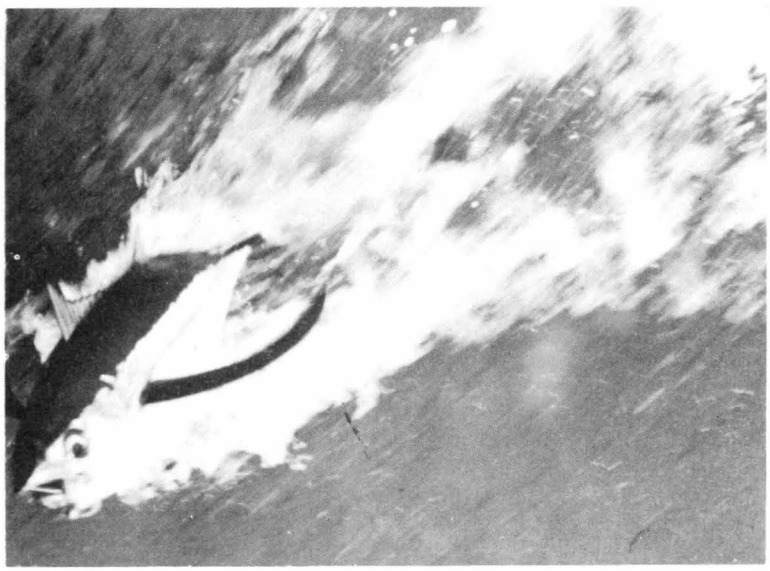
ALBACORE TUNA EXPLORATION IN ALASKAN AND ADJACENT WATERS---1949



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ALBACORE TUNA EXPLORATION IN ALASKAN AND ADJACENT WATERS--1949

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Illustrations

Introduction

Among the several species of tuna which make up the commercial pack in the United States, the albacore, Thunnus alalunga, the white-meat tuna, is the most highly prized. Although this fish has been caught commercially in California waters since the beginning of the tuna industry, it was not until the summer of 1937 that albacore were landed in commercial quantities in Pacific Northwest waters. In 1938, the first sizable pack was put up in Oregon and Washington, and since that time an ever-increasing number of boats have been engaged yearly in tuna fishing off the northwest coast.

In the summer of 1948, the Canadian Department of Fisheries patrol vessels discovered sizable concentrations of albacore in waters off the Queen Charlotte Islands, thus opening up new territory to the fishing fleet and indicating that the commercial range of the albacore was much more extensive than was formerly believed.

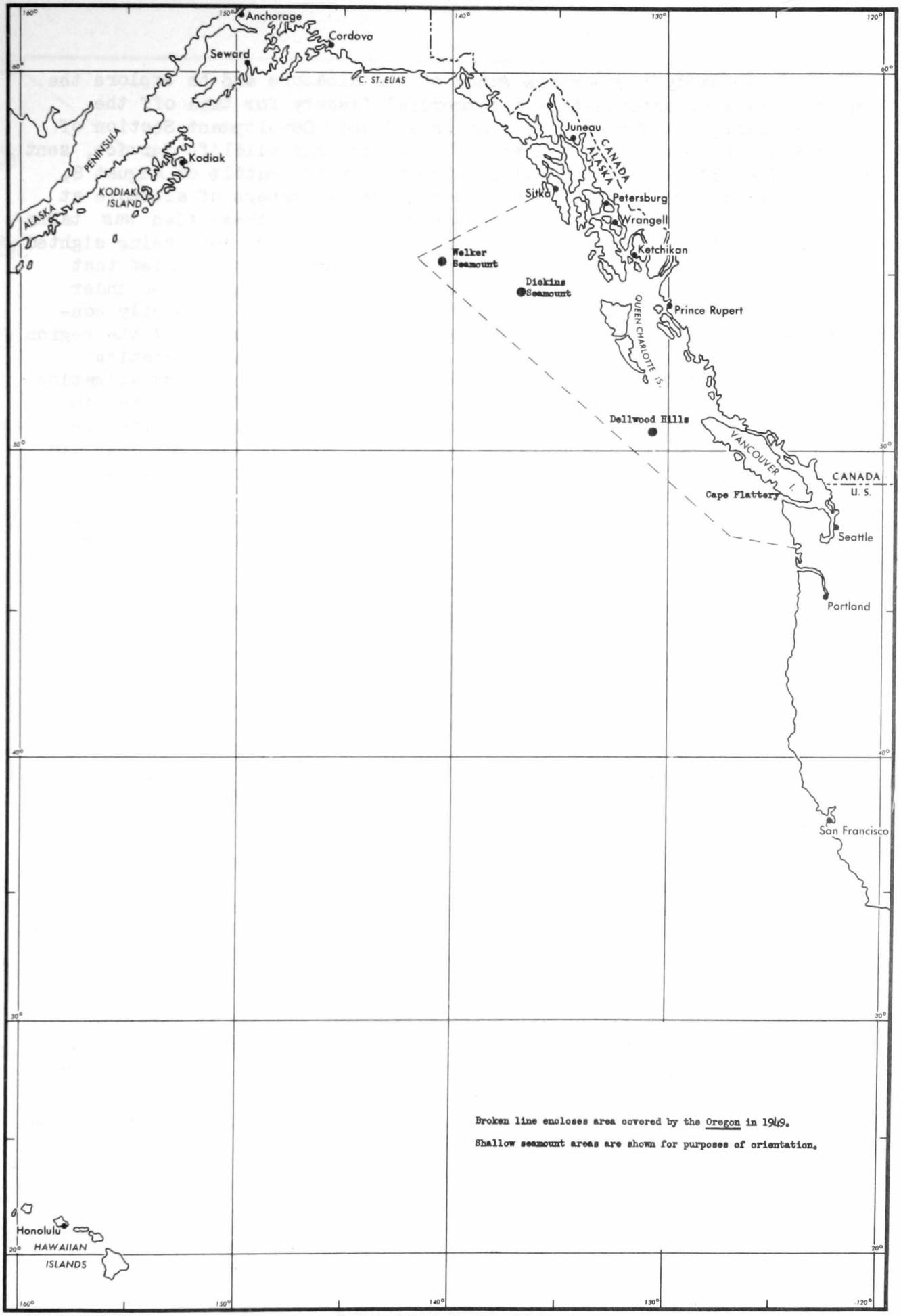

Fig. 1 - Chart of the Northeastern Pacific Ocean

To study further the range of the albacore and to explore the possibilities of establishing a commercial fishery for tuna off the Alaskan coast, the Exploratory Fishing and Gear Development Section of the Branch of Commercial Fisheries, U. S. Fish and Wildlife Service, sent the 100-foot all-steel tuna clipper Oregon out of Seattle on August 8, 1949. Alaskan trollers had landed considerable tonnage of albacore at Ketchikan in 1948. Although the greater portion of these fish was taken in waters south of Dixon Entrance, numerous reports of tuna being sighted and actually caught in Alaskan waters lent support to the belief that possibly an untouched fishery existed offshore at certain times under favorable conditions. Alaskan salmon trolling vessels are easily convertible to tuna fishing, and the advantages to the economy of the region if a tuna fishery could be established to supplement other existing fisheries, are indeed great enough to justify a full-scale investigation by a vessel suitably equipped to study both fishing and oceanographic conditions of the area. Because of unavoidable delay in securing the use of the Oregon for the proposed operation, work in the year 1949 did not begin until the tuna season was well under way. Even so, it was felt that the information to be gained concerning the habits of the albacore and the oceanographic data obtainable would constitute a valuable beginning for future studies to determine if an albacore fishery can exist off the Alaskan coast.

History of West Coast Albacore Fishery

In California, from the beginning of the tuna industry until 1925, the major portion of the tuna pack was made up of albacore. After a record catch in that year, the species apparently disappeared from those waters and did not reappear in any quantity until 1938, again assuming considerable commercial importance in the fishery in following years. Since that time, the California landings of albacore have increased until, in 1948 and 1949, the greatest volume of all times was reached, exceeding 43 million pounds the latter year.

While albacore had been taken occasionally by salmon trollers and halibut fishermen off the Oregon coast, it was not until August 1936 that a sardine purse seiner picked up a ton of these fish from a large school a few miles offshore.1/ The summer of 1937 saw commercial landings of albacore being made at Astoria, Oregon, and other northwest ports by numerous trollers, taken incidental to salmon fishing. A commercial pack was put up in Washington and Oregon in 1938, and by 1941 it was estimated that about 500 boats were engaged in albacore fishing during the month of August. Trollers accounted for the major portion of the catch, with seiners and live-bait boats making successful trips occasionally.

1/ PACIFIC FISHERMAN, P. 24, SEPTEMBER 1936, SEATTLE.

