-steel ball bearing swivels, and splices that were whipped and double-coated with thick rubber contact cement. Each Type III FAD system cost approximately US$ 3,900 to construct.

One of the four small-tyre systems promptly sank after being deployed due to the anchor settling into deeper water than the mooring system was designed to handle. This system aside, the other three Type III systems performed fairly well by remaining on station for an average of 369 days. Actual time on station ranged from a minimum of 226 days to a maximum of 640 days.

1987-1995

Surplus channel marker nun and can buoys

In 1987, DAWR adopted a second-generation FAD system design similar to that being used in the State of Hawaiian FAD programme during that same period. However, rather than using a spherical buoy, the Guam FAD programme utilized surplus US Coast Guard channel marker can and nun buoys (fig. 4). From 1987 to 1989, FAD project activity primarily concentrated on acquiring system components and contracting necessary services for preparation and deployment of FADs. Actual deployment of the first five of these systems did not occur until 1990.

As recommended in the South Pacific Commission Handbook no. 24, "Design improvements to Fish Aggregating Device mooring systems in general use in Pacific Island Countries" (Boy & Smith, 1984), the five nun and can buoy FADs described above incorporated the catenary loop concept to prevent the mooring line from rising to the surface. Another four such systems were deployed in March, 1992. However, rather than

