XPLORATORY FISHING EXPEDITION TO THE NORTHERN BERING SEA IN JUNE AND JULY, 1949

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EXPLORATORY FISHING EXPEDITION TO THE NORTHERN BERING SEA IN JUNE AND JULY, 1949

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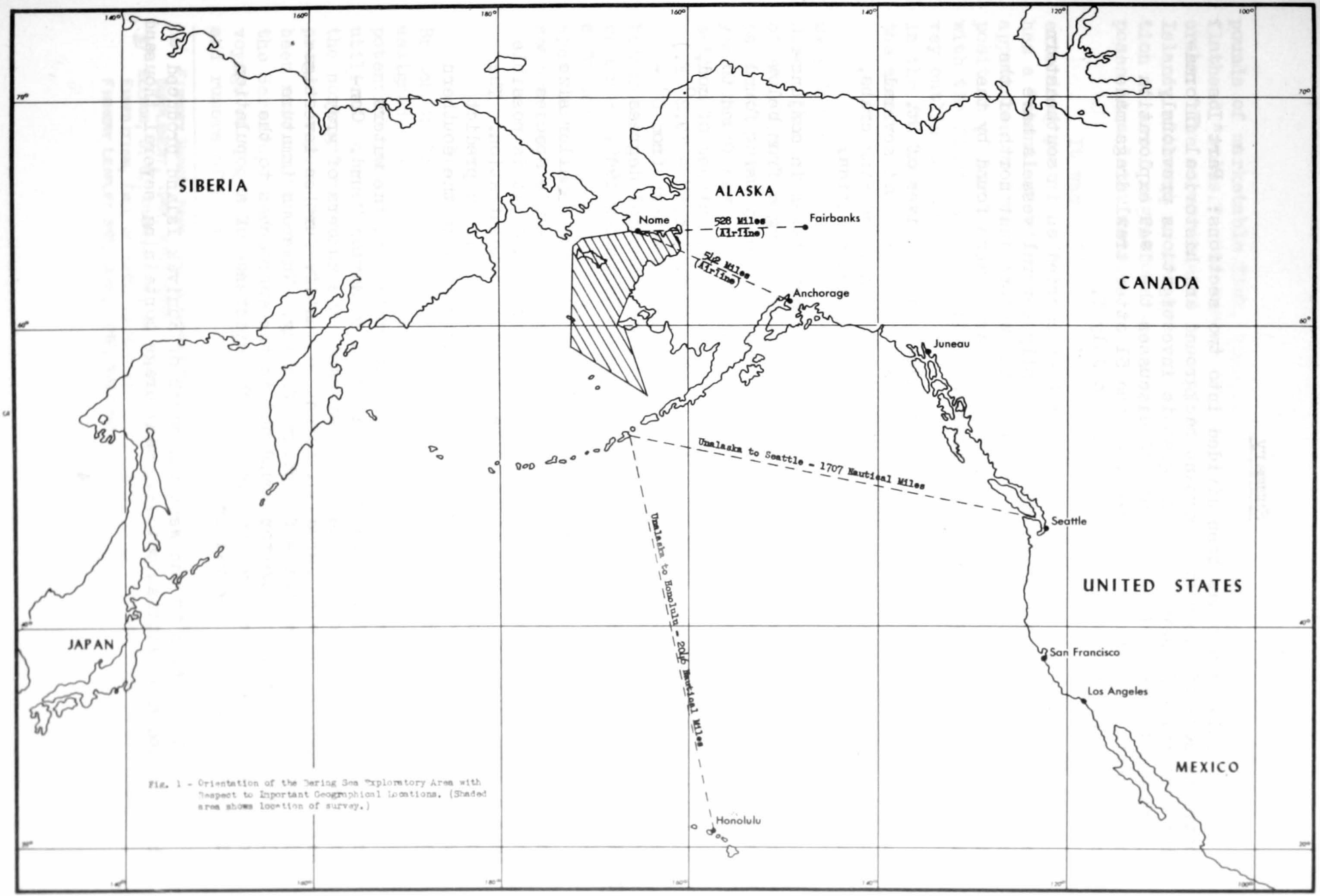

Fig. 1 - Orientation of the Bering Sea Exploratory Area with Respect to Important Geographical Locations. (Shaded area shows location of survey.)

Summary

This report has been divided into two sections: Part I abstracts some of the most important background and historical information concerning fishery and oceanographic investigations previously undertaken in the Bering Sea; Part II discusses the 1949 exploration and presents the results obtained from the 51 otter trawl drags made in northeastern Bering Sea from June 22 to July 5.

Commercial fishing for cod has been carried on in southeastern Bering Sea for a number of years, and recently several vessels have been engaged in fishing for king crabs in the waters just north of the Alaska Peninsula, where large populations of crabs were found by the Alaskan King Crab Investigation in 1940 and 1941.

Numerous reports from local residents and natives of St. Lawrence Island and the area around Nome have indicated that several species of fish and shellfish, including cod, shrimp, and king crabs, may exist in the northern Bering Sea in commercial quantities.

Water temperatures and bottom samples were taken in conjunction with each fishing effort. Bottom temperatures ranged from below zero to over 6° C. (42.8° F.), the colder water generally being found in the deeper portions of the region. Abundance of fish was found to be greatly influenced by bottom temperatures, the best catches of cod, flatfish, and king crabs occurring in the 2° - 4° C. (35.6° - 39.2° F.) temperature zones, while shrimp were found mostly in waters from 0° - 2° C. (32.0° - 35.6° F.). Water temperatures were several degrees warmer than those recorded by the Washington in September 1948.

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King crabs were widely scattered and of a much smaller size than those found to the south. Both the Alaskan and purple species were taken, and although no great quantities were found, it is possible that a more thorough survey might reveal areas of concentration. The shoal conditions in the northern area make it difficult to predict crab movements there on the basis of knowledge gained in the southern regions of deeper waters.

Five species of shrimp were caught, mainly in the waters around St. Lawrence Island and the approaches to Norton Sound. Considering the large mesh of the trawl net used, the numbers of gray shrimp taken may be considered sufficient to justify further investigation with gear more suitable for shrimp fishing. Numerous immature flounders were taken in Norton Sound and in the approaches to the Sound, which was considered evidence of the existence of a population of adult fish in the general area.

The waters to the west and south of Nunivak Island produced the best cod and flatfish catches, many drags containing several thousand

pounds of marketable fish, including prime lemon, yellowfin, rock and flathead "soles." Cod were found to be feeding on capelin and tanner crabs. The occurrence of capelin in the catch northeast of St. Lawrence Island, although no cod were taken this far north, may be an indication of a cod migration into the waters west of Nome for feeding purposes at a later date.

It was inferred that the sub-zero bottom temperature zone extending past St.Matthew Island to the west of St. Lawrence possibly has a "shunting" effect, causing the concentration of fish in the approaches to Bristol Bay and to the west of Nunivak Island. The position of the cold water corridor was found to agree substantially with the findings of previous investigators, but a more thorough survey outlining the exact extent of the cold water zone would aid greatly in the future study of problems concerning the migration of fish in the area.

Bottom hazards to trawling, resulting in damage to the gear, were common around St. Lawrence Island and also were encountered in Norton Sound and west of Nome. These were thought to consist primarily of shells and large boulders transported and dropped by the moving ice pack, which covers much of the Bering Sea for several months each year; however, the best fishing grounds along the eastern shore were entirely free from snags.

The plan of the operation was to take a general sample of the bottom fish life of the region, no attempt being made to concentrate on any one species. The results of this general survey should furnish a foundation for more intensive work in the future within certain specific localities which could be worked thoroughly for an entire season with various types of gear.

Introduction

The recently created Section of Exploratory Fishing of the Branch of Commercial Fisheries, Fish and Wildlife Service, has been assigned the duty of exploring oceanic areas having either actual or potential interest to American fishermen, with a view to ultimate utilization of these areas by the American fisheries. The waters of the northern Bering Sea were selected for the survey covered by the present report for several reasons: A small beginning has already been made in this region by previous exploratory surveys conducted by the Service, notably, the Alaskan King Crab Investigation[1/], and the voyage of the USFWS Washington[2/] in 1941 and 1948 respectively; reports and rumors of potential fishery possibilities, both for fish and

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1/ FISHERY MARKET NEWS, THE ALASKAN KING CRAB: U.S. FISH AND WILDLIFE SERVICE, MAY SUPPLEMENT, 1942, WASHINGTON, D. C.

2/ ELLSON, J. G., KNAKE, BORIS, AND DASSOW, JOHN, REPORT OF ALASKA EXPLORATORY FISHING EXPEDITION, FALL OF 1948, TO NORTHERN BERING SEA: U. S. FISH AND WILDLIFE SERVICE, FISHERY LEAFLET 342, JUNE, 1949, WASHINGTON, D. C.

shellfish, have been received and continue to persist[3]; such a resource, if actually located, would result beneficially to the economy of the communities and the local inhabitants of the area; the discovery of new productive grounds would benefit the fisheries by lessening pressure of fishing on existing grounds; practical and scientific knowledge gained would prove beneficial in attempting to understand the dearth, abundance, or migrations of fish in the area; and if or when the need should arise in the future to regulate the fisheries in the area, this type of information would prove of value.

Part I: Background and Historical Information

Description of the area and factors influencing development of a fishery

The relationship of the Bering Sea to the Pacific area, the Arctic Ocean, and the coasts of the continents of Asia and North America is shown in Figure 1. Covering a total area of 878,000 square miles, the Sea extends more than 1,200 miles east and west on its southern boundary, more than 800 miles north and south, while in the north only 48 miles separate the two continents at Bering Strait, the connecting waterway between the Bering Sea and the Arctic Ocean. The sea is bounded on the south by the Alaska Peninsula, the Aleutian chain of islands, and the Komandorski Islands.

The eastern and northern areas of the Sea are shallow. The 100 fathom curve trends northwesterly from Unimak Pass and south of the Pribilof Islands to the coast of Siberia near Cape Navarin. Forty-two percent of the area is less than 100 fathoms in depth; mean depth for the Sea is 790 fathoms, with the greatest depths in the southwestern portion, where a constant depth of about 1,900 fathoms is found.

The exploratory work reported in this paper was all accomplished in the area confined within the waters lying over the shallow continental shelf (see Fig. 1). The area explored was bounded roughly as follows: from the vicinity of St. Matthew Island north to the date line west of St. Lawrence Island, thence east to Nome and Norton Sound, and south to Nunivak Island and into the approaches of Bristol Bay on a line with Unimak Pass.

The United States Coast Pilot Vol. 2 (1947)[4] points out that present day charts of this area cannot be implicitly relied upon, since the area is incompletely surveyed. Mariners should exercise caution, particularly near the coast. Dead-reckoning positions cannot be depended upon because currents are influenced by the winds, are little understood, and are difficult to predict. North and east of

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3/ ANDERSON, A. W. AND CARLSON, C. B., A PRELIMINARY REPORT ON THE FISHERIES POSSIBILITIES OF THE NOME AREA: U. S. FISH AND WILDLIFE SERVICE, SEPTEMBER 1945, WASHINGTON, D. C.

4/ U. S. COAST PILOT, ALASKA, PART II, YAKUTAT BAY TO ARCTIC OCEAN, U. S. COAST AND GEODETIC SURVEY, 1947, WASHINGTON, D. C.

the 100 fathom line the waters shoal gradually to the coast. The Alaskan mainshore is characterized by extensive shoals leading far offshore, and generally all shore waters are shallow. Few landmarks to provide bearings are furnished by the flat coastal landscape, and the region is noted for its fog and thick weather. The shoals are formed by the silt from the rivers flowing into the sea. Two great river systems empty into the sea between Bristol Bay and Norton Sound, the Kuskokwin and the Yukon, plus many smaller ones. Several islands of volcanic origin exist in the area.

Other navigational difficulties are the uniformity of soundings in many areas, making it impossible to ascertain position by bottom topography, while celestial navigation is difficult because of exaggerated atmospheric refraction peculiar to large parts of the area, as well as fog. Few lighthouses, radio beacons, or other aids to navigation exist in the area. Many of these difficulties can be overcome somewhat by larger vessels using the latest electronic aids, such as loran and radar.

North of the Aleutians only a few harbors will be found in the entire area, and with the exception of Port Clarence, close to Bering Strait, those found will be inadequate. Repair facilities are not available in the area, and fishing vessels should plan to carry plenty of fresh water and fuel since docks for these purposes will not be found. Shelter is obtained at times by seeking the lee shore of an island if nearby, but since such shelter cannot be planned on, the fishing vessel must be prepared to take any kind of weather offered. The Coast Pilot[5/] states that "the weather over the Bering Sea is generally bad and very changeable. Good weather is the exception and does not last long when it does occur. Wind shifts are both frequent and rapid." Experience on both the fall trip with the USFWS Washington in 1948 and the present survey bears this out. Wind and sea conditions encountered on the present trip are shown in the table of fishing observations (Table 5).

Ice, during long periods of the year, is present in the area, restricting fishing to the open season. The open season varies with latitude, being more extended in the southern region than in the northern, and varies also from year to year throughout the area because of the great effect of the winds on the drift and break-up of the ice (see Fig. 2).

5/ U. S. Coast Pilot, Alaska, Part II, Yakutat Bay to Arctic Ocean, U. S. Coast and Geodetic Survey, 1947, Washington, D. C.

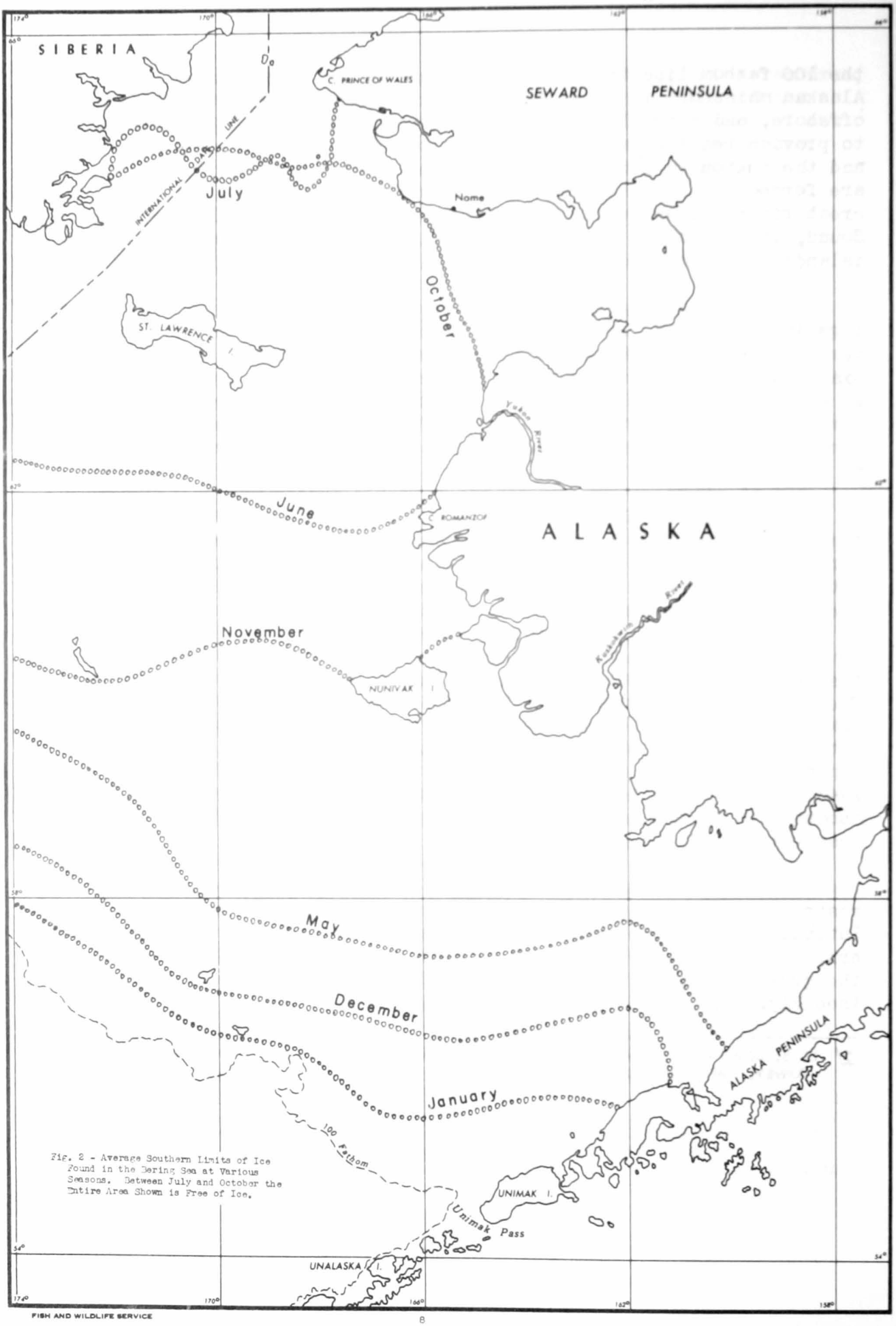

Fig. 2 - Average Southern Limits of Ice Found in the Bering Sea at Various Seasons. Between July and October the Entire Area Shown is Free of Ice.

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Although the ice encountered in the Bering Sea is young ice, forming afresh each season, the wind and seas often telescope it into heavy masses. The solid pack ice usually does not extend much south of St. Matthew Island, but concentrated drifting ice is found as far as 56° N., about 35 miles to the south of St. George Island. From the standpoint of fishing, no differentiation is necessary as to types of ice encountered since fishing is impeded or prevented by any type. On the average, the Pribilof area can be considered closed to fishing by ice four months each year, from late December to late April, while the St. Lawrence Island, Nome, and Norton Sound areas are closed for about seven months, from October or early November until late May or early June. In the spring break-up, the shores of both Alaska and Siberia clear of ice before the middle areas; the Siberian side clears before the Alaskan, and the pack ice north of St. Lawrence Island is the last to go. Aside from limiting fishing operations, ice very possibly plays an important part in the fisheries as well, because of its effect on currents, water temperatures, and upon the chemical characteristics of the water.

The population of this northern area is extremely sparse. Therefore, only a small fishing industry could be supported by local demand. Distances to American markets may be seen from Figure 1. Unalaska (Dutch Harbor) is the principal port or community in the Aleutian area of the Bering Sea, and would offer the most suitable fresh water and fuel center for operations in most of the area. Distances involved are indicated by the following: Unalaska to Seattle via the outside,and most direct, passage is 1,707 nautical miles; to Honolulu, a possible market, 2,040 nautical miles; to Nome 661 nautical miles; and Nome to Seattle is 2,288 nautical miles. The Nome harbor is an open roadstead, untenable in some winds, and only small draft vessels can enter the river to dock. However, Nome is very well connected with other important Alaskan communities by air, and very likely this means of transportation would be feasible in the case of high priced fishery products such as shrimp and crabmeat. Nome is 528 air miles from Fairbanks, and 542 air miles from Anchorage. Distance itself is not an insurmountable handicap in the case of large, well designed fishing vessels which are equipped with processing and freezing facilities and have a large cruising range. However, great distances restrict operations for smaller, less efficient vessels.

Information from various sources has been of value in the work under consideration. Chiefly, this consists of the results of previous expeditions conducted by the Fish and Wildlife Service and oceanographic cruises by the University of Washington. These findings are summarized on the following pages so that readers unacquainted with this background material will have it available. For a more detailed treatment, readers are referred to the original publications.