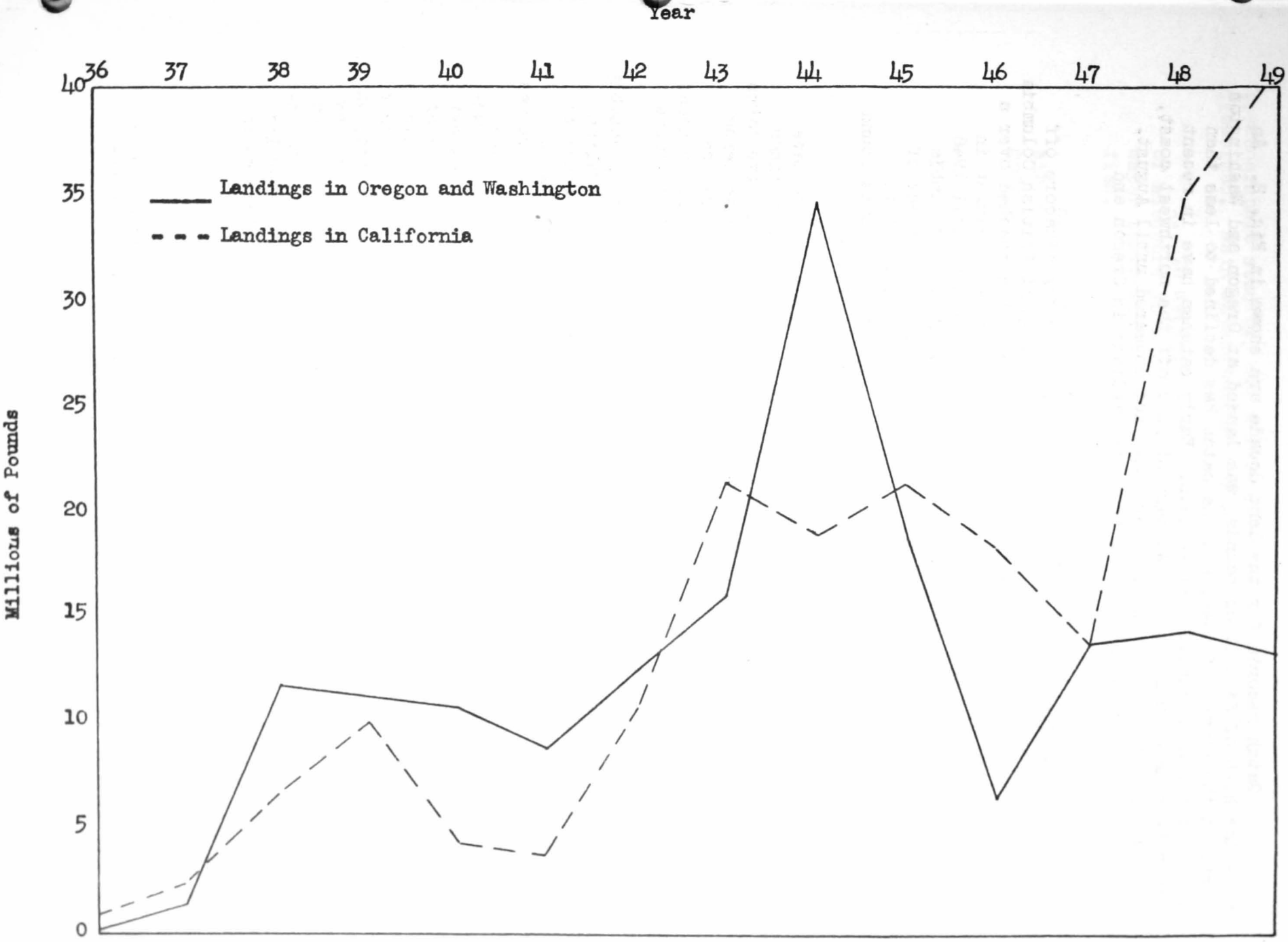

FIG. 2 - PACIFIC COAST ALBACORE LANDINGS FROM 1936 TO 1949

Catch records for the last decade are shown in Fig. 2. An all-time high of 34 million pounds was landed at Oregon and Washington ports in the summer of 1944, and the catch has declined to less than 15 million pounds annually since 1945. Early catches have in recent years been made during the first part of July off the northwest coast, although in some years, the albacore have not appeared until August. October usually sees the last of the tuna landings in Oregon and Washington.

Canadian boats began experimental fishing for albacore off Vancouver Island as early as 1939, and tuna landings at British Columbia ports, while fluctuating greatly from year to year, had reached over a million pounds by 1945. However, most of these fish were caught in offshore waters of Washington and Oregon, and it was not until 1948 that large catches were consistently made off the British Columbia coast. In that year, patrol vessels of the Canadian Department of Fisheries discovered concentrations of albacore far north of the previous commercial range, and both Canadian and American boats found good fishing off the Queen Charlotte and Vancouver Islands.

Rumors of the presence of albacore in Alaskan waters have occurred quite regularly since the mid-1920's. Commercial landings made at Ketchikan in 1948 were composed for the most part of fish taken off the Queen Charlotte Islands, and actual records of catches being made in Alaskan waters are lacking. Reported occurrences of tuna in the Gulf of Alaska have incited considerable interest among Alaskans, notably at Sitka and Kodiak. Salmon traps from Salisbury Sound to Kodiak have reported taking stray tuna. Special effort was expended during the present cruise in investigating a number of these rumors. The evidence found indicates many of the reports are unacceptable and are based upon porpoises at sea and, in inshore waters, on species of fish which are new to local inhabitants, such as the scad, Decapterus polyaspis. Nevertheless, the number and consistency of the reports cannot be entirely ignored or disproved until a complete investigation has been made of the existence of albacore in Alaskan waters.

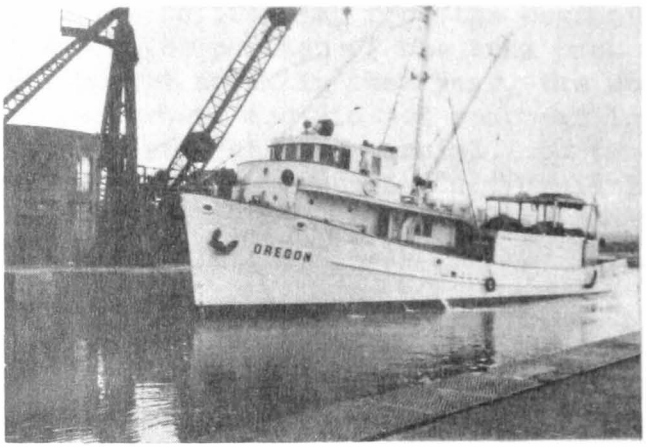

FIG. 3 - THE OREGON PASSES THROUGH THE GOVERNMENT LOCKS IN SEATTLE ENROUTE TO THE TUNA GROUNDS.

Purpose and Plan of Exploration

The Oregon left Seattle on August 8, 1949, fully equipped with several types of tuna fishing gear, scientific equipment for

oceanographic studies, and manned by a crew of experienced West Coast fishermen. Main objectives of the work were:

1. To determine the commercial range, abundance and movements of albacore in northeastern Pacific waters, and the effects of water temperature, currents and sea life on the movements of the fish.

2. To expand the known fishing area with the view of possible establishment of an albacore fishery in Alaska on a commercial scale.

3. To report the location of tuna to the fishing fleet by radio.

4. To check the accuracy of reports of tuna in Alaskan waters.

Plan of the program was to work northward to the present known limits of the fishery and attempt to follow any possible movements of tuna into Alaskan waters. Scientific equipment carried to aid in locating the fish included reversing thermometers for studying water temperatures and plankton nets to indicate presence of marine organisms upon which tuna might feed. The Oregon was also equipped with the most modern depth-finding apparatus, electronic navigation equipment, live-bait tanks and freezing and cold-storage facilities.

Although tuna fishing off the Canadian coast was done almost exclusively by trollers in the past, live-bait fishing had taken a considerable portion of the catch off the Washington and Oregon coasts in recent years. It was planned, therefore, to use the trolling jigs as the primary means of locating albacore, and to test the possibilities of live-bait fishing if tuna were found schooled in northern waters. First, operations were planned to secure suitable live bait in Washington waters, test the trolling gear in established tuna-producing areas off the Washington coast, then proceed north off the Queen Charlotte Islands and attempt to trace the albacore from there.

Discussion of Results

Abundance and location of albacore

Catch records (Fig. 2) show tuna landings in Washington and Oregon in 1949 were almost equal to those in 1948, but the catch in Canadian waters did not nearly approach that of the previous year. The Oregon found albacore scattered from the Washington coast to the Welker Seamount, 300 miles offshore from Dixon Entrance; however, the large concentrations of tuna which afforded good fishing in 1948 were either not present or the fish were not taking the lures offered.

The first albacore were caught in a test of the trolling gear on August 9, approximately 50 miles WSW of Cape Flattery. Four days later, upon returning from an unsuccessful attempt to obtain bait at Grays Harbor, tuna were again found to be concentrated in the same general area. The position and extent of the school were broadcast to the fleet, and subsequent reports indicated good catches were made in the area the following two days.

During the week of August 18 to 25, fishing was very slow off Vancouver Island and the Queen Charlottes. Several schools of tuna were sighted off Cape Cook and Cape Scott, but the fish were moving too fast to be approached for chumming with live bait.

Water temperatures were considered favorable (58° - 60° F.), and feed appeared to be abundant in spots; but the tuna were not striking the trolling gear. During this period, other tuna boats reported fish off the Queen Charlottes, with only fair catches being made. Scattered fish were taken by the Oregon over the Dellwood Hills, a shallow area off the northern tip of Vancouver Island.

On August 28, the Oregon set a course WxS of Cape Muzon, Dall Island, and ran 300 miles offshore. Water of 58° F. was reached in the vicinity of the Dickins Seamount, approximately 150 miles offshore, but no tuna were encountered until the Welker Seamount (55° 10' N. lat. 140° 20' W. long.) was reached on August 30. Several large albacore were caught on the trolling gear in 57.5° water in the afternoon. It appeared these were scattered fish, as they were all caught singly, and no school could be located in the area during that day or the day following.

Explorations were carried out in Alaskan waters during the following week as far north as Sitka. Surface temperatures were generally cold, and no tuna were seen or caught until the Dickins Seamount was again reached on September 4. Scattered fish were taken off Dixon Entrance and Graham Island on September 4, 5, 6, and 7, but at no time were any large schools encountered. On moving south off the Queen Charlottes, a definite offshore movement of the warm current was noted in the next several days, and no tuna were caught from Tasu Sound south until the Dellwood Hills were reached. On September 11 and 12, fairly good fishing was found in the Dellwood Hills area, 40 tuna being taken on September 12. The fish appeared to be in small schools and scattered over an area of several square miles. Throughout this exploratory work, no attempt was made to catch large quantities of tuna. When schools of tuna were located, only a sufficient number was taken to permit evaluation of the area being fished, and develop accurate reports for the commercial tuna fleet.

Despite a series of southeast storms which kept offshore operations at a minimum from the middle of September on, exploration was carried out until October 6, but no tuna were taken after September 12. A cruise 60 miles off Cape Ommaney on September 26 yielded no sign of tuna. Water temperatures were low (52° - 54.5° F.), and no blue water was found.

Taking advantage of moderate northerly and westerly winds on September 29, a course was run 252° M. from Cape Ommaney to a position 150 miles off Baranof Island, with no indications of albacore encountered. Maximum surface temperature was 54.5° F., the water was green over the entire course, and no feed or feeding birds were seen. Exploration in the vicinity north of the Dickins Seamount on October 5 and 6 yielded no further encouraging signs, and operations were terminated on October 6. Surface temperatures were 2° - 3° F. colder than those recorded off Baranof Island a month earlier in the season.

Effectiveness of gear used

All albacore taken by the Oregon were caught on trolled jigs of various sizes, colors, and construction, purchased fully made up on the commercial market or assembled by the fishermen on board. Two lines were trolled from each outrigger pole and two or three lines from the stern of the vessel. The lines varied from 15 to 25 fathoms in length and were usually fished without weights, the jigs trailing on or just below the surface of the water, depending on the speed of the ship and the state of the sea. Sub-surface jigs towed at various depths on several occasions using standard salmon trolling steel lines, gurdies, and lead weights up to 20 pounds, failed to catch fish. However, results were very inconclusive, and it is felt that much more work with sub-surface lures must be done, especially in areas where a substantial layer of warm surface water exists.

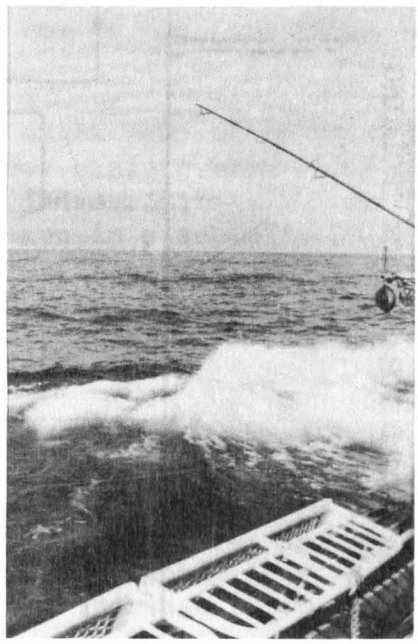

FIG. 4A - TROLLING GEAR USED BY THE OREGON. (RACKS FOR LIVE-BAIT FISHING ARE LASHED TO THE RAIL.)

