TECHNOLOGY AND EXPLORATORY FISHING SESSION

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New Methods of Purse Seining for Tuna in the Eastern Pacific Ocean

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THE UNITED STATES TUNA FISHERY originated in California in 1903 when albacore were canned successfully for the first time. Through the years, as demand for the canned product increased, there was a gradual expansion in the number of tuna vessels fishing for yellowfin and skipjack tunas in the more distant tropical waters. By 1930, prospecting for these species had extended south to the Galapagos Islands and waters off Central America. The fishery was further extended to waters off northern Peru in 1950 and to waters off northern Chile in 1958.

The production of tuna and tuna-like fishes by United States vessels rose to a peak in 1950. Since that time economic difficulties within the industry have resulted in a continuous decline in the number of vessels fishing for tuna and subsequently a decline in the total production.

Many bait fishing vessels were constructed during the post-war expansion period of 1946-1951. Since then, new construction has been limited to two or three vessels per year, a figure considerably less than losses due to sinkings, foreign transfers and withdrawals of older vessels from the fleet.

The tuna purse-seine fleet expanded, after World War II, from a nucleus of the larger sardine vessels. They fished for yellowfin, skipjack and bluefin tuna from February to August each year, laying-up or fishing for sardines during the fall period. These vessels were small (by bait vessel standards) and carried an average of about 120 tons of tuna. Additional vessels were added to this fleet during the post-war boom in vessel construction. Some of these new seiners were quite large (150-350 tons carrying capacity) but with one exception the large seiners were unsuccessful and were converted to bait fishing. The fishing range of the tuna purse-seine fleet was somewhat limited by vessel size and most vessels, other than the largest craft, resorted to transshipment of their catches when operating south of about 15 degrees north latitude.

Table 1 shows size of each fleet (California-based), their catches by species, catch-per-vessel and the approximate price of yellowfin tuna for each year during the period 1947-1959. Albacore landings have not been included, as they represent an extremely small portion of the catch of the large tuna vessels.

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TABLE 1

CATCH-PER-SPECIES, CATCH-PER-VESSEL AND APPROXIMATE PRICE OF YELLOWFIN (CALIFORNIA FLEET) DURING THE YEARS 1947-1959 FOR BOTH TYPES OF GEAR

	Bait Vessels				Purse-seine Vessels					
Year	Number of vessels	Yellowfin	Skipjack	Tons per vessel	Number of vessels	Yellowfin	Skipjack	Bluefin	Tons per vessel	Yellowfin price per ton (approx.)
1947	176	61,566	21,865	474	84	12,686	3,988	7,637	289	310
1948	198	78,385	26,746	531	89	17,352	2,230	2,036	243	340
1949	205	78,817	35,727	559	79	12,148	2,214	1,589	202	310-340
1950	204	72,665	54,602	624	67	17,478	6,329	1,004	370	310
1951	225	72,200	50,285	544	78	7,273	6,383	1,316	192	310
1952	202	72,871	36,072	539	64	15,141	5,298	1,803	348	310-320
1953	190	48,415	56,011	550	64	17,770	5,700	2,571	407	320
1954	182	51,302	67,484	653	69	8,405	9,390	9,041	389	330-350
1955	172	47,498	45,334	540	63	13,540	5,716	5,317	390	260-310
1956	175	54,221	57,033	636	64	20,095	2,787	5,246	440	270
1957	170	52,303	42,258	556	50	16,024	2,961	6,940	519	250-270
1958	159	41,117	56,780	616	44	20,088	2,144	10,352	741	250
1959	141	26,807	43,183	496	53	27,377	6,024	7,217	751	250

Source: Broadhead and Orange, 1959, U.S. Dept. of Interior Circular No. 65, 1959, and U. S. Tariff Commission Report, 1958.

Immediately evident is the steady decline in recent years in the number of operating units in each fleet, coincident with the steadily falling ex-vessel price of tuna. The increase in the numbers of purse-seine vessels in 1959 (and again in 1960 but not shown) is the result of the conversion of the bait vessels to net operations. No new construction has been added to either fleet in the past several years.