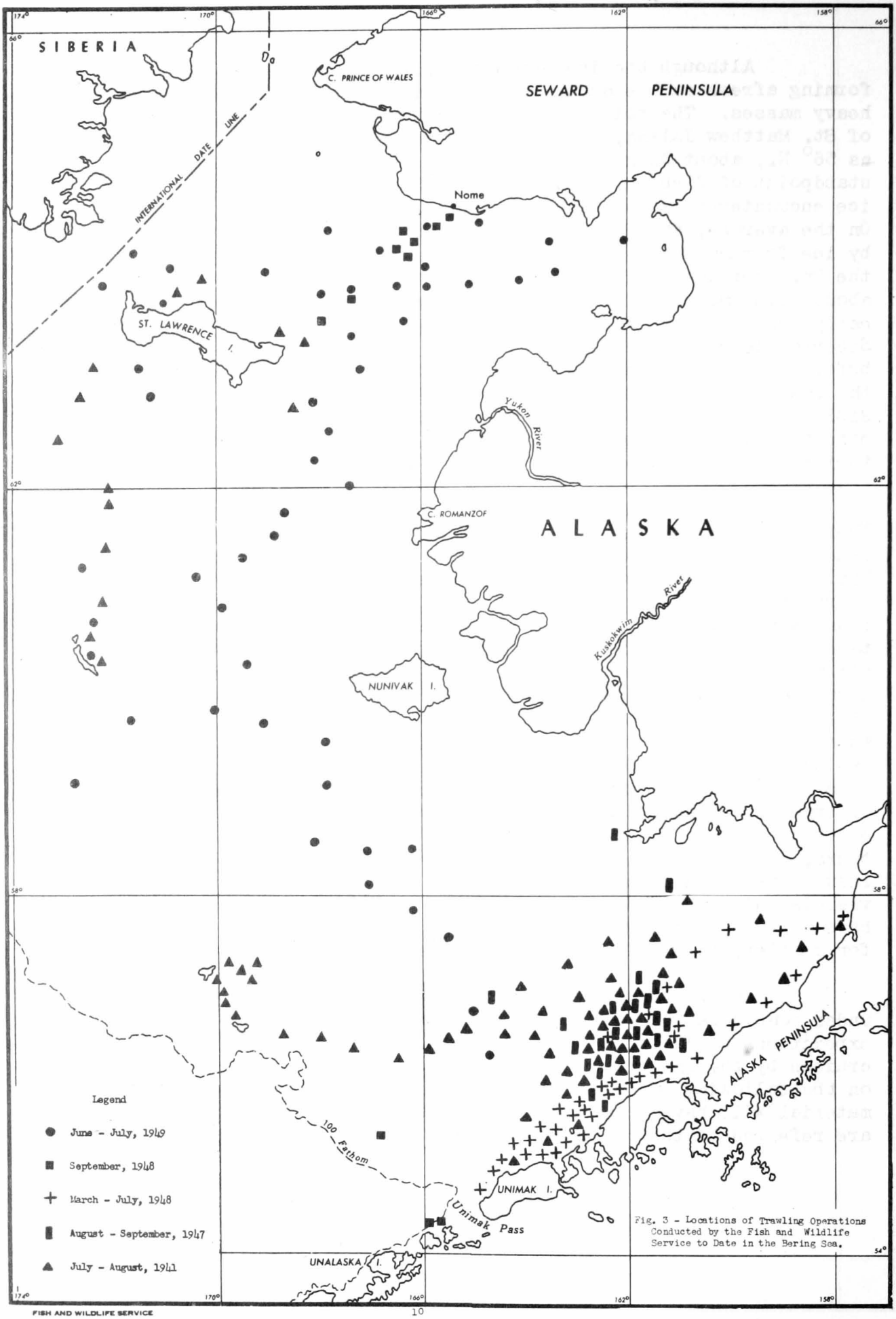

Fig. 3 - Locations of Trawling Operations Conducted by the Fish and Wildlife Service to Date in the Bering Sea.

Summary of results of previous Fish and Wildlife Service expeditions in the area, and information gained from other sources

King Crab Investigation[6/]

From mid-April to mid-September, 1941, the Service conducted an exploratory survey in the Bering Sea. While the primary purpose of this survey was to gain information concerning king crabs, a record was also kept of commercially important fish catches. The fishing was done in two areas: the southeastern part of the Bering Sea, immediately north of the Alaska peninsula, extending between Unimak Island and Ugashik Bay and seaward 100 miles; and the area from the vicinity of the Pribilof Islands to the north shore of St. Lawrence Island. (See Fig. 3.)

By far the most intensive work was done in the southeastern area, where large populations of both crabs and fish were located. Except for a few small ones of the purple species (Paralithodes platypus) captured in Herendeen Bay, all king crabs taken were the Alaskan king crab (Paralithodes camtschatica). Crabs were taken in depths from 5 to 80 fathoms, depending on the time of year. Although the nets used were designed for crabs, and therefore were assumed relatively inefficient for fish, surprisingly large amounts of marketable fish were caught. Flatfish alone averaged a ton to a drag, and some tows produced 9,000 pounds. They were quite uniformly distributed from Bristol Bay to the Pribilofs on gray sand or green mud bottom, but were scarce in areas where starfish, sponges, or crabs predominated. Good market cod were also widely distributed, the largest fish being found in the deeper waters; Alaskan pollock were also caught in quantity. Halibut were taken on many tows in this area.

Fishing from the Pribilofs to St. Lawrence was done in late July and early August. The tows made to the east of St. George Island produced no crabs, but large catches of pollock and yellowfin "sole" were made, plus a good showing of market cod, on a green mud bottom at depths of 37 to 59 fathoms. Crabs were taken northeast of St. Paul Island and near Cape Kukuliak on St. Lawrence Island, and large numbers of cast shells were found on the beach on the north side of St. Matthew. All king crabs (and shells) found were small, and were the purple species. Flatfish were extremely scarce, although a few good market cod were caught just north of St. Matthew Island. The bottom near the islands was covered largely by heavy shell which was very abrasive to the nets, while the middle ground was generally green mud. Results were considered inconclusive in view of the hurried survey, interruptions in the work, and confusing reports from local inhabitants as to the presence of large crabs around the islands.

6/ Fishery Market News, The Alaskan King Crab: U. S. Fish and Wildlife Service, May Supplement, 1942, Washington, D. C.

The Biological Report[7] based on the king crab survey indicates that with respect to king crab migrations, the moulting and mating cycle is the most important influence. The crabs congregate in shallow water (in southeastern Bering Sea in 18 - 25 fathoms) to mate, and after mating migrate to deeper water. Most females in southeastern Bering Sea have moulted prior to May 15, with the main incidence prior to May 5. Separation of the sexes is pronounced after mating, with the males found in the deeper water (40-45 fathoms). In southeastern Bering Sea the migration covers considerable distances, 50 to 60 miles from the mating grounds. One male traveled 61 miles in 113 days. Other migrations apparently occur in connection with feeding. In the southeastern area crabs preferred a sandy bottom, but in the northern area they were found on broken shell bottom. However, distribution was not uniform even in productive areas where bottom and depths were similar, especially in the mating season and late summer and fall. Immature crabs were found to prefer shallower depths (15 to 30 fathoms); large ones depths of 5 to 100 fathoms, depending on the season; females were not usually found in the deepest water, while both sexes were common in medium depths much of the time. These crabs are known to feed on clams, sea urchins and probably plankton, salmon also proving to be excellent crab bait.

The Trawler Alaska's Experimental Fishing Trip in 1947[8]

From August 1 to September 5, the motor vessel Alaska completed a series of otter trawl drags in southeastern Bering Sea with the object of supplementing work done by the Alaskan King Crab Investigation and determining profit potentialities of this type of operation. Most fishing was done on the known producing ground in an area about 50 miles in length lying 30 to 60 miles offshore between Port Moller and Black Hills in the outer portion of Bristol Bay. Scattered trial drags made outside this area in the Bering Sea and on the south side of the Peninsula were unprofitable.

Tagging of halibut caught incidently was undertaken, but they were found to be disappointingly scarce and small in size. The catch of king crabs averaged over 50 per hour of trawling in the Bristol Bay approaches, but only slightly over two per hour of trawling on the south side of the peninsula. Cod, pollock, and flounders were also caught.

Exploratory Survey, Fall of 1948[9]

In mid-September, 1948, a total of eight drags was made between Nome and Northeast Cape, St. Lawrence Island by the USFWS Washington (see Fig. 3). The work was interrupted considerably by stormy weather.

7/ WALLACE, M. MARVIN, PERTUIT, CAMILE J., AND HVATUM, ARTHUR R., CONTRIBUTION TO THE BIOLOGY OF THE KING CRAB (PARALITHODES CAMTSCHATICA TILESIUS): U. S. FISH AND WILDLIFE SERVICE, FISHERY LEAFLET 340, APRIL 1949, WASHINGTON, D. C.

8/ KING, JOSEPH E., EXPERIMENTAL FISHING TRIP TO BERING SEA: U. S. FISH AND WILDLIFE SERVICE, FISHERY LEAFLET 330, MARCH 1949, WASHINGTON, D. C.

9/ ELLSON, J. G., KNAKE, BORIS, AND DASSOW, JOHN, REPORT OF ALASKA EXPLORATORY FISHING EXPEDITION, FALL OF 1948, TO NORTHERN BERING SEA: U. S. FISH AND WILDLIFE SERVICE, FISHERY LEAFLET 342, JUNE 1949, WASHINGTON, D. C.

Scattered fish were caught, including small halibut, lemon "sole," starry and rock flounder, true cod and tom cod, pollock, herring, smelt, and many sculpin. Shellfish catches, in small quantity, included small purple king crabs, all female, and gray and pink shrimp.

The best signs of crabs and shrimp were found in the area near Nome, while best indications of fish were found approximately 25 to 45 miles northeast from Northeast Cape, St. Lawrence Island. Included in the catches were small quantities of prime cod and flounders. Although the bottom was abrasive, no trouble from snags was encountered, except for one bad snag very close to Nome. Bottom water temperatures ranged from 4.9° to 5.6° C. (40.8° to 42.1° F.) near Nome and were 6.3° C. (43.3° F.) to the northeast of St. Lawrence Island.

Operations of Pacific Explorer, 1948

The Pacific Explorer, with observers from the Fish and Wildlife Service aboard, conducted rather extensive fishing operations in the Bering Sea from April 18 to July 5, 1948, with a fleet of 10 fishing vessels.[10/] Trawling for king crab and bottom fish was carried out principally in the Amak Island and Black Hills area. Inshore areas mostly were fished during the month of May and the first part of June. King crab catches improved daily during this period, with the center of fishing operations moving in a north-northeasterly direction to a point about 25 miles from Amak Island. During the second week in June a storm seemed to have dispersed the crabs, and crab fishing became less productive. At the same time, however, catches of fish increased on the same grounds where crabs had been taken in abundance before the storm. About the middle of June several vessels explored the "gulley" area in depths of around 35 fathoms, about 65 miles N half W of Black Hill. It was found that, although the king crabs were numerous in this area, they were recently moulted and very light. Activity was then resumed on the former grounds in the vicinity of Amak Island where crab catches became progressively smaller until the close of operations on July 5.

Reports from Local Residents

In September 1945, the Service published A Preliminary Report on the Fishery Possibilities of the Nome Area.[11/] Based mainly on interviews with local inhabitants of the Nome area, the report points out the advantages to the local and native economy if a fishing industry could be established. Remoteness from markets is considered (also see Fig. 1), as is the shortness of the open fishing season. For example, the well-known run of herring in Golovnin Bay comes so late in the year that utilization is retarded because of difficulty in putting up the pack before the close of navigation.

10/ WIGUTOFF, NORMAN B., AND CARLSON, CARL B., S.S. PACIFIC EXPLORER, PART V, 1948 OPERATIONS IN THE NORTH PACIFIC AND BERING SEA: U. S. FISH AND WILDLIFE SERVICE, FISHERY LEAFLET 361, FEBRUARY 1950, WASHINGTON, D. C.

11/ ANDERSON, A. W., AND CARLSON, C. B., A PRELIMINARY REPORT ON THE FISHERIES POSSIBILITIES OF THE NOME AREA: U. S. FISH AND WILDLIFE SERVICE, SEPTEMBER 1945, WASHINGTON, D. C.

In the winter, king crabs are fished through the ice with baited lines at King Island, Nome, and St. Lawrence Island. At King Island, the crabs are reported to be both brown and white, while at Nome they are purple.

Cod are found trapped in slush ice at the start of the freeze at King Island, but the number is not large. Cod also are reported found on the north side of St. Lawrence Island 1 to 20 miles offshore, mostly in July and August. These fish are usually well off the bottom and are sometimes seen from the surface. Cod also were reported caught on grassy bottom 30 to 35 miles southwest of Nome in 13 fathoms. At Nunivak, steamer passengers have been reported catching cod while the ship is anchored. A few halibut are caught off King Island in September and October and well offshore near St. Lawrence Island, while the natives of Nunivak Island spear them in shoal water in June. Indications of shrimp have been seen near King Island, St. Lawrence Island, and Nome. Clams are a principal food of the walrus near King Island and St. Lawrence Island, and shells wash ashore at Nome.

Herring are observed close to the beach near Nome in June and in September and October, and school in Golovnin Bay, where they are caught in gill nets. The fall herring from Golovnin Bay are fat and of good quality. Herring are also found in Port Clarence. Other interviews with local inhabitants by Service representatives were very similar to those reported above.

As a result of the king crab survey, several commercial ventures in this fishery have been launched. Each season three or four trawlers are engaged in the fishery. Fishing so far is confined to the area in the southeastern portion of Bering Sea, within the limits found to be most productive in the king crab exploration (see Fig. 3). Also, each year one codfishing schooner, and at times more, operates within the same general area. A good tonnage of salt cod is produced by means of hook and line fishing from dories in relatively shallow waters.

Oceanographic Information for the Area from Other Investigations

Clifford A. Barnes and Thomas G. Thompson[12/] published in December 1938, the results of an oceanographic survey made in the Bering Sea and parts of the north Pacific Ocean. This investigation was made in 1933 and 1934, but the material applying to the area under consideration was obtained during the period July 26 - August 24, 1934.

The general flow of the water in the Bering Sea is from the Pacific, north through the Bering Sea, into the Arctic Ocean (see Fig. 4). Water in the Bering Sea moves fast at all depths, but the flow is usually

12/ BARNES, CLIFFORD A. AND THOMPSON, THOMAS G., PHYSICAL AND CHEMICAL INVESTIGATIONS IN BERING SEA AND PORTIONS OF THE NORTH PACIFIC OCEAN: UNIVERSITY OF WASHINGTON PUBLICATIONS IN OCEANOGRAPHY, VOL. 3, NO. 2, PP. 35-79, DECEMBER 1938, SEATTLE, WASHINGTON.

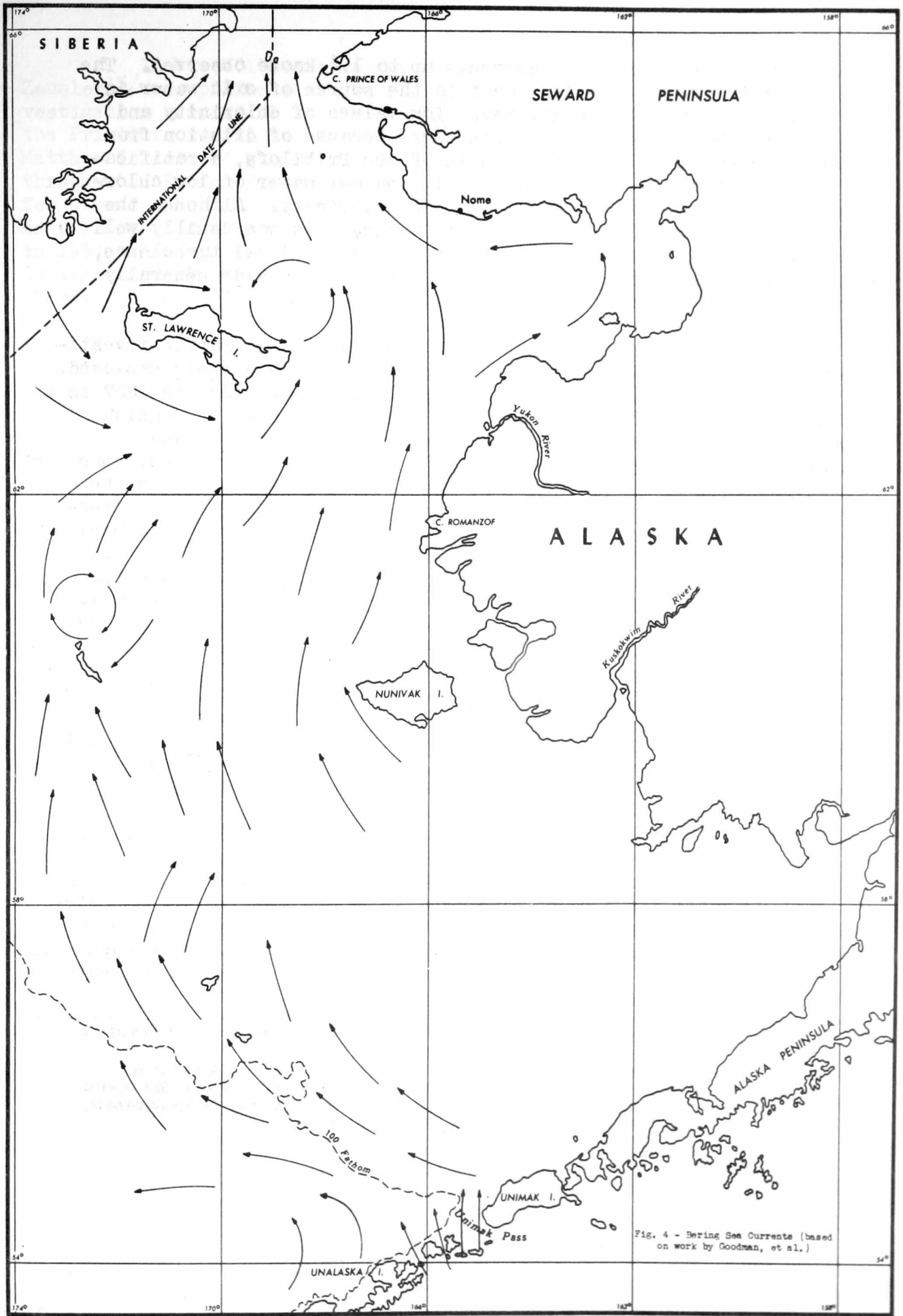

Fig. 4 - Bering Sea Currents (based on work by Goodman, et al.)

greatest at the surface, with currents up to 1.5 knots observed. The Gulf of Anadir on the Siberian Coast is the source of cold water in that portion of northern Bering Sea. Low values of chlorinity and salinity are found along the Alaskan shore because of dilution from the Yukon and Kuskokwim rivers. North of the Pribilofs, stratification of the waters was observed, with the warmer water of low chlorinity resting on the colder water of high chlorinity. Although the Alaskan side had warmer and more dilute water, this was usually well stratified except where homogeneity was induced by local turbulence, as in the Nunivak Island area. The currents on this side generally set northward.

During 1932 and 1933 Russian sponsored oceanographic investigations were conducted in parts of the area, with two vessels employed. The report of this work was published by G. E. Ratmanoff[13/] in 1937 in the Russian language. The following abstract is based on an English summary contained in a report by Goodman, Lincoln, Thompson and Zeusler[14/]. According to Ratmanoff, Pacific waters enter between the Komandorski Islands and the Near Islands; they flow northeast in the Bering Sea, partially back eddying along Kamchatka in a great counter-clockwise eddy. The main flow, nevertheless, continues northeastward passing to the east of St. Lawrence Island. An eddy in the Gulf of Anadir probably is the beginning of the northern flow to the west of St. Lawrence. The currents flowing to the north on the east and west sides of St. Lawrence Island join to the north of the island, continuing the constant flow to the north through Bering Strait, with a counter-clockwise eddy at East Cape.

The two low-temperature areas found at 25 meters in the Gulf of Anadir and near Cape Oliutorsk were designated as "cold spots," and were considered the residue from winter cold temperatures and ice. The Anadir cold water flows northward on the west side of St. Lawrence Island. Salinity is effected by the influx of Pacific water, land drainage in the Gulf of Anadir, and dilution along the Alaskan coast. The eastern waters of Bering Strait are found more dilute than the western, and the correlation between temperature and salinity was noted. Poor water transparency was attributed to plankton and to materials from land pollution. Where supersaturation of oxygen was noted, it was found correlated with a decrease in phosphate and an increase in plankton activity. The depth of the oxygen maximum was much greater in the lower latitudes.

13/ RATMANOFF, G. E., EXPLORATIONS OF THE SEAS OF RUSSIA: PUBLICATIONS OF THE HYDROLOGICAL INSTITUTE, NO. 25, PP. 1-175, 1937, LENINGRAD, RUSSIA.

14/ GOODMAN, JOE R., LINCOLN, JOHN H., THOMPSON, THOMAS G., AND ZEUSLER, FREDERICK A., PHYSICAL AND CHEMICAL INVESTIGATIONS: BERING SEA, BERING STRAIT, CHUKCHI SEA DURING THE SUMMER OF 1937 AND 1938: UNIVERSITY OF WASHINGTON PUBLICATIONS IN OCEANOGRAPHY, VOL. 3, NO. 4, PP. 105-169, MARCH 1942, SEATTLE, WASHINGTON.

In March 1942, a report by Goodman, Lincoln, Thompson and Zeusler[15/] was published concerning findings of an oceanographic investigation carried on in 1937 and 1938. Work was accomplished from the Pribilofs to Nunivak Island and Norton Sound on the east, to St. Matthew Island and the Strait of Anadir on the west, and northward through the Bering Strait and into the Chukchi Sea. In 1937 there were few storms, and ice was present longer than in 1938, when there were many storms. In 1937 surface temperatures were generally lower than in 1938, and surface waters near the Alaskan coast were warmer than towards the Siberian coast. In many areas stratification gave way to thermal homogeneity as summer progressed. Between the Pribilofs and St. Lawrence Island sub-zero water was found at 20 - 40 meters. Salinity was noted to decrease with latitude. Oxygen values were generally high in areas covered. Currents in the northern Bering Sea were observed to flow northward to Bering Strait, but eddies were found near St. Matthew, St. Lawrence and King Islands. The continuous movement of the waters from the Bering Sea to the Chukchi Sea is affected by meteorological conditions and the locations of ice.

