A MIDWATER FISH ATTRACTION DEVICE STUDY CONDUCTED FROM HYDROLAB

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ABSTRACT

The effectiveness of midwater fish attraction devices (FADs) in attracting harvestable concentrations of fish was tested at the Hydrolab undersea habitat 3–10 February 1983. Three midwater FAD designs deployed in the Salt River Submarine Canyon off the northern coast of St. Croix, U.S.V.I. at two natural reefs, Hydrolab and in the submarine canyon were assessed to determine: (1) composition, abundance and behavior of attracted species; (2) recruitment time and daily variation in abundance of attracted species; (3) effect of adjacent natural reefs on attractability of FADs; and (4) attractive differences of respective FAD designs.

The 20 species attracted to FADs concentrated around FADs in the early morning, exhibited maximum densities between morning and midday, and left FADs in the afternoon. Differences in fish attraction were the result of FAD position and not design. Greatest species diversity and abundance occurred at FADs located next to natural reefs where resident species used FADs to extend the distance that they could venture from these reefs. Fishes attracted to midcanyon FADs primarily were pelagic species recruited from adjacent coastal waters. Deployment of an adequate number of strategically positioned FADs should enhance the potential for aggregating harvestable concentrations of commercially- and recreationally-important fishes.

Fish attraction devices (FADs) have been used extensively to attract commercially- and recreationally-important pelagic fishes in different parts of the world. de Sylva (1982) described several relatively large island fisheries in the Pacific Ocean and Mediterranean Sea that use surface or combination surface-midwater FADs to attract harvestable concentrations of pelagic fishes.

Several researchers have studied the effectiveness of FADs in attracting pelagic fishes. Hunter and Mitchell (1968) evaluated different surface FAD configurations in the attraction of tuna off the Pacific coast of Central America. Commercial and sportfishing aspects of combination surface–midwater FADs were studied by Matsumoto et al. (1981) in deep water around the Hawaiian Islands and are presently under study by Mathews and Butcher (1983) in Australian waters. Hammond et al. (1977) evaluated midwater FADs employed over an existing benthic artificial reef in coastal waters off South Carolina. Klima and Wickham (1971) visually evaluated species composition and abundance of coastal pelagic fishes attracted to experimental midwater FADs in the Gulf of Mexico. Wickham et al. (1973) found that midwater FADs improved pelagic sportfish catches, and Wickham and Russell (1974) determined that commercial fishing gear could be used to harvest coastal pelagic fishes attracted to midwater FADs.

The use of FADs in the Caribbean is a fairly recent development, and to date little has been done to determine their effectiveness in attracting pelagic fishes or their potential for enhancing commercial or sport fisheries. Caribbean-type z-traps made of reed have been used as midwater FADs and have been sampled by

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trolling in the waters off Jamaica (de Sylva, 1982). Commercially manufactured midwater FADs are being employed off Puerto Rico and the Virgin Islands (Gregory MacIntosh, pers. comm.). Their effectiveness will more than likely be determined through landings by sport fishermen.

The purpose of this study was to determine if midwater FADs could be used to attract harvestable concentrations of commercially- or recreationally-important fishes in the Caribbean. Specific objectives included determining: (1) composition and abundance of attracted species, (2) behavior patterns of these species, (3) recruitment time and daily variations in the abundance of attracted species, (4) effects of adjacent natural reefs on attractability of FADs, and (5) attractive differences of various midwater FAD designs. In situ underwater observations were considered the best way to complete these objectives, and because of its unique location and obvious advantages in making underwater observations, the undersea laboratory Hydrolab was selected as a research base.

Study Site

This study was conducted in the Salt River Submarine Canyon (17°47′N, 65°45′W) off the northern coast of St. Croix, U.S.V.I. The canyon starts at the barrier reef that fronts Salt River Bay, cuts north-northwest across a narrow shelf for 450 m (1,300 ft) and extends downward 3,500 m (12,000 ft) to join with the Christiansted Submarine Canyon.

The two walls of the canyon are very different in character. The west wall is steep, often vertical with several overhangs, caves, and grooves. The east slope or wall starts off with a 10–20° coral cobble and boulder face and becomes more vertical further seaward.

