Fish Behavior Studies from an Undersea Habitat

William L. High and Alan J. Beardsley

Saturation diving from an undersea habitat permits scientists to make direct observations and to maximize their effective underwater time. During Mission I of Tektite II in the U.S. Virgin Islands, the authors conducted studies of fish behavior in and near pots (traps).

Three pot designs were studied: (1) the typical Virgin Island pot of chicken wire and wood strips, (2) an experimental collapsible pot utilizing nylon web and an aluminum frame, and (3) a commercially manufactured plastic pot.

The Virgin Island pot captured the greatest number of fish, although they were smaller than those captured in the experimental pot. The plastic pot caught few fish. Numerous behavioral characteristics relating to fishes within the influence of the pots were noted, including territorial defense, social behavior, and predator-prey relationships. Bait seemed to play a minor role in attracting fish to the pots.

For over 15 years, fishery scientists have utilized scuba gear effectively as a research tool. The ability to descend beneath the surface to observe directly harvesting gear in action and to study animal behavior has provided valuable information for the development of improved fishing gear and techniques (High, 1969). However, due to the effects of water pressure, divers can remain submerged only for relatively short time periods if they wish to return directly to the surface without decompressing. If a diver remained too long, nitrogen held in his tissues would cause the bends, a serious diver disease, when he returned to the surface.

The use of undersea habitats is one way in which the scientist-diver can remain under pressure for extended periods, either within the dry living space of the chamber or swimming in the water. At the conclusion of his study, the diver need only make a slow ascent to the surface using a decompression chamber. This permits nitrogen to escape slowly from saturated tissues, thereby eliminating those conditions responsible for the bends.

Recently, we utilized an undersea habitat for 2 weeks in research on fish behavior. Our experiments were carried out from the Tektite II undersea habitat (Figure 1) in the U.S. Virgin Islands. During the first mission of Tektite II (April 4-17, 1970), we investigated the behavior of fish around and within commercial and experimental fish pots. This study has direct application to the existing commercial pot fishery for reef fishes in the Virgin Islands, as well as the developing sable fish (Anoplopoma fimbria) pot fishery in the northeastern Pacific Ocean off Washington. Prior to Tektite II, we had collected information on fish behavior to pots using underwater TV, short-duration diving, and inferences from catch data; during Tektite II, we made direct observations of fish behavior for up to 7 hours a day.

METHODS AND MATERIALS

The steel Tektite habitat consisted of two 18-foot-high cylinders, each $12\frac{1}{2}$ feet in diameter, connected by a tunnel $4\frac{1}{2}$ feet in diameter (Figure 1). The cylinders were partitioned horizontally near the middle, creating

Mr. High and Dr. Beardsley are Fishery Biologists with BCF, EF&GRB, 2725 Montlake Blvd. E., Seattle, Washington 98102.