Part II. Results and Discussion of 1949 Operation

Method of presentation

There has been presented thus far in abstract form most of the material available at the commencement of the subject survey, which represents both the results of other investigations by the Service and the results from outside investigations and sources. Figure 3 shows in graphic form all locations fished in the area by the Service including the present survey.

Fishing operations on the present survey were conducted during the period June 24 to July 5, and consisted of 51 otter trawl drags made in various locations. In addition, miscellaneous data were collected at each location where a drag was made. The itinerary of the exploratory fishing vessel and locations fished are shown in Figure 5. For convenience in discussion and ease of presentation, the area has been divided into 5 sub-areas. These are shown in Figure 6. At every fishing station occupied, certain fishing, oceanographic, and meteorological data were collected. This material is abstracted in the tables of fishing observations (Table 5).

Certain matters of special importance have been illustrated by means of charts. For example, the trend of the bottom topography of the area explored is shown in Figure 8. Figure 10 shows the trend of surface water temperatures, while Figure 11 indicates the trend of bottom water temperatures. The charts mentioned incorporate the

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15/ Goodman, Joe R., Lincoln, John H., Thompson, Thomas G., and Zeusler, Frederick A., Physical and Chemical Investigations: Bering Sea, Bering Strait, Chukchi Sea During the Summer of 1937 and 1938: University of Washington Publications in Oceanography, Vol. 3, No. 4, pp. 105-169, March 1942, Seattle, Washington.

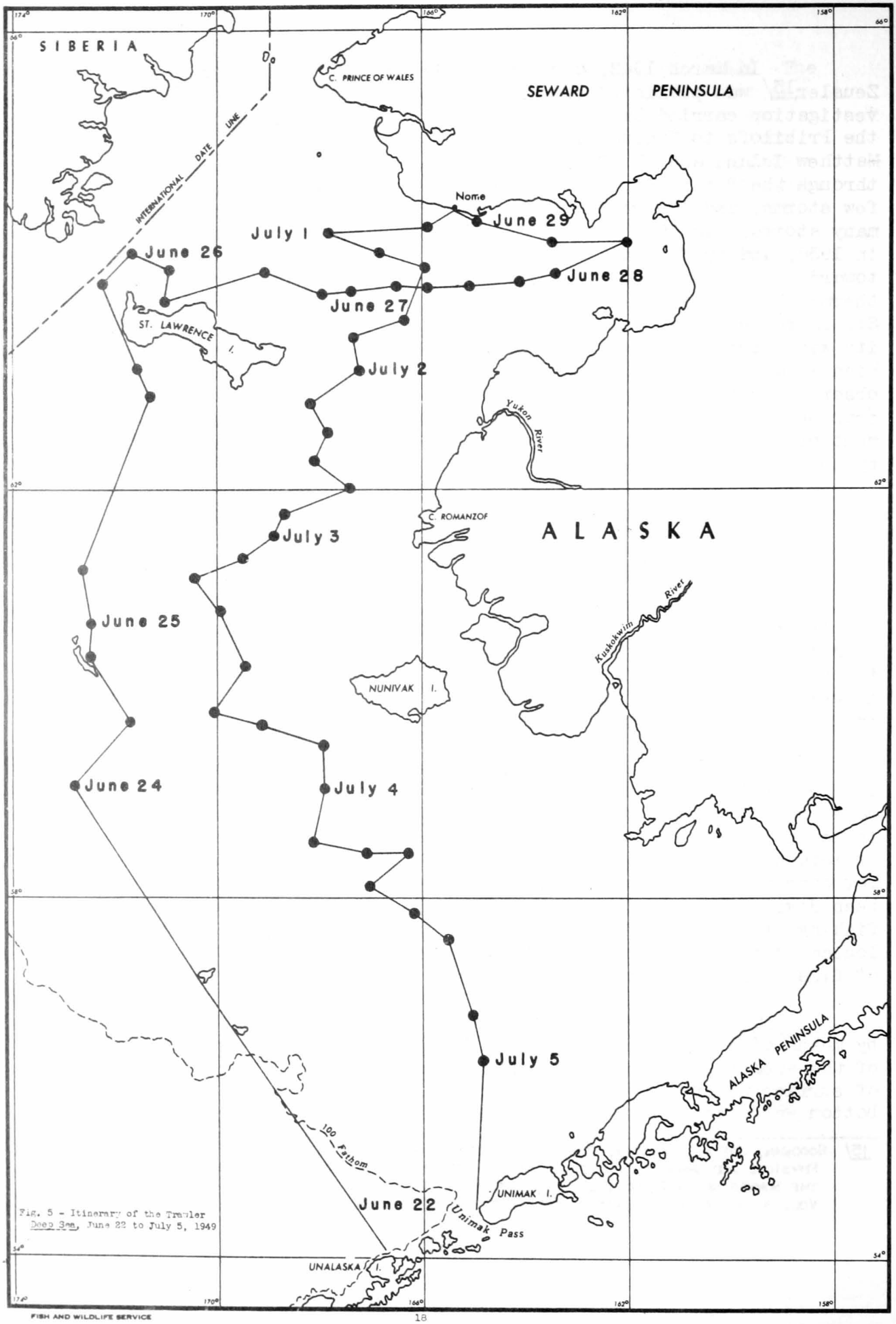


FIG. 5 - Itinerary of the Trawler Deep Sea, June 22 to July 5, 1949

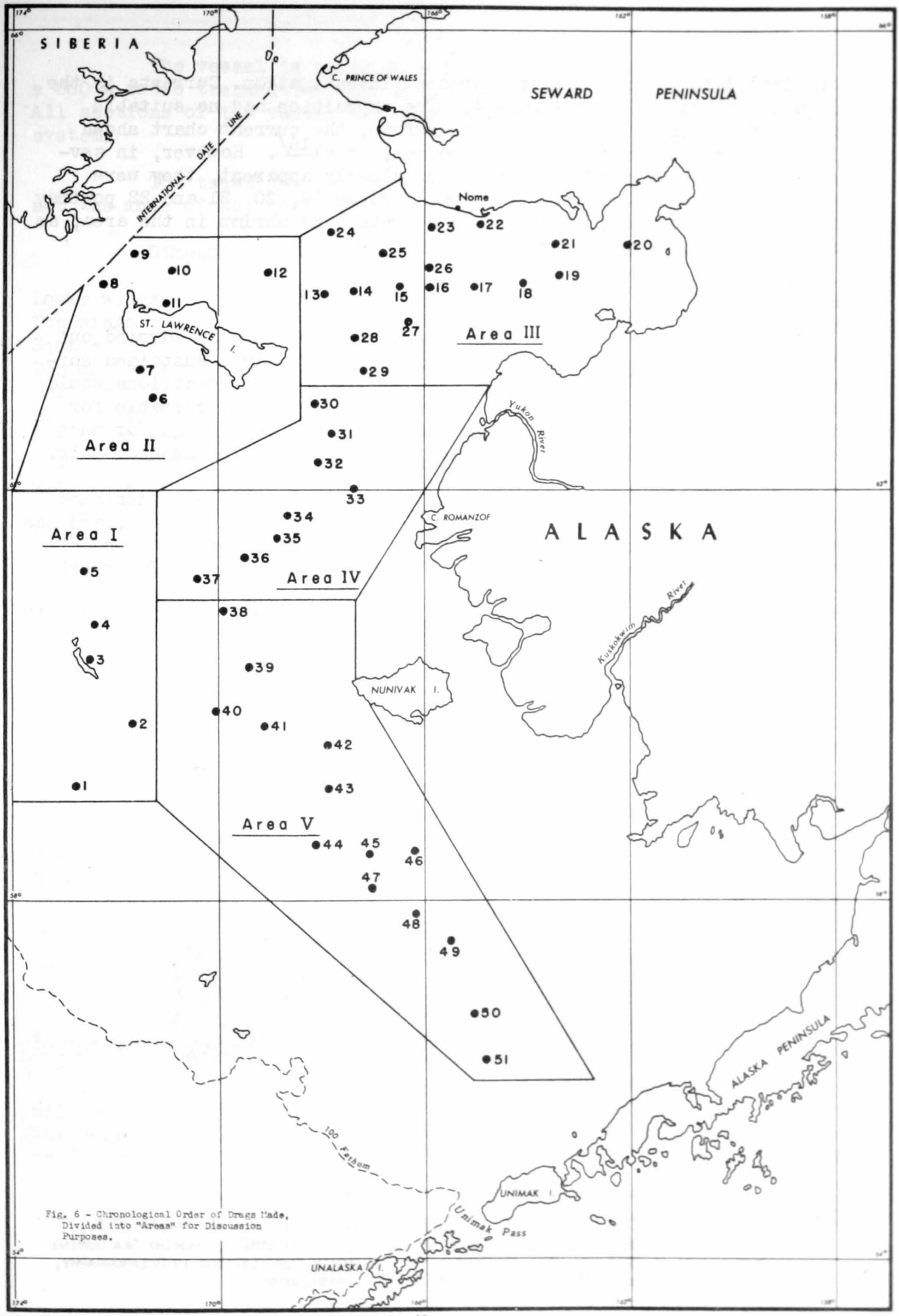


Fig. 6 - Chronological Order of Drags Made, Divided into "Areas" for Discussion Purposes.

original data secured from the present investigation. Currents in the area are illustrated in Figure 4. The expedition had no suitable means of working with currents; therefore, the current chart shown is based largely on the work of Goodman, et al[16]. However, in several instances when the currents were clearly apparent, they were found to agree with the chart shown. Figures 19, 20, 21 and 22 portray the incidence of cod, flatfish, king crabs, and shrimp in the area, as revealed by the exploratory work.

Vessel and equipment used

Experience gained from limited work previously carried out in the area revealed that to accomplish successfully a sustained survey, a vessel able to fish under unusually rough sea conditions would be desirable. The Deep Sea was therefore particularly suitable for this operation, since even though sea conditions were rough for much of the trip, no loss of fishing time was experienced because of this.

Commissioned in 1947, the Deep Sea was especially designed for king crab fishing and processing. The vessel is 140' long, and has the general external appearance and rig of a conventional east-coast trawler. It is powered by a 1,200 hp diesel main engine. The winch is powered by a 100 hp diesel, which operates through a hydraulic torque converter. The fishing gear is set from the side in accord with established eastern trawler practice.

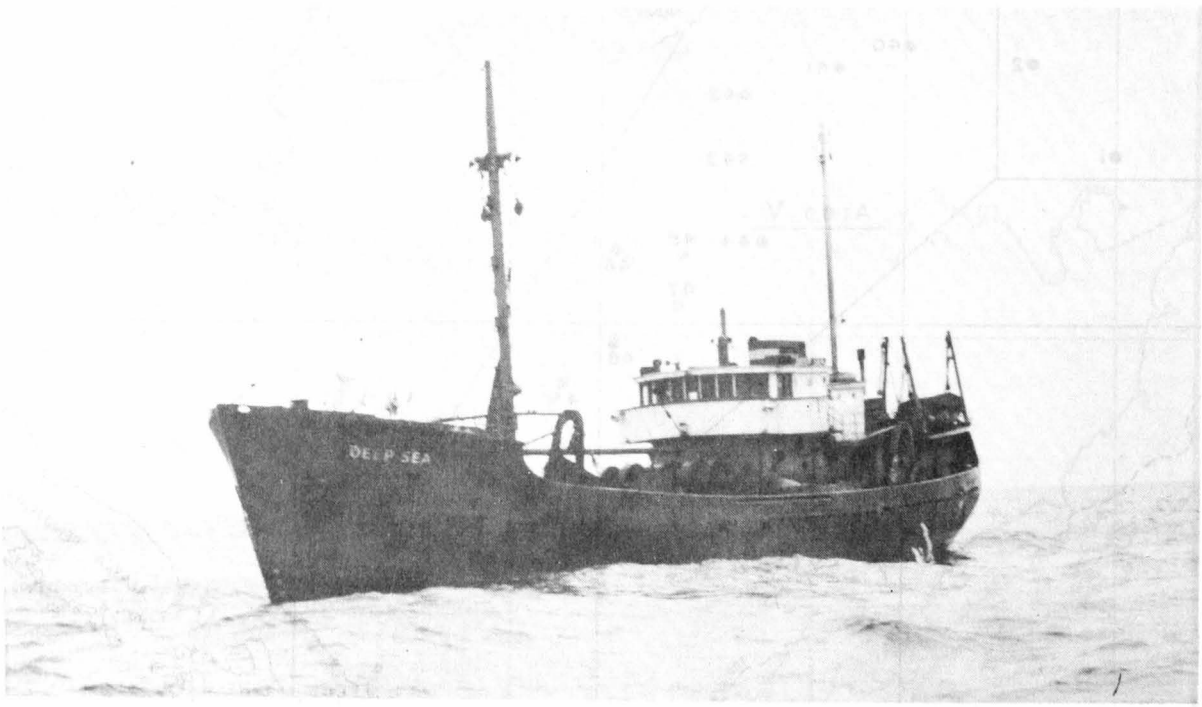


FIG. 7 - THE DEEP SEA AT ANCHOR IN THE NOME ROADSTEAD

16/ GOODMAN, JOE R., LINCOLN, JOHN H., THOMPSON, THOMAS G., AND ZEUSLER, FREDERICK A., PHYSICAL AND CHEMICAL INVESTIGATIONS: BERING SEA, BERING STRAIT, CHUKCHI SEA DURING THE SUMMER OF 1937 AND 1938: UNIVERSITY OF WASHINGTON PUBLICATIONS IN OCEANOGRAPHY, VOL. 3, NO. 4, PP. 105-169, MARCH 1942, SEATTLE, WASHINGTON.

The vessel is equipped with loran, radio direction finder, a 350 w radio transmitter, and a 1,000 fathom sonic sounding machine. All sections of the vessel are connected with an inter-communication system.

The trawl net used was an "Iceland" trawl #1½. The entire net was made of No. 1000 manila twine.

Dimensions of the trawl:

Lower wings	30 x 55 x 125 meshes	6" stretch mesh
Top wings	10 x 110 x 85 meshes	6" stretch mesh
Square	260 x 200 x 46 meshes	6" stretch mesh
Top and bottom Bellies	200 x 60 x 90 meshes	5½/4½/3½ stretch mesh
Bag specially lined with 3" mesh for this survey	24 x 24 x 10" meshes	
Head rope	78' x 5/8"	Wire served with manila to 1" dia.
Foot rope	116' x 5/8"	Served with burlap and 2½" soft laid manila.
Doors	1500#	4½' x 9'
Ground wire	7/8" x 60' long	
Upper leg	5/8" x 38' long	
Lower leg	7/8" x 30' long	
Towing warps	1" wire rope, galvanized	

To obtain bottom samples, an armed 14 lb. lead hauled with a manually operated windlass on the forecastle head was used.

Deep sea reversing thermometers, protected type, graduated to 0.1° C. and messenger tripped, were used to obtain bottom water temperatures. Surface temperatures were obtained by immersion in a drawn sample of surface sea-water using a protected mercury thermometer. Sonic depth readings, uncorrected for water density or temperature, but corrected for ship's draft, were basis of soundings. With a few minor exceptions, each fishing effort consisted of a drag for 60 minutes with the trawl net described.

Discussion of data

Bottom Topography

A reference to the chart of the bottom contours (Fig. 8) will show the general shallowness of a great part of the Bering Sea. The contour lines roughly parallel the 100 fathom curve, which trends in a northwesterly direction from Unimak Pass past the Pribilof Islands,

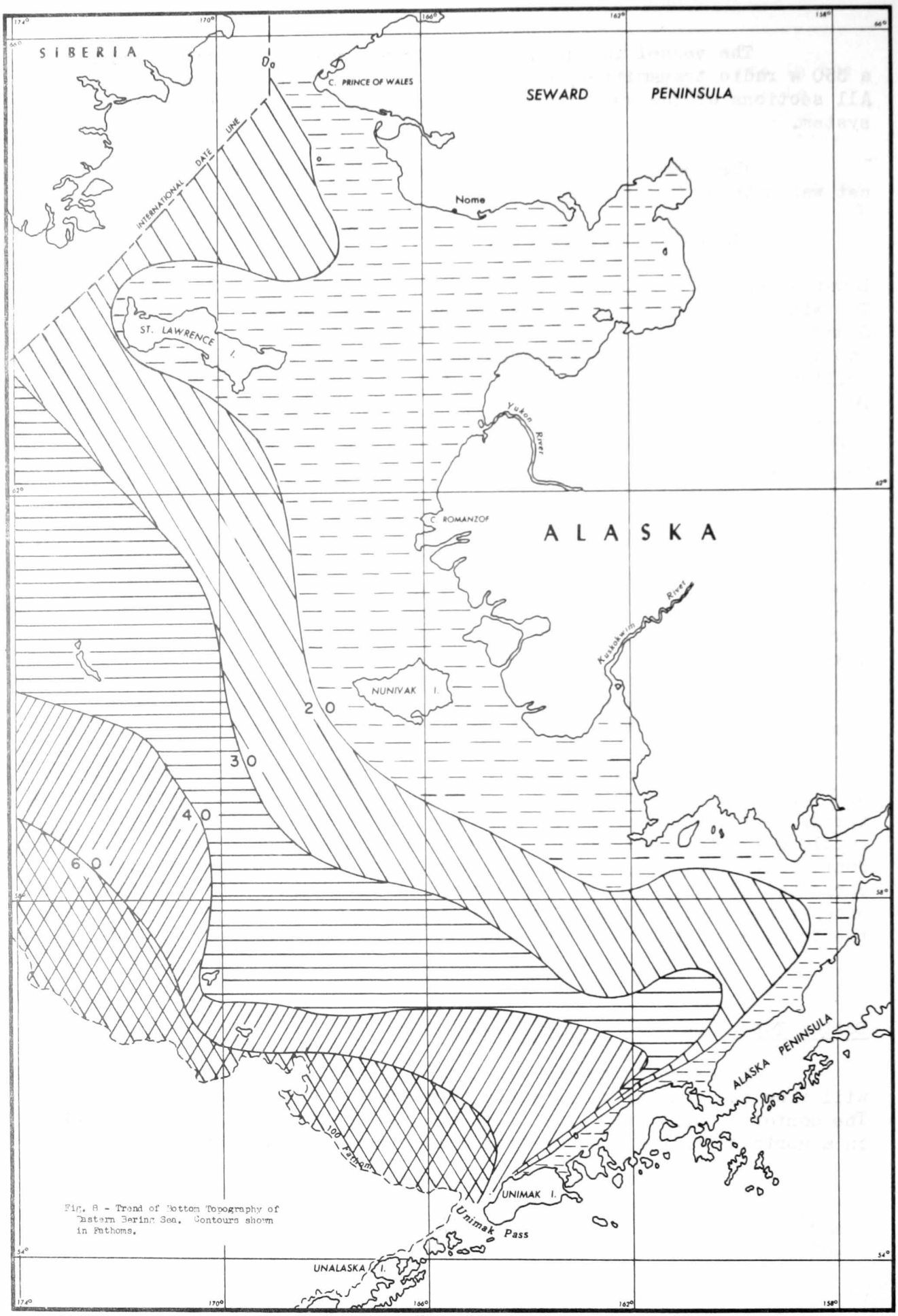


Fig. 8 - Trend of Bottom Topography of Eastern Bering Sea. Contours shown in Fathoms.

and depths show a gradual decrease as progress is made to the north and east. Norton Sound, Yukon Flats, and Etolin Strait are for the most part less than ten fathoms in depth. South and west from the 100 fathom curve the bottom falls off steeply to depths of over 2,000 fathoms. All fishing on this exploration was done on the shallow shelf in waters varying from 8 fathoms deep in Norton Sound to 54 fathoms south of St. Matthew Island.

In general, there was shown a correlation between depth and bottom temperatures, the shallow waters of the Norton Sound and Nunivak Island areas being much warmer than the deeper waters offshore; a notable exception was the zone of sub-zero water between St. Matthew and St. Lawrence Islands at moderate depths. Tables No. 1 and 2 indicate the depths at which fish were taken in the 51 drags made.