The shallower crest of the canyon (9–15 m) is marked by scattered stands of elkhorn coral (*Acropora palmeta*), head corals (primarily *Diploria* spp.), and an abundance of hydrocoral (*Millepora* spp.). Staghorn coral (*Acropora* spp.) and star corals (*Monastrea* spp.) cover canyon walls. Soft corals (gorgonians) and black coral (antipatharians) are also common as are several species of sponge.

The canyon floor is flat and slopes gently seaward. It is composed primarily of medium sand and silt with isolated grass beds (*Halophila* spp.) extending to depths of approximately 30.5 m (100 ft).

Materials and Methods

Hydrolab is located in 15.2 m (50 ft) of water and was used by four scientists-aquanauts to conduct this study from 3 to 10 February 1983 (Hydrolab Mission 83-2). Aquanauts equipped with standard SCUBA worked at depths of 15.2 to 45.7 m (50–150 ft).

FADs used in this study were three-dimensional structures of three basic designs—streamer, parasol, and complex parasol. The streamer design (Fig. 1) was constructed from three 1.5-m (5 ft) sections of 2.5-cm (1 in) PVC pipe joined in an H configuration. Vinyl streamers measuring 3.7 m × 2.5 cm (12 ft × 1 in) were attached at 15.2-cm (6 in) intervals along the two outside sections.

The parasol design (Fig. 1) consisted of three 3 m × 2.5 cm (10 ft × 1 in) PVC pipes joined at 33° angles to a central PVC apex cap to form a three-sided pyramid. Fish netting with a 10-cm (3.5 in) stretched mesh was attached to the PVC frame to increase surface area.

The complex parasol was commercially manufactured by MacIntosh Marine, Inc. from four 1.8 m × 1 cm (6 ft × ⅜ in) fiberglass rods connected at 33 angles to a central PVC apex cap to form a four-sided pyramid. Hexagonal fish netting with a 60-mm (¼ in) bar measurement was attached between the rods. These FADs were termed complex because they were deployed in pairs. The complex parasols were arranged in three different configurations—floated with apex horizontal, floated with apex vertical, and two parasols combined to form a diamond shape (Fig. 1).

FADs were deployed at four study sites (Fig. 2). West wall and east slope study sites were adjacent to natural reefs. A midcanyon study site was over sand bottom, and the fourth study site was adjacent to Hydrolab. Each FAD design (three total) was deployed at the three study sites in the submarine canyon. Deployment of the east slope and midcanyon FADs was completed on the first day, and on the second day the west wall FADs were deployed. Also, one streamer and one parasol FAD design, both modified by attaching luminescent and reflective tape, were deployed next to Hydrolab on the second day. The submarine canyon FADs were spaced from 30.5 to 45.7 m (100–150 ft) apart, anchored in 30.5 to 39.6 m (100–130 ft) of water, and suspended 18.3 m (60 ft) below the surface. The FADs at Hydrolab were anchored in 15.2 to 18.3 m (50–60 ft) and suspended 9.1 to 12.2 m (30–40 ft) below the surface.

