Construction and Evaluation of a Midwater FAD Design in the U.S. Virgin Islands

ILEANA E. CLAVIJO, JOSEPH LaPLACE and WILLIAM TOBIAS
Division of Fish and Wildlife
Department of Conservation and Cultural Affairs
St. Thomas, U.S. Virgin Islands 00802

ABSTRACT

The Division of Fish and Wildlife of the U.S. Virgin Islands has developed an experimental midwater FAD, the LaPlace FAD, primarily for use by recreational fishermen. The design is simple, easily constructed and can be deployed from a small boat. Results to date show a life term of two years for an improved design. Visual observations with SCUBA showed that recruitment by coastal pelagic fishes is rapid, usually within a few hours. Results of trolling on the study site compared to a control site without FAD demonstrated that LaPlace FAD increased the number of fish caught during summer months.

INTRODUCTION

The association of pelagic fishes with floating and drifting objects has been used consistently by both recreational and commercial fishermen to improve their catches. The reason for this attraction is not fully understood, although it has been suggested that the availability of food, shelter or shade, as well as orientation advantages may play an important role (Seki, 1983). The effectiveness of artificial FAD (fish attracting devices) has led to the development of structures with increasing complexity and cost (Bergstrom, 1983; Boy and Smith, 1983). Anchored buoys have been used effectively to concentrate pelagic game fishes (Matsumoto et al., 1981). Three-dimensional structures positioned in midwater are also effective in attracting pelagic fishes (Wickman et al., 1973; Workman et al., 1985). Midwater attractors are reported to be more stable and last longer than surface buoys (Myatt, 1985).

Limiting factors preventing the widespread use of midwater fish attractors in the Caribbean have included the high cost of materials and problems associated with deployment of the structures. A large vessel is usually necessary for emplacement of FAD. Once deployed, a regular maintenance program is needed to extend their longevity. Overall life terms are relatively short and structures must be replaced within one or two years. These factors have contributed in keeping midwater FAD beyond the reach of most fishermen in the Caribbean.

The Division of Fish and Wildlife, Government of the U.S. Virgin Islands, initiated a project in 1980 to develop a compact, easily built and inexpensive midwater FAD, which would work efficiently in attracting coastal pelagic fishes. The objectives of the study were as follows: (1) to design and construct a structure that would be cost effective, long lasting and built with locally available materials, (2) to deploy these structures successfully using a small boat and (3) to evaluate the effectiveness of FAD in attracting coastal pelagic fishes.

STUDY SITES, MATERIALS AND METHODS

The area selected for experimental FAD was located south-southeast of St. Thomas, approximately 3 km from shore (Fig. 1). Water depth averaged 26 m and the bottom had little vertical relief. The substrate was composed of coarse sand, coralline algal fragments and fleshy macroalgae. Small, isolated corals and sponges were present, but were not abundant.

The project was carried out in two phases. Phase I took place from February 1981 to December 1982 consisting of trolling work at study and control sites prior to deploying FAD and after their emplacement. A series of 50 structures were deployed linearly along a 7 km transect. A control site was located 0.3 km south of the study site.

Phase II was carried out from October 1983 to February 1985. The eastern half of the original transect used as control site became the study site; the western half remained as the control site. Sixty structures were deployed along the 3.5 km transect in clusters of 6 FAD placed within 20 to 30 m from each other. Clusters were positioned approximately every 0.3 km along the transect.

The design of Phase I and II FAD was identical (Fig. 2). However, Phase II FAD were modified by replacing a stainless steel cable with polypropylene rope and removing all metal components. The modified structure was named the "LaPlace FAD" after its principal designer. Buoys consisted of polyvinyl chloride (PVC) tubes 10.2 cm in diameter by 1 m in length. These tubes were capped at one end, reinforced at the open end, filled with closed-cell styrofoam for buoyancy and then bridled together in groups of three. A crosspiece of PVC tubing, 1.8 cm in diameter by 1.5 in length, supports two 3 m long 9.7 m wide sheets of black, 6-mil thick polyethylene plastic. The sheets are held in place by two lengths of 1.2 cm diameter PVC tubing, approximately 0.7 m long, inserted at both ends of the larger tube. Each sheet wraps around the smaller tube forming a double layer 1.5 m long that emerges along a slit cut on one side of either end of the larger tube. The crosspiece is attached to the 8 mm polypropylene line approximately 15 m from the bottom. The structure is held in place by two 50 kg anchors of molded concrete. Rubber hose is used at various contact points to prevent chafing in the line.