TABLE 1 - DEPTHS AT WHICH FISH WERE TAKEN

Depth Fished	Drags Made	Portion of total drags	COD			FLATFISH		
			Fish Caught	Portion of total	Average per drag	Fish Caught	Portion of total	Average Per drag
Fathoms	Number	Percent	Number	Percent	Number	Number	Percent	Number
0 - 20	25	49	76	5.5	3	1,105	11.2	44
20 - 30	16	31	758	53.9	47	4,888	49.7	305
30 - 40	6	12	93	6.6	15	526	5.4	88
40 - 60	4	8	478	34.0	120	3,319	33.7	830
Total	51	100	1,405	100.0	27	9,838	100.0	193

TABLE 2 - DEPTHS AT WHICH SHELLFISH WERE TAKEN

Depth Fished	Drags Made	Portion of total drags	KING CRAB			SHRIMP		
			Crabs Caught	Portion of total	Average Per drag	Shrimp Caught	Portion of total	Average Per drag
Fathoms	Number	Percent	Number	Percent	Number	Number	Percent	Number
0 - 20	25	49	86	75.4	3	853	50.2	34
20 - 30	16	31	28	24.6	2	447	26.3	28
30 - 40	6	12	0	0	0	400	23.5	66
40 - 60	4	8	0	0	0	0	0	0
Total	51	100	114	100.0	2	1,700	100.0	33

It is realized that many other factors are important as concerns the incidence of fish and shellfish in the area, aside from depths and bottom conditions. As shown from the above tabulation, 49 percent of the fishing was done in depths not exceeding 20 fathoms. This effort produced only 5.5 percent of the cod and 11.2 percent of the flatfish caught, but in the case of king crabs it produced 75.4 percent, and for shrimp 50.2 percent. The plan of exploratory fishing called for testing as many varied depth conditions as possible. However, due to the uniformity of depths in most of the area, little variation was possible. In the area fished, most of the king crabs were caught in depths under 20 fathoms and none were taken in waters exceeding 30 fathoms.

Figure 8 clearly shows the shoal condition of the waters in the northern Bering Sea. The area under 20 fathoms comprises Norton Sound, and circumscribes St. Lawrence Island, and extends well seaward from the mainland to the west of Nunivak, and into Bristol Bay. The deepening is so gradual that the 40-fathom curve is found south of St. Matthew and St. Paul Islands. Thus, the depths at which the king crabs are found in the northern area are much shallower than those in which they are found in the southern area, being about the same as the shallow waters used for mating in the southern area. While the southern Bering Sea king crabs are known to migrate as much as 60 miles to deeper water after mating, a migration of this distance would have little effect on water depth in most of the northern area. In the southern area it was found that the small immature crabs prefer shallower depths (15 to 30 fathoms); however, while the crabs found in the northern area were mature, they were in size comparable to a southern Bering Sea immature king crab.

St. Matthew Island is surrounded by deeper water than other parts of the northern area. From this district were captured the largest purple king crabs taken on the trip. Purple king crabs in the St. Lawrence Island to Norton Sound area were smaller. However, the Alaskan king crabs taken in Norton Sound were nearly as large as the purple king crabs from St. Matthew, and were larger than the purple crabs from the same region. It is difficult to apply any knowledge concerning migrations of king crabs learned from the southern region, except to suggest the possibility that minor differences within a relatively shallow area might possibly correspond to much more radical differences in the southern area. For example, a change from 15 to 20 fathoms in the north might correspond to a change of from 15 to 45 fathoms in the south. Much more information, such as the effect of changes in salinity, temperature, etc., is needed before any attempt can be made to understand these problems.

The character of the bottom deposits was found to agree quite well with that shown on the navigational charts of the area, gray sand and gravel, green mud, and gray clay predominating over the fishing area. Green mud was quite common in the area from St. Matthew to St. Lawrence Island where fishing was poor and the catch consisted mostly of tanner crabs, starfish, and other bottom trash. Drag No. 3, adjacent to St. Matthew Island, resulted in a bad snag.

Gray sand, gravel, and clam shells formed the principal deposits north of St. Lawrence Island, with snags and severe chafing of the net being encountered on drags No. 8, 9, 11, and 12. The bottom of Norton Sound was mostly gray sand and mud deposited by the Yukon and other streams emptying close by. A bad snag was encountered on drag No. 21, suspected to be due to ice-borne boulders off Golovnin Bay. The net was torn almost beyond repair on drag No. 23 close to Nome, the bottom sample yielding gray mud and sand.

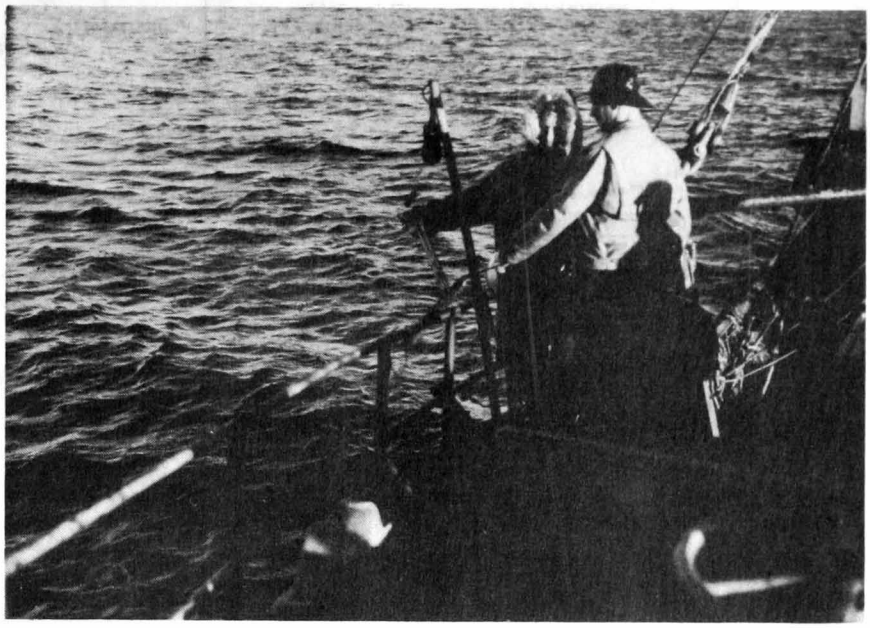


FIG. 9 - TAKING BOTTOM SAMPLES AND TEMPERATURES

No rocks are shown on the charts of these waters, and it is believed that the snags encountered on this trip were large boulders carried from shore by the moving ice pack and dumped at the points where the ice melted sufficiently to release them. There is a possibility that these boulders, due to a gradual sinking into the mud and sand bottom would not be a menace to the nets later in the season. They might also be encountered at different places each year due to the movements of the ice pack.

Areas No. IV and V, along the east coast, were completely free from snags. The best catches of cod and flatfish were made west and south of Nunivak Island on gray sand bottom. Drag No. 51, yielding one of the best catches, was made on a bottom of sand and black mud.

Water Temperatures

Bottom water temperatures, probably more than any other one factor, were found to be positively correlated with the abundance of fish taken over the entire area. Sufficient temperatures were taken to indicate certain trends in both surface and bottom water temperatures. Obviously many more stations should be occupied to clearly define the various zones, and it is fortunate that temperatures recorded by the Deep Sea can be supplemented by the work of the University of Washington Oceanographic Department and other data from the western Bering Sea. Temperatures obtained are recorded in the table of fishing observations (Table 5), and charts outlining the general areas of prevailing temperatures are included as Figures 10 and 11. In referring to these charts, it must be kept in mind that the readings prevail

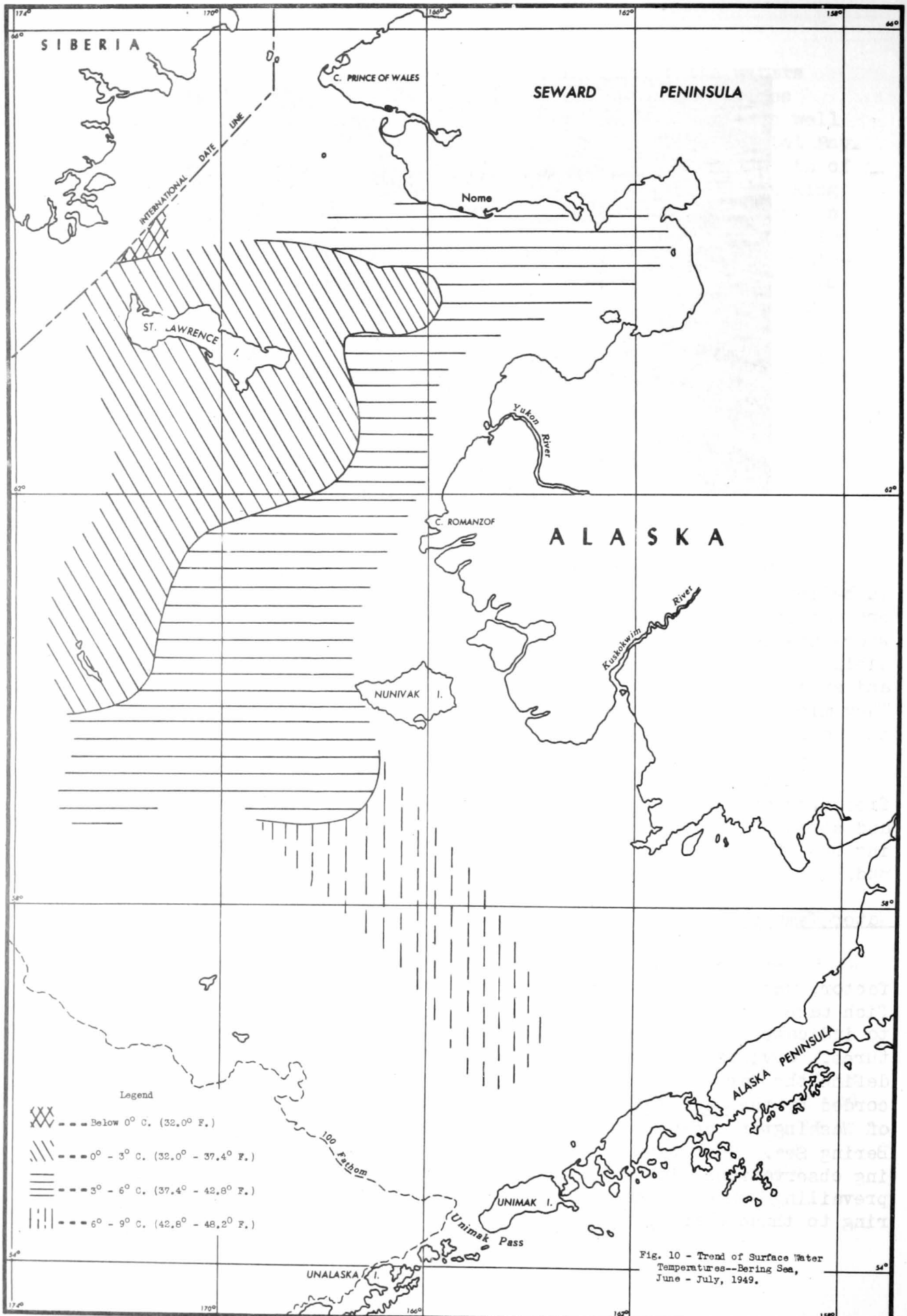


Fig. 10 - Trend of Surface Water Temperatures--Bering Sea, June - July, 1949.

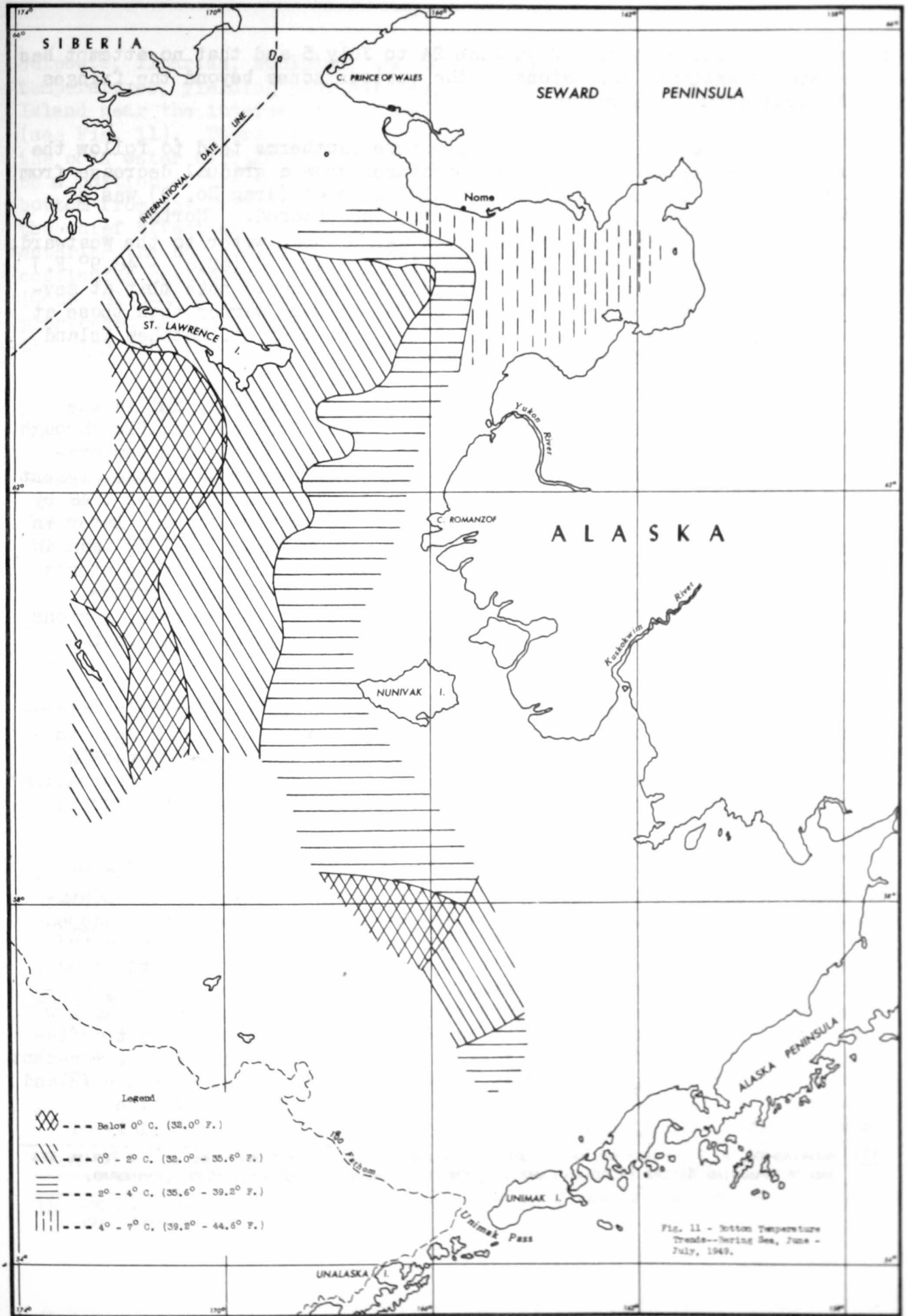


Fig. 11 - Bottom Temperature Trends--Bering Sea, June - July, 1949.

for only the limited period from June 24 to July 5 and that no attempt has been made to estimate extensions of the various zones beyond the fringes of the area actually surveyed.

In general, the bottom temperature isotherms tend to follow the bottom topography, while surface temperatures show a gradual decrease from east to west and south to north. In only one spot (drag No. 9) was a surface temperature below 0° C. (32.0° F.) encountered. Norton Sound and Nunivak Island areas were much warmer than water to the westward, the warmest surface water of the voyage (6° - 9.4° C.) (42.8° - 48.9° F.) being found below Nunivak Island. It is interesting to note that at several stations in Norton Sound the bottom waters were warmer than those at the surface, which was also the case at drag No. 3 at St. Matthew Island and at drag No. 33 off Cape Romanzof.

The current along the Alaskan shelf is northward, and in the summer, when the influence of warm water entering from the Pacific through the Aleutian Passes is greatest, it causes a large increase in temperature. Temperatures at both the surface and bottom recorded on the present trip were several degrees colder than those reported in September 1948 by the Washington and those reported by other investigators working later in the summer. Goodman, et al (1942), reports warmer waters in 1938 than in 1937, due to the earlier breakup of the ice pack caused by severe storms in 1938. He also points out the gradual decrease in the temperature gradient from the surface to the depths as the summer progresses, regions of thermal uniformity existing in the Nunivak Island area later in the season.

This summer warming of the water influences the northward migration of many fish in the Bering Sea. It can be expected that higher temperatures than those found on this voyage will be encountered later in the summer, and that from year to year, due to meteorological disturbances affecting the break-up of the ice pack, temperatures at both the surface and bottom will vary to a considerable degree.

A glance at Figure 11 will reveal the presence of the corridor of sub-zero bottom water extending past St. Matthew Island to the southwestern portion of St. Lawrence Island, obviously existing quite independent of the bottom topography. It would seem probable that this is the outer fringe of the well-known Gulf of Anadir "cold spot," described by Goodman, et al, as the possible result of the accumulation of cold, concentrated sea water released by the formation of ice on the more shallow portions of the Alaskan shelf. The boundaries of this area are not definitely known, but it effectively acts as a faunistic barrier to the movement of many species through the strait between Siberia and St. Lawrence Island as Andriashev (1939)[17] has pointed out. In this area of negative temperatures, the Deep Sea found the bottom fauna to consist mainly of

17/ ANDRIASHEV, A. P., ESSAY ON THE ZOOGEOGRAPHY AND ORIGIN OF THE FISH FAUNA OF THE BERING SEA AND NEIGHBORING WATERS (RUSSIAN LANGUAGE, ENGLISH SUMMARY): 185 PP., 1939, LENINGRAD.

eelpouts, liparids, soulpins, and tanner crabs. Similar sub-zero bottom temperatures, yielding poor catches, were observed south of Nunivak Island near the intersection of 58° N. latitude and 166° W. longitude (see Fig. 11). There exists a possible connection between this zone and the cold water corridor in the St. Matthew Island area. This may also be a portion of the tongue of cold water reported to extend along the bottom from the Pribilof Islands into southeastern Bering Sea. Probably the chief effect of this barrier is to cause a shunting of the species entering the Bering Sea through the Aleutian passes to the eastward before continuing northward. This is supported by the cod fishing industry (Cobb 1917)[18] which started first on Slime Bank in the spring and then progressed to Baird Bank. This cold water zone undoubtedly influences the king crab migration to some degree.

A breakdown of fishing efforts into the various temperature zones is shown in Tables 3 and 4.

TABLE 3 - TEMPERATURES AT WHICH FISH WERE TAKEN

Bottom Temperature	Drags Made	Portion of Total Drags	Cod			Flatfish		
			Fish Caught	Portion of Total	Average per Drag	Fish Caught	Portion of Total	Average per Drag
Degrees	Number	Percent	Number	Percent	Number	Number	Percent	Number
Below 0°C.(32.0°F.)	6	12	13	.9	2	282	2.8	47
0°C. - 2° C. (32.0° - 35.6°F.)	20	39	562	40	28	2,449	24.9	122
2°C. - 4°C. (35.6° - 39.2°F.)	18	35	785	55.9	44	6,654	67.7	370
4°C. - 7°C. (39.2° - 44.6°F.)	7	14	45	3.2	6	453	4.6	65
Total	51	100	1,405	100.0	27	9,838	100.0	193

TABLE 4 - TEMPERATURES AT WHICH SHELLFISH WERE TAKEN

Bottom Temperature	Drags Made	Portion of Total Drags	King Crab			Shrimp		
			Crabs Caught	Portion of Total	Average per Drag	Shrimp Caught	Portion of Total	Average per Drag
Degrees	Number	Percent	Number	Percent	Number	Number	Percent	Number
Below 0°C. (32.0°F.)	6	12	0	0	0	20	1.2	3
0°C. - 2°C. (32.0° - 35.6°F.)	20	39	22	19.3	1	1,350	79.4	66
2°C. - 4°C. (35.6° - 39.2°F.)	18	35	78	68.4	4	258	15.2	14
4°C. - 7°C. (39.2° - 44.6°F.)	7	14	14	12.3	2	72	4.2	10
Total	51	100	114	100.0	2	1,700	100.0	33

18/ Cobb, John N., The Pacific Cod Fisheries: Report U. S. Comm. of Fish, App. IV, 111 pp., 1917, Washington.

It appears that the 2° - 4° C. (35.6° - 39.2° F.) temperature zone is the most favorable to the occurrence of cod, flatfish and king crab, while shrimp were found in largest concentrations in water of 0° - 2° C. (32.0° - 35.6° F.). Cod and flatfish also were in numbers at temperatures from 0° - 2° C. (32.0° - 35.6° F.) in certain areas. These fish might conceivably tend to "lead" along the edges of the cold water barrier, which would explain the concentrations of these species found in the approaches to Bristol Bay and northward along the warm water channel adjacent to the mainshore. Admittedly much more work needs to be done to substantiate this hypothesis; but the fact remains that fish were not found abundant in sub-zero water, and were in the adjacent warmer waters, which at least justifies posing this possibility as a suggested explanation.