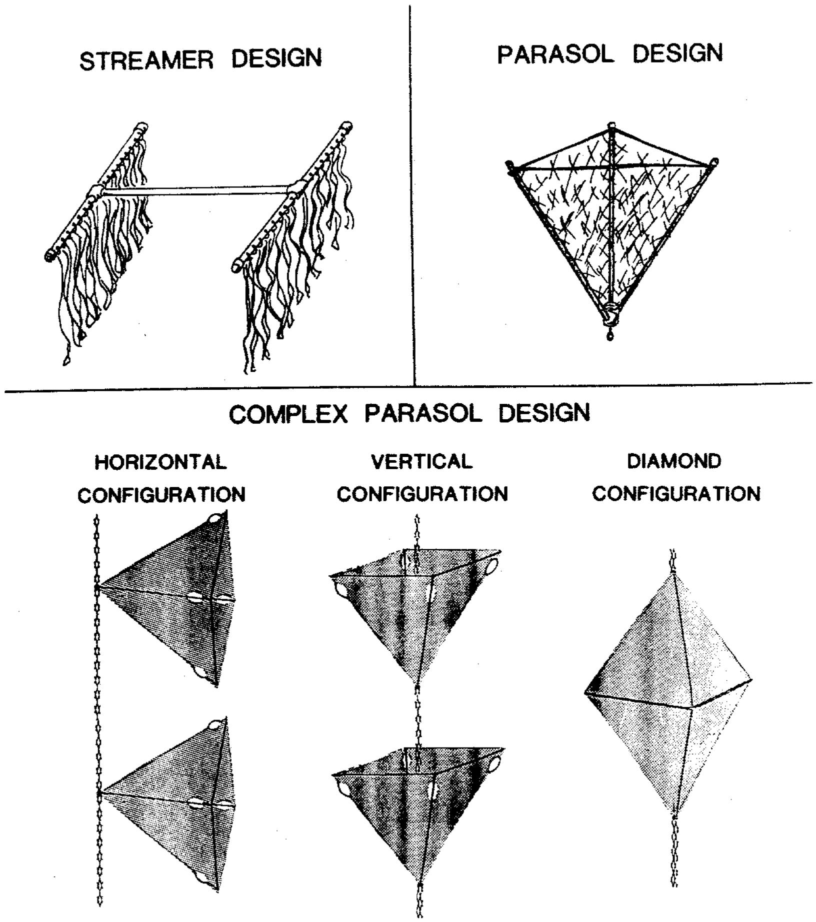

Figure 1. Streamer, parasol and complex parasol FAD designs.

Assessment of fishes attracted to FADs began on the third day of the mission and continued through the last day of the study. Four assessment periods were used—early morning from 0600 to 0900 h, late morning from 0900 to 1200 h, early afternoon from 1200 to 1500 h, and late afternoon from 1500 to 1800 h. At least one morning and one afternoon assessment were conducted each day except the last day when only one early morning assessment could be conducted. FADs at Hydrolab were observed at different times throughout the day. Assessment methods included visual counts, rapid visual assessments, and photo assessments with movie and still cameras and were conducted from a distance dependent on visibility but normally about 15.2 m (50 ft) away from the FAD.

Visual counts were made independently by two members of an aquanaut team over a 10-min period. All fishes attracted to a FAD were identified and counted during that time. Total lengths were estimated for all species. All data including behavioral observations were recorded with graphite pencils on white plastic slates.

Rapid visual assessments, like visual counts, were made independently by both members of an aquanaut team. The aquanauts scanned the water around a FAD and assigned one of the following abundance (number of individuals) ranges to each species observed. The abundance range was determined to be: (1) 1–20; (2) 21–50; (3) 51–100; (4) 101–500; (5) 501–1,000; and (6) >1,000.

Photographic assessments were made with 16 mm movie cameras and 35 mm still cameras equipped with wide angle lenses. A photo assessment was made by panning the movie camera or, in the case of the still camera, overlapping the shots from one side of a FAD to the other.

