ARTICLES

DETECTION OF FISH SCHOOLS BY SONAR
(Eastern Tropical Pacific, July-November 1967)

By Robert I. McClendon*

In 1967 an investigation of the physical and biological oceanography of the eastern tropical Pacific was begun. This program, known as EASTROPAC, is intended to provide the necessary data for more effective use of marine resources of the area, especially tropical tunas. The investigation is coordinated by the Bureau of Commercial Fisheries (BCF) at its Fishery-Oceanography Center, La Jolla, California. Other United States Government agencies participating are the Coast Guard, Environmental Science Services Administration, The Naval Oceanographic Office, and the Smithsonian Institution. Other participants include the Scripps Institution of Oceanography of the University of California San Diego, Texas A & M University, and the University of Miami, Coral Gables, Florida. International cooperation is given by the Inter-American Tropical Tuna Commission at the Fishery-Oceanography Center, and its member nations--Chile, Ecuador, Mexico, and Peru.

The area from 20° N. to 20° S. and from the coast of South America to 126° W. is covered by multiple-ship (4 to 5 vessels) survey cruises. Single-vessel monitoring cruises are made bimonthly from 20° N. to 20° S. and from 98° W. to 119° W.

This report concerns occurrence of fish schools as determined from the sonar data collected aboard the BCF research vessel "David Starr Jordan" (fig. 1) on two EASTROPAC monitoring cruises during July 10 through November 27, 1967. Because data for Legs 1 and 2 for these two cruises were not available for comparison, only the information from Acapulco, Mexico, to the end of the cruise was used. The number of targets encountered on each cruise may be used as a measure of productivity and fish population in the area covered. A target is defined as any object in the open sea that appears on the sonar recorder. The presence of echoes was used as an indication of fish schools.

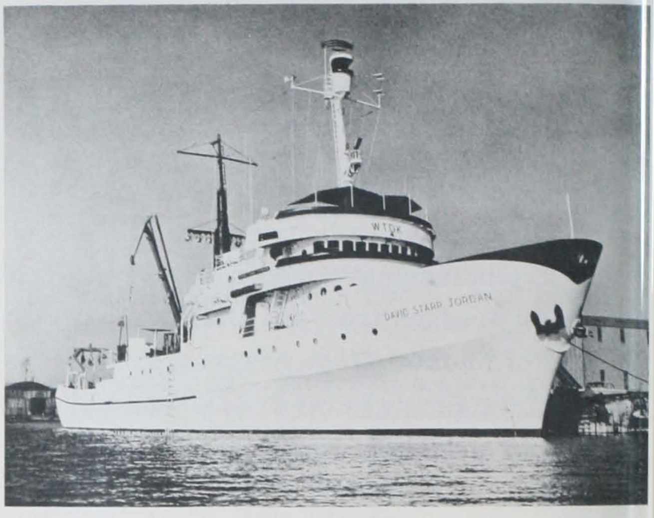

Fig. 1 - The Bureau's research vessel David Starr Jordan. (Photo: Herb Reynolds)

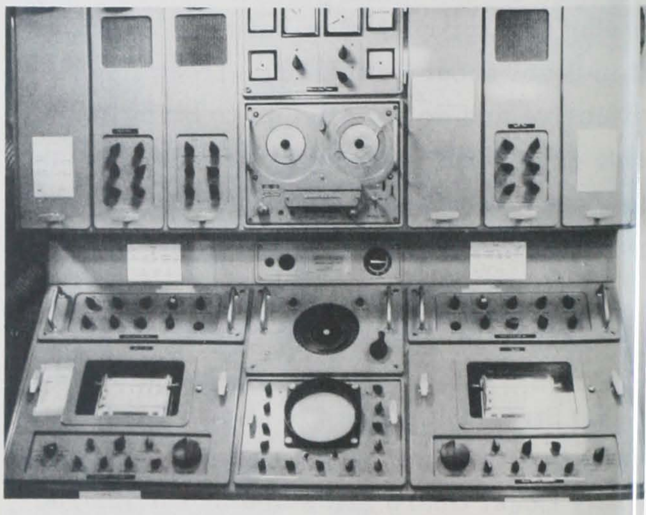

Fig. 2 - Operator's control and display console showing the 11 kHz unit on the right and the 30 kHz unit to the left.

