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Alaska Marine Environmental Assessment Project

FINFISH RESOURCE SURVEYS IN NORTON SOUND AND KOTZEBUE SOUND

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SUMMARY

These studies have included an evaluation of the subsistence use of Pacific herring and other fishery resources to coastal residents in Norton Sound and Kotzebue Sound. In addition, the spatial and temporal distribution of fishery resources in the nearshore coastal waters of Norton Sound was investigated. Pacific herring are used to a lesser degree for subsistence purposes by coastal residents in Kotzebue Sound than by those in Norton Sound. Extent of use is influenced by herring abundance, harvest of marine and large terrestrial mammals and employment opportunities such as commercial salmon fishing.

Important herring spawning areas consist of exposed rocky headlands shallow bays, lagoons or inlets. Spawning is associated with ice breakup of the Bering Sea, occurring in late May-early June in south Norton Sound, commencing progressively later in a northward direction; as late as August in parts of Kotzebue Sound. Herring populations north of the Yukon River are relatively small in comparison to those of the southern Bering Sea. Independent stocks of Pacific herring occur north of Norton Sound and spawn, overwinter and rear in shallow lagoons and embayments along the Seward Penninsula. A relatively small percentage of the coastline is used for spawning by herring stocks and the integrity of these areas must be maintained to insure continued use of this important resource. Contamination of important spawning, rearing and/or overwintering areas from petroleum related activities could destroy one or more year classes, resulting in either a general weakening and decline in populations or possible elimination of an entire population, depending upon the severity and extent of pollution.

More than 115,000 finfish representing 39 species and 15 families, were captured in nearshore coastal waters of the study area in 1976-77. Various cottids were included in this catch but were only identified to family (Cottidae). The 38 species identified were represented by 19 marine, 10 anadromous and 9 freshwater forms. Percent composition among these forms was similar in 1976 and 1977 in areas examined. At least 90% of the anadromous species, 75% freshwater species and 30% marine species are utilized for subsistence purposes by coastal residents. Approximately 60% of the anadromous species, 10% freshwater species and, at present, 5% marine species are harvested commercially by domestic fisheries. Pacific sand lance (Ammodytes hexapterus), juvenile pink (Oncorhynchus gorbuscha) and chum salmon (O. keta), saffron cod (Eleginus gracilis) and osmerids were among the most abundant species captured. Saffron cod, starry flounder (Platichthys stellatus), coregonids and osmerids were among the most frequently encountered fishes. Both frequency of occurrence and abundance varied spatially and temporally in all areas examined.

Some concerns related to petroleum exploration and development and the potential impact of oil spills on the fishery resources throughout the study area are discussed. A major concern is the absence of data on distribution, relative abundance, range, age structures, etc. of fishery resources during the ice covered months. A second concern is the lack of information available on fishery resources which utilize the Yukon River Delta. This is considered as possibly the single most important

ecosystem in our area and potentially the most vulnerable to disruption from either acute or chronic pollution problems. The deep water harbor of Port Clarence is also discussed as an area where further studies are needed to ensure proper planning and development of petroleum related activities in this area.

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INTRODUCTION

This completion report covers studies conducted under Research Unit (R.U.)19, formerly 19e, FINFISH RESOURCE SURVEYS IN NORTON SOUND AND KOTZEBUE SOUND. The study was supported by the Bureau of Land Management (BLM) through interagency agreement with the National Oceanic and Atmospheric Administration (NOAA), under which a multi-year program responding to needs of petroleum development of the Alaskan continental shelf is managed by the Outer Continental Shelf Environmental Assessment Program (OCSEAP) office. The period of field work includes March 1976 through November 1977.

Work was initially funded in March 1976 for $146,825 as an extension of R.U.19, HERRING SPAWNING SURVEYS IN THE SOUTHERN BERING SEA. Additional funding for fiscal year (FY) 1977 (October 1, 1976 through September 30, 1977) consisted of $250,825, of which $100,000 was designated for large vessel sampling of the offshore waters of Norton Sound and Kotzebue Sound. Final funding ($60,000) was made available for FY78 to allow completion of 1977 field sampling through freezeup and for preparation of this report. Total funding level for this project was $457,650.

Stimulus for these investigations is provided by proposed offshore leasing of Alaska's continental shelf for oil exploration and development, and the current lack of knowledge concerning the range, distribution, seasonal occurrence, relative abundance and life history characteristics of important fishery resources occurring throughout the study area. These data are necessary to provide information for predicting and mitigating impacts of potential petroleum related activities on coastal fishery resources within the study area. Specific objectives include the following:

1. Determine the spatial and temporal distribution, species composition and relative abundance of pelagic finfish in the coastal waters of Norton Sound east of 166° W. Longitude.

2. Determine the timing and routes of juvenile salmon migrations as well as examine age and growth, relative maturity and food habits of important species in Norton Sound east of 166° Longitude.

3. Determine the spatial and temporal distribution and relative abundance of spawning populations of herring and other forage fish within the study area.

4. Monitor egg density, distribution and development and document types of spawning substrates of herring and other forage fish species.

5. Monitor local resident subsistence utilization of the herring fishery resource.

To accomplish the task outlined above, the following studies were conducted:

- Subsistence fishery utilization survey of coastal residents. Surveys were primarily confined to FY76 with minimal effort in FY77.

- Spawning herring surveys. This consisted primarily of aerial surveillance of the coastline, apart from areas where nearshore finfish studies were being conducted. Aerial surveys were complemented by ground surveys at the latter locations.

- Pelagic finfish surveys. Both nearshore and offshore surveys were made. Nearshore sampling was confined to Norton Sound while attempts were made to sample offshore waters of both Norton Sound and Kotzebue Sound.

Pacific herring (*Clupea harengus pallasi*) are discussed at length in this report not only because a major portion of this R.U. was designed to investigate this species, but also because of the growing concern for this species in the eastern Bering Sea. Domestic interest in this species has risen dramatically in the past several months with implementation of the 200 mile fisheries and management conservation zone. Lack of biological knowledge of this species and apparent over-exploitation of eastern Bering Sea herring stocks by foreign fisheries has made it the focal point of much discussion.

Information gained on the relative abundance and seasonal distribution of pelagic fishery resources and their subsistence use throughout the study area is not complete, but nevertheless, is of considerable scientific value. Subsequent work will no doubt supplement and improve the existing data base and insure proper planning for oil and gas exploration and development, thus providing protection to valuable resources.

CURRENT STATE OF KNOWLEDGE

Knowledge of fishery resources in the northern Bering Sea and Kotzebue Sound is quite limited. Most available information is contained in records kept by the Alaska Department of Fish and Game (ADF&G). The bulk of this data deals with species of Pacific salmon indigenous to the study area, of which chum salmon (*Oncorhynchus keta*) are the most abundant. Most of this information concerns run timing and magnitude, age, size and sex relationships and spawning distribution of adult returns. Virtually nothing is known in regards to the relative abundance, distribution, migrational patterns and habits of juvenile salmon after entering the marine environment.

Other species common to the fresh water and coastal marine habitats in the study area are: sheefish (Inconnu, *Stenodus leucichthus*), several species of whitefish (Coregonidae), Arctic char (*Salvelinus alpinus*), lake trout (*Salvelinus namaycush*), grayling (*Thymallus arcticus*), burbot (*Lota lota luptura*), suckers (*Catostomidae*), sculpins (Cottidae), blackfish (*Dallia pectoralis*), sticklebacks (Gasterosteidae), lampreys (Petromyzontidae), smelt (*Osmeridae*) and several species of cod (Gadidae), flatfishes (Pleuronectidae), crabs, shrimp and molluscs (Cunningham 1975). Fifty-two fish species were captured and identified in August 1959 in the

Chukchi Sea/Kotzebue Sound area under bioenvironmental investigations of Project Chariot (Alverson & Wilimosky 1966). Most of the forms were benthic or demersal with the pelagic element limited to about eight species. Nine freshwater species were identified. Among the catches were an estimated 1,000 herring captured in a single gillnet set made at Cape Thompson. It was stated that small catches of juvenile smelt were often experienced in midwater sets below the thermocline.

Field sampling with variable mesh gillnets by Alt (1971) in the Port Clarence area in July 1970 resulted in 23 species of fish of which nine were marine. Herring were captured in Imuruk Basin and the lower Agiapuk Basin. Six nights of gillnet fishing in the Agiapuk River in 1971 resulted in nine species, of which least cisco (Coregonus sardinella) were the most abundant (Alt 1972). Herring were again included in the catch.

Alt (1971, 1972) also discussed spawning populations and domestic use of sheefish on the Koyuk River, Kobuk River and in the Selawik Lake - Hotham Inlet area. Herring, ranging in size from 115-160 mm in total length, were reported as comprising the major food item (the only identifiable species) in sheefish captured in Hotham Inlet in late November 1963 (ADF&G files).

Pacific herring and other fishery resources in the study area are known to be an important food fish for coastal residents, but the magnitude and importance of this harvest has not been fully documented. Zagoskin (1967) mentioned the importance of herring subsistence utilization by resident natives as early as the mid 1800's. The first actual biological studies on Bering Sea herring were conducted by Rounsefell (1930). Mention is made several times in his report of herring vertebrae counts taken at Unalaska and Golovin Bay (Norton Sound). Documentation of several life history parameters of herring are included in his report as well as the condition of the fishery in Alaska.

The herring fishery in the early portion of the 20th Century centered around salt curring and later declined because of poor marketing conditions arising from foreign competition. Rounsefell indicated that the earliest American commercial effort on Bering Sea herring took place in the early part of this century at Golovin Bay, "...since before 1909". Early records (Pacific Fisherman 1917-1942) indicate that about 6.1 million pounds of fall herring were commercially processed in Norton Sound from 1916 to 1941, of which 98.6% was from Golovin (Table 1). This figure is based upon 250 pounds of herring packed per barrel (Andersen 1945; Wigutoff 1950).

Rounsefell (1930) also pointed out that the first extensive commercial herring fishery existed in Western Alaska in 1928 when about one-half of the Central Alaska purse seine fleet fished in Unalaska in the Aleutian Islands. This fishery ended in 1946. Domestic commercial effort on herring in the north Bering Sea (Norton Sound) resumed on an experimental basis in 1964 near Unalakleet and has continued on a sporadic basis ever since (Table 2). This fishery is on spring herring for sac roe extraction in contrast to the earlier fall fisheries for a salt cured product.

Barton et al. (1977) points out that herring may be a commercially exploitable resource of potential benefit to coastal residents of western Alaska as well as a potential major international food source. Foreign fishing of eastern Bering Sea herring stocks began in 1961 after Soviet exploratory trawlers located large concentrations of wintering herring northwest of the Pribilof Islands. The Japanese entered the trawl fishery on the winter grounds in 1964 and also began a gillnet fishery east of 175° West longitude in 1968 (Low 1976, not seen by author; cited from Wespestad 1978). Japanese and Soviet fleets have harvested some 45,000 metric tons (m.t.) of herring annually in the eastern Bering Sea from 1970-1976 (North Pacific Fisheries Management Council 1977, NPFMC). The bulk of this harvest has come from two trawl fisheries which operate along and inside the 200 meter line between the Pribilof Islands and St. Matthew Island during the winter-spring months. The Japanese gillnet fishery has operated in the past in the nearshore waters from April to June, from Bristol Bay to Norton Sound, until 1977 when those coastal waters were closed by the Secretary of Commerce to protect native subsistence fisheries. Dudnik and Usol'tsev (1972) believed the trawl harvests were on stocks which reproduce along the coast from Unimak Pass to Norton Sound.

Combined harvest information for the winter trawl fishery by both Japanese and Soviet fleets is only available since 1967, although Japanese trawl and gillnet catches have been reported since 1964 (Table 3) (ADF&G 1977). Available catch data indicates that peak production occurred in 1968-69 when 128,000 m.t. were harvested by both the trawl and gillnet fisheries. Production has steadily declined since that time.

The Japanese began their gillnetting in 1968 in Norton Sound (north of 63° North latitude and east of 167° West longitude) with three vessels ranging from 46 to 61 meters in length (ADF&G 1968). Effort was concentrated about 20 km offshore in the area between St. Michael and Golovin for several days. Japanese gillnetting effort as well as peak catches occurred in 1969 (Table 4). A fleet of approximately 40 vessels operated in Norton Sound during the spring of 1969 (ADF&G 1969). The fleet was composed of approximately 10 longliner type vessels (37 to 55 meters) that arrived on May 19 and operated gillnets, processed and held their own catch. On the first of June two factory ships arrived accompanied by 24 to 27 gillnetters all in the 26 to 27 meter class. Three stern trawlers rounded out the Japanese fleet in 1969. The U.S. Coast Guard apprehended two Japanese gillnetters on June 7, 1969 which were fishing within the contingual zone in the vicinity of St. Michaels (ADF&G 1969). A total of 20 mt of herring was aboard the two apprehended vessels. Most herring examined consisted of spawned out males. The total reported 1969 Japenese gillnet herring catch in Norton Sound amounted to 1,270 metric tons. This was the largest herring catch by Japanese fleets in Norton Sound from 1968 through 1976.

The Republic of Korea (ROK) operated a small trawl fishery for herring between Kuskokwim Bay and Norton Sound in 1973 and 1974.

Herring are known to spawn in intertidal and shallow subtidal zones in the study area. Developing eggs and larvae are therefore highly susceptible to surface-born pollution. These fish and their spawn constitute one of the fundamental sources of food for many species of fish, mammals and birds.

Apart from present investigations, the most recent studies dealing with the distribution and relative abundance of fishery resources in the northern Bering Sea and southeastern Chukchi Sea was a six week survey conducted in 1976 by the National Marine Fishery Service (NMFS) under the auspice of OCSEAP/R.U.175. Results of the survey defined the distributions and centers of abundance of several finfish and shellfish species. In addition, standing stock estimates and species composition of demersal fauna were determined. Estimates of biological characteristics, including size and age composition, length and weight relationships, and growth characteristics were provided for dominant fish species.

These foregoing studies comprise the investigator's knowledge of fishery research in the north Bering Sea and Kotzebue Sound area, with the exception of cruise reports by various American and foreign agencies, which list simple occurrance.

STUDY AREA

The study area includes all coastal waters of western Alaska extending north from the Yukon River Delta to Point Hope (Figure 1). The coastline of this area totals 2,496 km (1,551 miles). Subsistence utilization surveys were conducted throughout the entire study area while spawning herring investigations included the coastal waters from the Yukon River to Eschscholtz Bay in Kotzebue Sound. The study area for nearshore finfish surveys consisted of the coastal waters from the Yukon River to Port Clarence, while offshore studies included both Norton Sound and Kotzebue Sound.

SOURCES, METHODS AND RATIONALE OF DATA COLLECTION

Several news releases via local radio stations (Nome) and newspapers were made prior to and throughout the course of the 1977 sampling season. These releases explained the purpose of the Outer Continental Shelf (OCS) program, informed listeners to 1977 field projects being conducted and solicited local information on fishery resources. Releases were made in March, June, July, August and September.

Subsistence Utilization Surveys

The only information obtained pertaining to subsistence use of fishery resources in 1977 was associated with aerial herring surveys conducted along the coast. Residents from five Seward Peninsula villages were questioned during the course of these surveys about herring and the status of fall runs and their importance to subsistence use. Several preserved specimens of different fish species were taken on flights for species verification by local residents to insure information was obtained for appropriate species.

Herring Aerial Surveys

The entire coastline of the study area was divided into census areas delineated by prominent geographical features prior to field investigations (Table 5). These divisions were made to facilitate transcribing aerial survey data onto a data management format with keypunching output to be later submitted to the National Oceanic Data Center (NODC) for archiving. At least two aerial reconnaissance surveys were to be attempted of the entire study area within the range of estimated spawning dates. Aerial surveillance of primary spawning areas was conducted as frequently as possible beginning with the onset of ice breakup in Norton Sound. The purpose of the surveys was a dated continuum on location, timing and relative abundance of spawning populations of herring and other schooling fish species.

Aerial surveys were conducted from chartered aircraft (single engine, fixed-wing) at altitudes ranging from 75-500 m and air speeds of about 160-260 km/hr. Portable tape recorders were used to record aerial survey data and information transcribed daily onto aerial survey data management forms. Polaroid sunglasses were worn to reduce sunglare and enhance water depth visability.

Following is a listing of data parameters recorded during each survey:

1. Observer, type aircraft, speed, altitude and time.

2. Weather and sea conditions.

3. Species identity and location of fish schools.

4. Number and surface area estimates of fish schools.

The relative abundance of fish was estimated by subjectively categorizing schools into one of three arbitrary groups: 1) small schools (estimated surface area of less than 50 m^2); 2) medium schools (surface area estimates between 50-450 m^2); and 3) large schools (estimated to be greater than 450 m^2). These same categorizations were employed under Research Unit 19 in the southern Bering Sea (Barton et al. 1977).

Every attempt was made to properly identify schools of fish observed from the air. This was done by OCS crews already present in an area sampling the nearshore waters with various types of fishing gear. Return flights to selected villages were also made and trips made by rubber raft along the coast to collect samples from fish observed in that area. Where fish could not be captured, Alcids and Larids were collected when possible for stomach analysis.

Photographs (color slides) utilizing a polarizing filter were made of fish schools and spawn (milt) when possible to assist in determining surface area estimates. Major emphasis on photography in 1977 was to obtain high altitude photographs during the peak of spawning in major areas as opposed to 1976 aerial photographs which were made of as many schools of fish and spawn as possible. All photographs were made with a handheld 35mm camera. The altitude, film and frame numbers were recorded on aerial survey forms for later identification. The location of the photographed target was recorded on United States Geogological Survey (USGS) topographical maps and a corresponding number entered by its location signifying the frame number of the photograph for later analysis.

Nearshore Finfish Surveys

Pelagic fish sampling of the nearshore waters (0-6 meters) was restricted to the Yukon River, Norton Sound and Port Clarence in 1977. Sampling was based from four field camps: Unalakleet, Golovin, Teller and the Anuk River (tributary to the Yukon River).

Unalakleet

A three man crew established a base camp in Unalakleet on May 27. The nearshore waters of eastern Norton Sound were sampled from May 30 through June 20 and from July 16 through August 10. The sampling area extended north from Unalakleet approximately 65 km to Cape Denbigh and south from Unalakleet for a distance of about 85 km to Cape Stebbins. A seven meter (22 foot) open skiff was used, equipped with fishing gear consisting of variable mesh gillnets, beach seines, dipnets and castnets. Both floating and sinking variable mesh gillnets were used. All gillnets were multifilament nylon and consisted of six 7.6 m panels with the following stretch mesh sizes: 25, 38, 51, 64, 76 and 102 mm. The nets were 46 m long by three meters deep. Sixty-one meter beach seines of 3.2 mm mesh were fished. Seines tapered from three meters in the center to one meter at either end. One beach seine haul and two gillnet sets were made at each sample station when possible. An onshore set was made with a floating gillnet and an offshore set was made with a sinking gillnet. Sampling stations held consistent with those established in the 1976 field season.

Records were kept of the time each gillnet was set and retrieved and depth and distance from shore for offshore sets. Other data recorded included weather conditions, surface water temperatures, escarpement and beach type. Depth was determined with a Ross depth sounder, while distances were estimated visually.

Sampling with dipnets and castnets was conducted randomly between established sampling stations, primarily for species composition of schools of fish observed in areas away from established sample locations.

Golovin

A base camp was established in Golovin on May 25 from which a two man crew conducted sampling operations. Sampling was conducted from June 9 through July 20 and from August 19 through October 21 from a five meter (17 foot) open skiff. The sampling area included coastal waters inside Golovin Bay and west from Rocky Point to Bluff. Sampling techniques and gear types were the same as those of the Unalakleet crew.

Port Clarence

A two man crew stationed at Teller was responsible for sampling Port

Clarence, Grantley Harbor and Imuruk Basin. Camp was established on June 25 and sampling conducted from breakup (June 27) until freezeup (October 12). Permanent sample stations were selected and fished after a reconnaissance of the study area. Sampling design and gear types were consistent with those of other Norton Sound crews.

Anuk River

A two man crew was relocated to Emmonak (south mouth of the Yukon River) on May 18 to prepare and assemble sampling gear for this field project. The crew departed Emmonak on June 4, shortly after ice breakup in the Yukon River and traveled upriver to the confluence of the Anuk River (101 km upriver from Flat Island). A field camp was established about one mile upstream on the Anuk River from which sampling operations were conducted (Figure 2).

Adult fall chum salmon stocks in the Yukon River have been found to separate on their upstream migration by river bank (Mauney, 1976). It was felt that a similar separation by river bank may also apply to smolting juvenile salmon in the spring months, since most of the major salmon spawning tributaries drain from the north side. Information concerning the timing, distribution and migration routes of juvenile salmon through the Yukon River Delta to the Bering Sea would be extremely valuable because of potential petroleum development in that area. Consequently, the two man crew stationed on the Anuk River sampled transects of the main Yukon River just below the confluence of the Anuk River. This section was chosen because of its restricted single channel as opposed to other sections of the lower Yukon River which are often extremely braided, very wide and characterized by sandbars.

The crew was equipped with a hand purse seine 46 m long by seven meter deep (3.2 mm bar mesh). The center section was eight meters in length and had two outer 11.5 m sections of 13 mm bar mesh. Eight seine stations were established across the Yukon River at the sampling site. A series of seine sets were made daily across the river channel at each sample station. Fishing stations were rotated daily beginning at first one side of the river and then the other. The primary objective was to observe smolt timing and distribution at the sample site as well as collect age and length data by species. Surface water temperatures and fluctuations in the Anuk River were recorded daily at 12 o'clock noon. Sampling occurred from June 7 through July 7, 1977.

Catch Sampling and Data Analysis

Catch sampling by nearshore pelagic finfish crews included the following:

1. Total catch monitoring by species, gear type and station for each set made.

2. Fork length measurements of not more than 120 fish of each species excluding herring, captured per set by gear type.

3. Standard length measurements of not more than 180 herring, relative maturity, sex and age for each set by gear type. The relative maturity index is shown in Table 6.

4. No length measurements or scales were taken from adult salmon.

5. Length and scale sampling from all juvenile salmon captured except that scales were not taken from pink (Oncorhynchus gorbuscha) and chum salmon. Scales were mounted on glass slides for later age analysis.

Catch sampling for the Anuk River project consisted of the following:

1. The total catch by species was recorded for each seine haul by station number and date.

2. A maximum of 40 juvenile king salmon (Oncorhynchus tshawytscha) was sampled daily for lengths and scales. A minimum of four fish per seine haul for any given day was always collected.

3. A maximum of 12 coho (Oncorhynchus kisutch) and chum salmon each was sampled daily for scales.

4. A maximum of 40 lengths per seine haul of juvenile salmon other than pinks and king were taken daily.

5. No lengths or scales were collected from adult salmon.

All herring were aged by counting annual rings on scales. Reid (1971a) pointed out that new annuli of herring scales appear near the time of spawning. He stated, "For convenience in age designation, April is used as the birth date for Alaska herring, although spawning ranges from early March to late June." The birth date for herring in our study area could be considered about May or June since spawning occurs on the average, significantly later than in more southern areas of Alaska and in Canada. Consequently, some adjustment to age designation in 1977 was made as herring were captured in both the spring spawning periods as well as just prior to freezeup in some areas.

Herring captured prior to August 1 were aged by counting all annuli plus the outside edge of the scale as shown in photographs 33 through 37. Herring captured after August 1 were also aged by counting annuli but the outside edge of the scale was not included, since it was assumed that some significant summer growth was present in the fall months. This is consistent with methods used in R.U. 175 (Wolotira et al. 1977). All herring scales were aged by not less than two (sometimes three) experienced ADF&G herring biologists.

This interpretation of the characteristics of herring scale growth closely follow results obtained by Rumyantsev and Darda (1970). They stated, "statistical processing...showed that in August 50% of the herrings (of the eastern Bering Sea) had no or very little growth increments on their scales; in September it was 14%, in October 17% of the fish."

Herring stomachs were collected along the west coast of Alaska in the spring of 1976 as part of RU 19 and RU 19e. Data analysis was carried out by Mr. Lee Neimark, Institute of Marine Science (IMS), University of Alaska, Fairbanks. Contents from stomachs that were collected on a single date and station were combined into a single sample. Each food item was identified and counted. Where several stomach contents were combined the contents were placed into a measured amount of water and a five mm random aliquot sample taken with a Stemple pipet. Each item in the five mm sample was counted and results corrected for the average item per stomach. The percent content of each food item identified was estimated by visual inspection of each stomach. The three areas where samples were collected were the Togiak area of Bristol Bay, Yukon-Kuskokwim River Delta area (Goodnews Bay, Nelson Island, Hooper Bay) and Norton Sound (Golovin Bay, Unalakleet, St. Michaels Bay).

Foreguts from 23 species of fish were collected along the eastern coast of Norton Sound from June 17 through September 1, 1976. These samples were also sent to the IMS where they were examined by Mr. Neimark. Methods of analysis can be found in Neimark et al. (1978).

Catches of larval fish were tentatively identified in the field by samplers and later submitted to the NMFS, Northwest and Alaska Fishery Center in Seattle for verification.

The study area was divided into several sections for ease in reporting pelagic fish survey results (Figure 3): Golovin Bay (Area A), Cape Denbigh to Egavik (Area B), Egavik to Tolstoi Point (Area C), Tolstoi Point to Cape Stebbins (Area D), Fish River (Area E), Bluff to Rocky Point (Area F), Grantley Harbor (Area G), Port Clarence (Area H), and Imuruk Basin (Area I). Although as many areas were not sampled in 1976, divisions are consistent for yearly comparisons between 1976 and 1977.

The field season was divided into nine 2-week sampling periods in which catch results were examined by species and gear type:

1. June 7 through June 21.
2. June 22 through July 6.
3. July 7 through July 21.
4. July 22 through August 6.
5. August 7 through August 21.
6. August 22 through September 6.
7. September 7 through September 21.
8. September 22 through October 6.
9. October 7 through October 21.

Herring data are often grouped as follows in comparing results:

Spring (breakup) - Sample Periods 1-3 (June 7 - July 21)

Summer - Sample Periods 4-6 (July 22 - September 6)

Fall (freezeup) - Sample Periods 7-9 (September 7 - October 21)

Offshore Finfish Surveys

A 33 m commercial vessel (M/V Royal Atlantic) was chartered in 1977 to fish preselected offshore gillnet and surface townet stations in Norton Sound and Kotzebue Sound (Figure 4). Each sample grid represents approximately 375 square kilometers. The study region exists as an area of proposed oil exploration where various resources used for commercial and subsistence fishing occur. Two cruises were planned with the first beginning in Norton Sound immediately after breakup followed by a sampling round of Kotzebue Sound and then a second round of Norton Sound. The Royal Atlantic departed Dutch Harbor for Norton Sound on June 19 and the charter terminated in Dutch Harbor on July 14. A two man crew assisted in all fishing operations during the charter period.

Gillnetting Studies - Large Vessel

A series of variable mesh multifilament gillnets secured end to end to form one long net were fished daily at preselected stations. Gillnets were allowed to soak overnight from 8 to 10 hours. A set was made each evening and retrieved the following morning.

Two sizes of variable mesh nets were used for this sampling design:

1. Thirty-eight by 5.5 m consisting of five 7.6 m panels of the following stretch mesh sizes (25, 38, 51, 64 and 76 mm).

2. Twenty-three by 5.5 m consisting of three 7.6 m panels of the following stretch mesh sizes (102, 114 and 133 mm).

At least nine of the smaller mesh paneled nets were secured end to end to form one long net (411 m). The larger mesh panel nets were not fished during the early part of the cruise to minimize adult salmon catches. Target species were juvenile salmon and herring. Gillnets were either secured in place overnight by anchors and buoys or else allowed to drift by tacking one end of the net to the vessel. They were retrieved with a hydraulic gillnet drum onboard the vessel.

Townetting Studies - Large Vessel

Surface townetting was conducted at preselected stations with a 3x3x9 m townet equipped with a rigid frame. The cod end of the net consisted of 1.6 mm mesh webbing. Each tow was 30 minutes in duration at a speed of two to three knots. All tows were conducted in hours of daylight.

Catch Sampling and Data Analysis

The total catch by species and panel size was recorded for each gillnet set. All species of salmon were measured (fork length for juveniles and mideye to fork of tail for adults) and scales collected for later age analysis. All herring were weighed, sexed, scale sampled, measured (standard length) and examined for relative maturity. The total weight of each species captured per set was also recorded. Tow samples were processed in the same manner as gillnet samples.

RESULTS

Subsistence Utilization Surveys

Surveys to determine subsistence utilization of fishery resources during the course of these OCS investigations were conducted only during the 1976 field season. Emphasis was directed toward obtaining information on herring utilization by village throughout the study area with other fishery resource use documented as possible. Results of the 1976 surveys can be found in Barton (1977). Information collected in 1977 is included in the discussion section of this paper since effort was primarily directed toward obtaining information on fall herring runs and winter distribution and use. No subsistence surveys, per se, were conducted in 1977. Information was solicited only in villages on the Seward Peninsula: Golovin, Teller, Shishmaref, Deering and Buckland.

Herring Aerial Surveys

A total of 25 individual aerial surveys were flown throughout the study area from June 9 through October 28, 1977 (Stuart Island/Cape Stebbins to Choris Peninsula/Eschscholtz Bay) (Figure 5). Aerial surveillance was initiated with the onset of ice breakup in Norton Sound and intensified during peak herring spawning activities along the coast. Surveys included 60 hours of airtime, 8,010 km (4,977 miles) of coverage and 24 survey days. Coverage of southern and eastern Norton Sound was intensified throughout mid-July, while intensive coverage of the Seward Peninsula occurred from mid-July on. A total of 480 fish schools were counted throughout the season with the following distribution of counts: 192 schools from Cape Stebbins to Cape Nome; 109 schools from Nome to Cape Prince of Wales; and 179 schools from Cape Prince of Wales to Pt. Garnet (Table 7). In addition, spawn (milt) was observed on possibly three occasions.

Most surveys were flown on an opportunistic basis, particularly after mid-July, due to inclement weather and/or water conditions. Survey conditions were exceptionally good from early June (after breakup) until the first weather front moved into the study area on July 23. Foul weather and extremely bad smoke conditions created from tundra fires hindered surveys for nearly a month until mid-August. From this time on, fall storms were frequent (strong winds especially) throughout the study area. Storms left coastal water extremely turbid causing poor to unacceptable survey ratings. As the season progressed into September, blowing snow and near whiteout conditions hindered and finally terminated aerial surveillance of the study area in October.

Cape Stebbins to Unalakleet

The only observation of schooled fish made along the coast from Cape

Stebbins to Unalakleet in 1977 was on June 22 when a single small school was observed about ten meters from shore near Black Point. Earlier surveys were conducted in this area on June 9, 15 and 17 but no schooled fish were observed.

Unalakleet to Cape Denbigh

Seven surveys were flown along the coastal waters from Unalakleet to Point Dexter (north side of Cape Denbigh) from June 9 through July 21. The first observations of herring were made on June 14 when 22 schools were seen around the Cape Denbigh Peninsula. Two small schools were located on the south side of the Cape while 18 small and two medium schools were observed from the Cape to Point Dexter. No spawning was observed. Herring were again observed the following day; six schools near Point Dexter, six schools immediately south of Cape Denbigh, 30 schools between Shaktoolik River and the village of Shaktoolik and three more small schools observed near Egavik.

Peak aerial counts along this section of the study area occurred on June 17. Fifty-four schools of herring were counted between Cape Denbigh and Point Dexter and three schools were located just south of the Cape. Schools were never observed farther than 300 meters from shore and all were dark green to blue in color and ball-shaped. No spawning (bands of fish or milt) was observed.

Three additional surveys were flown along this coastal section on June 22, June 25 and July 21. Three herring schools were observed near Cape Denbigh on both June 22 and June 25. None were observed on July 21, but spawn (milt) was seen about 24 km south of the village of Shaktoolik.

Distribution of schools and peak aerial survey counts along this section of the study area coincided with peak commercial herring catches in this area in 1977.

Norton Bay (East of Cape Darby)

The only aerial observations of herring in Norton Bay in 1977 were made from Elim to Bald Head. Five surveys near Bald Head revealed the presence of herring on three occasions. Six schools were observed on June 15, two on June 17 and six on June 25. No herring were observed in this area on June 14 or July 21. Schools were observed up to 800 m from shore. No spawn was seen on any of the surveys.

Four medium herring schools were observed on June 25, about 50 m off the mouth of Iron Creek. One medium and three small schools were also observed about 800 m offshore near Moses Pt.

Golovin Bay (Cape Darby to Rocky Point)

Five surveys of Golovin Bay were flown from June 14 through July 21. Only 14 schools of herring were observed: three small schools on June 14 and four small and seven medium schools on June 25. Most of these schools were observed in the vicinity of Carolyn Island. However, two of the medium schools observed on June 25 were located near Cape Darby. Thus, all schools were observed on the eastern side of Golovin Bay; between Golovin and Cape Darby. All schools were within 500 m of shore. No spawn was observed.

Rocky Point to Nome

No spawning was observed in 1977 from Rocky Point to Nome. Only 18 schools of fish were seen: five small schools near Topkok on June 14 and 11 small and two medium schools scattered between Bluff and Rocky Point on June 17. These schools were oval to round in shape and within 20 m of shore. Identity of the schools was not known but could very possibly have been capelin (*Mallotus villosus*), herring or sand lance (*Ammodytes hexapterus*). A later survey of this area on August 29 revealed several small schools of fish immediately onshore. An actual count was not possible due to water conditions and the survey was thus rated unacceptable. These fish were recorded as sand lance since ground crews sampled the same area with beach seines on August 28. An estimated 45,000 sand lance were captured in a single set. Numerous other schools of sand lance were reported by the ground crew in the sampling area on that date. No herring or capelin were captured.

Aerial surveillance from Rocky Point to Nome was also conducted on July 10, July 21 and September 21 but no schools of fish or spawn was observed.

Nome to Cape Prince of Wales

A total of ten surveys were flown along the coastal waters from Nome to Cape Prince of Wales during the period June 21 through October 16. Most effort was from Nome to the Port Clarence/Grantley Harbor complex. Fish were first encountered on June 28 when five small unidentified schools were observed near the mouth of Cripple Creek about eight kilometers west of Nome. Four medium and two small schools were observed on July 10, between Cape Wooley and Cape Rodney. These six schools (unidentified) were moving toward Port Clarence between 75-100 m from shore. The following day (July 11) 23 more schools were observed from the Sinuk River to Cape Rodney. This survey was terminated at Cape Rodney due to cloud cover and wind. Thus, no survey could be made in the Port Clarence/Grantley Harbor complex but the surveyor indicated more fish were probably present.

Seventy-two unidentified fish schools (believed to be herring) were counted from Cripple Creek to Grantley Harbor on July 21. This was the peak count for this area in 1977. Forty-six of these schools were located from Cripple Creek to Point Spencer, the majority of which were within 10-75 m of the shoreline. All appeared moving northward toward Port Clarence. Three schools were inside the Port Clarence Spit within 50 m of shore. Seven schools were located inside Grantley Harbor immediately in front of Teller; five more in the upper end of Grantley Harbor at the Tuksuk Channel mouth and eleven schools ranging from small to medium were observed within 10 m of shore from Brevig Mission to Grantley Harbor entrance.

No fish carcasses (capelin) or spawn (herring milt) was observed on any of the surveys flown from Nome to Cape Prince of Wales. Inclement weather limited the number of acceptable surveys flown in the area after the July 21 survey. Five more surveys were flown and only two more schools of fish were observed about 200 m from the mouth of the Sinuk River on August 23. Imuruk Basin surveys were all rated unacceptable in 1977 due to extremely thick phytoplankton present which obscured water visibility. It is doubtful whether or not spawn (milt) could have been seen even if it were present in Imuruk Basin. Alt (1971) also found an extremely heavy phytoplankton bloom in Imuruk Basin in July 1970.

A single small unidentified school was observed near the mouth of Lost River in 1977 along the coastline from Brevig to Cape Prince of Wales. The direction of migration could not be determined. This school was seen on July 11. Two other surveys were flown along this section of coastline on August 13 and September 9, but no fish were observed.

Cape Prince of Wales to Cape Espenberg

Nine survey attempts were made along the coastal section from Cape Prince of Wales to Cape Espenberg from July 11 through October 28. At least five of these surveys were rated as unacceptable, particularly in the fall (August through October) when smoke and inclement weather became a problem on the Seward Peninsula.

Peak counts of fish schools occurred on the first survey of July 11. Fourteen schools (11 small; three medium) were counted in the coastal waters in front of Ipek Lagoon. These schools were all 50-75 m from shore and moving toward Shishmaref. A total of 77 schools (20 small; 30 medium; 27 large) were located from Arctic Lagoon along the coast, northward, to Kividlo. About 10 of the large schools were observed in entrance channels of Shishmaref Inlet on either side of the village of Shishmaref and also at Kividlo (entrance into Cowpack Inlet). Five of the medium and one large school were observed inside Shishmaref Inlet about 20 km northeast of Shishmaref. No survey was flown on that day of Shishmaref Inlet due to its size and aircraft fuel supply.

A return survey on July 15 from Arctic Lagoon to about 30 km north of Shishmaref revealed 22 schools (10 small; eight medium; four large) present along the coastline. With the exception of two small schools seen near Shishmaref, the remainder were observed further north in the last 15-20 km surveyed.

The majority of schools observed along the coast on both July 11 and July 15 were circular to oval in shape and located at the edge of a littoral shelf. They appeared to be moving in a northerly direction 50-200 m from shore until they reached the "proper" lagoon channel. No spawn was observed and the fish were apparently heading for the inlets and lagoons present along this area of the Seward Peninsula. No schools were observed between Kividlo and Cape Espenberg apart from the large concentration of fish present in the channel mouth to Cowpack Inlet at Kividlo. Most schools were dark green to bluish in color. Survey conditions (weather and water) were excellent. Where schools were observed in more shallow water (on the littoral shelf), they took on more irregular shapes and appeared lighter in color (brownish). These two phenomenon were apparently due to fish being more dispersed and consequently less dense in shallow water.

Coastal marine waters were sampled from Shishmaref to Kividlo from July 15 through July 17 with a rubber raft using a floating variable mesh gillnet and snag line (Figure 6). The gillnet was the same as used by ground crews sampling Norton Sound coastal waters. Total gillnet soak time for the entire three days was only 15 hours due to Chukchi Sea ice conditions. No overnight soaks were possible due to large chunks of pan ice carried by longshore currents and wind. Nets had to be constantly watched, frequently pulled and reset to avoid moving icebergs even when fished in daylight (Photographs 28 and 29). Water clarity was excellent but no fish schools could be located by boat nor by climing shoreline bluffs for better observations.

A total of eight gillnet sets were made: one onshore, six offshore near the littoral shelf (100-200 m) and one in a lagoon channel mouth. In the single onshore, two and one-half hour set at Glass Ball Bluffs on July 15, two Arctic char, 44 Arctic flounder(<u>Liopsetta glacialis</u>) and four Bering cisco(<u>Coregonus lauretta</u>) were captured. Offshore sets amounted to nine and one-half hours and were made July 16 and 17 from Skull Flats to Cape Coke. Results were 17 Pacific herring and one starry flounder(<u>Platichthys stellatus</u>). The three hour set on July 17 in a lagoon channel near Rebel's Rest resulted in two Bering cisco.

The only finfish taken in all offshore sets, with the exception of one starry flounder, were Pacific herring. Only 17 were captured with most taken in the lower one-half meter of the gillnet. The net was not always fishing on the bottom since it was set near the edge of the littoral zone (where most schools were observed from the air). Consequently, it is possible that passing fish may have been deeper than the depth of the net. Of the 17 herring captured, three were taken at Reindeer Butte and 14 about five kilometers below Kividlo.

Sixteen of the 17 herring captured were sampled for age, length and sexual maturity:

11 male	Standard length range 174-190 mm. Mean standard length 183.2 mm (S.D. = 4.6 mm). Sexual maturity index II for all samples. Ten ageable samples all aged V.
5 female	Standard length range 180-191 mm. Mean standard length 187.2 mm (S.D. = 4.3 mm). Sexual maturity index II for all samples. Five ageable samples aged V.

The only success with the snag line produced two egg-bearing shrimp (sp. ukn) near Glass Ball Bluffs on July 15. One glaucous gull (<u>Larus</u>

hyperboreus) was obtained for stomach analysis about five kilometers southwest of Cape Coke. Contents consisted of three isopods (Mesidotea entomon) and one large shrimp (sp. ukn).

As a result of the three day test fishing trip, fish schools observed on July 11 and 15 along this section of coastline were recorded as herring.

Nine small and three medium schools of fish (believed to be herring) were observed on August 6 from Ipek Lagoon to Shishmaref. The survey was aborted due to low ceilings from smoke but the surveyor believed more schools were present. Eight more schools (six small, two medium) were again observed under similar survey conditions (poor) in the same vicinity on August 20. Four other attempts were made to survey this coastal area, but all survey ratings were unacceptable and no schools were seen.

Cape Espenberg to Choris Peninsula (Eschscholtz Bay)

At least four attempts were made to survey parts of Eschscholtz Bay from July 11 through August 20. The best survey was made on July 20 when fair to excellent survey conditions prevailed. Nineteen schools (nine small; eight medium; two large) were observed within 150 meters of shore from Rex Point to the Inmachuk River. No spawn was seen but fish were believed to be herring based upon timing information gleaned from local residents at Deering. Four more schools were observed on the east side of the Choris Peninsula.

A survey was flown on August 13 in which three schools were observed near Deering in addition to one sighting of possible spawn (milt). The survey was rated as unacceptable due to smoke and weather conditions. A survey of the area on August 20 resulted in the sighting of 17 small and one medium school along the coast from Rex Point to Kugruk Lagoon. Most of these schools were located just east of Nine Mile Point. Light spawning was observed in the immediate vicinity of Cape Deceit.