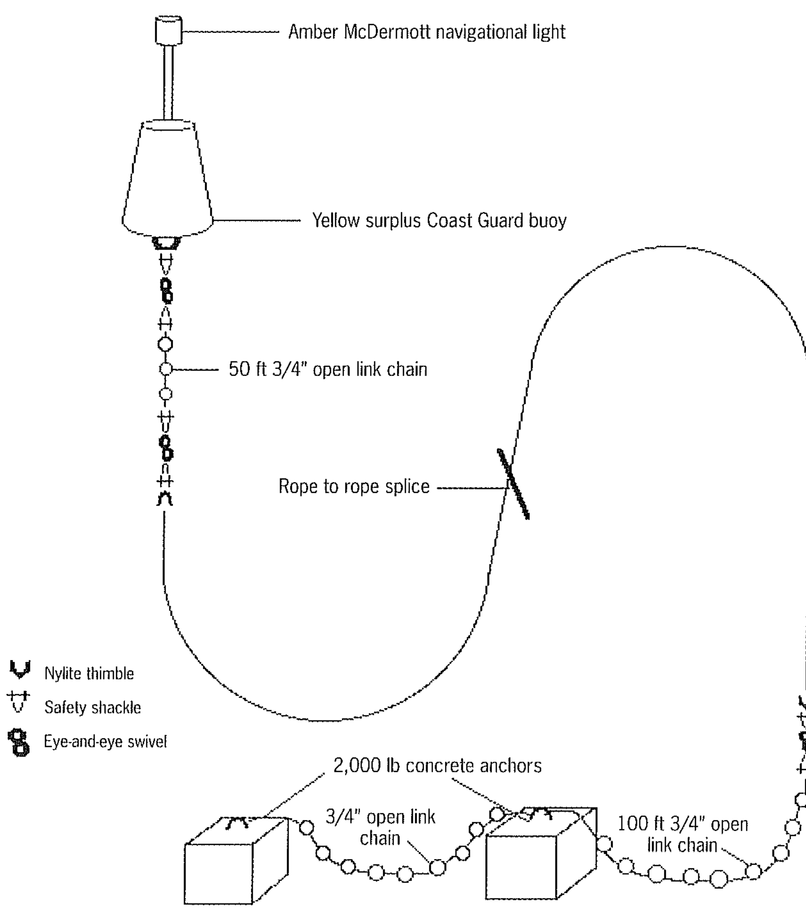


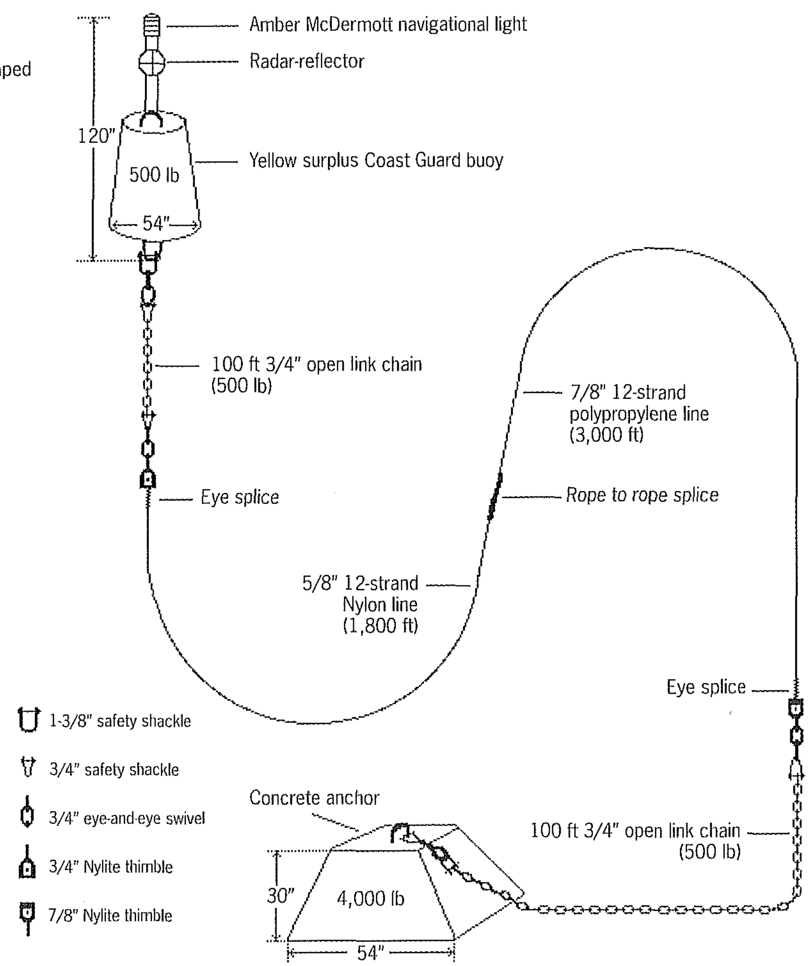
Figure 4
Nun and can buoy FAD with two-block anchor.

using the single 900-kg anchor block recommended by SPC, DAWR instead continued use of the two-block system in order to deplete an existing inventory of 680-kg anchors. The last two sets of nun and can buoy FADs with double-block anchors were deployed in December, 1992, at the Cocos Island and Facpi Point sites.

Given the additional complications with loading and deploying two-block anchoring systems, as opposed a one-block system, the switch was eventually made to a single pyramid-shaped 1,800-kg anchor after the last of the 680-kg anchors was used (fig. 5). This change resulted in much less troublesome loading and deployment procedures.

By 1993, the average cost to construct and deploy a DAWR FAD increased to US$ 11,500, largely the result of deployments that were charged a flat rate of US$ 4,500 per FAD regardless of location. In 1994 and 1995, the average cost per system was cut approximately 25% to about

Figure 5
Nun and can buoy FAD with single pyramid-shaped anchor.



US$ 8,400 after another tug company was contracted to conduct the deployments based on an hourly rate for equipment and services rather than at a flat rate.