The waters in Norton Sound and between Nome and St. Lawrence Island, even though possessing bottom water temperatures which would not appear unfavorable, produced no cod and only immature flatfish. Possibly the northward migration of the cod does not progress this far at this time of year. Still, reports from the natives, which appear well founded, place the cod in the St. Lawrence Island area at later seasons of the year. Cod would not be expected in any abundance in Norton Sound proper because of the great inflow of fresh water into the shallow sound; hence, absence of cod from this region was not surprising.

The warm waters of Norton Sound produced the only Alaskan king crabs taken in the northern area, none being taken in waters less than 2° C. (35.6° F.), and the majority were found in the range from 3° - 6.8° C. (37.4 - 44.2° F.). Purple king crabs, on the other hand, were found almost exclusively in waters from 0° to 2.6° C. (32.0° - 36.7° F.), only two small specimens being taken in warmer water (4.9°C.) (40.8° F.). It is not inferred that these figures are critical temperatures for these species, as their occurrence is undoubtedly influenced by other environmental factors.

Nearly 80 percent of the shrimp caught were taken at bottom temperatures between 0° and 2° C. (32.0° and 35.6° F.), mainly in the area adjacent to St. Lawrence Island and the approaches to Norton Sound. Gray shrimp were found to inhabit areas of a wide temperature range (-1.4° to 6.8° C.) (29.5° to 44.2° F.).

The corridor of bottom water between 2° and 4° C. (35.6° and 39.2° F.), extending from Norton Sound to south of Nunivak Island produced the best fishing of the voyage, good catches of cod and flatfish were common. Fair catches were also made in slightly colder adjacent waters. The pattern of fishing, plus the time element involved in completing such a cruise in less than two weeks time, did not allow for a complete set of bottom temperatures sufficient to establish definite isotherms. This fact, coupled with the knowledge that higher temperatures are known to exist in this same area later in the summer,

of necessity makes the temperature data of this report valid only for this limited period of the season and indicative of only the trends and general boundaries of temperature zones. It is possible that ranges of temperature for the various species will be greatly altered later in the summer and may vary from year to year.

FIG. 12 - A CATCH OF FLATFISH FROM THE NUNIVAK ISLAND AREA

Weather

Weather conditions varied widely from smooth to very rough seas, with sudden changes occurring from day to day. Wind shifts were frequent and unpredictable, with southerly and southwesterly blows prevailing slightly more often than from any other direction. Rain and fog were encountered on several days, making the loran equipment a necessity in the calculation of position, which was extremely important in this work.

Fourteen days elapsed from the time of leaving Dutch Harbor to the completion of the last drag. For six days the seas were rough, five days produced calm waters, and moderate seas prevailed three days. Fog ranging from scattered patches to thick layers was encountered on five of the fourteen days, usually accompanying the calm seas with very little wind.

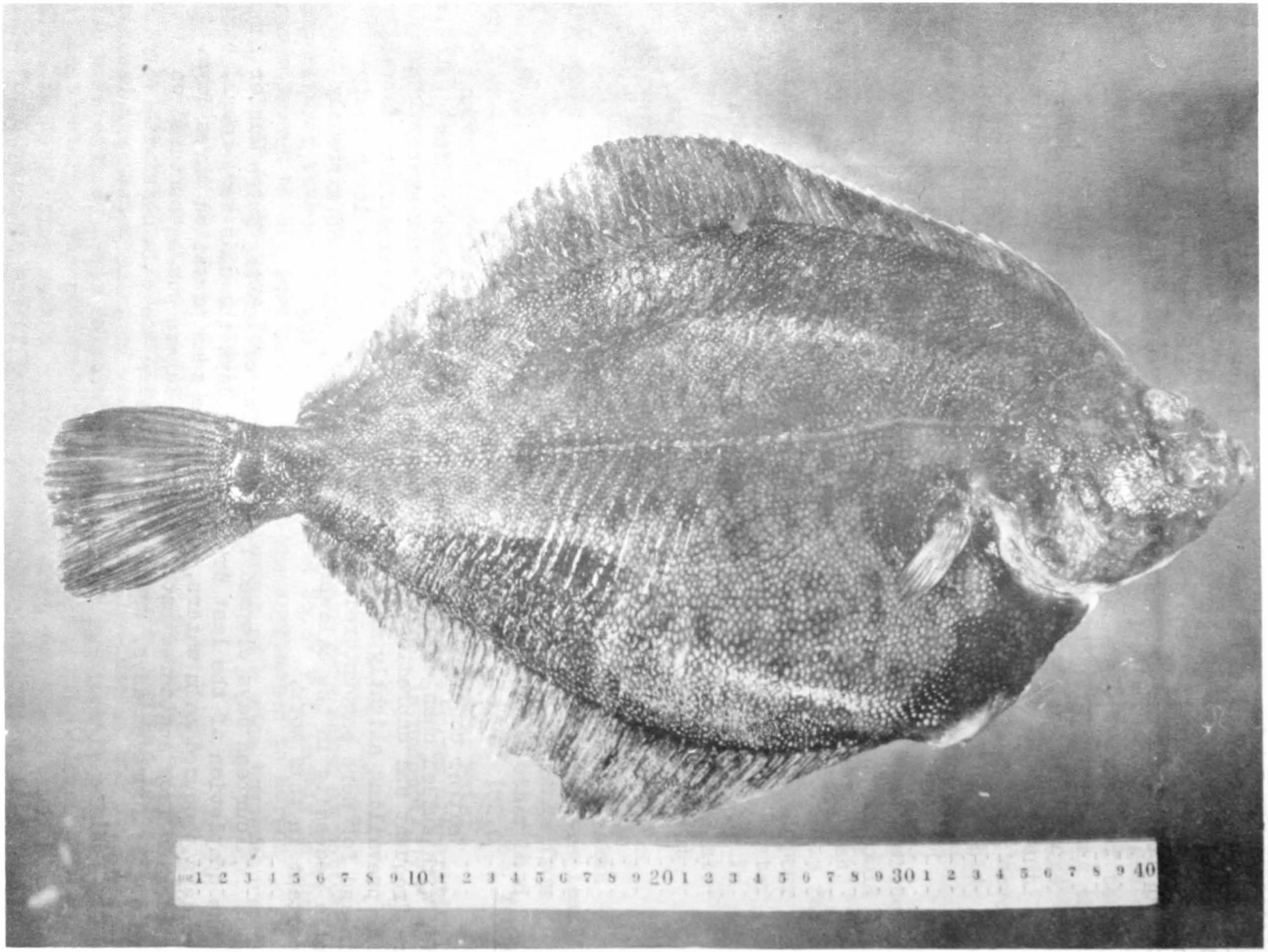


FIG. 13 - LEMON "SOLE" (PLEURONECTES QUADRITUBERCULATUS)

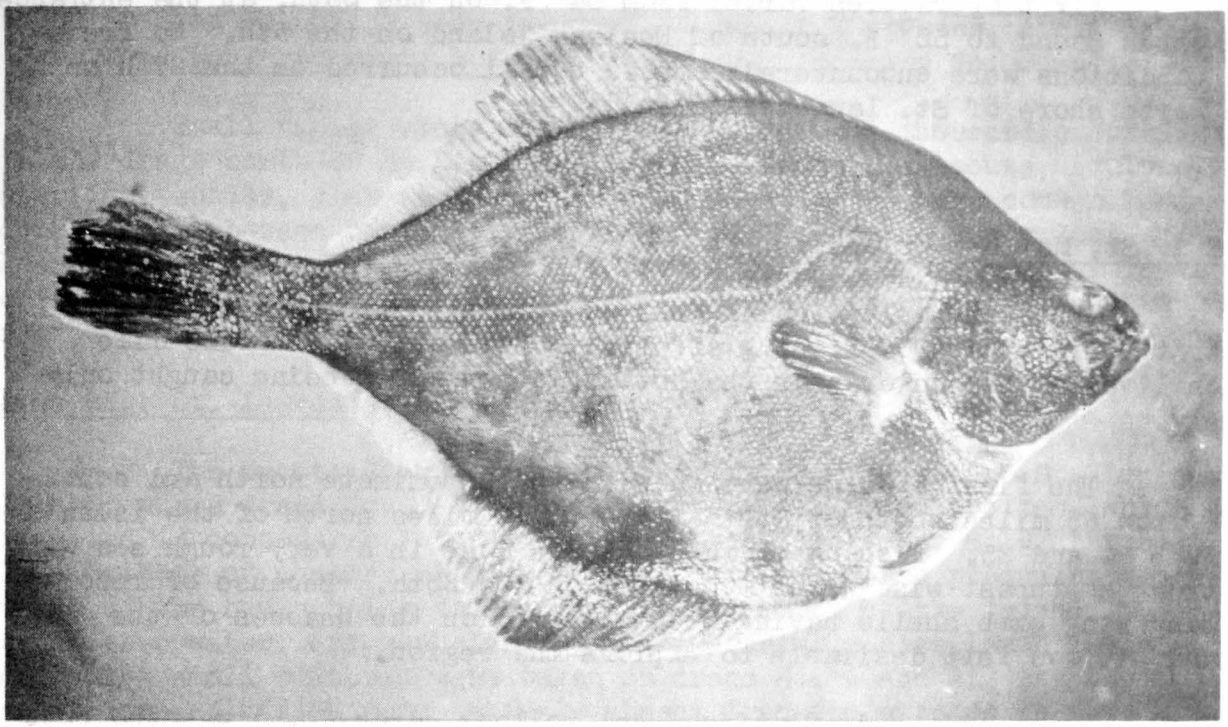


FIG. 14 - YELLOWFIN "SOLE" (LIMANDA ASPERA)

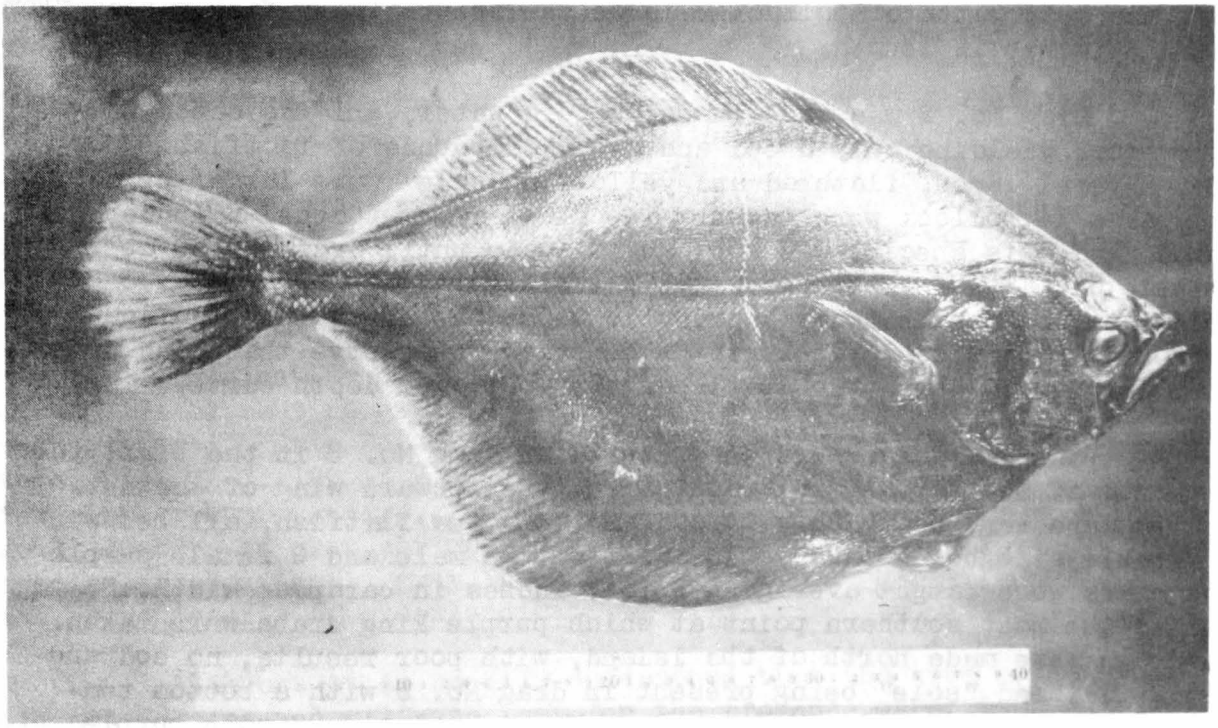


FIG. 15 - FLATHEAD "SOLE" (HIPPOGLOSSOIDES ROBUSTUS)

Air temperatures varied from 34° F. on the 28th, at the entrance of Norton Sound to 52° F. south of Nunivak Island on the 5th. No freezing conditions were encountered; a hail squall occurred on the 27th on the north shore of St. Lawrence Island.

Discussion of fishing results

Area I. St. Matthew Island

Since the only fishing gear used in this exploration was the otter trawl, results of fishing efforts include only the marine life which lives either on or near the bottom, other types being caught only rarely.

The first 5 drags were made in an approximate north and south line from 65 miles south of St. Matthew to 40 miles north of the island on June 24 and 25. Fishing on the 24th was done in a very rough sea with a strong southeast wind which moderated on the 25th. Because of reports of many king crab shells having been observed on the beaches of the island, it was felt desirable to explore the region.

As regards cod, flatfish, and pollock, drag No. 1 was the best in the area, producing 25 excellent cod, 2 halibut, rock "sole", arrow-toothed flounder, and flathead "sole" in prime condition and nearly all of marketable size. Total catch of flatfish in this drag was estimated at 150 pounds. Five hundred pounds of pollock were landed in this first drag, the best catch of pollock made on the trip. These fish varied from 12 to 18 inches in length.

Drag No. 2 was made in below zero water, and the catch was quite poor, yielding only 3 cod and about 25 pounds of flatfish. However, several lemon, flathead and yellowfin "sole" were large, prime fish. Also 14 pollock were taken. Two small arrow-toothed flounder were landed, and this species was not caught again until drag No. 50 at latitude 56° 47' N. Therefore, the position of drag No. 2, 59° 48' N. represents the farthest north point at which the arrow-toothed flounder was found on this survey. It is interesting to observe that both drag No. 2 and No. 50 were practically on the 40-fathom depth curve.

Several snags were encountered on drag No. 3 in the bight to the north of St. Matthew Island, tearing the forward wing of the net. Results were very poor, only 14 cod and very few flatfish, all below marketable size being taken. In addition, 23 male and 9 female purple king crabs were caught averaging 6 to 7 inches in carapace width. This is the most southern point at which purple king crabs were taken. Two drags were made north of the island, with poor results, no cod and only 2 flathead "sole" being present in drag No. 5 with a bottom temperature of -1.4° C. (29.5° F.). Drag No. 4 produced 23 more purple king crabs, 1 cod, and several small flatfish. The 6 pollock in this catch represented the last time these fish were caught until drag No. 41 was made west of Nunivak Island; thus, 60° 44' N. latitude represents

the northern limit of pollock for this investigation. One herring was taken in drag No. 5. A very few gray shrimp of 2 species, Argis lar (Owen) and Schlerocrangon boreas, were caught in drags No. 3 and 4.

Small tanner crabs were abundant, several thousand occurring in the drags north of St. Matthew. Also liparids, eelpouts, sculpin, starfish, snails, clam shells, tunicates, and skates were common. No doubt, the sub-zero bottom temperatures encountered on several of the hauls were responsible, at least in part, for the generally poor results obtained. Possibly also the green mud bottom which prevails in this region is significant.

Area II. St. Lawrence Island

The outstanding characteristic of the area around St. Lawrence Island, where drags No. 6 to 12 were made, was the foul bottom, which resulted in considerable damage to the net on drags No. 8, 9, 11, and 12. Catches of commercial species were rare, with the predominant contents of the hauls being small tanner crabs south of the island, in below zero water, and sculpin. Several marketable size lemon "sole" and a few small flathead were taken on drags No. 6 and 7; with these exceptions, flatfish were entirely absent from the catches in this area.

No cod were taken in this series of drags; however, both capelin and sand lances (upon which cod are known to feed) were caught, evidence to indicate that cod might have been present at depths not fished by the otter trawl. Natives of St. Lawrence have reported catching cod offshore with hand lines later in the summer around the month of August. For these reasons, the chances of producing cod around St. Lawrence Island with types of gear other than the otter trawl and at a later time of the season do not seem out of the question.

Purple king crabs, predominantly males, were caught in small quantities on drags No. 8, 9, 10, and 11. These were quite small, approximately half being under 6 inches in carapace width, although several females were found to be ripe with eggs.

Interesting catches of shrimp were made both north and south of the island, but no great quantities were taken because of the large mesh net used. Drag No. 6 produced 20 gray shrimp at a bottom temperature of -1.4° C. (29.5° F.), and drag No. 7 yielded 400 of gray and a few pink or humpy shrimp, Pandalus goniurus. Drags No. 8 and 10 produced small numbers of gray shrimp and drag No. 12 approximately 400 or 3 species, predominantly gray, plus the less common Sclerocrangon boreas, and Spirontocaris of groenlandica.

Although it is readily understood that the type of gear used did not furnish a legitimate test for the presence of shrimp, still the quantities of gray shrimp which were taken may indicate the presence of

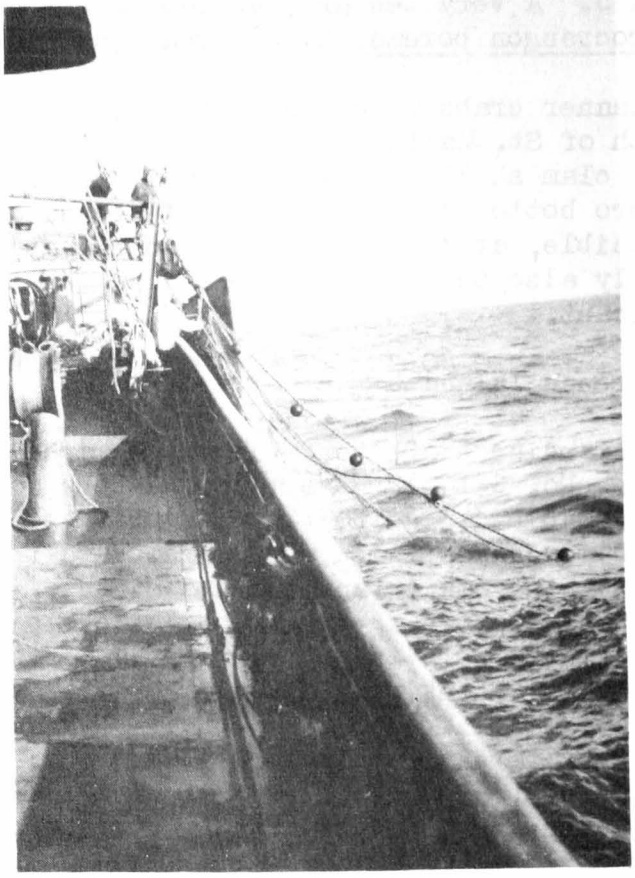


FIG. 16 - HAULING IN THE TRAWL NET

a sizeable population of this species in the vicinity and the possibility of locating large concentrations by systematic fishing with shrimp gear both north and south of St. Lawrence. Local knowledge of the bottom would have to be gained to reduce the damage to gear which was experienced on the present trip and which accounted for the sparseness of drags made along the north coastline of the island by the Deep Sea.

Small numbers of arctic cod were taken on drags No. 6, 7, 8, and 12, together with several northern "tomcod." The greater part of these catches were considered as "trash," consisting mainly of tanner crabs, sculpin, starfish, snails, clam shells, toad or spider crabs, sea urchins, liparids, lumpsuckers and tunicates.

Area III. Nome - Norton Sound

Seventeen drags (No. 13 to 29) were made in Norton Sound and waters off Nome. Bottom temperatures varied several degrees from slightly above 1° C. (33.8° F.) at the entrance to 6.8° C. (44.2° F.) near the head of the sound at a depth of 8 fathoms, and considerable variety existed in the catch.

A noticeable characteristic of the hauls in this area was the abundance of immature flatfish taken, including rock "sole," lemon "sole," yellowfin "sole," and long-nosed dabs, with yellowfin and lemon predominating. Several large starry flounders and occasional yellowfin and lemon "sole" of marketable size were caught.

Drag No. 29 produced 100 yellowfin all under 6 inches in length. Considering the large size of the mesh used, the number of small flounders which were caught is worthy of notice, and indicates that a population of adult flatfish must exist in the general area, possibly in close to shore at this time of the year. Unconfirmed reports were received from natives in the vicinity of Nome that large starry flounder and other flatfish were being caught in quantity in salmon gill nets near the beaches. Because of the impossibility of taking the Deep Sea into the shoal water, these reports could not be followed up; but it is reasonable to believe that small craft equipped with suitable gear, such as beam trawls, might find good fishing in the shallower waters near shore.