Nearshore Finfish Surveys

A total of 32,458 finfish were captured in 1976 from the Yukon River Delta to Golovin Bay during the period June 9 through September 21. In 1977, 83,292 finfish were captured in the coastal waters of Norton Sound from St. Michaels to Port Clarence during the ice free period of May 30 through October 21. Combined catches for both seasons amounted to 115,750 finfish representing 38 species and 15 families (Table 8). Various cottids were also captured but were only identified to family (Cottidae) after approval from the OCSEAP project office. The 38 species identified were represented by 19 marine, 10 anadromous and nine freshwater forms (50.0, 26.3 and 23.7 percent, respectively). Species diversity by area and gear is shown in Tables 9 and 10.

The percent of marine, anadromous and freshwater species occuring in coastal marine waters in 1976 and 1977 were quite consistent from area to area (Figure 7 and Table 11). Marine species ranged from about 50-53 percent, anadromous species about 32-35 percent, and freshwater species about 11-15 percent in all marine waters sampled. Figure 7 also shows the increase in percent occurrence of anadromous and freshwater species in brackish water and the decrease of marine forms.

Pacific Herring

A total of 2,352 herring were captured in 1977 throughout the study area from May 30 through October 21: 2,065 adults (88%) and 287 juveniles (12%). Juveniles were sexually immature, virgin fish (ages 0,I,II) and quite often could not be sexed. Twenty percent of the herring were captured in beach seines, 51 percent in floating gillnets and 29 percent in sinking gillnets.

A total of 306 herring were captured in Golovin Bay (Area A) of which 20 percent were juveniles (Table 12). Largest catches occurred in the Port Clarence area (Areas G,H,I): 1,750 adults (89%) and 215 juveniles (11%). Only 71 adult and 10 juvenile herring were captured in the remaining nearshore waters of the study area (Areas B,C,D, F). However, fishing effort in 1977 was limited in areas apart from Port Clarence and Golovin Bay. Only the Port Clarence and Golovin Bay areas were sampled from ice breakup to freezeup; the remaining coastal areas were only sampled periodically through mid summer.

Port Clarence - Grantley Harbor - Imuruk Basin: Beach seines captured 95% of all juvenile herring taken in the Port Clarence area but only 11% of the total adult herring catch. Floating gillnets were the most effective in catching adult herring (57%) followed by sinking gillnets which resulted in 32% of the adult herring catches (Tables 13 and 14). Of the juveniles captured, 59% were taken in Imuruk Basin with 23% and 18% taken in Grantley Harbor and Port Clarence, respectively. A total of 58% of the adult herring catches were in Grantley Harbor, with 36% in Port Clarence and only six percent in Imuruk Basin. Fishing effort however was lowest in Imuruk Basin.

No significant selection to sex by any of the gear types was found. The male to female ratios by gear types was 1:1.2, 1:0.8 and 1:1.1 for beach seines, floating gillnets and sinking gillnets, respectively. The overall sex ratio was 1:0.95 (Table 15).

Relative maturity of herring captured in the Port Clarence area was monitored by age class and date (Tables 16 through 18). Sexual maturity began mainly in the third year, also in the fourth and rarely in the fifth year. Relative maturity by sex for the entire season was also examined (Figure 8). Results show 75.8% of all males examined in 1977 from the Port Clarence area spawned and 71.9% of all females examined spawned. Therefore, it can be assumed that the ratio of male to female spawners approached one to one. Results on relative maturity also showed that adult herring captured in the spring were spawners while those in the fall were non-spawners (Figures 9 and 10). Most herring captured during the spring and summer were post spawning fish (Figure 11) indicating at least some spawning occurred prior to the start of sampling. Juvenile herring were not captured in significant numbers until mid-August although they were captured in the spring during ice breakup.

A total of 1,068 herring were sexed and measured (standard length) throughout the sampling season. The overall mean length for males and females combined was 185.5 mm, having a standard deviation of 24.4 mm (Figure 12). Mean length at age was calculated on 834 herring (Figures 13 and 14; Table 45).

In addition to the 834 herring which were compared for mean length and age, 78 more juveniles were captured during the season but no scales were available for age analysis. Nineteen juveniles were captured on June 29 in Grantley Harbor. The mean standard length for these herring was 88.0 mm with a standard deviation of 9.96 mm. It is not known whether these herring were Age 0 or Age I. Fifty-seven juvenile herring were captured at several stations throughout the Port Clarence area from August 22-30. Their mean length was 40.9 mm (standard deviation equals 13.1 mm). It is safe to assume that these 57 fish were young of the year (Age class 0) since the Age 0 herring in Table 45 have a mean length of 90.5 mm and they were all captured from September 29 through October 8 (approximately 30 to 35 days later). This represents a daily growth rate of about 1.4 to 1.7 mm or 3.5-4.0% in this area for Age Class 0 herring. Two other juveniles were captured in Imuruk Basin; one on July 10 (length 89 mm) and the other October 4 (length 99 mm).

One hundred and three herring ranging from 0-14 years of age were sampled in October for fork and standard length comparisons by sex. Results were plotted and linear regressions calculated for each sex (Figure 15):

Sex	n	Slope (a)	Intercept (b)	r	r^2
male	37	1.08158	2.14568	0.99507	0.99016
female	56	1.08548	0.91009	0.99576	0.99153
juvenile	10	1.08121	2.35171	0.99703	0.99407
combined	103	1.07922	2.33062	0.99839	0.99678

A change in age composition occurred from spring (breakup) to fall (freezeup) in the Port Clarence area in 1977 (Figures 16 through 19). Both juvenile and adult herring were present in the spring with the oldest ageable herring being 15 years. Spring spawning herring were dominated by Age Class V (75.6%). As the season progressed into the summer and fall, Age Class V herring were still abundant but Age Class III herring dominated the percent age composition. Age Class V was again dominant by freezeup followed closely by Age Class III. The highest percentage of ageable juvenile herring were Age Class 0 followed by Age Class I and Age Class II. Herring as old as 14 years were present throughout the entire sampling season. Fifty-six percent of the herring captured in Imuruk Basin were juveniles (Age Class 0,I,II), while only six and five percent of herring captured in Port Clarence and Grantley Harbor, respectively, were juveniles. These figures include both aged and non-aged juveniles.

Golovin Bay: Beach seines captured 100% of the catch of juveniles and less than one percent of the catch of adult herring in Golovin Bay in 1977. With the exception of two Age II herring captured in early July identified as spawners, all juveniles (sexually immature fish) were taken in early September at a single station in Golovin Bay. This location was at Carolyn Island on the east side of Golovin Bay. Floating gillnets captured 79% of all adult herring; sinking gillnets caught 21% (beach seines caught only one adult herring). There was no apparent selection by sex of different gear types and the overall male to female ratio was 1.00:0.61 (Table 19).

Relative maturity of herring captured in Golovin Bay was monitored by age class and date. Sample size of juvenile herring was too small to determine when sexual maturity begins but some evidence suggested it occurs in the third and fourth year. Results on relative maturity show that herring captured in the spring were spawners while those in the fall were non-spawners (Figure 20).

A total of 228 herring were sexed and measured (standard length) throughout the sampling season. The overall mean length for males and females combined was 212.8 mm with a standard deviation of 28.3 mm (Figure 21). Mean length at age was calculated on 229 herring (Figures 22 and 23; Table 45).

One hundred fourteen herring ranging from 1-9 years of age were sampled in October for fork and standard length comparisons by sex. Results were plotted and linear regressions calculated for each sex (Figure 24):

Sex	n	Slope (a)	Intercept (b)	r	r^2
male	69	1.04224	6.21020	0.99546	0.99094
female	45	1.02564	9.89105	0.99580	0.99162
combined	114	1.03596	7.59044	0.99561	0.99124

There was little change in the percent age composition of spring spawning herring and non-spawning fall herring. Herring of Age Class III were dominant followed by Age Class V (Figure 25). Herring of older ages were present in both the spring (up to Age Class X) and fall (up to Age Class IX) samples.

Stomach Analysis: Most of the 146 herring stomachs examined (75%) from the spring of 1976 at IMS were either empty or contained only traces of food items. Only 25% of those stomachs examined were at least 25% or more full of which only 3.4% were 100% full (Table 20). The frequency of occurrence and percent number of food items found per stomach are shown in Table 21 and Figure 26.

Juvenile Salmon

In 1977 good sampling coverage was made in the Golovin Bay area (Area A) with limited coverage along the southern and eastern coastline of Norton Sound (Areas B,C,D). However all four areas, unlike 1976, received coverage during a two week period immediately following ice breakup. The best coverage in 1977 was in Area A.

A total of 4,584 and 1,717 juvenile pink and chum salmon, respectively, were captured in beach seines in Golovin Bay from June 9 (ice breakup) until July 9. Catches of both species peaked from June 20 through June 26. The last juvenile pink salmon was captured in Golovin Lagoon on July 7 while the last juvenile chum salmon in the nearshore waters of Area A was captured in outer Golovin Bay on July 9.

Fork lengths of 329 and 360 juvenile pink and chum salmon, respectively, indicated that juvenile chum salmon average about 4.2 mm larger than juvenile pink salmon (Table 22 and Figure 27). Overall mean fork lengths were 38 mm and 42 mm for pink and chum salmon, respectively. Juvenile pink salmon increased from about 32 mm in the second week of June to about 54 mm by the first week in July (Table 23). This increase in growth (22 mm) over 28 days indicates a daily growth rate of 0.79 mm. Juvenile chum salmon for the same period increased from about 35 mm to about 59 mm, resulting in a daily growth rate of about 0.86 mm. Growth curves are shown for each species in Figures 28 and 29.

The only other area where juvenile salmon were captured in any numbers was between Bluff and Rocky Point (Area F). A total of 75 juvenile pink salmon and 14 juvenile chum salmon were captured during Period 1 on June 27 and 28. The mean fork lengths of the juvenile pink salmon were 44.5 mm and 52.0 mm on June 27 and 28, respectively. No measurements were taken on the chum salmon. Ninety additional juvenile pink salmon were captured in this area during Period 2 but no lengths were taken.

Only 11 juvenile chum salmon and no juvenile pink salmon were captured throughout the remainder of the study area in 1977. Seven of the chum salmon were caught in Area C, one in Grantley Harbor and one in Imuruk Basin. The only other juvenile salmon captured in 1977 consisted of 12 cohos taken in Golovin Bay during Periods 1-3.

Larval Fish Catches

A total of 5,402 larval fish were captured incidentally in beach seines throughout the nearshore waters of the study area in 1977. Three families were represented: 1) Osmeridae, 2) Gadidae and 3) Cottidae (Table 24). Two species of Osmerids were identified: boreal smelt and pond smelt. These catches were not included when calculating catch per unit efforts since they were considered too small to be effectively captured by sampling gear. However, Osmerids were by far the most abundant and frequently encountered larval fish. Larval boreal smelt were encountered in all areas while larval pond smelt were only encountered in Imuruk Basin (Area I).

Other Finfish Catches

Combined gillnet and beach seine effort in coastal marine waters from St. Michaels to Port Clarence resulted in a total finfish catch of 83,123 from May 30 through October 21,1977 (Table 25). Included in this catch were 5,402 larval fish taken with beach seines. An additional 169 finfish were captured in beach seines in the lower part of Fish River and the Unalakleet River lagoon. Excluding these latter areas (E and URL), 155 beach seine sets were made in marine waters. Only two sets did not produce catches. These two sets were in the Port Clarence/Grantley Harbor area. The remaining 153 sets resulted in 73,326 finfish (excluding larval fish catches).

The highest beach seine CPUE (6,302) occurred in the area from Rocky Point to Bluff (Area F) (Figure 30), reflecting the high abundance of sand lance along this section of Norton Sound. The lowest beach seine CPUE's were in southern Norton Sound from Egavik to Cape Stebbins, being less than 40 fish per set. Beach seine CPUE's from Egavik to Cape Denbigh, in Golovin Bay and in the Port Clarence/Grantley Harbor area ranged from 131-239 fish per set. Higher catches were experienced in Imuruk Basin; 444 fish per set.

Excluding the Unalakleet River lagoon and Fish River sampling effort, 509.4 gillnet hours were fished in 1977. Thirty-eight percent (193.6 hours) of this effort was made with sinking gillnets (offshore sets) while 62% (315.8 hours) was with floating gillnets (onshore sets) (Table 25). The average duration of offshore and onshore sets was 1.3 and 1.4 hours, respectively. Negative catches occurred in 26.1% (50.6 hours) of the offshore sets while only 9.8% (30.8 hours) of the onshore sets resulted in no catch.

Offshore sinking sets throughout the study area always caught the fewest species and numbers of fish in both 1976 (Barton 1977) and 1977. Onshore floating sets were more closely, if not equal to beach seines in the number of species captured. The average water depths for sample areas where offshore sets were made with sinking gillnets were:

South and eastern Norton Sound (Areas B,C,D)	4.4 m
Golovin Bay to Bluff (Areas A,F)	5.7 m
Port Clarence area (Area H)	3.6 m
Grantley Harbor area (Area G)	3.4 m
Imuruk Basin area (Area I)	3.1 m
Mean depth for entire study area	4.4 m

It is difficult to say in which area certain species or fish were most abundant in 1977 since all areas did not receive equal coverage during each two week sampling period. Species abundance varies by area with time as shown by CPUE values (Table 26). Among the most abundant species captured in 1977 were sand lance, pond smelt (*Hypomesus olidus*), juvenile pink and chum salmon, saffron cod (*Eligenus gracilis*), starry flounder and Pacific herring.

The three most frequently encountered species in 1977 captured in beach seines for the entire season and all areas combined were starry flounder (43%), saffron cod (41%) and pond smelt (37%). The three most frequently occurring in gillnets were saffron cod (33%), starry flounder (30%) and Pacific herring adults (27%). Percent frequency of occurrence for gear types combined was saffron cod (36%), starry flounder (34%), Pacific herring (19%) and pond smelt (11%). Again, the percent frequency of occurrence among species also changed with time and by area just as species abundance (Table 27).

Southern and Eastern Norton Sound: A total of 25 stations were fished from Cape Stebbins to Cape Denbigh (areas B, C, D) in 1977 (Figure 3). Only eleven of the 25 stations could be beach seined in addition to fishing gillnets. Consequently, beach seine effort was minimal along this area of Norton Sound.

The first sampling round was conducted during the first two weeks following ice breakup from May 30 through June 20 (Period 1), with a second round of sampling conducted from July 16 through August 10 (Periods 4 and 5). A total of 17 seine sets and 99.9 gillnet hours were fished during these periods. The CPUE was 91.4 fish. Beach seines and floating gillnets captured 19 different species of fish while sinking sets only captured eight species. Sand lance was the only species captured in 1977 which was not found in these areas in 1976. All were captured in Period 4 in two seine sets; 600 at Wagonbox Creek near Golsovia and 135 at the mouth of Junction Creek between Egavik and Beeson Slough.

Four juvenile herring (3 years of age) were among the nine fish caught in sinking gillnets in area B during the entire sampling season. They were captured in Period 4 on the south side of Cape Denbigh. Six more juvenile herring were also captured in Period 4 with beach seines and were taken near the mouth of Wagonbox Creek in area D.

The only juvenile salmon captured were caught during Period I in area B. Twelve pink and seven chum salmon juveniles were all captured on the north side of Tolstoi Point. No other juvenile salmon were captured in any of these three areas in 1977.

The most abundant species captured with beach seines in area C was saffron cod while sand lance were the most abundant in seine catches in areas B and D. Arctic char, starry flounder and Pacific herring adults were among the most abundant species taken with gillnets in all areas. Ciscos were also abundant. Least cisco, boreal smelt (*Osmerus eperlanus*) and starry flounder were among the most frequently encountered species in these three areas.

Golovin Bay: Sampling in Golovin Bay from Cape Darby to Rocky Point (area A) began June 9 (breakup) and was conducted through July 20 (Periods 1-3) (Figure 3). Further sampling was conducted from August 19 through October 21 (Periods 6-9). A total of 14,928 fish were captured in 68 beach seine sets. Forty-four sinking gillnet sets captured 230 fish during 69.9 hours of fishing time. Floating gillnets fished for 182.7 hours resulting in 879 fish. The CPUE for sinking and floating gillnets was 3.3 and 4.8, respectively, for the entire sampling season. The beach seine CPUE was 219.5 fish. Fourteen species were represented in the sinking gillnet catches, 17 in floating gillnet and 22 in beach seine catches.

Abundance of fish, based upon CPUE indices, varied by species with time (Table 28). For example, juvenile salmon were only present in significant numbers during Periods 1 and 2 and were not found anytime after Period 3. Sand lance were present in large numbers beginning in Period 3 and remained significantly abundant through Period 7; very few were captured in the early spring or fall in Golovin Bay. Gillnet catches of herring were only made during Periods 1, 7 and 8 in 1977, although beach seines caught herring in all periods fished.

The most abundant species captured with beach seines in Golovin Bay in 1977 were sand lance and pink and chum salmon juveniles. Pacific herring, saffron cod and starry flounder were the three most abundant species captured in gillnets in 1977. Among the most frequently encountered species taken in gillnets were saffron cod, Pacific herring, starry flounder and humpback whitefish. Saffron cod, starry flounder and ninespine stickleback were the three most frequently encountered species in beach seine.

Port Clarence Area: Selected stations were periodically fished in the Port Clarence area (areas G, H, I) from June 27 through October 12, 1977 (Figure 3). Gillnets were fished 137.3 hours of which 48%, 38% and 14% of the effort was in Port Clarence, Grantley Harbor and Imuruk Basin, respectively. The highest gillnet CPUE occurred in Grantley Harbor and the lowest in Imuruk Basin. Adult Pacific herring were the most abundant species captured with this gear type in both Grantley Harbor and Imuruk Basin and the third most abundant in Port Clarence. This species was also the most frequently encountered with gillnets in all three areas. Other abundant species captured with gillnets in these areas were saffron cod, Bering cisco, starry flounder and boreal smelt.

The highest beach seine CPUE occurred in Imuruk Basin followed by Grantley Harbor and Port Clarence, respectively. Pond smelt, sand lance and saffron cod were the three most abundant species captured with beach seines in Grantley Harbor and Port Clarence, while pond smelt, ninespine stickleback (*Pungitius pungitius*), least cisco and juvenile Pacific herring were the most abundant as well as frequently occurring species in Imuruk Basin. Saffron cod, pond smelt, sand lance, juvenile Pacific herring and least cisco were the most frequently occurring species in Grantley Harbor and Port Clarence. Abundance and frequency of occurrence of species varied from area to area with time.

Length Frequencies: A total of 12,000 length measurements were obtained from species other than herring. An examination of the ranges and means sampled by gear type (Tables 29 through 32 and Figures 31 through 41) shows that larger and/or older fish were sampled with gillnets, whereas beach seines were more selective for smaller and/or younger fish. Except in the southern and eastern portion of Norton Sound (Areas B, C, D) beach seines always captured more species than gillnets (Figure 42). They also captured larger numbers of fish (in all areas) than gillnets.

This is probably due to the affinity of small and young fish to school in large numbers.

Physical and Chemical Data

Surface water temperatures revealed the southern coastal section of Norton Sound to be much cooler than in other areas examined during the first two weeks following ice breakup in early June (Table 33). This was the last area in eastern Norton Sound to become ice free (Photographs 1 through 3). Water temperatures in the Golovin Bay and Port Clarence areas were much warmer for the same period of time, probably owing to the influx of relatively warm river water in these areas.

Surface salinities were monitored along eastern Norton Sound coastal areas in 1976. The lowest salinities occurred in June and progressively increased into the fall (Table 34). This is probably a function of melting pack ice and freshwater runoff throughout the season from many of the river systems in Norton Sound as well as Yukon River discharge.

Stomach Analysis

A detailed discussion of results on the stomach analysis of 23 species of finfish collected from eastern Norton Sound in 1976 can be found in Neimark et al. (1978). Opossum shrimps (*Neomysis spp*) were found to be the most important food source. This genera was the most frequently occurring prey and occupied the largest percentage by volume of stomach contents. Unidentified eggs and the copepods, *Acartis clausi* and *Eurytemora* spp. were the most abundant food item in stomach contents.

It was found that most predators appeared to be opportunistic feeders, although boreal smelt and saffron cod, the most frequently captured fish species, were generalists, i.e., they consumed all food groups. Eighty-five different taxa of prey were identified. Larval boreal smelt were among the most important prey consumed. This taxon occurred in 30% of the 23 fish species examined.

Offshore Finfish Surveys

The *Royal Atlantic* fished preselected townet and gillnet stations in the offshore waters of Norton Sound from June 22 through July 12. An attempt was made to enter the Chukchi Sea on July 8 to begin sampling in Kotzebue Sound. However, severe pack ice conditions necessitated return to Norton Sound. An aerial survey along the Seward Peninsula was flown on July 11 to examine ice conditions in Bering Strait and the Chukchi Sea (Photographs 6 and 28). The large vessel charter was terminated on July 12 due to main pack ice and drifting pan ice conditions which precluded entry into the Kotzebue Sound study area at Cape Espenberg.

Gillnetting Studies

A total of 22 offshore gillnet sets were made in Norton Sound resulting in 232.9 hours of total soak time. Sets ranged from 4.2 to 23.0 hours in duration with an average of 10.6 hours per set. Seven stations were fished with stationary gear while 15 sets were made by drifting with the gillnets. Distance drifted ranged from about two to forty kilometers with an average drift of ten kilometers for the 15 drift sets. Two of the 22 sets made (23%) resulted in no catch.

Surface water temperatures at the 22 gillnet stations ranged from 3-15 C° with an average temperature of 9.9°C. Depth of stations sampled ranged from 5-36 m with a mean of 15.7 m.

Eight species were represented in a total catch of 345 fish:

Species	Catch	Percent
Pacific herring	315	91
Arctic char	11	3
Starry flounder	8	2
Bering Cisco	5	1
Chum salmon	2	1
Coho salmon	2	1
Pink salmon	1	TR
Cottid	1	TR
Total	345	100

Ninety-one percent of the total catch was Pacific herring of which 82% were captured in only two of the 22 stations sampled (Stations 1 and 20) (Table 35). Consequently, data was grouped as follows for analysis of herring results: station 1; stations 2-19; stations 20-21; and, station 22 (Table 36). All herring catches in offshore waters occurred in Norton Sound (east of 166° W. longitude) with the exception of a single specimen captured on July 2 inside Port Clarence.

Spawning herring were taken only in June at stations 1-6 (Table 37). Post spawners were captured from July 9 through July 12 at stations 19, 20 and 22. Sexually immature herring (gonad index II) were present at all stations where herring were captured in significant numbers. These were predominantly Age Class III-V herring (Table 38). Relative maturity by age class is shown in Figure 43.

Herring catches were examined by panel mesh size and results revealed 20% were captured in 38 mm, 68% in 51 mm and 12% in 64 mm mesh (Table 39). Various mesh sizes were selective on herring age classes (fish size) (Figure 44). Age Classes IV and V dominated catches from 38 mm mesh nets; Age Classes V - VIII dominated in 51 mm mesh nets; and, Age Classes VIII and IX were dominant in 64 mm mesh catches.

Mean length and weight-at-age were plotted for the total herring catch in 1977 (Figure 45). Percent age composition of herring captured on June 22 at station 1 were dominated by Age Classes VII and VIII, while those taken on July 10 at station 20 were predominantely Age Class V (Figure 46). Overall length frequency distribution is shown in Figure 47.

Lengths and weights of other species captured were:

1. Fork lengths for eleven Arctic char ranged from 149-485 mm with a mean of 292 mm (SD=118.3). Weight ranged from 21-1,175 gms with a mean of 350 gms (SD=329.1).

2. Five boreal smelt captured ranged in length from 169-360 mm with a mean of 241 mm (SD=93.1). Range in weight was from 58-367 gms with a mean of 169 gms (SD=155.1).

3. Eight starry flounder ranged in length from 259-425 mm with a mean of 363 mm (SD=53.6). Range in weight was from 167-1,000 gms with a mean of 627 gms (SD=254.7).

4. Two adult male chum salmon had weights and lengths (mideye to fork of tail) of 3.4 and 3.8 kgs, and 575 and 603 mm, respectively. An adult coho salmon female measured 580 mm with a weight of 4.0 kgs. A juvenile coho salmon measured 162 mm (44 gms) while a single adult male pink salmon measured 455 mm and weighed 1.45 kgs.

Townetting Studies

A total of 83 thirty minute tows were made in Norton Sound from June 22 through July 13, 1977. Depth of towing stations ranged from four to 36 meters with an average of 14.7 m. Surface water temperatures among stations ranged from -1° to +15°C. with a mean of 9.2°C.

Species captured and frequency of occurrence of each are shown in Table 40. Larval fish were the most frequently encountered (66%) but were considered as incidental catches due to their small size. Larval fish catches consisted of: Cottidae; Gadidae (*Eleginus gracilis*); Stichaeidae (*Lumpenus* sp.); Agonidae (*Sarritor frenatus*); Liparidae (*Liparis* sp.); Osmeridae (*Mallotus villosus*); and Ammodytidae (*Ammodytes hexapterus*).

Larval fish were encountered throughout the entire sampling period. Figure 48 shows the general distribution of larval fish catches as well as stations or areas (in the case of gadids and sandlance) where distribution of these species was documented. Catches from many stations were mixed when submitted for identification and the station of occurrence for a particular species could not be determined. Consequently distribution, apart from where larval fish in general were captured, is not completely accurate. For example, gadids made have also been present in other areas denoted as larval fish in addition to areas designated as gadid occurrence. The only completely accurate distribution information concerns crab larval. All larval crabs (species unknown) were taken in the vicinity of Port Clarence.

Five fish species were captured in addition to larval fish during the sampling period: Ninespine stickleback, starry flounder, Bering wolffish (*Anarhichas orientalis*), saffron cod and pink salmon. Forty-five ninespine stickleback were taken at eight stations. Forty-two were measured and ranged from 37-56 mm. The mean length was 49 mm. Eleven starry flounder were captured at five stations and their mean length and weight were 309 mm and 355 gms, respectively. Lengths and weights ranged from 242-387 mm and 152-825 gms, respectively.

Three juvenile wolffish were captured at three stations and had lengths of 42, 42 and 50 mm. A single juvenile saffron cod was captured. Its length was 92 mm and weight three grams. A single juvenile pink salmon was captured off Cape Nome on June 23 and measured 31 mm (0.7 gms).

Anuk River

Hand purse seining for salmon smolt in the Yukon River was conducted for 23 days at eight stations during the period June 7 through July 7. A depth profile of the sampling area was developed (Figure 49). The deepest part of the river was 16.2 meters on the cut bank side near the mouth of the Anuk River. The Yukon River water current was estimated at 2.1 m/sec at the sample location.

A total of 1,915 finfish were captured during the sample period of which five were lamprey (Table 41). The most abundant catches were juvenile whitefish species (Figure 50). Distinction between juvenile broad and humpback whitefish could not be made. Juvenile burbot and chum salmon smolt, respectively, were the next most abundant species captured.

Catch per unit effort (number of fish per seine set) was calculated for each species to examine spatial and temporal distribution during the sampling period (Figures 51 through 58). Although there was no apparent affinity of any species to migrate down a particular section of the river, distinct differences in timing by species occurred (Table 42). Peak catches of chum salmon smolt occurred on June 13 and 15. No salmon smolt were captured in significant numbers after June 24. A downstream migration of juvenile whitefish, juvenile burbot and juvenile sheefish was documented, occurring during the first week of July.

Fork lengths were collected on 265 chum salmon smolt throughout the sample period (Figure 59 and Table 43). Lengths ranged from 31-58 mm, with a mean of 41 mm and standard deviation of 7.5 mm. Ninety-two juvenile sheefish fork length measurements ranged from 35-74 mm with a mean of 56 mm (Figure 60). Juvenile whitefish were also sampled for fork length. Eighty-nine ranged from 20-51 mm with a mean and standard deviation of 34 mm and 7.1 mm, respectively (Figure 61). An additional 468 measurements fell between 20 and 45 mm, but no mean was calculated. Thirty-five juvenile burbot ranged from 18-32 mm, with a mean and standard deviation of 23 mm and 3.4 mm, respectively. An additional 88 ranged from 19-25 mm. A single burbot specimen measured 105 mm (Table 43).

Daily water level fluctuations in the Anuk River (Figure 62) and surface water temperatures (Figure 63) in the Yukon River were monitored at noon from June 6 through July 7. Peak chum salmon smolt catches occurred when water temperatures ranged between 9°-11°C. Peak catches of other juvenile fish occurred when water temperatures were 14°-14.5°C during the first week of July.

DISCUSSION
Subsistence Utilization Surveys

Species utilized for subsistence differs somewhat by village throughout the study area (Table 44). A similarity does exist among villages in that about seven families of fish are used by almost all villages to some degree. These include: Clupeidae, Osmeridae, Gadidae, Pleuronectidae, Salmonidae, Coregonidae, and Thymallidae. Species Utilization depends to a great extent upon seasonal availability. Herring for example are captured in the spring when spawning runs occur in the southern and eastern portion of Norton Sound. Villagers residing on the Seward Peninsula, however, take herring both from spring spawning runs and also in the fall when herring appear in nearshore waters, at for example, Golovin, Teller and Shishmaref. Another species which is taken on an opportunistic basis is capelin which apparently spawn along the beaches of Nome in some years.

Saffron cod are utilized in all villages but subsistence effort is primarily limited to the fall and winter months. Its use is supplemented by other fishery resources during the spring and summer although this species is present year round in all areas according to survey information.

It was not possible to accurately quantify the amount of herring or other fishery resources harvested for subsistence purposes during the course of these investigations for two major reasons: 1) absence of village fishermen at the time of subsistence surveys; and, 2) the absence of subsistence caught fish on many occasions for identification by OCS personnel. Information obtained from personal interviews often resulted in a local name (underlined in Table 44) given for a fish species taken for subsistence use. The authenticity of species harvested could not be verified by the surveyor since fish were often unavailable. These problems also occurred in studies conducted south of the Yukon River Delta in 1976 (Barton et al. 1977). However, they seemed more pronounced north of the Yukon River. Typical examples include capelin being called "hooligan" in the Nelson Island area and "cigarfish" in Nome; pond smelt are also called "cigarfish" by some residents of Nome and other areas of Norton Sound; ciscos are referred to as "herring" in some areas of Kotzebue Sound and are called "whitefish" by Shishmaref residents.

A third factor which hindered accurate catch quantification was differences found in units of catch reporting. Residents would record subsistence catches in numbers, strings, sacks, buckets, tubs or pounds of fish.

Herring

Most subsistence fishing for herring within the study area centered on spring spawning runs, although a number of residents from Golovin northward to Kotzebue also harvested herring from non-spawning fall runs to a limited extent. Limited winter catches are also made while jigging for cod through the ice from Port Clarence northward. Consequently, the duration of herring subsistence fishing normally lasts for only a short period each year. Effort generally commences immediately following ice breakup of the Bering and Chukchi Seas from late May to early July with intense fishing usually lasting not longer than two to three weeks. An exception to this is the limited fall herring harvests made on the Seward Peninsula.

Most subsistence caught herring are intended for human consumption. They are generally woven into grass strings or draped over wooden racks and allowed to sun-dry for several days. Late fall and winter herring are often eaten raw after freezing and slicing into small pieces. Some are fed to dogs, especially in those villages where dog teams are more common. Herring spawn on rockweed kelp is also harvested but on a small scale. Its use is primarily confined to southern and eastern Norton Sound.

Herring are usually caught with set gillnets with mesh sizes of 57-64 mm although some are beach seined. Gillnets are either purchased or salvaged Japanese nets found washed ashore.

Herring use as a subsistence item throughout the study area is influenced by timing and abundance of herring spawners, occurrence of other fishery resources, occurrence of marine mammals and large game animals, commercial salmon fishing and other employment opportunities, such as firefighting, and the number of dog teams per village. These factors no doubt influence the extent of use of other fishery resources as well.

Survey results from 1976 indicated that herring were more important as a subsistence item in Norton Sound than in Kotzebue Sound. In general, subsistence use by village decreases in a northerly direction with greatest herring harvests occurring in southern Norton Sound. Utilization at Point Hope was not documented. Stebbins and St. Michaels residents utilized herring in 1976 more than other residents throughout the study area. Commercial salmon fishing is restricted in this area.

Residents of Unalakleet, Shaktoolik, Moses Pt., and Elim also utilized herring, but most effort was devoted toward commercial salmon fishing, thereby, limiting the effort on herring. Subsistence fishing for herring by villagers along the Seward Peninsula was quite limited in 1976. This was attributed to the lack of dog teams and occurrence of other fishery resources available for harvest such as smelt, whitefish and sheefish. OCS ground crews in 1977, had difficulty in finding local residents in Teller who wanted excess herring captured for samples from the spring spawning run in late June and early July. Subsistence effort in 1976 and 1977 in Kotzebue Sound appeared to be centered around the harvest of marine mammals and large game animals.

Most Norton Sound residents indicated that herring subsistence utilization has decreased from previous years for three major reasons: 1) lack of dog teams, many of which have been replaced with snowmachines; 2) employment opportunities, and 3) fewer numbers of herring. Many also feel that foreign fishing effort has reduced herring abundance from previous years. This view was also shared by coastal residents on the west coast residing below the Yukon River Delta (Barton et al. 1977).

It should be realized, however, that the major gear for subsistence herring fishing throughout the study area is set gillnets having a particular mesh size (generally 57 to 64 mm). Results from the Royal Atlantic cruise in 1977 indicate that these mesh sizes select older age classes (larger) of herring. Barton et al. (1977) also found a similar situation for gillnet caught subsistence herring near Cape Romanzof in 1975. Therefore, in years when the age composition of herring is predominantly III-V, smaller subsistence catches may be experienced than when the predominant age class composition is VI-IX. This is one factor which should be considered when examining catch trends.

It is apparent that herring are more important as a subsistence item to residents below the Yukon River Delta than to those residents in Norton Sound and Kotzebue Sound. This difference in herring subsistence utilization may possibly be explained by: 1) The availability of alternate food sources, e.g., marine and large terrestrial mammals; 2) a lower abundance of herring; and, 3) employment opportunities north of the Yukon River.

Clupeidae (Herring)

Timing and Distribution

Appearance of herring on spawning grounds appears to be greatly influenced by climatological conditions particularly the extent and distribution of the Bering Sea ice pack. Results reveal that herring spawn throughout most of Norton Sound during the spring and early summer (late May through June). Spawning occurs slightly later in the Port Clarence area (late June through early July) and mid to late July along the northern portions of the Seward Peninsula. Some evidence found in 1977 suggests that spawning may occur as late as August in parts of Kotzebue Sound.

The first record of herring spawning was reported in St. Michaels Bay in mid June in 1976 and 1977. Spawning has been recorded as early as May 30 in this area (ADF&G files), being greatly dependent upon ice breakup conditions. Zagoskin (1956, not seen by author; cited by Rumyanstev and Darda 1970) reported, during his travels on the southern coast of Norton Sound, that herring arrived annually in the Sound at the end of April, passing under the ice. Rumyanstev and Darda (1970) therefore made the assumption that spawning did not begin before the second half of May (taking into account the difference between the Gregorian and Julian calenders). Alaska Department of Fish and Game files indicate that peak spawning in Norton Sound usually occurs from June 1-14.

Two pulses of spawning were documented at Cape Denbigh in 1976. Spawn was observed on June 20 and on June 30 on the south side of the Cape. The peak aerial survey count in 1977 of this area occurred on June 17, which coincided with peak commerical herring catches at Cape Denbigh in that year. A total of 20,896 pounds of herring were captured with beach seines and gillnets from June 15 through June 20 by commercial fishermen. The average roe recovery rate of 6.5%. Tests made prior to commercial operations by the processor revealed a 9.0% roe recovery, but the percentage decreased once production began. A few herring were taken commercially with gillnets at Tolstoi Point on June 24 but roe recovery was poor (3.5%).

Tests conducted by a commercial herring buyer revealed a 14.3% roe recovery from a sample of herring captured in Golovin Bay in late May 1976. The OCS sampling program began in Golovin Bay on July 3, 1976, and few herring were captured. No information was gleaned on spawn timing in that year. Spawning was documented in Golovin Bay in 1977 at Carolyn Island during the last week of June as OCS crews encountered herring with a relative maturity index of 6. The largest percentage of these herring were captured from June 22 through July 6 (79.6%). A total of 27.3% of herring sampled from July 7-21 were spawners and no evidence of spawning was documented after that date in 1977 in Golovin Bay.

The Port Clarence area was sampled only in 1977. Sampling commenced with ice breakup on June 27, and until July 6, only 4.7% of the herring sampled were spawners (maturity index 6), while 44% of those collected were post spawners (maturity indices 7 and 8). Young-of-the-year herring were also present during this period, although not in significant numbers. These data indicate that some spawning occurred prior to ice breakup in the Port Clarence area in 1977. From July 7-21 only 3.6% of the samples collected were spawners while 84.7% were post spawners. Therefore, it can be concluded that spawning commenced in the Port Clarence area in 1977 prior to late June and continued through mid-July with peak spawning apparently occurring sometime in the early part of July. Peak aerial survey counts of fish schools in the Port Clarence/Grantley Harbor area in both 1976 and 1977 occurred on July 21.

Herring arrived along the northwestern coast of the Seward Peninsula in about mid-July in 1977. These herring were believed destined for the lagoon areas which connect and comprise Shishmaref and Cowpack Inlets, since no fish schools were observed further north than Kividlo in either 1976 or 1977; the last entrance along this coastal section to the lagoon system. Peak aerial survey counts in 1977 occurred on July 11 in these areas. Limited samples collected from July 15-17 revealed sexually immature, Age V herring present. No spawners or post spawners were captured. Consequently, it is assumed that spawning occurred later than mid-July in this area in 1977. Aerial survey observations along this section of coastline indicated that the herring were moving into the lagoon areas from a southerly direction.

Peak herring survey counts along the northern coastline of the Seward Peninsula and southern Kotzebue Sound (Eschscholtz Bay) occurred on July 20 and August 20, 1977. Possible herring spawn was observed on August 13 at Cape Deceit and again on August 20 at Nine Mile Point. Weather conditions precluded a positive verification on both surveys.

In general, it can be said that most herring spawning populations appear near the western Alaska coast immediately after ice breakup in mid-May and early June (Figure 64). Spawning progresses in a northerly direction along the coastline beginning in mid to late May in Bristol Bay (Barton et al. 1977) and continues until late July and August along portions of the Seward Peninsula and the Chukchi Sea. Both pre and post spawning segments of herring populations remain in the nearshore waters throughout the early spring and summer months.

Relatively small fall runs of herring are known to occur in Golovin Bay, Port Clarence, along the west coast of the Seward Peninsula and in Kotzebue Sound. Samples collected from Golovin Bay and Port Clarence in 1977 revealed that the reproduction organs were relatively undeveloped and that these herring do not spawn in the fall (September and October). A similar finding was made from samples collected in Golovin Bay in mid-October, 1963 (ADF&G files). Herring of this run are of prime quality with firm flesh and a high oil content. It was these fall herring runs which supported earlier commercial herring operations in Norton Sound from 1916-1941. Fall herring were apparently also present in former years in other areas of Norton Sound according to local residents.

Herring are widely distributed throughout the coastal and offshore waters of Norton Sound and Kotzebue Sound in the fall and early winter months. This is not only evident from local resident interviews, but also from demersal trawl catches of herring in September and October (Wolotira et al. 1977). Both mature prespawning and sexually immature herring were captured in offshore waters during this period. These herring may or may not have been segments of the fall herring runs which occur in the nearshore waters along the Seward Peninsula in September and October.

Herring are captured in several areas under the ice throughout the winter months. Most of these fish are taken by local subsistence fishermen while jigging for cod. These areas include Golovin Bay and Safety Sound in Norton Sound, Imuruk Basin in Port Clarence, Shishmaref and Cowpack Inlets along the northwest coast of the Seward Peninsula and Kugruk and Kiwalik Lagoons in southern Kotzebue Sound. Herring were captured in mid-October in Cowpack Inlet in 1977 and in Shishmaref Inlet in March 1978. These samples were positively identified by ADF&G biologists. Herring were found in the stomachs of sheefish captured in Hotham Inlet on November 23, 1963 (ADF&G files).

Other evidence of the presence of herring in nearshore waters throughout the winter months include the occurrence of this species in seal stomachs. Herring occurred in one of 27 ringed seals (<u>Phoca hispida</u>) collected at Nome from March 9-18, 1977. Herring occurred in 11 of 14 spotted seals (<u>P. largha</u>) collected at Shishmaref from October 14-24, 1977 and in 13 of 30 ringed seals collected January 6 through February 2, 1978. Marine mammal biologists who analyzed the stomachs indicated that there was no doubt these herring were ingested in the area where the seals were taken (Frost, Personal Communication).

Herring have also been reported present in Shishmaref Inlet as early as April and May. Local residents indicate that dead herring can be found in the spring on top of the ice in this area; dead from what they refer to as "died from frosted gills". These herring apparently swim through open ice leads, get caught in the overflow and freeze. Similar observations have also been reported in Golovin Bay.

<u>Relative Abundance</u>

There are only a few sections of coastline where herring surveys have been flown with any consistency prior to OCS studies. These are the southeastern coastline of Norton Sound and the Togiak district of Bristol Bay. Trends in the relative abundance of herring populations have differed between these areas. Estimates of herring abundance from aerial surveys in the Togiak area in 1977 revealed some of the largest and most numerous schools ever observed in that area since surveys began in the 1960's (Nelson, Personal Communication). The opposite has been observed in Norton Sound where survey results have indicated a decline in herring abundance. A total of 236 and 137 schools were observed along beaches between St. Michaels and Unalakleet during 1968 and 1972, respectively. During 1975 and 1976 aerial surveys were intensified, particularly in 1976 when OCS funding was made available. Not more than 10 schools were observed in either year in the same area. In 1977 only a single school was observed. A similar trend was indicated from surveys made in the Cape Denbigh area until 1977. Nearly twice as many herring schools were observed at Cape Denbigh in 1977 as was observed in 1972, 1975 or 1976. Similar comparative data is not available for other spawning areas along the west coast.