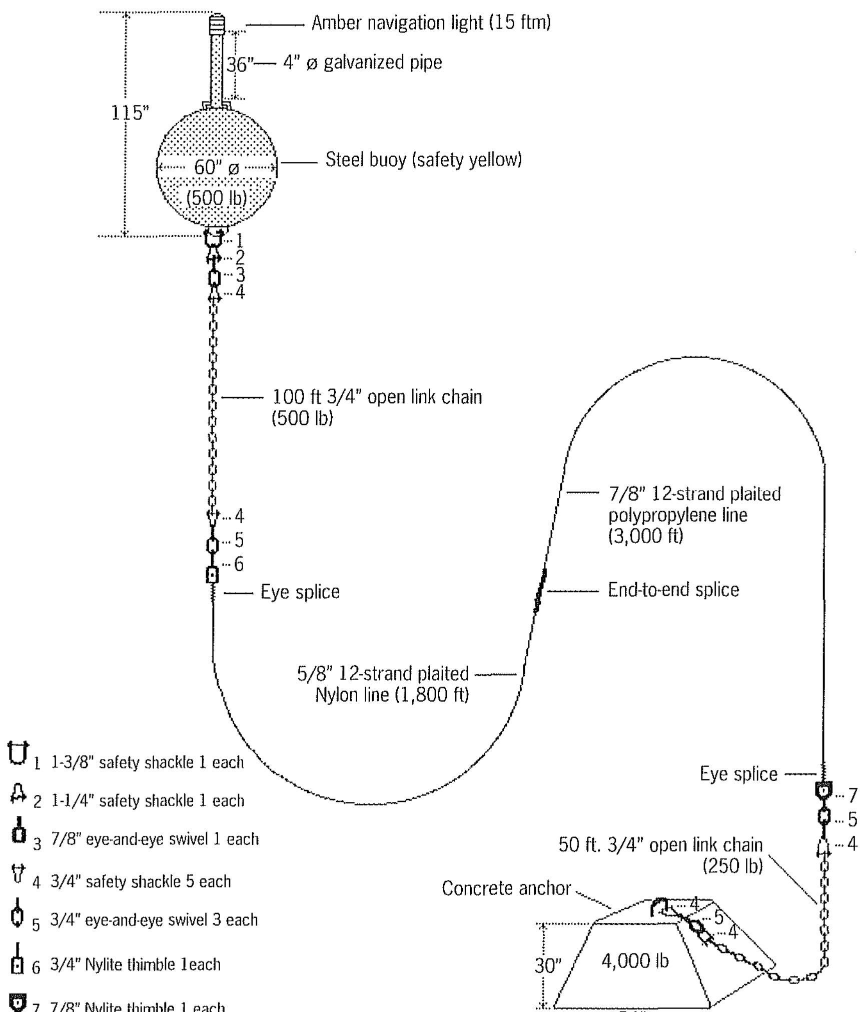
The average time on station for DAWR nun and can buoy FADs was 446 days. Actual time on station ranged from a minimum of 120 days to a maximum of 1,320 days.

1995-Present

Surplus spherical buoys

In 1995, DAWR acquired thirty surplus spherical steel buoys from a scrap yard in Honolulu to replace the depleted inventory of nun and can buoys (fig. 6). These buoys are approximately 1.75 metres in diameter and weigh about 230 kilogrammes. DAWR initially planned to copy

Figure 6
Spherical buoy FAD.



Hawaiian FAD buoy modifications that included the welding of a 1.1 m length of 100-mm diameter galvanized pipe on top of the buoy to serve as the mast for the navigation light, and another length of pipe below to serve as a counterbalance. However, to simplify modification of the newly acquired buoys for FAD use, DAWR experimented with using 15 and 30-m lengths of 19-mm link chain to determine if the weight of the chain, 129 and 258 kg respectively, was sufficient to hold the buoy upright. The results were both lengths of chain held the buoy and light mast with navigation light assembly inserted in a full upright position. Given these results, DAWR was able to forego the additional modification of welding a length of pipe below the FAD buoy to serve as a counterbalance. In addition to making buoy modification procedures less complicated and costly, the absence of the lower length of pipe also made loading and deployment of the buoy less cumbersome and much more convenient.

The average FAD time on station between 1995 and 1998 was approximately 457 days. However, this figure may have been underestimated because several annual figures used in the final calculation included newly deployed FAD lifespans without end dates. Since some of these new systems eventually remained on station for longer periods, a recalculation would likely yield an increased average lifespan.