The experimental design used to evaluate the FAD was modelled after Wickham et al. (1973) with some modifications. Trolling was used as the sampling method with equal fishing effort at both the study and control sites. A 1/2-ounce yellow feather and a No. 2 Pet spoon were fished simultaneously with 120 to 200 lb test monofilament handlines at a trolling speed of approximately 6 knots. A 27-foot boat was used to fish the structures. Data

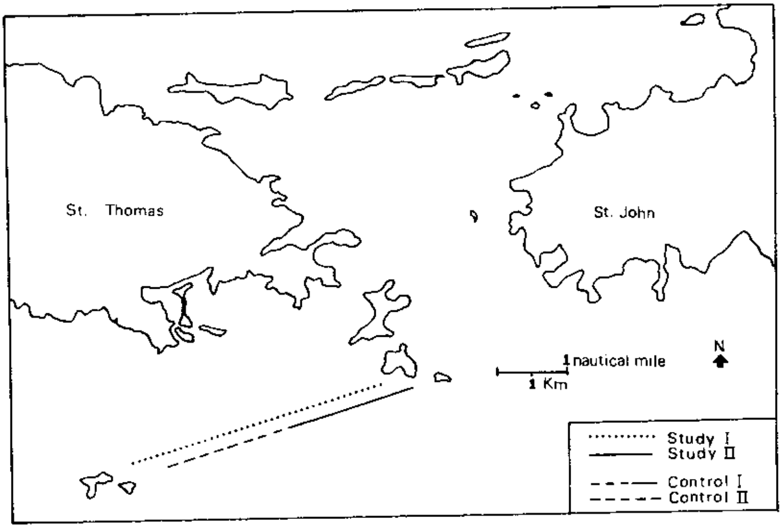

Figure 1. Map of study and control sites for Phase I and II of the midwater F.A.D. project in the U.S. Virgin Islands (refer to text for explanation).

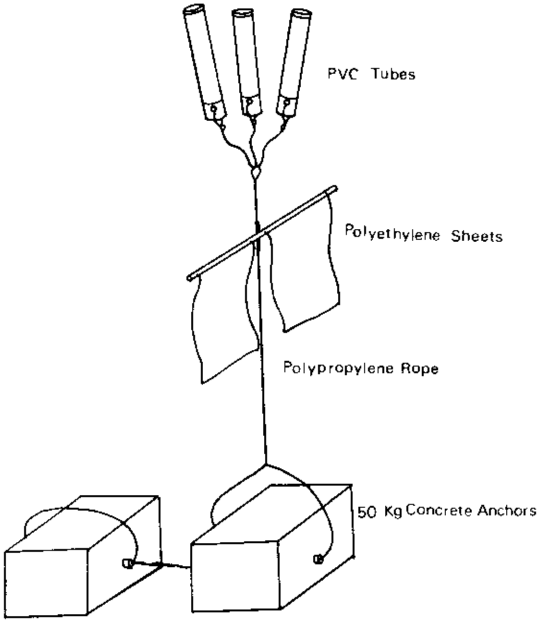

Figure 2. LaPlace midwater F.A.D. showing main components.

recorded included time of day, number of strikes and species of fish caught. Trolling was carried out during 30-minute periods alternatively at the study and control sites to avoid possible variations in fish abundance due to time of day.

Observations were carried out periodically at the study site using SCUBA. Fishes observed within 1 m of FAD were recorded. FAD inspections were also made by two divers towed from a boat to allow a rapid visual check of all structures. Maintenance and replacement of component parts were carried out as needed by divers.

RESULTS

Results of trolling during Phase I show a significantly larger number of strikes and fish caught at the study site compared to the control site prior to deploying FAD (Mann-Whitney U-Test, $p < 0.01$). The control site was adjacent to the study site and therefore these results were unexpected. However, factors not obvious to researchers may have affected the experimental design. After emplacement of FAD, the number of strikes and fish caught at the study site were significantly greater than the control site before and after FAD emplacement, as well as the study site prior to FAD emplacement (Mann-Whitney U-Test, $p < 0.01$). The number of strikes and fish caught at the control site were not significantly different before and after FAD emplacement (Mann-Whitney U-Test, $p = 0.10$). This indicates that the FAD sucessfully attracted fish.