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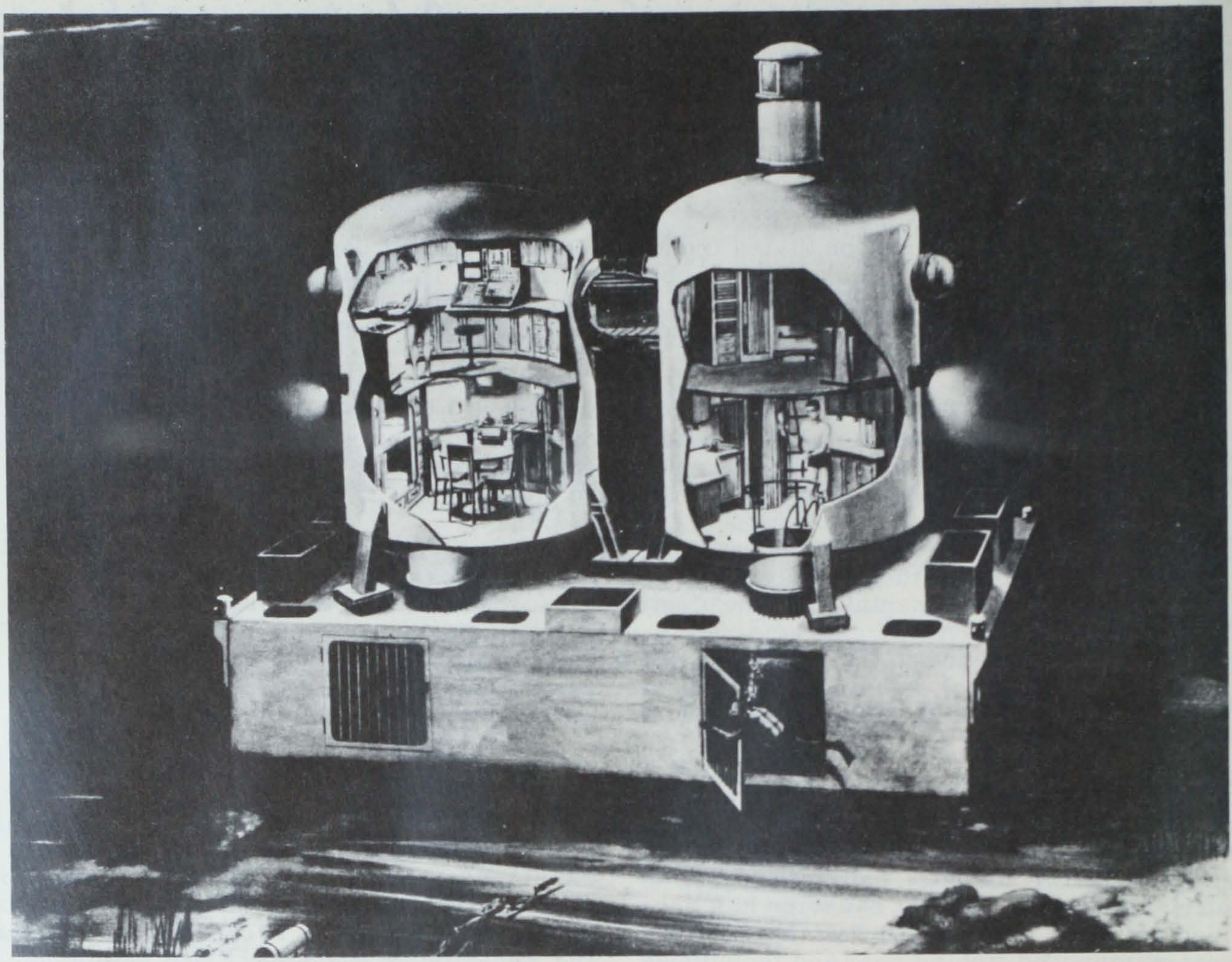

Fig. 1 - Artist's conception of the Tektite II 4-room underwater living and research habitat 50 feet beneath the Caribbean Sea.

four individual rooms. The gas mixture inside the habitat was controlled to 8% oxygen and 92% nitrogen at the ambient pressure of approximately 45 feet of seawater. The habitat site was selected because of the generally calm, warm, clear water and the nearby biologically diverse coral reef. Over 300 species of fish are represented in nearby waters (Randall, 1968).

Divers left the habitat wearing double scuba tanks permitting excursions from the habitat up to $1\frac{1}{2}$ hours. Diver safety equipment included dual regulators, tank pressure gauge, watch, compass, emergency sonic pinger, and CO_2 inflatable marker float. Hand-held, battery-operated lights were used during night dives. Observations of fish behavior were recorded using pencil and acetate cards.

Experiments were conducted with a total of six pots, two each of three different designs. Duplicity in pots permitted modifications in one pot while the other was being used as a control.

Virgin Island Pots

Two identical pots were borrowed from a local Virgin Island commercial fisherman (Figure 2). These pots were constructed of chicken wire ($1\frac{1}{2}$-inch mesh) supported by a frame made of $\frac{3}{4}$-inch by $1\frac{1}{2}$-inch wooden stringers. External dimensions were 20 inches high, 3 feet across and 4 feet long. The chicken wire tunnels were oval in shape and terminated in a right angle with the trap tunnel gate below. A plywood door at one end of the pot provided access to the pot interior for baiting and fish removal.