Indian Ocean rafts

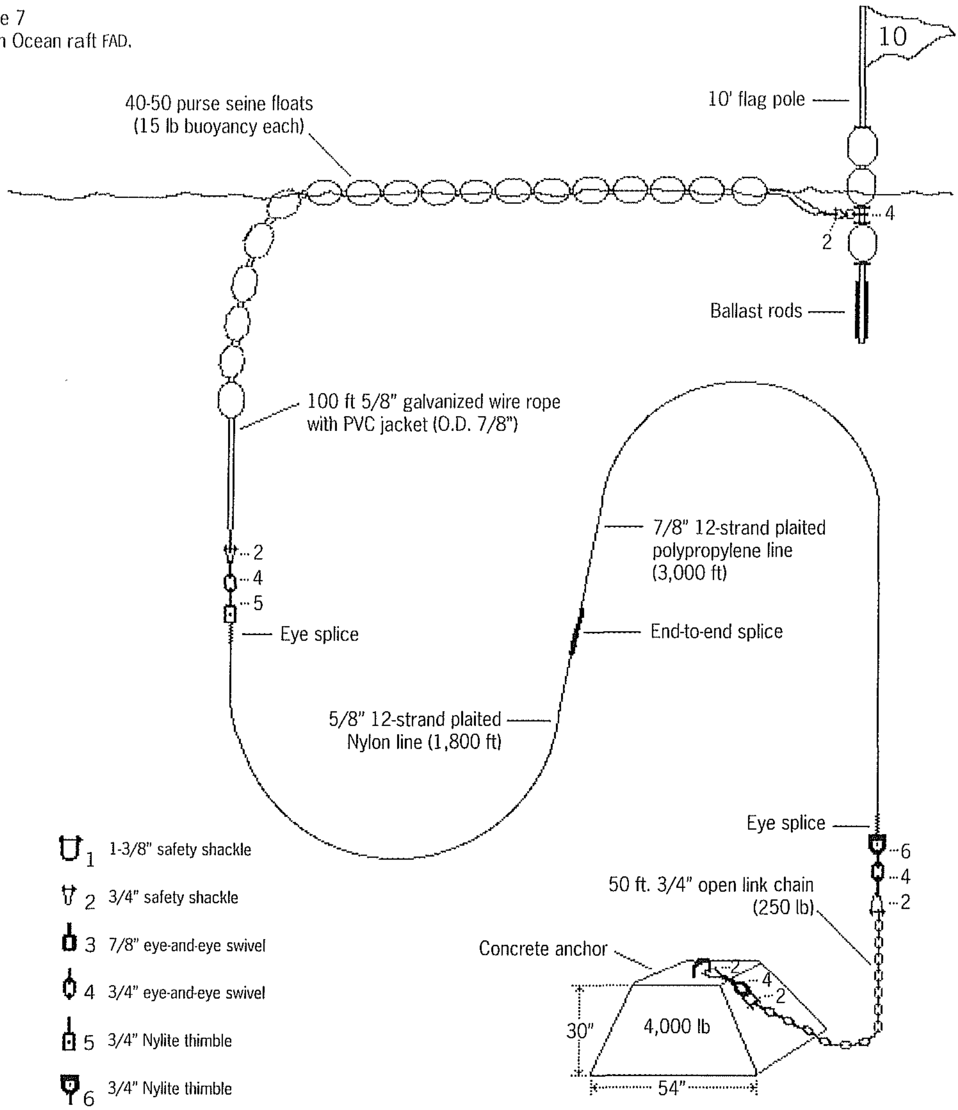
Materials necessary for the construction of ten SPC-recommended Indian Ocean rafts were acquired in 1995 (fig. 7). This low-cost, lightweight and low-resistance design will eventually be incorporated into the DAWR FAD programme once a better end-float is identified or designed to accommodate the US Coast Guard requirement for a navigation light on each system. Up until 1999, DAWR relied on 9-kg battery-powered navigation lights to meet Coast Guard lighting requirements.