Trolling poles were of fir, 38 feet long and tapering from 4½ inches in diameter at the base to 2 inches at the tip. Coiled galvanized steel springs, 12 inches long and 1½ inches in diameter, were used between the poles and tag lines as shock absorbers. Hemp or cotton line, No. 96 or 120 and from 15 to 25 fathoms in length, was connected to the tag lines by a rubber bumper and was joined to 5 fathoms of No. 360 braided nylon or linen leader. Four feet of No. 16 wire leader was attached to the jig and

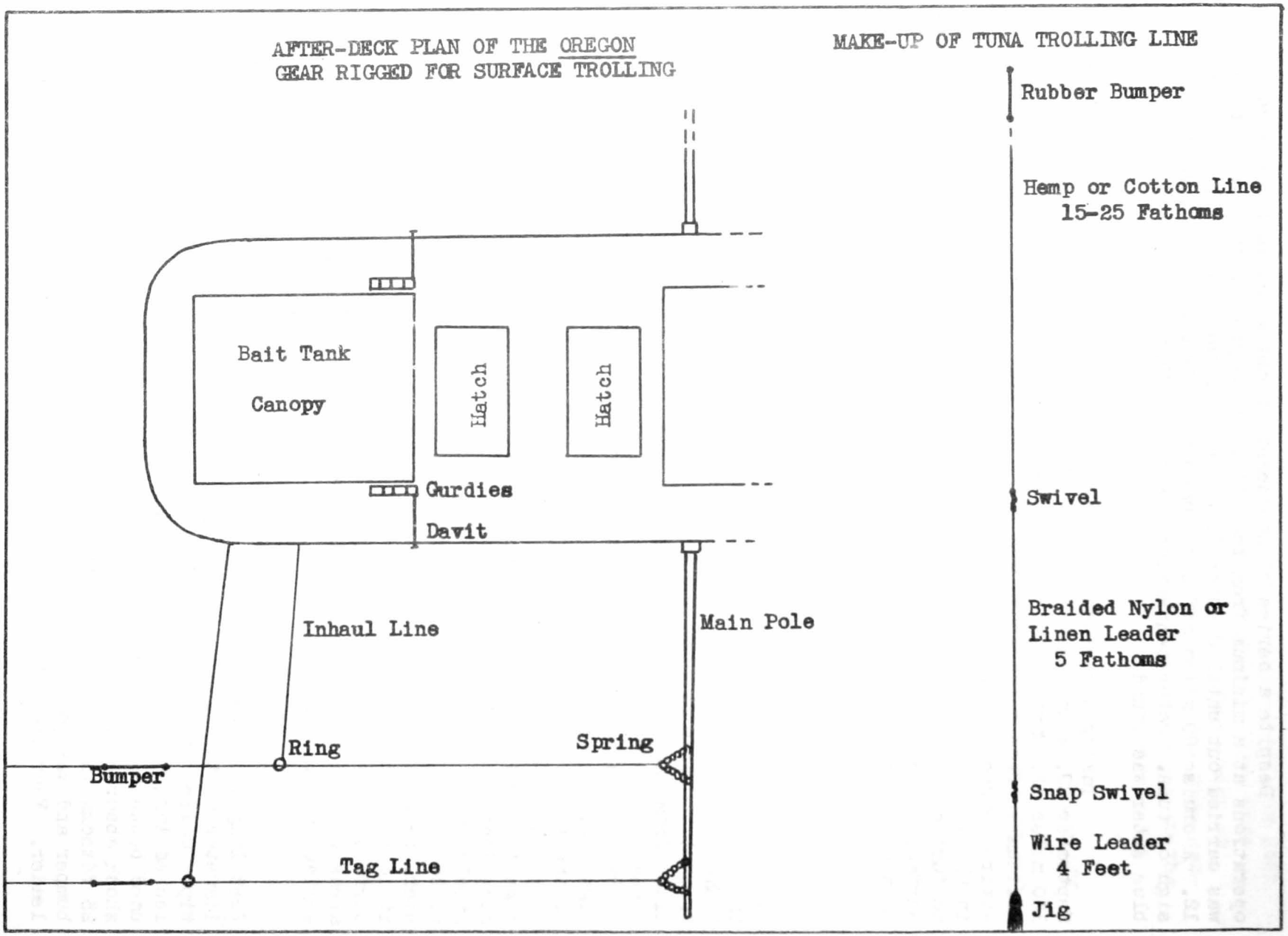

FIG. 48 - DIAGRAM OF TROLLING GEAR USED BY THE OREGON

connected to the nylon or linen by a snap swivel. This gear was hauled by hand.

For the sub-surface trolling, 1/16 inch stainless steel 7-strand wire was used. Gurdies powered by a 1 horsepower motor with a 32 to 1 reduction drive were used to release and haul in the lines. Spherical lead weights from 10 to 20 pounds were attached at the end of the steel lines, and jigs were attached by snaps and wire leaders at intervals of several fathoms from the leads. Although no tuna were taken the few times this gear was used, no operational difficulties were encountered, and it is very possible this method will produce fish if the proper depths can be found.

Preference for certain lures varied from time to time. In the area of good fishing off Cape Flattery, white bone jigs and amber-head plastic jigs produced most fish. It was noted that the white bone jig was especially effective on a very dark, rainy day. At the Dellwood Hills and along the Queen Charlotte Islands, green-head jigs with red and white feathers were generally most successful, while pearl-eyed jigs led in fish caught on several occasions. When schools of tuna were encountered, all lures took fish. Both barbed and barbless hooks were used. Little difference in effectiveness was noted; however, there was some evidence that less fish were lost on the barbed hooks than on those lacking barbs.

It was noted that single tuna were caught more often on the two outside pole lines than on the inside lines, whereas when a school of fish began to strike, all lines were taken indiscriminately, sometimes the short stern lines leading in fish taken in a school. It is possible that single, stray fish are more wary of the boat, while the school fish are more bold, coming in close to take the short lines. A more simple explanation may be that fish approaching from the side would naturally encounter the outside lines first.

Estimated trolling speed was varied from 5 to 10 knots. Albacore were caught at all speeds within this range, but best fishing was found between 6 and 6½ knots. At slower speeds, strikes were few, while at speeds above 6½ knots, fish would strike, but more were lost. There was also evidence that decreasing the speed slightly in rough water resulted in less fish being lost, a slight increase in speed being more effective in calm water.

Water temperatures

Surface temperatures recorded at hourly intervals or less ranged from 49° F. to 61.5° F., the warm water of the North Pacific current being encountered at various distances offshore, depending on the latitude, time of year, and geographical features of the coastline. Albacore were caught in water from 56.8° to 61° F., the best fishing being found between 58° and 61° F.