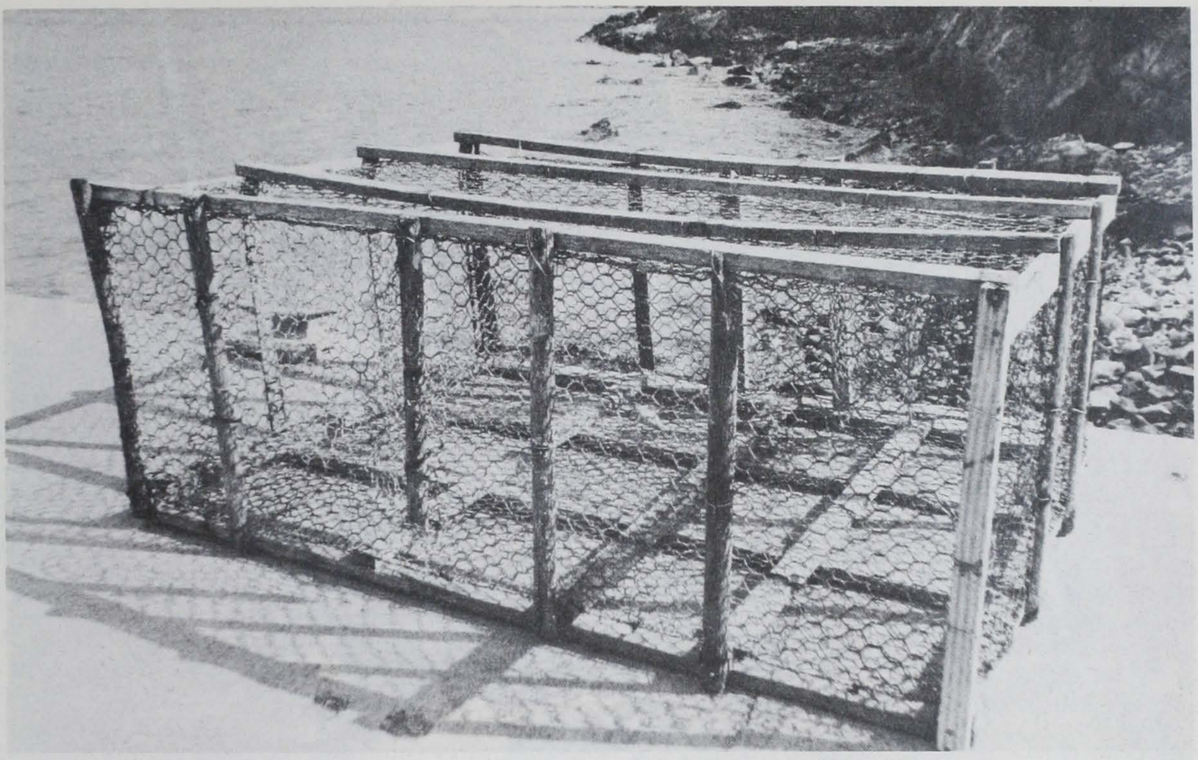

Fig. 2 - The typical Virgin Island fish pot constructed of chicken wire and wood lathe has two tunnels, one on each side.