The number of species caught at the study site increased from two to nine after FAD emplacement, whereas only two species were caught at the control site (Table 1). Combined catch and strikes totalled 2.83 per hour at the study site after FAD deployment compared to 0.34 before and 0.04 and 0.12 respectively, at the control sites before and after deployment.

FAD deployed during Phase I of the study lasted an average of 14 months. By August 1983, 22 months after emplacement, midwater components of all FAD had disappeared from the study site. Electrolysis of metal parts is believed to have been the main cause for their destruction.

Results of trolling during Phase II show that the number of strikes and fish caught were significantly greater from July to September 1984 at the study site compared to the control site (Mann-Whitney U-Test, $p < 0.05$). The number of strikes and fish caught did not differ significantly at the control and study sites from January to February 1985 (Mann-Whitney U-Test, $p = 0.9$).

The number of species caught was greater at the study site than at the control site in both Phase II sampling periods (Table 2), although differences were not as marked as those recorded during Phase I. The combined catch and strikes during summer months was 1.26 per hour at the control site and 2.24 at the study site. Winter months yielded very high combined catch and strikes: 4.53 per hour at the control site and 4.84 at the study site. The increased numbers of fish caught at both sites during the winter months may be due to a greater abundance of

Table 1. Results of trolling at the control and experimental F.A.D. sites, Phase I.

	Before Deploying (2/1/81 to 10/1/81)		After Deploying (10/1/81 to 12/21/82)	
	Control	Study	Control	Study
Hours fished	23	23	24	24
Fish strikes	1	5	12	44
Strikes per hour	0.04	0.22	0.5	1.83
Fish Caught:				
Caranx ruber (bar jack)	0	0	0	3
Elagatis bipinnulata (rainbow runner)	0	2	0	2
Euthynnus alletteratus (little tunny)	0	0	0	3
Ocyurus chrysurus (yellowtail snapper)	0	0	0	1
Scomberomorus regalis (cero mackerel)	1	0	0	2
Seriola dumerili (greater amberjack)	0	0	0	1
Sphyraena barracuda (great barracuda)	0	6	2	8
Synodus sp. (lizardfish)	0	0	1	3
Tylosurus crocodilus (houndfish)	0	0	0	1
Total Fish Caught	1	8	3	24
CPUE (catch per hour)	0.04	0.34	0.12	1.00

Table 2. Results of trolling at the control and experimental F.A.D. sites, Phase II

	July to September 1984		January to February 1985	
	Control	Study	Control	Study
Hours fished	24.5	24.5	16.5	16.5
Fish strikes	28	50	61	72
Strikes per hour	1.14	2.04	3.69	4.36
Fish Caught:				
Caranx ruber (bar jack)	0	3	0	2
Euthynnus alletteratus (little tunny)	0	0	5	3
Ocyurus chrysurus (yellowtail snapper)	0	0	2	1
Scomberomorus regalis (cero mackerel)	0	1	3	1
Sphyraena barracuda (great barracuda)	0	1	0	0
Synodus sp. (lizardfish)	3	0	4	1
Total Fish Caught	3	5	14	8
CPUE (catch per hour)	0.12	0.20	0.84	0.48

Table 3. Fishes observed within 1 meter of F.A.D. structures.

BUOYS AND LINE TO SURFACE (0.5 to 12.5 m depth)

Cantherhines pullus (orangespotted filefish)
Caranx ruber (bar jack)
Kyphosus sectatrix (Bermuda chub)
Ophioblennius atlanticus (redlip blenny)
Sphyraena barracuda (great barracuda)

PLASTIC SHEETS AND LINE (12.5 to 19 m depth)

Acanthurus coeruleus (blue tang) - juveniles only
Aluterus scriptus (scrawled filefish)
Caranx crysos (blue runner)
Elagatis bipinnulata (rainbow runner) - juveniles only
Emmelichthyidae (rovers)
Scomberomorus regalis (cero mackerel)
Sphyraena picudilla (southern sennet)