The weight and size of these lights make the current SPC-recommended end-float design impractical in terms of securing and supporting this light. Now that twenty 2.6-kg solar-powered lights have been purchased by DAWR, it is likely that a reasonably-priced deepwater spar buoy system will be purchased to secure and support this much lighter navigation light at a practical height above the water.

FAD sites

There are now sixteen operational sites in the DAWR FAD programme (fig. 8). Contrary to the usual practice of setting FADs at least ten miles apart and at the 1,000-fathom depth contour, the majority of the Guam FADs are spaced relatively close together and usually at a depth of 500 fathoms. Given the relatively high number of recreational-subsistence vessels in the troll fleet, and their early demand for more FADs closer to the major launch sites, DAWR gave priority to making more FADs available rather than making a few FADs more productive. DAWR also

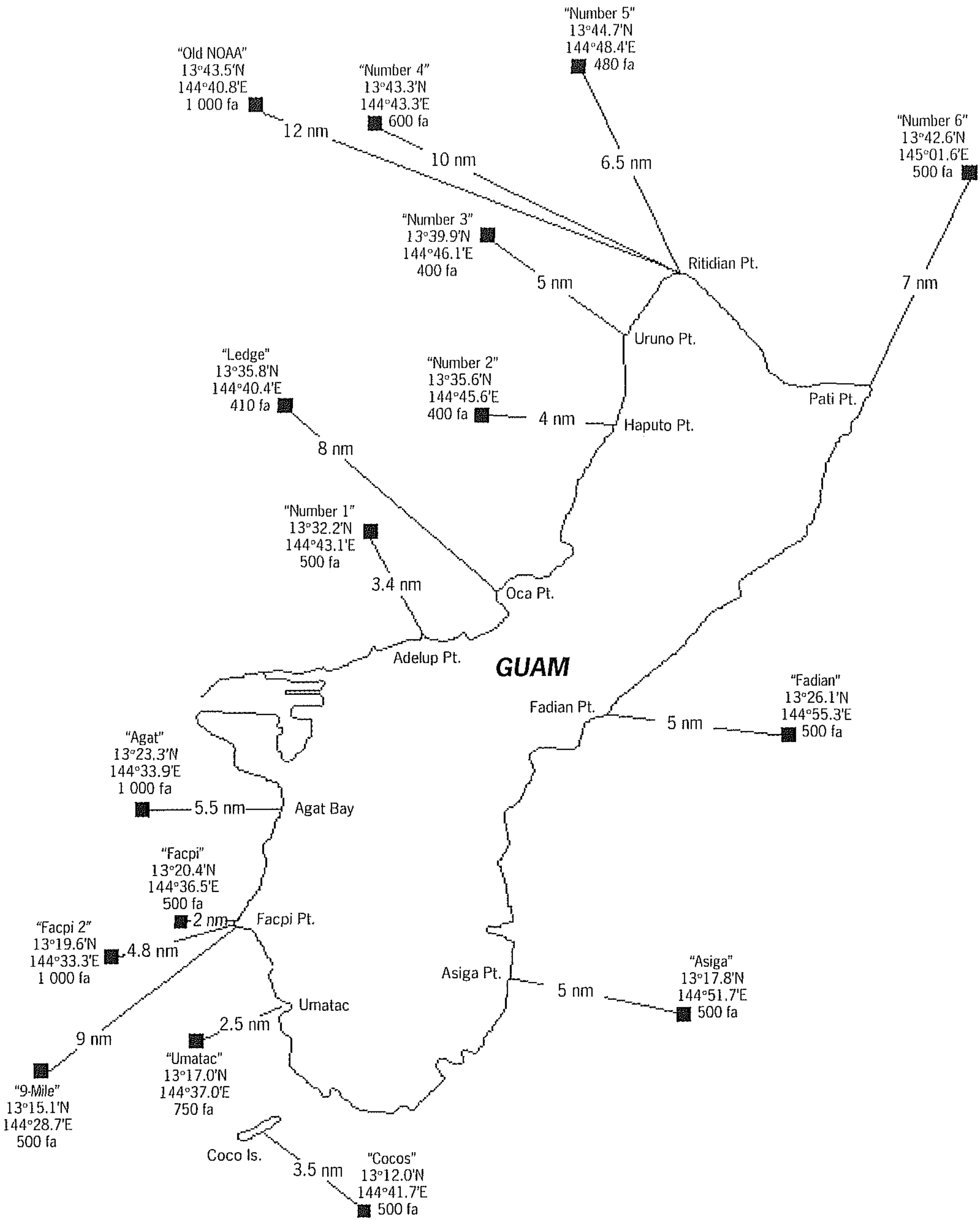
Figure 7
Indian Ocean raft FAD.