Purse-seine fishing was not particularly successful during the early part of the period under discussion. These vessels produced less than 20 per cent of the yellowfin and only about seven per cent of the skipjack tuna catch. Their catches of bluefin tuna were erratic and were dependent on the availability of the fish to the fishery and on demand for this species. By 1956 this fleet of aging vessels appeared to be heading for extinction by attrition. However, beginning in 1957, and before large-scale technical changes were introduced to the fleet, the catch-per-vessel began to increase substantially. Concurrently, several technological advances were being pioneered by certain vessels in the fleet. These caused two significant trends to develop:

1. Modernization of the existing fleet of purse-seine vessels, beginning in 1958 and continuing through 1959.

2. Conversion of many of the bait vessels to purse-seiners, beginning in 1958 and accelerating during the latter part of 1959 and early 1960.

Technological Changes

A preliminary documentation of the technological advances within the tuna fleets and their effects on the costs of catching tuna was made by Orange and Broadhead (1959). These are summarized briefly with certain additional information on fishing experience during the past year.

A. Power Block

This mechanical means of retrieving the tuna seine was introduced in the latter part of 1955; an adaption from the original design used for salmon and herring seine operations in the Pacific northwest. By the end of 1958, six vessels in the fleet were equipped with power blocks, and a year later almost all of the fleet had abandoned the slower method of strapping the net aboard the vessel. Records[3] of individual sets show that use of the power block, in combination with the nylon net, has cut the time of "no catch" sets in half, or from two hours to one hour, on the average. Sets-per-fishing-day have increased from an average of 0.7 during the period 1952-1957 to about 1.0 during 1958 and 1959.

B. Nylon Nets

The all-nylon tuna seine was introduced to the California tuna seine fleet in 1956. Despite immediate recognition by the fishermen of its superiority over cotton, several years passed before the nylon net became standard in the fleet. The delay was primarily due to economic factors; two of which were lack of capital and the fact that many of the costly cotton nets were still in serviceable condition. By the end of 1959, practically all of the fleet were using the nylon net.

Scofield (1951) reported that the average cotton tuna seine measured 325

[3]Inter-American Tropical Tuna Commission.

fathoms in cork line length and 32 fathoms in depth. Bulkiness prevented the use of nets of larger dimensions. Today, using the lighter and stronger nylon webbing, the nets used by the larger seiners average some 425 fathoms on the cork line and 42 fathoms in depth. The body of the net is 4¼- or 4½-inch stretched mesh, 42-thread nylon, with heavier and larger mesh nylon near the lead and cork lines. These nets represent an investment of about $45,000 each.

Catch-per-successful-set for the period 1952-1958, given by Orange and Broadhead (1959), for a select group of 34 of the older type seiners, was shown to fluctuate within a narrow range of 13 to 16 tons per set. During 1959 the catch-per-successful set rose to 18 tons for this same group of vessels. In all years the number of successful sets has been approximately half of all sets made.

C. Handling, storage and refrigeration changes

Until quite recently, many vessels in the purse-seine fleet employed ice as a means of refrigerating their catch. Brine freezing, developed in the late 1930's and used by nearly all of the bait vessels, was not practical for many of the seiners. The latter were too small for effective conversion to brine, and they continued to use ice. In 1957 a new method of refrigeration called brine-spray was developed. Using spray rather than a full tank of brine water to freeze the tuna, the method was so successful that a large number of the seiners converted to its use, with subsequent increases in the efficiency in handling catches of fish. Bait vessels which have converted to net fishing have retained their brine wells with some modification to permit the installation of the net platform on the vessel stern.

Ancillary fishing equipment has also been improved. The power skiffs have been enlarged, and their buoyancy increased. Brailing and stowage of the tuna has been expedited by installation of a central hopper with chutes to the various brine wells. Technical descriptions of the many gear modifications within the fleet are currently being undertaken by the Gear and Exploratory Fishing Section of the Bureau of Commercial Fisheries.

D. Land-based Scout Aircraft

During the period of prosperity and post-war expansion of the tuna fleet, many of the larger bait vessels carried their own float planes for spotting schools of tuna bait and tuna. As the ex-vessel price of tuna declined, vessel operating costs were pared, and these aircraft gradually disappeared from the fleet. In their place there developed a small group of independent pilots operating from land bases in Baja California and along the central coast of Mexico. The planes have been most effective during the spring fishery for yellowfin tuna in the Gulf of California. The spotter aircraft assist in two ways:

1. By scouting the general area for tuna schools and guiding the seine vessels toward worthwhile targets.

2. By detailed direction in laying the net around the school.

For their "spotting" services the vessels contribute five per cent of the catch from assisted sets. The consensus among vessel operators is that assistance from these aircraft is well worth the costs involved.