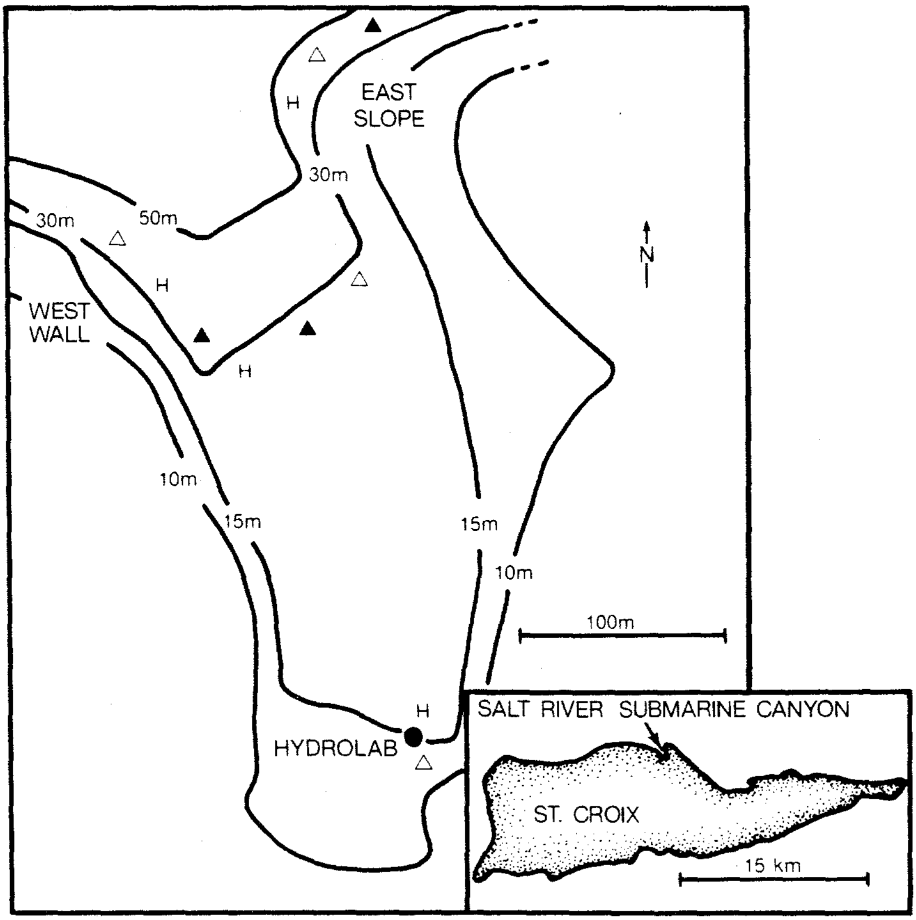

Figure 2. Deployment sites for parasol (△), complex parasol (▲) and streamer (H) FAD designs in the Salt River Submarine Canyon, St. Croix, U.S.V.I.

Results and Discussion

Hydrography and Census Techniques.—Hydrographic conditions were fairly stable during the study. Water temperatures and salinities ranged from 26 to 27°C and 33 to 35‰, respectively. Underwater visibility ranged from 6.1 m (20 ft) to over 30.5 m (100 ft) and averaged approximately 15.2 m (50 ft). Water quality was generally clear and blue but on occasion became milky (probably related to tidal influence). Large suspended particulates occasionally caused reduced visibility. Currents ranged from 0 to approximately 1 knot and were generally southerly.

Only visual counts and rapid visual assessments proved effective in characterizing fish attraction. Photo assessment was limited by distance that the cameraman had to be from fishes in order not to disturb them and by the wide angle lenses used. Fishes in resulting photographs were too small to identify or count with any degree of accuracy. Visual counts were very accurate when censusing a few individuals or small fish schools, but when large fish schools were encountered, the

Table 1. Species frequency of occurrence (%) for taxa observed at west wall, midcanyon and east slopes FADs. S = streamer; P = parasol; CP = complex parasol

	West wall			Midcanyon			East slope		
Taxa	S (N = 9)	P (N = 9)	CP (N = 9)	S (N = 14)	P (N = 14)	CP (N = 14)	S (N = 9)	P (N = 9)	CP (N = 9)
Hemiramphus brasiliensis		11				14			
Alectis crinitus									22
Caranx latus		22	11						11
Caranx ruber							11	11	
Decapturus macarellus		22		43	36	50	33	11	22
Inermia vittata	11	44					56	22	33
Ocyurus chrysurus	44	78	44	7	21	14	44	56	44
Clepticus parrai	44	67	22		7		44	56	56
Scarus guacamaia	22		11						
Sphyraena barracuda	11	11		14	7	21	56	22	33
Scombrid (tuna)								11	
Scomberomorous cavalla							11		
Scomberomorous regalis	11		22	7	7				11
Canthidermis sufflamen					7				
Melichthys niger	11	33	11				11	44	56
Lactophrys quadricornis							11		
Lactophrys triqueter							11		
Diodon hystrix		11	11				11		
Unidentified species #1						29			
Unidentified species #2						7			
Total taxa attracted	7	9	7	4	6	6	11	8	9

censusor had to use a number range to estimate abundance. Rapid visual assessments provided a fast and adequate method of assessing larger schools of fish.

Fish Attraction.—Seventeen identified species representing 11 families and 3 unidentified species were observed in association with midwater FADs deployed at the three submarine canyon study sites (Table 1). FADs at Hydrolab attracted only one bar jack (*Caranx ruber*) and a few horse-eye jack (*Caranx latus*). These FADs could not compete with the attraction of Hydrolab itself.

Recruitment patterns of fishes attracted to FADs were different at each submarine canyon study site (Fig. 3). Fishes were initially observed at west wall parasol and complex parasol FADs on assessment day 1 (one day after deployment). Attraction to the parasol FAD continued through the remainder of the study but with large fluctuations in daily abundance. Fishes returned to the west wall complex parasol and were first observed at the west wall streamer on assessment day 3. They continued to occur in varying abundances at these FADs through the last day of the study.