Most coastal residents interviewed in the last two years indicated that herring abundance has declined. The only exceptions were residents interviewed in Shishmaref. This possibility is also expressed in the downward trend of foreign herring trawl catches in the Bering Sea between 1968 and 1976.

The relative abundance of herring populations along the west coast of Alaska has been better identified during the course of these studies. Results from this investigation and from studies conducted by Barton et al. (1977) in the southern Bering Sea indicate herring abundance, based upon surface area estimates of school size, is greatest south of the Yukon River with the Togiak district in Bristol Bay having, by far, the largest concentrations (Figure 65). The relative abundance of spawning herring north of the Yukon River is greatest in the southern and eastern portions of Norton Sound. Many schools of fish believed to be herring were observed along the north coast of the Seward Peninsula in 1977, but exact identity of all of these schools was not possible.

Spawning Habitat Types

Little can be said about actual herring spawning habitats throughout the study area from the standpoint of extent and density of spawn deposition. Only a limited amount of spawn was actually recovered by ground crews while sampling in 1976 and 1977. However, certain generalizations in reference to spawning habitats can be made. Whereas herring spawning is common throughout the intertidal zones in areas along the west coast of Alaska below the Yukon River, particularly in the Togiak area of Bristol Bay (Barton et al. 1977), the greatest percentage of spawning throughout the Norton Sound and Kotzebue Sound areas is subtidal although some intertidal spawning does occur. This is basically a function of the relatively small tide changes which occur in these areas. Very little intertidal beach area is available for spawning in contrast to more southern areas. In areas north of Golovin Bay (Norton Sound) most spawning occurs in shallow subtidal bays, lagoons and inlets.

There are basically two habitat types utilized by spawning herring in Norton Sound and Kotzebue Sound. Spawning in Norton Sound from Cape Stebbins to Golovin Bay was only observed to occur in areas of exposed rocky headlands. In such areas rockweed kelp (Fucus sp.) was common on rocks in intertidal and/or shallow subtidal zones (Photograph 18). Samples of spawn collected along the southern coastline of Norton Sound from St. Michaels to Tolstoi Point in June 1976 were found deposited on Fucus. A small commercial harvest of herring roe on kelp in Norton Sound in 1977 indicated that Fucus fracactus occurs on the south side of Cape Denbigh. In Golovin Bay, spawning occurred on the east side of Carolyn Island in an area of rocky coastline. Fucus is common in that area but local residents reported that herring spawn was harvested several years ago on bare rocks at Rocky Point. Bluff and Topkok Head are both exposed rocky headlands and are two important spawning areas along the northern coast of Norton Sound. Barton et al. (1977) found herring spawn on bare rock at Nelson Island in 1976 under conditions of dense spawning. Reid (1971b) also indicates that bare rock and most any other substrate is utilized under such conditions.

A distinct change in herring habitats was noticed from Bluff northward to Cape Espenberg in Kotzebue Sound. Where herring spawning was documented in areas along this section of coastline, habitats consisted of relatively shallow bays, lagoons or inlets, such as Imuruk Basin in Port Clarence. Eelgrass (Zosteria sp.) was the most common vegetative type found in Port Clarence, Grantley Harbor or Imuruk Basin and Fucus was not found in these areas. McRoy (1968) also documented Zosteria as being common to the Port Clarence area (Brevig Lagoon).

Dmitriev (1958) states that Pacific herring in the White Sea, which spawn in inlets and bays, deposit eggs in shallow water (2-5 m, mostly 2-3 m) on underwater vegetation such as eelgrass (Zosteria sp.) and less often on Fucus algae, Cladophora and Phyllophora. The White Sea lies at the same latitude as Port Clarence, the northern Seward Peninsula and Kotzebue Sound (Figure 66). Aerial survey results indicated that herring along the northwest coast of the Seward Peninsula from Cape Prince of Wales to Cape Espenberg were entering the shallow lagoons and inlets.

Fishermen from Shishmaref stated that subsistence fishing for herring used to occur in the Serpentine and Arctic rivers in Shishmaref Inlet, but now most effort occurs only at the mouths of these rivers. That herring occur in rivers is not unplausible, since Galkina (1957) reported that herring in the Sea of Okhotsk, not only enter the estuaries of rivers but also the river proper. Residents of Shishmaref were not familiar with the herring spawning act and those interviewed had never observed eggs on substrate either in the spring or fall in Shishmaref Inlet. However, early spring ice conditions hinder boat travel to this area of Shishmaref Inlet and spawn could easily be overlooked by the time fishing effort begins. Assuming that some spawning does occur in the lagoon areas, spawning habitat is quite typical of that in Imuruk Basin; Zosteria is common, the water brackish and depths very shallow. Herring were only documented to spawn along the north coast of the Seward Peninsula along exposed rocky headlands in eastern Eschscholtz Bay. Other areas where herring are reported to spawn in Kotzebue Sound are in Kugruk and Kiwalik lagoons. Again, these areas are shallow and protected; vegetative types have not been examined.

A major difference exists between herring which spawn in the two general types of spawning habitats in Norton Sound and Kotzebue Sound. Herring which spawn from Port Clarence northward are euryhaline, being able to tolerate wide-range fluctuations in salinity; more so than stocks which spawn further south. Salinities in Grantley Harbor ranged from 2.9-1.9 ppt on July 1, 1977. On July 6, salinities in Port Clarence (near the mouth of Grantley Harbor) ranged from 22.0-13.3 ppt, while in Imuruk Basin on July 10, two readings were made; 1.3 and 2.3 ppt. Alt (1971) also found a similar steep gradient in salinities in July 1970 in the Port Clarence area: In Imuruk Basin salinities ranged from 3.8-5.4 ppt, in Grantley Harbor 23.4 ppt; and, in Port Clarence they ranged from 28.5-29.7 ppt. Although no salinity measurements were obtained in Shishmaref Inlet, low readings would be expected due to the influx of fresh water from the Serpentine and Arctic rivers. Herring occurring in these areas are also probably eurythermal as well as euryhaline since over-wintering occurs in these areas. Dmitriev (1958) stated White Sea herring were both euryhaline and eurythermal.

Age and Growth

Length-at-age data collected from herring spawning stocks in Golovin Bay and Port Clarence in 1977, revealed Port Clarence stocks to be significantly smaller than those in Golovin Bay (Figure 67). Mean standard length for Age V herring (the predominant spawning age class in 1977) in Port Clarence and Golovin Bay was 183 mm and 220 mm, respectively; a difference of 37 mm. This was the average difference in mean length-at-age for Age Classes I through X between the two areas in 1977.

A comparison of length-at-age data on herring spawning stocks along the western North America coast from British Columbia to the Seward Peninsula in Alaska reveales that size increases from south to north into northern Bristol Bay and the Yukon-Kuskokwim Delta. Stocks north of this area become significantly smaller in Norton Sound and Port Clarence (Table 45 and 46).

No samples have been obtained from the Kotzebue Sound area apart from some collected offshore in 1976 (Wolotira et al. 1977). Wolotira found age groups II through IV to predominate both north and south of the Bering Strait, with older-aged fish more numerous in the Chukchi Sea and younger ages south of the Bering Strait. Overall, fish less than 110 mm accounted for 3% of his population estimate in numbers, 120-200 mm fish accounted for 83% and fish larger than 200 mm comprised 14% of the estimated population. He stated that "Pacific herring...displayed greater lengths-at-age and maximum sizes south of Bering Strait than to the north...."

Growth rate of Age 0 herring captured in Port Clarence in 1977 was estimated at about 1.4-1.7 mm per day from late August to late September. No growth information was available on herring taken in Golovin Bay in that year. However, growth of older-age herring (IV-V+) appears to be greater in Golovin Bay than in Port Clarence, while similar growth occurred among young herring in both areas (Figure 67). Wespestad (1978) reported herring stocks in the Bering Sea to grow at about the same rate as stocks in the Gulf of Alaska and British Columbia until ages III-IV, with faster growth of older fish in the Bering Sea as opposed to more southern stocks.

Stock Considerations

Svetovidov (1944) classified subspecies of oceanic herring on the basis of vertebral counts. He states that the subspecies may be assigned to one of two groups, those with high vertebral counts and those with low. He found in his investigations that the two groups also differ in cranium width. The Atlantic and Baltic herrings belong to the narrow-headed, high vertebral count group; the White Sea, Chosha and Pacific herrings to the wide-headed, low vertebral count group. He points out that forms with low vertebral counts are the most euryhaline.

Rounsefell (1930) examined herring samples from San Diego to Golovin for vertebral counts and several other meristic comparisons. In his summary on vertebral counts he stated that following the general trend of the coastline northward and westward from San Diego, mean vertebral counts increased with distance, being practically linear and widely departed from only by herring of the Shumagin Islands and Golovin Bay. Vertebral counts increased from south to north from San Diego to the Shumagin Islands, then decreased from there northward to Golovin Bay (Table 47). A similar trend has been shown to exist based upon mean length-at-age data presented earlier. Rounsefell concluded from the analysis of all characters examined that several distinct herring stocks existed along the west coast of North America with Golovin Bay herring listed as one.

The mean vertebral count of Golovin Bay herring sampled by Rounsefell was 52.79. Averinzev (1926, not seen by author, cited from Rounsefell 1930) indicated that the average vertebral count of different "races" of herring in the White Sea vary from 52.14 to 56.18. Dmitriev (1958) states there are two forms of herring in the White Sea: A large form, *Clupea harengus pallasi maris-albi major* and a small form as *C.h.p. maris-albi minor*. Consequently, it can be assumed that Rounsefell's Golovin Bay herring samples were quite similar to the small form of White Sea herring based upon vertebral counts.

OCS studies indicate that herring populations from Golovin Bay northward differ significantly from herring populations occurring from southern Norton Sound and southward into the southern Bering Sea in size and behavorial characteristics. Differences between these two regions are summarized as follows:

Seward Peninsula Populations	South Norton Sound to southern Bering Sea populations
Smaller herring with lower vertebral counts.	Larger herring with probable higher vertebral counts.
Lower abundance.	Higher abundance.

Subtidal spawning (3m) in shallow bays, inlets & lagoons.	Intertidal and shallow subtidal spawning along exposed rocky headlands.
Zosteria sp. primary spawning substrate.	_Fucus_ sp. primary spawning substrate.
More euryhaline.	Less euryhaline.
Overwinter in shallow bays; water is warmed by river discharge under ice cover.	Overwinter in deep ocean layers near the Pribilof Islands.
Fall (non-spawning) runs documented.	No fall runs documented
Larval development in brackish water.	Larval development probable in more saline water.

Data collected from herring populations along the Seward Peninsula during OCS studies strongly indicate that independent stocks of herring occur in this region. This does not preclude the possibility of the occurrence of more southern stocks from utilizing this region, i.e., those stocks described by Dudnik and Usol'tsev (1964), Saboneev (1965) and others, which winter near the Pribilof Islands and migrate to the western Alaska coast to spawn. It is unlikely however, that herring stocks along the Seward Peninsula migrate to the central Bering Sea for wintering, but rather remain in coastal lagoons, bays or inlets. These stocks closely parallel some of the White Sea small herring which exhibit a similar behavior. They remain in shallow bays and inlets which are warmed by river discharge under the ice. This in itself is probably a major factor in explaining size differences, i.e., environmental conditions. Water temperatures and feeding conditions in deep ocean waters are probably more favorable for growth than those prevailing in herring winter habitats along the Seward Peninsula, which apparently (like the White Sea herrings) have become adapted to Arctic conditions.

Salmonidae (Salmon and Trout)

Six species of salmonids were captured during the course of these studies: Arctic char, chum salmon, pink salmon, coho salmon, king salmon and sockeye salmon. All five species of Pacific salmon are indigenous to the Norton Sound area with chum salmon being the most abundant. Pink salmon are second in abundance followed in order by coho, king and sockeye salmon.

Commercial salmon fishing provides local residents with a major source of employment and first began in eastern Norton Sound in 1961. Although early effort was primarily stimulated by interest in king and coho salmon, chum salmon are now the most important commercial species followed by pink salmon. General run timing of adult salmon in Norton Sound and the Port Clarence area is as follows (ADF&G 1976):

Species	Present in bays and estuaries	Spawning
King	June 15 to July 10-15	July 10 to August 5
Sockeye	June 25 to July 25	July 15 to September 10
Coho	August 1 to August 20	August 20 to Sept 30
Pink	June 25 or July 1 to July 15-20	July 15 to August 5
Chum	June 20-25 to July 20-25	July 10 to August 15

Commercial salmon fishing since its inception in Norton Sound has extended annually from June 1 to September 30. Commercial fishing in the Port Clarence area only occurred in 1966 and 1,266 adult salmon were taken in the Grantley Harbor - Tuksuk Channel area. Since that time salmon have been harvested exclusively in this area for subsistence purposes. A unique feature of the Port Clarence area is the Pilgrim River sockeye salmon run, one of the northernmost occurrences of this species in North America.

In 1976, no sampling was conducted during about a two to three week period of open-water immediately following ice breakup (Barton 1977). In 1977, sampling commenced with the onset of ice breakup to examine the early open-water period for occurrence of juvenile salmon. The only significant catches made that year were in Golovin Bay. Data obtained on juvenile salmon in the southern and eastern portion of Norton Sound in 1977 are inconclusive in that no significant catches were made. However, this is partially explained by sampling coverage in that area. The Unalakleet crew was responsible for sampling 205 km of exposed coastline as opposed to the more protected and smaller waters of Golovin Bay. Consequently, much more time was required for the Unalakleet crew to "adequately" sample their area due to inclement weather problems and distances involved.

All information collected during the course of these studies on juvenile pink and chum salmon indicate they are present in nearshore coastal waters of Norton Sound with the onset of ice breakup and remain present until about the second week of July. It should be realized however, that juvenile salmon were primarily captured with beach seines, being too small for gillnets early in the season. Our findings suggest that juveniles vacate the immediate onshore littoral area by mid-July. Since no juveniles were captured in any gear type from mid-July until freezeup in nearshore waters, it is probable that they migrated offshore to more pelagial regions. This is interesting as McPhail and Lindsey (1970) and Hart (1973) indicate that both species generally remain nearshore until about September when they depart for deeper water. The mean surface water temperature in Golovin Bay during the last two weeks of June in 1977 was 12.0°C and 12.8°C in the first two weeks of July.

Information obtained on growth of both juvenile pink and chum salmon in Norton Sound indicates very similar growth rates (Table 23). This is not surprising since the diets and feeding habits of these species is basically the same (McPhail and Lindsey 1970; Hart 1973; and others). Growth rates of pink and chum salmon juveniles from Golovin Bay during the period from ice breakup until mid-July 1977, exhibited a 2.5% increase in growth per day. Offshore marine growth was examined using both 1977 length data and 1976 length information collected by Wolotira et al. (1977). Only four juvenile pink and two juvenile chum salmon were captured in offshore waters in the first week of September 1976. Examination of length differences shows a 3.3% and 3.4% increase in growth per day for pink and chum salmon juveniles, respectively, from mid-July until early September. Overall from breakup until September the growth rate was 4.6% and 4.7%, respectively for juvenile pink and chum salmon. In comparison, daily growth rates of Age 0 herring in Port Clarence were about 3.5-4.0% from late August to early October.

Arctic char was the sixth salmonid captured in the study area. It was the most widespread species encountered being present in all areas sampled in both 1976 and 1977. Bendock (1977) found this species widely distributed throughout the coastal waters of the Beaufort Sea from Harrison Bay to Haxman Island, while Kendel et al. (1975) found the distribution of Arctic char to be mainly concentrated from Hershal Island to Point Kay off the MacKenzie River Delta. Char at sea are known to cover great distances (Griffiths et al. 1975, not seen by author, cited in Kendel et al. 1975). Consequently, populations of char throughout the coastal waters of Norton Sound are likely a mixture of stocks from various rivers, the degree to which is not known.

Beach seines captured char ranging in size from 99-640 mm with a mean of 297 mm and standard deviation of 168.9. A distinct mode was observed between 160 and 169 mm. Gillnet samples ranged from 139-598 mm with a mean of 404 mm and standard deviation of 85.2 mm. Two distinct modes represented in these samples occurred between 390-399 mm and 450-459 mm. It is apparent that gillnets selected toward the older and larger char (Figure 38). No char were captured in beach seines after June 21 in the Golovin Bay and eastern Norton Sound areas while none were captured with beach seines in the Port Clarence area after July 21. These findings suggest that smaller (younger) char were not present about one month after ice breakup in the immediate littoral zone when considering breakup in Port Clarence occurred one month later than in the remainder of Norton Sound. It is also interesting to note that no char were captured in any area with offshore sinking gillnets suggesting they were primarily confined to the immediate shoreline surface waters in the coastal areas.

Eleven char were captured with floating gillnets from June 22 through July 7 in the offshore surface waters of Norton Sound in 1977. Lengths ranged from 149-485 mm with a mean of 292 mm and standard deviation of 118.3. Eight arctic char captured in the offshore waters in 1976 from September 2 through October 9 had lengths ranging from 242-259 mm with a mean of 250 mm and standard deviation of 6.8.

Fork lengths ranged from 154-685 mm with a mean of 427 mm on 3,739 Arctic char captured by Bendock (1977) in 1975 and 1976. He states a length mode occurred between 520 and 529 mm, and further, that juveniles less than 200 mm were abundant in nearshore waters between the Colville and Sagavanirktok rivers during the open water season. Our studies indicated that juveniles less than 200 mm were not present in the coastal waters in significant numbers approximately one month after ice breakup.

Arctic char were most abundant in the eastern section of Norton Sound, particularly between Cape Denbigh and Tolstoi Point (area B and C). In general, char catches decreased as the season progressed into the Fall in all areas examined.

Stichaeidae (Pricklebacks)

Two members of the family Stichaeidae were captured during the course of our investigations; snake prickleback and pighead prickleback (Figure 80). These species were primarily captured in nearshore waters of southern and eastern Norton Sound from Cape Stebbins to Cape Denbigh. Their frequency of occurrence was 5% and 18% in gillnets and beach seines, respectively. Total abundance was relatively low, comprising only 2.4% of all species captured in that area. The only other area where prickleback were captured was between Rocky Point and Bluff (Area F) when six juveniles (species unknown) were captured in late July 1976.

Wolotira et al. (1977) found five members of this family widely distributed offshore in Norton Sound and the southern Chukchi Sea in the fall of 1976. The snake prickleback was not found in their catches. They found that Stichaeidae, together with Zoarcidae (eelpouts) and Agonidae represented only about 5% of the total fish biomass within their study area.

Seventy-one length samples collected from southern and eastern Norton Sound in 1977 from beach seines had a range of 208-420 mm with a mean of 294 mm and standard deviation of 50.5. Two pricklebacks caught in gillnets measured 234 mm and 235 mm. Certain species of <u>Lumpenus</u> are apparently a prime factor in determining colony size and nesting success of many sea birds throughout the study area (Drury, personal communication). Kittiwakes at Bluff produced about one chick per two nests in 1975 and one chick per 50 nests in 1976. Drury suggested this difference to have been due to differences in food supply between July 5-20. He indicated similar affects seemed to have occurred with murres and puffins and that sand lance and one species of <u>Lumpenus</u> are the main food for Common Murres, Horned Puffins and Kittiwakes.

Larval <u>Lumpenus</u> species were captured in the surface waters of several offshore stations sampled by the <u>Royal Atlantic</u> from June 22 through July 7, 1977 (Figure 48).

Ammodytidae (Sand Lance)

Sand lance were the most abundant fish captured in either 1976 or 1977 in absolute numbers. Although widely distributed throughout Port Clarence and Grantley Harbor (Figure 71), they were most abundant in the Golovin Bay and Bluff areas (Areas A and F), comprising 80.8% of the entire catch composition of all species in those areas (Figure 68). They were found infrequently and at low abundance in the southern and eastern portions of Norton Sound coastal waters being captured at only two locations: Klikitarik and Egavik.

Sand lance were present in significant numbers and most abundant in the Golovin Bay area from July 7-September 21 (Period 3-7) (Table 28). Only a few were present during Periods 2 and 8 with none captured in Period 1 (June 7-21) or Period 9 (October 7-21). Examination of 1977 length frequencies revealed the presence of large sand lance in the spring while smaller ones occupied nearshore waters in summer and fall (Figure 31). Three distinct modes were present during these seasonal periods: 80-84 mm in spring (May 29-July 21); 50-54 mm in summer (July 22-September 6); and, 60-64 mm in fall (September 7-October 21). Mean lengths were 83 mm, 59 mm and 63 mm, respectively. A mode existed at 65-69 mm from 456 length samples collected from July 7 through September 21, 1976 in this same area. The mean length was 64 mm.

The reproductive cycle of this species in the northeast Bering Sea is virtually unknown. However, larval sand lance were captured in the surface waters of several offshore stations during the Royal Atlantic cruise from June 22 through July 7, 1977 which suggests that spawning occurs in late May-early June (Figure 48).

Osmeridae (Smelts)

Osmeridae were represented by three species: Boreal smelt, pond smelt and capelin. This family ranked third by frequency of occurrence in beach seine catches and fifth in gillnet catches throughout the coastal waters of our study region. Boreal smelt were the most abundant and widely distributed Osmeridae throughout the surface waters of the study area in both 1976 and 1977. They were the most frequently encountered species in beach seines for all areas combined (44.2%), while ranking first (75%) in southern and eastern Norton Sound and fourth in both Golovin Bay (31%) and the Port Clarence area (32%) (Tables 48 and 49).

Pond smelt were the most frequently encountered species in Port Clarence (57%) and ranked sixth in overall frequency of occurrence (24.1%) for all areas combined. They made up the greatest percent composition (68.1%) of all species captured in the Port Clarence area (Figure 68). Although both boreal smelt and pond smelt were widely distributed throughout the Port Clarence and Golovin Bay areas, pond smelt were primarily restricted to the vicinity of the Unalakleet River in the coastal waters of eastern Norton Sound. In this area boreal smelt were the most abundant while pond smelt were the most abundant in the Port Clarence area. The percent composition of species in the Port Clarence area was 68.1% for pond smelt and 2.5% for boreal smelt, while in the southern and eastern sections of Norton Sound boreal smelt consisted of 36.8% and pond smelt 1.1% of the species compositon. In Golovin Bay the percent composition was about the same for both species being 2.2% for boreal smelt and 2.0% for pond smelt (Figure 68).

Results of offshore sampling in Norton Sound in the southern Chukchi Sea in 1976 by Wolotira et al. revealed boreal smelt to be widely distributed throughout the entire region in September and October. This species ranked fourth in frequency of occurrence of all species captured in demersal trawls and ranked fifth in abundance. The percent occurrence of boreal smelt in demersal trawls was 57% and 71% in the Chukchi Sea and Norton Sound areas, respectively. They also found that boreal smelt were the most abundant and frequently occurring species captured with variable mesh gillnets in offshore surface waters of Norton Sound and the southern Chukchi Sea for the same time period. Only a single pond smelt was captured in floating gillnets and none in demersal trawls. Alverson and Wilimosky (1966) reported the presence of juvenile osmerids in midwater sets below the thermocline in offshore waters of northern Kotzebue Sound in August 1959. Only two osmerids were identified during his studies: boreal smelt and capelin.

Beach seines and gillnets sampled different size frequencies of several species in nearshore waters in 1977. Small smelt were sampled with beach seines while gillnets were more selective toward larger smelts (Figures 32 and 33). The mean length for boreal smelt and pond smelt captured in beach seines throughout the entire study period was 49 mm and 55 mm, respectively. Mean lengths of boreal smelt and pond smelt captured in gillnets were 185 mm and 118 mm, respectively. Wolotira et al. (1977) found that fish less than 200 mm comprised nearly the entire population of boreal smelt captured in demersal trawls in 1976 although appreciable numbers of boreal smelt larger than 200 mm occurred in outer Norton Sound south of Port Clarence. He reported that in general, average size of boreal smelt was less in shallow water nearshore as opposed to deep offshore regions.

Larval boreal smelt were frequently encountered during our studies throughout the entire study area in the nearshore waters of Norton Sound (Figure 81). They were captured as late as Period 2 (August 22-September 6) in Golovin Bay and Period 7 (September 7-22) in Grantley Harbor. Larval pond smelt were captured in Imuruk Basin as late as October 6. Larval osmerids were also found present from June 9 through July 7 in the offshore surface waters of Norton Sound in 1977. Neimark (Personal Communication) found larval smelt (Osmerus eperlanus) to be the most important teleostid in diets of several species examined in Norton Sound in 1976.

All information collected indicates that boreal smelt have a wider distribution throughout the marine waters of Norton Sound as opposed to pond smelt, which showed a greater affinity for nearshore brackish waters. Boreal smelt were captured in pelagic and nearshore waters from breakup through freezeup at various stages of development. This is contrary to Warner and Shafford (1977) who hypothesized that boreal smelt do not migrate to sea in great numbers, subjecting themselves to "riggers of the open marine tropic system". They identified boreal smelt as being principally a species of estuarine habitats.

A fall run of adult boreal smelt was observed in October 1977 in the Imuruk Basin area. Large numbers of adult boreal smelt were captured for subsistence purposes in the Tuksuk Channel in that month.

Only four capelin were collected throughout the entire study period, two of which were taken in a beach seine haul made in July 1976 near Tolstoi Point in southeastern Norton Sound. Two other specimens were taken in 1977: one at Jones Spit and one near the Tuksuk Channel in Grantley

Harbor. Residents of Teller were shown these samples and no one interviewed had ever seen this species before. Similar results were obtained in Shishmaref when samples of capelin were shown to residents there.

A single male capelin carcass (spawner) was found immediately in front of Nome by the breakwater on August 3, 1976 indicating some spawning occurred in that year. An aerial survey of the beaches from Penny River to Cape Nome on August 4 did not reveal the presence of additional capelin carcasses. That same day a ground reconnaissance of the coast from the Nome jetties to Penny River also resulted in no observations of capelin. It was assumed that if any spawning in this area was occurring, it was away from the immediate shoreline in subtidal waters. Wind conditions were such that if spawning in any significant numbers had occurred in the surf areas of the shoreline that more carcasses would have in all probability been present along the beaches.

Barton et al. (1977) found that primary capelin spawning habitats along the west coast of Alaska consisted of relatively smooth sand and gravel beaches. Areas of this type predominantly occur on the Seward Peninsula from near Bluff to Port Clarence and from Cape Prince of Wales to Cape Espenberg. At least two residents of Nome indicated that appearance of capelin (cigarfish) along the beaches of Nome in the vicinity of Fort Davis is not an annual occurrence. A spawning run was documented to have occurred in this area at the end of June in 1974 (Grauvogel ADF&G, Personal Communication and other residents), although no records were found in ADF&G files to this affect. However, many ADF&G records were destroyed during the 1974 Nome flood.

Most information available on capelin distribution in the study area was obtained by Wolotira et al. (1977). Only trace amounts were encountered, mostly in offshore and deeper waters and total estimated biomass was 190 metric tons (+ 91 mt @ 95%). More than 52% of this amount was found in offshore waters between St. Lawrence Island and Port Clarence. An additional 34% was distributed in the offshore waters of northern Kotzebue Sound south of Point Hope. Alverson and Wilimosky (1966) also found capelin present in demersal trawls in northern Kotzebue Sound and as far north as above Cape Lisburne in offshore waters during August 1959.

Indications are that although capelin are present in our area their abundance is relatively low especially when compared to areas in the southern Bering Sea.

Gadidae (Cods)

Two members of the Gadidae family were captured in nearshore waters during our studies. The only freshwater member of this family, burbot, was captured only in the Yukon River Delta area. Alt (1971; 1972) captured a single burbot in Imuruk Basin in July 1970 and three more specimens in the Agiapuk River delta in 1971.

Burbot are an important subsistence food item in the Yukon River. Data presented by Crawford (June 1978, unpublished report) indicate peak subsistence catches of burbot occur in February, although they are taken in the lower reaches of the Yukon River (Russian Mission and downriver) throughout the winter months. A run of juvenile burbot down the Yukon River was documented at the mouth of the Anuk River to occur during the first week of July in 1977. This downstream migration coincided with downstream migrations of juvenile sheefish and juvenile whitefish.

Saffron cod was the second gadid captured during our studies. It was the most frequently encountered species in gillnet catches (30.8%) and the second most frequently encountered in beach seines (42.4%). It was one of the most widely distributed species throughout the entire study area. Crawford (January 1978, unpublished report) indicates this species is taken for subsistence purposes by local residents in September and October at Kotlik, Sheldon's Point, Alakanuk and Emmonak. This species was not captured in the Flat Island area in 1976 during our investigations. Saffron cod is a major subsistence food item to local residents throughout the study area.

The percent composition of saffron cod captured in the nearshore waters of Norton Sound was 4.6%, 2.1% and 17.1% in the Port Clarence, Golovin Bay and southern and eastern Norton Sound areas, respectively (Figure 68). Table 37 shows the selectivity of gillnets to larger (older) saffron cod as opposed to beach seines. Saffron cod length samples from beach seine catches range from 32-358 mm with a mean of 112 mm and standard deviation of 63, while lengths from gillnet samples range from 92-420 mm with a mean of 252 mm and standard deviation of 50.7. An examination of catch per unit effort values in Table 55 reveal seine catches were in general greatest in all areas during Periods 4-6 (July 22-September 6), while gillnet catches held fairly consistent from breakup through freezeup.

Wolotira et al. (1977) reported saffron cod as the most abundant fish species encountered in September and October 1976 during offshore surveys of Norton Sound and the southern Chukchi Sea. The frequency of occurrence of saffron cod in demersal trawls was 78% and it represented 45% of the total apparent biomass of all fish species combined during their studies. They found that, although most saffron cod encountered north of Bering Strait were small, the highest relative abundance for young saffron cod was in Norton Sound. Their investigation showed that saffron cod ranging from 130-250 mm comprised about 25% of their estimated population in the study area.

No other gadids were found in nearshore waters in 1976 or 1977, although three additional members of the Gadidae family were captured in the offshore waters by Wolotira et al. Saffron cod therefore show a stronger affinity to frequent brackish/freshwater areas (excluding burbot) than the other gadids present in our study area.

Larval finfish were the most frequently encountered (66%) organism in the offshore surface waters of Norton Sound in June, 1977. Of these, gadid larvae were among the most frequently encountered and widely distributed (Figure 48). These larval gadids were identified to be saffron cod.

Pleuronectidae (Flat Fishes)

Pleuronectidae was the second most frequently encountered fish family in our area in both beach seines (71%) and gillnets (39%) (Table 50). Starry flounder was the most widespread and frequently encountered species followed by Arctic flounder (Figure 75; Tables 48 and 49). These two species made up a higher percentage of the species catch composition in southern and eastern Norton Sound (7.8%) than in any other area (Figure 68). Starry flounder were the only flatfish species encountered in slightly brackish water such as Imuruk Basin, the Unalakleet River lagoon and the Yukon River Delta.

Alaska plaice, yellowfin sole and longhead dab were the three other species represented by this family. Of these, yellowfin sole was captured only in Golovin Bay and southeastern Norton Sound, while Alaska plaice were distributed in all areas except the Yukon River Delta. Longhead dab were only captured in 1976 in eastern Norton Sound from Cape Denbigh to the Unalakleet River (Figure 78). These three species were relatively low in abundance in nearshore waters when compared to starry flounder and Arctic flounder.

Wolotira et al. (1977) found all five of these species common in offshore demersal trawls in September and October 1976 in Norton Sound and the southern Chukchi Sea. Starry flounder were also found in offshore surface waters in 1976 and 1977.

The only flatfish species encountered in nearshore waters of the Beaufort Sea by Bendock (1977) was Arctic flounder, while Kendel et al. (1975) found both Arctic flounder and starry flounder present in his studies along the coast of the Yukon Territory in Canada.

Coregonidae (Whitefishes)

Six species of coregonids were encountered during our studies. This family of fish was more frequently encountered than any other in both beach seines (96%) and gillnets (58%). They were represented by two anadromous and four freshwater forms: Bering cisco and least cisco (anadromous); Innconu, broad, humpback and round whitefish (freshwater). Ciscos were among the ten most frequently encountered species in all areas, with Bering cisco being, generally, more frequently encountered than least cisco.

Bering cisco had a slightly wider distribution throughout the coastal waters of Norton Sound and were found to be much more common than least cisco in the Flat Island study area (Figures 73 and 82). Bering cisco were also captured in offshore surface waters of Norton Sound in the fall of 1976 and spring of 1977. This data suggests that least cisco in our study area have a greater affinity for brackish waters of the mainland coast. Bendock (1977) also documented a similar finding among least cisco populations along the north Alaska coastline in the Beaufort Sea.

Gillnets were selective to large ciscos while beach seines sampled both larger and smaller fish (Figures 34 and 35). Bering cisco sampled in the Port Clarence area were larger than either Golovin Bay or southeastern

Norton Sound samples. The mean length of Bering cisco in Port Clarence was 239 mm for beach seines and 285 mm for gillnets. Lengths of Bering cisco captured in beach seines in Golovin Bay and the southern and eastern portion of Norton Sound were 142 mm and 122 mm, respectively. Mean lengths of gillnet catches for these two areas was 212 mm and 218 mm respectively. The largest individuals were captured in the spring in all areas.

Ciscos comprised 3.5%, 2.0% and 6.5% of the species catch composition in Port Clarence, Golovin Bay and southeastern Norton Sound, respectively. Percent composition of ciscos in the Flat Island area was 43%. They were present in all areas in the nearshore waters throughout the entire sampling season.

Humpback whitefish displayed a wider distribution in nearshore coastal waters, followed in order by broad whitefish and round whitefish (Figures 72 and 83). The broad whitefish was common to Port Clarence and Golovin Bay, but its distribution was more restricted in the southeastern portion of Norton Sound being primarily confined to coastal waters south of the Unalakleet River. Round whitefish were only captured in the Port Clarence area and in nearshore waters of southeastern Norton Sound between Unalakleet River and Tolstoi Point. Humpback and broad whitefish showed a greater distribution in brackish and coastal marine waters than round whitefish. These three species were less frequently encountered than either of the ciscos in all areas examined. Abundance of these three species was greatest in slightly brackish to near freshwater areas and their presence did not appear to be seasonal.

The only other coregonid captured in our studies was Inconnu. This species was only found in the Yukon River (Figure 84), although resident populations are also known to occur in the Kobuk River in Norton Bay (Alt 1977). Also, scattered catches of this species have been made at various locations along the Norton Sound coast (Geiger, ADF&G, Personal Communication).

Juvenile Inconnu were captured in June, 1977, 101 kilometers upriver from Flat Island in the Yukon River. Fork lengths ranged from 35-74 mm with a mean of 56 mm. A downstream migration of this species was documented to occur during the first week of July. Timing coincided with downstream migrations of juvenile whitefish and juvenile burbot. A total of 557 fork length measurements of juvenile whitefish (juvenile humpback and broad whitefish) ranged from 20-51 mm. The mean length from 89 of these samples was 34 mm.

Other Fish Species

Eight other families of fish were captured during our investigations: Esocidae, Catastomidae, Agonidae, Cottidae, Gasterosteridae, Hexagrammidae, Liparidae and Anarhichadidae. Northern pike and northern sucker were only found in two areas examined; Imuruk Basin in the Port Clarence area and in the Yukon River Delta. Only a single specimen of these two species was captured in Imuruk Basin in 1977 while both species were widely distributed throughout the Flat Island study area at the south mouth of the Yukon River (Figure 85). Northern pike are taken for subsistence use by villages along the lower part of the Yukon River in the fall and early winter months. Crawford (June 1978, unpublished report) showed subsistence catches in nine villages throughout the period October 1977 through March 1978. A peak catch of 152 northern pike was reported in October, although fishing effort in these villages peaked in November. The total catch in November was 145 fish.

Three members of the family Agonidae were captured: Tubenose poacher, Bering poacher and sturgeon poacher. Tubenose poachers were the most widely distributed throughout Norton Sound coastal waters followed closely by Bering poacher (Figure 76). Sturgeon poachers were the least abundant and frequently encountered Agonidae; being found at only a single station in Golovin Bay and another at the mouth of Wagonbox Creek in southern Norton Sound. All three of these species were captured by Wolotira et al. (1977). They found sea poachers widely distributed throughout both Norton Sound and the southern Chukĉhi Sea. Sturgeon poachers ranked sixth by frequency of occurrence (62%) and 17 by abundance (0.03 kg/km). Larval sea poachers were present in June in the offshore surface waters of Norton Sound and Port Clarence in 1977.

Both threespine and ninespine stickleback were present in the study area with ninespine stickleback being among the most widely distributed species (Figure 77). This species was also found in the surface waters of Norton Sound in June 1977 between Cape Denbigh and Cape Darby. Ninespine stickleback were more widely distributed in marine waters than threespine stickleback and were the fifth most frequently occurring species (25.5%) sampled within beach seines.

Threespine stickleback were only found in the Port Clarence area with the exception of a single specimen captured in Golovin Bay in August 1976. Threespine stickleback appeared to be primarily confined to marine estuaries of relatively low salinity. Thus, ninespine stickleback appeared to be more tolerant of marine waters. Wolotira et al. (1977) also documented ninespine stickleback in demersal trawl catches in 1976.

Several species of cottids were present in the study area and this family (Cottidae) ranked eighth and nineth by frequency of occurrence of all families sampled in gillnets and beach seines, respectively. In contrast, Wolotira et al. (1977) reported this family ranked third in estimated biomass suseptible to trawls of all fish species captured during offshore demersal sampling of Norton Sound and the southern Chukchi Sea in 1976. Overall, this family constituted only 2% of the estimated biomass of all fish and invertebrae taxa captured in offshore demersal regions. Larval cottids were common in the offshore surface waters of Norton Sound in June 1977.

The distribution of whitespotted greenling and rock greenling in nearshore waters differed (Figure 79). Rock greenling were present in Port Clarence, Golovin Bay and southeastern Norton Sound between Tolstoi Point and the Unalakleet River. In contrast, whitespotted greenling were primarily confined to the Golovin Bay area. This species was found at only one other area; just north of Tolstoi Point. The family Hexagrammidae ranked seven by frequency of occurrence of all families captured in gillnets. However, in no area did species of this family constitute more than 0.4% of the total catch composition. Frequency of occurrence and relative abundance of rock greenling was greatest in southeastern Norton Sound. Wolotira et al. (1977) reported only the whitespotted greenling was captured during their surveys in September and October 1976.

Bering wolffish were documented only in Port Clarence and Golovin Bay. Only three adult specimens were obtained in nearshore waters. Three juvenile wolffish (42 mm, 42 mm and 50 mm) were captured in offshore surface waters of Norton Sound in June 1977 (Figure 48). This species was also taken in demersal trawls in the offshore waters of Norton Sound and the southern Chukchi Sea in September and October 1976 (Wolotira et al. 1977).

A single liparid (ringtail snailfish) was captured in August 1976 in eastern Norton Sound. Larval lipards were captured in offshore surface waters of Norton Sound as far north as Cape Prince of Wales in June 1977.

AREAS OF CONCERN AND NEEDS FOR FURTHER STUDY

It is not within the scope of this paper to determine the possible or probable impacts of oil pollution on fishery resources in our study area. However, we attempt to point out and identify possible areas of concern where further studies may be warrented.

Hayes et al. (1977) derived a scale of environmental susceptibility to oil spill impacts on the basis of two case studies: The Metula spill in the Strait of Magellan on August 9, 1974 and the Urguiola spill along the northwestern coast of Spain on May 12, 1976. Their scale relates primarily to the longevity of oil in each environment and is listed below in order of increasing susceptibility to oil spills.

1. Straight, rocky headlands:

   "Most areas of this type are exposed to maximum wave energy. Waves reflect off the rocky scarps with great force, readily dispersing the oil. In fact, waves reflecting off the scarps at high tide tend to generate a surficial return flow that keeps the oil off the rocks." Herring spawning in much of Norton Sound is associated with this habitat type and may be typified by such areas as Cape Denbigh, Bald Head and Bluff.

2. Eroding wave-cut platforms:

   "These areas are also swept clean by wave erosion. All of the areas of this type at the Metula spill site had been cleaned of oil after one year. The rate of removal of the oil would be a function of the wave climate. In general, no clean-up procedures are needed for this type of coast."

3. Flat, fine-grained sandy beaches:

   "Beaches of this type are generally flat and hard-packed. Oil that is implaced on such beaches will not penetrate the fine sand. Instead, it usually forms a thin layer on the surface that can be readily scraped off by a motorized elevated scraper or some other type of road machinery. Furthermore, these types of beaches change slowly, so burial of oil by new deposition would take place at a slow rate."

4. Steeper, medium to coarse-grained sandy beaches:

   "On these beaches, the depth of penetration would be greater than for the fine-grained beaches (though still only a few centimeters), and rates of burial of the oil would be greatly increased. Based on earlier studies...it is possible for oil to be buried as much as 50-100 cm within a period of a few days on beaches of this class. In this type of situation, removal of the oil becomes a serious problem, inasmuch as it would be necessary to destroy the beach in order to remove the oil....Another problem is that burial of the oil preserves it for release at a later date when the beach erodes as part of the natural beach cycle, thus assuring long-term pollution of the environment."

5. Impermeable muddy tidal flats (exposed to winds and currents):

   "One of the major surprises of the study of the *Metula* site was the discovery that oil did not readily stick to the surfaces of mud flats. Also, penetration into the sediments was essentially non-existent. Therefore, if an oiled tidal flat is subject to winds and some currents, the oil will tend to be eventually removed, although not at the rapid rate encountered on exposed beaches." Typical examples of this habitat type include the Yukon River Delta and the Unalakleet and Shaktoolik rivers in eastern Norton Sound.