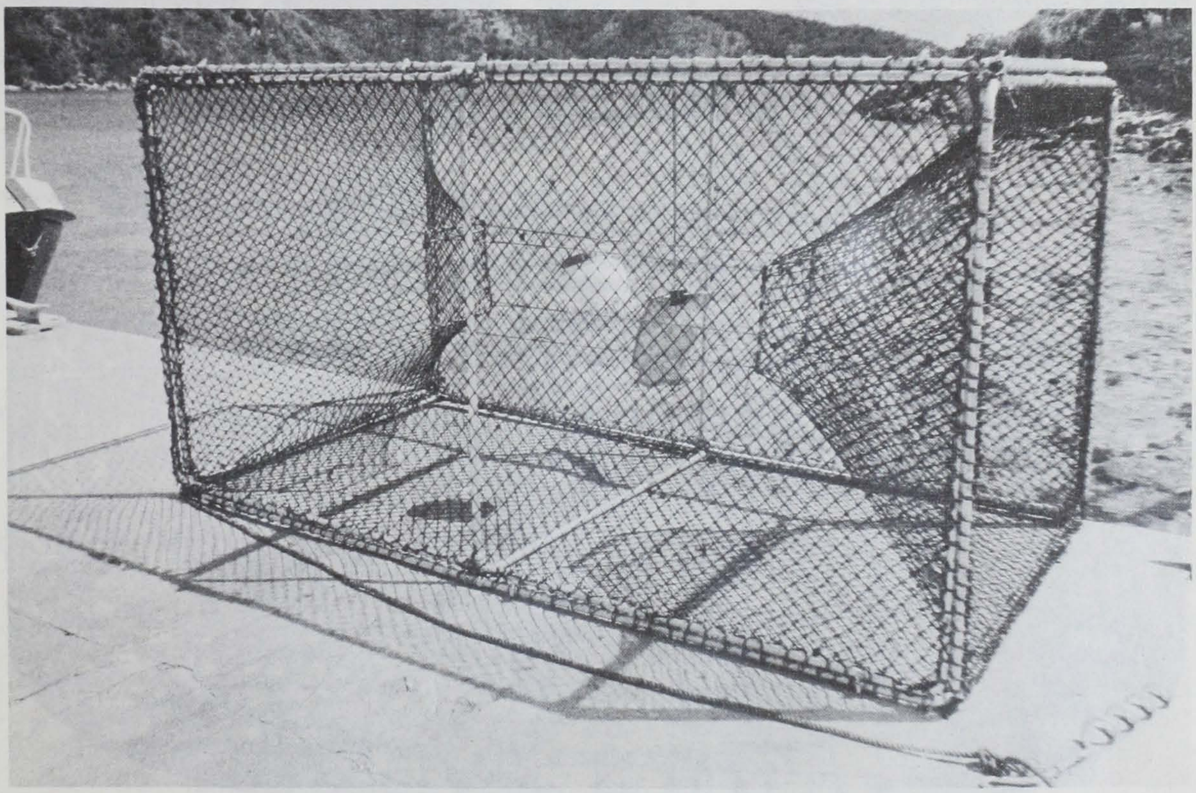

Fig. 3 - The lightweight experimental pot could be easily collapsed for shipment. One cone-shaped tunnel was placed in each end.

Fig. 4 - Underwater view of experimental pot lid opened to release captured fish.

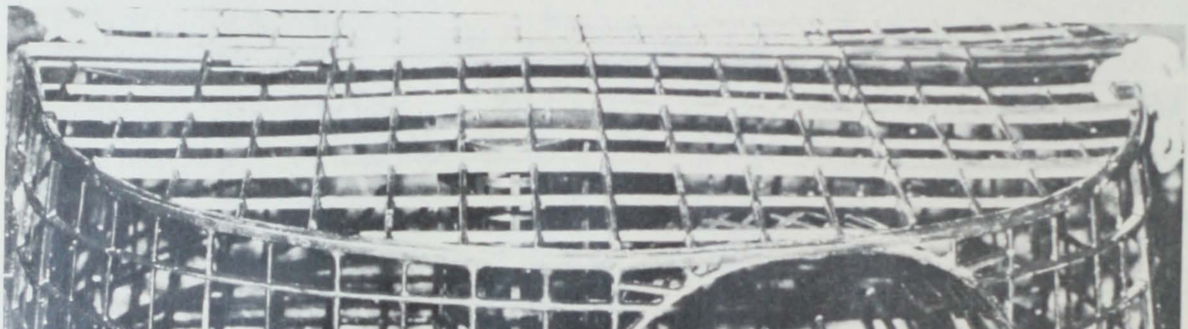

Fig. 5 - This small, molded-plastic pot proved ineffective for either fish or lobsters.

Two experimental collapsible pots--similar in design to the sablefish pots now being tested in the northeastern Pacific--were constructed in Seattle, Wash., and shipped to the Virgin Islands (Figure 3). These pots used 2-inch nylon web hung on a framework of $\frac{5}{8}$-inch-diameter aluminum rod. Nylon web formed the tunnels that led directly into the pot interior. Overall dimensions of these pots were 3 feet high, 3 feet across, and 6 feet long. Both 3- by 3-foot frames forming the top of the pot could be swung open for access to the pot interior (Figure 4).

The remaining two commercial pots were oval and constructed of black molded plastic (Figure 5). The mesh size of the plastic was $1\frac{3}{4}$ inches, and the external dimensions of these pots were $2\frac{3}{4}$-foot diameter by 1-foot high. Flexible plastic "spears" projected inward from the 8-inch-diameter tunnels to discourage the escape of either fish or lobsters.