The Simrad Research Sonar, Model 580-10[1] (fig. 2), on the Jordan is designed for research. It is more versatile, more powerful, and has a much greater range than the sonar units on most fishing vessels. Although the complete

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1/Mention of firm does not imply endorsement by BCF.

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Fish and Wildlife Service
Sep. No. 811

installation comprises two combination sonar/depth sounder sets operating at 11 kHz and 30 kHz (1 kHz equals 1,000 cycles per second), only the information from the 11 kHz set was used for this particular study. The 11 kHz transducer was aimed 10° off the starboard bow and set at a range of 2,500 meters. Thus, the sonar beam of approximately 23° covered a horizontal band about one-half nautical mile wide. As the ship moved through the water at an average speed of 10 knots, an area of about 5 square miles was searched each hour. In a day's running, an area of 75-85 square miles was sampled.

Unless identified otherwise, all targets included in this study were assumed to be fish, either single specimens or schools. Undoubtedly some debris floating in the water was encountered on both cruises. The number of these inanimate objects for cruise 30 was not available, but on cruise 50, during daylight, sight records of all surface objects were kept. Only two of nearly a thousand targets were disregarded when they were identified as driftwood. Because so few nonbiological targets were encountered during the day (0.02 percent of identified targets), I believe that they may be considered of no consequence in the data. Since the probability of nonbiological targets should be the same day or night, I assume that few of the nighttime targets on either cruise were flotsam.

Only a few fish schools other than flyingfish were sighted on the surface within the sonar beam; therefore the species composition of the schools recorded is not known. Skipjack tuna and "bait" (unidentified) were the only sightings. Whales and porpoises were sighted often from the ship but were recorded only twice. Although some porpoises and whales are frightened by sonar at certain frequencies, research to date has shown no reaction by fish at the sonar frequencies used (Miyaki 1952, Cushing and Richardson 1955). It is assumed, therefore, that fish in the area covered by this survey were not disturbed by the sonar.

The number of targets in 6-hour periods are shown on the track charts of the two cruises (figs. 3 and 4). The number of targets are estimates of total population along the track lines. The targets recorded for daylight hours were estimated from running time and expressed as targets per mile; the number of targets recorded for nighttime was adjusted for the day-night difference.

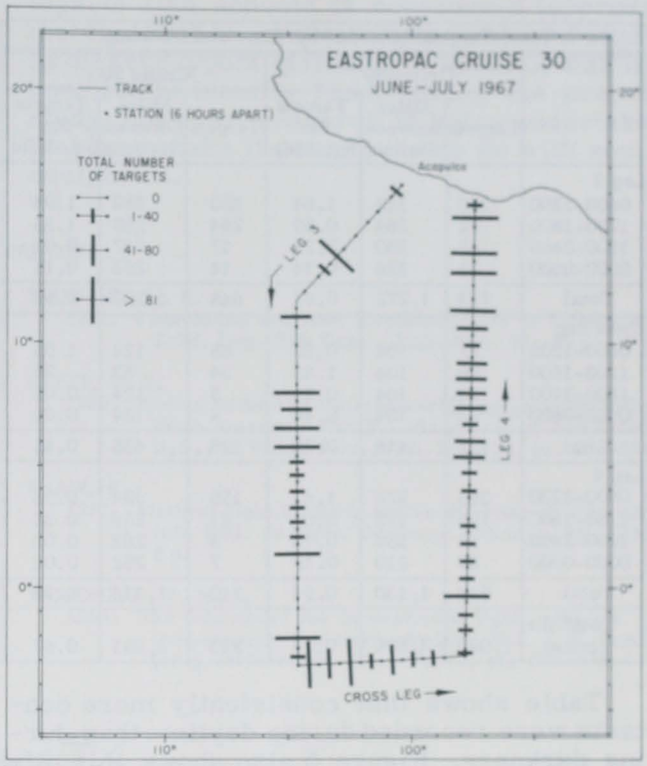

Fig. 3 - Estimated total population per 6-hour interval based on number of targets recorded on EASTROPAC cruise 30.