6. Mixed sand and gravel beaches:

   "On beaches of this type, the oil may penetrate several centimeters, and rates of burial are quite high (a few days in Spain). The longevity of the oil at the *Metula* site, particularly on the low-tide terraces and berm top areas, attests to the high susceptiblilty of these beaches to long-term oil spill damage." A large majority of the beaches in Norton Sound are of this type.

7. Gravel beaches:

   "Pure gravel beaches have large penetration depths (up to 45 cm in Spain). Furthermore, rapid burial is also possible. A heavily oiled gravel beach would be impossible to clean up without completely removing the gravel." Most of the Seward Peninsula coastline falls into this class.

8. Sheltered rocky headlands:

   "....Oil tends to stick to rough rocky surfaces. In the absence of abrasion by wave action, oil could remain on such areas for years, with only chemical and biological processes left to degrade it." Few areas in Norton Sound can be found with this type of coastal morphology; most rocky coasts are exposed.

9. Protected estuarine tidal flats:

"Once oil reaches a backwater, protected, estuarine tidal flat, chemical and biogenic processes must degrade the oil if it is to be removed." Much of the Seward Peninsula coastline from Golovin Bay to Kotzebue Sound is characterized by embayments and inlets which fall into this class. They represent an important habitat type for spawning herring in these areas. It is probable that removal by chemical and biogenic processes would proceed at a slow rate in cold environments.

10. Protected estuarine salt marshes:

"In sheltered estuaries, oil from a spill may have long-term deleterious effects....Oil from the Metula on the salt marshes of East Estuary, on the south shore of the Strait of Magellan...showed essentially no change in 1-1/2 years." Hayes et al. predicted a life span of at least 10 years for that oil. The Yukon River Delta is perhaps the most typical example of this habitat type in our area.

The possible general effects of an oil spill on fishery resources have been summarized by Trasky et al. (1977) and can be considered as either acute or chronic in nature. They state, "acute oil spills are those that result from a single infusion of oil into the marine environment from an accidental spill....Chronic oil pollution is the discharge of hydrocarbons into the marine environment either continuously or sufficiently often that the biota does not have time to recover between doses."

Our studies indicate, that during the open water period from breakup to freezeup, anadromous species comprise the bulk of fish (by percent composition) inhabiting coastal waters. Consequently, they would be among the most vulnerable to disruption from oil pollution. These species collectively dominate the subsistence fishery in our area with salmon species comprising nearly all of the commercial fishery income.

Kendel et al. (1975) speculated that anadromous Arctic fish populations other than salmon encountered during their studies can withstand short term and to a lesser degree long term fluctuations of the marine environment due to their life history patterns. His reasons were as follows:

a. Spawning occurs in freshwater, hence mass disruption of this critical life stage is not likely to occur;

b. Residence at sea of mature populations is limited to two to three months annually (possibly longer in our area);

c. The distribution of species is widespread;

d. The great variance of age classes insures that survival is not dependent on any single year class (Craig and McCarty 1975, not seen by author); and

e. Differences in habitat preference by various life stages ensures that entire populations are not affected by disruptions in a given area.

Although little is known about the life history of anadromous forms in our area it is probable that great similarities exist between them and those anadromous populations described by Kendel. Consequently, it is not likely that acute oil spills as defined by Trasky et al. (1977) would eliminate an entire population. However, long term chronic pollution problems could have deleterious effects upon these fishery resources by disrupting any of the numerous events necessary for feeding, migration, spawning, etc.

Certain marine forms are also abundant in coastal waters during the ice free period; some showing both spatial and temporal separation throughout our study area. Herring for example, are known to spawn only in the spring immediately following ice breakup along various coastal habitats ranging from those of low susceptibility (e.g., Cape Denbigh) to those of high susceptibility (e.g., Imuruk Basin). Although herring provide the second most important source of commercial fishery income, their commercial exploitation in our area has not been fully realized as in other areas of the Bering Sea.

Major contamination of herring spawning habitats during the spring months could have catastrophic effects upon these populations depending upon recruitment from previous years. It is more likely that spawning populations along the Seward Peninsula which utilized shallow lagoons, bays and inlets would be most effected because these habitats are impacted to a greater extent by chronic pollution than exposed rocky headlands which are primarily utilized by spawning herring populations in the eastern portion of Norton Sound. An acute oil spill in either habitat type during the spring spawning period could conceivably eliminate an entire year-class of herring from the affected area.

In general, several coastal sections throughout our study region would be high risk areas based upon the criteria described by Hayes et al. (1977). Perhaps one of the most vulnerable would be the Yukon River Delta, a habitat type having the highest susceptibility rating. The Yukon River Delta is perhaps the most important ecosystem in the Norton Sound-Kotzebue Sound areas in terms of biomass of fish produced. The delta complex encompasses approximately 3,900 square kilometers and is subject to potential impact from oil exploration and development. Contamination of this area could have catastrophic effects upon fishery resources common to the region. Among these resources are the commercially important salmon species as well as ciscos, sheefish and other whitefish, all of which are major subsistence fishery items to local residents. It is also likely that heavy pollution of this area could be spread to other areas of Norton Sound by Bering Sea currents.

At least two seasons of work in the delta area are needed. Studies should be designed to determine the seasonal distribution and movement by species into and within the study area, growth and relative maturity of major species and trophic relationships.

A second area which is nearly certain to be impacted from petroleum related activities and one which exists as having variable susceptibility ratings is the Port Clarence/Grantley Harbor complex. Port Clarence is the only deep water harbor north of Dutch Harbor. Consequently, it could be an important staging or refueling stop for large vessels associated with oil activities, particularly if leasing of the Norton Sound area occurs. Potential impact also exists from activities even further north in the Arctic Ocean. Only a single season of work has been conducted in this area during our investigations. Our studies merely documented various species which occur and also that nearly 100% of all fish harvested locally are utilized for subsistence needs. Such species include salmon, Arctic char, ciscos and other whitefish species, flounder, saffron cod, smelts and herring. Of the three major areas in the Port Clarence region, Imuruk Basin possesses the highest susceptibility to spills based upon Hayes' criteria. It was in this area that the largest number of juvenile herring (Ages 0, I and II) were found. Imuruk Basin is probably an important overwintering and/or rearing area for other species as well.

That a major oil spill in Port Clarence or Grantley Harbor could impact Imuruk Basin was observed during our studies in 1977. A sinking gillnet was deployed on September 30 at the mouth of the Tuksuk channel in Grantley Harbor. Within one to two hours the net was recovered approximately three to four kilometers up the Tuksuk Channel near Imuruk Basin. It had been carried by deep currents flowing up the channel from Grantley Harbor toward Imuruk Basin; currents which flowed in the opposite direction of outflowing surface water.

Studies should be conducted in the Port Clarence/Grantley Harbor complex to determine trophic relationships for major fish species, spawning and rearing areas, and also to examine age dependent movement of populations and seasonal growth characteristics.

Virtually nothing is known concerning the range, distribution, relative abundance, age structures or relative maturity of fishery resources during the winter months (that period from freezeup to breakup). This period encompasses roughly seven months of the year, usually from the end of October through early June. The lack of knowledge makes it difficult to even conjecture the degree of vulnerability for that time period.

Age, sex, size and maturity information as well as abundance and distribution of major species in winter months should be obtained. It is reasonable to assume that seasonal variation occurs especially in the case of anadromous species. Approximately 26% (10 species) of the species in the coastal waters of Norton Sound during the ice free period (1976-77 OCS studies) are anadromous, 24% freshwater, and 50% marine forms. Undoubtedly, marked shifts in abundance and distribution occur during the winter months. Many marine and/or anadromous forms could be greatly affected by petroleum pollution during the winter months and at critical times of their life cycle. This is especially applicable for some herring populations where juveniles apparently overwinter in several lagoon areas along the Seward Peninsula.

Winter sampling would be difficult due to weather conditions in the study area for that period of the year. Consequently, such studies should be conducted for at least two years, working selected areas each year. Winter weather conditions would create logistical problems not encountered during the ice free period, consequently, large coastal sections (e.g., St. Michaels to Nome) could not be sampled in a single winter. Important areas to be sampled would include Shismaref Inlet, Port Clarence, Golovin Bay and south and eastern Norton Sound (St. Michael to Cape Denbigh). South and eastern Norton Sound could be sampled in one winter. Shismaref Inlet and the Port Clarence area could be sampled in a second year, possibly, along with Golovin Bay.

CONCLUSIONS

1. Subsistence utilization of fishery resources depends to a great extent upon seasonal availability although about seven families of fish are used by almost all villagers to some degree: Clupeidae, Osmeridae, Gadidae, Pleuronectidae, Salmonidae, Coregonidae and Thymallidae.

2. Herring use as a subsistence item is greater in Norton Sound than in Kotzebue Sound. However, subsistence use throughout the study area is markedly low in comparison to the Yukon-Kuskokwim region. Use is influenced by abundance of herring, village location, marine and large terrestrial mammal harvests as well as employment opportunities.

3. Spawning herring populations north of the Yukon River are relatively small in comparison to those in the southern Bering Sea (Bristol Bay). The relative abundance of herring throughout the study area has decreased from historic levels.

4. Timing of herring spawning throughout the study area is associated with spring breakup (ice recession) of the Bering Sea. Spawning generally commences in southern Norton Sound in early June and occurs progressively later to the north; as late as August in parts of Kotzebue Sound.

5. Some herring spawning occurred prior to ice breakup in the Port Clarence area in 1977 based on the presence of young-of-the-year herring and post spawning adults immediately at ice breakup.

6. There are basically two habitat types associated with herring spawning; exposed rocky headlands in the Norton Sound area and shallow embayments and lagoons on the Seward Peninsula.

7. Sexual maturity of herring in our area begins mainly in the third year, also in the fourth and rarely in the fifth year. Sexual maturity may occur later in herring populations further north.

8. Independent stocks of herring occur north of Norton Sound. These herring differ significantly in size and behavioral characteristics from those in Norton Sound and southward, into the southern Bering Sea. Herrings north of Norton Sound have a smaller mean size-at-age and spawn, overwinter and rear in shallow lagoons and embayments; as such are considered euryhaline in salinity tolerance.

9. Pacific herring are widely distributed throughout coastal and offshore waters of Norton Sound in the fall and early winter.

10. Juvenile pink and chum salmon are present in the nearshore coastal waters of Norton Sound from ice breakup through about the first week of July. Both species exhibit similar growth rates during this period.

11. There appears to be no stock separation by river bank of smolting chum salmon in the Yukon River.

12. Arctic char populations throughout coastal marine waters of Norton Sound are likely a mixture of stocks from various rivers; the degree of mixing is not known.

13. The relative abundance of Arctic char in the coastal waters of Norton Sound is greatest in the spring and early summer months. Juvenile Arctic char (less than 200 mm) are not present in coastal marine waters in significant numbers approximately one month after ice breakup.

14. The frequency of occurrence and abundance of finfish species is greatest in nearshore surface waters. However, both vary spatially and temporally throughout the study area.

15. Although species diversity of finfish is similar among all areas in nearshore waters, abundance appears to be lowest in the southern and eastern portion of Norton Sound as opposed to either Golovin Bay or the Port Clarence area.

16. At least 90% of the anadromous species, 75% freshwater species and 30% marine species occurring in nearshore waters are utilized for subsistence purpose. Approximately 60% of the anadromous species, 10% freshwater species and, at present, 5% of marine species are harvested commercially by domestic fisheries.

17. The distribution of larval finfish is widespread throughout nearshore and offshore surface waters of Norton Sound during spring and early summer. This is particularly true of larval boreal smelt in nearshore waters and larval saffron cod in offshore surface waters.

18. Further studies are needed in the Norton Sound area to ensure proper planning and development of petroleum related activities.

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APPENDIX TABLES

Table 1 . Northern Bering Sea fall herring production, 1916-1941.

Year	Location	Number of Processors	Scotch Cured Barrels	Scotch Cured Half Barrels	Hard Salted Barrels	Remarks
1916	Golovin	4	559*			*Norwegian pack as opposed to Scotch style.
	Teller	1	9*			
1917 1/	Golovin	5	1,275*			1/ Introduction of Scotch method of curing by U.S. Bureau of Fisheries.
	Teller	1	300*			
1918	Golovin	11	5,169* 2/			
	Council	1	167*			
1919	Golovin	6	2,555* 3/			2/ Includes 500 bbls. of Scotch style.
1920	Golovin	4	331			
1921	Golovin	1	562			3/ Includes 900 bbls. of Scotch style.
	St. Michael	1	60			
1922	Golovin	2	500			
1923	Golovin	1	352			
1924	Golovin	1	750			
1925	Golovin	1	200			
1926	Golovin	1	620			
1927	Golovin	1	490	100		
1928	Golovin	1	850 4/	370		4/ Includes 435 bbls. of bloater stock.
1929	Golovin	1	200* 5/	887*		
1930	Golovin	3	1,637 6/	1,614		5/ Plus an additional 432 half tierces of bloater stock.
1931	Golovin	2	219 7/	180		
1932	Golovin	3	3,533 8/	905		6/ Includes 26 tierces and 500 half tierces; plus an additional 62 tierces of roused herring.
1933	Golovin	2	8 9/	75		
1934	Golovin	1		42	100	
1935	Golovin	1		57	96	7/ Plus an additional 238 half tiercse of bloated stock.
1936	No commercial operations reported					
1937						8/ Plus an additional 31 tons of bloater stock.
1938	Golovin	1		35	62	
1939	Golovin	1		27	30	9/ Plus an additional 25 tons of bloater stock.
1940	Golovin	1	16	22	85	
1941	Golovin	1			30	

Summary: 10/

3,201,625 lbs.	Scotch cured (52.0%)
2,319,375 lbs.	Norwegian cured (37.7%)
488,750 lbs.	Bloater stock (7.9%)
100,750 lbs.	Hard salted (1.6%)
49,600 lbs.	Roused herring (0.8%)
6,160,100 lbs.	All products (1916-1941)

10/ One full barrel contains 250 pounds of herring. Three size grades were packed: large herring (No. 1) measuring 30-33 cm total length were packed 450 to a barrel; No. 2 herring went 550 to a barrel; No. 3 herring went 650-700 to a barrel (Wigutoff and Carlson, 1950). One tierce equals 800 pounds (Pacific Fisherman, 1931). A total of 98.6% of the total production from 1916-1941 was processed in Golovin.

Table 2. Commercial harvest of spring herring for roe extraction in Norton Sound, 1964-1977.

Year 1/	Production Location	Herring Pounds	Herring Metric Tons	Sac Roe (Pounds)	Percent Recovery	Remarks
1964	Unalakleet	40,000	18.1	2,520	6.3	Roe product poor due to poor handling methods.
1965		NO DOMESTIC COMMERCIAL OPERATIONS				
1966	Golovin	23,700	10.8	-	-	
1967-68		NO DOMESTIC COMMERCIAL OPERATIONS				First foreign effort on herring occurred in Norton Sound in 1968.
1969	Unalakleet	$\lesssim$4,000	$\lesssim$1.8	$<$350	$\simeq$8.7	Heavy foreign effort. Two Japanese vessels apprehended near St. Michael.
1970	Unalakleet	16,000	7.3	1,345	8.4	
1971	Unalakleet	39,000	17.7	3,180	8.2	
1972	Unalakleet	33,706 2/	15.3	8,734	25.9 3/	
1973	Unalakleet	71,264	32.3	2,160	3.0	
1974	Unalakleet	5,264	2.4	0	0	Roe loss due to herring spoilage in the round and poor quality of roe.
1975		NO DOMESTIC COMMERCIAL OPERATIONS				
1976	St. Michael	17,000	7.7	?	?	
1977 4/	Unalakleet	20,896	9.5	1,254	6.5	Herring fishing closed to all foreign nations by Secretary of Commerce.
	Total	270,830	122.8			

1/ Approximately six million pounds of fall herring were commercially processed in Norton Sound from 1916-1941.
2/ Approximately 1,200 pounds of this amount was taken in Nome.
3/ The value of this figure suggests that female herring only may have been reported.
4/ First commercial harvest of roe on kelp occurred; 743 pounds were taken June 25 at Cape Denbigh.

Table 3 . Herring production of Japan and USSR in the eastern Bering Sea, 1964-1977 1/

Year 2/ (July - June)	Trawl Fishery USSR 3/	Trawl Fishery Japan	Japanese Gillnet Fishery	Total
1964-65	-	1,362		--
1965-66	-	3,117		-
1966-67	-	2,831		-
1967-68	9,800	9,486	818	20,104
1968-69	75,379	50,857	1,949	128,185
1969-70	92,228	23,901	1,585	117,714
1970-71	60,126	24,236	4,603	88,965
1971-72	67,547	13,143	472	81,162
1972-73	39,999	346	1,878	42,223
1973-74	16,810	219	3,337	20,366
1974-75	15,039	2,663	736	18,438
1975-76	9,518	2,728 4/	2,668 4/	14,914
1976-77	18,104	1,766	- 5/	19,870

1/ All harvests expressed in metric tons. Source of Japanese catches from INPFC documents while USSR catches furnished under provisions of US-USSR bilateral agreements.

2/ Trawl fishery normally occurs from Nov to Apr while the gillnet fishery lasted from April to June.

3/ The USSR trawl fishery began in 1961, but harvest data was not available until 1967.

4/ Preliminary.

5/ Japanese gillnet fishery closed.

Table 4. Japanese gillnet herring catches in Norton Sound (north of 63° N. latitude and east of 167° W. longitude) 1968-77.

Year	Gillnet Catch 1/	Remarks
1968	0.119	First foreign effort on herring in Norton Sound.
1969	1.270	Peak catch with large effort (about 40 ships). Two vessels apprehended.
1970	0.063	
1971	0.638	
1972	0.014	
1973	0.035	
1974	0.693	
1975	0	
1976	-	Data unavailable at time of writing this report.
1977	-	Herring fishery closed to foreign nations.
Total	2.832	Excludes 1976 catches.

1/ Catch expressed in thousands of metric tons. All catches were made in the second quarter April through June.

Table 5. Census areas from the Yukon River Delta to Point Hope, 1976-77.

Census Areas				Linear Shoreline Distance		Census Area 1/ Mid Point (km)
Area	No.	North* Latitude	West* Longitude	Miles	km	
Black River-North Mouth Yukon River	31	63°08'30"	164°33'50"	120.0	193.0	96.5
North Mouth Yukon River-Canal Point	32	63°12'30"	162°47'20"	40.9	65.8	32.9
Canal Point-Cape Stebbins	33	63°28'40"	162°18'00"	12.3	19.8	9.9
Stuart Island	34	63°33'05"	162°20'30"	41.9	67.5	Perimeter
Cape Stebbins-St. Michael	35	63°30'50"	162°08'00"	15.5	25.0	12.5
St. Michael- Klikitarik	36	63°27'05"	161°57'05"	18.3	29.5	14.8
Klikitarik-Unalakleet River	37	63°37'30"	161°01'00"	40.4	65.0	32.5
Unalakleet River-Cape Denbigh	38	64°13'45"	160°58'15"	52.8	85.0	42.5
Cape Denbigh-Bald Head	39	64°38'40"	160°47'30"	80.8	130.0	65.0
Bald Head-Cape Darby	40	64°41'10"	162°08'10"	70.5	113.5	56.8
Cape Darby-South Spit	41	64°36'10"	163°06'00"	55.9	90.0	45.0
South Spit-Topkok Head	42	64°30'20"	163°20'35"	36.0	58.0	29.0
Topkok Head-Point Spencer	43	64°30'00"	165°24'20"	94.4	152.0	76.0
Point Spencer-Cape Prince of Wales	44	65°18'40"	166°17'54"	124.3	200.0	100.0
Cape Prince of Wales-Cape Espenberg	45	66°15'50"	166°04'00"	149.1	240.0	120.0
Cape Espenberg-Kiwalik	46	66°07'10"	163°51'00"	127.4	205.0	102.5
Kiwalik-Point Garnet(Choris Pen.)	47	66°11'35"	160°59'30"	90.1	145.0	72.5
Point Garnet - Selawik Lake entrance	48	66°56'15"	162°31'20"	119.6	192.5	96.3
Selawik Lake entrance-Sheshalik	49	67°00'40"	161°38'50"	111.8	180.0	90.0
Sheshalik-Point Hope	50	67°43'25"	164°36'00"	149.1	240.0	120.0
Total	31-50			1,551.1	2,496.6	

1/ Linear shoreline distance on either side of census area mid point.

* Latitude and Longitude of mid point of census area.

Table 6. Characteristics and indices used to determine the relative maturity of Pacific herring.

Index	Key Characteristics
I	Virgin herring. Gonads very small, threadlike, 23 mm broad. Ovaries wine red. Testes whitish or grey-brown.
II	Virgin herring with small sexual organs. The height of ovaries and testes about 3-8 mm. Eggs not visible to naked eye but can be seen with magnifying glass. Ovaries a bright red color; testes a reddish-grey color.
III	Gonads occupying about half of the ventral cavity. Breadth of sexual organs between 1 and 2 cm. Eggs small but can be distinguished with the naked eye. Ovaries orange; testes reddish-grey or greyish.
IV	Gonads almost as long as body cavity. Eggs larger varying in size, opaque. Ovaries orange or pale yellow; testes whitish.
V	Gonads fill body cavity. Eggs large, round; some transparent. Ovaries yellowish, testes milkwhite. Eggs and sperm do not flow, but sperm can be extruded by pressure.
VI	Ripe gonads; eggs transparent; testes white. Eggs and sperm flow freely.
VII	Spent herring. Gonads baggy and bloodshot. Ovaries empty or containing only a few residual eggs. Testes may contain remains of sperm.
VIII	Recovering spent. Ovaries and testes firm and larger than virgin herring in Stage II. Eggs not visible to naked eye. Walls of gonads striated; blood vessels prominent. Gonads wine red color. This Stage passes into Stage III.

Table 7 . Relative size and abundance of herring schools from aerial surveys conducted from Stuart Island to Point Garnet (Eschscholtz Bay), from June 9 through October 28, 1977.

Area Surveyed 1/	Date	Survey Rating Index 2/	Fish School Size 3/					Spawn Observations		Remarks
			small	medium	large	unc.	total	No.	Su. Area (m2)	
Stuart Island (34a - 34d)	6/15	F					none			
	6/22	P					none			
Cape Stebbins to Unalakleet (35, 36, 37)	6/9	G-E					none			
	6/15	G-F					none			
	6/17	G-P					none			
	6/22*	F-P	1				1			
Total			1				1			
Unalakleet to Shaktoolik River (38a, 38b)	6/9	E-G					none			
	6/14	G					none			
	6/15*	G-F	23				23			3 small schools near Egavik; remainder between Shaktoolik & Shaktoolik River.
	6/17	G					none			
	6/22	P					none			
	6/25	F						1		Adjacent to Beeson Slough.
	7/21	F					none			
Total			23				23	1		
Shaktoolik River to Island Point (Cape Denbigh) (38c, 39a, 39b)	6/9	E-G					none			
	6/14	G	20	2			22			2 small schools south of Cape Denbigh; remainder between Cape Denbigh & Pt. Dexter.
	6/15	G-F	23	3	3		29			5 small and 1 med school near Pt. Dexter, remainder between C. Denbigh & Shaktoolik R.
	6/17*	G	41	12	4		57			2 large & 1 med school just south of Cape Denbigh; remainder between Cape Denbigh and Pt. Dexter.
	6/22	P	1	2			3			Schools all on N. side of Cape Denbigh.
	6/25	F		3			3			Schools all on N. side of Cape Denbigh.
	7/21	G					none			
Total			85	22	7		114			
Kuiukrulik River to Kwik R. (Bald Head) (39d, 40a)	6/14	G					none			
	6/15*	F	5	1			6			Schools at Bald Head.
	6/17	E	2				2			Schools at Bald Head.
	6/25*	F	4	3			7			Schools between Bald Head & Kuiukrulik R
	7/21	G					none			
Total			11	4			15			
Kwik River to Cape Darby (40b, 40c, 40d)	6/9	E-G					none			
	6/14	G					none			
	6/15	F					none			
	6/17	E					none			
	6/22	U					none			
	6/25*	F	3	5			8			4 med schools at Elim; remainder off-shore at Moses Pt.
	7/21	G					none			
Total			3	5			8			
Cape Darby to Rocky Point (Golovin Bay) (41a, 41b, 42a)	6/14*	G	3				3			Schools at Carolyn Island.
	6/17	F					none			
	6/22	U					none			
	6/25*	F	4	7			11			One med at Rocky Pt; remainder on east side of bay between Cape Darby and Golovin
	7/21	G					none			
Total			7	7			14			
Rocky Point to Cape Nome (42b, 42c, 43a)	6/14*	G	5				5			Schools near Topkok Head.
	6/17*	F	10	2			12			Schools from Rocky Pt. to Topkok Head.
	7/10	F					none			
	7/21	G					none			
	8/29	U								Several small schools seen (Rocky Pt. to Topkok Head) believed to be sand-lance.
	9/1						none			
Total			15	2			17			
Cape Nome to Point Spencer (43b, 43c, 43d)	6/21	F					none			
	6/28*	G	5				5			Schools at mouth of Cripple Cr. Species unknown.
	7/10	F	2	4			6			Schools between Cape Wooley & Cape Douglas.
	7/11*	F	8	14	1		23			Schools from Sinuk R. to Cape Douglas.
	7/21*	G	21	15	10		46			Schools from Cripple Cr. to Pt. Spencer.
	8/4	U					none			Capelin carcass survey.
	8/6	G					none			Ft. Davis - Penny R.
	8/23*	F	2				2			Schools about 2 miles east of Sinuk R.
	10/16	U					none			
Total			38	33	11		82			

(Table Continued)

Table 7 continued. Relative abundance of herring schools from aerial surveys conducted from Stuart Island to Point Garnet (Eschscholtz Bay) from June 9 through October 28, 1977, shown by school size.

Area Surveyed 1/	Date	Survey Rating Index 2/	Fish School Size 3/ small	medium	large	unc.	total	Spawn Observations No.	Su. Area (m2)	Remarks	Remarks
Point Spencer to Wales (Port Clarence/Grantley Harbor) (44a - 44f)	6/21	U					none			Shore ice - too early.	
	6/28	P					none				
	7/10	F					none				
	7/11	F	1				1			School near Lost River (No survey Pt. Clarence).	
	7/21*	G	18	6	2		26			Two small & 1 med inside Pt. Clarence & Pt. Spencer; 10 small & 1 med. from Brevig to Grantley Harbor; remainder in Grantley Harbor @ Teller & Tuksuk Channel. Believed to be herring.	
	8/6	G					none				
	8/13	P					none			Survey of Lost R. area only.	
	8/20	U					none			Survey of Lost R. area only. Poor water visibility - turbid.	
	8/23	F					none				
	9/9	G					none				
	10/16	U					none				
Total			19	6	2		27				
Wales to Shishmaref (45a and 45c)	7/11*	E	16	16	11		43			Schools migrating north; believed herring.	
	8/6*	P	9	3			12			Schools believed to be herring.	
	8/13	P					none				
	8/20*	U	1	1			2			Turbid water - species unknown.	
	9/9	F					none				
	10/8	U					none			Turbid water & high winds.	
	10/26	U					none			Blowing snow - survey aborted.	
	10/28	U					none			Blowing snow - survey aborted.	
Total			26	20	11		57				
Shishmaref to Cape Espenberg (45e and 45h)	7/11*	E	15	17	16		48			Schools all along coastline. Many in lagoon entrance to Shishmaref Inlet and Cowpack Inlet. Fish believed to be herring.	
	7/15	E	10	8	4		22			Surveyed only Shishmaref to Kividlo.	
	8/6	U					none				
	8/20*	U	6	2			8			Turbid water - species unknown.	
	9/9	F					none				
	10/8	U					none			Turbid water and high winds.	
	10/26	U					none			Blowing snow-survey aborted.	
	10/28	U					none			Blowing snow-survey aborted.	
Total			31	27	20		78				
Cape Espenbert to Good Hope (River (46a)	7/11	F-P					none			Turbid water and shallow. Poor surveyable area.	
	9/9	U					none				
Goodhope River to Kiwalik (46b, 46c, 46d, 46e)	7/11	G					none				
	7/20*	E	9	8	2		19			Schools from Rex Pt. to Ninemile Pt.	
	8/13	U		1	1		3	1(?)		Schools & possible spawn just east of Cape Deceit & Deering.	
	8/20*	P	17	1			18	1(?)		One med & 1 small just east of Clifford Pt. 16 small about 2 miles east of Ninemile Pt. Possible spawn at Ninemile Pt. Fish believed to be herring	
Total			26	10	3	1	40	2(?)			
Kiwalik to Point Garnet on Choris Peninsula (47a, 47b, 47c)	7/11	G					none			Partial survey to Buckland.	
	7/20*	F	1	2	1		4			One med & 1 large school in Kiwalik; One small & 1 med school on east side of Choris Pen. 66 Beluga moving west on south side of Baldwin Pen.	
	8/20	P					none			Partial survey to Buckland.	
Total			1	2	1		4				
TOTAL 1977 COUNT			286	138	55	1	480	1			

1/ Number in parenthesis indicate census areas.
2/ Survey rating index: E - excellent; G - good; F - fair; P - poor, U - unacceptable.
3/ Classification to fish schools: small - surface area estimate less than 50 m2 (500 ft2).
medium - surface area estimate 50 - 450 m2 (500 - 5,000 ft2).
large - surface area estimate greater than 450 m2 (5,000 ft2).
unclassified - surface area estimate not made.

*Relative Abundance Index (RAI): Days on which survey counts were used for determining the relative abundance of fish schools in a given area of the coastline. If sightings in a given area were within 10 - 15 days of each other, they were considered to be the same fish schools. The dates used to arrive at the RAI for a given area do not necessarily coincide with peak spawning.

Table 8. List of fish species collected in nearshore coastal waters of Norton Sound, 1976-77.

Species	Common Name
CLUPEIDAE	
Clupea harengus pallasi	Pacific herring
SALMONIDAE	
Oncorhynchus keta	Chum salmon
Oncorhynchus gorbuscha	Pink salmon
Oncorhynchus kisutch	Coho salmon
Oncorhynchus tshawytscha	King salmon
Oncorhynchus nerka	Sockeye salmon
Salvelinus alpinus	Arctic char
COREGONIDAE	
Stenodus leucichthys	Inconnu (sheefish)
Coregonus lauretta	Bering cisco
Coregonus sardinella	Least cisco
Coregonus pidschian	Humpback whitefish
Coregonus nasus	Broad whitefish
Prosopium cylindraceus	Round whitefish
OSMERIDAE	
Osmerus eperlanus (*mordax dentex*)	Boreal (American, toothed) smelt
Mallotus villosus	Capelin
Hypomesus olidus	Pond smelt
AMMODYTIDAE	
Ammodytes hexapterus	Sand lance
GADIDAE	
Eleginus gracilis	Saffron cod
Lota lota leptura	Burbot
HEXAGRAMMIDAE	
Hexagrammus lagocephalus	Rock greenling (terpug)
Hexagrammus stelleri	Whitespotted greenling
LIPARIDAE	
Liparis rutteri	Ringtail snailfish
AGONIDAE	
Pallasina barbata aix	Tubenose poacher
Ocella dodecaedria	Bering poacher
Agonus acipenserinus	Sturgeon poacher
PLEURONECTIDAE	
Platichthys stellatus	Starry flounder
Liopsetta glacialis	Arctic flounder
Liopsetta bilineata	Rock flounder
Pleuronectes quadrituberculatus	Alaska plaice
Limanda aspera	Yellowfin sole (muddab)
Limanda proboscidea	Longhead dab
GASTEROSTEIDAE	
Pungitius pungitius	Ninespine stickleback
Gasterocteus aculeatus	Threespine stickleback
STICHAEIDAE	
Lumpenus sagitta	Snake prickleback
Acantholumpenus mackayi	Pighead prickleback
ANARHICHADIDAE	
Anarhichas orientalis	Bering wolffish
ESOCIDAE	
Esox lucius	Northern pike
CATOSTOMIDAE	
Catostomus catostomus	Northern sucker (longnose)
COTTIDAE	
Species in this family were grouped.	

Table 9. Fish species composition for selecte reas in the coastal waters of Norton Sound, 1976-77.

CODE	CLASSIFI-CATION 1/	COMMON NAME	SCIENTIFIC NAME	A 76	A 77	B 76	B 77	C 76	C 77	D 76	D 77	E 76	E 77	F 76	F 77	G 77	H 77	I 77	FI 76	AR 77	URL 76	URL 77
PS	A	Pink Salmon	Oncorhynchus gorbuscha	x	x	x		x	x	x		x			x	x	x	x	x	x	x	
CS	A	Chum Salmon	Oncorhynchus keta	x	x	x	x	x	x	x	x				x	x	x	x	x	x	x	x
SS	A	Coho Salmon	Oncorhynchus kisutch	x	x	x		x	x	x		x				x		x	x	x		
KS	A	King Salmon	Oncorhynchus tshawytscha	x		x		x											x	x	x	x
RS	A	Sockeye Salmon	Oncorhynchus nerka													x	x					
HW	F	Humpback whitefish	Coregonus pidschian	x	x	x	x	x	x	x	x				x	x		x	x		x	x
BW	F	Broad whitefish	Coregonus nasus	x	x		x	x	x	x		x				x	x	x	x		x	x
RW	F	Round whitefish	Prosopium cylindraceus					x	x				x			x		x			x	
BC	A	Bering cisco	Coregonus laurella	x	x	x	x	x	x	x	x				x	x	x	x	x		x	x
LC	A	Least cisco	Coregonus sardinella	x	x	x	x	x	x	x	x	x				x	x	x	x		x	
SF	M	Starry flounder	Platichthys stellatus	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x		x	x
AF	M	Arctic flounder	Liopsetta glacialis	x	x	x	x	x	x		x				x	x	x				x	x
RF	M	Rock flounder	Liopsetta bilineata														x					
AP	M	Alaska plaice	Pleuronectes quadrituberculatus	x	x	x		x	x						x	x	x					
YS	M	Yellowfin sole (muddab)	Limanda aspera	x	x	x	x	x	x	x							x					
LD	M	Longhead dab	Limanda proboscidea			x		x														
TP	M	Tubenose poacher	Pallasina barbata aix	x	x	x	x	x	x						x	x	x					x
SP	M	Sturgeon poacher	Agonus acipenserinus	x						x												
BP	M	Bering poacher	Ocella dodecaedria	x	x	x		x	x	x												
MV	M	Capelin	Mallotus villosus	x				x									x					
PH	M	Pacific herring	Clupea harengus pallasi	x	x	x	x	x	x	x	x				x	x	x	x			x	x
BS	A	Boreal smelt (American, toothed)	Osmerus eperlanus (mordax dentex)	x	x	x	x	x	x	x	x			x	x	x	x	x	x		x	x
HO	A	Pond smelt	Hypomesus olidus		x	x		x	x						x	x	x	x			x	
SL	M	Sandlance	Ammodytes hexapterus	x	x		x				x			x	x	x	x					
S3	F	Threespine stickleback	Gasterocteus aculeatus	x												x	x	x				
S9	F	Ninespine stickleback	Pungitius pungitius	x	x	x		x		x	x	x			x	x	x	x	x			x
RG	M	Rock greenling (terpug)	Hexagrammus lagocephalus	x		x		x	x	x	x					x	x					
WG	M	Whitespotted greenling	Hexagrammus stelleri	x	x	x		x														
AC	A	Arctic char	Salvelinus alpinus	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x		x	x
SC	M	Saffron cod	Eleginus gracilis	x	x	x	x	x	x	x	x			x	x	x	x	x			x	x
LR	M	Ringtail snailfish	Liparis rutteri					x														
SH	F	Sheefish	Stenodus leucichthys																x	x		
NP	F	Northern pike	Esox lucius															x	x	x		
NS	F	Northern sucker (longnose)	Catostomus catostomus															x	x	x		
LL	F	Burbot	Lota lota leptura																x	x		
PR	M	Pricklebacks 2/	Stichaeidae 2/			x	x	x		x				x								
CT	-	Sculpins	Cottidae	x	x	x	x	x	x	x	x	x	x		x	x	x	x			x	x
WF	M	Bering wolffish	Anarhichas orientalis		x																	
		Total number species (less cottidae)		26	22	24	16	28	20	19	13	7	2	6	15	22	22	18	16	8 3/	15	13

AREA IDENTIFICATION:

A Golovin Bay
B Cape Denbigh - Egavik
C Egavik - Tolstoi Point
D Tolstoi Point - Cape Stebbins
E Fish River mouth
F Rocky Point - Bluff
G Grantley Harbor
H Port Clarence
I Imuruk Basin
FI Flat Island (south mouth Yukon River)
AR Anuk River (101 km upstream from Flat Island).
URL Unalakleet River lagoon

1/ A - anadromous; F - freshwater; M - marine.

2/ Includes two species: Lumpenus sagitta (snake prickleback) and Acantholumpenus mackayi (pighead prickleback).

3/ Juvenile Coregonidae were also captured.

Table 10 . Total catch by species, area and gear type of finfish captured in the nearshore waters of Norton Sound from May 30 through October 21, 1977.

Species	A BS	A GNF	A GNS	B BS	B GNF	B GNS	C BS	C GNF	C GNS	D BS	D GNF	D GNS	F BS	F GNF	F GNS	G BS	G GNF	G GNS	H BS	H GNF	H GNS	I BS	I GNF	I GNS	Totals BS	Totals GNF	Totals GNS	Unalakleet River Lagoon Catches 1/ BS
Pink salmon (adult)	0	5	0	0	5	0	0	6	0				0	2	0	0	2	0	0	7	0				0	27	0	0
Pink salmon (juvenile)	4,584	0	0				12	0	0				165	0	0				1	0	0	4	0	0	4,766	0	0	1
Chum salmon (adult)	0	20	0	0	3	0	0	7	0	0	1	0	0	35	0	0	1	0	0	5	0				0	72	0	0
Chum salmon (juvenile)	1,710	0	0				7	0	0				14	0	0	1	0	0				3	0	0	1,735	0	0	47
King salmon (juvenile)																												15
Coho salmon (adult)	0	3	0				0	4	0							0	1	0	0	3	0				0	11	0	
Coho salmon (juvenile)	12	0	0																						12	0	0	
Sockeye salmon (adult)																0	1	0	0	1	0				0	2	0	
Pacific herring (adult)	1	192	51	1	19	0				0	10	27	0	11	3	0	670	395	156	338	142	36	34	29	194	1,274	647	
Pacific herring (juvenile)	62	0	0	0	0	4	6	0	0							45	1	4	37	0	2	123	2	1	273	3	11	
Humpback whitefish	269	109	3	4	1	0	5	1	0	0	4	0	0	1	0	5	11	0	1	0	0	0	8	1	284	135	4	3
Broad whitefish	22	3	0	0	1	0	11	2	0							21	5	1	3	2	0	34	2	2	91	15	3	2
Round whitefish							0	1	0							4	1	0				13	8	1	17	10	1	
Bering cisco	174	35	4	47	16	2	20	30	0	0	10	0	1	0	0	29	24	4	63	35	10	23	30	6	357	180	26	4
Least cisco	611	104	9	3	23	0	0	24	0	1	25	0				31	42	0	5	34	1	160	27	12	811	279	22	
Arctic flounder	44	36	1	3	18	1	2	19	0	2	3	1	0	2	0	13	15	0	5	2	0				69	95	3	14
Rock flounder																			0	1	0				0	1	0	
Starry flounder	217	86	45	6	37	0	1	79	7	14	50	4	25	1	7	12	33	16	9	34	26	7	2	0	291	322	105	9
Alaska plaice	3	0	0				0	0	1				4	0	0	1	0	0	2	1	0				10	1	1	
Yellowfin sole (muddab)	1	0	11	0	2	0	10	0	1				0	0	1				0	1	0				11	3	13	
Tubenose poacher	75	1	0	1	0	0	2	0	0							9	0	0	11	0	0				99	1	0	1
Bering poacher	1	0	0				26	0	0																27	0	0	
Capelin																			1	0	0				1	0	0	
Boreal smelt	427	35	11	83	5	0	38	1	0	2	0	0	1	11	11	40	11	6	68	6	194	56	0	0	715	69	222	4
Pond smelt	1,554	7	1				3	2	0				25	0	0	1,830	2	13	2,543	1	1	3,962	11	0	11,917	23	15	
Sandlance	4,454	0	0	600	0	0				130	0	0	43,874	0	0	102	0	0	243	0	0				49,403	0	0	
Threespine stickleback																1	0	0	3	0	0	128	0	0	132	0	0	
Ninespine stickleback	251	0	0							1	0	0	1	0	0	12	0	0	36	0	0	318	0	0	619	0	0	3
Rock greenling							0	5	0	0	9	2				0	0	3	2	4	1				2	18	6	
Whitespotted greenling	5	5	26										0	0	1										5	5	27	
Arctic char	26	30	0	0	59	0	1	90	0	0	9	0	1	0	0	16	0	0	0	7	0	0	9	0	44	204	0	17
Saffron cod	392	179	69	375	11	2	62	2	2	0	20	6	1	7	3	252	48	36	221	56	29	7	17	31	1,310	340	167	27
Sculpin	13	29	8	2	7	0	1	7	0	1	2	2	2	0	0	7	4	2	1	7	0	12	8	0	39	64	12	7
Prickleback				71	2	0																			71	2	0	
Northern pike																						1	0	0	1	0	0	
Northern sucker																						1	0	0	1	0	0	
Wolffish	0	0	1																						0	0	1	
TOTALS	14,920	879	230	1,196	209	9	207	280	11	151	143	41	44,114	70	26	4,431	830	480	3,411	545	406	4,888	145	91	73,326	3,101	1,294	149

1/ These catches are not included in the "TOTALS" column.