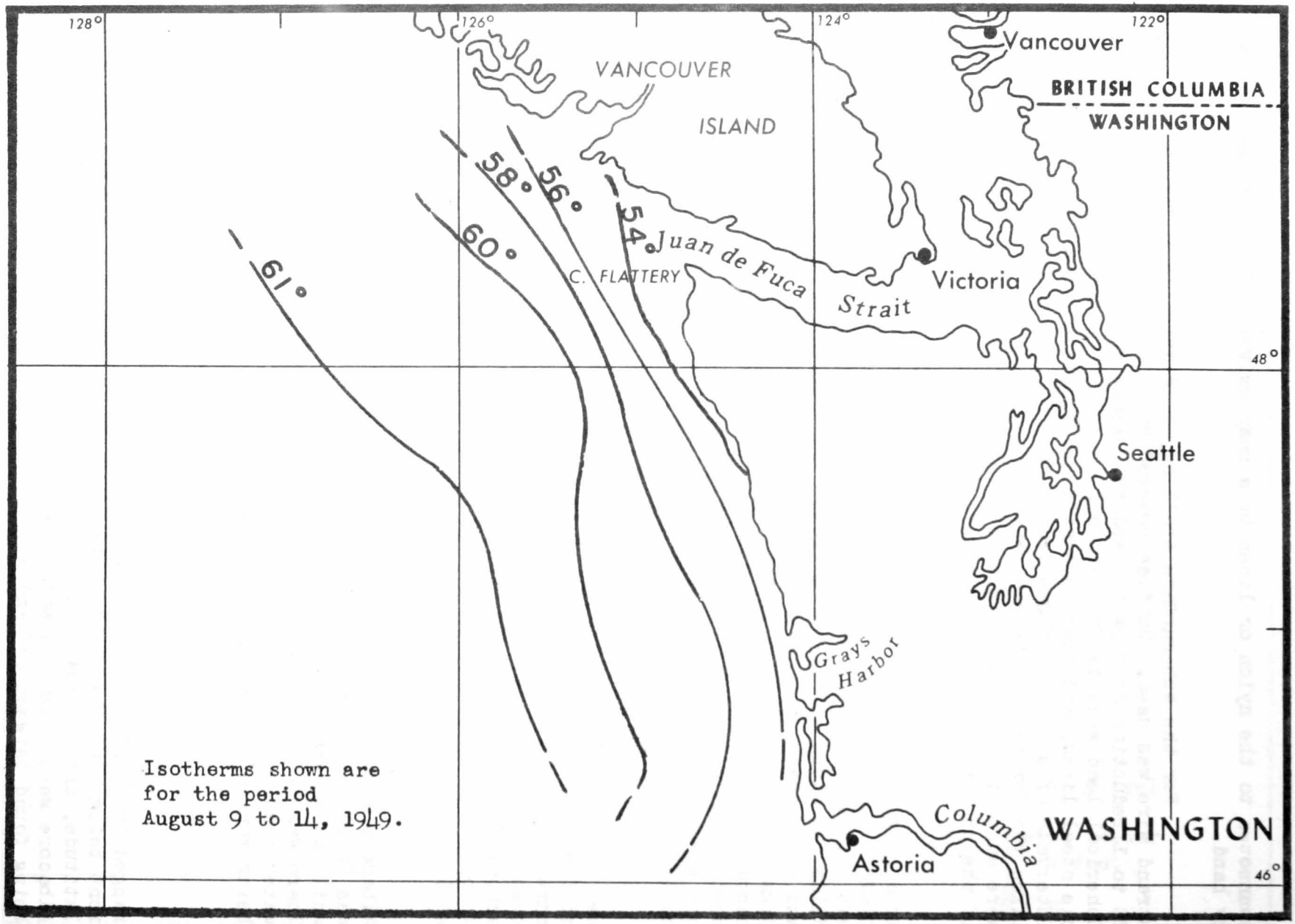

FIG. 5 - SURFACE WATER TEMPERATURE DISTRIBUTION OFF THE WASHINGTON COAST

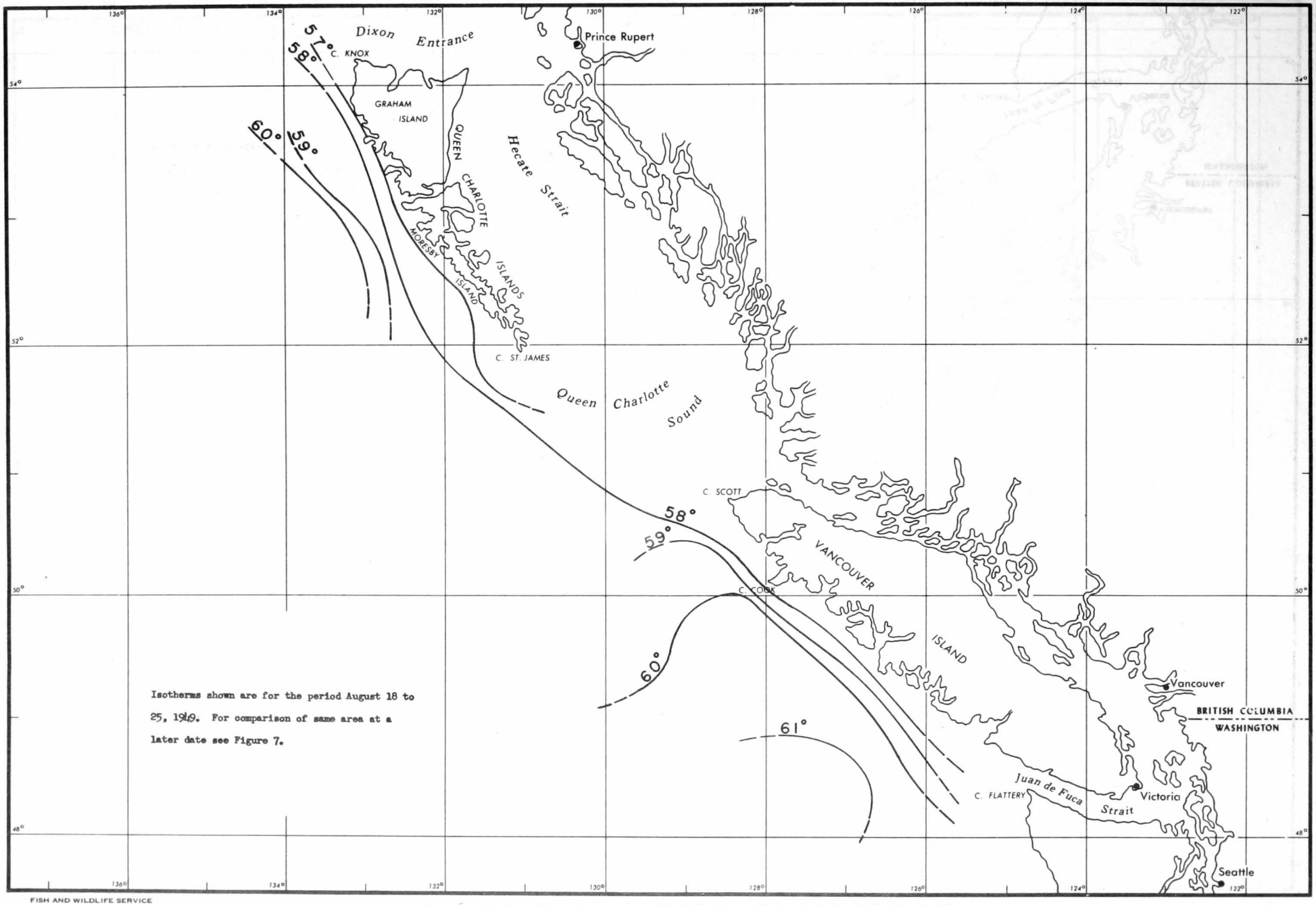

Fig. 6 - Surface Water Temperature Distribution off the British Columbia Coast

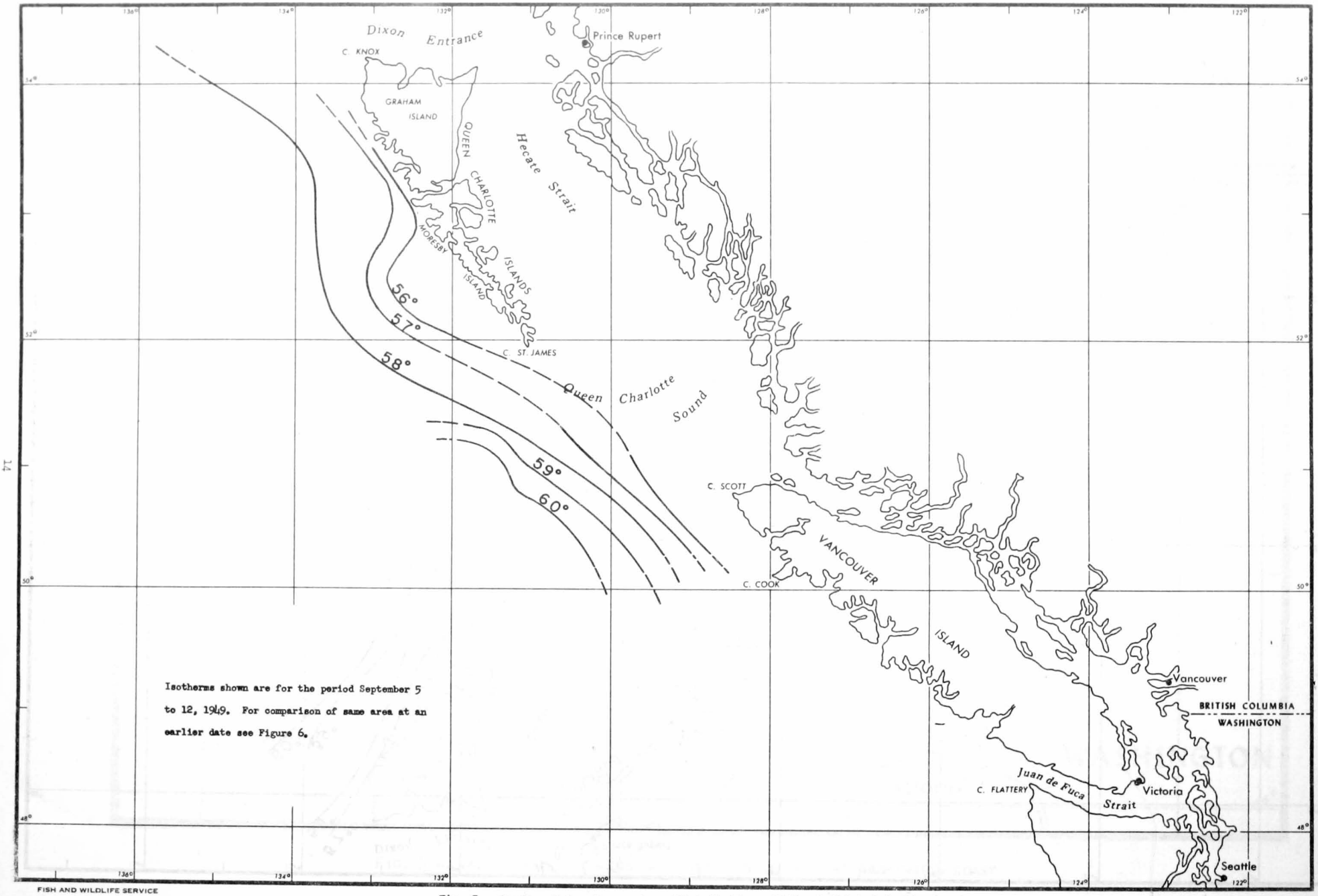

Fig. 7 - Surface Water Temperature Distribution off the British Columbia Coast

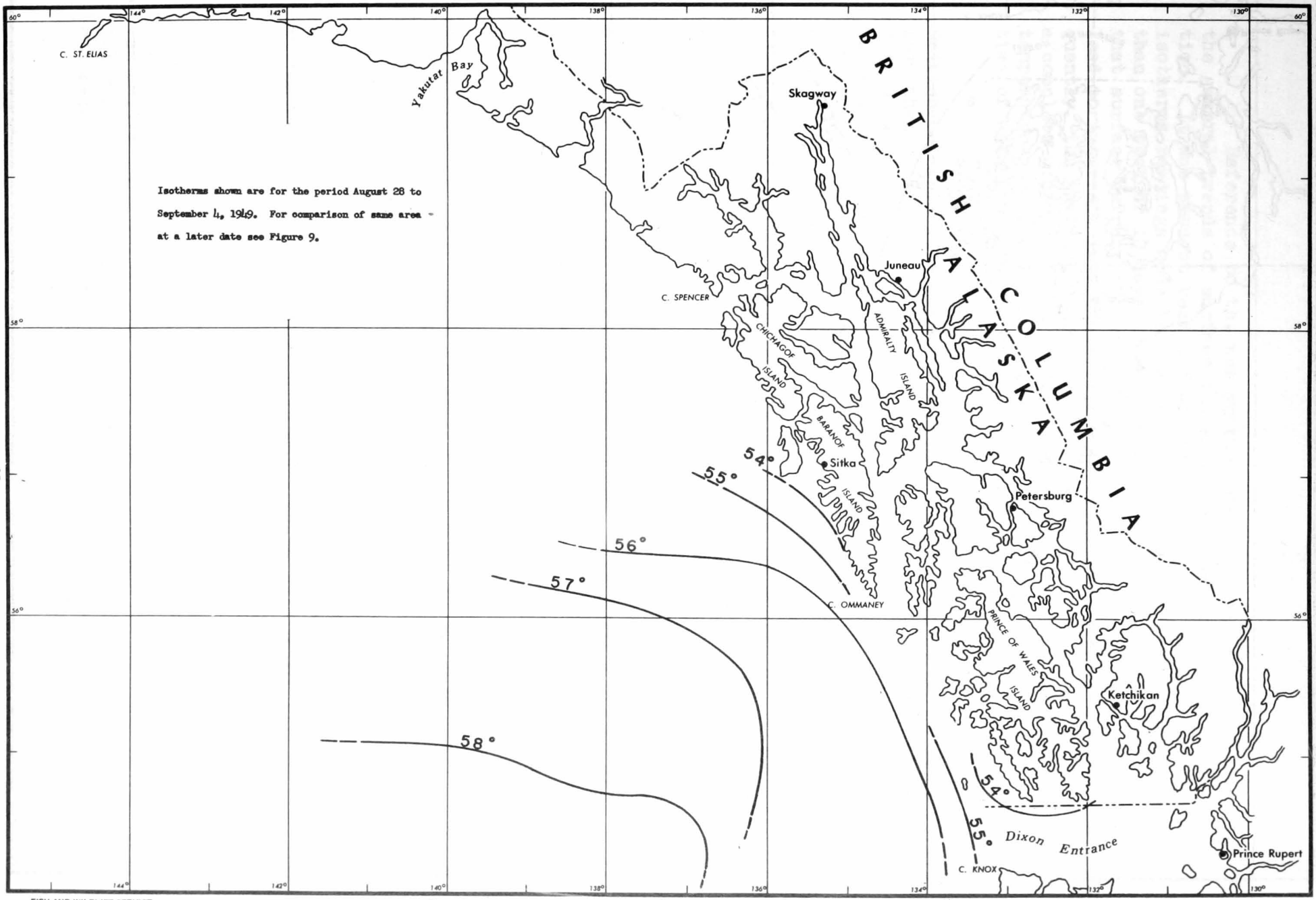

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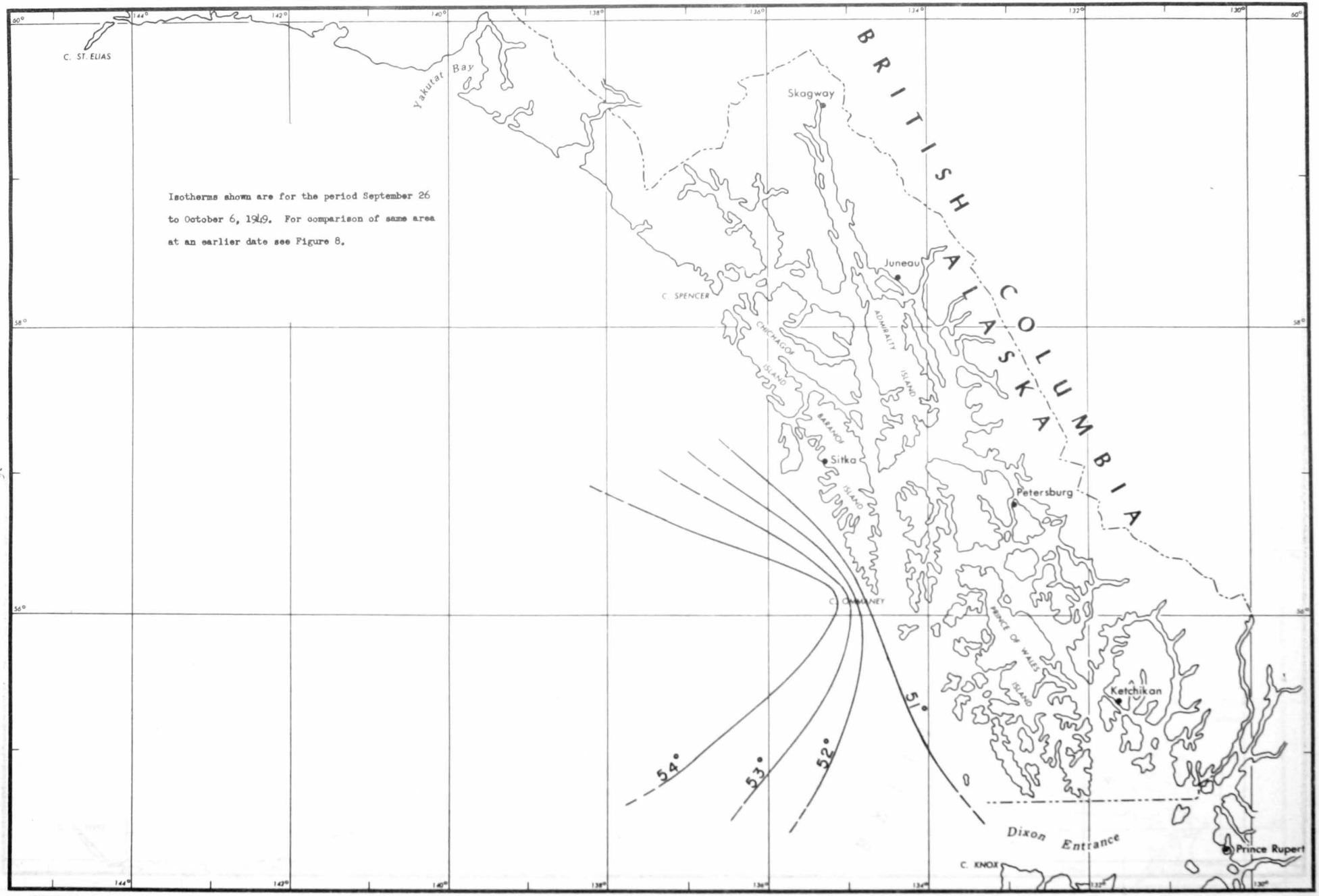
Fig. 8 - Surface Water Temperature Distribution off the Southeastern Alaska Coast



Isotherms shown are for the period September 26 to October 6, 1949. For comparison of same area at an earlier date see Figure 8.

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Fig. 9 - Surface Water Temperature Distribution off the Southeastern Alaska Coast

Reference to the temperature charts (Figs. 5 - 9) will show the general trends of surface temperatures existing during the exploration. It was thought best not to incorporate into the same set of isotherms readings made in a given area at intervals of time greater than one week or 10 days apart. Had this been done, it is probable that surface current changes due to meteorological conditions would lead to incorrect interpretations of temperature boundaries. Consequently, the number of readings on each chart is not great enough for a complete picture of the prevailing conditions, and only average temperature lines are shown in the various areas for the periods of time of actual operations by the Oregon.

The warm current swings close to the shores of Washington and British Columbia during the summer months, 60° F. water being encountered less than 50 miles from Cape Flattery in August and only 20 miles off Cape Cook on Vancouver Island where the continental edge is very close to land. A comparison of Figs. 6 and 7 will reveal