The three east slope FADs attracted fishes (Fig. 3) on assessment day 1 (two days after deployment). The number of fishes attracted to these FADs decreased on assessment day 2 but began increasing daily through day 4. On the last assessment day fish abundance at the east slope streamer exhibited a continued increase while that at the east slope parasol and complex parasol decreased substantially. This decrease was probably due to a very early morning assessment (just after sunrise) which was made because of excursion time and depth restrictions placed on aquanauts during the last mission day. This assessment was earlier than the time fishes normally became active around the FADs.

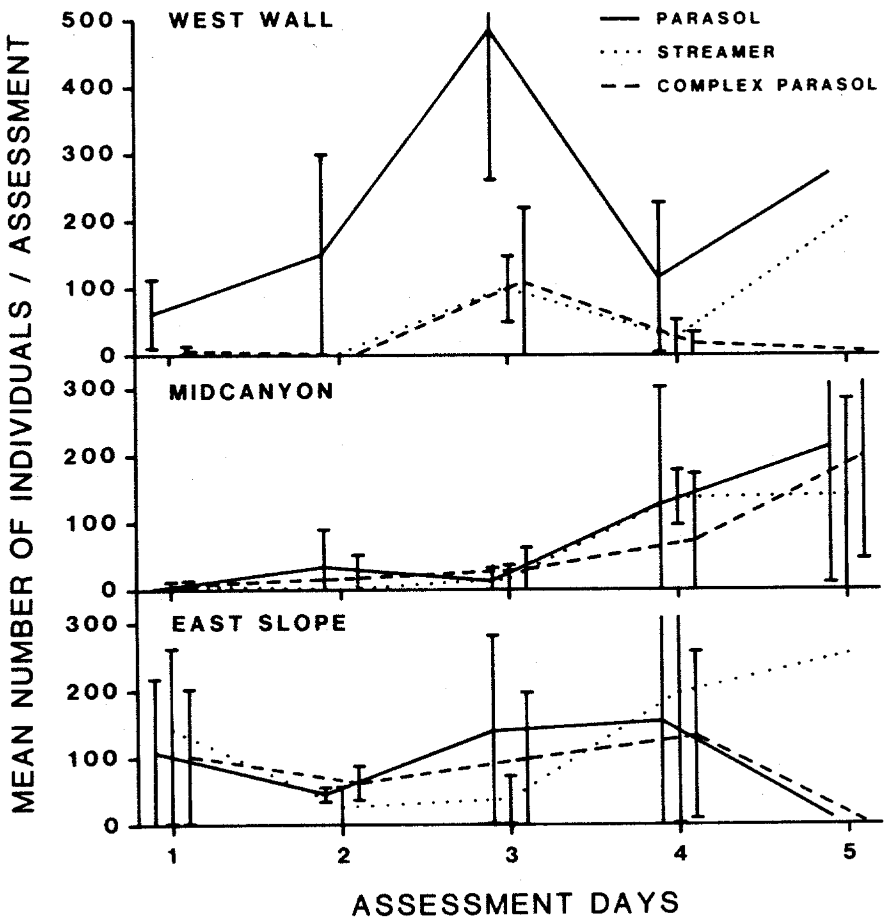

Figure 3. Average number of fishes observed during daily assessments of west wall, midcanyon and east slope FADs. Vertical bars represent standard deviation of the mean.

The midcanyon streamer and complex parasol FADs aggregated fishes (Fig. 3) on assessment day 1 (two days after deployment). The number of fishes attracted to the complex parasol increased daily. Recruitment at the midcanyon parasol was initially observed on assessment day 2, and, after a slight decrease in fish abundance on day 3, continued to increase daily. Fishes returned to the midcanyon streamer on assessment day 3 and increased in abundance through the last assessment day.