Sampling areas are as follows: AREA A - Cape Darby to Rocky Point (Golovin Bay); AREA B - Cape Denbigh to Egavik; AREA C - Egavik to Tolstoi Point; AREA D - Tolstoi Point to Cape Stebbins; AREA F - Rocky Point to Bluff; AREA G - Grantley Harbor; AREA H - Port Clarence; AREA I - Imuruk Basin

AREA E (Fish River) catches are not included in table: 17 round whitefish, 1 sculpin and 2 starry flounders.
Gear type codes: BS - beach seine, GNF - gillnet floating (onshore), GNS - gillnet sinking (offshore).

Table 11. Species diversification by area of fin-fish captured in the coastal waters of Norton Sound from the Yukon River Delta to Port Clarence in 1976 and 1977 (OCS/RU 19).

	Golovin Bay Area			South and Eastern Norton Sound Area				Port Clarence Area				FI	URL	All Areas
	A	F	AF	B	C	D	BCD	G	H	I	GHI			Total
Freshwater	4	2	4	3	4	3	4	5	3	7	7	7	4	9 (23.7%)
Anadromous	9	6	9	9	9	7	9	9	8	8	9	8	8	10 (26.3%)
Marine	14	9	16	14	15	11	17	8	11	3	11	1	5	19 (50.0%)
Total	27	17	29	26	28	21	30	22	22	18	27	16	17	38
Cottidae	x 1/	x	x	x	x	x	x	x	x	x	x		x	

1/ Indicates that this family of fish (Cottidae) was also represented in an area.

A - Golovin Bay
B - Cape Denbigh to Egavik
C - Egavik to Tolstoi Point
D - Tolstoi Point to Cape Stebbins
F - Rocky Point to Bluff

G - Grantley Harbor
H - Port Clarence
I - Imuruk Basin
FI - Flat Island (South Mouth Yukon River - Delta Area)
URL - Unalakleet River Lagoon

Table 12. Total catch, effort and catch per effort of Pacific herring by sample area in Norton Sound from ice breakup to freezeup, 1977.

	Golovin Bay (Area A)		Port Clarence (Area H)		Grantley Harbor (Area G)		Imuruk Basin (Area I)		Remainder of Norton Sound (Areas B, C, D, F)	
Catch	#	%	#	%	#	%	#	%	#	%
Adult herring	244	80	636	94	1,015	95	99	44	71	89
Juvenile herring	62	20	39	6	50	5	126	56	10	11
Total	306		675		1,065		225		81	
*EFFORT 1/										
Gillnets	252.6		66.2		52.2		18.9		119.5	
Beach Seines	68		26		26		11		24	
*CATCH/EFFORT 2/										
Gillnets	0.9		7.3		19.5		3.5		0.6	
Beach seines	0.9		7.4		1.7		14.5		0.3	

* Includes both adults and juveniles.

1/ Effort is expressed as number of gillnet hours and number of good beach seine sets.

2/ Catch per effort is expressed as number of herring per gillnet hours and number of herring per good beach seine set.

Table 13. Total catch of adult and juvenile herring by gear type captured in the Port Clarence area from June through October, 1977.

Sex	Beach Seine #	Beach Seine %	Floating Gillnet #	Floating Gillnet %	Sinking Gillnet #	Sinking Gillnet %	Total #	Total %
Adults (♂+♀)	192	11	992	57	566	32	1,750	100
Juveniles	205	95	3	1	7	4	215	100
Total	397	20	995	51	573	29	1,965	100
Adults (♂+♀)	192	48	992	99	566	99	1,750	89
Juveniles	205	52	3	1	7	1	215	11
Total	397	100	995	100	573	100	1,965	100

Table 14. Percent composition by area and gear type of herring captured in Port Clarence, Grantley Harbor and Imuruk Basin from June through October, 1977.

	gear type	Port Clarence #	Port Clarence %	Grantley Harbor #	Grantley Harbor %	Imuruk Basin #	Imuruk Basin %	Total #	Total %
Juvenile Herring	Beach seine	37	18	45	22	123	60	205	100
	Floating gillnet	0	-	1	33	2	66	3	100
	Sinking gillnet	2	29	4	57	1	14	7	100
	Total	39	18	50	23	126	59	215	100
	Beach seine	37	95	45	90	123	97	205	95
	Floating gillnet	0	-	1	2	2	2	3	1
	Sinking gillnet	2	5	4	8	1	1	7	4
	Total	39	100	50	100	126	100	215	100
Adult Herring	Beach seine	156	81	0	-	36	19	192	100
	Floating gillnet	338	34	620	63	34	3	992	100
	Sinking gillnet	142	25	395	70	29	5	566	100
	Total	636	36	1,015	58	99	6	1,750	100
	Beach seine	156	25	0	-	36	36	192	11
	Floating gillnet	338	53	620	61	34	34	992	57
	Sinking gillnet	142	22	395	39	29	30	566	32
	Total	636	100	1,015	100	99	100	1,750	100

Table 15. Percent composition by gear type and sex of herring captured in the Port Clarence area from June through October, 1977.

Sex	Beach Seine		Floating Gillnet		Sinking Gillnet		Total	
	#	%	#	%	#	%	#	%
Male	52	10	248	46	239	44	539	100
Female	62	12	199	39	253	49	514	100
Total	114	11	447	42	492	47	1,053	100
Male	52	46	248	55	239	49	539	51
Female	62	54	199	45	253	51	514	49
Total	114	100	447	100	492	100	1,053	100

Table 16. Relative maturity by age class of herring captured in the Port Clarence area from ice breakup (late June) through July 21, 1977.

Age	Immature Gonad I	n	Possible Mature 1/ Gonad II	n	Mature Gonads III-VIII	n	Total n
III	32.1%	9	21.4%	6	46.5%	13	28
IV	0		5.9	1	94.2	16	17
V	1.0	5	4.2	21	94.8	479	505
VI	0		10.3	3	89.5	26	29
VII	0		7.1	2	92.9	26	28
VIII	0		0		100.0	14	14
IX+	0		6.4	3	93.6	44	47
		14		36		618	668

1/ Possible mature in older age classes since gonad VIII and II are very similar.

Table 17. Relative maturity by age class of herring captured in the Port Clarence area from July 22 through September 6, 1977.

Age	Immature Gonad I	n	Possible Mature 1/ Gonad II	n	Mature Gonads III-VIII	n	Total n
III	0%		0%		100.0%	21	21
IV	0		0		100.0	3	3
V	0		0		100.0	15	15
VI	0		0		100.0	1	1
VII	0		0		100.0	2	2
VIII	0		0		100.0	1	1
IX+	0		0		100.0	10	10
						53	53

1/ Possible mature in older age classes since gonad VIII and II are very similar.

Table 18. Relative maturity by age class of herring captured in the Port Clarence area from September 7 through October 21, 1977.

Age	Immature Gonad I	n	Possible Mature 1/ Gonad II	n	Mature Gonads III-VIII	n	Total n
0	100%	13	0%		0%		13
I	80	4	20	1	0		5
II	0		100	2	0		2
III	4.0	1	24.0	6	72.0	18	25
IV	0		0		100.0	10	10
V	0		0		100.0	30	30
VI	0		0		100.0	8	8
VII	0		0		100.0	7	7
VIII	0		0		100.0	4	4
IX+	0		0		100.0	9	9
		18		9		86	113

1/ Possible mature in older age classes since good gonad VIII and II are very similar.

Table 19. Percent composition by gear type and sex of herring captured in Golovin Bay from June through October, 1977.

Sex	Beach Seine		Floating Gillnet		Sinking Gillnet		Total	
	#	%	#	%	#	%	#	%
Male	0	-	103	72	40	28	143	100
Female	1	1	67	78	18	21	86	100
Juvenile	62	100	0	-	0	-	62	100
Total	63	22	170	58	58	20	291	100
Male	0	-	103	61	40	69	143	49
Female	1	2	67	39	18	31	86	30
Juvenile	62	98	0	-	0	-	62	21
Total	63	100	170	100	58	100	291	100

Table 20. Percent fullness of herring stomachs examined during the spring of 1976 from selected areas along the western Alaska coast.

Stomach Percent Full	Togiak Area		Yukon-Kuskokwim Delta Area		Norton Sound Area		Total	
	Number	Percent of Total	Number	Percent of Total	Number	Percent of Total	Number	Percent of Total
Empty	8	40	30	64	16	20	54	37.0
Trace	7	35	12	26	34	43	53	36.3
25%	2	10	5	10	11	14	18	12.3
50%	0	0	0	0	9	11	9	6.2
75%	1	5	0	0	3	4	4	2.7
100%	0	0	0	0	5	6	5	3.4
Distended	2	10	0	0	1	1	3	2.1
Sample Size	20		47		79		146	

Table 21. Percent frequency of occurrence and number of food items found in herring stomachs examined from selected areas along the western Alaska coast in the spring, 1976.

Item	Togiak Area		Yukon-Kuskokwim Delta Area		Norton Sound Area	
	Percent Frequency Occurrence	Percent Food	Percent Frequency Occurrence	Percent Food	Percent Frequency Occurrence	Percent Food
Mysidacea (opposum shrimp)			25	10	8	1.8
Copepoda			75	30	67	15.1
Cladocera	33	11.1			83	18.9
Cirripedia (barnacles)	67	22.2	50	20	50	11.3
Cumacea					33	7.5
Decopoda (shrimp, crayfish, lobsters)					25	5.7
Molluska					17	3.8
Annelida (segmented worms)					17	3.8
Platyhelminth (flatworms)	100	33.3	25	10	8	17.0
Miscellaneous	Algae Egg Case 100	33.3	Detritus Egg Egg Case 75	30	Fish Scale Detritus Egg Herring 67	15.1

Table 22. Fork lengths of juvenile pink and chum salmon captured in the nearshore waters of Golovin Bay from June 9 through July 7, 1977. 1/

		Pink Salmon mean fork length			Chum Salmon mean fork length		
Date	Station	Golovin Lagoon	Eastside Outer Golovin Bay	Westside Outer Golovin Bay	Golovin Lagoon	Eastside Outer Golovin Bay	Westside Outer Golovin Bay
June 9	7	31.0			34.6		
June 11	9			31.9			35.0
	10			31.7			36.4
June 12	2		30.6			35.7	
June 14	5	32.4			36.2		
	7	36.0			37.3		
June 17	9			33.6			35.9
June 20	6	33.6			40.2		
June 22	5	38.0			40.6		
June 23	1		37.2			42.0	
	2		37.6			41.2	
June 24	9			39.4			46.5
	10			35.3			44.1
June 26	6	41.3	43.8		46.0	47.0	
July 4	10			52.4			54.0
July 6	2		55.2			60.4	
July 7	5	54.0			63.2		

1/ Sample sizes were 329 for pink salmon and 360 for chum salmon.

Table 23. Daily growth rates (percent) of juvenile pink and chum salmon captured in Norton Sound, 1976-77.

	28 days			62 days	
	mean length 2nd week June (breakup)	change in length	mean length 1st week July (depart nearshore waters)	change in length	mean length 1st week September (reside in offshore waters)
Pink	32 mm	22 mm (68.8% increase)	54 mm	111 mm (205.6% increase)	165 mm
Chum	35 mm	24 mm (68.6% increase)	59 mm	124 mm (210.2% increase)	183 mm

	increase in length per day	increase in length per day
Pink	0.79 mm	1.79 mm
Chum	0.86 mm	2.00 mm

	Average % increase in growth per day	Average % increase in growth per day
Pink	2.46%	3.32%
Chum	2.45%	3.39%

	Average % increase in growth per day from 2nd week June to 1st week Sept. (90 days)
Pink	4.62%
Chum	4.70%

Table 24. Larval finfish captured in the nearshore waters of Norton Sound from breakup to freezeup, 1977.

Sample Area	Larval Species			
	Boreal Smelt	Pond Smelt	Gadids	Cottids
A	2,248		39	1
B	7			
C	114			
D	6			
F	100			
G	475			
H	619			7
I	1,415	371		
Total	4,984	371	39	8

Table 25 . Catch, effort and species diversification by gear type of finfish sampled in the nearshore waters of Norton Sound from May 30 through October 21, 1977.

Area	Gear[1/]	Number of stations	Number of sets	Effort[2/] negative	Effort[2/] total	Total[3/] catch	CPUE[2/]		Larval[4/] fish catch	Number of species captured [5/]
A - Golovin Bay	GNS	12	44	13.4	69.9	230	3.3	4.4		13
	GNF	12	98	22.1	182.7	879	4.8			17
	BS	12	68	0	68	14,928	219.5		5,402	22
B - Cape Denbigh to Egavik	GNS	6	12	9.1	14.1	9	0.6	7.7		4
	GNF	6	13	0	14.3	209	14.6			14
	BS	6	5	0	5	1,196	239.2		7	11
C - Egavik to Tolstoi Point	GNS	7	15	9.2	15.3	11	0.7	9.6		4
	GNF	7	15	0	15.0	280	18.7			16
	BS	7	8	0	8	207	25.9		114	16
D - Tolstoi Point to Cape Stebbins	GNS	12	19	9.0	20.5	41	2.0	4.5		4
	GNF	12	19	2.0	20.7	143	6.9			11
	BS	12	4	0	4	151	37.8		6	7
E - Fish River	BS	2	2	0	2	20	10.0			3
F - Rocky Point to Bluff	GNS	6	3	0	6.7	26	3.9	4.9		6
	GNF	6	7	0	12.9	70	5.4			8
	BS	6	7	0	7	44,114	6,302.0		100	12
G - Grantley Harbor	GNS	9	25	2.0	26.6	480	18.1	25.1		10
	GNF	9	24	3.9	25.6	830	32.4			18
	BS	9	26	1	26	4,431	170.4		475	19
H - Port Clarence	GNS	9	28	7.9	32.7	406	12.4	14.5		9
	GNF	9	28	2.8	33.5	545	16.3			19
	BS	9	26	1	26	3,411	131.2		626	20
I - Imuruk Basin	GNS	5	7	0	7.8	91	11.7	12.5		9
	GNF	5	8	0	11.1	145	13.1			12
	BS	5	11	0	11	4,888	444.4		1,786	17
Unalakleet River Lagoon	BS	1	6	0	6	149	24.8			14
TOTALS	GNS	66	153	50.6	193.6	1,294	6.7	8.6		17
	GNF	66	212	30.8	315.8	3,101	9.8			24
	BS	69	163	2	163	73,495	450.9		5,402	29

1/ Gear types: GNS - gillnet sinking (offshore), GNF - gillnet floating (onshore), BS - beach seine.
2/ Gillnet effort is expressed in hours with catch per effort in fish per net hour.
Beach seine effort is expressed in number of good sets with catch per effort in fish per good set.
3/ This column does not include larval catches; they were considered as incidental and not used in calculating CPUE.
4/ Incidental catches - mesh size of beach seines was not small enough to adequately sample larval populations, therefore listed separately.
5/ Cottidae is considered as a species in this table.

Table 26. Most abundant species of finfish captured in the coastal waters of Norton Sound and Port Clarence from ice breakup to freezeup, 1977.

Area	Beach Seines 1/ Species	CPUE	Gillnets 2/ Species	CPUE
Golovin Bay	pink salmon*	67.4	Pacific herring	1.0
	sand lance	65.5	saffron cod	0.9
	chum salmon*	25.1	starry flounder	0.5
Rocky Point to Bluff	sand lance	6,267.7	chum salmon	1.8
	pink salmon*	23.6	boreal smelt	1.1
	pond smelt	3.6	Pacific herring	0.7
	starry flounder	3.6		
Cape Denbigh to Egavik	sand lance	120.0	Arctic char	3.4
	saffron cod	75.0	starry flounder	2.1
	boreal smelt	16.6	least cisco	1.3
Egavik to Tolstoi Point	saffron cod	7.8	Arctic char	3.0
	boreal smelt	4.8	starry flounder	2.6
	Bering poacher	3.3	Bering cisco	1.0
Tolstoi Point to Cape Stebbins	sand lance	32.5	starry flounder	1.3
	starry flounder	3.5	Pacific herring	0.9
	boreal smelt	0.5	saffron cod	0.6
	Arctic flounder	0.5	least cisco	0.6
Port Clarence	pond smelt	97.8	Pacific herring	7.6
	sand lance	9.4	boreal smelt	3.2
	saffron cod	8.5	saffron cod	1.3
Grantley Harbor	pond smelt	147.3	Pacific herring	19.4
	saffron cod	9.7	saffron cod	1.6
	sand lance	3.9	starry flounder	0.9
Imuruk Basin	pond smelt	360.2	Pacific herring	3.5
	ninespine stickleback	28.9	saffron cod	2.5
	least cisco	14.5	Bering cisco	1.9
	Pacific herring*	11.2		
All Areas Combined	sand lance	306.9	Pacific herring	3.7
	pond smelt	74.0	saffron cod	1.0
	pink salmon*	29.6	starry flounder	0.8

1/ Beach seine CPUE is number of fish captured per seine set.
2/ Includes both floating and sinking gillnet catches. The CPUE is fish captured per net hour.
* Indicates juvenile fish.

Table 27. Most frequently occurring species of finfish (by percent) captured in the coastal waters of Norton Sound and Port Clarence from ice breakup to freezeup, 1977.

Area	Beach Seines		Gillnets1/	
	Species	Percent	Species	Percent
Golovin Bay	starry flounder	57	saffron cod	40
	saffron cod	41	Pacific herring	28
	ninespine stickleback	41	humpback whitefish	25
Rocky Point to Bluff	pink salmon*	86	saffron cod	50
	starry flounder	71	boreal smelt	40
	chum salmon*	29	Pacific herring	40
	Alaska plaice	29	chum salmon	40
	sand lance	29		
Cape Denbigh to Egavik	Bering cisco	80	least cisco	36
	boreal smelt	60	Arctic char	32
	Arctic flounder	40	Arctic flounder	32
	least cisco	40	Bering cisco	32
	humpback whitefish	40		
	starry flounder	40		
Egavik to Tolstoi Point	boreal smelt	75	starry flounder	50
	chum salmon*	50	Arctic char	43
	saffron cod	50	least cisco	20
Tolstoi Point to Cape Stebbins	boreal smelt	50	starry flounder	39
	starry flounder	50	rock greenling	21
	Arctic flounder	25	least cisco	21
	least cisco	25		
	sand lance	25		
	ninespine stickleback	25		
Port Clarence	saffron cod	58	Pacific herring	32
	pond smelt	54	saffron cod	30
	sand lance	38	starry flounder	27
Grantley Harbor	saffron cod	50	starry flounder	43
	pond smelt	50	saffron cod	39
	Pacific herring*	31	Pacific herring	37
	least cisco	31		
	starry flounder	31		
Imuruk Basin	pond smelt	82	Pacific herring	67
	least cisco	64	saffron cod	67
	ninespine stickleback	64	Bering cisco	53
All Areas Combined	starry flounder	43	saffron cod	33
	saffron cod	41	starry flounder	30
	pond smelt	37	Pacific herring	27

1/ Includes both floating and sinking gillnet catches.
* Indicates juvenile fish.

Table 28. Abundance of selected species of finfish captured with beach seines and gillnets in Golovin Bay, 1976-77. The CPUE for gillnets and beach seines is fish per net hour and fish per set, respectively.

BEACH SEINES

AREA	SPECIES	SAMPLING PERIOD I 76	I 77	II 76	II 77	III 76	III 77	IV 76	IV 77	V 76	V 77	VI 76	VI 77	VII 76	VII 77	VIII 76	VIII 77	IX 76	IX 77
A	BC		7.2		0.3	0.6	0.1	1.0		3.8		2.4	1.4	4.8	1.0		5.9		1.0
	average	7.2		0.3		0.4		1.0		3.8		1.9		2.9		5.9		1.0	
	LC		1.3		1.9	0.1	0.6	11.8		23.2		0.4	40.9	0.8	3.4		3.7		1.3
	average	1.3		1.9		0.4		11.8		23.2		20.7		2.1		3.7		1.3	
	SC		0.3		1.0	1.7	0.1	2.8		36.9		24.0	22.1	4.8	13.0		1.7		2.7
	average	0.3		1.0		0.9		2.8		36.9		23.1		8.9		1.7		2.7	
	SF		5.5		3.9	0.8	0.5	1.1		0.5		1.4	3.6	1.2	1.8		2.6		0.7
	average	5.5		3.9		0.7		1.1		0.5		2.5		1.5		2.6		0.7	
	PH		0.1		0.0	0.0	0.0	0.0		0.0		0.0	0.0	0.0	12.0		0.3		0.0
	average	0.1		0.0		0.0		0.0		0.0		0.0		6.0		0.3		0.0	
	BS		1.4		3.3	4.6	0.0	11.3		34.3		32.1	25.2	3.7	0.2		1.4		7.0
	average	1.4		3.3		2.3		11.3		34.3		28.7		1.9		1.4		7.0	
	SL		0.0		4.4	327.1	4.5	589.0		114.0		328.9	157.4	55.0	458.2		0.3		0.0
	average	0.0		4.4		165.8		589.0		114.0		243.2		256.6		0.3		0.0	
	PS*		37.3		270.7	1.1	0.1	0.0		0.0		0.0	0.0	0.0	0.0		0.0		0.0
	average	37.3		270.7		0.6		0.0		0.0		0.0		0.0		0.0		0.0	
	CS*		62.1		54.9	0.3	1.5	0.0		0.0		0.0	0.0	0.0	0.0		0.0		0.0
	average	62.1		54.9		0.9		0.0		0.0		0.0		0.0		0.0		0.0	

GILLNETS

AREA	SPECIES	I 76	I 77	II 76	II 77	III 76	III 77	IV 76	IV 77	V 76	V 77	VI 76	VI 77	VII 76	VII 77	VIII 76	VIII 77	IX 76	IX 77
A	BC		0.3		0.2	0.2	0.1	0.1		0.04		0.2	0.1	0.4	0.2		0.5		0.0
	average	0.3		0.2		0.2		0.1		0.04		0.2		0.3		0.5		0.0	
	LC		0.1		0.2	0.5	0.1	1.1		0.2		0.6	0.5	0.4	0.8		2.5		0.0
	average	0.1		0.2		0.3		1.1		0.2		0.6		0.6		2.5		0.0	
	SC		0.8		0.5	0.7	0.4	1.0		0.2		0.6	0.4	1.0	1.4		3.0		1.0
	average	0.8		0.5		0.6		1.0		0.2		0.5		1.2		3.0		1.0	
	SF		0.7		0.8	0.2	0.7	0.2		1.0		0.4	0.2	0.3	0.4		0.2		0.1
	average	0.7		0.8		0.5		0.2		1.0		0.3		0.4		0.2		0.1	
	PH		0.6		1.7	0.03	1.2	0.0		0.0		0.0	0.0	0.1	0.5		4.7		0.5
	average	0.6		1.7		0.6		0.0		0.0		0.0		0.3		4.7		0.5	
	BS		0.0		0.0	0.0	0.1	0.0		0.0		0.04	0.1	0.0	0.2		0.2		0.4
	average	0.0		0.0		0.05		0.0		0.0		0.1		0.1		0.2		0.4	

* juvenils only

Table 29. Sample size, range, standard deviation and mean lengths (mm) by geartype of finfish species captured in nearshore waters of Norton Sound from June through October, 1977.

	BEACH SEINE				FLOATING GILLNET				SINKING GILLNET				FLOATING+SINKING			
SPECIES	N	LENGTH RANGE	MEAN	SD	N	LENGTH RANGE	MEAN	SD	N	LENGTH RANGE	MEAN	SD	N	LENGTH RANGE	MEAN	SD
PINK SALMON	420	27- 71	39	8.1	18	332-492	427	32.8	0	0- 0	0	0.	18	332-492	427	32.8
CHUM SALMON	407	25- 68	42	7.1	16	551-676	585	30.7	0	0- 0	0	0.	16	551-676	585	30.7
SILVER SALMON	5	109-126	119	6.7	7	490-615	560	38.8	0	0- 0	0	0.	7	490-615	560	38.8
RED SALMON	0	0- 0	0	0.	1	617-617	617	0.	0	0- 0	0	0.	1	617-617	617	0.
HUMPBACK WHITEFISH	198	72-418	174	112.6	134	114-465	326	74.2	4	172-371	295	87.8	138	114-465	325	74.5
BROAD WHITEFISH	82	70-400	270	103.9	14	194-490	364	81.1	3	103-347	205	126.7	17	103-490	336	106.1
ROUND WHITEFISH	17	91-390	233	90.8	10	167-382	298	74.5	1	161-161	161	0.	11	161-382	286	81.9
BERING CISCO	285	51-374	173	86.1	178	67-408	252	86.9	23	117-360	257	64.7	201	67-408	253	84.6
LEAST CISCO	463	66-330	156	69.2	271	100-415	237	58.2	21	158-282	212	27.7	292	100-415	235	56.9
STARRY FLOUNDER	329	31-451	156	80.7	312	43-491	255	92.8	85	157-465	314	68.2	397	43-491	268	91.3
ARCTIC FLOUNDER	99	24-298	121	59.4	100	69-300	177	49.1	3	72-111	88	20.6	103	69-300	175	50.7
ALASKA PLAICE	10	60-160	99	34.7	1	64- 64	64	0.	1	132-132	132	0.	2	64-132	98	48.1
YELLOWFIN SOLE(MUDDAB)	11	81-155	119	23.9	3	107-164	137	28.6	13	93-254	146	41.6	16	93-254	145	38.8
TUBENOSE POACHER	96	37-147	81	18.8	1	131-131	131	0.	0	0- 0	0	0.	1	131-131	131	0.
BERING POACHER	27	53-120	73	13.9	0	0- 0	0	0.	0	0- 0	0	0.	0	0- 0	0	0.
CAPELIN	1	69- 69	69	0.	0	0- 0	0	0.	0	0- 0	0	0.	0	0- 0	0	0.
BOREAL SMELT	2064	10-269	49	26.0	69	122-288	182	44.1	58	136-277	189	40.5	127	122-288	185	42.5
POND SMELT	2733	22-136	55	19.9	21	108-146	119	8.1	19	110-125	117	3.6	40	108-146	118	6.3
SANDLANCE	795	27-137	63	14.3	0	0- 0	0	0.	0	0- 0	0	0.	0	0- 0	0	0.
THREESPINE STICKLEBACK	132	16- 93	29	16.8	0	0- 0	0	0.	0	0- 0	0	0.	0	0- 0	0	0.
NINESPINE STICKLEBACK	473	20- 80	45	9.6	0	0- 0	0	0.	0	0- 0	0	0.	0	0- 0	0	0.
WHITESPOTTED GREENLING	5	88-216	151	62.3	5	111-274	204	60.6	26	153-310	222	45.1	31	111-310	219	47.2
ROCK GREENLING	2	84- 97	91	9.2	18	116-281	213	43.8	6	58-215	156	59.4	24	58-281	198	53.2
ARCTIC CHAR	45	99-640	297	168.9	184	139-598	404	85.2	0	0- 0	0	0.	184	139-598	404	85.2
SAFFRON COD	833	32-358	112	63.0	412	110-420	253	50.8	167	92-362	251	50.8	579	92-420	252	50.7
SCULPIN	39	24-435	149	102.0	59	84-542	225	117.6	12	127-480	274	101.9	71	84-542	233	115.9
PRICKLEBACK	71	208-420	294	50.5	2	234-235	235	0.7	0	0- 0	0	0.	2	234-235	235	0.7
NOTHERN PIKE	1	330-330	330	0.	0	0- 0	0	0.	0	0- 0	0	0.	0	0- 0	0	0.
NORTHERN SUCKER	1	110-110	110	0.	0	0- 0	0	0.	0	0- 0	0	0.	0	0- 0	0	0.
WOLFFISH	0	0- 0	0	0.	0	0- 0	0	0.	1	540-540	540	0.	1	540-540	540	0.

Table 30. Sample size, range, standard deviation and mean lengths (mm) by gear type of finfish species captured in Port Clarence, Grantley Harbor and Imuruk Basin from June through October, 1977.

	BEACH SEINE				FLOATING GILLNET				SINKING GILLNET				FLOATING+SINKING			
SPECIES	N	LENGTH RANGE	MEAN	SD	N	LENGTH RANGE	MEAN	SD	N	LENGTH RANGE	MEAN	SD	N	LENGTH RANGE	MEAN	SD
PINK SALMON	3	35- 51	45	9.0	7	332-443	415	38.5	0	0- 0	0	0.	7	332-443	415	38.5
CHUM SALMON	3	48- 53	50	2.6	5	560-676	591	48.7	0	0- 0	0	0.	5	560-676	591	48.7
SILVER SALMON	0	0- 0	0	0.	3	490-615	563	64.9	0	0- 0	0	0.	3	490-615	563	64.9
RED SALMON	0	0- 0	0	0.	1	617-617	617	0.	0	0- 0	0	0.	1	617-617	617	0.
HUMPBACK WHITEFISH	6	314-388	362	25.2	19	257-416	356	35.8	1	342-342	342	0.	20	257-416	356	35.0
BROAD WHITEFISH	47	78-400	311	81.1	8	245-490	364	71.4	3	103-347	205	126.7	11	103-490	320	110.6
ROUND WHITEFISH	17	91-390	233	90.8	9	167-382	312	64.8	1	161-161	161	0.	10	161-382	297	77.5
BERING CISCO	107	67-374	239	67.6	89	104-378	285	72.7	17	223-360	286	43.0	106	104-378	285	68.6
LEAST CISCO	196	66-312	177	72.4	95	115-386	258	44.7	12	158-282	222	29.5	107	115-386	254	44.6
STARRY FLOUNDER	28	46-451	246	122.8	68	43-491	303	80.2	34	262-452	330	51.3	102	43-491	312	72.8
ARCTIC FLOUNDER	18	54-264	156	54.4	17	84-238	170	39.4	0	0- 0	0	0.	17	84-238	170	39.4
ALASKA PLAICE	3	112-160	144	27.4	1	64- 64	64	0.	0	0- 0	0	0.	1	64- 64	64	0.
YELLOWFIN SOLE (MUDDAB)	0	0- 0	0	0.	1	107-107	107	0.	0	0- 0	0	0.	1	107-107	107	0.
TUBENOSE POACHER	19	62-108	81	15.2	0	0- 0	0	0.	0	0- 0	0	0.	0	0- 0	0	0.
BERING POACHER																
CAPELIN	1	69- 69	69	0.	0	0- 0	0	0.	0	0- 0	0	0.	0	0- 0	0	0.
BOREAL SMELT	1215	21-269	44	26.4	17	138-288	224	53.3	36	140-277	198	40.4	53	138-288	206	46.1
POND SMELT	2540	22-125	55	20.3	12	108-128	117	5.4	18	110-125	118	3.7	30	108-128	117	4.4
SANDLANCE	346	41-113	63	11.3	0	0- 0	0	0.	0	0- 0	0	0.	0	0- 0	0	0.
THREESPINE STICKLEBACK	132	16- 93	29	16.8	0	0- 0	0	0.	0	0- 0	0	0.	0	0- 0	0	0.
NINESPINE STICKLEBACK	311	23- 80	44	9.4	0	0- 0	0	0.	0	0- 0	0	0.	0	0- 0	0	0.
WHITESPOTTED GREENLING																
ROCK GREENLING	2	84- 97	91	9.2	4	116-201	164	39.2	4	58-189	133	61.3	8	58-201	149	50.3
ARCTIC CHAR	16	132-581	187	106.1	15	139-598	313	133.4	0	0- 0	0	0.	15	139-598	313	133.4
SAFFRON COD	476	52-358	104	55.7	123	139-420	279	51.5	95	92-362	261	47.2	218	92-420	271	50.3
SCULPIN	20	24-396	126	95.2	20	106-264	192	40.6	0	0- 0	0	0.	20	106-264	192	40.6
PRICKLEBACK																
NOTHERN PIKE	1	330-330	330	0.	0	0- 0	0	0.	0	0- 0	0	0.	0	0- 0	0	0.
NORTHERN SUCKER	1	110-110	110	0.	0	0- 0	0	0.	0	0- 0	0	0.	0	0- 0	0	0.
WOLFFISH																

Table 31. Sample size, range, standard deviation and mean lengths (mm) by gear type of finfish species captured from Bluff to Cape Darby (Golovin Bay area) from June through October, 1977.

	BEACH SEINE				FLOATING GILLNET				SINKING GILLNET				FLOATING+SINKING			
SPECIES	N	LENGTH RANGE	MEAN	SD	N	LENGTH RANGE	MEAN	SD	N	LENGTH RANGE	MEAN	SD	N	LENGTH RANGE	MEAN	SD
PINK SALMON	404	27 71	39	8.1	0	0- 0	0	0.	0	0- 0	0	0.	0	0- 0	0	0.
CHUM SALMON	374	25 68	42	7.2	0	0- 0	0	0.	0	0- 0	0	0.	0	0- 0	0	0.
SILVER SALMON	5	105 126	119	6.7	0	0- 0	0	0.	0	0- 0	0	0.	0	0- 0	0	0.
RED SALMON																
HUMPBACK WHITEFISH	179	73 390	159	100.2	109	114-415	315	76.4	3	172-371	279	100.3	112	114-415	314	76.8
BROAD WHITEFISH	22	141 378	273	67.8	3	194-447	316	126.8	0	0- 0	0	0.	3	194-447	316	126.8
ROUND WHITEFISH																
BERING CISCO	106	88 358	142	69.1	33	100-365	216	79.7	4	117-248	178	53.7	37	100-365	212	77.6
LEAST CISCO	263	61 285	139	60.4	104	100-285	202	41.6	9	178-235	197	17.8	113	100-285	202	40.2
STARRY FLOUNDER	244	36 440	150	62.3	78	105-340	164	40.7	40	177-465	312	79.7	118	105-465	214	90.2
ARCTIC FLOUNDER	50	24 298	99	61.7	43	69-300	177	55.2	1	72- 72	72	0.	44	69-300	175	56.8
ALASKA PLAICE	7	60 93	80	12.0	0	0- 0	0	0.	0	0- 0	0	0.	0	0- 0	0	0.
YELLOWFIN SOLE (MUDDAB)	1	125 125	125	0.	0	0- 0	0	0.	12	93-254	150	41.0	12	93-254	150	41.0
TUBENOSE POACHER	71	37 120	80	17.8	1	131-131	131	0.	0	0- 0	0	0.	1	131-131	131	0.
BERING POACHER	1	120 120	120	0.	0	0- 0	0	0.	0	0- 0	0	0.	0	0- 0	0	0.
CAPELIN																
BOREAL SMELT	595	10 160	51	17.5	46	122-250	170	31.1	22	136-251	174	37.0	68	122-251	171	32.9
POND SMELT	189	31 136	60	13.0	7	110-146	123	11.6	1	116-116	116	0.	8	110-146	122	11.0
SANDLANCE	251	47 137	70	17.2	0	0- 0	0	0.	0	0- 0	0	0.	0	0- 0	0	0.
THREESPINE STICKLEBACK																
NINESPINE STICKLEBACK	158	20 71	46	9.7	0	0- 0	0	0.	0	0- 0	0	0.	0	0- 0	0	0.
WHITESPOTTED GREENLING	5	88 216	151	62.3	5	111-274	204	60.6	26	153-310	222	45.1	31	111-310	219	47.2
ROCK GREENLING																
ARCTIC CHAR	21	99 640	335	175.2	24	264-560	404	74.2	0	0- 0	0	0.	24	264-560	404	74.2
SAFFRON COD	158	32 292	108	59.5	255	110-394	243	47.4	63	109-355	246	48.8	318	109-394	243	47.7
SCULPIN	14	40 435	192	114.3	23	100-520	253	108.9	10	127-480	279	112.1	33	100-520	261	108.7
PRICKLEBACK																
NOTHERN PIKE																
NORTHERN SUCKER																
WOLFFISH	0	0 0	0	0.	0	0- 0	0	0.	1	540-540	540	0.	1	540-540	540	0.

Table 32. Sample size, range, standard deviation and mean lengths (mm) by gear type for finfish species captured in nearshore waters of southern and eastern Norton Sound (area B,C,D) from June through October, 1977.

SPECIES	BEACH SEINE N	LENGTH RANGE	MEAN	SD	FLOATING GILLNET N	LENGTH RANGE	MEAN	SD	SINKING GILLNET N	LENGTH RANGE	MEAN	SD	FLOATING+SINKING N	LENGTH RANGE	MEAN	SD
PINK SALMON	13	29- 4	32	1.8	11	395-492	434	27.9	0	0- 0	0	0.	11	395-492	434	27.9
CHUM SALMON	30	33- 2	37	2.1	11	551-613	581	20.8	0	0- 0	0	0.	11	551-613	581	20.8
SILVER SALMON	0	0- 0	0	0.	4	538-569	558	13.8	0	0- 0	0	0.	4	538-569	558	13.8
RED SALMON																
HUMPBACK WHITEFISH	13	72-4 8	299	144.4	6	376-465	413	31.0	0	0- 0	0	0.	6	376-465	413	31.0
BROAD WHITEFISH	13	70-3 8	118	89.4	3	376-451	415	37.6	0	0- 0	0	0.	3	376-451	415	37.6
ROUND WHITEFISH	0	0- 0	0	0.	1	177-177	177	0.	0	0- 0	0	0.	1	177-177	177	0.
BERING CISCO	72	51-3 9	122	72.2	56	67-408	220	92.6	2	170-171	171	0.7	58	67-408	218	91.4
LEAST CISCO	4	188-3 0	279	64.9	72	122-415	260	69.5	0	0- 0	0	0.	72	122-415	260	69.5
STARRY FLOUNDER	57	31-3 9	139	97.7	166	97-460	278	86.5	11	157-360	274	54.9	177	97-460	278	84.8
ARCTIC FLOUNDER	31	31-2 3	135	43.5	40	81-300	180	46.6	2	80-111	96	21.9	42	80-300	176	49.1
ALASKA PLAICE	0	0- 0	0	0.	0	0- 0	0	0.	1	132-132	132	0.	1	132-132	132	0.
YELLOWFIN SOLE(MUDDAB)	10	81-1 5	119	25.1	2	140-164	152	17.0	1	100-100	100	0.	3	100-164	135	32.3
TUBENOSE POACHER	6	60-1 7	94	34.7	0	0- 0	0	0.	0	0- 0	0	0.	0	0- 0	0	0.
BERING POACHER	26	53- 8	71	10.4	0	0- 0	0.	0.	0	0- 0	0	0.	0	0- 0	0	0.
CAPELIN																
BOREAL SMELT	254	15-1 7	62	33.6	6	127-162	149	12.3	0	0- 0	0	0.	6	127-162	149	12.3
POND SMELT	4	53- 5	59	5.7	2	115-119	117	2.8	0	0- 0	0	0.	2	115-119	117	2.8
SANDLANCE	198	27- 3	56	10.8	0	0- 0	0	0.	0	0- 0	0	0.	0	0- 0	0	0.
THREESPINE STICKLEBACK																
NINESPINE STICKLEBACK	4	40- 4	55	10.3	0	0- 0	0	0.	0	0- 0	0	Q.	0	0- 0	0	0.
WHITESPOTTED GREENLING																
ROCK GREENLING	0	0- 0	0	0.	14	172-281	227	34.8	2	185-215	200	21.2	16	172-281	223	34.1
ARCTIC CHAR	8	100-5 8	419	137.5	145	222-569	413	75.3	0	0- 0	0	0.	145	222-569	413	75.3
SAFFRON COD	199	42-3.4	134	75.9	34	126-321	235	37.5	9	118-228	183	45.2	43	118-321	224	44.2
SCULPIN	5	64-1 9	121	54.4	16	84-542	226	176.9	2	248-256	252	5.7	18	84-542	229	166.4
PRICKLEBACK	71	208-4 0	294	50.5	2	234-235	235	0.7	0	0- 0	0	0.	2	234-235	235	0.7
NOTHERN PIKE																
NORTHERN SUCKER																
WOLFFISH																

Table 33. Surface water temperatures (C°) at various coastal sampling locations in Norton Sound from June 1 through October 16, 1977 (OCS/RU19).[1/]

Date	(A) Golovin Bay	(B) C. Denbigh to Egavik	(C) Egavik to Tolstoi Pt.	(D) Tolstoi Pt. to C. Stebbins	(H) Port Clarence	(G) Grantley Harbor	(I) Imuruk Basin
6/1-6/15	6.6° (33/10)[2/]	7.5° (14/6)[3/]	3.6° (15/7)[5/]	1.3° (11/5)[7/]	-	-	-
6/15-6/30	12.0° (28/10)	-	-	6.8° (10/6)[8/]	-	12.8° (6/5)	-
7/1-7/15	12.8° (44/10)	-	-	-	10.0° (16/9)	13.4° (14/7)	16.1° (5/5)[11/]
7/16-7/31	-	16.0° (15/6)	14.5° (18/7)	-	-	-	-
8/1-8/15	-	-	-	11.0° (21/10)	-	-	-
8/16-8/31	13.0° (32/10)	13.0° (2/1)[4/]	14.0° (2.1)[6/]	-	13.7° (27/9)[9/]	12.7° (26/9)	12.3° (11/4)[12/]
9/1-9/15	10.4° (18/10)	-	-	-	-	-	-
9/16-9/30	4.8° (22/8)	-	-	-	-	3.8° (15/5)[10/]	-
10/1-10/16	1.8° (26/10)	-	-	-	3.6° (24/9)	-	3.1° (10/4)[13/]

1/ Numbers in parenthesis: (number of surface water readings/number of locations where readings were taken).
2/ Readings from 6/9-6/15 only.
3/ Readings on 6/15 and 6/16 only.
4/ Readings on 8/9 only.
5/ Readings from 6/1-6/10 only.
6/ Readings on 8/10 only.
7/ Readings on 6/12 only.
8/ Readings from 6/18-6/20 only.
9/ Readings from 8/20-8/23 only.
10/ Readings from 9/27-9/29 only.
11/ Readings on 7/10 only.
12/ Readings on 8/30 only.
13/ Readings on 10/1 only.