the offshore movement of the warm water along the Queen Charlotte Islands which took place during the last of August and the first few days of September. A similar condition off the Alaskan coast is shown in Figs. 8 and 9, where temperatures decreased 2 to 3 degrees between the last of August and the first week in October. Many more observations over a period of years may lead to some degree of success in predicting current movements and resulting temperature changes.

Subsurface temperatures taken with reversing thermometers revealed that the depth of the warm surface water varied from place to place, extending only a short distance below the surface in certain areas and down to as much as 70 feet in others. Average depth (as shown in Fig. 10) was close to 50 feet. In local areas of mixing off Queen Charlotte Sound and Dixon Entrance, the colder water was within a few feet of the surface.

Water color was found to be definitely correlated with temperature and presence of tuna. Cold coastal water below 56.5° F. was unmistakably green, sometimes brown or grey; the warm Pacific current (58° F. and above) was of a definite bluish hue. Various shades of blue-green water were found to exist in the intermediate zones (56.5° - 58° F.) near the edge of the current, sometimes overlapping into the colder or warmer waters. No albacore were caught in green water. Fair fishing was found in blue-green water in several instances, but the majority of fish were taken in water definitely blue.

Size of albacore

Length and weight measurements were taken of 185 albacore caught from August 9 to September 12 in the area extending from Grays Harbor, Washington, to Sitka, Alaska. Fish ranged from 23.6 inches (60 cm.) to 34.6 inches (88 cm.), with an average length of 27.9 inches (71 cm.) (see Fig. 11). Weights ranged from 8.5 pounds to 30 pounds and averaged 14.2 pounds.