During the 13-day experiment, experimental pot parameters were varied, including: triggers on tunnels, size of tunnel openings, location of pot relative to reef, type of bait, and length of time pots were fished.

Bait included crushed sea urchin, fish meal, conch, chopped fish, and a local cactus commonly used by Virgin Island fishermen. At the conclusion of a designated fishing period, fish were enumerated by species and then released.

RESULTS

During comparative fishing experiments on the coral reef, the three pot types exhibited distinct differences in their rate of fish capture and in species composition of the catch (Figure 6). The black plastic pots rarely caught fish, so catch records for these pots have not been included. In general, the Virgin Island-style pots caught greater numbers of fish than the experimental pots (Figure 6), but the fish were smaller. Only in the experimental pots were the larger, 4- to 5-pound Nassau groupers, caught. This selectivity by size of fish can be attributed to the larger tunnel and overall pot size. Spiny lobster entered the experimental pots; as many as four were caught during a 24-hour period.

It was possible to make many valuable observations of the behavior of fishes, both

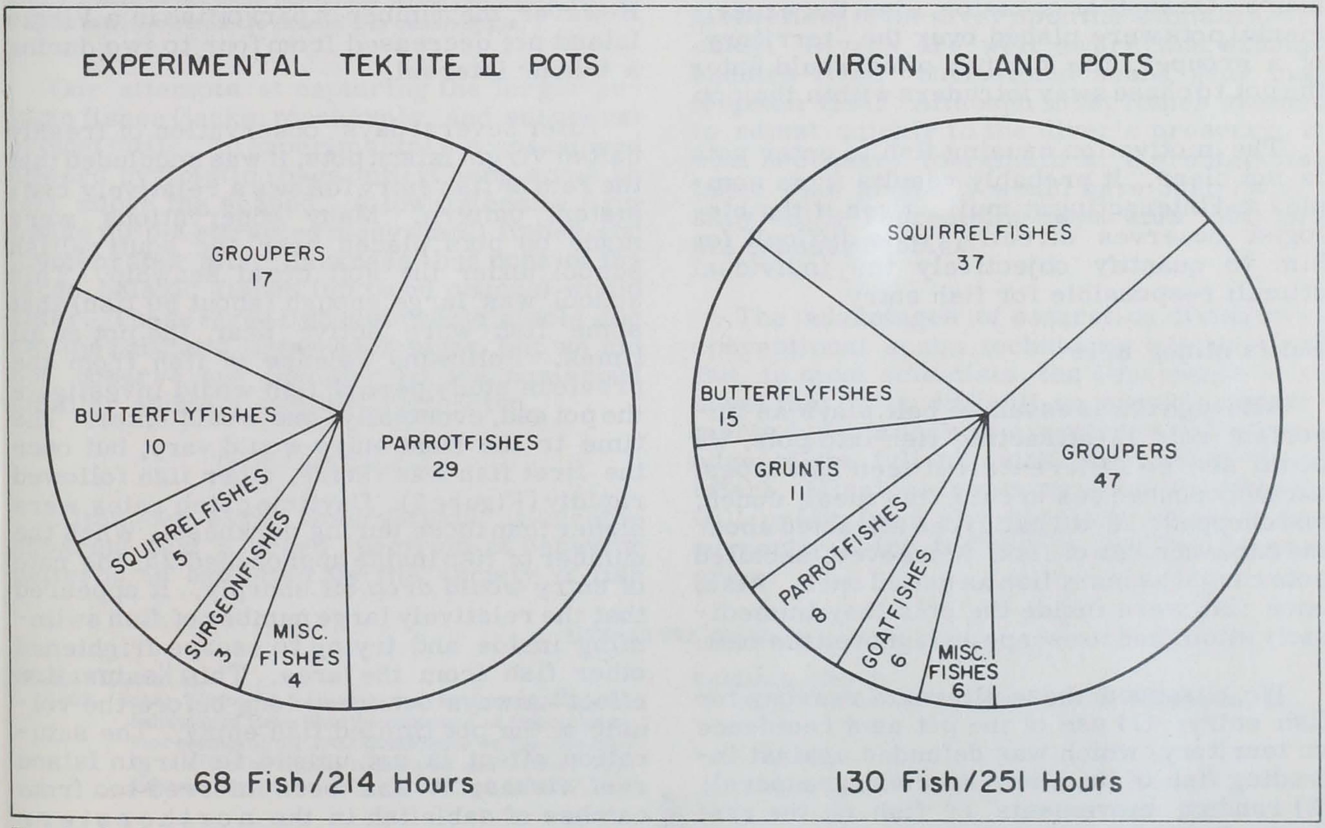

Fig. 6 - Catch (no. of fish) by fish family for experimental and Virgin Island pots. Only those sets where the bait was the same and pot locations were similar are considered here.

undisturbed on the reef and in the vicinity of pots. The behavior of an individual fish species may be as characteristic of that species as body morphometry or color. For example, some species were found consistently as solitary individuals and approached the pot with caution (groupers); other schooling species either would enter the pot readily as a group (squirrelfishes, goatfishes) or independently (parrotfishes, bigeyes); paired fish would follow their mates readily into the pots (butterflyfishes and some parrotfishes).

Pot's Location on Reef Important

We found that the location of the pot on the reef is an important factor determining the number and species of fish caught. Although squirrelfish were numerous on all reef areas surrounding the habitat, they tended to congregate in localized areas, including a soft coral seawhip located on the sand flats three feet from the reef. One Virgin Island pot was placed 15 feet from the coral seawhip for two 24-hour periods. The pot caught five fish; only one was a squirrelfish. When the pot was moved within 5 feet of the coral seawhip, catches increased to 25 squirrelfish in 24 hours. On another occasion, when the experimental pots were placed over the "territory" of a grouper, the grouper often would enter the pot to chase away intruders within the pot.

The motivation causing fish to enter pots is not clear. It probably results from complex and interacting stimuli. Even if the biologist observes directly, it is difficult for him to quantify objectively the individual stimuli responsible for fish entry.

Bait's Minor Role