Table 34. Surface salinity readings (ppt) at selected stations in Norton Sound from June through September, 1976.

Date		Stations 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
June	23						3.7										
	24						4.6										
	25								13.2								
	26														0.7		
	28				13.7	13.5	13.3										
July	1						12.9										
	2												15.3	17.4			
	5									13.5	13.8	13.7					
	6								15.3								
	10	13.4	13.4	13.4	13.3	13.2	13.3										
	11-14															13.5	27.2
	16						13.7	14.1									
	18								14.0	14.9	14.8						
	21						13.5					15.1	15.1	15.1			
	25						11.0										
	26					13.9	8.1										
	27				15.1	14.6	9.3										
	28			16.3													
	31						15.5	15.0	14.8	15.7	15.5	14.9					
August	1												16.6	16.4			
	4									15.8	15.5	15.4					
	5						15.5	15.5	15.7								
	8						10.5										
	9			16.5													
	12	17.0	16.9				16.8										
	13			16.8		16.8	16.5										
	24				19.5	19.6	18.9										
	26	19.6	19.6	19.5													
	27						9.0	18.7									
	28								15.7	18.5	18.3	10.8					
	29												18.3	18.3			
	30										18.1						
	31								19.2	18.9							
September	1						18.9										
	7	19.7	20.1				19.7										
	9					19.5											
	10					11.2	19.4	18.0									
	Mean	17.4	17.5	16.5	15.4	15.3	17.7	16.3	15.4	16.2	16.0	14.0	16.3	16.8	-	-	-

Stations 1-14 occur in nearshore waters of eastern Norton Sound from Tolstoi Point to Cape Denbigh. Station 15 was in Golovin lagoon near the village of Golovin. Station 16 was at the jetties in Nome.

Table 35. Finfish catches of variable mesh gillnets during offshore sampling in Norton Sound from June 22 through July 12, 1977.

Station	Date	Time of Set	Hours Fished (1/10)	Station Depth (1/10 Fathoms)	Surface Water Temperature (C)	Catch							
						PH	BC	AC	CS	SS	SF	PS	CT
G 1	6/22	2125	9.7	13.0	8	103		3					
G 2	6/23	2035	11.0	6.5	8								1
G 3	6/24	2000	4.2	6.0	13	9							
G 4	6/25	0040	5.5	6.5	12	10							
G 5	6/25	1830	11.8	8.0	15	1		1					
G 6	6/26	2040	9.8	6.0	13	4	2						
G 7	6/27	2035	10.8	11.0	14	2	1						
G 8	6/28	2045	11.0	9.0	6	4		1	1				
G 9	6/30	2240	8.6	10.0	3								
G 10	7/1	2100	12.8	10.0	6					1			
G 11	7/2	2300	9.5	5.0	11	1					1		
G 12	7/3	1055	5.4	2.0	8						6		
G 13	7/3	1745	13.8	5.0	12		1						
G 14	7/4	1525	4.3	2.5	9				1				
G 15	7/5	2100	10.8	3.0	8			1			1		
G 16	7/6	0945	23.0	3.5	7								
G 17	7/7	1945	12.5	20.0	5								
G 18	7/8	2015	11.1	18.0	4								
G 19	7/9	1905	12.5	14.0	13	4		1					
G 20	7/10	2000	11.0	8.5	14	156	1	3		1			
G 21	7/11	1930	12.1	7.0	13								
G 22	7/12	1945	11.7	8.0	15	21		1				1	
			Ave. 10.6	Ave. 8.3	Ave. 9.9	315	5	11	2	2	8	1	1

Table 36. Mean length (mm) and weight (gms) of herring captured with gillnets in the offshore surface waters of Norton Sound from June 22 through July 12, 1977.

Stations		Age Class								
		III	IV	V	VI	VII	VIII	IX	X	Total
G1	length			222	235	245	255	264	268	245
N=101	weight			141	169	196	221	243	261	197
G2-G19	length	181		225	225	262	256		271	235
n=35	weight	65		127	124	199	201		222	156
G20-G21	length	176	196	218	225	232	237	262	244	224
n=155	weight	64	88	124	137	150	160	212	175	135
G22	length	173	183	176						
n=20	weight	63	76	66						

Table 37. Relative maturity (percent composition) by gillnet station of herring captured in offshore surface waters of Norton Sound from June 22 through July 7, 1977.

Relative Maturity Index		Gillnet Station 1	3	4	6	19	20	22	Total Percent
Virgin	1	0	0	0	0	0	0	0	0
Herring	2	0	71	100	33	0	8	44	13
Pre-	3	4	0	0	0	0	34	31	21
Spawners	4	30	0	0	0	0	0	0	10
Spawners	5	66	29	0	33	0	0	0	23
	6	0	0	0	34	0	0	0	1
Post-	7	0	0	0	0	0	3	0	2
Spawners	8	0	0	0	0	100	55	25	30
Sample		81	7	10	3	1	125	16	100

Table 38. Relative maturity (percent composition) by age class of herring captured in offshore surface waters of Norton Sound from June 22 through July 7, 1977.

Relative Maturity Index		Age Class III	IV	V	VI	VII	VIII	IX	X	Total Percent
Virgin	1	0	0	0	0	0	0	0	0	0
Herring	2	100	30	17	8	3	6	0	17	14
Pre-	3	0	20	23	27	17	17	18	17	21
Spawners	4	0	0	5	14	23	8	18	17	10
Spawners	5	0	0	11	14	34	58	55	50	23
	6	0	0	1	0	0	0	0	0	TR
Post-	7	0	0	1	3	3	3	0	0	2
Spawners	8	0	50	42	35	20	8	9	0	30
Sample		4	20	94	37	35	36	11	6	100

Table 39. Selectivity of gillnet mesh size on finfish captured in the offshore surface waters of Norton Sound from June 22 through July 12, 1977.

Mesh size (mm)	Total weight all species (kg)	Total catch all species	Catch by species PH	BC	AC	CS	SS	PS	SF	CT
25	0.02				1*					
38	6.19	68	63	3	1*		1*			
51	33.36	216	213		3					
64	14.38	48	39	1	3				5	
76	10.28	7		1		2		1	3	
102	2.12	3			3					
114	4.00	1					1			
133	-	1								1
Total	70.36	345	315	5	11	2	2	1	8	1

* Indicates juvenile fish.

Table 40. Frequency of occurrence (percent) of species encountered with a surface tow net in the offshore waters of Norton Sound from June 22 through July 12, 1977.

	Number of tows captured in	Frequency of occurrence (%)
Finfish		
Larval fish	55	66
S9	8	10
SF	5	6
WF	3	4
SC	1	1
PS	1	1
Lamprey	2	2
Miscellaneous species		
Jelly fish	49	59
Snails	12	14
Larval crabs	4	5
Polychaete worms	2	2
Shrimp	1	1
Nudibranchs	2	2
Unidentified crustacea	3	4
Unidentified mollusks	1	1
No Catch	5	6

Table 41. Catch by species and sample station of fish captured in the Yukon River 101 kilometers upriver from Flat Island from June 7-July 7, 1977.

Station	Species 1/								Total	Lamprey	Grand Total
	CS	SS	KS	PS	Wsp. 1/	SH	LL	NS			
1	36	1	1	2	234	24	100	1	399	2	401
2	45		2		237	23	88		395		395
3	47		2	2	205	19	53		328	2	330
4	29		4	1	102	7	55		198		198
5	25		2		80	10	37		154		154
6	45		1		115	11	39		211		211
7	20	1	1	1	63	2	14		102		102
8	28	2	1		57	1	34		123	1	124
Totals	275	4	14	6	1,093	97	420	1	1,910	5	1,915

1/ Wsp - represents whitefish species.

Table 42. Catch by date of juvenile finfish captured in the Yukon River 101 kilometers upriver from Flat Island from June 7 through July 7, 1977.

	Species								
Date	CS	SS	KS	PS	Wsp[1/]	SH	LL	NS	lamp.
6/7	1								
8	11		1						3
9	15				1				
10[2/]	—	—	—	—	—	—	—	—	—
11	29	1	2	2					2
12	27	2							
13	36	1	1	1					
14	—	—	—	—	—	—	—	—	—
15	34		2						
16	21		1						
17	—	—	—	—	—	—	—	—	—
18	26								
19	—	—	—	—	—	—	—	—	—
20	12		1	1					
21	15		1	1					
22	3								
23	24				20			1	
24	12		1		36				
25	—	—	—	—	—	—	—	—	—
26	2		1		46				
27	6				54		1		
28	—	—	—	—	—	—	—	—	—
29	—	—	—	—	—	—	—	—	—
30	—	—	—	—	—	—	—	—	—
7/1					114		26		
2	1				197	10	42		
3			1		162	21	90		
4			1		206	23	104		
5					89	12	62		
6					70	10	42		
7			1		98	21	53		
Total	275	4	14	6	1,093	97	420	1	5

1/ Wsp. - Whitefish species.
2/ Dates not fished.

Table 43. Sample size, range, mean length, and standard deviation of finfish captured in the Yukon River 101 kilometers upstream from Flat Island from June 7 through July 7, 1977.

Species	Sample	Fork Length Range (mm)	Mean Fork Length (mm)	Standard Deviation	Additional Samples: Sample	Additional Samples: Fork Length Range (mm)
CS smolt	265	31-58	41	4.8		
KS smolt	14	75-112	96	12.1		
PS smolt	6	32-42	35	--		
SS smolt	4	46-54	50	--		
SH juveniles	92	35-74	56	7.5		
Wsp. juveniles 1/	89	20-51	34	7.1	468	20-45
LL juveniles 2/	35	18-32	23	3.4	88	19-25
Lamprey					5	120-140
BW	1		120			
NS	1		49			

1/ Wsp. - whitefish species
2/ An additional specimen measured 105 mm.

Table 44 . Subsistence fishery resources of selected coastal villages in Norton Sound and Kotzebue Sound. Information from 1976 OCS subsistence surveys.

Village	Herring	Smelt species	Tomcod (Saffron Cod)	Flounder species	Arctic grayling	Arctic char (trout)	Whitefish species	Cottidae	Skipjacks	Northern pike	Cigarfish (Capelin?)	Capelin	Mud sucker	Blue cod	Pollack	Halibut	Blackfish species	Needlefish	Sheefish	Lingcod	King crab
Stebbins	Sp	F,W	W	Su		Su,F	Su,F	Su								X	X	F	F		
St. Michael	Sp	F	W	W			Su,F														
Unalakleet	Sp	X	W	Su	Su,F	Su,F	Su,F														Sp
Shaktoolik	Sp	X	W	Su	Su,F	Su,F	Su,F														
Koyuk*		X	X		X	X													X		
Moses Pt.	Sp	Sp,Su	W,Sp	Su	F	Su,F	F,W	Su	F											X	
Elim	Sp	Sp,Su	W,Sp	Su	F	Su,F	F,W	Su	F		X									X	
Golovin	Sp,F	X	W		W	Su,F,W	F				X										Sp
Nome*	X		X		X	X						Su 1/									W
Teller	Sp,F	Sp,F	W	Su	Su,F	Su,F	S,S,F,W	X	F	X										X	
Shishmaref	F,W,Sp	S,S,F,W	F,W	F	F	F	X	Sp,Su						W						F,W	
Deering	Su,F	Su,F	W	Su	Su,F	Su,F	Sp,Su	Su			X										
Buckland	Su,F	Sp	W	Su,F	Su,F	Su,F	F	Su,F		X			X		X						
Kotzebue*	X	X	X		X	X													X		
Pt. Hope		X	X		X																

* Villages that were not included in 1976 OCS survey. Information from ADF&G files.

1/ Capelin are taken in Nome only in some years.

Code: Sp - Spring (3-4 weeks immediately following ice breakup)
Su - Summer
F - Fall (3-4 weeks immediately preceding ice freezeup)
W - Winter (ice freezeup to ice breakup)
X - Resource used for subsistence. Dates of harvest not obtained.

Various species of salmon are utilized by all villages for subsistence purposes.

Table 45. Standard length comparisons of Pacific herring from selected Bering Sea areas.

Age Class	Port Clarence 1977	Norton Sound: Golovin Bay 1977 1/	Norton Sound: St. Michaels 1968	Yukon-Kuskokwim River Delta and Bristol Bay: Nelson Island 1976	Goodnews Bay 1976	Togiak Area 1968	Togiak Area 1969	Togiak Area 1974	Togiak Area 1976	Togiak Area 1977	North Alaska Peninsula 1976
0	90 2/	50 3/									
1	114	150									151
2	159	175						141			156
3	164	184		200	219		216	203		209	182
4	173	198	208	228	222	238	245	217	217	229	205
5	183	219	227	231	222	253	256	234	244	232	216
6	200	225	231	248	246	262	277	249	237	248	230
7	202	240	236	267	288	272	280	261	286	268	262
8	204	252	244	277	281	282	290	267	281	276	256
9	207	259	250	295	284	289	314	275	291	276	261
10	211	272	244	263		297	303	268	290	271	265
11	229		260			300	305				
12	228		275			305	312		302		
13	228					302	310				
14	244										
15	240						330				
Sample Size	834	472	350	45	56	673	403	451	54	2,670	1,198

1/ Includes offshore herring samples collected in eastern Norton Sound in June.

2/ Measurements taken from September 29 to October 5.

3/ Measurements taken on September 8.

Table 46. Standard length comparisons of herring from selected Pacific Ocean and Bering Sea areas.

Age Class	Port Clarence	Eastern Norton Sound	Yukon-Kuskokwim Delta 3/	Togiak 3/	North Alaska Peninsula 4/	Prince William Sound 5/	Southeast Alaska 6/	British Columbia 6/
0	90 1/	50 2/						
1	114	150			151			148
2	159	175		141	156		152	186
3	164	184	210	209	182	177	176	194
4	173	203	225	229	205	189	198	203
5	183	223	227	244	216	199	207	215
6	200	228	247	255	230	209	223	220
7	202	238	278	273	262	214	222	223
8	204	248	279	279	256	221	238	220
9	207	255	290	289	261	231	236	
10	211	258	263	286	265		237	
11	229	260		303		215		
12	228	275		306				
13	228			306				
14	244							
15	240			330				
Sample	834	822	101	4,257	1,198	417		

1/ Measurements taken from September 29 to October 5, 1977.
2/ Measurements taken on September 8, 1977.
3/ Data from Barton et al. 1976.
4/ Data from Warner and Shafford 1977.
5/ Data from Fridgen, personal communication.
6/ Data from Randall 1975.

Table 47. Variation in number of herring vertebrae from samples collected at selected sites along the North American Pacific Coastline (data from Rounsefell, 1930).

Area	Locality	Number	Mean	Probable Error	Standard Deviation of Distribution
California	San Diego Bay	408	50.68	0.023	0.691
California	Monterey Bay	89	51.03	0.06	---
California	San Francisco Bay	820	50.78	0.019	0.797
Washington	Puget Sound	100	51.71	0.052	0.758
British Columbia	South British Columbia	1,263	51.78	0.01	---
Southeastern Alaska	Gravina Island	50	52.32	0.075	0.786
Southeastern Alaska	Craig	344	52.40	0.026	0.712
Southeastern Alaska	Larch Bay	463	52.66	0.021	0.681
Southeastern Alaska	Tebenkof Bay	683	52.68	0.018	0.683
Southeastern Alaska	Point Gardner	352	52.72	0.023	0.634
Southeastern Alaska	Whale Bay	25	52.92	0.078	0.580
Southeastern Alaska	Stephens Passage	962	52.36	0.017	0.769
Southeastern Alaska	Yakutat Bay	25	52.48	0.163	0.205
Prince William Sound	Puget Bay	177	52.45	0.038	0.750
Prince William Sound	Elrington Passage	401	52.76	0.024	0.719
Prince William Sound	Macleod Harbor	367	52.72	0.027	0.755
Prince William Sound	Snug Harbor	322	52.55	0.029	0.772
Prince William Sound	Eshamy Bay	150	52.83	0.035	0.636
Prince William Sound	McClure Bay	224	52.90	0.030	0.657
Prince William Sound	Naked Island	138	52.80	0.040	0.693
Prince William Sound	Port Fidalgo	137	52.44	0.040	0.692
Cook Inlet	Dogfish Bay	100	52.50	0.051	0.763
Cook Inlet	Kachemak Bay	740	52.76	0.031	0.790
Kodiak	Shuyak Strait	531	52.72	0.022	0.757
Kodiak	Zachar Bay	87	52.85	0.048	0.670
Kodiak	Shearwater Bay	165	52.91	0.041	0.776
Kodiak	Old Harbor	115	52.95	0.050	0.790
Alaska Peninsula	Chignik	107	53.33	0.053	0.806
Alaska Peninsula	Shumagin Islands	456	54.67	0.029	0.928
Alaska Peninsula	Belkofski Bay	8	53.13	---	---
Alaska Peninsula	Unalaska	183	53.22	0.032	0.650
Norton Sound	Golovin Bay	140	52.79	0.038	0.671

Table 48. Rank order by frequency of occurrence (percent) of the 20 most common species captured in beach seines in the nearshore waters of Norton Sound, 1976-1977.

Rank	Species	All areas combined	Golovin Bay area	South and eastern Norton Sound	Pt. Clarence Area
1	Boreal smelt	44.2	31	75	32
2	Saffron Cod	42.4	37	48	48
3	Bering cisco	42.1	41	51	33
4	Starry flounder	41.4	52	34	27
5	Ninespine stickleback	25.5	31	16	25
6	Pond smelt	24.1	15	17	57
7	Sand lance	23.7	34	3	24
8	Arctic flounder	23.0	25	39	14
9	Tubenose poacher	23.0	31	14	16
10	Least cisco	22.7	25	13	25
11	Sculpins	20.1	19	12	19
12	Pink salmon *	16.2	25	10	5
13	Humpback whitefish	15.5	23	12	3
14	Chum salmon *	15.1	23	9	6
15	Broad whitefish	12.6	15	9	13
16	Pacific herring*	7.2	-	1	27
17	Bering poacher	7.2	6	18	-
18	Threespine stickleback	6.5	1	-	11
19	Arctic char	6.1	9	4	3
20	Pricklebacks	5.0	-	18	-

* Indicates juveniles.

Table 49. Rank order by frequency of occurrence (percent) of the 20 most common species captured in variable mesh gillnets in the nearshore waters of Norton Sound, 1976-1977.

Rank	Species	All areas combined	Golovin Bay area	South and eastern Norton Sound	Pt. Clarence Area
1	Saffron cod	30.8	35	25	38
2	Starry flounder	24.6	24	23	32
3	Pacific herring	21.0	16	19	32
4	Least cisco	20.7	21	20	23
5	Bering cisco	20.3	14	24	24
6	Arctic char	14.1	10	20	9
7	Boreal smelt	13.1	8	17	16
8	Humpback whitefish	10.8	18	6	8
9	Arctic flounder	9.4	8	12	7
10	Sculpins	7.4	9	5	10
11	Broad whitefish	4.7	8	2	7
12	Pond smelt	4.4	3	3	13
13	Whitespotted greenling	4.1	10	1	-
14	Yellowfin sole	4.1	3	6	1
15	Rock greenling	4.0	TR	6	7
16	Pricklebacks	2.3	-	5	-
17	Pacific herring *	1.2	-	1	6
18	Round whitefish	1.2	-	1	5
19	Bering poacher	1.0	TR	2	-
20	Sturgeon poacher	0.6	1	TR	-

* Indicates juveniles.

Table 50. Rank order by frequency of occurrence (percent) of the 10 most common families of fish sampled in Norton Sound with beach seines and variable mesh gillnets, 1976-77.

Beach seine	%	Rank	%	Gillnet
Coregonidae	96	1	58	Coregonidae
Pleuronectidae	71	2	39	Pleuronectidae
Osmeridae	69	3	31	Gadidae
Gadidae	42	4	22	Clupeidae
Salmonidae 1/	41	5	17	Osmeridae
Gasterosteidae	32	6	15	Salmonidae 1/
Agonidae	31	7	8	Hexagrammidae
Ammodytidae	23	8	7	Cottidae
Cottidae	20	9	2	Stichaeidae
Clupeidae	10	10	2	Agonidae

1/ Includes only Arctic char and juvenile salmon. Adult salmon are not included.

Table 51. Abundance of Bering cisco captured in the nearshore waters of Norton Sound, 1976-77.

AREA	I 76	I 77	II 76	II 77	III 76	III 77	IV 76	IV 77	V 76	V 77	VI 76	VI 77	VII 76	VII 77	VIII 76	VIII 77	IX 76	IX 77
BEACH SEINES*																		
A	-	7.2	-	0.3	0.6	0.1	1.0	-	3.8	-	2.4	1.4	4.8	1.0	-	5.9	-	1.0
average	7.2		0.3		0.4		1.0		3.8		1.9		2.9		5.9		1.0	
B	1.5	-	2.0	-	2.6	-	1.2	14.7	2.3	-	4.2	-	-	-	-	-	-	-
average	1.5		2.0		2.6		8.0		2.3		4.2		-		-		-	
C	-	1.5	0.1	-	0.9	-	2.8	5.0	5.4	-	13.7	-	4.0	-	-	-	-	-
average	1.5		0.1		0.9		3.9		5.4		13.7		4.0		-		-	
D	-	0.0	-	-	-	-	-	0.0	-	-	-	-	-	-	-	-	-	-
average	0.0		-		-		0.0		-		-		-		-		-	
G	-	-	-	0.2	-	5.3	-	-	-	-	-	0.6	-	-	-	0.2	-	-
average	-		0.2		5.3		-		-		0.6		-		0.2		-	
H	-	-	-	6.6	-	6.3	-	-	-	0.0	-	0.0	-	-	-	1.3	-	0.0
average	-		6.6		6.3		-		0.0		0.0		-		1.3		0.0	
I	-	-	-	-	-	17.6	-	-	-	-	-	2.3	-	-	-	0.0	-	-
average	-		-		17.6		-		-		2.3		-		0.0		-	
GILLNETS*																		
A	-	0.3	-	0.2	0.2	0.1	0.1	-	0.04	-	0.2	0.1	0.4	0.2	-	0.5	-	0.0
average	0.3		0.2		0.2		0.1		0.04		0.2		0.3		0.5		0.0	
B	-	0.4	0.7	-	0.7	-	0.3	0.5	0.5	1.5	0.5	-	-	-	-	-	-	-
average	0.4		0.7		0.7		0.4		1.0		0.5		-		-		-	
C	-	0.0	0.7	-	2.1	-	0.4	1.9	0.4	1.5	0.5	-	0.3	-	-	-	-	-
average	0.0		0.7		2.1		1.2		1.0		0.5		0.3		-		-	
D	-	0.0	-	-	0.2	-	0.3	1.9	0.3	1.5	-	-	-	-	-	-	-	-
average	0.0		-		2.1		1.1		0.9		-		-		-		-	
G	-	-	-	0.1	-	-	-	0.1	-	-	-	0.3	-	-	-	1.0	-	-
average	-		0.1		-		0.1		-		0.3		-		1.0		-	
H	-	-	-	-	-	2.4	-	0.0	-	0.0	-	0.7	-	-	-	0.5	-	0.6
average	-		-		2.4		0.0		0.0		0.7		-		0.5		0.6	
I	-	-	-	-	-	-	-	-	-	-	-	1.2	-	-	-	2.7	-	-
average	-		-		-		-		-		1.2		-		2.7		-	

*CPUE equals fish per net hour & fish per set for gillnets and beach seines, respectively.

Table 52. Abundance of least cisco captured in the nearshore waters of Norton Sound, 1976-77.

AREA		I 76	I 77	II 76	II 77	III 76	III 77	IV 76	IV 77	V 76	V 77	VI 76	VI 77	VII 76	VII 77	VIII 76	VIII 77	IX 76	IX 77
BEACH SEINES*																			
A		-	1.3	-	1.9	0.1	0.6	11.8	-	23.2	-	0.4	40.9	0.8	3.4	-	3.7	-	1.3
	average	1.3		1.9		0.4		11.8		23.2		20.7		2.1		3.7		1.3	
B		-	0.5	0.0	-	0.0	-	1.0	0.7	0.0	-	0.2	-	-	-	-	-	-	-
	average	0.5		0.0		0.0		0.9		0.0		0.2		-		-		-	
C		-	0.0	0.1	-	2.4	-	0.2	0.0	0.0	-	2.9	-	1.5	-	-	-	-	-
	average	0.0		0.1		2.4		0.1		0.0		2.9		1.5		-		-	
D		-	0.3	-	-	-	-	-	0.0	-	-	-	-	-	-	-	-	-	-
	average	0.3		0.1		2.4		0.0		-		-		-		-		-	
G		-	-	-	3.4	-	0.3	-	-	-	-	-	1.6	-	-	-	0.0	-	-
	average	-		3.4		0.3		-		-		1.6		-		0.0		-	
H		-	-	-	0.0	-	1.3	-	-	-	0.0	-	0.0	-	-	-	0.0	-	0.0
	average	-		0.0		1.3		-		0.0		0.0		-		0.0		0.0	
I		-	-	-	-	-	17.6	-	-	-	-	-	24.0	-	-	-	0.0	-	-
	average	-		-		17.6		-		-		24.0		-		0.0		-	
GILLNETS*																			
A		-	0.1	-	0.2	0.5	0.1	1.1	-	0.2	-	0.6	0.5	0.4	0.8	-	2.5	-	0.0
	average	0.1		0.2		0.3		1.1		0.2		0.6		0.6		2.5		0.0	
B		-	0.5	0.0	-	0.0	-	0.1	1.2	0.4	0.3	0.3	-	-	-	-	-	-	-
	average	0.5		0.0		0.0		0.7		0.4		0.3		-		-		-	
C		-	0.1	0.3	-	0.2	-	0.2	1.6	0.1	0.0	0.05	-	0.1	-	-	-	-	-
	average	0.1		0.3		0.2		0.9		0.1		0.05		0.1		-		-	
D		-	0.8	-	-	0.2	-	0.3	0.4	0.3	-	-	-	-	-	-	-	-	-
	average	0.1		-		0.2		0.4		0.3		-		-		-		-	
G		-	-	-	2.0	-	-	-	0.0	-	-	-	1.0	-	-	-	0.1	-	-
	average	-		2.0		-		0.0		-		1.0		-		0.1		-	
H		-	-	-	-	-	2.9	-	0.6	-	0.0	-	0.3	-	-	-	0.2	-	0.0
	average	-		-		2.9		0.6		0.0		0.3		-		0.2		0.0	
I		-	-	-	-	-	-	-	-	-	-	-	3.0	-	-	-	4.0	-	-
	average	-		-		-		-		-		3.0		-		4.0		-	

*CPUE equals fish per net hours and fish per set for gillnets and beach seines, respectively.

Table 53. Abundance of boreal smelt captured in the nearshore waters of Norton Sound, 1976-77.

		SAMPLING PERIOD																	
		I		II		III		IV		V		VI		VII		VIII		IX	
AREA		76	77	76	77	76	77	76	77	76	77	76	77	76	77	76	77	76	77
								BEACH SEINES *											
A		-	1.4	-	3.3	4.6	0.0	11.3	-	34.3	-	32.1	25.2	3.7	0.2	-	1.4	-	7.0
	average	1.4		3.3		4.6		11.3		34.3		28.7		1.9		1.4		7.0	
B		-	9.5	3.3	-	10.3	-	49.3	21.3	19.3	-	14.6	-	-	-	-	-	-	-
	average	9.5		3.3		10.3		35.3		19.3		14.6		-		-		-	
C		-	0.0	2.9	-	107.3	-	55.4	8.0	61.4	-	63.6	-	4.5	-	-	-	-	-
	average	0.0		2.9		107.3		31.7		61.4		63.6		4.5		-		-	
D		-	0.7	-	-	-	-	-	0.0	-	-	-	-	-	-	-	-	-	-
	average	0.7		-		-		0.0		-		-		-		-		-	
G		-	-	-	6.2	-	0.0	-	-	-	-	-	0.5	-	-	-	0.6	-	-
	average	-		6.2		0.0		-		-		0.5		-		0.6		-	
H		-	-	-	1.6	-	0.0	-	-	-	0.3	-	1.D	-	-	-	5.5	-	7.8
	average	-		1.6		0.0		-		0.3		1.0		-		5.5		7.8	
I		-	-	-	-	-	9.6	-	-	-	-	-	2.7	-	-	-	0.0	-	-
	average	-		-		9.6		-		-		2.7		-		0.0		-	
								GILLNETS *											
A		-	0.0	-	0.0	0.0	0.1	0.0	-	0.0	-	0.04	0.1	0.0	0.2	-	0.2	-	0.4
	average	0.0		0.0		0.1		0.0		0.0		0.1		0.1		0.2		0.4	
B		-	0.0	0.5	-	2.4	-	0.6	0.3	0.4	0.3	0.1	-	-	-	-	-	-	-
	average	0.0		0.5		2.4		0.5		0.4		0.1		-		-		-	
C		-	0.0	3.8	-	4.9	-	0.9	0.1	8.1	0.0	0.3	-	0.1	-	-	-	-	-
	average	0.0		3.8		4.9		0.5		4.1		0.3		0.1		-		-	
D		-	0.0	-	-	0.5	-	0.2	0.0	0.02	-	-	-	-	-	-	-	-	-
	average	0.0		-		0.5		0.1		0.02		-		-		-		-	
G		-	-	-	0.7	-	-	-	0.0	-	-	-	0.0	-	-	-	0.5	-	-
	average	-		0.7		-		0.0		-		0.0		-		0.5		-	
H		-	-	-	-	-	23.0	-	0.0	-	0.0	-	0.0	-	-	-	0.4	-	4.0
	average	-		-		23.0		0.0		0.0		0.0		-		0.4		4.0	
I		-	-	-	-	-	-	-	-	-	-	-	0.0	-	-	-	0.0	-	-
	average	-		-		-		-		-		0.0		-		0.0		-	

*CPUE equals fish per net hour and fish per set for gillnets and beach seines, respectively.

Table 54. Abundance of Pacific herring captured in the nearshore waters of Norton Sound, 1976-77.

AREA		SAMPLING PERIOD																
	I		II		III		IV		V		VI		VII		VIII		IX	
	76	77	76	77	76	77	76	77	76	77	76	77	76	77	76	77	76	77
BEACH SEINES *																		
A	-	0.1	-	0.0	0.0	0.0	0.0	-	0.0	-	0.0	0.0	0.0	12.0	-	0.3	-	0.0
average	0.1		0.0		0.0		0.0		0.0		0.0		6.0		0.3		0.0	
B	-	0.0	0.0	-	0.0	-	0.0	0.3	32.0	-	0.2	-	-	-	-	-	-	-
average	0.0		0.0		0.0		0.2		16.0		0.2		-		-		-	
C	-	0.0	0.0	-	0.0	-	0.2	1.5	0.0	-	0.1	-	0.0	-	-	-	-	-
average	0.0		0.0		0.0		0.9		0.0		0.1		0.0		-		-	
D	-	0.0	-	-	-	-	-	0.0	-	-	-	-	-	-	-	-	-	-
average	0.0		-		-		0.0		-		-		-		-		-	
G	-	-	-	3.8	-	0.0	-	-	-	-	-	2.5	-	-	-	0.7	-	-
average	-		3.8		0.0		-		-		2.5		-		0.7		-	
H	-	-	-	0.0	-	39.5	-	-	-	1.0	-	5.3	-	-	-	0.0	-	0.0
average	-		0.0		39.5		-		1.0		5.3		-		0.0		0.0	
I	-	-	-	-	-	7.4	-	-	-	-	-	40.7	-	-	-	0.0	-	-
average	-		-		7.4		-		-		40.7		-		0.0		-	
GILLNETS *																		
A	-	0.6	-	1.7	0.03	1.2	0.0	-	0.0	-	0.0	0.0	0.1	0.5	-	4.7	-	0.5
average	0.6		1.7		0.6		0.0		0.0		0.0		0.3		4.7		0.5	
B	-	1.7	11.8	-	1.1	-	0.4	0.3	0.1	0.0	0.1	-	-	-	-	-	-	-
average	1.7		11.8		1.1		0.4		0.05		0.1		-		-		-	
C	-	0.0	7.9	-	2.4	-	0.6	0.0	0.0	0.0	0.0	-	0.0	-	-	-	-	-
average	0.0		7.9		2.4		0.3		0.0		0.0		0.0		-		-	
D	-	1.3	-	-	1.6	-	1.1	0.5	0.12	-	-	-	-	-	-	-	-	-
average	1.3		-		1.6		0.8		0.12		-		-		-		-	
G	-	-	-	92.5	-	-	-	0.0	-	-	-	0.9	-	-	-	1.1	-	-
average	-		92.5		-		0.0		-		0.9		-		1.1		-	
H	-	-	-	-	-	48.9	-	0.0	-	0.0	-	0.6	-	-	-	2.7	-	0.5
average	-		-		48.9		0.0		0.0		0.6		-		2.7		0.5	
I	-	-	-	-	-	-	-	-	-	-	-	3.8	-	-	-	3.2	-	-
average	-		-		-		-		-		3.8		-		3.2		-	

*CPUE equals fish per net hour and fish per set for gillnet and beach seines, respectively.

Table 55. Abundance of saffron cod captured in the nearshore waters of Norton Sound, 1976-77.

AREA		I 76	I 77	II 76	II 77	III 76	III 77	IV 76	IV 77	V 76	V 77	VI 76	VI 77	VII 76	VII 77	VIII 76	VIII 77	IX 76	IX 77
		SAMPLING PERIOD																	
		BEACH SEINES *																	
A		-	0.3	-	1.0	1.7	0.1	2.8	-	36.9	-	24.0	22.1	4.8	13.0	-	1.7	-	2.7
	average	0.3		1.0		0.9		2.8		36.9		23.1		8.9		1.7		2.7	
B		-	0.5	0.0	-	2.1	-	15.0	124.7	0.7	-	2.8	-	-	-	-	-	-	-
	average	0.5		0.0		2.1		69.9		0.7		2.8		-		-		-	
C		-	0.3	0.0	-	3.5	-	34.2	15.3	30.8	-	27.0	-	29.0	-	-	-	-	-
	average	0.3		0.0		3.5		24.8		30.8		27.0		29.0		-		-	
D		-	0.0	-	-	-	-	-	0.0	-	-	-	-	-	-	-	-	-	-
	average	0.0		-		-		0.0		-		-		-		-		-	
G		-	-	-	0.0	-	7.3	-	-	-	-	-	25.5	-	-	-	2.1	-	-
	average	-		0.0		7.3		-		-		25.5		-		2.1		-	
H		-	-	-	0.0	-	1.0	-	-	-	0.0	-	0.5	-	-	-	0.3	-	0.3
	average	-		0.0		1.0		-		0.0		0.5		-		0.3		0.3	
I		-	-	-	-	-	0.0	-	-	-	-	-	2.0	-	-	-	0.3	-	-
	average	-		-		0.0		-		-		2.0		-		0.3		-	
		GILLNETS *																	
A		-	0.8	-	0.5	0.7	0.4	1.0	-	0.2	-	0.6	0.4	1.0	1.4	-	3.0	-	1.0
	average	0.8		0.5		0.6		1.0		0.2		0.5		1.2		3.0		1.0	
B		-	0.3	1.9	-	0.6	-	0.5	0.7	0.8	0.0	0.6	-	-	-	-	-	-	-
	average	0.3		1.9		0.6		0.6		0.4		0.6		-		-		-	
C		-	0.2	0.9	-	1.0	-	0.2	0.1	0.2	0.0	0.3	-	1.7	-	-	-	-	-
	average	0.2		0.9		1.0		0.2		0.1		0.3		1.7		-		-	
D		-	1.1	-	-	1.0	-	0.5	0.1	0.2	-	-	-	-	-	-	-	-	-
	average	1.1		-		1.0		0.3		0.2		-		-		-		-	
G		-	-	-	3.9	-	-	-	0.5	-	-	-	1.4	-	-	-	0.8	-	-
	average	-		3.9		-		0.5		-		1.4		-		0.8		-	
H		-	-	-	-	-	5.4	-	0.4	-	0.0	-	0.4	-	-	-	0.5	-	14.8
	average	-		-		5.4		0.4		0.0		0.4		-		0.5		14.8	
I		-	-	-	-	-	-	-	-	-	-	-	3.0	-	-	-	2.0	-	-
	average	-		-		-		-		-		3.0		-		2.0		-	

*CPUE equals fish per net hour and fish per set for gillnets and beach seines, respectively.

APPENDIX FIGURES

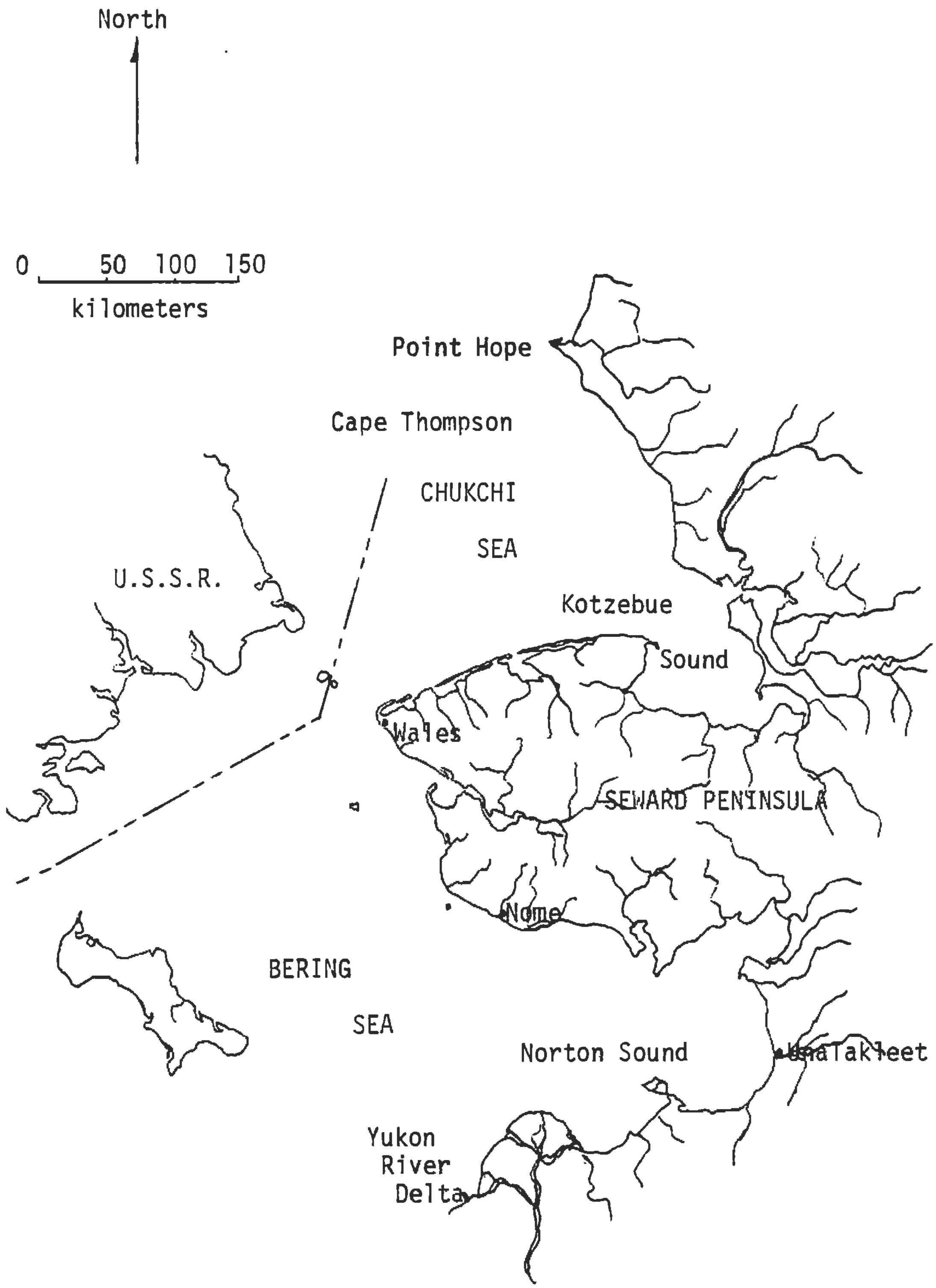


Figure 1. Study area for Research Unit 19 , Finfish Resource Surveys in Norton Sound and Kotzebue Sound, 2,496 kilometers, 1976 -77.