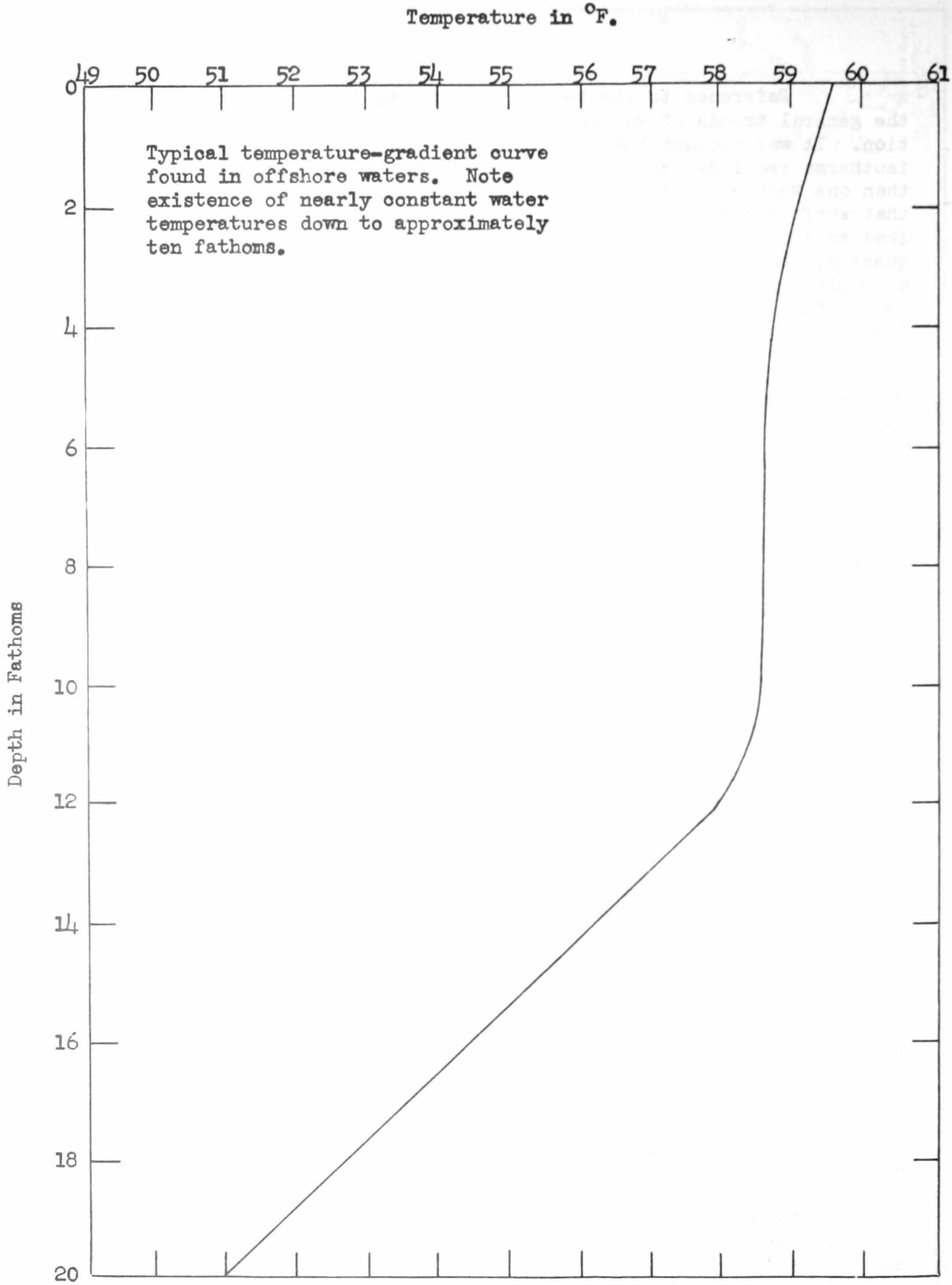

FIG. 10 - DEPTH-TEMPERATURE DISTRIBUTION

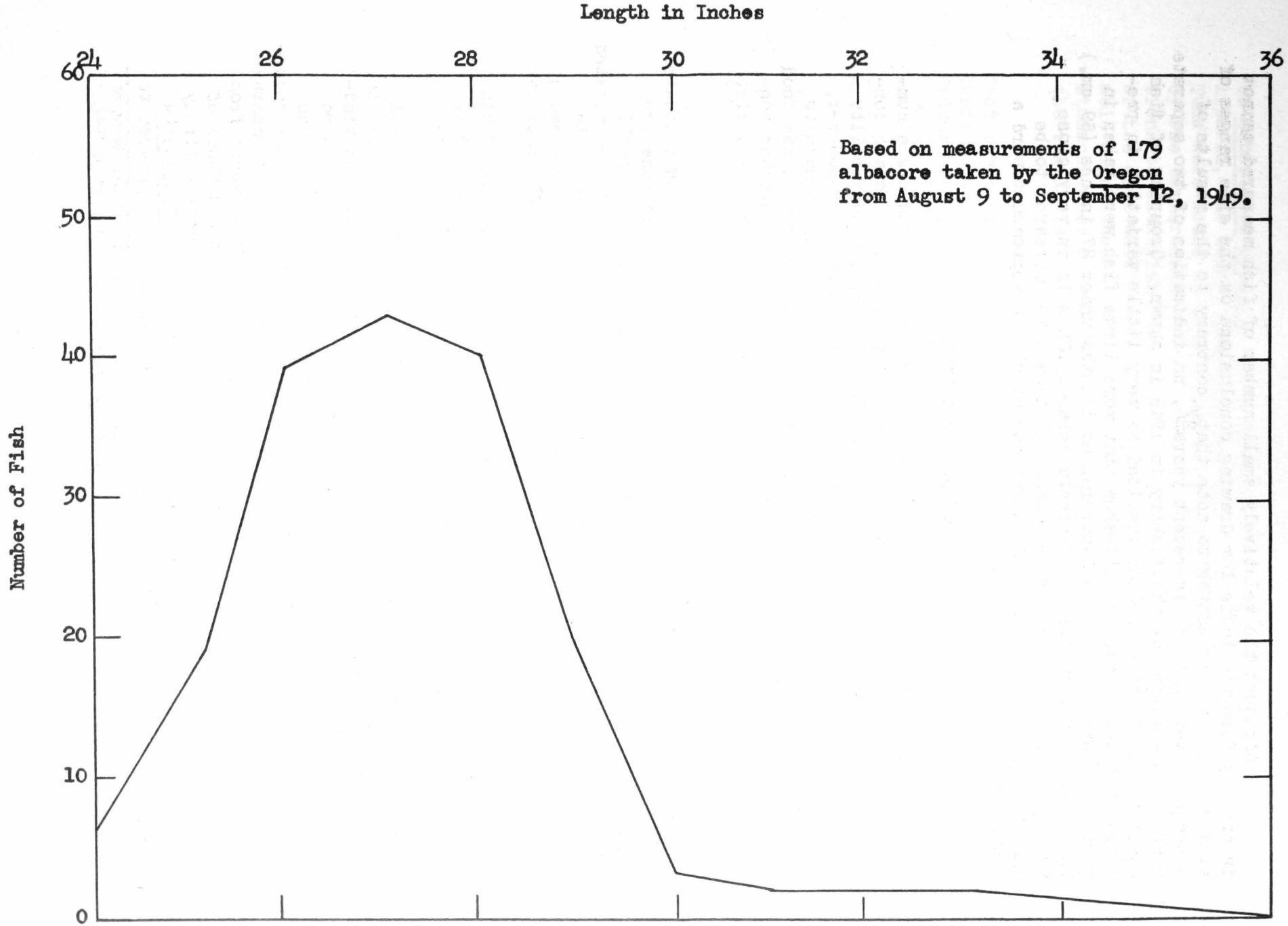

FIG. 11 - LENGTH-FREQUENCY CURVE OF ALBACORE

Although the relatively small number of fish measured cannot in any way form the basis for drawing conclusions on the size ranges of albacore, it is interesting to note that, contrary to the results of Canadian investigations in recent years[2], no indication of two separate year classes making up the fishery in 1949 is shown. Grouping of fish according to fishing grounds resulted in very little variation in predominant size groups, but did show that more large fish were taken in northern areas than in the southern, no lengths under 27 inches (69 cm.) being recorded from north of Moresby Island. This is in very close agreement with the Canadian results. All tuna taken appeared to be immature fish. None examined showed the slightest approach toward a spawning condition.

Analysis of albacore food

Analysis of the stomach contents of albacore presents a number of difficulties. Often the tuna disgorge much of the stomach contents immediately upon landing on deck. There is also a possibility that this can occur before the tuna are brought aboard ship; however, the latter condition was not observed. A special effort was made to obtain a qualitative survey of the marine organisms comprising the food of the albacore taken by the Oregon through collection of stomach contents as soon as possible after landing the fish aboard ship, and also by examination of disgorged contents.

FIG. 12 - OBTAINING STOMACH CONTENTS OF ALBACORE.

The limited investigation indicates that, in the northeastern Pacific, tuna are omnivorous feeders on plankton and small swimming fish. Two items of food predominated throughout most of the area worked by the Oregon; these were euphausiids ("red feed") and small rockfish. Saury replaced rockfish over the Welker Seamount, most northerly point at which albacore were taken. Squid were also common in the stomach contents, and were taken at nearly all localities.

The presence of rockfish, small juvenile forms from 1 to 3 inches in length, suggests the possibility of good tuna feeding areas existing in the offshore waters where young rockfish are in abundance and perhaps contribute significantly to the occurrence of albacore near the coasts of Washington and British Columbia. Tuna caught from August 9 to 14 about 45 miles southwest of Cape Flattery were feeding almost entirely on rockfish, possibly of three species; identifiable were Sebastodes alutus and Sebastodes melanops with lesser amounts of what appeared to

2/ HART, J. L., THE LENGTH OF ALBACORE IN THE COMMERCIAL CATCH: FISHERIES RESEARCH BOARD OF CANADA, REPORT ON THE INVESTIGATION OF ALBACORE, CIRCULAR NO. 17, P. 19, MAY 6, 1949, NANAIMO, B. C.

be Sebastodes crameri. Also present were several squid, one larval liparid, one saury, and unidentifiable fish fragments, possibly mackerel. Tuna were found in this same general area for several days afterwards by the commercial fleet. Use of fine-mesh trawls in future investigations to establish any possible connection between major spawning areas of the deep-water rockfishes and presence of tuna might have considerable significance to the fishery. Predominantly rockfish taken from stomachs were a deep-water species, Sebastodes alutus, which enters the trawl fishery at depths from 65 to 200 fathoms.

Euphausiids are one of the principal food organisms eaten by food fishes in the northeastern Pacific. These small shrimp-like planktonic forms are known to migrate through an extensive vertical range. Hydrographic, light and other conditions not fully understood govern the depths at which euphausiids occur. Large patches of "red feed" have been reported on the surface of the water off the British Columbia coast. Albacore taken over the Dellwood Hills on September 11 and 12 were feeding almost exclusively on euphausiids, plus some copepods, rockfish, and a few larval fish which appeared to be lantern fishes. Similar conditions were found along the Queen Charlotte Islands. The amount of material recovered from fish taken over the Dickins Seamount on September 5 indicated good feeding conditions in the area. The following organisms were taken from the stomach of one tuna caught at 7:00 a.m. on September 6 at a position 53° 38' N. lat. 134° 53' W. long. with a surface temperature of 57 to 58° F.: 1 small octopus, 14 euphausiids, 2 small squid, 2 larval fish. Fish caught from 11:00 a.m. to 1:00 p.m. contained chiefly euphausiids plus several small squid and a single octopus.

It is interesting to observe that although numerous pteropods were taken in plankton tows, none were obtained from tuna stomachs, while the reverse was true of euphausiids. The data available is insufficient to determine whether euphausiids were obtained chiefly by the tuna at night, when a diurnal migration toward the surface would be expected, or whether the tuna were feeding on euphausiids at some depth below the surface, possibly near the bottom of the warm surface water layer. An answer to these questions would indicate the feasibility of trying luminescent lures and night fishing, or fishing with long lines and deep jigs near the bottom of the warm water. Saury appear to be an important source of food of albacore in the offshore areas, and more information concerning this fish might offer another method of approach to the problem of tuna distribution and migration.

Use of live bait and its problems

Large scale commercial tuna fishing in the eastern Pacific is based largely upon the use of live bait, although purse seines and jigging are used in some areas with success. Along the northern limits of the present commercial fishery, trolling with various types of lures has

proved most successful. Fishery methods will have to be adapted to the conditions in the region in question, and whether production can be increased by methods used in the southern fishery awaits further investigation. One reason the small trollers have been able to operate so successfully in the north is the extreme narrowness of the continental shelf. The following information is based upon experiences aboard the Oregon, which admittedly were too limited for conclusive results. On two occasions live bait was obtained, but albacore were not found in concentrations affording opportunities for effective "chumming" or pole-and-line fishing. Obtaining suitable bait is very definitely a problem for the tuna fishery off the northwest coast.

The species of fish which are readily available to the bait boats in the area investigated are the anchovy (Engraulis mordax), pilchard (Sardinops caerulea), herring (Clupea pallasii), and the candlefish or eulachon (Thaleichthys pacificus). Other fish of unknown value are the saury (Cololabis saira) and small rockfish (Family Scorpaenidae).

Anchovies

Anchovies are the favorite bait fish of the Oregon and Washington tuna fishermen because of their relative hardiness with respect to surviving conditions in the bait tanks. However, anchovies are often difficult to obtain and the Oregon lost several days fishing time, as did other commercial tuna boats, searching for bait in Neah Bay and Grays Harbor, Washington, during mid-August, 1949. According to Clemens and Wilby,3/ anchovies are rather sporadic in abundance along the coast of Vancouver Island, and do not range north of the north end of Vancouver Island. Local residents reported anchovies were common in Barkley Sound during the spring of 1949. None were seen in that area during mid-August. Anchovies apparently occur sparingly in Quatsino Sound, and in exceptional years they would be in sufficient numbers for bait fishing. In Alaskan waters, anchovies have not been authoritatively recorded.

Pilchards

While not as desirable as anchovies, pilchards are acceptable as bait. Pilchards, like the anchovies, fluctuate greatly in abundance along the northern limits of their range, but occur much further to the north than does the anchovy. In 1940 and 1941, pilchards appeared in unusual abundance in the Straits of Georgia.4/ The abundant occurrence of this species in the waters of Alaska may well indicate the same favorable hydrographic conditions which would permit the northward extension of the tuna fishery. In this connection, it is interesting

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3/ CLEMENS, W. A. AND WILBY, G. V., FISHES OF THE PACIFIC COAST OF CANADA: FISHERIES RESEARCH BOARD OF CANADA, BULLETIN LXVIII, P. 81, 1946, OTTAWA.

4/ IBID, P. 78.