Shrimp were taken in small quantities in nearly all drags in this area, including the 4 species encountered in areas I and II, plus the coon stripe (Pandalus hypsinotus), a few of which were caught in drag No. 22 near Nome, the only time this shrimp was taken on the trip. As was the case on the previous drags, the gray shrimp was found to be most common, occurring in greatest numbers in drags No. 16, 26, 28, and 29 at the approaches to Norton Sound.

Both the Alaskan king crab and the purple species were taken at various points in the Sound and near Nome, but never in any sizeable quantities. Most were small, below six inches in carapace width. This occurrence of P. camtschatica may constitute a new northern record for the species. Further investigation might reveal migration patterns for the crabs in this northern region, possibly leading to the discovery of concentrations of mature adults.

No cod were caught in Norton Sound or the Nome region until drag No. 29 (40 miles east of St. Lawrence Island) was made on the way south. One 12-pound cod was taken in this catch, which represents the northern limit of this fish for the trip. The fact that capelin and sand lances, staple items of cod food, were taken on several drags further north in the entrance to Norton Sound, together with the knowledge that cod were caught by the Washington in September 1948 northeast of St. Lawrence, suggests the probability of a northward migration of cod past the eastern end of St. Lawrence Island into the waters west and north of Nome. As no cod are known to spawn in the northern Bering Sea, this migration would apparently be for feeding purposes, the capelin and sand lances probably preceding the appearance of the cod. Fishing with various types of gear in this area at a later date would undoubtedly throw much more light on the presence and movements of the Bering Sea cod.

Rainbow smelt, in very small quantities, were taken at several stations in Norton Sound. Northern tomcod were found quite frequently and in considerable numbers; also arctic cod were taken in several hauls. Several of the catches were predominantly starfish, ascidians, and other bottom "trash," including tanner crabs, spider crabs, tunicates, sea poachers, sculpin, sailor fish, liparids, blennies, wolf fish, clams, greenlings, sea anemones, hermit crabs, and snails.

Area IV. Norton Sound to Nunivak Island

Drags No. 30 to 37 were made in the waters between 63° N. latitude and 61° N. latitude from the southwestern approach to Norton Sound to a position approximately 100 miles northwest of Nunivak Island. No king crabs of either species were taken in this series of hauls. A very few gray shrimp were found in drags No. 30 and 35, this marking the southern limit of shrimp occurrence in the catch for the remainder of the exploration.

FIG. 17 - A MIXED CATCH NEAR NUNIVAK ISLAND

Cod were taken in every drag except No. 31, being accompanied by good showings of capelin in the catches. These were prime fish, ranging from 12 to 17 pounds and showing no signs of infestation. Experienced fishermen aboard the Deep Sea expressed the opinion these were very good cod. Stomach analysis revealed capelin, tanner crabs and shrimp, bearing out the probability that schools of cod feeding entirely on capelin pelagically were not being taken by the otter trawl, which was catching almost exclusively those cod which were feeding on or near the bottom. Other gear would possibly be much more effective for this reason.

Encouraging catches of flounders were made, with the percentage of small, immature fish much less than farther north. Starry flounder, yellowfin, rock, and lemon "sole" were common, with lemon and yellowfin predominating. Many flatfish were small, but a good percentage were large, prime fish in excellent condition. Drag No. 32 produced 100 lemon "sole" of which 75 percent were prime fish of marketable size, and 200 yellowfin of which only 5 percent were marketable. Several rock "sole" were of extremely large size and in excellent condition. Drag No. 37 produced over 100 large prime lemon "sole," with the percentage of marketable size yellowfin also increasing. Several halibut were caught, mostly very small, only 1 being of marketable size.

Drag No. 33, made within 40 miles of Cape Romanzof in 14 fathoms, yielded very few cod and an abundance of immature yellowfin and lemon "sole." The bottom temperature (3.5° C.) (38.3° F.) was above that of the previous drags, and the catch was predominantly starfish, similar to conditions encountered farther north at the entrance to Norton Sound. On moving offshore on the following drags, fishing improved considerably.

Area V. Nunivak Island and South

The waters west and south of Nunivak Island, in which drags No. 38 to 51 were located, proved to be the most productive grounds fished on this trip, many catches containing several thousand pounds of cod and flatfish. No shrimp were caught in this area; however, considerable numbers were taken from the stomachs of cod on drag No. 38. One Alaskan king crab was taken in each of drags No. 42 and 43, 1 female being ripe with eggs. The complete absence of crabs from the remaining catches was surprising, especially in the southernmost hauls. The fact that the only 2 crabs taken were in the catches made nearest to Nunivak Island may be evidence that the crabs, if in the area, are closer to shore at this time.

Some good catches of cod, up to 350 per drag (see Fig. 19), and ranging in size up to 16 pounds, were made in this series of hauls.

They were found to be feeding on tanner crabs and capelin, with shrimp and clam meat appearing in the stomach contents on drag No. 38. Much variation in size of the cod was noted as the work progressed southward. Drags No. 38, 39, and 40 produced only large, prime fish from 10 to 16 pounds; somewhat smaller fish were taken in No. 41, and only 1 cod was caught in drag No. 42 near Nunivak Island. However, on the next 2 hauls good catches of prime fish were again made, but more small sizes again appeared in the following 2 drags (No. 45 and 46) and the cod were very few and small at No. 47 and 48 where sub-zero bottom temperatures were again encountered. Although a favorable temperature (1.8° C.) (35.2° F.) existed on No. 49, the 70 cod taken were all of a size too small for marketing. The last 2 catches contained several hundred cod, ranging from very small to large prime fish, over 200 being of marketable quality in drag No. 50. The abundance of capelin taken from cod stomachs (drag No. 41 contained a number of cod which had been feeding exclusively on capelin) further indicates that a large number of cod were feeding above the bottom.

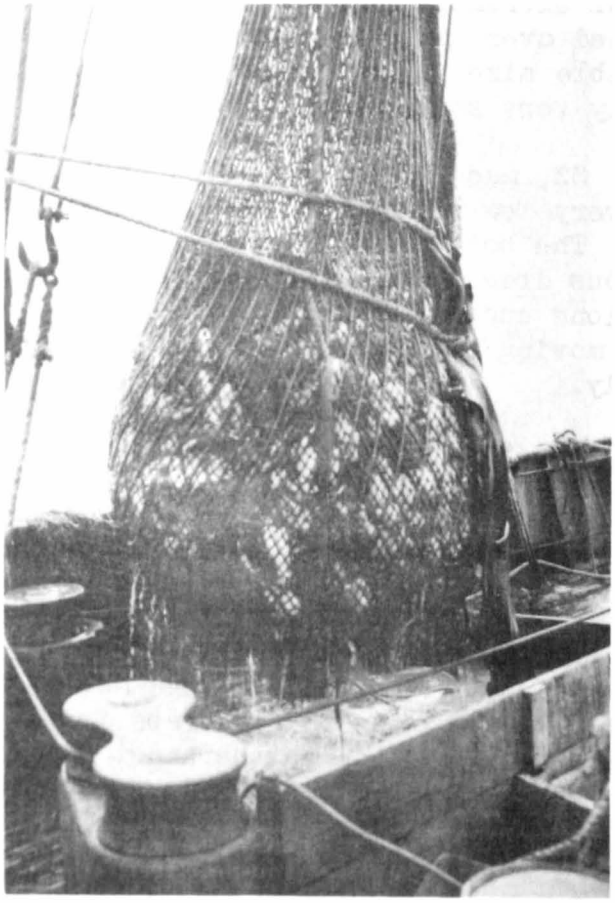


FIG. 18 - A CATCH OF COD AND FLOUNDER ABOUT TO BE DUMPED ON DECK.

This series of fishing efforts also produced excellent catches of flatfish, up to 5,000 pounds per haul, including rock, yellowfin, and flathead "sole," and arrow-toothed flounder, most of which were large fish in prime condition, plus a few halibut. Drag No. 44 yielded 2,000 yellowfin, 80 percent marketable; 500 rock, 70 percent marketable; and 200 lemon "sole," 60 percent marketable. Drag No. 51 produced 450 rock, 80 percent marketable; 45 lemon, 100 percent marketable; 250 arrow-toothed flounder, 100 percent marketable; and 1,200 flathead "sole," 95 percent marketable. Yellowfin were notably absent from this haul, and there was evidence that definite areas of abundance for each species exists. For instance, large lemon "sole" were predominant in drags No. 37 and 38 further north, while yellowfin and rock "sole" increased in percentage in subsequent catches; and in drag No. 51, flathead "sole" were in the majority, with a good showing of arrow-toothed flounder.

Halibut were found to be thinly scattered over the area, an occasional one appearing in most of the catches. Sizes were generally small, drag No. 44 producing the largest catch of halibut, including 7 mediums and 8 small. In no case was evidence of any large population of halibut found in the waters fished, but the effectiveness of the otter trawl as a test for halibut is questionable. Pollock were taken at various stations in assorted numbers, catches of over 200 occurring in drags No. 50 and 51. The quality and size were excellent, many measuring well over 2 feet in length. One herring was taken in drag No. 38. Varying amounts of sculpin, snails, starfish, ascidians, spider crabs, sea poachers, liparids, eelpouts, and skates were commonly mixed in with the catch. Drags No. 47 and 48 produced several thousand small tanner crabs, which appear to be a characteristic of the sub-zero water and a poor catch.

List of common and scientific names used in this report

Fish

Pacific herring	Clupea pallasii
Capelin	Mallotus catervarius
Rainbow smelt	Osmerus dentex
Arctic cod, polar cod	Boreogadus saida
Alaska pollock	Theragra chalcogramma
Wachna cod, northern "tomcod"	Eleginus gracilis
Pacific cod, gray cod	Gadus macrocephalus
Arrow-toothed flounder, turbot	Atherestes stomias
Pacific halibut	Hippoglossus stenolepis
Flathead "sole," flathead flounder	Hippoglossoides robustus and elassodon
Rock "sole," rock flounder	Lepidopsetta bilineata
Yellowfin "sole," Alaska dab	Limanda aspera
Long-nosed dab	Limanda proboscidea
Lemon "sole," Alaska plaice	Pleuronectes quadrituberculatus
Starry flounder	Platichthys stellatus
Sculpins	Family Cottidae (sensu lato)
Sea snails, liparids	Family Liparidae
Sand lance	Ammodytes personatus
Blennies	Family Lumpenidae & Stichaeidae
Eelpouts	Family Zoarcidae (Lycodinae)
Wolf fish	Anarhichas orientalis

Shellfish

Shrimp:

Humpy	Pandalus goniurus
Coonstripe	Pandalus hypsinotus
No common name	Spirontocaris of groenlandica
Gray	Argis lar (Owen)
No common name	Sclerocrangon boreas

Crabs:

Alaska king crab	Paralithodes camtschatica
Purple king crab	Paralithodes platypus
Tanner crab	Chionoecetes opilio
Toad crab	Hyas coarctatus
Korean horse crab	Erimacrus isenbeckii

Mollusca:

Whelks	Buccinum sp. & Chrysodomus sp.

Weights and measurements of food fishes from the Northern Bering Sea

Cod (Gadus macrocephalus)

In Area I the cod ranged in size from 40 to 82.2 cm. (15.7 to 32.4 in.) with an over-all average of 66.6 cm. (26.2 in.). In Area IV the cod ranged in size from 60 to 89 cm. (23.6 to 35.0 in.) with an over-all average of 73.8 cm. (29.1 in.). Twenty-seven cod weighed ranged from 5 lb. 6 oz. to 17 lb. 4 oz. with an average of 8 lb. 4 oz. In Area V, marketable cod ranging from 55 to 88 cm. (21.7 to 34.6 in.) averaged 68.2 cm. (26.9 in.). Nineteen specimens weighed from Area V ranged in weight from 4 lb. 7 oz. to 15 lb. 12 oz. with an over-all average of 7 lb. 14 oz. For a composition of the population of the cod of the Bering Sea, see accompanying graph.

Herring (Clupea palasii)

Four specimens taken ranged from 14.6 to 18.7 cm. (5.7 to 7.4 in.), with an average of 16.6 cm. (6.5 in.) in length.

Capelin (Mallotus catervarius)

Ripe females ranged in length from 12.5 to 15 cm. (4.9 to 5.9 in.).

Rainbow Smelt (Osmerus dentex)

Two specimens 18.2 and 19.6 cm. (7.2 and 7.7 in.) respectively were obtained in the Norton Sound area.

Arctic Cod (Boreogadus saida)

Adult specimens ranged in length from 16.8 to 29 cm. (6.6 to 11.4 in.)

Alaska Pollock (Theragra chalcogramma)

In Area V, 27 adult specimens measured 48 to 70 cm. (18.9 to 27.6 in.) with an average of 58.8 cm. (23.2 in.).

Northern "Tomcod," Wachna Cod (Eleginus gracilis)

Adults ranged from 20 to 32 cm. (7.9 to 12.6 in.) in length.

Arrow-toothed Flounder (Atherestes stomias)

In Area I, 30 marketable specimens ranged from 44 to 67 cm. (17.3 to 26.4 in.) in length. Average length was 59.65 cm. (23.5 in.) and average weight 4.9 lbs. In Area V, 255 marketable specimens (over 40 cm. (15.7 in.) in length) were examined with an estimated mean length of 60 cm. (23.6 in.).

Pacific Halibut (Hippoglossus stenolepis)

Area I:

No. of drag	No. of halibut	Range of Length cm.	Range of Length in.	Average Length cm.	Average Length in.
1	2	77 - 90	30.3 - 35.4	83.5	32.9
3	1	43	16.9	43	16.9
4	1	56.5	22.2	56.5	22.2

Area V:

41	3	33.6 - 66	13.2 - 26	51.9	20.4
43	8	35 - 80.7	13.8 - 31.8	55.1	21.7
44	15	43 - 124.5	16.9 - 49.0	62	24.4
50	1	104	40.9	104	40.9

Flathead "Sole" (Hippoglossoides robustus and elassodon)

In Area I, marketable size specimens ranged from 33.6 cm. to 48.4 cm. (13.2 to 19.1 in.) with an average of 40.3 cm. (15.9 in.). In Area V, adults ranged in size from 37 to 48 cm. (14.6 to 18.9 in.) averaging 42.7 cm. (16.8 in.), with an average weight of 1 lb. 12 oz.

Rock "Sole" (Lepidopsetta bilineata)

In Area I, 5 marketable specimens ranged in size from 30 to 42.6 cm. (11.8 to 16.8 in.), with an average of 37 cm. (14.6 in.). In Area IV rock "sole" ranged in size from 33.3 to 55 cm. (13.1 to 21.7 in.) in length, with an over-all average of 43.1 cm. (17.0 in.), and an average weight of 2 lb. 4 oz. In Area V, the range of sizes was 34 to 40 cm. (13.4 to 15.7 in.), with an average of 38.4 cm. (15.1 in.).

Yellowfin "Sole" (Limanda aspera)

In Area I, the average length of commercial size specimens was 30.5 cm. (12.0 in.), the range 29.5 to 31.2 cm. (11.6 to 12.3 in.). In Area IV, the range in length was from 30 to 44 cm. (11.8 to 17.3 in.), with an average of 38.3 cm. (15.1 in.) and an average of 1 lb. 11 oz. in weight. In Area V, the range was from 30 to 44.6 cm. (11.8 to 17.6 in.) with an average of 39.2 cm. (15.4 in.) and 1 lb. 8 oz. in weight.

Lemon "Sole" (Pleuronectes quadrituberculatus)

In Area I, the range in size was from 31.1 to 45.2 cm. (12.2 to 17.8 in.), with an average of 39.3 cm. (15.5 in.). In Area IV, the range was from 31.1 to 52.9 cm. (12.2 to 20.8 in.), with an average of 39.4 cm. (15.5 in.) and an average weight of 1 lb. 15 oz.

Starry Flounder (Platichthys stellatus)

In Area III, the range was from 34.6 to 50 cm. (13.6 to 19.7 in.) with an over-all average of 42.6 cm. (16.8 in.).

In all species of fish described except the halibut these weights and measurements are representative of the class of fish marked marketable in the trip log. All lengths are fork lengths. Weights were taken in the Seattle laboratory after return from the trip. As the fish were well glazed, it is believed that the weight loss was not significant.

Notes on the stomach content analysis of the principal food fishes taken by the Deep Sea

Pacific Cod

Area I.--Drags No. 1, 2, 3, and 4 were examined. In drags No. 1, 2, and 4 the food was 90 percent fish, chiefly small pollock, and the remainder was tanner crabs, with a few euphasids in several stomachs. In drag No. 3, in the shoal water of St. Matthew Island bight, the food was predominantly toad and tanner crabs; the remainder was miscellaneous invertebrates and unidentified fish fragments.

Area IV.--Drags No. 30, 32, 35, 36, and 37 were examined. A variety of forms were taken from cod stomachs in this area. The two principal

food items were tanner crabs and capelin. Other food items taken from the stomachs were echiuroid worms, shrimp, snails, euphasids, hermit crabs and fish (yellowfin "sole" and sculpins). The relative abundance of crabs and capelin taken from the stomachs varied from drag to drag. Rarely were these two forms present in a single stomach. Drag No. 37 brought up cod which had been feeding exclusively on capelin.

Area V.--Drags No. 38, 39, 40, 41, and 51 were examined. The food contents resembled the previous area, except that capelin became less abundant and none were taken in drag 51. Noteworthy were the large numbers of shrimp (Hippolytidae) obtained from cod taken in drag No. 38, where shrimp comprised one-third of the stomach contents. Also present in drag No. 38 were two cod with only clam meats in the stomachs. Drag No. 41 contained a number of cod which had been feeding exclusively on capelin. This was interpreted to mean that the cod were feeding above the bottom.

Alaska Pollock

Area V.--Four pollock taken in drag No. 49 were found to be feeding on young cod and crustacea (amphipods and euphasids).

Pacific Halibut

Area I.--Chiefly fish remains (small Alaska pollock), with a lesser amount of tanner crabs, were taken from halibut in this area.

Area V.--Stomach contents were primarily fish (small cod, pollock, flatfish and capelin). Invertebrates noted were chiefly tanner crabs, and one octopus was taken from a large specimen.

Flathead "Sole"

Area V.--Fifty stomachs examined from drag No. 50 contained only brittle starfish, except for two small cockles (Cardium sp.) taken from one stomach. Four flatheads examined from drag No. 51 had been eating nothing but brittle starfish.

Rock "Sole"

Area IV.--Food contents were primarily polychaete worms, other large annelids, small clams, shrimp, echiuroids, amphipods and a single ascidian in 15 stomachs examined.

Yellowfin "Sole"

Area IV.--Ten stomachs examined from drag No. 33 contained predominantly clam meats with lesser amounts of snails, liparids, holothurians and echiuroids.

Lemon "Sole"

Area I.--Food contents were primarily amphipods and tube worms.

Area IV.--Food contents were predominantly polychaete worms with lesser amounts of other annelids, amphipods and small clams.

Area V.--Drag No. 38 was examined. Stomach contents consisted primarily of amphipods, polychaete worms, other large annelid worms and a few small clams.

Starry Flounders

Area III.--Stomach contents were polychaete worms and unidentified clam fragments.

Area IV.--Only small sand dollars were taken from the stomachs. One stomach taken from drag No. 33 contained six 1-inch sand dollars.