Although it was assumed bait plays an important role in attracting fish into pots, we could see no difference between bait types: cactus, crushed sea urchin, fish meal, conch, and chopped fish; all bait types attracted about the same number of fish. Moreover, unbaited pots caught as many fish as baited ones. Also, once fish were inside the pots they immediately attempted to escape and ignored the bait.

We observed these alternate reasons for fish entry: (1) use of the pot as a residence or territory, which was defended against intruding fish of the same species (groupers); (2) random movements of fish on the reef (butterflyfishes, parrotfishes); (3) curiosity (butterflyfishes, squirrelfishes); (4) social behavior or gregariousness with one or more fish attracting others into the pot (butterflyfishes, squirrelfishes); and (5) predator-prey relationships, where the predator (groupers, parrotfishes) would chase the prey (squirrelfishes, parrotfishes) into the pot, or the predator would be attracted into the pot by the already captured prey (groupers, parrotfishes). Although parrotfish are not generally considered predators, they were observed on numerous occasions attacking weak and dead parrotfish in the trap.

Behavior Inside Pots

Once inside the pots, butterflyfishes, goatfishes, squirrelfishes, and parrotfishes would swim in circles continuously--compared to groupers' intermittent search behavior. The fish would congregate in the corners of the pot and, on several occasions, fish (we assume parrotfishes) bit through the nylon web creating holes large enough for fish to escape. Fish spent little time near the tunnel openings of the experimental pots, and only two fish were seen escaping through these openings. The complexity of the Virgin Island-type tunnel largely prevented escape by all fish species. However, the number of parrotfish in a Virgin Island pot decreased from four to two during a 4-hour interval.

After several days' observation of freshly baited Virgin Island pots, it was concluded that the rate of fish entry follows a relatively consistent pattern. Many observations were made on pots placed near the squirrelfish school under the soft coral seawhip. This school was large enough (about 60 fish) that some fish were active near the pot at all times. Following release of fish from the previous study period, fish would investigate the pot and, eventually, one would enter. The time to the first entry would vary, but once the first fish was inside, other fish followed rapidly (Figure 7). Daytime catch rates were higher than those during darkness. When the number of fish inside approached 25, the rate of entry would drop off sharply. It appeared that the relatively large number of fish swimming inside and trying to escape frightened other fish from the area. This "saturation effect" always occurred long before the volume of the pot limited fish entry. The saturation effect is not unique to Virgin Island reef fishes; it has been inferred too from catches of sablefish in the northeastern Pacific.