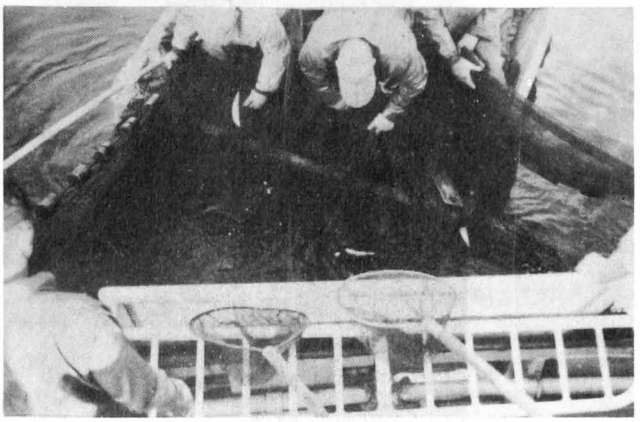

FIG. 13 - A NET-FULL OF LIVE PILCHARDS IS PREPARED FOR BRAILING INTO THE BAIT TANKS ABOARD THE OREGON.

to note that in 1939, when tuna were reported caught off Sitka, pilchards spawned north of their usual spawning grounds in considerable numbers.[5/] This 1939 year class appeared in the commercial herring fishery at Cape Ommaney in abundance in 1941.

Pilchards were obtained only in Bamfield Inlet on August 18, 1949, by special agreement with Canadian authorities. These pilchards were taken at the head of the inlet in 4 fathoms of water with a surface temperature of 58° F. It was necessary to tow the lampara seine with the fish several hundred yards before they could be loaded into the bait tanks. Some scaling took place, but it was not considered excessive. The catch of 205 scoops of 8 to 10 inch pilchards was loaded into the bait tank with dip nets, several hours were allowed for the fish to "settle" and then the Oregon put out to sea at reduced speed. Surface temperatures ranged from 55.5° to 60° F. the first day and then varied between 59° and 61° in the offshore areas worked on August 19 and 20. The loss of fish was less than 50 scoops through August 21, and most of the fish dying had been scaled badly. Mortality continued light until the boat passed through 54.5° F. on August 23, and then the mortality became excessive, many being badly scaled from the towing in the seine or from beating against the sides of the tank during periods of rough weather. The difference of temperature between the inshore waters and the offshore areas will have a large effect on the ability to keep bait in northern areas.

5/ WALFORD, L. A. AND MOSHER, KENNETH, EXTENSION OF PILCHARD SPAWNING TO NORTH PACIFIC WATERS INDICATED: PACIFIC FISHERMAN, P. 47, FEBRUARY 1941, SEATTLE.

FIG. 14 - PILCHARDS MILLING NEAR THE SURFACE IN THE LIVE-BAIT TANK.

Herring

Herring are not as popular as anchovies and pilchards with the tuna fishermen for use as live bait, for they are reported to be more difficult to keep alive in bait tanks. Possibly this can be attributed to differences in temperature in the sea water which passes through the bait tank in inshore and offshore waters. However, herring are readily available and easily obtained throughout most of the area fished.

Approximately 30 scoops of small herring, about 4 inches long, were taken in Verney Bay, Quatsino Sound, Vancouver Island on September 14, 1949, in cooperation with the Canadian authorities. These herring were kept almost without mortality until September 18, when bait tanks were drained for stability purposes in rough seas off Quatsino Sound. Nearly uniform temperatures (53° - 55° F.) were present in the bait tank the entire time the herring were in the tank as the boat did not leave Quatsino Sound due to weather conditions. However, the salinity of the water possibly varied due to heavy rains; this, plus the wastes from the whale processing plant at Coal Harbor, apparently had no adverse effect on the herring. Experiments are still necessary to determine if the northern stocks of herring can be used successfully for bait.

Candlefish

Candlefish are mentioned because they are often present in quantities adequate for bait purposes. However, their use would probably

be only as a last resort. Fishermen reported that candlefish were too small for satisfactory "chumming," and were difficult to keep alive in the tanks.

Saury

Saury have not to the writers' knowledge been used as live bait for tuna in the eastern Pacific, although they are one of the commonest offshore pelagic species. This fish is not an uncommon market fish in Japan, but has not been landed in North America in significant amounts. A few have been marketed commercially in California.[6/] Methods for the successful capture of this fish pelagically would possibly be of great value to the tuna fishery, if the fish should prove to be a satisfactory live bait.

Rockfish

The young of rockfish were found to be very common in the stomach contents of tuna taken by the Oregon. Whether the pelagic young exist in quantities suitable for bait requires additional investigations. The small size, 2 to 3 inches in length, while possibly suitable for "chumming" under certain conditions, would be too small for live bait fishing. Very little is known of the life history of the rockfishes in the northern Pacific.

Plankton sampling

Dense surface concentrations of plankton were not observed from aboard the Oregon. One of the commonest organisms sighted was the goose barnacle, Lepas sp., which was thickly attached to every floating piece of kelp and driftwood. Eight plankton stations were occupied, and samples were taken with a silk one-meter net towed behind the Oregon. As the vessel's speed could not be reduced sufficiently for satisfactory plankton towing, it was found necessary to reduce speed by periodical stopping and starting. This makes estimates of depths at which the net was towed difficult. Equal lengths of line were used on each tow, and the depth sampled was predominantly between the surface and ten fathoms.

Pteropods and jellyfish comprised the bulk of organisms collected in the net. A tow off the Washington coast on August 13, produced only a few jellyfish and fish eggs (unidentified as yet). Pteropods (pelagic snails), possibly of genera Limacina and Clio were taken in amounts up to two quarts per 20-minute tow off the British Columbia coast. A pint of copepods was obtained over the Dickins Seamount on August 29, along with several larval fishes and pteropods. The bag end of the net was filled with jellyfish, plus a small number of copepods, in a tow over the Welker Seamount on August 30.

6/ California Division of Fish and Game, Fish Bulletin No. 74, 1949, Sacramento.

This limited amount of data cannot be expected to yield any conclusions regarding the nature of plankton present in an area and the abundance of tuna.

Marine life in relation to albacore abundance (tuna indicators)

This section is primarily concerned with easily observed organisms and their value as indicators of good fishing areas for tuna. In the northeastern Pacific, these include surface indications of fish and mammals and "working birds" above the ocean surface. Observations as reported herein are confined primarily to the open ocean beyond the continental shelf (the 100-fathom contour) from Grays Harbor, Washington, to Sitka, Alaska. Many of the indicators useful to the tuna fishery off the California coast and south into the tropics either do not range this far north or do so rarely; correspondingly, "tuna signs" differ between the two areas. Because large or numerous schools of albacore were not observed in the course of this work, attempts to evaluate various surface phenomena with the occurrence of tuna are necessarily limited. Therefore, the following discussion is primarily an analysis of the surface life observed from the Oregon.

Common names are used, which were in usage among the fishermen associated with the investigation. It should be emphasized that these names vary widely from one locality to another, and often there is disagreement as to which species a given name belongs. Especially among birds, it was noted that the common names of shearwater, albatross, and petrels were not in general use, but rather a land-bird name with the qualifying adjective of "sea," such as sea-pigeon for the shearwaters. Most of the identifications are field identifications, which among ocean birds can be misleading. In a few instances specimens were collected.

Tuna indicators can be divided under 4 headings: plankton, fish, birds, and marine mammals.

Plankton

Plankton cannot properly be called an indication of tuna, but the presence of large concentrations of "red feed" off the continental shelf is stated to be indicative of good tuna fishing, if corresponding temperature conditions are favorable. No such concentrations were seen by the crew of the Oregon, but have been documented by Canadian investigators and often reported by commercial tuna boats. Some of this "red feed" may be the copepod Calanus, but possibly most of it refers to the swarming concentrations of euphausiids (see section on albacore food).

Fish

Fish and their activity are valuable aids in predicting the presence and size of tuna schools. For the purpose of discussion, this

section may be loosely divided into the antics of the tuna, bait species, and associated species.

Tuna can be recognized by the excited breaking of the surface of the water by the fish in their pursuit of food. While the distinction between tunas and porpoises is accomplished with some degree of accuracy by the experienced fisherman, it presents considerable difficulty for the novice. Many of the reports of tuna from the Gulf of Alaska, which have accumulated over a considerable period of years, quite probably originate from the antics of porpoises since no such accounts have been verified from persons actually catching tuna from the reported schools.

Bait species of fish has reference to easily sighted schools of fish upon which the tuna feed. Only one species of fish warrants discussion for the area investigated by the Oregon. This is the saury, Cololabis saira, whose skip-like leaps over the surface of the water has led to a common name of "skipper." Skipping is accelerated when the fish are pursued by the tuna. Although saury were taken from tuna stomachs frequently, only one small school of this species was sighted in the vicinity of Patoka Shoal on August 19, 1949.

Associated species of fish are defined as easily observed fishes which commonly occur with tuna but are not sought by the tuna as food. Although other fish are often observed in the offshore waters where tuna occur, only one was noted as abundant. This was the blue shark, Prionace glauca, a species cosmopolitan in distribution in warm water and very commonly observed in areas of tuna concentration. This shark reaches the large size of 25 feet in length, but none so large has been recorded from the northeastern Pacific. Seven specimens taken off the British Columbia coast in August, 1949, ranged from 4 to 6 feet in length. Jaws of four of these specimens were collected. Possibility of the species preying on tuna, while not definitely disproven, seems unlikely, although this shark would undoubtedly quickly dispose of a dead or wounded tuna. They proved to be some nuisance to Canadian workers in attempts to develop longline methods of taking albacore, which resulted chiefly in catches of blue shark. The livers are small, and the vitamin A potency is low. An inquiry to a liver oil producer in Seattle revealed that 10 cents a pound was paid for blue shark liver in 1949, but as it was not valuable enough to separate from other low potency livers no information is available on the amount purchased.

It is interesting to comment that the blue shark was first definitely reported from British Columbia waters in 1930, although local reports would indicate that this shark was occasionally taken by pilchard and herring fishermen off the west coast of Vancouver Island as early as 1925.[7/] While known to range as far as Sitka, none was

7/ CLEMENS, W. A. AND WILBY, G. V., FISHES OF THE PACIFIC COAST OF CANADA: FISHERIES RESEARCH BOARD OF CANADA, BULLETIN LXVIII, P. 59, 1946, OTTAWA.

encountered north of Dixon Entrance by the Oregon. What value this conspicuous shark may have as an indicator of changing hydrographic conditions along the northern edge of its range awaits further investigation. However, it well may be that this fish, when noted in conjunction with other species north of its usual range, may indicate favorable conditions for tuna north of the present limit of the commercial fishery.

Birds

The excited, frenzied activities of working birds in pursuit of food are of interest to the tuna fishermen, and are often investigated in the offshore fishing areas for tuna. These observations should not be considered as typical for any area beyond that covered in the present work. The use of the name "tuna bird" is the result of the experience of the individual fisherman in determining which bird is most commonly associated with schools of tuna. The following is a brief description of the bird life observed beyond the 100-fathom contour.