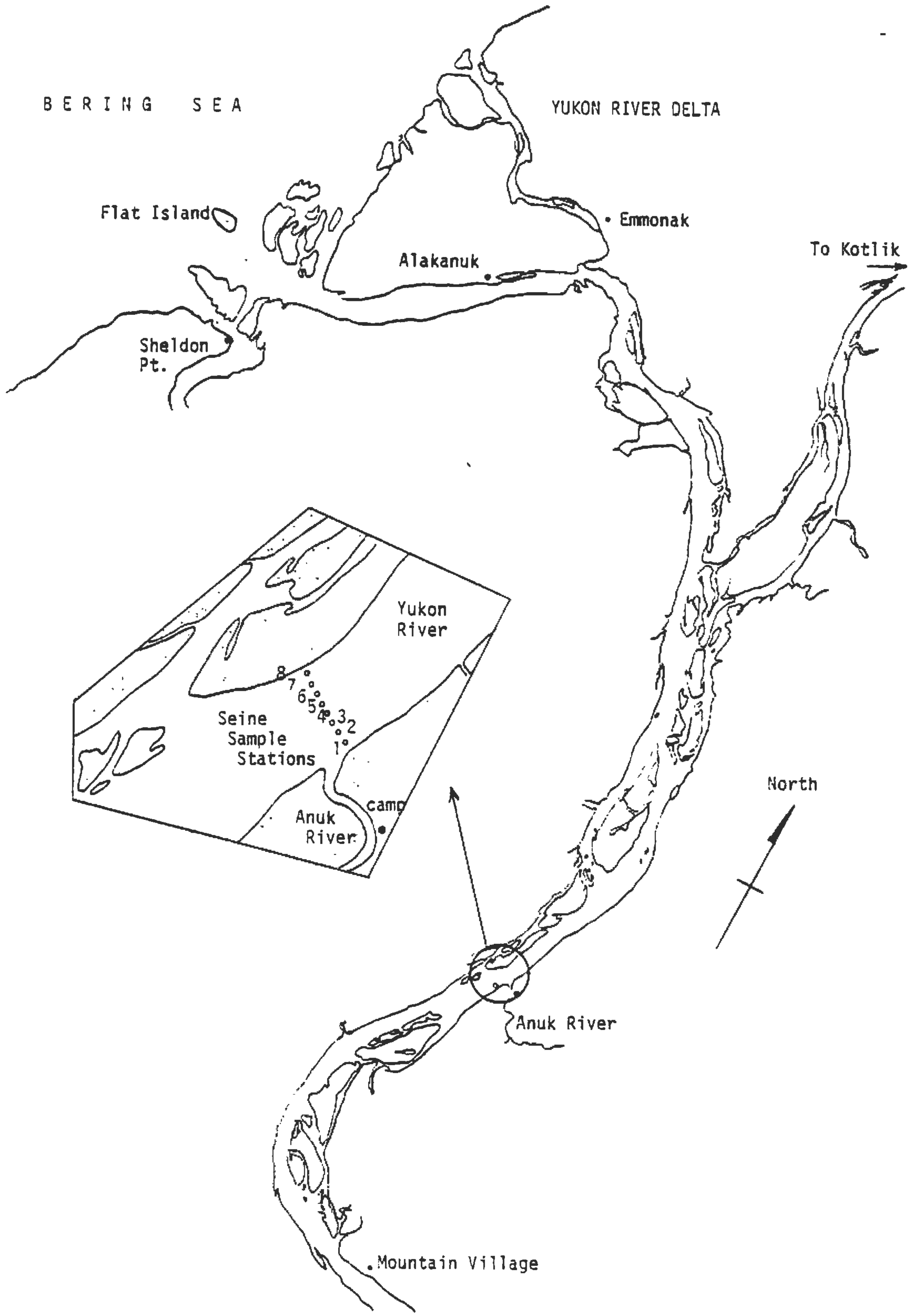


Figure 2. Yukon River smolting site June 7 through July 7, 1977. Site was located 101 kilometers upriver from Flat Island at the confluence of the Anuk River.

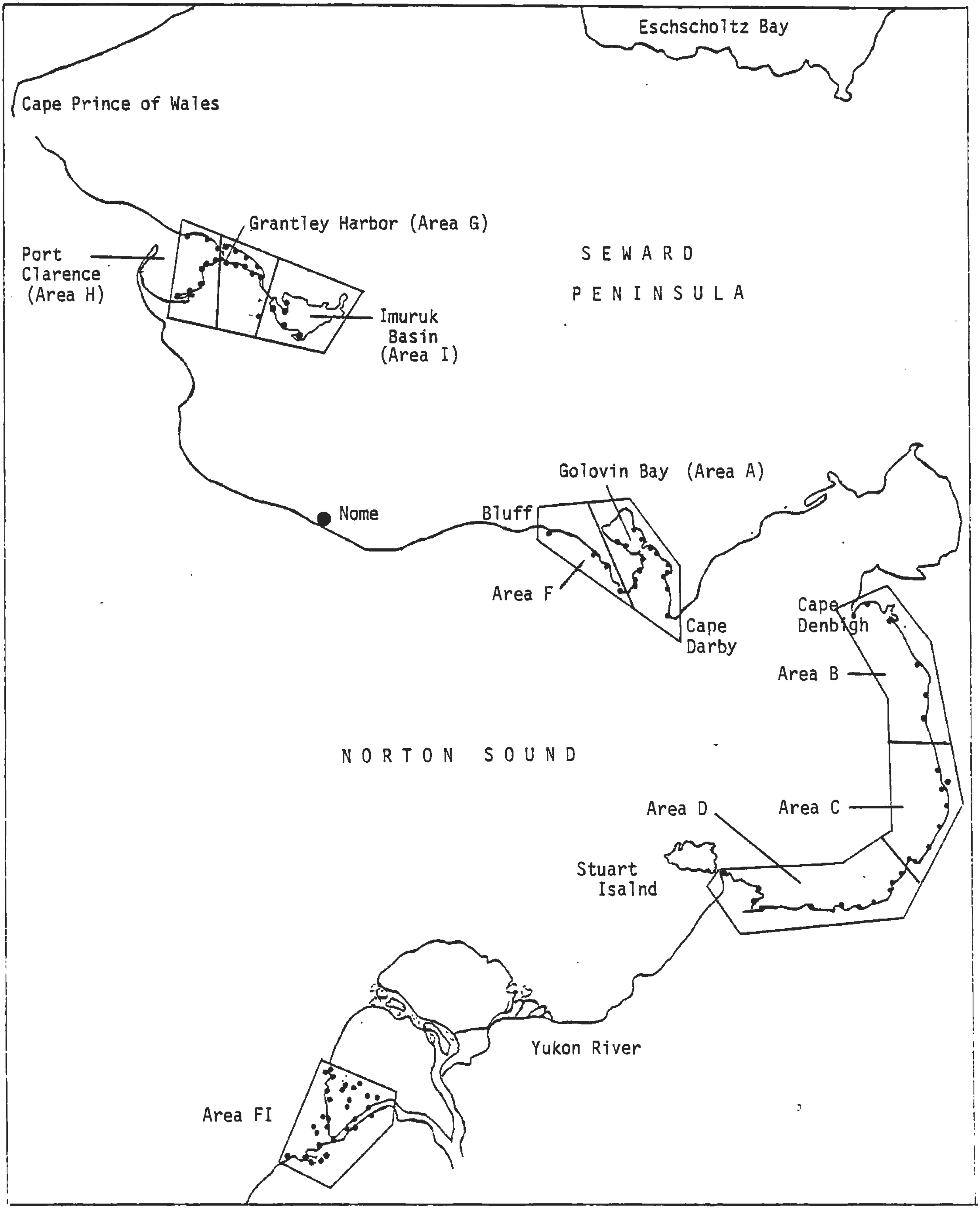


Figure 3 . Sample locations for nearshore studies conducted under R.U. 19 throughout Norton Sound and the Yukon River Delta, 1976-77.

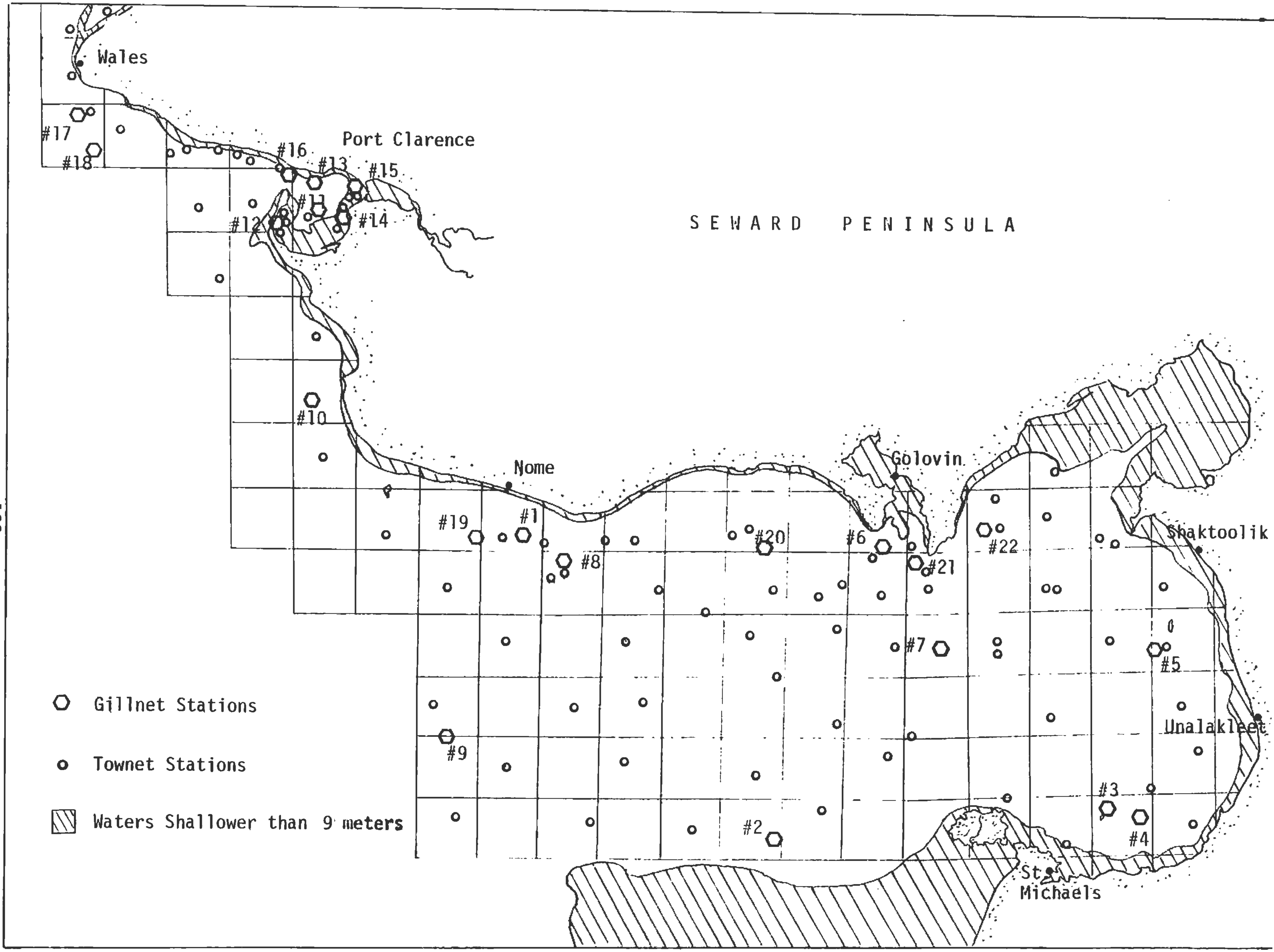


Figure 4. Surface townet and gillnet sample stations from June 22 through July 12 in Norton Sound, 1977.

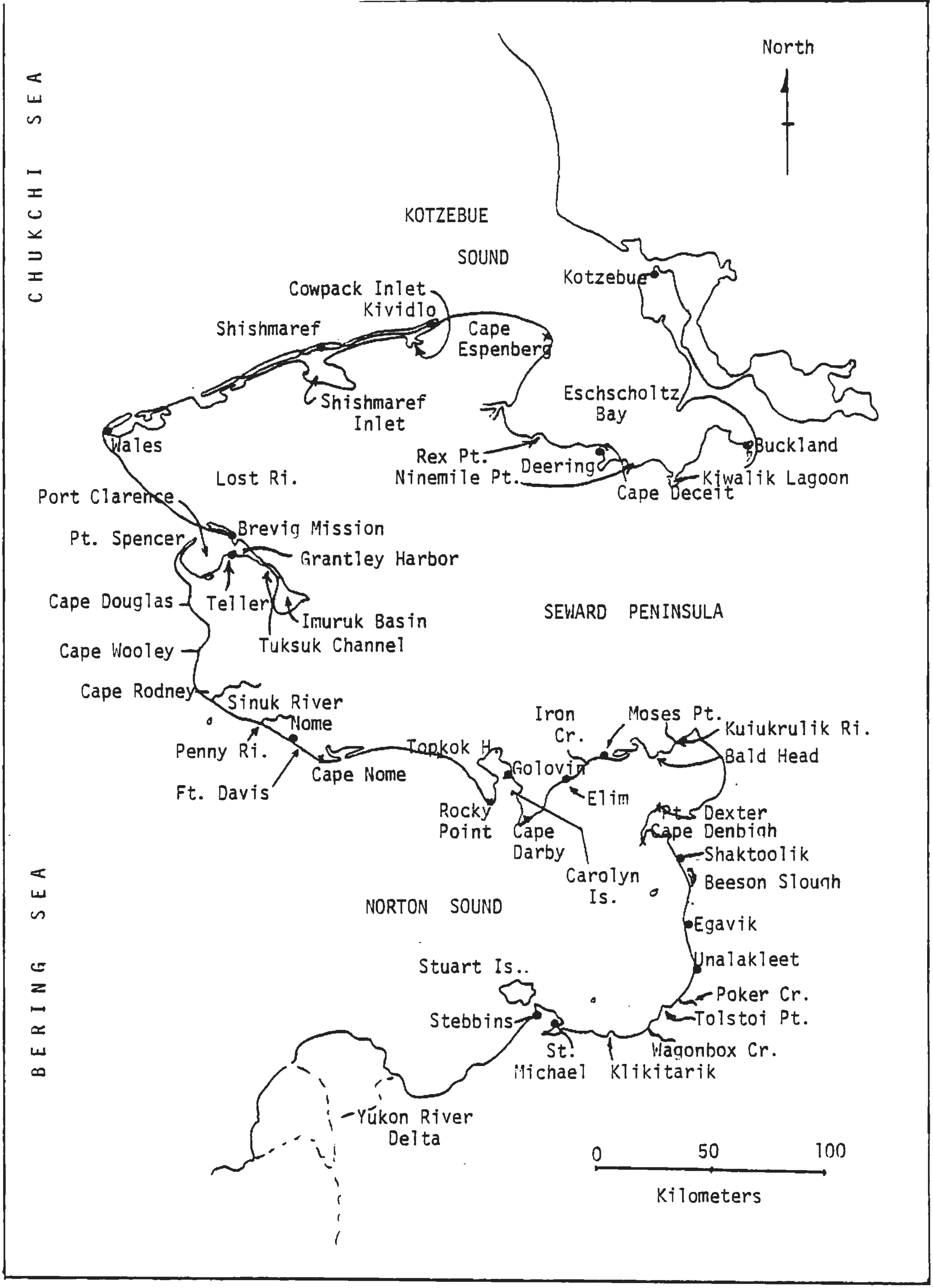


Figure 5. Study area for aerial herring surveys.

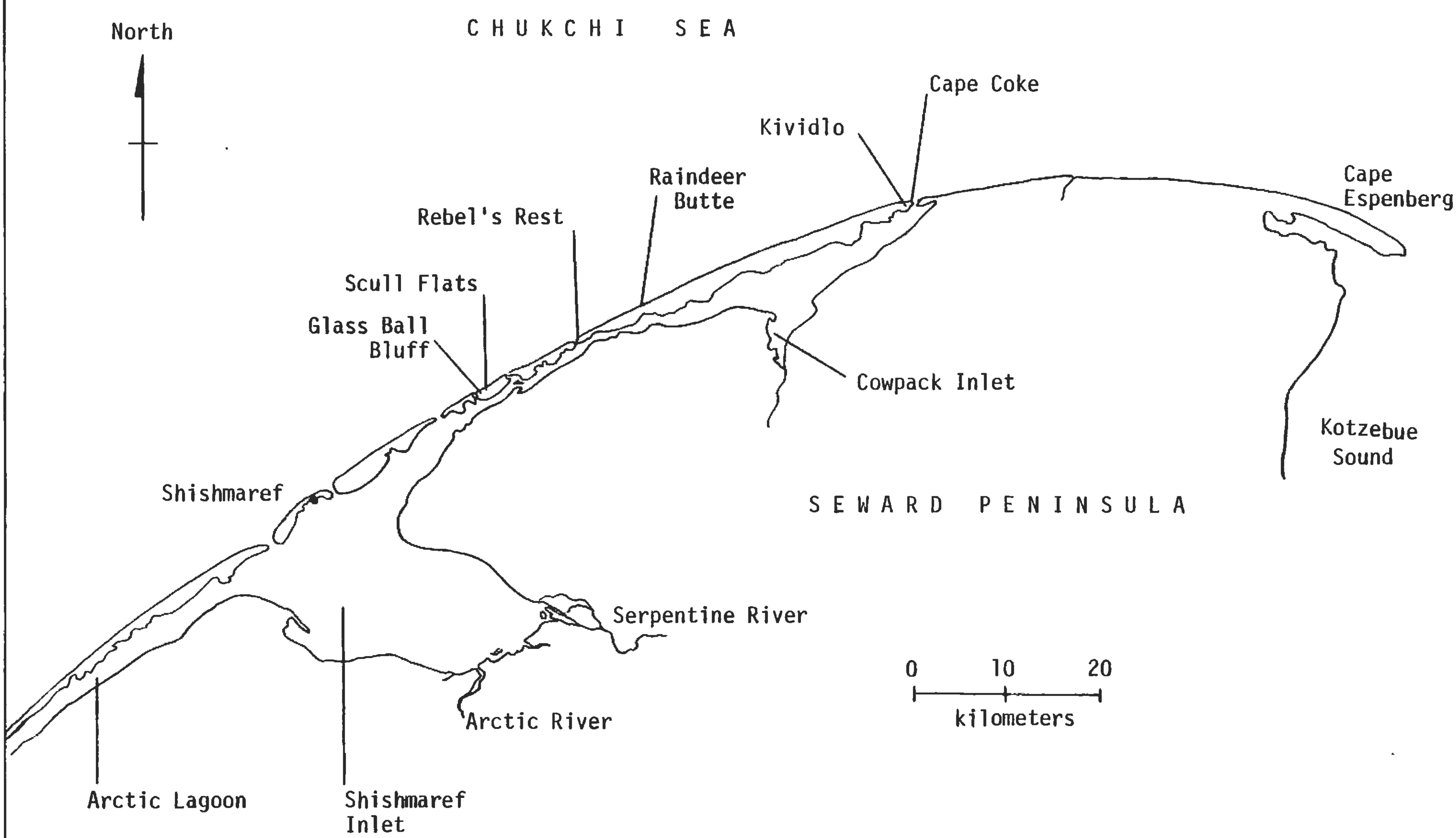


Figure 6. Study area on northwest coast of Seward Peninsula, 1977.

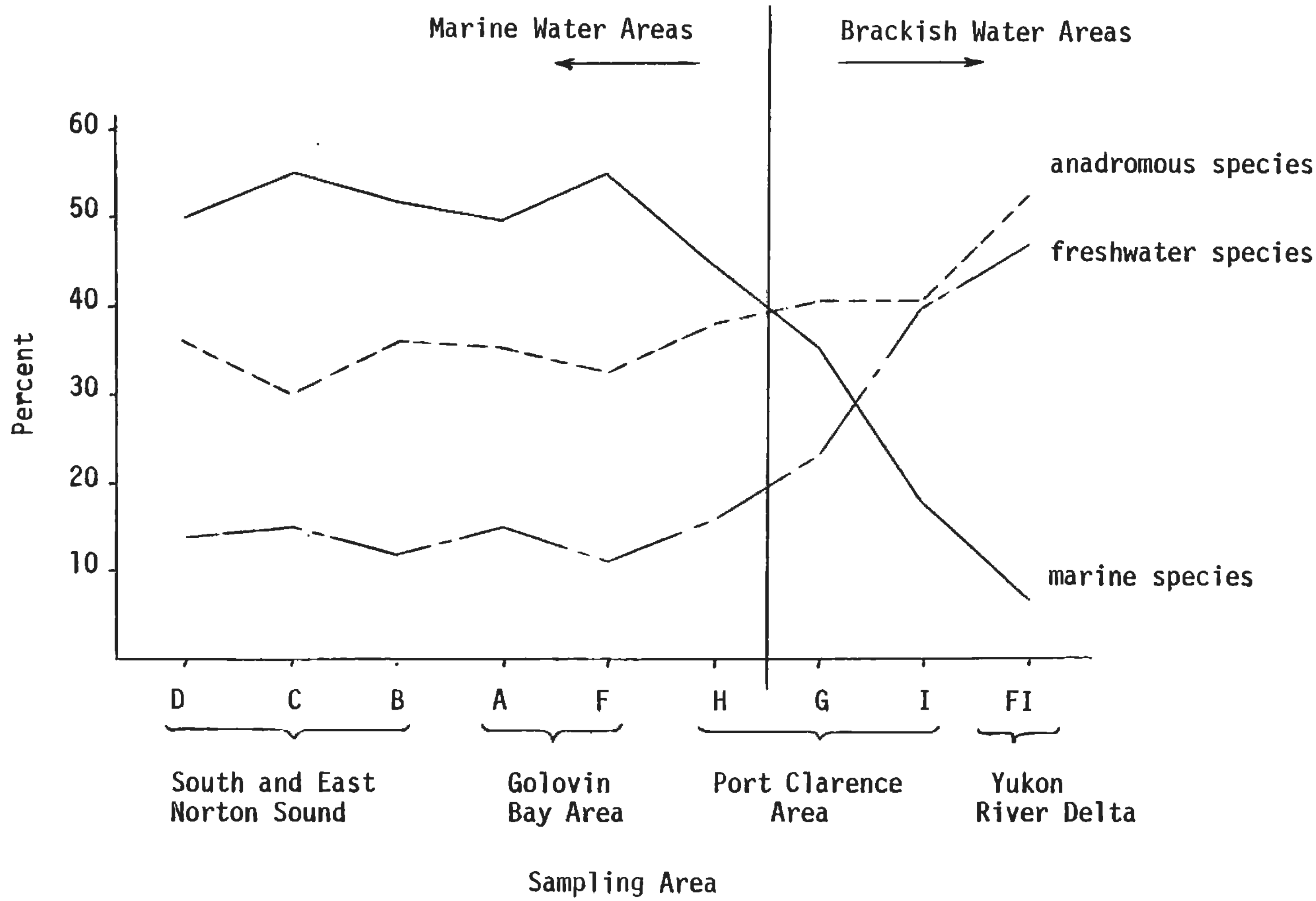


Figure 7. Species diversification by area of finfish captured in the coastal waters of Norton Sound from the Yukon River Delta to Port Clarence, 1976-77.

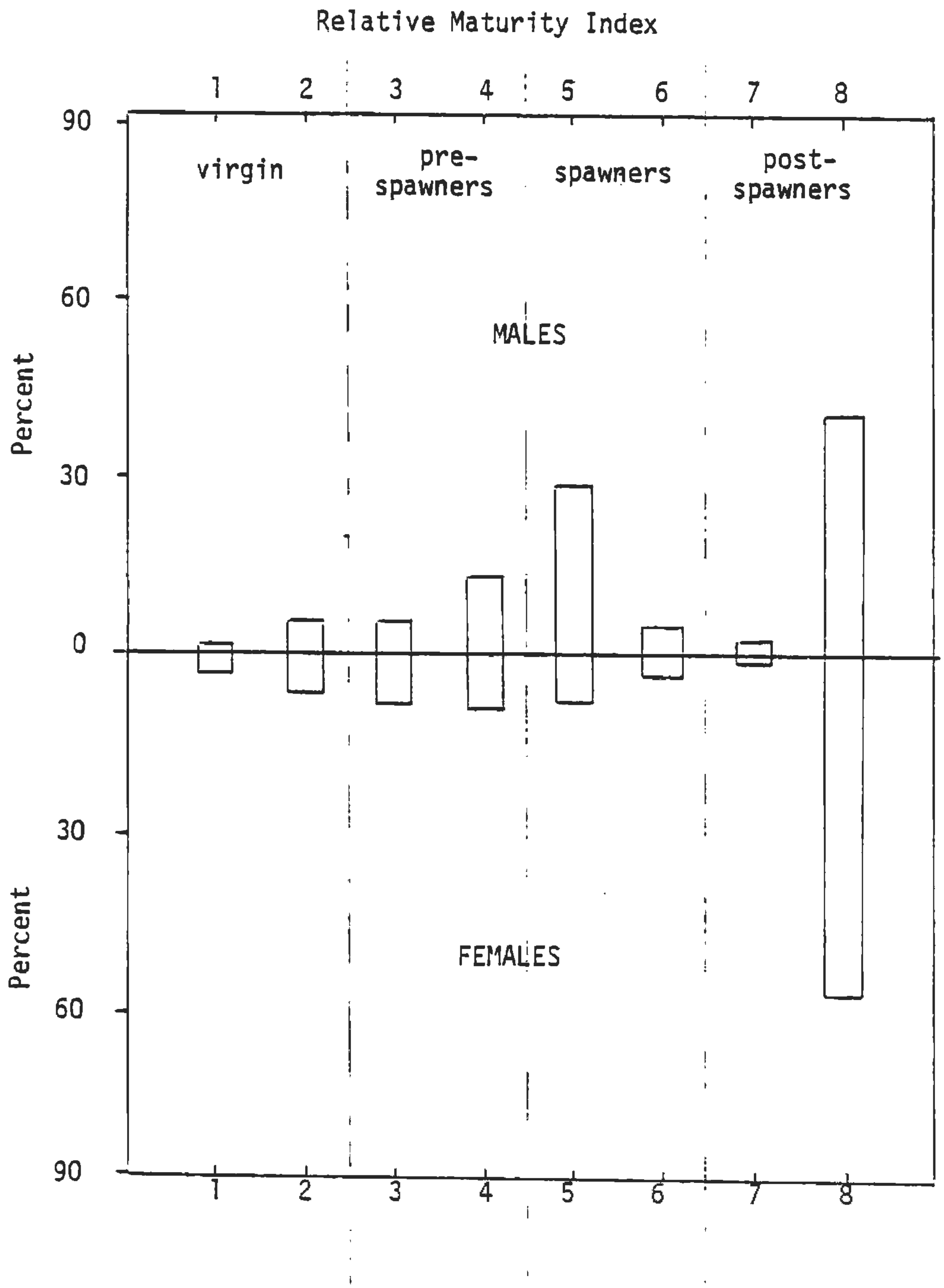


Figure 8 . Relative maturity by sex of herring captured in the Port Clarence area from ice breakup (late June) through freezeup (late October), 1977.

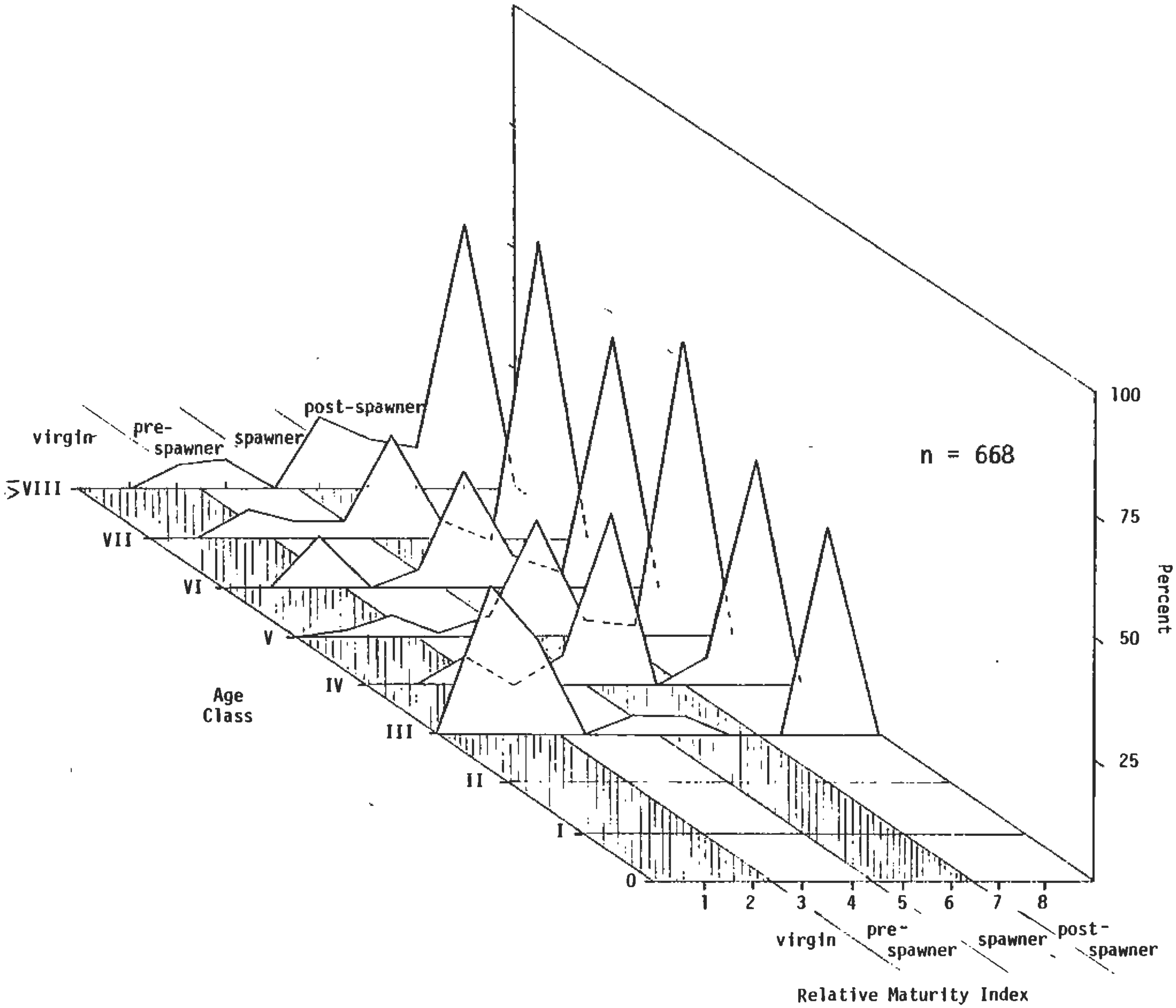


Figure 9. Relative maturity by age of herring captured in the Port Clarence area from ice breakup (late June) through July 21, 1977.

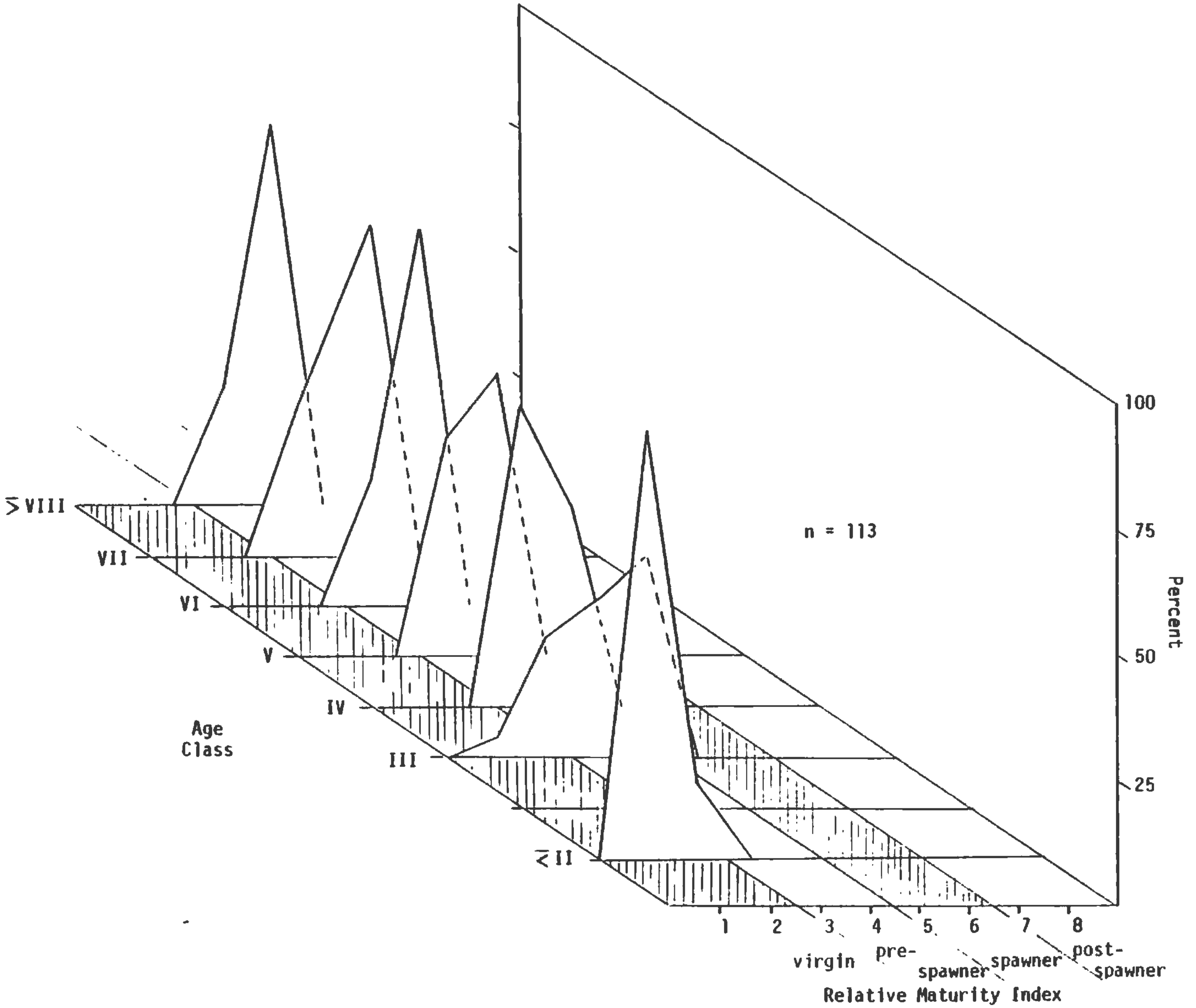


Figure 10. Relative maturity by age of herring captured in the Port Clarence area from September 7 through freezeup (late October), 1977.

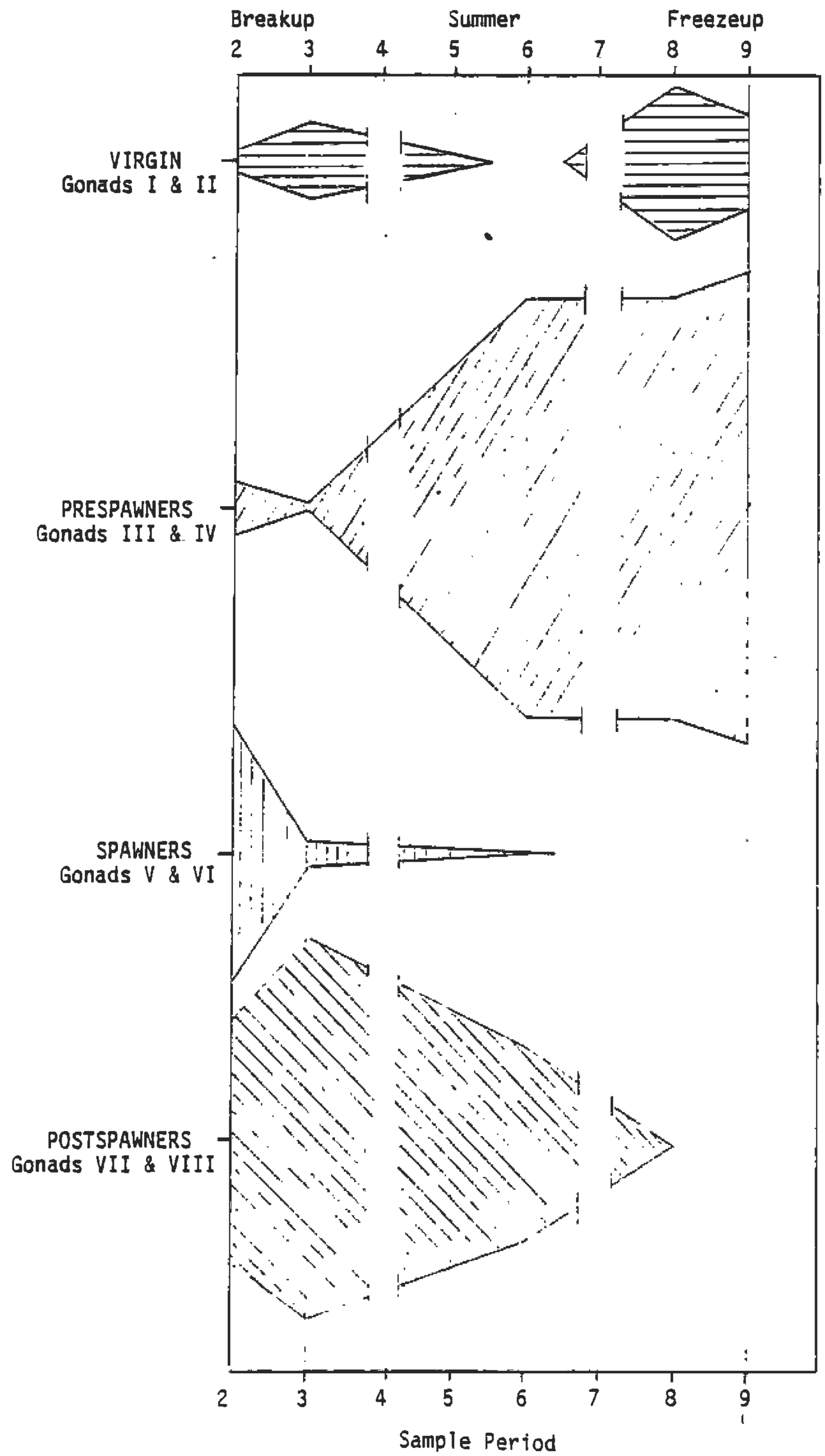


Figure 11. Relative maturity of herring captured in the Port Clarence area from ice breakup (late June) through freezeup (late October), 1977.

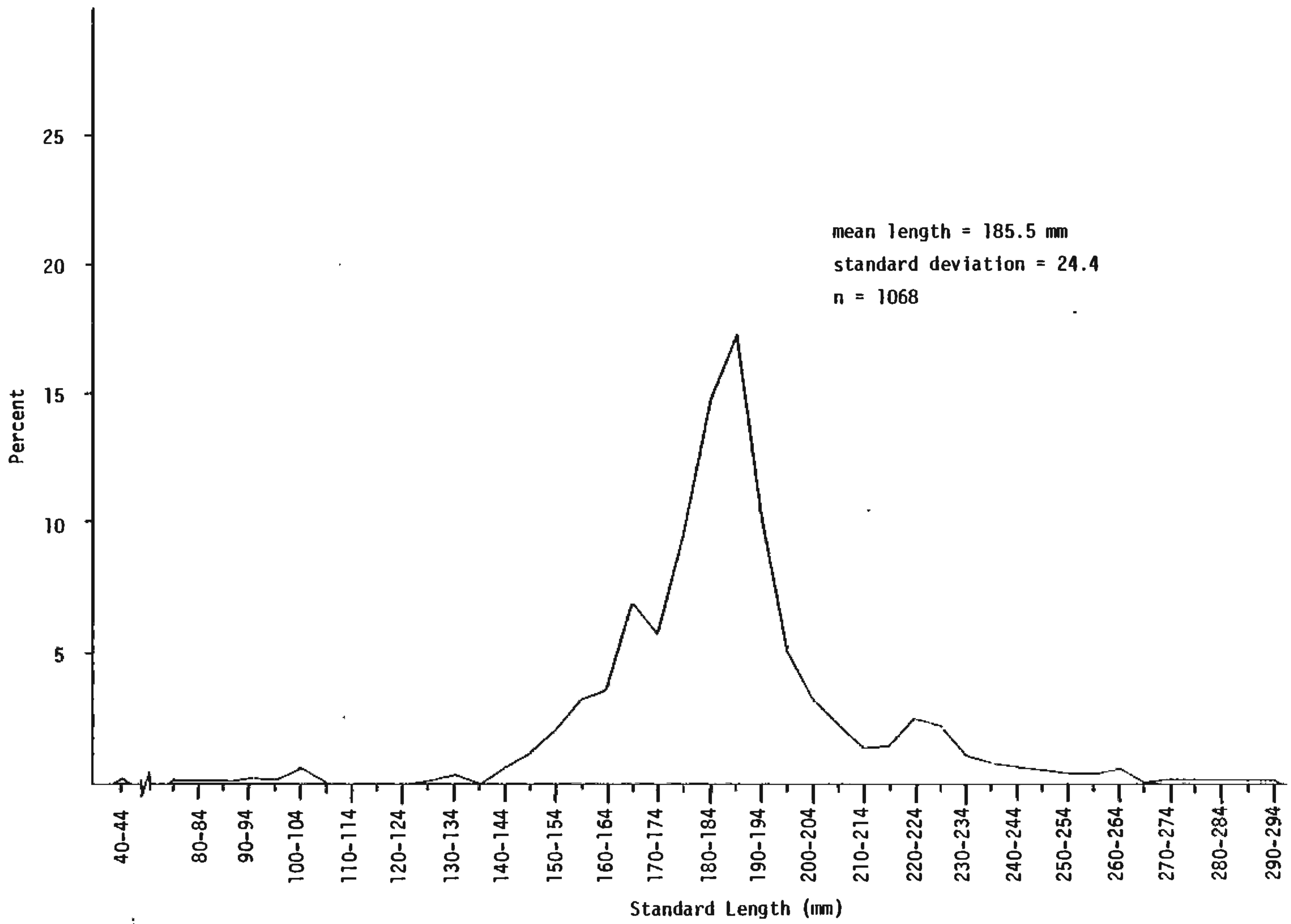


Figure 12. Length frequency (percent) of herring captured in the Port Clarence area from ice breakup (late June) through freezeup (late October), 1977.