responded to requests for FADs in the more-distant and less-frequented areas on the eastern windward side of the island and to the north. The Fadian Point and Asiga FADs were thus deployed for those fishermen favouring the eastern side of the island, while the Pati Point (no. 6) FAD was installed for those choosing to fish the northern portion of the island.

DAWR continues to consider additional FAD sites and annually budgets for the bathymetric surveys of potential new sites. DAWR thus contracts a qualified and properly equipped local charter boat company for two full days of depth sounding services each year. There are several potential new sites currently being considered which will require appropriate

Figure 8
FAD sites.



permission before a FAD can be installed. Conversely, there are a few existing sites that may be eliminated from the programme because the FADs are reported to be non-productive, seldom used, frequently lost and located in areas that make them more expensive to maintain and replace.

FAD losses

Fishbite

Between 1994 and 1999, ten FADs that came off station were eventually recovered. The depth at which the mooring systems failed ranged from 31 m to 721 m, the average being approximately 150 metres. Interestingly, none of the systems failed as a result of a faulty splice or a defective piece of hardware at the top or bottom of the FAD. Fishbite is therefore the likely cause of the majority of FAD system losses based on the depth of the breaks in the line, the appearance of the end strands recovered and the age of the system. This is consistent with studies by Berteaux and Prindle (1987) that suggest the frequency of fishbite increases as the geographical location of a deep-sea buoy gets closer to the equator. According to their data, two thirds of experimental buoys set within 10 degrees of the equator showed signs of fishbite. However, similar fishbite experiments that compared frequency of fishbites as a function of depth yielded results that indicated peak activity occurred between 900 m and 1,000 m, which is significantly deeper compared to the 150-m average depth for Guam mooring system failures. This is probably due to regional differences in the fish species likely to bite and damage mooring lines and their peak activity depths. The speculation therefore, is that protection of the mooring system from fishbite down to 300 m will possibly result in doubling the average lifespan of most FAD systems.

Corrosion and mechanical wear

If fishbite is the primary cause of FAD losses, especially in the early portion of a system's life, corrosion and mechanical wear of hardware would be the next likely reason as the system gets older. This was the case between 1990 and 1995 when DAWR was still using nun and can buoys for its FAD systems. The relative instability of these buoys resulted in excessive rocking and twisting motions which in turn lead to increased wear of the upper mooring hardware.

Onsite underwater photographs taken in 1995 of a channel marker FAD buoy system, in particular the then nearly two-year-old Facpi Point FAD, clearly documented the dramatic difference in degree of wear between the hardware just below the surface and the hardware 30-m down. Based on the level of wear on the eye-and-eye swivel below the buoy, it was not surprising that these nun and can buoy systems broke off station after two to four years. In fact, two such systems, the Adelup Point and Haputo Point FADs deployed in March 1992, came off station after 24 and 25 months respectively. Two other similar systems, the Cocos Island and Facpi Point FADs deployed in December, 1992, broke off after 38 and 44 months respectively.