ANCHOR (26.5 to 31 m depth)

Abudefduf saxatilis (sergeant major)
Acanthurus bahianus (ocean surgeon) - juveniles only
Canthigaster rostrata (sharpnose puffer)
Centropyge argi (cherubfish)
Epinephelus fulvus (coney) - juveniles only
E. guttatus (red hind) - juveniles only
Halichoeres spp (wrasses)
Hemipteronotus sp (razorfish)
Ocyurus chrysurus (yellowtail snapper) - juveniles only
Pomacentrus (=*Stegastes*) *partitus* (bicolor damselfish)
Pseudupeneus maculatus (spotted goatfish) - juveniles only
Sparisoma atomarium (greenblotch parrotfish)

coastal pelagic species such as cero mackerel, Scomberomorus regalis, and little tunny, Euthynnus alletteratus.

Phase II FAD have lasted two years, from October 1983 to October 1985, although only 35 of the original 60 FAD still remain at the site in good condition. Maintenance over this time has been minimal and consisted of divers restoring flotation to buoys and replacing polyethylene plastic sheets. Styrofoam in the PVC buoys compresses underwater with time and positive buoyance is lost. This problem was solved by inserting air-filled 12 by 30 cm "whirl-pak" polyethylene bags inside the tubes which then maintain positive buoyancy for 8 months or longer. Two plastic sheets were lost after one to two years and these were replaced. Various stages of tearing have been observed on approximately twenty additional sheets.

Table 3 lists the fishes observed in association with various FAD components. Bar jacks, great barracuda, juvenile rainbow runner and blue runner were observed within hours after FAD were emplaced. Some reef fishes became permanent residents on the structures after several months, presumably when food became available. Juvenile red hind and coney were seasonal residents at anchors and may have moved to larger reefs as they increased in size. Juvenile spiny lobster approximately 3 to 5 cm in body length were often seen within the folds of the polyethylene sheets.

Materials utilized in the construction of a LaPlace FAD and their cost are presented in Table 4. Modifications can be made depending on the availability of materials. For instance, a company in the U.S. Virgin Islands has donated cylindrical polypropylene containers 1 m long and 18 cm in diameter. These can be used as buoys instead of PVC tubes, thus reducing the total cost of each FAD by 33 percent.

DISCUSSION

Polyethylene sheets became heavily colonized with algae and invertebrates such as tunicates, sponges, bryozoans and hydrozoans. One bivalve, Pinctada imbricata, was found abundantly on some FAD. The weight of these accumulated organisms can eventually cause the plastic to tear away from the crosspiece. FAD may sink due to a combination of factors including the weight of organisms causing loss of buoyancy. A FAD that sinks may be lost because of chafing of the line on the bottom. It is therefore important to repair buoys as soon as the need arises.

On several occasions, fisherman's traps were found entangled with FAD. They may be the primary cause for lost FAD. Fishermen hauling entangled traps may drift some distance from the study site, making it difficult to locate the eventually released attractors. Damage to a fish trap is negligible, but fishermen may be forced at times to cut the FAD line. Care should be exercised to deploy FAD in areas where trapping activity is minimal.

Fish recruitment to the LaPlace FAD is rapid as with larger and more expensive structures (Mottet, 1985). The present study showed that the number of strikes and fish caught increased around the FAD. In addition, a greater diversity of fish species are caught around the FAD. The concentrating effect may not be present year-round. The LaPlace FAD is longlasting and requires minimal maintenance, thus providing continuous fish attraction during several seasons.

Table 4. Costs of materials and labor for one LaPlace FAD in 1983

ITEM	COST (U.S.$) with buoys	donated buoys
PVC		
4-inch (3 buoys)	15.15	-
1- and 2-inch (crossbar)	3.95	3.95
end caps (3)	8.10	-
couplings (3), cement	6.50	-
ROPE		
100 feet, 8-mm polypropylene	2.95	2.95
ANCHORS (2)		
cement, sand and gravel	10.00	10.00
PLASTIC SHEETS		
polyethylene	2.50	2.50
MISCELLANEOUS		
plastic thimbles (4) (bridle attachment)	3.00	3.00
12-mm rubber hose (to prevent chafing)	1.50	1.50
LABOR	25.00	25.00
OVERHEAD	10.00	10.00
TOTAL COST	$88.65	$58.90

No apparent advantage was gained by deploying FAD in clusters. Single units are just as efficient in concentrating fish and it is possible to cover a larger area with a linear deployment pattern. This experimental result differs from that of Wickham et al. (1973) who found that multiple structures increased the number of bait fish as well as the catch of pelagic game fish. The orientation of FAD in an area relative to the movement patterns of bait fish may be a more critical factor in the attraction of coastal pelagic fishes than the use of multiple structures.