Daily variation in the number of fishes attracted to midwater FADs at the three submarine canyon study sites was similar (Fig. 4). Fishes began concentrating around FADs in the early morning, reached maximum concentration between morning and midday, and left FADs in the afternoon (Table 2). An exception to this pattern existed at the midcanyon streamer where a slight increase in the number of attracted fishes was observed in late afternoon. Observations made just before sunrise and sunset and at night indicated that few fishes occurred around FADs during periods of little or no light. Census statistics including total

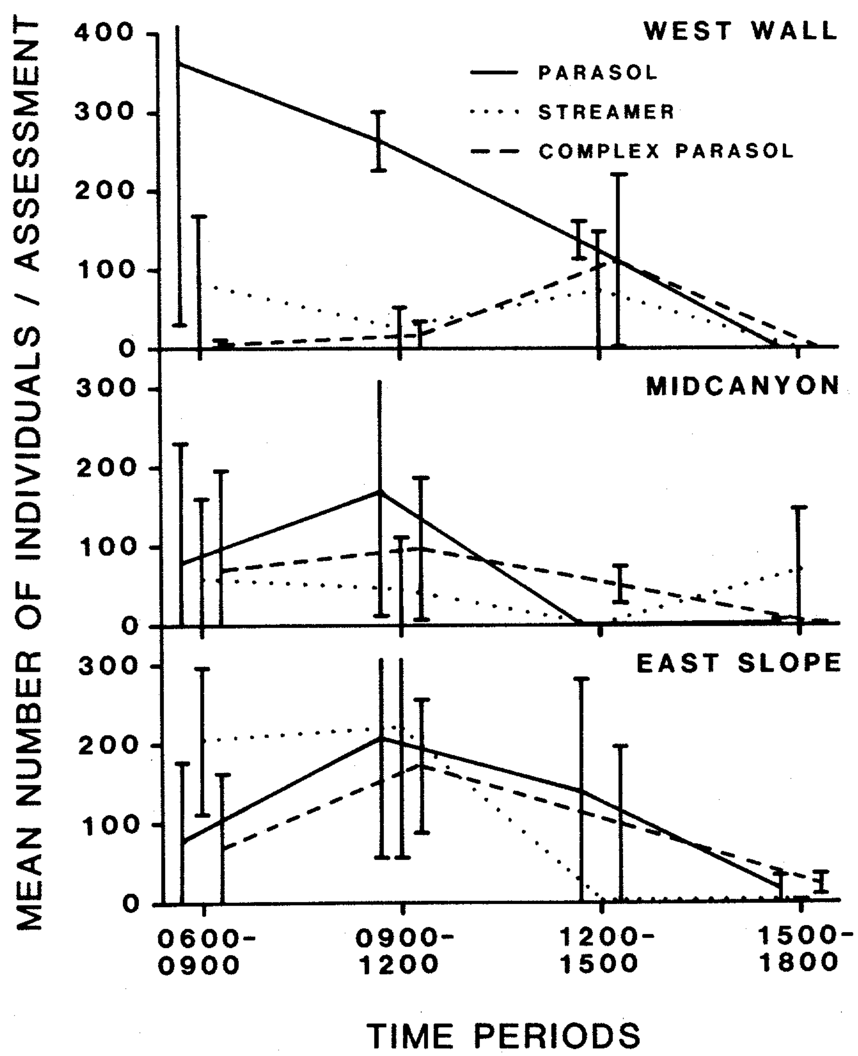

Figure 4. Average number of fishes occurring at FADs during morning and afternoon assessment periods. Vertical bars represent standard deviation of the mean.

number of species and individuals, mean number of species and individuals per assessment, and percent of assessments with fish were greatest during the 0900–1200 h and, to a lesser degree, 0600–0900 h assessment periods.

No clear distinction existed between attractive qualities of respective FAD designs (Table 2). Parasol FADs exhibited the largest mean number of fish per assessment and highest total number of attracted species (together with streamer FADs). Average number of species per assessment was greatest at parasol FADs while frequency of observing attracted fishes was highest at complex parasol FADs.

Differences in number of species attracted to the three different FAD designs were few (Table 2) and were inconsistent from one study site to the next (Table 1). The parasol attracted the most species and had greater frequency of occurrence

Table 2. Number of species and individuals and frequency of occurrence (%) of fishes during FAD assessments (SD = standard deviation)