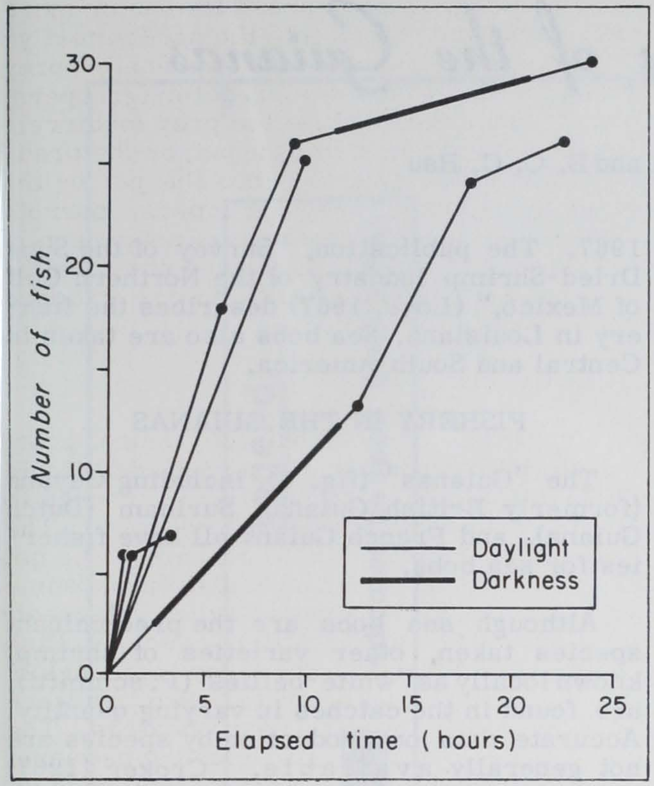

Fig. 7 - Date of fish entry into Virgin Island pots during five different sets. Dots indicate time of fish enumeration.

Our attempts at capturing the larger pelagic fishes (jacks, mackerels, and snappers) proved futile. An experimental pot was buoyed upward by flotation bags until it hung some 25 feet above the seabed. A low-intensity light inside the pot attracted many small fishes and invetebrates after darkness, but none of the large pelagic fishes (up to 50 pounds) would enter. These large fish also would circle under the habitat's lights each night, but we did not observe any foraging on the numerous smaller animals similarly attracted.

CONCLUSIONS

After our early observations, it became apparent that a broad spectrum of behavior patterns is exhibited by the variety of fish species present on the coral reef. Although our research during Tektite II has direct bearing on the local Virgin Island pot fishery (placement of pots, use of bait, time between lifts, rate of escape, etc.), its relevance to the sablefish fishery in the northeastern Pacific may not be as straightforward. We were able to observe repeatedly the "saturation effect" as the number of squirrelfish built up in the pots and believe this phenomenon may be occurring with sablefish in the northeastern Pacific. Since each species exhibits its own behavior patterns, it is difficult to draw conclusions from a study of a particular species and transfer these observations to another species. By and large, the most legitimate way to reach conclusions regarding the behavior of a fish species in a species-specific fishery (sablefish) is to observe the species. Future studies in Pacific Northwest waters undoubtedly will include more observations of sablefish held in salt-water pens.

Diver's Effect On Fish

A major concern of behaviorists making direct underwater observations is the possible effect of the diver upon the animals under study. Divers are well aware that exhaust bubbles from conventional scuba gear may frighten fish. Although most fishes seemed to adjust quickly to the diver's presence, it was necessary to remain at a greater distance than probably would have been necessary using rebreathing apparatus that does not exhaust bubbles.

The advantages of saturation diving over conventional scuba techniques are obvious. But, to most scientists, the experience is so novel that it is difficult to preplan experiments due to a lack of experience and knowledge of the full potential this type of diving offers. Missions in coming years undoubtedly will profit from the expertise of aquanauts currently being trained in the Tektite program.

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