Trends in Fishing Success

Figure 1 is a plot of the ratio of the catch-per-day's-fishing by the original purse seine fleet (standardized) to the catch-per-day's-fishing for bait vessels

(also standardized). The quarterly values have been smoothed by threes and plotted for the period 1951-1959. For yellowfin tuna, the ratio remains fairly constant until 1956 and then turns sharply upward as the purse-seine catches rose. For skipjack tuna, a species taken less frequently by the seine fleet, an obvious upward trend is noticeable during these latter years although it is not so clear-cut. Also of interest but not well understood is the marked divergence of yellowfin ratio from that for skipjack beginning toward the end of 1954. No wide-spread technological changes were effected within the fleet until the 1959 season, whereas the catch-per-day's-fishing values began to climb in 1957.

Converted bait boats (Figure 2) began to appear in force in the purse-seine fleet during the 1959 season. For comparative purposes the catch-per-day's-

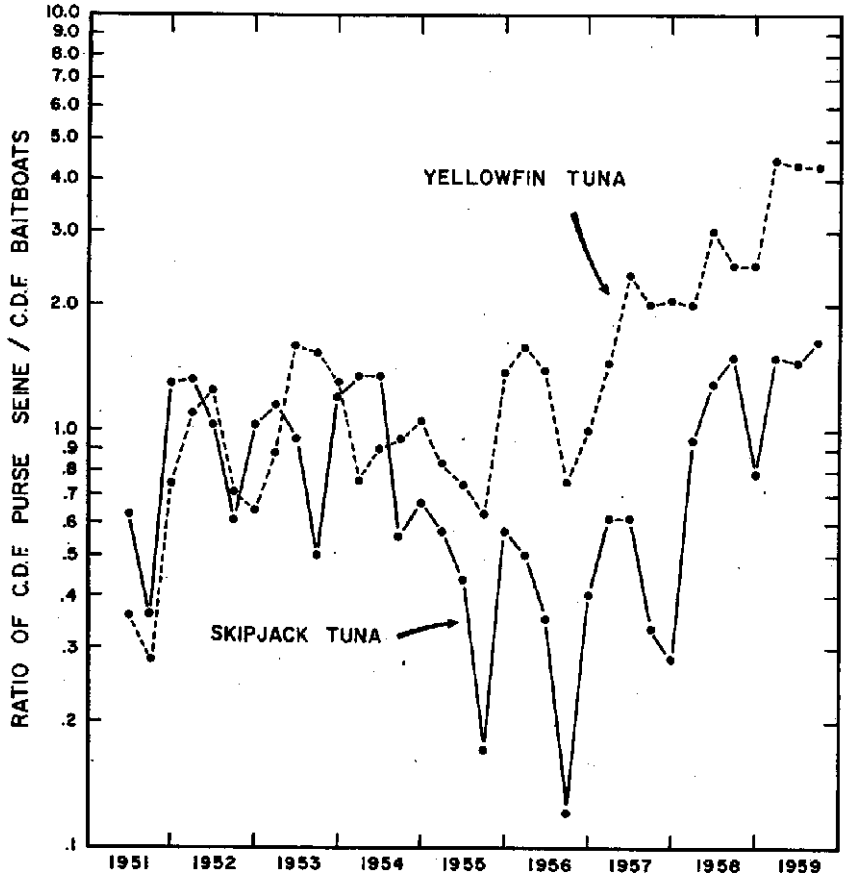

FIGURE 1. Ratios, for quarters of the year, of fishing success of purse-seine vessels, plotted for years 1951-1959. Five-degree areas where there were more than 20 standard days fishing each quarter, for each gear, were included. Equal weight was given to each five-degree area regardless of total catch of tuna in the area.

fishing for the first eleven conversions has been tabulated for 1958 and 1959 when they operated as bait vessels and for the subsequent period during 1959 and 1960 when they operated as purse-seiners. As bait vessels they fished 49 per cent of their time while at sea and caught an average of 7½ tons of tuna per day's fishing and as purse-seine vessels they fished 60 per cent of their time at sea and caught an average of 15½ tons of tuna per day's fishing.