	Total no. assess.	Total no. spp.	Mean no. spp.	Total no. ind.	Mean no. ind.	SD	%
FAD design							
Streamer	33	15	1.6	2,280	69.1	104.9	54.5
Parasol	33	15	2.0	3,854	116.8	179.2	63.6
Complex parasol	33	14	1.8	1,894	57.4	92.5	66.7
Time period							
0600–0900	36	18	2.0	3,650	101.4	169.3	66.7
0900–1200	21	13	2.0	2,766	131.7	133.4	71.4
1200–1500	18	11	2.0	1,235	68.6	91.4	66.7
1500–1800	24	8	0.7	382	15.9	40.5	41.7
Location							
West wall	27	12	2.1	2,630	97.4	169.3	63.0
Midcanyon	45	9	0.9	2,565	57.0	107.7	46.7
East slope	27	16	2.9	2,835	105.0	125.6	85.2

of the predominant species at the west wall. The greatest number of species at the east slope occurred at the streamer, while frequency of occurrence of the predominant species was similar for all three FAD designs. The parasol and complex parasol attracted the most midcanyon species with little difference in the frequency of occurrence of predominant species at any of the three FADs.

Species diversity and fish abundance were greater at FADs located near natural reefs (west wall and east slope) than at midcanyon (Tables 1 and 2). FADs at the east slope site attracted more species, exhibited a greater average number of fishes observed per assessment and had a higher percentage of assessments with fish near FADs than those at the west wall or midcanyon (Table 2). The most frequently occurring species at the east slope (Table 1) included: creole wrasse (*Clepticus parrai*), yellowtail snapper (*Ocyurus chrysurus*), boga (*Inermia vittata*) and great barracuda (*Sphyraena barracuda*). Similarly, creole wrasse, yellowtail snapper, and, to a lesser extent, boga were predominant species at the west wall. These four species were primarily associated with natural reefs but were observed extending their excursion range from the reefs to the FADs and beyond. The pelagic mackerel scad (*Decapturus macarellus*), along with great barracuda and yellowtail snapper, were predominant at the midcanyon site.

Supplemental observations of fish attraction were made by Hydrolab personnel during the mission. These observations indicated an increase in the activity of fishes near the surface. Baitfishes appeared to be more abundant, and several blackfin tuna (*Thunnus atlanticus*), a species that had only been observed on one other occasion in the 6 years that Hydrolab had been located in the submarine canyon, were sighted. A depth recording of the midcanyon study site made by Hydrolab personnel the morning following mission completion indicated fish activity, possibly more than that observed by aquanauts during the mission, near FADs.

Summary and Conclusions

Fish recruitment occurred fairly rapidly at the three submarine canyon study sites. Recruitment times and patterns varied somewhat at all three sites and among the different FADs at each site, but generally greater species diversity and abundance occurred at FADs located next to natural reefs. Most fishes observed around west wall and east slope FADs were reef-associated species recruited directly from adjacent natural reefs. These reef fishes appeared to use FADs to extend the distance that they would venture from the natural reef. Fishes attracted to mid-canyon FADs were primarily pelagic species recruited from adjacent coastal waters. Daily variation in number of fishes attracted to FADs was similar at the three submarine canyon study sites. FADs served only as daylight attractants with fishes initially being attracted and reaching maximum concentrations between morning and early afternoon and leaving FADs in late afternoon.

FADs at Hydrolab were not successful in attracting fishes probably because they could not compete with the attraction of Hydrolab itself. Hydrolab and its life support and mooring systems serve as a relatively large combination surface, midwater and benthic FAD.

No large-scale differences in attraction could be determined among respective FAD designs. Differences in abundance of fishes attracted to the various FAD designs occurred at each site, but none of the designs consistently attracted more or less fishes than other FADs at all of the study sites. Differences in attraction were therefore considered to have been the result of FAD position and not design.

The commercial and recreational significance of using midwater FADs in the Caribbean was demonstrated during the mission and by supplemental observations made by the Hydrolab staff. Fishes of commercial and recreational importance were attracted to FADs. Their abundance was not at a level that would support large-scale fisheries, but they would provide an adequate resource for artisanal and recreational fishermen. Increasing the number of FADs used and strategically locating these structures may further increase the potential for attracting large numbers of these species. The knowledge gained during this study (e.g., recruitment rates and daily variation in the number of fishes attracted) will aid in determining the best methods of harvesting fishes that have been concentrated through the use of midwater FADs.

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ADDRESSES: *(I.K.W. and J.W.W.) National Marine Fisheries Service, Pascagoula, Mississippi 39567; (A.M.L.) Department of Marine Biology, Texas A&M University at Galveston, Galveston, Texas 77553; (J.W.B.) NOAA Diving Office, 6001 Executive Blvd., Rockville, Maryland 20852.*