Diomedia nigripes, blackfooted albatross, gooney.--

Gooney appears to be the universal name among fishermen for this oceanic bird along the Pacific Coast. Goonies are very common and characteristic birds in the offshore waters of the northeastern Pacific from California to the Aleutians. Their graceful soaring is a source of considerable pleasure to sea travelers in the region. Goonies nest in numbers on the oceanic islands north of Hawaii and west toward Japan at the start of what would be the winter season in the North Pacific. Non-breeding birds may be sighted off the coast during any month of the year.

A correlation between this bird and good tuna fishing was not demonstrated by the work of the Oregon. However, goonies are stated by the fishermen to congregate in areas of good fishing for the sablefish or black cod (Anoplopoma fimbria). At least one pair, and usually two, could be observed following the Oregon while working offshore. Concentrations of these birds would gather around the stern of the vessel when the boat drifted at night. On August 10, 1949, twenty-five albatrosses were observed around the stern of the boat after an all night drift approximately 50 miles southwest of Cape Flattery. When trolling was started in the morning, frenzied efforts were made by the albatrosses to capture the feathered lures. One gooney was successful in seizing a lure while the ship was moving at 6 knots. The bird was pulled aboard and released unharmed. Another area of seemingly heavier than usual concentrations of goonies was over Welker Seamount in the Gulf of Alaska on August 30, 1949. Whether this was due to the activity of the Oregon or to feeding conditions in that area, is unknown.

While goonies rarely venture into narrow channels or bays, they were common around Cape Ommaney and entered Chatham Strait at least as far as Point Ellis, where seven were observed on September 27, 1949.

Diomedia immutabilus, laysan albatross, white gooney.--

The white gooney was a very rare bird during the investigations of the Oregon. One was sighted off the entrance to Tasu Sound on August 24, 1949 and another over the Dellwood Hills, seamounts off the west coast of Vancouver Island, on September 12, 1949.

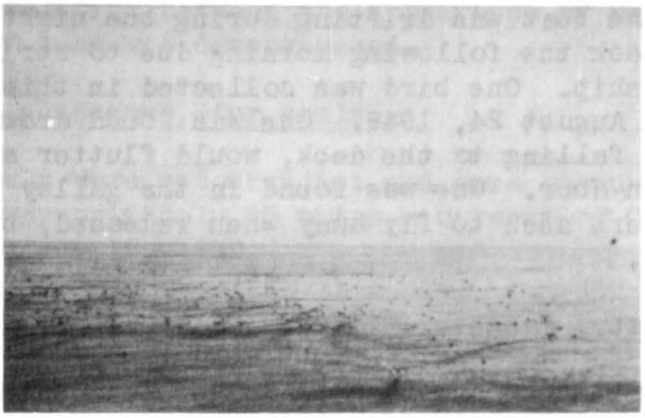

FIG. 15 - A FLOCK OF "WORKING BIRDS" FOLLOW A SCHOOL OF ALBACORE.

Puffinus griseus, sooty shearwater, whale bird, black tuna bird.--

Sooty shearwaters are widely distributed along the Pacific Coast northward into the Bering Sea. The activity of this sea bird is most carefully sought in the offshore areas as an indication of tuna. However, this bird is certainly not partial to the tuna and would often be found following whales, porpoises, or schools of small fish. They were observed outside Tasu Sound in considerable numbers on September 7, 1949, but the presence of tuna was not verified. A large flock was sighted off Cape Edgecumbe on September 30, 1949; it was surmised that this concentration was due to the activity of herring.

Sooty shearwaters are often sighted flying above schools of tuna off the coasts of Queen Charlotte and Vancouver Islands, and plunging in among the fast moving tuna. One flock (see Fig. 15) was followed for considerable distance off Cape Cook on August 21, 1949. One bird was collected from this group, but apparently had disgorged its stomach contents as no recognizable food fragments were recovered. Smaller concentrations of the species were seen off Patoka Shoal on August 19 and 20, 1949. Often the shearwaters would be seen resting in circular schools on the surface of the water.

Sooty shearwaters, while not specific to the tuna, are evidently one of the best indicators of good tuna fishing in Canadian waters in the warm offshore areas. Every large flock is investigated by the fishermen for the presence of tuna.

Oceanodroma leucorhoa, Leach's petrel.--

This petrel was often sighted in the entire offshore area investigated. This bird did not prove valuable in predicting the presence or absence of tuna, other than that it added to the total amount of bird life visible in a given area. They were also seen fluttering among the sooty shearwaters observed following the school of tuna on August 21, 1949 off Cape Cook. This bird was attracted to the lights aboard ship while the boat was drifting during the night. Often it would be found on deck the following morning due to striking some obstruction on the ship. One bird was collected in this manner off Frederick Island on August 24, 1949. One was found drowned in the bait tank, others, after falling to the deck, would flutter along the deck and through any open door. One was found in the galley sink one morning. These birds were seen to fly away when released, but whether they survived is unknown.

Sterocorarius sp., Jaegers.--

Jaegers were seen only in the Welker Seamount area on August 29 and 30, 1949. This falcon-like sea bird, with a hawk-like habit of flight, is easily recognizable. A group of seven birds was repeatedly seen around the boat over the seamount. These were possibly migratory birds as the young of the year were also present with the adults. Although identification was not positive, all birds were probably long-tailed jaegers, S. longicaudus. Jaegers would be expected only during migration, and therefore their value as indicators of tuna would be expected to be unimportant.

Larus sp., gulls.--

Although gulls have been recorded as indicators of tuna in Japanese waters, no connection was found in the area investigated by the Oregon, so records of species observed along the coast will be omitted as not pertinent to this report. However, the possibility of gulls following tuna off the narrow continental shelf in the vicinity of Cape Cook and the Queen Charlotte Islands should not be discounted until further investigations are completed. One immature gull (herring-gull type) was observed 135 miles due west of Forrester Island on September 29, 1949, and is one of the few of this group obtained by the Oregon beyond the continental shelf.

Sterna sp., terns.--

Terns were not identified as to species but possibly belong to S. forsteri. One fisherman, who has fished tuna off the coast of Oregon since 1937, reported that he considered these birds one of the best indicators of tuna. Terns were usually sighted in areas where albacore

were caught, but not in large enough numbers to be valuable as indicators. Several terns were sighted a few minutes before albacore were taken off Cape Flattery on August 14, 1949. Terns were also seen singly over Patoka Shoals, and four were sighted flying above the sooty shearwaters following tuna about twenty miles off Cape Cook on August 21.

Marine Mammals

No correlation between the appearance of marine mammals and the occurrence of tuna was demonstrated.

Callorhinus alascanus, fur seals.--

Fur seals were not abundant and were encountered irregularly. One was sighted approximately 45 miles southwest of Cape Flattery, Washington, on August 12, 1949.

Phocaenoides dalli, Dalls porpoise.--

Porpoise were a very common inhabitant of the entire area investigated by the Oregon. Usually three or four could be seen at all times while the vessel was underway. No correlation was found between the presence of porpoise and tuna abundance, although in tropical waters porpoises are always investigated for the presence of accompanying tuna. At no time were groups of more than twenty of the species observed. Although it is not commonly known, porpoises do school in numbers in the Gulf of Alaska, especially in the late fall and early winter, and could possibly lead to reports of tuna from those areas.

Whales.--

No correlation was noted between the appearance of whales and the occurrence of tuna. However, whales were noted in greatest abundance off Cape Cook, a well-known tuna fishing area, which may be due to a postulated abundance of euphausiids in that area on which both whales and tuna feed. Most of the whales observed were identified in the field as finner and humpback whales, but identification is very difficult for the inexperienced observer.

Conclusion

The difficulties involved in attempting to reach conclusions regarding the range and habits of the albacore, in only one season's work, are quite apparent. The observations recorded in this report apply only to a relatively small sector within the albacore range and during only two months of the fishing season. The amount of area which can be covered by one vessel in such a short period of time is very limited, and it is certain that tuna were by-passed during the exploration. However, reports received from commercial boats fishing in the same waters were generally agreeable with the information herein contained.

A glance at the history of the west coast albacore fishery reveals that in the course of a very few years the northern limit of the commercial range has been extended northward from California to waters off Oregon, then to the Washington coast, and in 1948 to offshore waters of British Columbia. Therefore, it is not unreasonable to believe that the coming years may possibly see the establishment of a tuna fishery in Alaskan waters.

In 1949, the Oregon caught albacore 300 miles off the coast of southeastern Alaska, and the oceanographic conditions encountered suggested no positive reasons why these fish could not occur in larger concentrations further north at certain times. The fact that the large schools of tuna which afforded good fishing in 1948 off the Canadian coast were not found this year indicates either an annual variation in migration pattern or that the fish were present and were not taking the lures being used. Possibly, different methods of fishing need to be introduced. Future work, perhaps with some emphasis on the shallow seamount areas, should aid greatly in analyzing and predicting the movements of albacore and in determining factors responsible for their so-far unpredictable behavior.

Summary

Albacore, the white-meat tuna, has been fished commercially in California waters for many years, but only in the past decade has the industry been established in Oregon and Washington. In 1948, the commercial range was extended to waters off the Canadian coast. The 1949 exploration, discussed in this report, was undertaken with the view of studying albacore movements in the northeastern Pacific and the possibility of establishing a tuna fishery in Alaskan waters.

Albacore were taken by the Oregon on trolled jigs during August and September in scattered areas from the Washington coast to the Welker Seamount, 300 miles offshore from Dixon Entrance. However, large schools, such as were present off the British Columbia coast in 1948, were not found this year, indicating possible annual variation in migration pattern.

Surface water temperatures were correlated with the appearance of albacore; fish were caught in waters as cold as 56.8° F., but best fishing was found at temperatures between 58° and 61° F.

Stomach analysis indicated that in the northeastern Pacific tuna feed almost solely on plankton and small fish. Euphausiids ("red feed") and small rockfish constituted the bulk of their diet. Methods of locating concentrations of these food organisms would probably be of benefit to the fishery.

From the experiences of this year, it appears that obtaining live bait (anchovies, pilchards, etc.) is a very serious problem for the bait boats, and may at times prove even more difficult than finding the albacore. Although carrying live bait on two occasions, the Oregon did not locate large schools of tuna affording opportunity for its use.

Various species of birds, fish, and marine mammals usually associated with the appearance of tuna in southern waters were observed, but no great degree of correlation between these forms of life and albacore abundance was noted. The fish were found widely scattered or in small schools, and with very few exceptions no surface indications of tuna were seen before or during the time fish were caught.

The 1949 work represents only a small beginning, and much more exploration must be carried on over a period of years before any definite picture of tuna migration can be formed. The Oregon took albacore over several seamounts (a number of which give the Gulf of Alaska great bottom relief), and future work may shed light on the possibility of accumulation of tuna in these areas. Oceanographic data collected furnishes some reason for believing that commercial quantities of albacore may be present in Alaskan waters at certain times, but further exploration will be necessary to verify this indication.