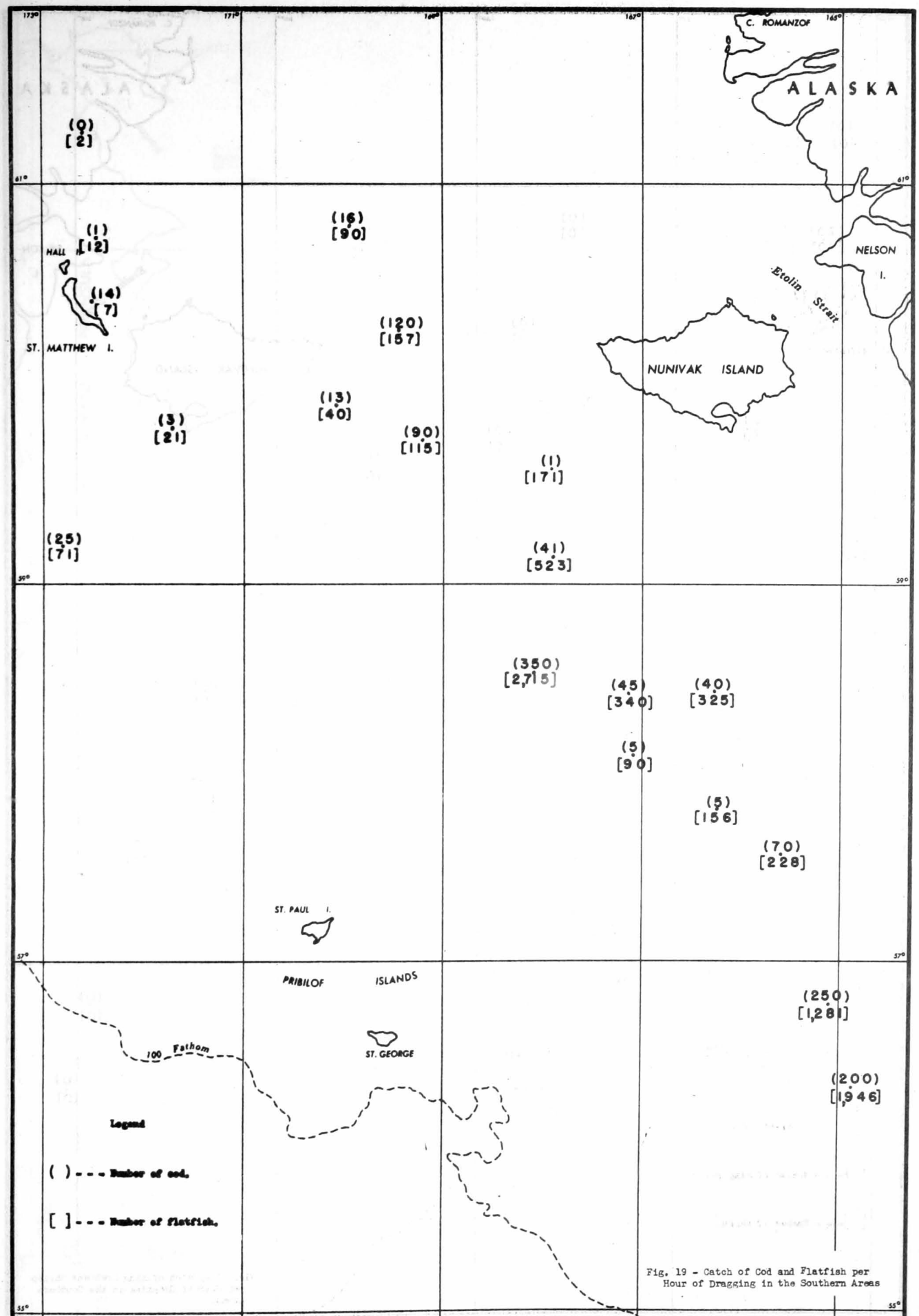


Fig. 19 - Catch of Cod and Flatfish per Hour of Dragging in the Southern Areas

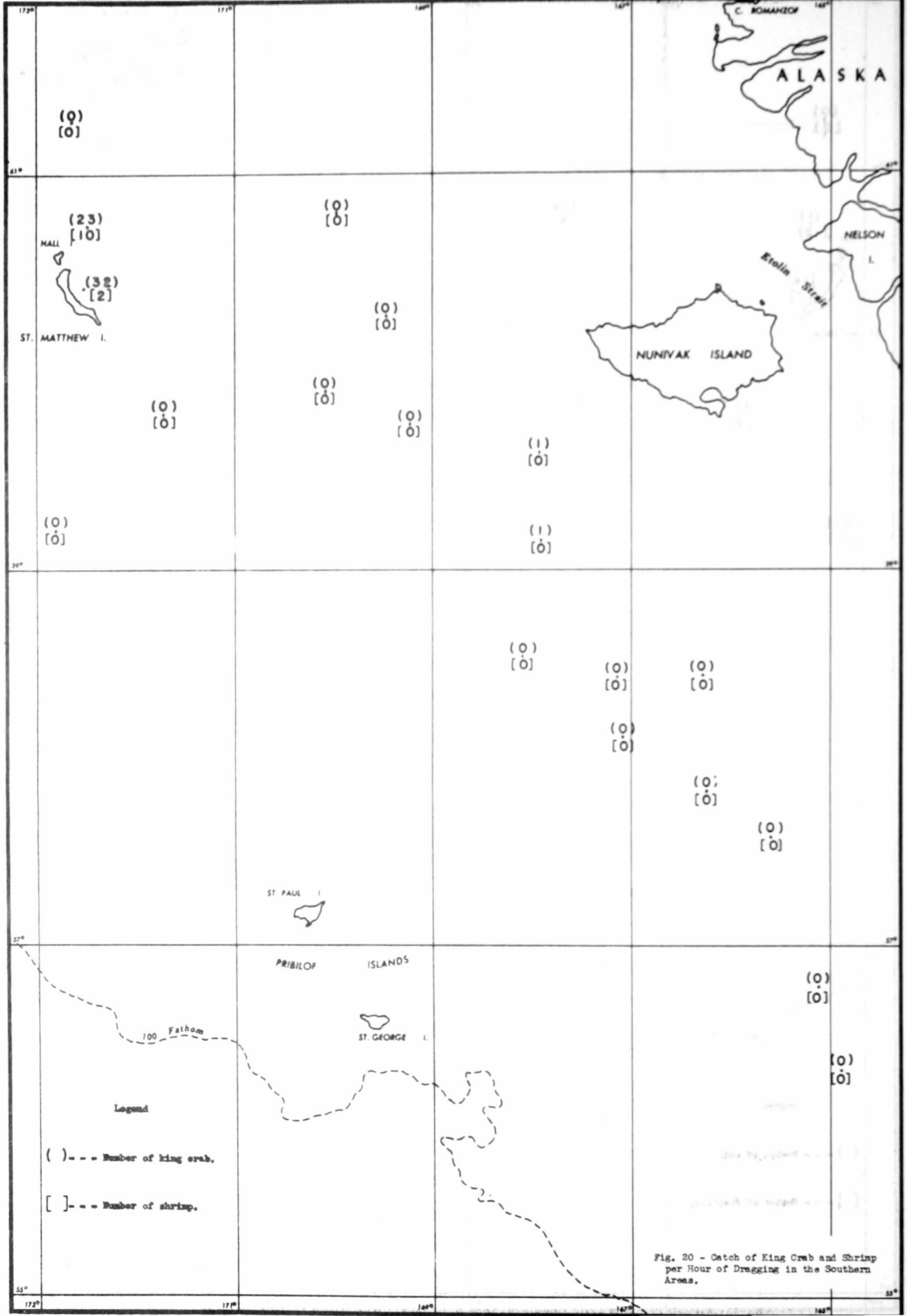


Fig. 20 - Catch of King Crab and Shrimp per Hour of Dragging in the Southern Areas.

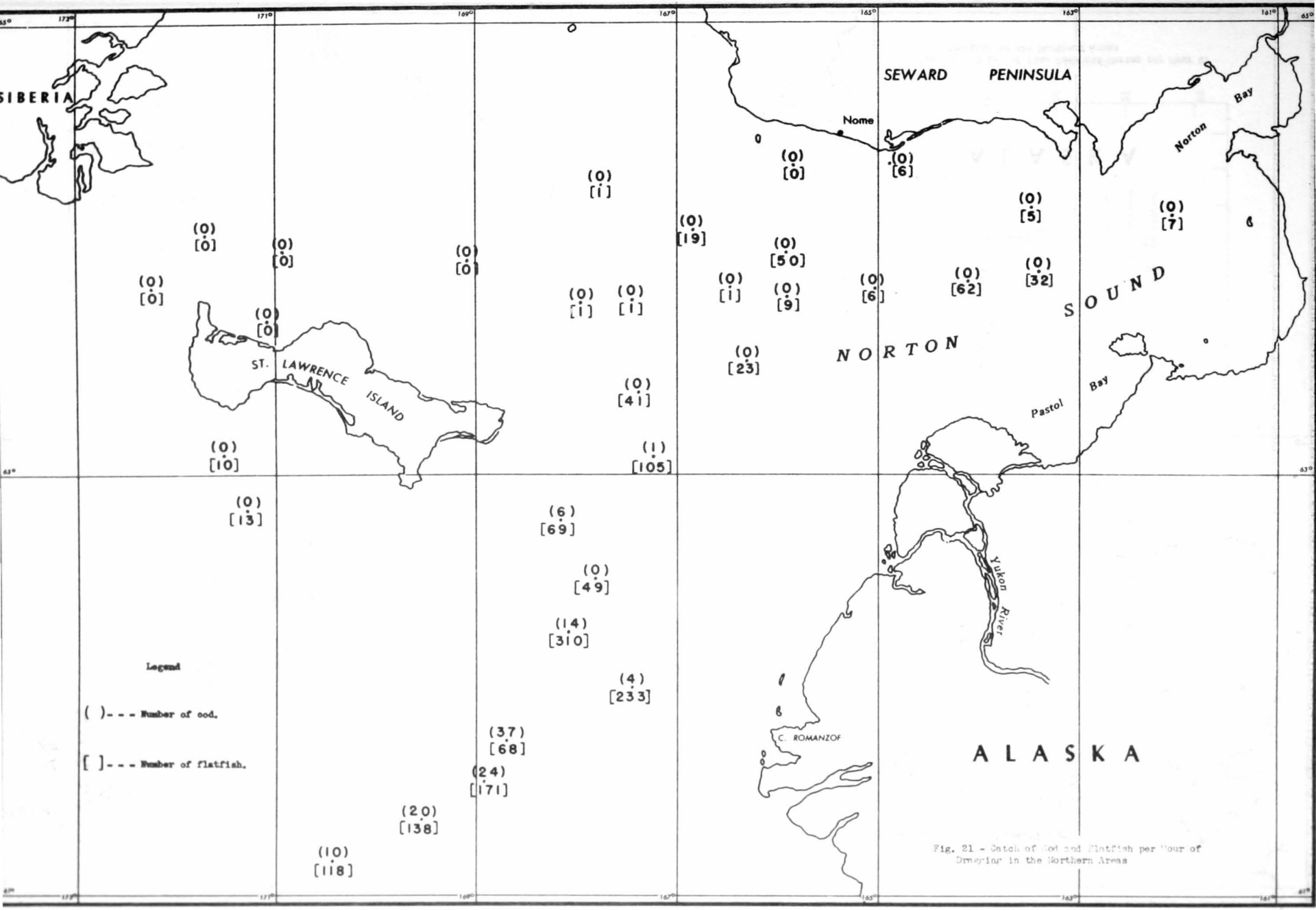
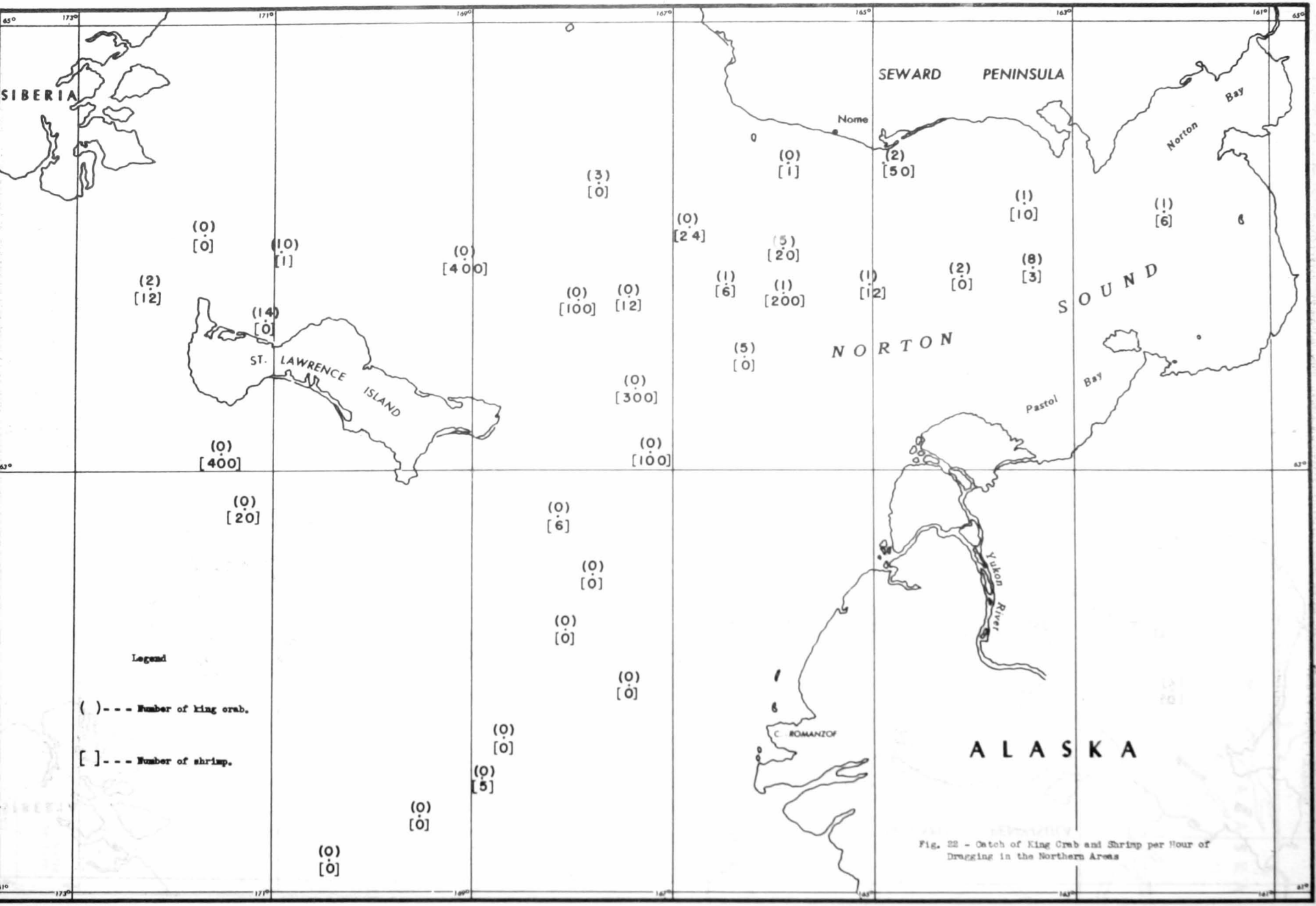


Fig. 21 - Catch of Cod and Flatfish per Hour of Dredging in the Northern Areas

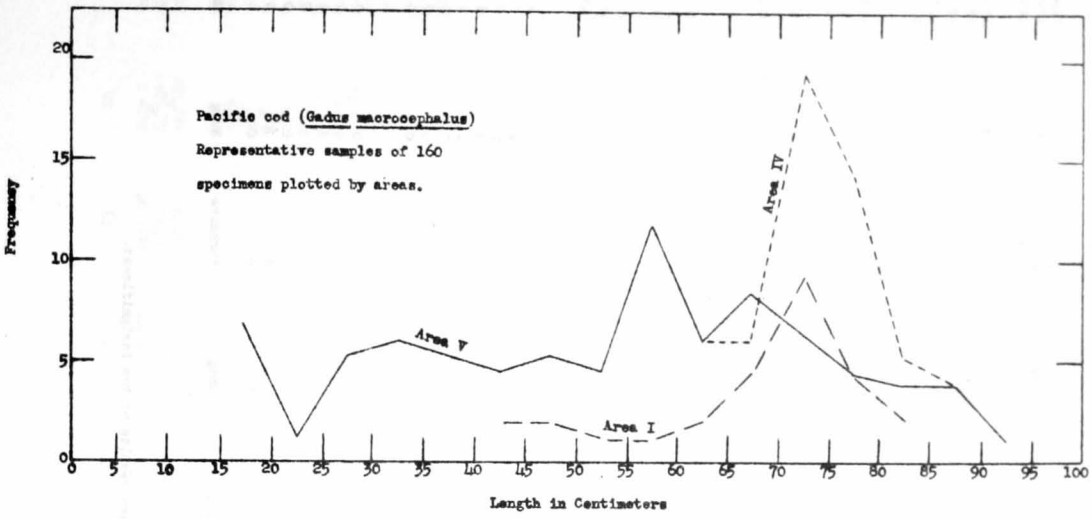


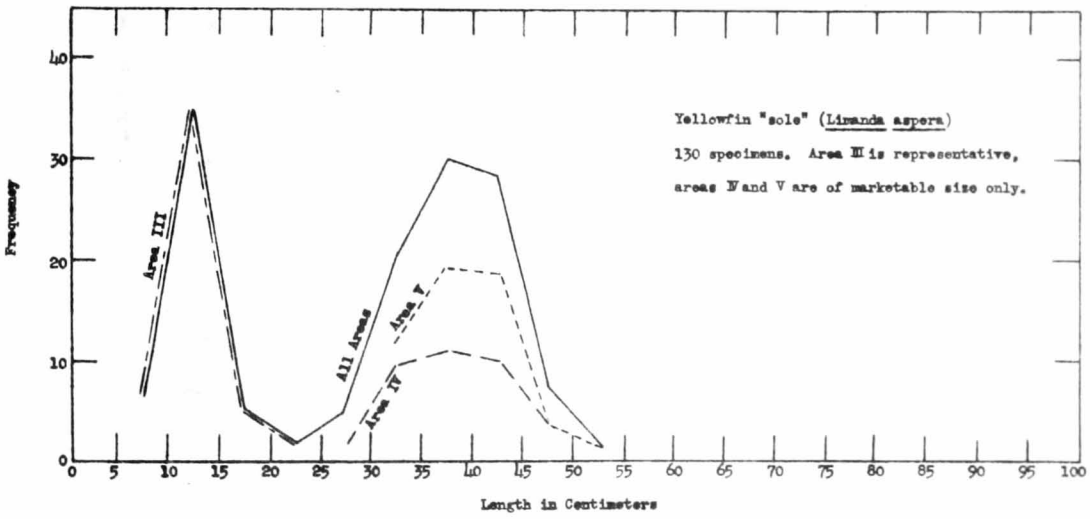
Legend

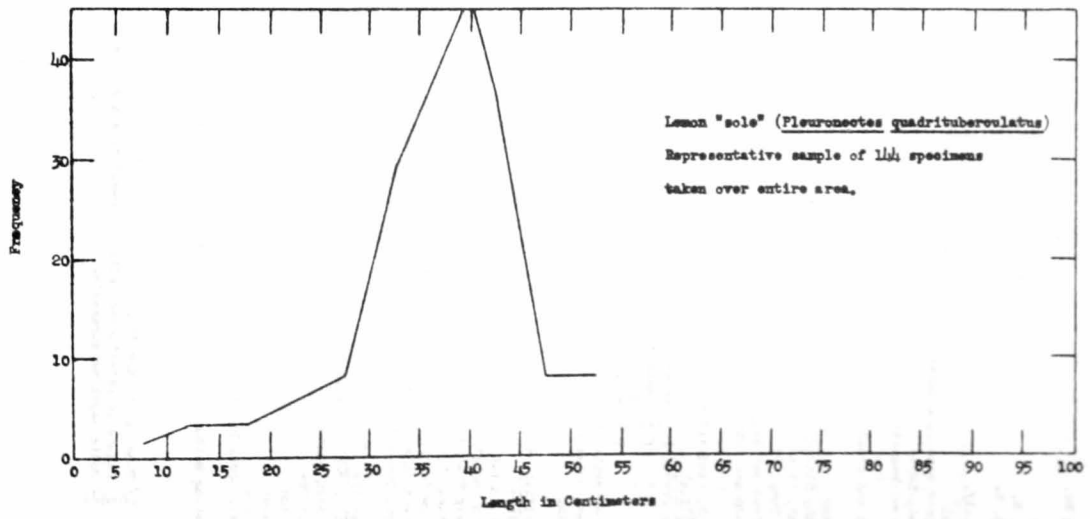
( ) - - - Number of king crab.

[ ] - - - Number of shrimp.