DAWR addressed the problem of premature losses due to corrosion and mechanical wear of the uppermost hardware by switching to larger diameter hardware. Thus, rather than the 19-mm safety shackles and eye-and-eye swivel previously used to connect the buoy to the upper chain, DAWR now uses a 35-mm or 30-mm safety shackle, followed by a 22-mm swivel and a 19-mm shackle, to connect to the 19-mm chain.

Streamlining costs and effort

At a current cost of approximately US$ 10,000 per system, concern for the rising costs of replacing and maintaining FAD systems has prompted DAWR to investigate alternative FAD replacement and maintenance strategies. Several cost-cutting measures include standardization of FAD site depths and the use of reliable long-life solar-powered navigation lights to reduce the number of maintenance trips required annually.

Prefabricated 500 and 1,000-fathom mooring systems

Efforts to standardize site depths to 500 and 1,000 fathoms in recent years have made it possible to maintain an inventory of backup systems which in turn allows for immediate replacement of a FAD that has come off station. For example, the Facpi Point FAD recovered on August 27, 1996, was redeployed the following day on August 28. In the past, mooring systems were essentially custom built for each site. Considerable effort and time were required to measure out the lengths of line needed, before tackling splicing and eventual faking of the mooring system into the deployment container. These time-consuming procedures are still necessary for those sites with depths not equal or close to 500 or 1,000 fathoms. On the other hand, prefabricated (pre-measured,-spliced and-faked) mooring systems boxed and palletized at the factory, have allowed for readily-available mooring systems that are quite convenient to store, prepare, load, transport and deploy.

Battery-powered versus solar-powered navigation lights

Prior to 1999, the Guam FADs utilized battery-powered navigation lights that required replacement every 4 to 6 months. At approximately US$ 250 for each light unit and about US$ 150 per battery pack, the estimated costs over a two-year period would amount to around US$ 850 for just the light and batteries. However, this figure does not include the cost of hiring a commercial vessel to transport DAWR staff and equipment to the FAD site to conduct maintenance procedures. In most cases, light replacements are made on the same day a FAD deployment in the area is conducted, and therefore, the need for additional voyages for the sole purpose of replacing navigation lights are kept to a minimum. However, such "maintenance only" voyages, although infrequent, still occur because scheduled light changes do not always coincide with an upcoming FAD deployment. Such trips increase the total cost of maintaining a FAD with a battery-powered navigation light by approximately US$ 350 each occurrence.

To address this concern, DAWR acquired 20 solar-powered navigation lights in 1999 to replace the battery-powered lights presently in use.

Costing less than US$300 each, these lights are purported to have a lifespan of up to eight years. If the solar-powered lights meet expectations, DAWR could realize a significant reduction in the expenses associated with maintenance of navigation lights because the procedure may be reduced to annual test inspections and cleaning of bird droppings off the solar panel on the top of the light.

Recommendations

Improvements to the DAWR FAD programme in the future will focus on making the upper 300 metres of the mooring system invulnerable to fishbite and converting to the SPC-recommended Indian Ocean raft design to replace the spherical metal buoy presently being used. DAWR is thus considering use of a 300-m length of thick-strand 16-mm, or thicker, stainless-steel cable to connect directly to the spherical buoy currently being used. Although this may serve well to make the FAD less vulnerable to fishbite, it is not certain whether this length of cable can also serve to replace the Nylon line in the catenary curve. Another concern is whether the thick-strand cable will alter deployment procedures considerably. In addition, DAWR will eventually explore the possibility of incorporating this length of stainless-steel cable to string the floats of the Indian Ocean raft.

Other minor improvements include the attachment of plastic strapping appendages to the upper mooring chain, affixing radar-reflectors to the spherical buoy light masts, and a switching from lantern-battery-powered navigation lights to solar-powered lights.

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