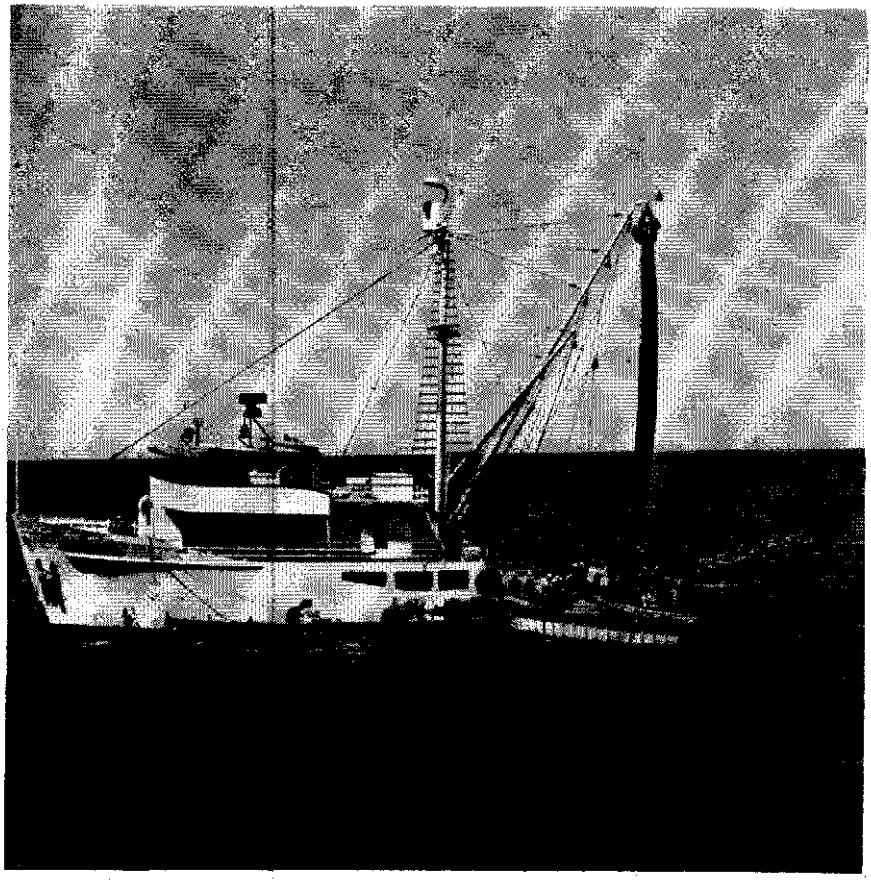

FIGURE 2. Bait vessel with hull modifications and gear for tuna purse seining. (Courtesy *Pacific Fisherman*)

Changes in Oceanic Climate during Recent Years

The unusually warm water throughout the Eastern Pacific Ocean during the period 1957-1959 had considerable effect on the distribution of tuna catches (Alverson, 1960; Schaefer, 1960). Yellowfin tuna were noticeably absent from the central regions of the fishery. Skipjack tuna, and to a lesser extent yellowfin tuna, were found concentrated at the northern and southern ranges of the fishery. Bluefin tuna were abundant off Baja California and southern California

and were readily available to the purse-seine fleet. The shifts in tuna distribution have been favorable to the purse-seine fleet, which is equipped to harvest the yellowfin tuna appearing in quantity in the Gulf of California and the bluefin tuna that appeared off Baja California and southern California. The bait fleet fishing off Central America found very poor fishing for yellowfin tuna, and much of the fishing effort was concentrated in the distant grounds for skipjack off northern Peru.

SUMMARY

In the past several years there have been radical changes in the composition of the fleets fishing for tuna in the Eastern Pacific Ocean. Conversion of many of the bait vessels to purse-seine fishing has built up a large fleet of modernized seine vessels, many of which are capable of operating over the entire range of the fishery from California to Peru. Technological improvements in gear and fish handling have been responsible for a portion of the increase in seiner fishing success, the remainder being attributed to increased availability of the stock, in recent years, to this type of gear.

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Air-Bubble and Electrical-Field Barriers as Aids to Fishing

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THE U. S. BUREAU OF Commercial Fisheries Research Station at Boothbay Harbor, Maine, has for several years conducted fishing gear experiments with new and unconventional methods for catching the Atlantic herring *(Clupea harengus)* that are canned as Maine sardines. Two such methods, called the Air-Bubble Curtain and the Marine Electric Fence, also show some promise of being useful for guiding and driving other species of fish. A considerable