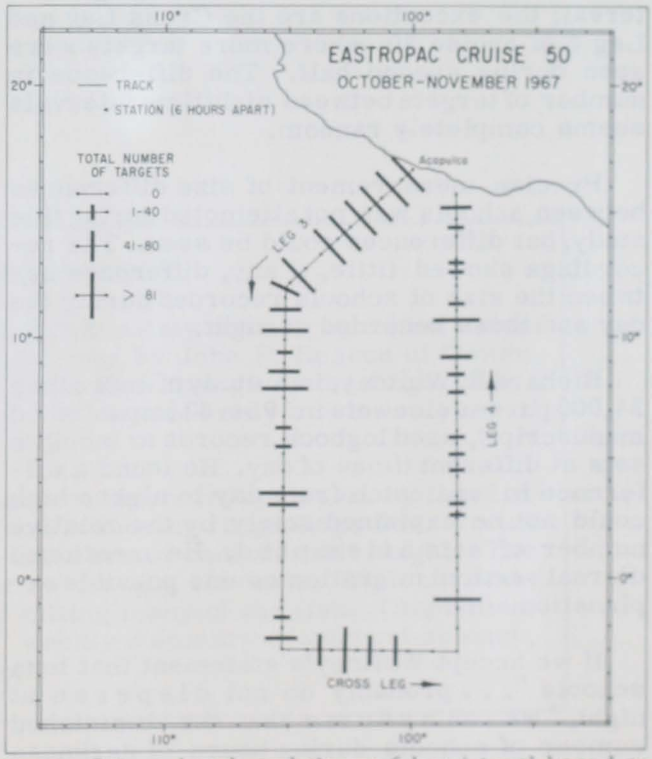

Fig. 4 - Estimated total population per 6-hour interval based on number of targets recorded on EASTROPAC cruise 50.

Total Targets Recorded by Time and Distance						
	Cruise 30			Cruise 50		
	Targets	Miles Between Stations	Targets Per Sq. Mile	Targets	Miles Between Stations	Targets Per Sq. Mile
Leg 3						
0600-1200	280	342	1.64	350	360	1.94
1200-1800	72	264	0.55	264	285	1.85
1800-2400	48	330	0.29	17	387	0.09
0000-0600	23	336	0.14	14	258	0.11
Total	423	1,272	0.67	645	1,290	0.98
Cross Leg						
0600-1200	27	104	0.52	65	124	1.05
1200-1800	96	104	1.85	24	63	.76
1800-2400	11	104	0.21	5	124	0.08
0000-0600	23	104	0.44	4	124	0.06
Total	157	416	0.75	98	435	0.45
Leg 4						
0600-1200	265	374	1.42	159	324	0.98
1200-1800	196	192	2.04	41	258	0.32
1800-2400	32	354	0.18	3	282	0.02
0000-0600	20	210	0.19	7	252	0.06
Total	513	1,130	0.91	210	1,116	0.38
Total for cruise	1,093	2,816	0.78	953	2,851	0.67

Table shows that consistently more contacts were recorded during daytime than during darkness. Figure 5 also shows this difference; further, it indicates a trend toward more targets in first half of the daylight interval; the exceptions are the Cross Leg and Leg 4 of cruise 30, where more targets were seen during second half. The difference in number of targets between nighttime intervals seems completely random.

Precise measurement of size differences between schools was not attempted during this study, but differences could be seen. The recordings showed little, if any, difference between the size of schools recorded during the day and those recorded at night.

Richard R. Whitney, in a study of more than 34,000 purse seine sets in 1954-62 (unpublished manuscript), used logbook records to tabulate sets at different times of day. He found a difference in tuna catch from day to night which could not be explained solely by the relative number of sets attempted. He mentioned diurnal vertical migration as one possible explanation.