The effectiveness of the LaPlace FAD in attracting coastal pelagic fishes may be directly related to the area in which the FAD are deployed. Experimental deployment of LaPlace FAD off the north coast of St. Croix at a depth of 20 m has yielded poor results. Although bottom depths of the St. Thomas and St. Croix project sites were approximately the same, the bottom topography and benthic communities were very different. The St. Thomas FAD were located on an extensive, flat, sand and algal plain with little vertical relief. The FAD deployed in this area apparently provided some of the only available surface areas which subsequently supported food organisms and habitat for fishes.

In comparison, the St. Croix project site was located along the fore-reef slope of a well developed deep fringing reef, which provides abundant habitat and food sources for coastal fishes. Depth profiles of the study and control areas differ markedly in contour and distance from the 20-m depth contour to the insular shelf edge. These differences may have affected the abundance of pelagic fishes found in the study and control areas, which initially were assumed to be similar. Future experimental work with fish attractors will be necessary to validate this hypothesis.

SUMMARY

The LaPlace FAD developed during this study appears to be an effective means by which recreational fishing can be enhanced throughout the Caribbean. The simple design, economy of materials used in construction and ease with which FAD can be deployed make them assessible to recreational and commercial fishermen.

ACKNOWLEDGMENTS

Funding for this project was provided by the Department of Interior's U.S. Fish and Wildlife Service through the Federal Aid to Fish Restoration Projects FW-3 and F-7 to the Division of Fish and Wildlife, Department of Conservation and Cultural Affairs, Government of the U.S. Virgin Islands. Phase I of the project was initiated and completed by D. Olsen, R. Wood and L. McLain. Their contribution to this paper is gratefully acknowledged. Many past and present staff members of the Division of Fish and Wildlife helped with the construction and deployment. R. Boulon, M. Brandon and D. Rodriguez aided with the field portion of the research. R. Boulon and R. Norton provided valuable editorial comments. C. McAlpin and A. Fahie are thanked for typing portions of the manuscript.

LITERATURE CITED

Bergstrom, M. 1983. Review of experiences with the present knowledge about fish aggregating devices. FAO-BOBP-WP-23. 57 p.

Boy, R.L. and B.R. Smith. 1983. An improved FAD mooring line design for general use in Pacific Island countries. Rep. South Pacific Comm. 15th Reg. Tech. Meeting. on Fisheries. New Caledonia. 76 p.

Matsumoto, W.M., T. Kazama and D.C. Aasted. 1981. Anchored fish aggregating devices in Hawaiian waters. Mar. Fish. Rev. 43:1-13.

Mottet, M.G. 1985. Enhancement of the marine environment for fisheries and aquaculture in Japan. pp. 13-112 in F.M. D'itri, ed. Artificial Reefs, Marine and Freshwater Application. Lewis Publishers, Inc., MI.

Myatt, D.O., III. 1985. Midwater fish attractors. pp. 303-315 in F.M. D'itri (ed.), Artificial Reefs, Marine and Freshwater Application. Lewis Publishers, Inc., MI.

Seki, M.P. 1983. Summary of pertinent information on the attractive effects of artificial structures in tropical and subtropical waters. Southwest Fisheries Center Admin. Rep. H-83-12. Hawaii. 49 p.

Wickman, D.A., J.W. Watson, Jr. and L.H. Ogren. 1973. The efficiency of midwater artificial structures for attracting pelagic sport fish. Trans. Am. Fish. Soc. 102:563-572.

Workman, I.K., A.M. Landry, Jr., J.W. Watson, Jr. and J.W. Blackwell. 1985. A midwater fish attraction device study conducted from Hydrolab. Bull. Mar. Sci. 37:377-386.