Fig. 22 - Catch of King Crab and Shrimp per Hour of Dragging in the Northern Areas







(2.54 centimeters = 1 inch)

Fig. 23 - Length-frequency Graphs of Several Important Species of Food Fish Taken by the Jean in

TABLE 5 --ABSTRACTS OF FISHING OBSERVATIONS--BERING SEA, 1949

	Area I. St. Matthew Island					Area II. St. Lawrence Island						
Drag No.	1	2	3	4	5	6	7	8	9	10	11	12
Date	June 24	June 24	June 24	June 25	June 25	June 25	June 25	June 26	June 26	June 27	June 27	June 27
Lat. N.	59°11'	59°48'	60°26.5'	60°44'	61°15'	62°51'	63°06'	63°50'	64°04'	64°00'	63°40'	63°58'
Long. W.	172°50'	171°44'	172°39'	172°34'	172°40'	171°18'	171°33'	172°15'	171°42'	170°56'	171°04'	169°05'
Start[1]	0435	1220	2115	0050	0550	1645	2350	0715	2220	0205	0540	1210
Stop[1]	0535	1320	2215	0150	0650	1745	0050	0815	2320	0305	0640	1315
Elapsed time in minutes	60	60	60	60	60	60	60	60	60	60	60	65
Speed, Knots	3.5	3.6	3.5	3.5	4.0	3.5/4.5	3.5	3.5	4.0	3.5	3.5	3.5
Course, Magnetic	SExS	ExS	SExS	NxW	NxW	NxW	WSW	ESE	NNE	SSW	E	E
Wind and (velocity)[2]	SW (7)	SW (8)	SW (4)	WNW (3)	NW (2)	SSW (4)	SW (3)	S (7)	NE (3)	NW (2)	N (5)	N (4)
Sea	V. rough	High	Slight	Slight	Moderate	Slight	Slight	Rough	Slight	Slight	Slight	Moderate
Bottom	gn. M.	gn. M.	gy. S. G.	gn. M.	gy. Cl.	gy. S. Cl.	gn. M.	G.	G.	gy. S. Sh.	G. gy. S.	gy. S.
Depth, Start[3]	56	42	19	29	40	26	30	26	29	17	12	22
Depth, Stop[3]	56	42	20	30	39	26	31	24	27	19	13	21
Air Temp. °F.	43	46	37	35	42	43	39	38	35	35	35	40
Surface sea temp. °F. (°C.)	39 (3.9)	38 (3.3)	36 (2.2)	35 (1.7)	37 (2.8)	38 (3.3)	36 (2.2)	37 (2.8)	31.5 (-.3)	36 (2.2)	35 (1.7)	36 (2.2)
Bottom sea temp. °F. (°C.)	34.9 (1.6)	30.6 (-.8)	36.7 (2.6)	35.8 (2.1)	29.5 (-1.4)	29.5 (-1.4)	32.2 (0.1)	32.4 (0.2)	31.8 (-.1)	35.8 (2.1)	34.9 (1.6)	35.4 (1.9)
Catch, (individuals)								*			*	
Shellfish												
King Crabs, P.c. males	0	0	0	0	0	0	0	0	0	0	0	0
" " P.c. females	0	0	0	0	0	0	0	0	0	0	0	0
" " P.p. males	0	0	23	20	0	0	0	2	1	5	10	0
" " P.p. females	0	0	9	3	0	0	0	0	0	5	4	0
Tanner crabs, est.	30	400	100	5000	2000	300	2000	0	0	10	10	0
Korean horse crabs	0	0	0	15	0	0	0	0	0	0	0	0
Shrimp	0	0	2	10	0	20	400	12	0	1	0	400
Flatfish (% marketable)												
Halibut	2 (100%)	0	1 (0%)	1 (0%)	0	0	0	0	0	0	0	0
Rock "Sole"	4 (100%)	1 (0%)	0	2 (0%)	0	0	0	0	0	0	0	0
Lemon "Sole"	0	7 (100%)	3 (0%)	2 (0%)	0	6 (100%)	0	0	0	0	0	0
Starry Flounder	0	0	0	0	0	0	0	0	0	0	0	0
Flathead "Sole"	23 (60%)	2 (100%)	2 (0%)	6 (0%)	2 (50%)	7 (0%)	10 (10%)	0	0	0	0	0
Yellowfin "Sole"	0	9 (60%)	1 (0%)	1 (0%)	0	0	0	0	0	0	0	0
Arrow-toothed flounder	42 (75%)	2 (0%)	0	0	0	0	0	0	0	0	0	0
Est. Gross Wt. (lbs.)	150	25	5	5	2	15	5	0	0	0	0	0
Other fish												
Pacific Cod (% marketable)	25 (90%)	3 (33%)	14 (100%)	1 (100%)	0	0	0	0	0	0	0	0
Northern tomcod	0	0	0	0	0	0	2	0	0	0	0	0
Artic Cod	0	0	0	0	6	20	5	1	0	0	0	6
Herring	0	0	0	0	1	0	0	0	0	0	0	0
Pollock	300	14	0	6	0	0	0	0	0	0	0	0
Capelin	0	0	0	Several	0	12	1	0	0	0	0	0
Est. Gross Wt. (lbs.)	700	50	120	10	2	10	4	1	0	0	0	2
Trawling Bottom	Clear	Clear	Snag	Clear	Clear	Clear	Abrasive	Snag	Snag	Abrasive	Snag	Snag

1/ Time is 160 Meridian.
2/ Figure in parentheses indicates Beaufort scale of wind.
3/ Sonic depth measurements.

*NOTE: Bad tear in net makes results of tow insignificant.

TABLE 5 —ABSTRACTS OF FISHING OBSERVATIONS—BERING SEA, 1949 (Continued)

Area III. Nome - Norton Sound

Drag No.	13	14	15	16	17	18	19	20	21	22	23	24	25
Date	June 27	June 27	June 28	June 28	June 28	June 28	June 28	June 28	June 29	June 29	June 30	July 1	July 1
Lat. N.	63°46'	63°47'	63°51'	63°48'	63°50'	63°53'	63°55'	64°09'	64°11'	64°23.3'	64°23'	64°18'	64°06'
Long. W.	167°58'	167°28'	166°28'	165°55'	165°02'	164°08'	163°25'	162°04'	163°30'	164°55.6'	165°54'	167°48'	166°52'
Start 1/	1650	2030	0120	0535	0950	1410	1830	2300	0330	1105	2000	0235	0700
Stop 1/	1750	2130	0220	0640	1050	1515	1930	2400	0430	1205	2100	0320	0800
Elapsed time in minutes	60	60	60	65	60	65	60	60	60	60	60	45	60
Speed, Knots	3.8	3.5	3.5	3.5	3.8	3.5	3.5	3.5	3.5	4.0	3.5	3.5	3.7
Course, Magnetic	S	SE	SE	SE	ESE	NE	E	ESE	NW	SWxS	WSW	ESE	E
Wind and (velocity) 2/	N (6)	NW (8)	NW (8)	NW (8)	W (6)	NW (3)	NW (5)	NW (5)	WNW (7)	SW (7)	SW (3)	NW (1)	W (2)
Sea	Rough	Rough	V. Rough	V. Rough	Rough	Moderate	Rough	Moderate	Moderate	Moderate	Smooth	Smooth	Smooth
Bottom	gy. S.	gy. S.	gy. S. M.	gy. M.	gy. M. Sh.	gy. S. M.	gy. S. M.	gy. S.	gy. M.	gy. bk. M.	gy. M. S.	gy. S.	gy. S.
Depth, Start 3/	19	18	17	14	11	10	10	12	17	19	16	21	19
Depth, Stop 3/	19	17	17	14	10	11	10	12	14	20	16	20	18
Air Temp. °F.	38	35	34	37	39	44	41	37	35	43	41	38	41
Surface sea temp. °F. (°C.)	35 (1.7)	36 (2.2)	35 (1.7)	37 (2.8)	40 (4.4)	43.5 (6.4)	43 (6.1)	37 (2.8)	42 (5.6)	42 (5.6)	39 (3.9)	38 (3.3)	40 (4.4)
Bottom sea temp. °F. (°C.)	34.3 (1.3)	34.0 (1.1)	35.4 (1.9)	35.8 (2.1)	39.9 (4.4)	43.2 (6.2)	44.2 (6.8)	40.8 (4.9)	37.6 (3.1)	40.8 (4.9)	39.4 (4.2)	36.3 (2.4)	37.9 (3.3)
Catch, (individuals)											*		
Shellfish													
King Crabs, P.c. males	0	0	0	1	1	2	5	1	1	0	0	0	0
" " F.c. females	0	0	0	0	0	0	3	0	0	0	0	0	0
" " F.p. males	0	0	1	0	0	0	0	0	0	0	0	0	0
" " F.p. females	0	0	0	0	0	0	0	0	0	2	0	3	0
Tanner crabs, est.	500	100	10	0	10	10	6	0	0	0	0	20	0
Korean horse crabs	0	0	0	0	0	2	2	0	1	10	0	0	0
Shrimp	100	12	6	200	12	0	3	6	10	50	1	0	24
Flatfish (% marketable)													
Halibut	0	0	0	0	0	0	0	0	0	0	0	0	0
Rock "Sole"	1 (0%)	0	0	0	0	0	0	0	0	0	0	0	0
Lemon "Sole"	0	0	1 (100%)	4 (0%)	2 (0%)	10 (10%)	20 (0%)	0	2 (0%)	0	0	0	2 (0%)
Starry Flounder	0	1 (100%)	0	0	0	2 (100%)	0	0	0	1 (0%)	0	0	3 (100%)
Flathead "Sole"	0	0	0	0	0	0	0	0	0	0	0	0	0
Yellowfin "Sole"	0	0	0	5 (0%)	25 (0%)	50 (2%)	12 (0%)	7 (0%)	3 (0%)	5 (0%)	0	1 (0%)	12 (0%)
Arrow-toothed flounder	0	0	0	0	0	0	0	0	0	0	0	0	0
Est. Gross Wt. (lbs.)	0	2	2	3	4	15	3	1	1	1	0	0	12
Other fish													
Pacific Cod (% marketable)	0	0	0	0	0	0	0	0	0	0	0	0	0
Northern tomcod	0	0	0	6	200	30	50	40	10	20	0	0	2
Artic Cod	15	0	0	3	0	0	0	0	0	0	0	0	3
Herring	0	0	0	0	0	0	0	1	0	0	0	0	0
Pollock	0	0	0	0	0	0	0	0	0	0	0	0	0
Capelin	6	20	6	0	0	0	0	0	0	2	0	0	10
Est. Gross Wt. (lbs.)	10	2	1	3	50	10	20	20	5	10	0	0	5
Trawling Bottom	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Snag	Clear	Bad Snag	Clear	Clear

1/ Time is 160 Meridian.
2/ Figure in parentheses indicates Beaufort scale of wind.
3/ Sonic depth measurements.

*NOTE: Bad tear in net makes results of tow insignificant.

TABLE 5 —ABSTRACTS OF FISHING OBSERVATIONS—BERING SEA, 1949 (Continued)

	Area III (Continued)				Area IV. Norton Sound to Wunivak Island							
Drag No.	26	27	28	29	30	31	32	33	34	35	36	37
Date	July 1	July 1	July 2	July 2	July 2	July 2	July 2	July 2	July 2	July 3	July 3	July 3
Lat. N.	64°00'	63°30'	63°22'	63°05'	62°47'	62°31'	62°16'	62°01'	61°46'	61°34'	61°22'	61°10'
Long. W.	165°56'	166°20'	167°23'	167°14'	168°11'	167°50'	168°06'	167°28'	168°42'	168°56'	169°32'	170°26'
Start 1/	1030	1420	0035	0330	0800	1020	1320	1640	2210	0015	0435	0830
Stop 1/	1130	1520	0135	0430	0900	1120	1420	1740	2310	0120	0535	0930
Elapsed time in minutes	60	60	60	60	60	60	60	60	60	65	60	60
Speed, Knots	3.5	3.5	3.5	3.5	3.5	3.8	3.5	4.0	4.2	4.2	4.2	4.2
Course, Magnetic	SSE	SW	ESE	S	SE	S	SSE	S	SE	S	SW&W	ESE
Wind and (velocity) 2/	W (3)	S (3)	S (4)	S (6)	S (6)	SW (6)	SSW (5)	S (5)	SW (5)	SSW (4)	SW (2)	SW (1)
Sea	Slight	Slight	Moderate	Rough	Moderate	Rough	Rough	Rough	Rough	Rough	Slight	Smooth
Bottom 3/	gy. S.	gy. S. M.	gn. M.	gy. S.	gy. S.	gy. S.	gy. S.	gy. S.	gy. S.	gy. S.	gy. S.	gn. M.
Depth, Start 3/	14	15	19	19	17	17	18	16	20	23	25	30
Depth, Stop 3/	14	15	18	20	15	18	18	15	20	23	25	30
Air Temp. °F.	43	44	37	37	39	40	41	41	41	40	45	43
Surface sea temp. °F. (°C.)	40 (4.4)	37 (2.8)	38 (3.3)	38 (3.3)	36 (2.2)	37 (2.8)	37 (2.8)	38 (3.3)	38 (3.3)	38 (3.3)	40 (4.4)	40 (4.4)
Bottom sea temp. °F. (°C.)	35.6 (2.0)	36.3 (2.4)	33.3 (0.7)	32.5 (0.3)	37.2 (2.9)	35.0 (1.7)	36.3 (2.4)	38.3 (3.5)	34.2 (1.2)	36.3 (2.4)	34.9 (1.6)	35.4 (1.9)
Catch, (individuals)												
Shellfish												
King Crabs, P.c. males	5	5	0	0	0	0	0	0	0	0	0	0
" " F.c. females	0	0	0	0	0	0	0	0	0	0	0	0
" " F.p. males	0	0	0	0	0	0	0	0	0	0	0	0
" " F.p. females	0	0	0	0	0	0	0	0	0	0	0	0
Tanner crabs, est.	25	10	20	20	20	0	0	5	30	25	40	12
Korean horse crabs	0	0	0	0	0	0	0	0	0	0	0	0
Shrimp	20	0	300	100	6	0	0	0	0	5	0	0
Flatfish (% marketable)												
Halibut	0	0	0	0	0	0	0	0	2 (0%)	6 (0%)	3 (33%)	0
Rock "Sole"	0	0	0	0	9 (100%)	13 (100%)	10 (100%)	0	0	4 (100%)	10 (80%)	1 (0%)
Lemon "Sole"	25 (0%)	7 (0%)	10 (0%)	5 (0%)	20 (10%)	10 (50%)	100 (75%)	30 (15%)	30 (80%)	40 (50%)	25 (75%)	107 (95%)
Starry Flounder	5 (100%)	4 (100%)	1 (100%)	0	2 (100%)	1 (100%)	0	3 (100%)	1 (100%)	1 (100%)	0	0
Flathead "Sole"	0	0	0	0	0	0	0	0	0	0	0	0
Yellowfin "Sole"	20 (0%)	12 (0%)	30 (0%)	100 (0%)	30 (10%)	25 (10%)	200 (5%)	200 (3%)	35 (60%)	120 (40%)	100 (10%)	10 (60%)
Arrow-toothed flounder	0	0	0	0	0	0	0	0	0	0	0	0
Est. Gross Wt. (lbs.)	15	15	10	20	50	45	150	100	150	200	150	300
Other fish												
Pacific Cod (% marketable)	0	0	0	1 (100%)	6 (100%)	0	14 (100%)	4 (100%)	37 (100%)	24 (100%)	20 (100%)	10 (100%)
Northern tomcod	2	0	0	0	0	0	0	0	0	0	0	0
Artic Cod	0	0	40	25	0	3	0	5	0	0	0	0
Herring	0	0	0	0	0	0	0	0	0	0	0	0
Pollock	0	0	0	0	0	0	0	0	0	0	0	0
Capelin	12	12	4	10	Some	Many	Many	Some	Some	Some	Some	Many
Est. Gross Wt. (lbs.)	2	1	20	25	65	2	200	50	600	300	250	130
Trawling Bottom	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear

1/ Time is 160 Meridian.
2/ Figure in parentheses indicates Beaufort scale of wind.
3/ Sonic depth measurements.

TABLE 5 —ABSTRACTS OF FISHING OBSERVATIONS--BERING SEA, 1949 (Continued)

Area V. Nunivak Island and South

Drag No.	38	39	40	41	42	43	44	45	46	47	48	49	50	51
Date	July 3	July 3	July 3	July 4	July 4	July 4	July 4	July 4	July 4	July 4	July 5	July 5	July 5	July 5
Lat. N.	60°52'	60°18'	59°55'	59°49'	59°36'	59°09'	58°35'	58°28'	58°30'	58°08'	57°52'	57°37'	56°47'	56°17'
Long. W.	169°58'	169°27'	170°04'	169°08'	167°56'	167°56'	168°06'	167°09'	166°16'	167°08'	166°14'	165°34'	165°05'	164°53'
Start[1]	1135	1615	2020	0000	0455	0755	1205	1630	2000	2320	0405	0745	1330	1735
Stop[1]	1240	1715	2120	0100	0555	0855	1305	1730	2100	0020	0505	0845	1430	1835
Elapsed time in minutes	65	60	60	60	60	60	60	60	60	60	60	60	60	60
Speed, Knots	4.2	5.0	3.5/5.0	3.5/5.0	3.5/5.0	3.5/5.0	3.5/5.0	3.5/5.0	3.5/5.0	3.5/5.0	3.5/5.0	3.5/5.0	3.5	3.5
Course, Magnetic	ESE	SSW	ExN	E	SSE	S	SSE	SE	SWxS	SWxS	SSE	SE	SE	SSE
Wind and (velocity)[2]	S (2)	S (2)	S (3)	S (3)	0	E (2)	E (2)	NE (1)	NW (1)	0	0	SW (2)	W (1)	0
Sea	Smooth	Smooth	Smooth	Smooth	Calm	Smooth	Calm	Smooth	Calm	Calm	Calm	Smooth	Smooth	Calm
Bottom	gy. S.	gy. S.	gy. S.	gy. S.	gy. S.	gy. S.	gy. S.	gy. S.	gy. S.	gy. S.	gy. S.	gy. S.	gy. S.	bk. S. M.
Depth, Start[3]	28	27	35	27	23	23	27	27	28	37	35	36	42	51
Depth, Stop[3]	27	27	34	27	24	23	30	27	27	37	36	36	43	51
Air Temp. °F.	46	43	41	41	41	44	50	53	47	47	47	48	52	49
Surface sea temp. °F. (°C.)	40 (4.4)	40.5 (4.7)	41 (5.0)	41 (5.0)	41 (5.0)	40.5 (4.7)	46 (7.8)	49 (9.4)	46 (7.8)	48 (8.9)	48 (8.9)	47 (8.3)	—	48 (8.9)
Bottom sea temp. °F. (°C.)	33.3 (.7)	34.9 (1.6)	32.9 (.5)	36.7 (2.6)	38.1 (3.4)	37.4 (3.0)	36.5 (2.5)	40.8 (4.9)	36.7 (2.6)	31.1 (-.5)	30.6 (-.8)	35.2 (1.8)	35.0 (1.7)	37.9 (3.3)
Catch, (individuals)														
Shellfish														
King Crabs, P.c. males	0	0	0	0	0	1	0	0	0	0	0	0	0	0
" " P.c. females	0	0	0	0	1	0	0	0	0	0	0	0	0	0
" " P.p. males	0	0	0	0	0	0	0	0	0	0	0	0	0	0
" " P.p. females	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tanner crabs, est.	50	20	50	40	24	500	500	10	0	6000	7000	100	12	100
Korean horse crabs	2	0	0	1	3	6	10	1	5	0	0	0	0	0
Shrimp	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Flatfish (% marketable)														
Halibut	0	2 (0%)	0	3 (65%)	1 (100%)	9 (30%)	15 (45%)	0	0	0	0	1 (0%)	1 (100%)	1 (0%)
Rock "Sole"	10 (100%)	5 (100%)	0	0	100 (40%)	200 (80%)	500 (70%)	20 (60%)	50 (50%)	0	6 (50%)	100 (80%)	550 (90%)	450 (80%)
Lemon "Sole"	60 (90%)	50 (50%)	30 (60%)	12 (60%)	10 (60%)	14 (60%)	200 (60%)	20 (60%)	25 (50%)	60 (75%)	60 (75%)	75 (100%)	80 (90%)	45 (100%)
Starry Flounder	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Flathead "Sole"	0	0	0	0	0	0	0	0	0	0	0	2 (100%)	250 (100%)	1200 (95%)
Yellowfin "Sole"	20 (40%)	100 (25%)	10 (50%)	100 (70%)	60 (90%)	300 (50%)	2000 (80%)	300 (60%)	250 (50%)	30 (75%)	90 (60%)	50 (40%)	400 (70%)	0
Arrow-toothed flounder	0	0	0	0	0	0	0	0	0	0	0	0	5 (0%)	250 (100%)
Est. Gross Wt. (lbs.)	150	100	50	200	300	600	4000	500	500	125	200	300	2000	5000
Other fish														
Pacific Cod (% marketable)	16 (100%)	120 (100%)	13 (100%)	90 (60%)	1 (100%)	41 (100%)	350 (100%)	45 (60%)	40 (20%)	5 (40%)	5 (0%)	70 (0%)	250 (80%)	200 (40%)
Northern tomcod	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Artic Cod	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Herring	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Pollock	0	0	0	2	1	0	6	23	5	5	0	4	200	250
Capelin	Some	Some	Few	0	few	0	0	few	0	0	0	0	0	0
Est. Gross Wt. (lbs.)	250	1500	150	700	15	600	4000	600	300	50	15	250	2000	3000
Trawling Bottom	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear

1/ Time is 160 Meridian.
2/ Figure in parentheses indicates Beaufort scale of wind.
3/ Sonic depth measurements.

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UTILIZATION OF FISHERY BY-PRODUCTS IN WASHINGTON AND OREGON*

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Contents

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