If we accept Whitney's statement that tuna schools "... probably do not disperse at night," we can assume that the diminished number of schools during hours of darkness indicates a diurnal change in the depth at which schools are likely to be found. Diurnal vertical migration is well known in many species of schooling fish; it has been shown by changes in amount of catch by fishing gear as well as by direct studies (Woodhead 1964).

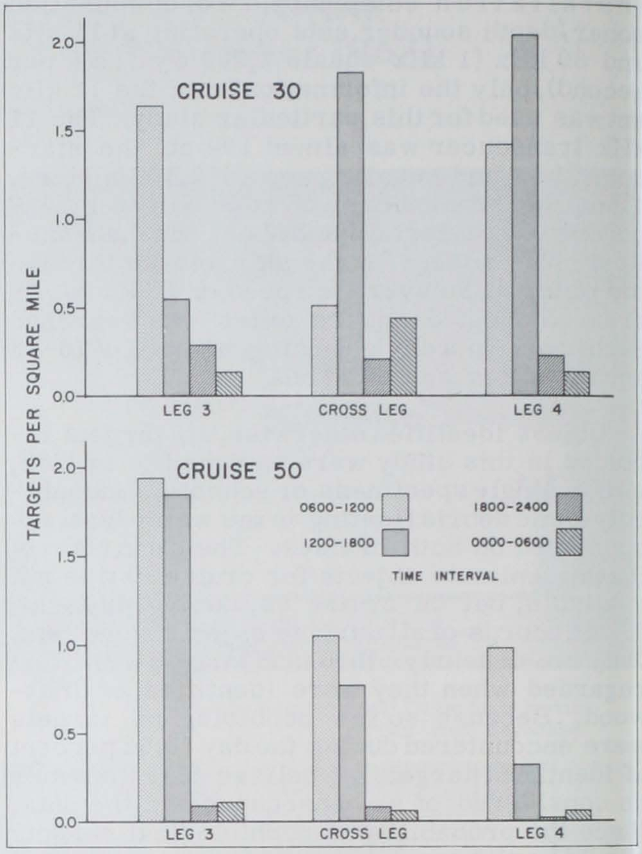

Fig. 5 - Distribution of targets per square mile by time interval for EASTROPAC cruises 30 and 50.

Aschoff (1964) stated that light is a common stimulus for change in behavior, and that it is probably more important in the marine environment than on land. He suggested that competition between species is reduced by differential rhythmicity of behavior. The difference in times that different species appear at the surface during the day also suggests that they may be at different depths during the night.

The sonar on these cruises was recording targets primarily above the thermocline (about 50-60 meters deep); fish schools would be less likely to be detected below this depth. That schools disperse during darkness has been suggested (Blaxter 1964). Others (Scofield 1951, Sette 1950, Shaw 1961) have stated that starlight, skylight, and bioluminescence may be sufficient to enable some species to maintain their schools.

This study has shown the usefulness of sonar in the estimation of total population over a wide area in a short time. Had we depended on surface sightings alone to estimate the fish population on these two cruises, we would have tabulated a different distribution and a different total number of schools. If the difference between sonar recordings and surface sightings of fish schools is considered (approximately 100:1 on cruise 50), the value of sonar in direct support of fishing is seen. It was not possible to identify fish during the present study; however, research is being undertaken that may make it possible to do so with sonar equipment.

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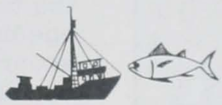

SAVING FINGERLINGS

A system for transporting fingerling fish safely downstream past a dam or similar obstruction was patented recently by John P. Roscoe of Cutten, Calif. Roscoe's solution provides a bypass flow that gives the fingerlings a descent ladder at one side of the dam. It requires only a relatively small amount of power to operate.

Although salmon and other fish can be transported upstream by fish ladders without difficulty, there is a problem in moving fingerlings downstream from spawning grounds especially when dams are of considerable height. The difficulty is that fingerlings tend to follow flowing currents. Such currents often pass through power turbines thus killing many of the fish. (Reprinted, with permission from "Science News," weekly summary of current science, copyright 1966, by Science Service, Inc.)