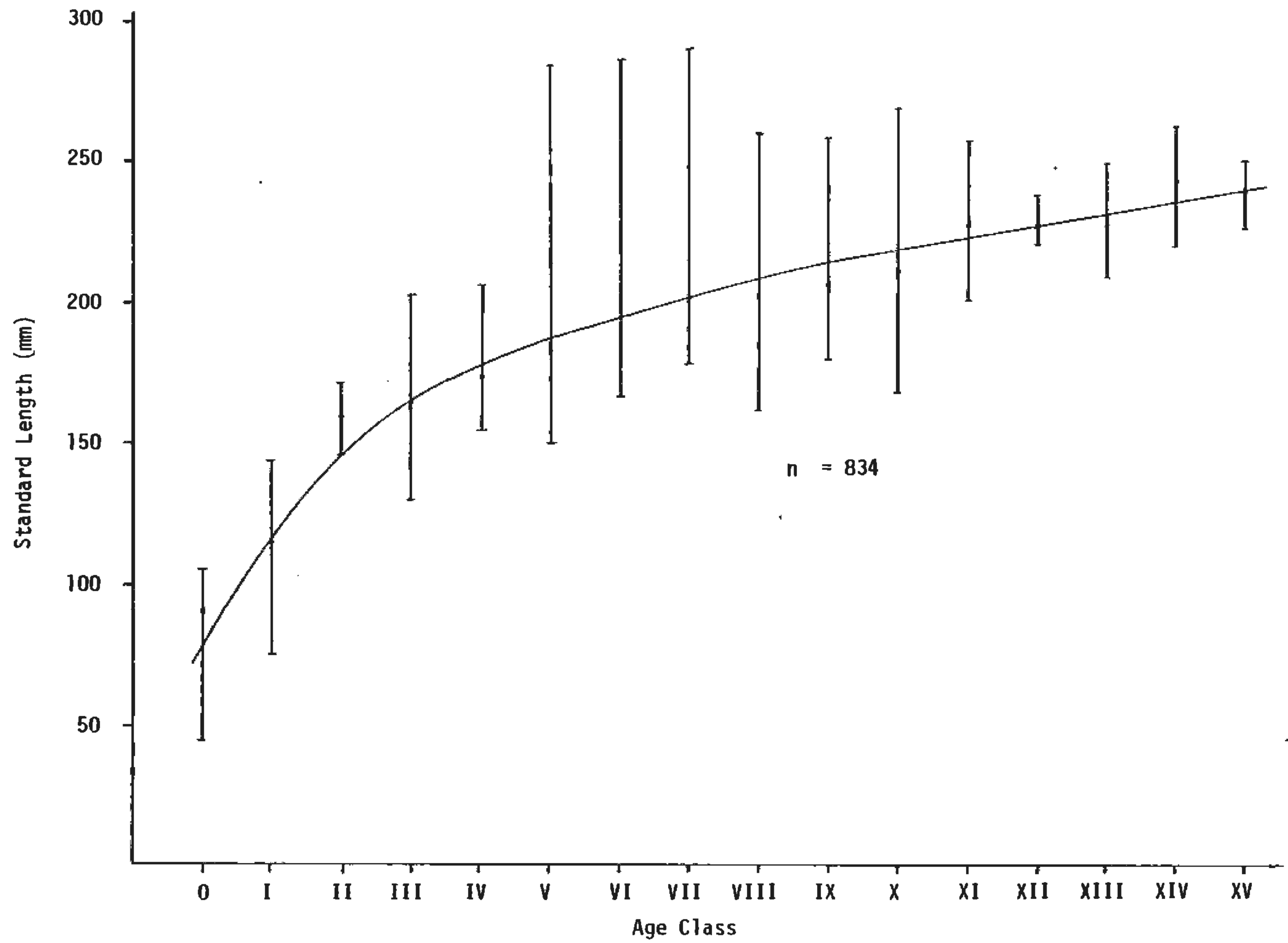


Figure 13. Mean length-at-age (shown with ranges) for herring captured in the Port Clarence area, 1977.

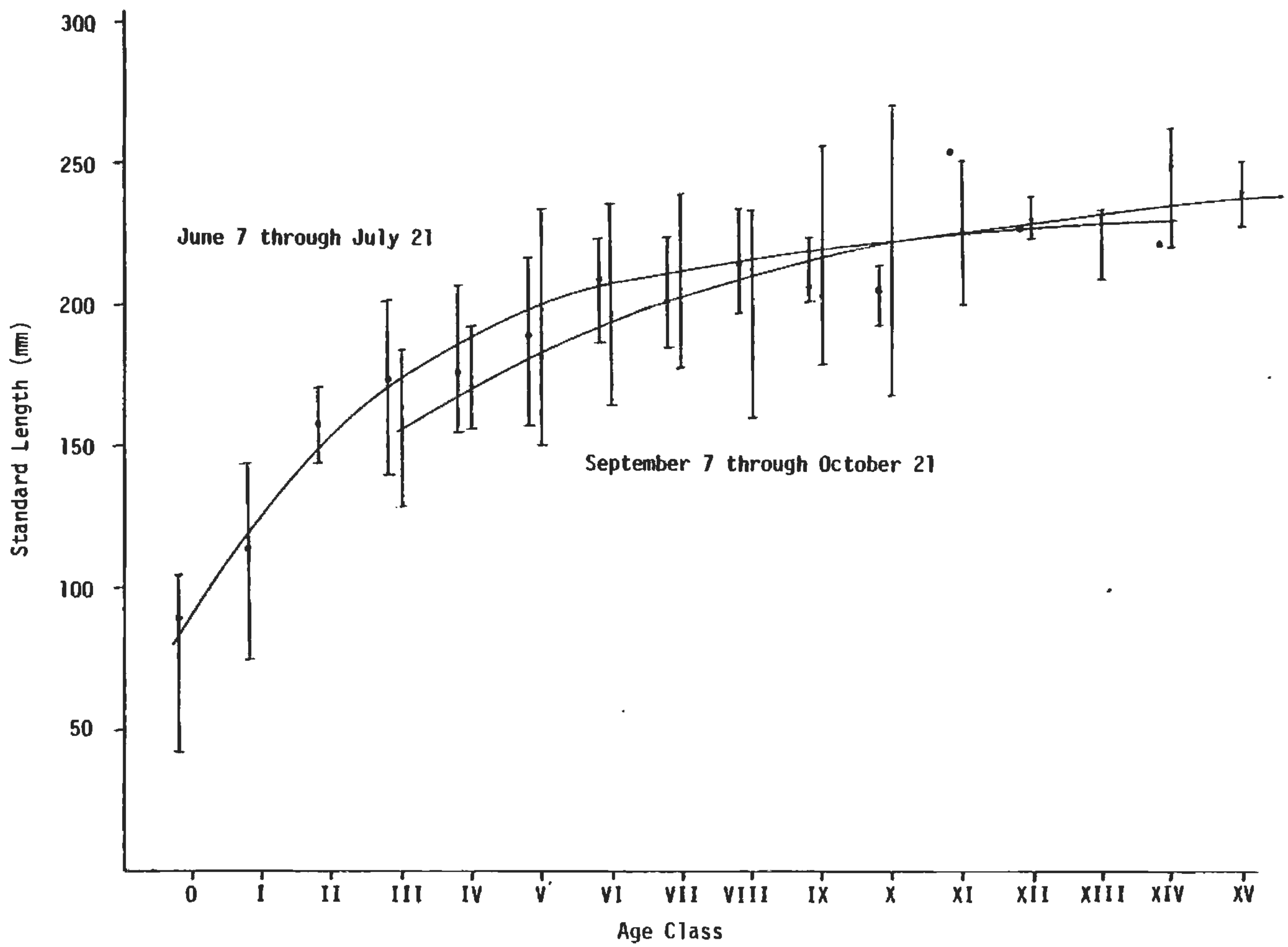


Figure 14. Mean length-at-age for herring captured in the spring (June 7 - July 21) and fall (September 7 - October 21) in the Port Clarence area in 1977. Mean lengths are shown with ranges.

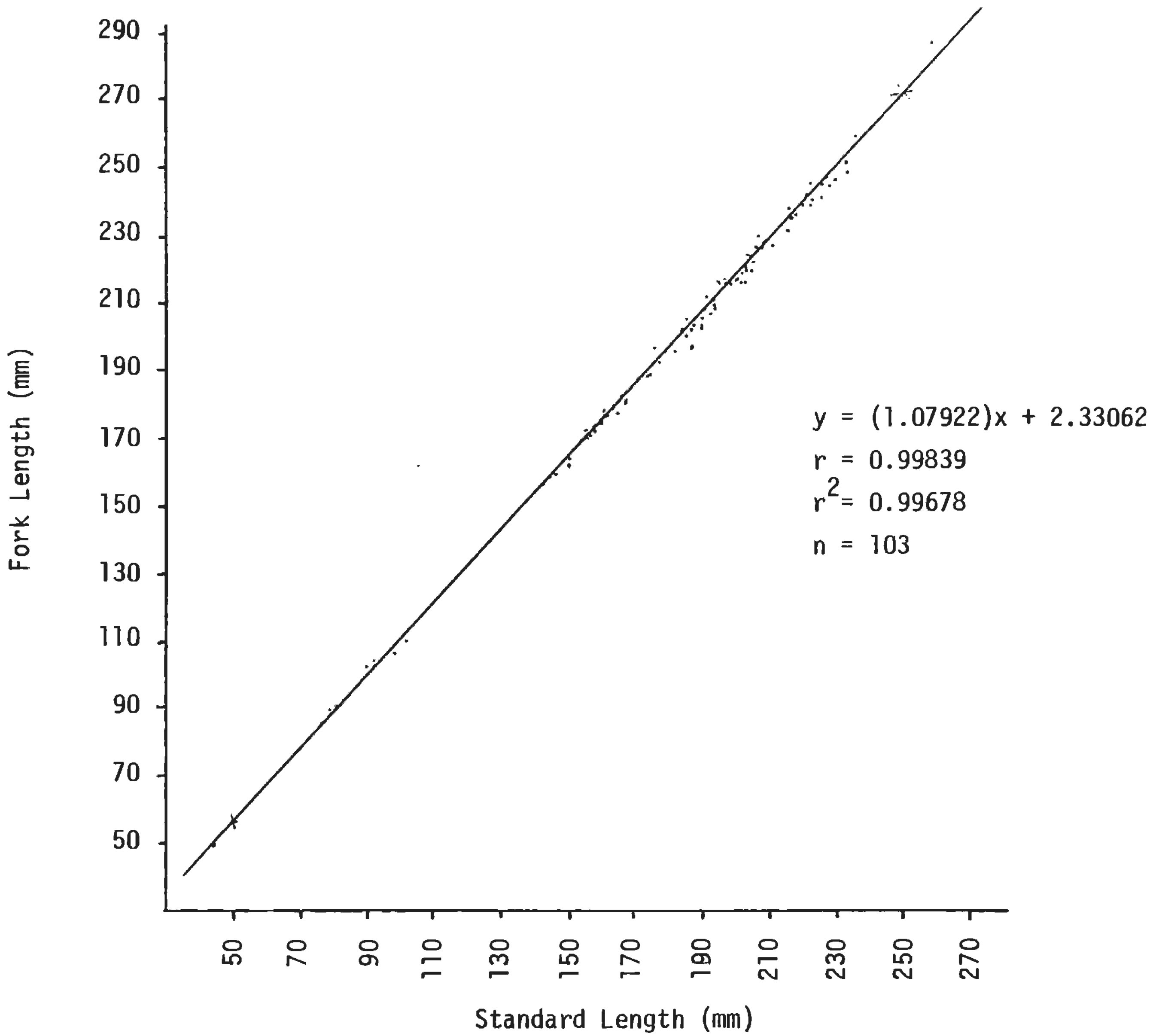


Figure 15. Relationship between fork length and standard length of Pacific herring captured in Port Clarence June through October, 1977.

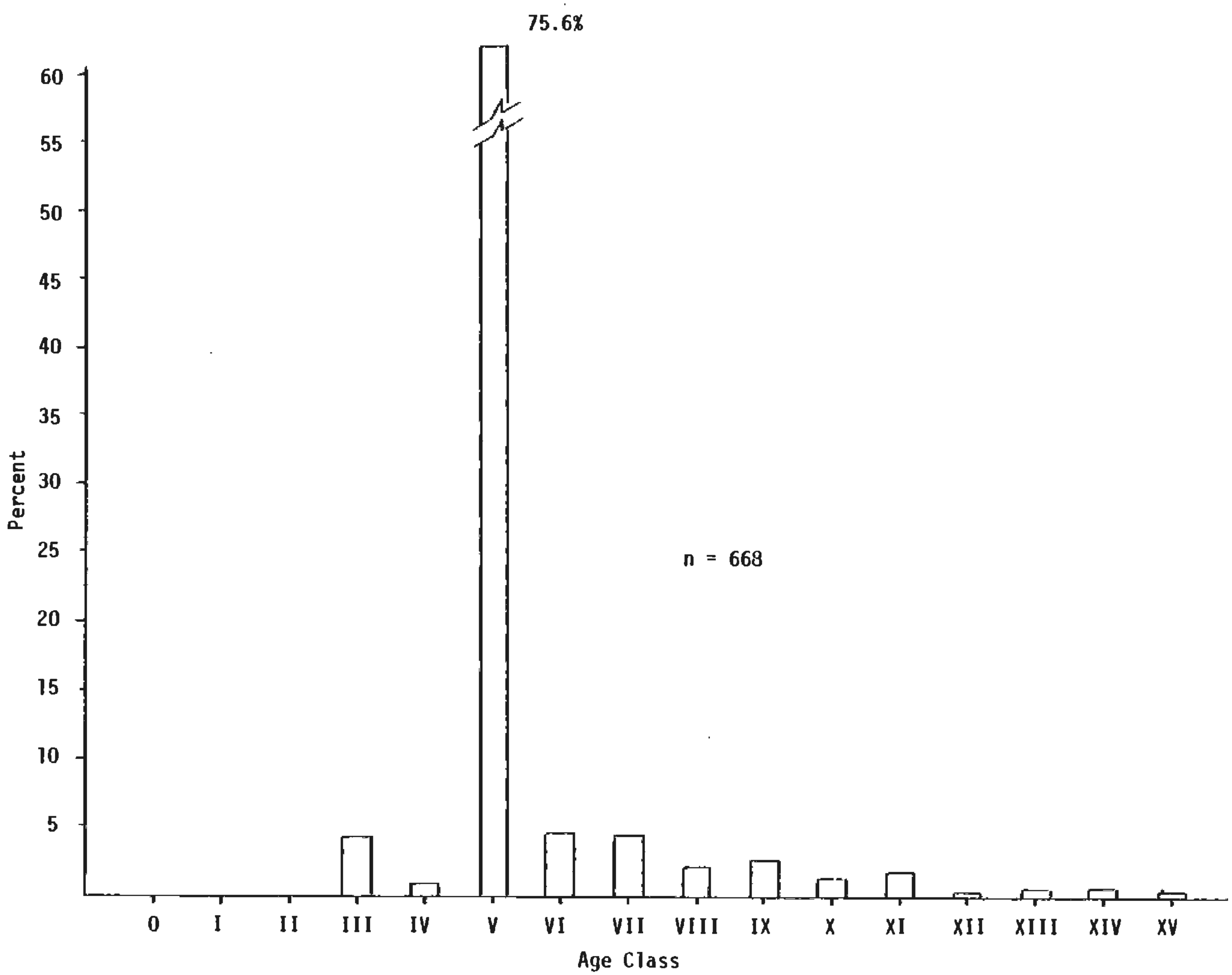


Figure 16. Percent age composition of herring captured in the Port Clarence area from ice breakup to July 21, 1977.

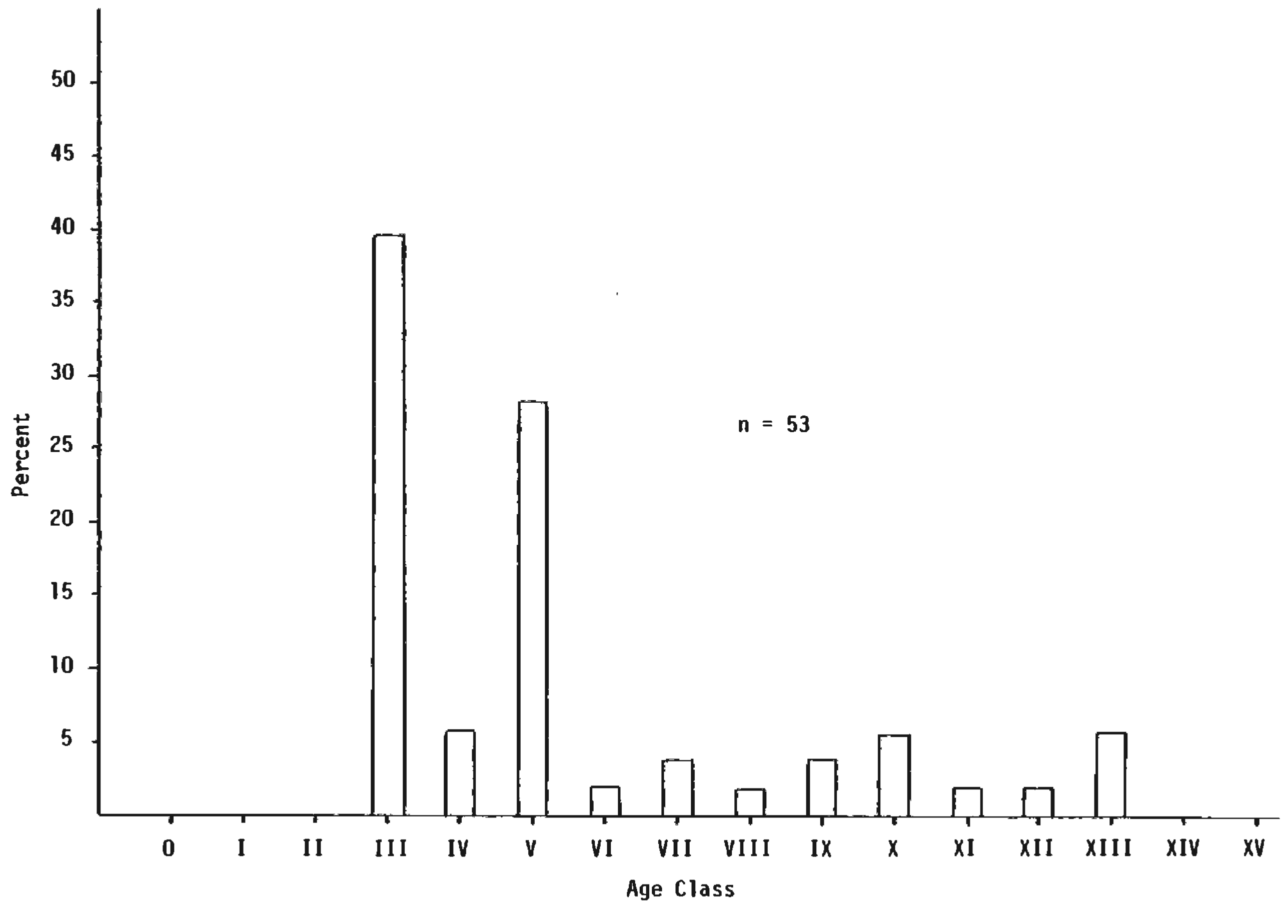


Figure 17. Percent age composition of herring captured in the Port Clarence area from July 22 through Spetember 6, 1977.

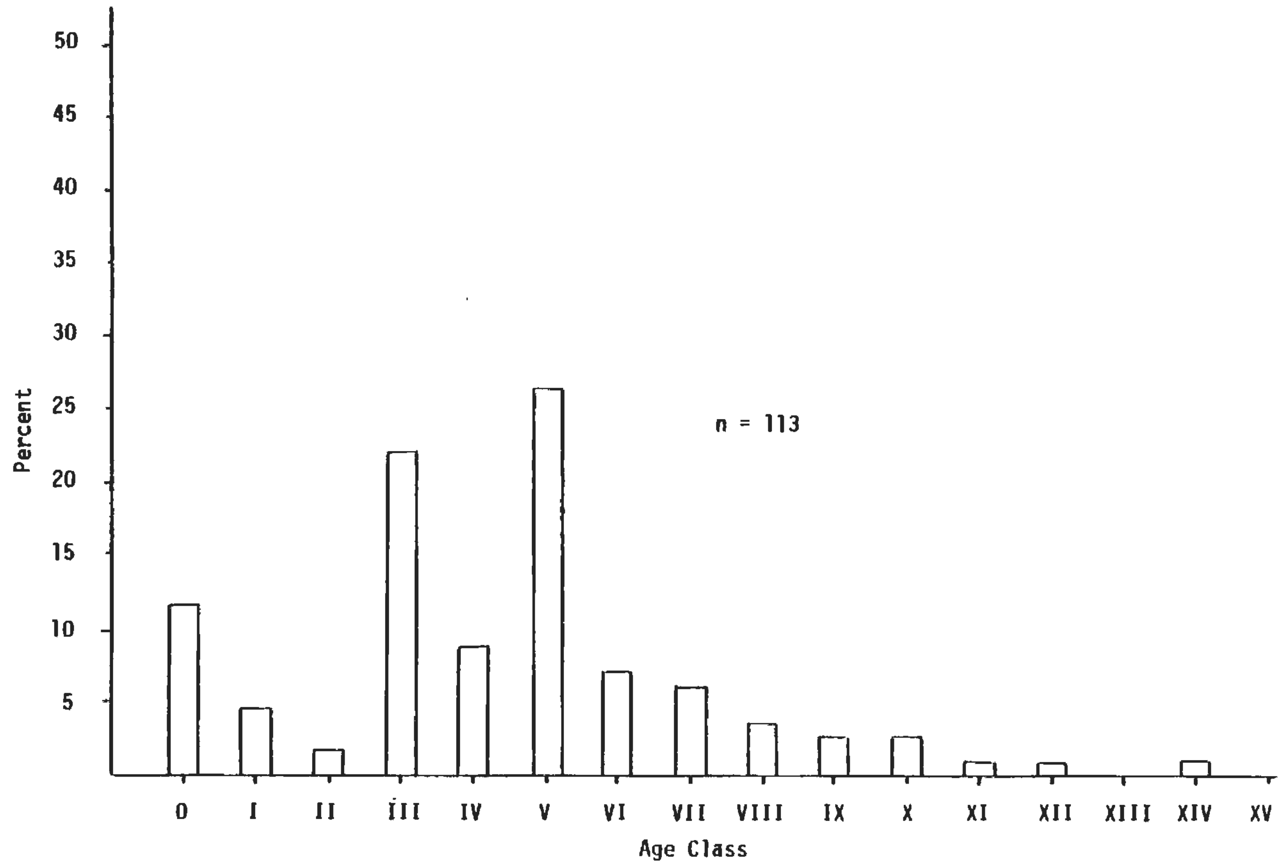


Figure 18. Percent age composition of herring captured in the Port Clarence area from September 7 through freezeup, 1977.

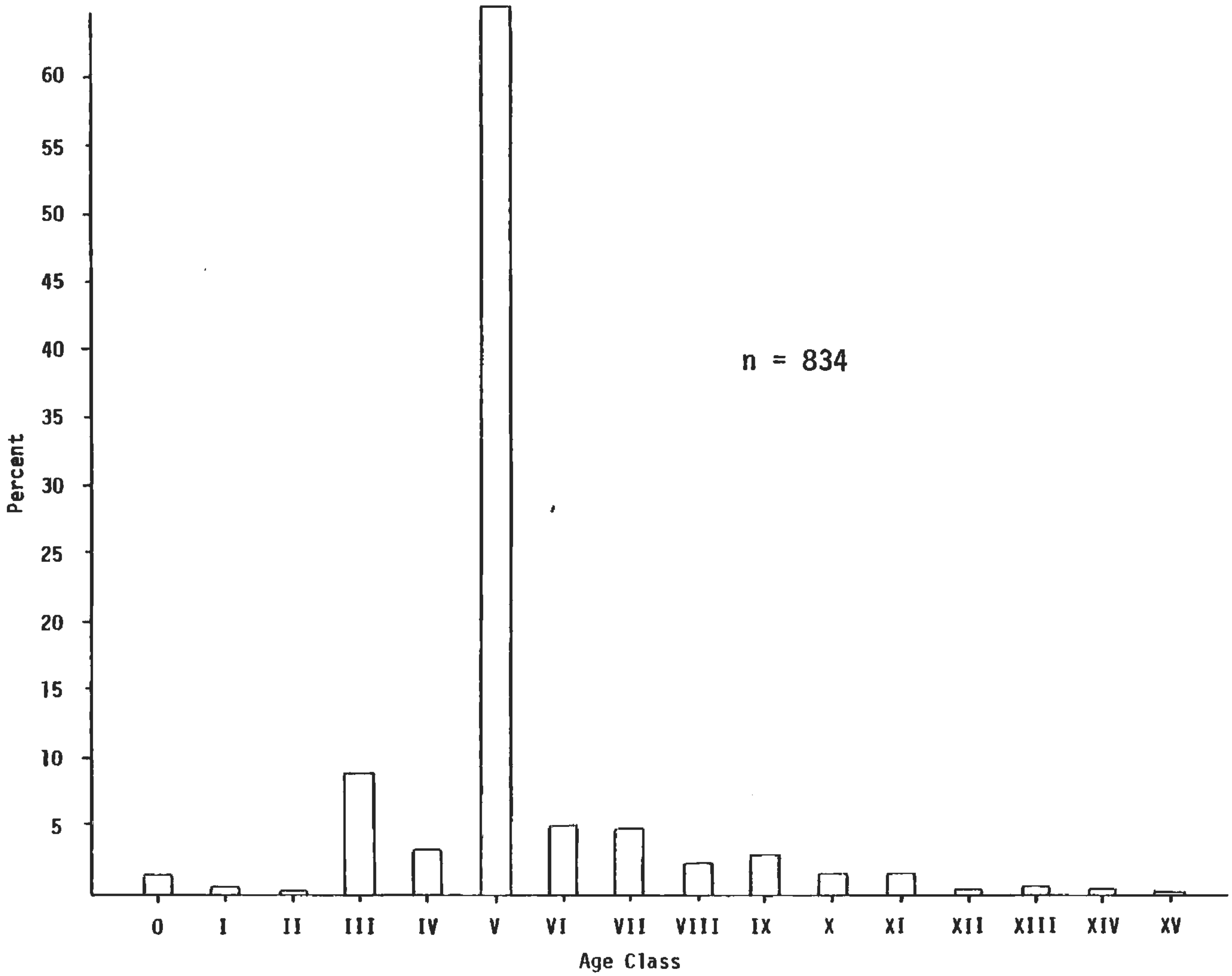


Figure 19. Percent age composition of herring captured in the Port Clarence area from ice breakup (late June) through freezeup (late October), 1977.

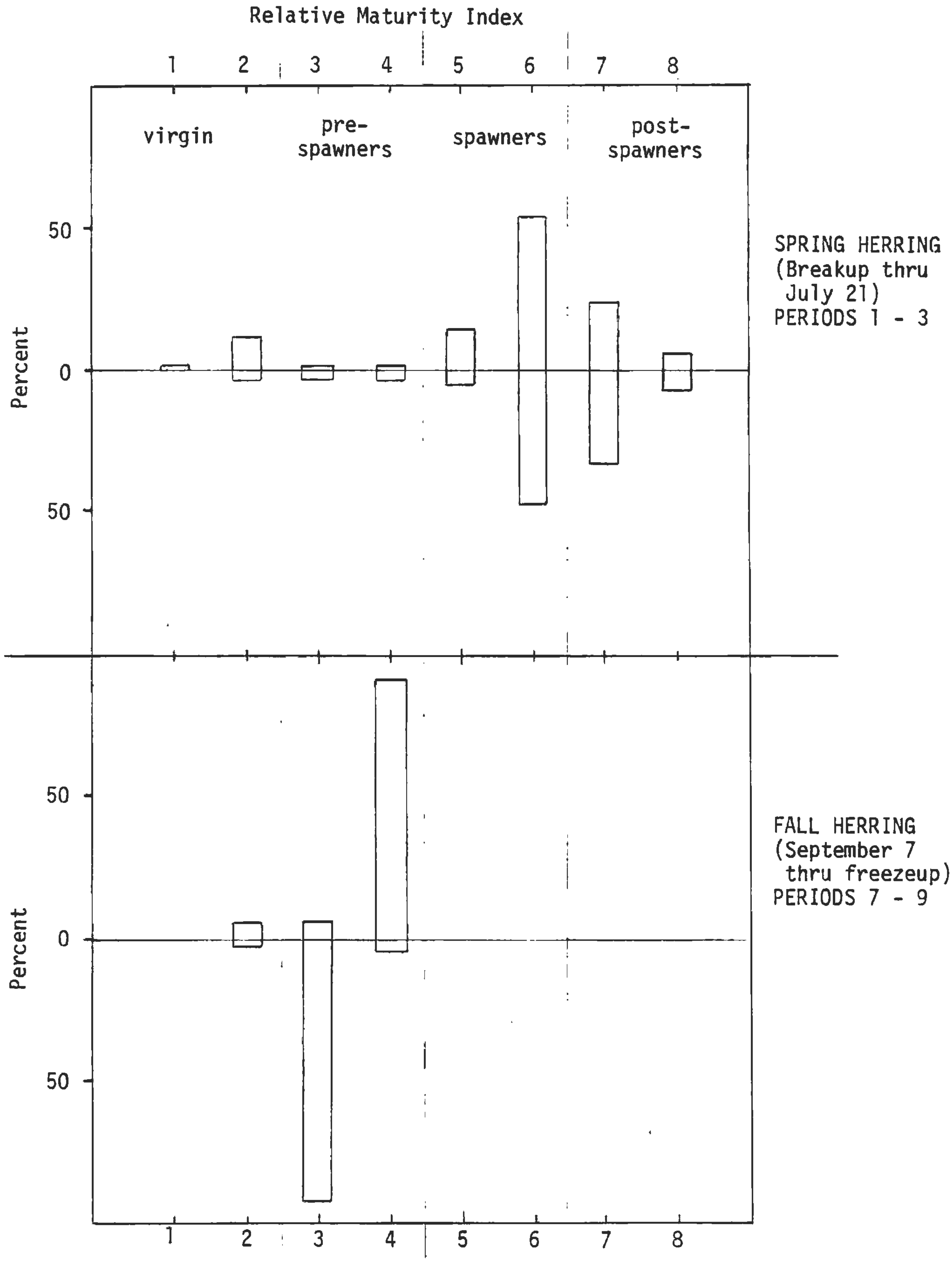


Figure 20. Comparison of the relative maturity of spring and fall herring captured in Golovin Bay 1977.

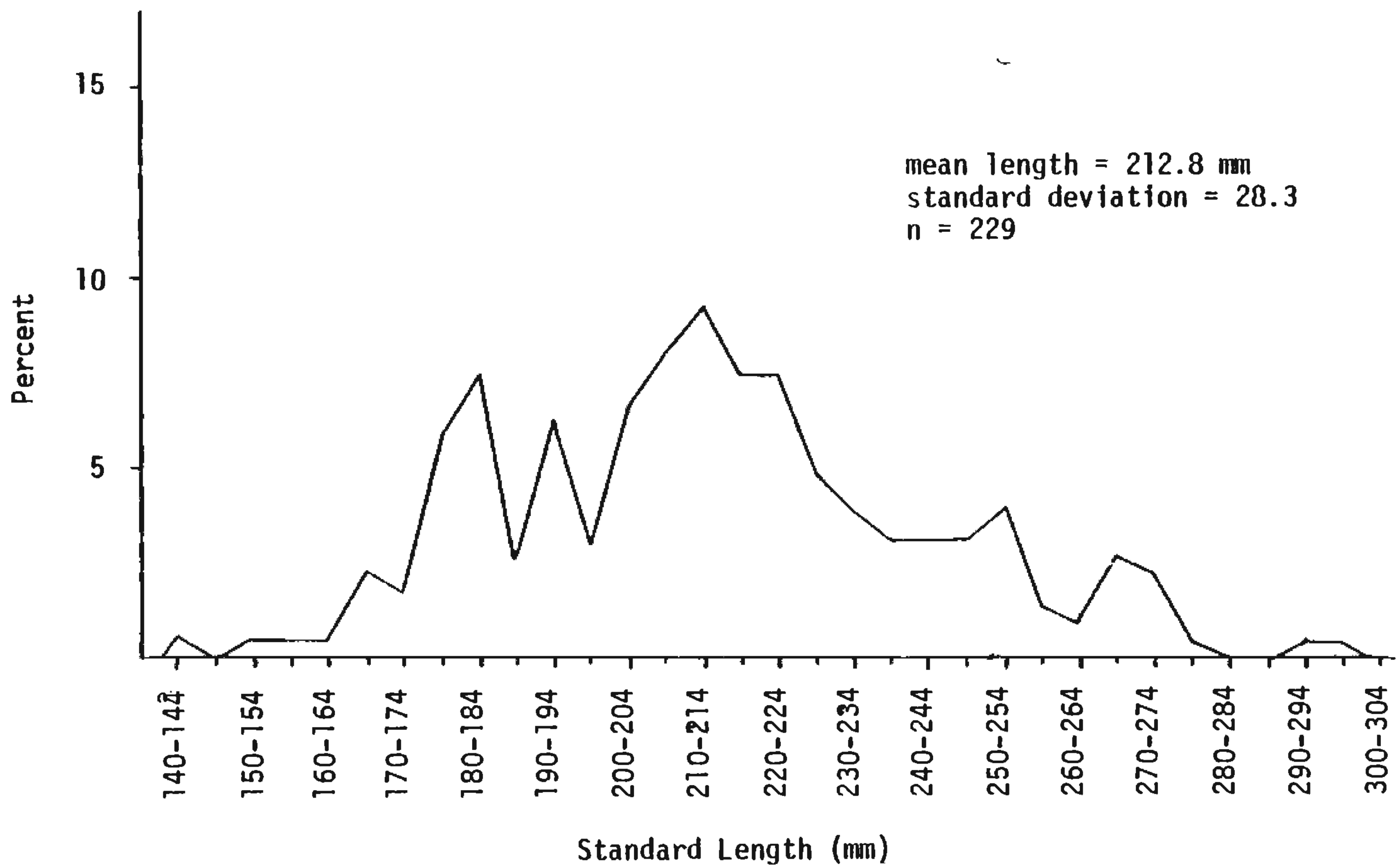


Figure 21. Length frequency (percent) of herring captured in Golovin Bay from ice breakup (June) through freezeup (October), 1977.

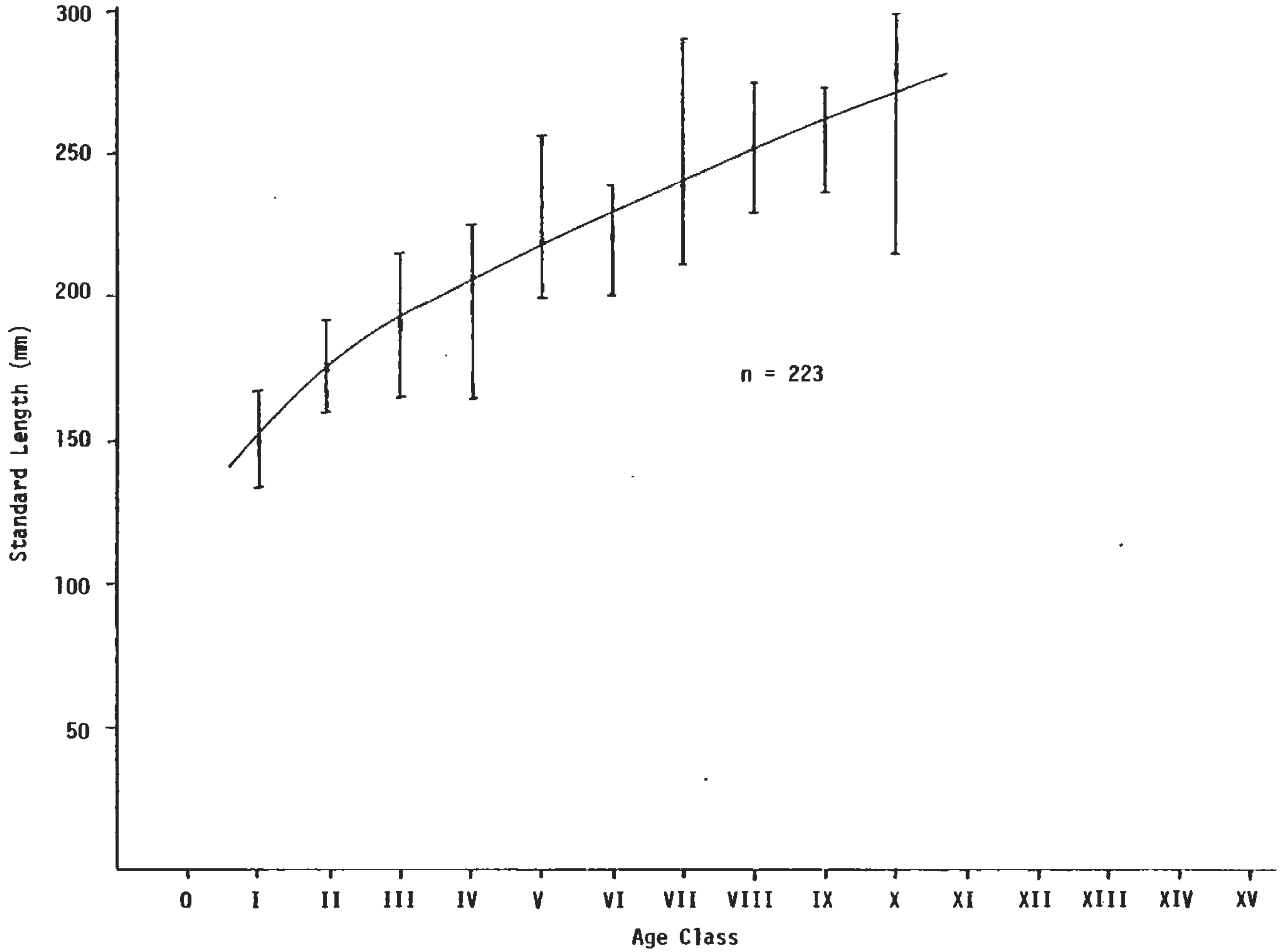


Figure 22. Mean length-at-age (shown with ranges) for herring captured in Golovin Bay, 1977.

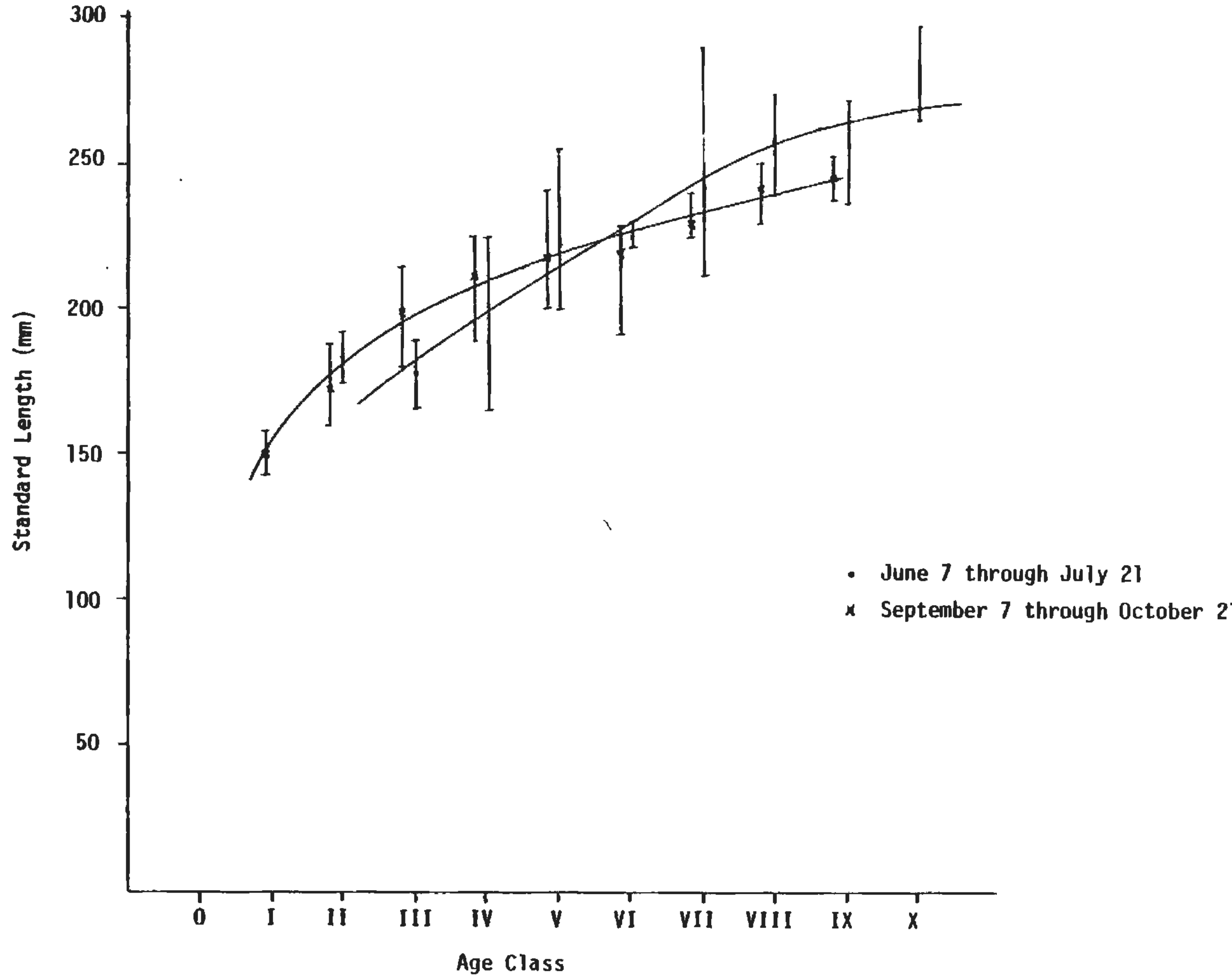


Figure 23. Mean length-at-age for herring captured in the spring (June 7 - July 21) and fall (September 7 - October 21) in Golovin Bay, 1977. Mean lengths are shown with ranges.

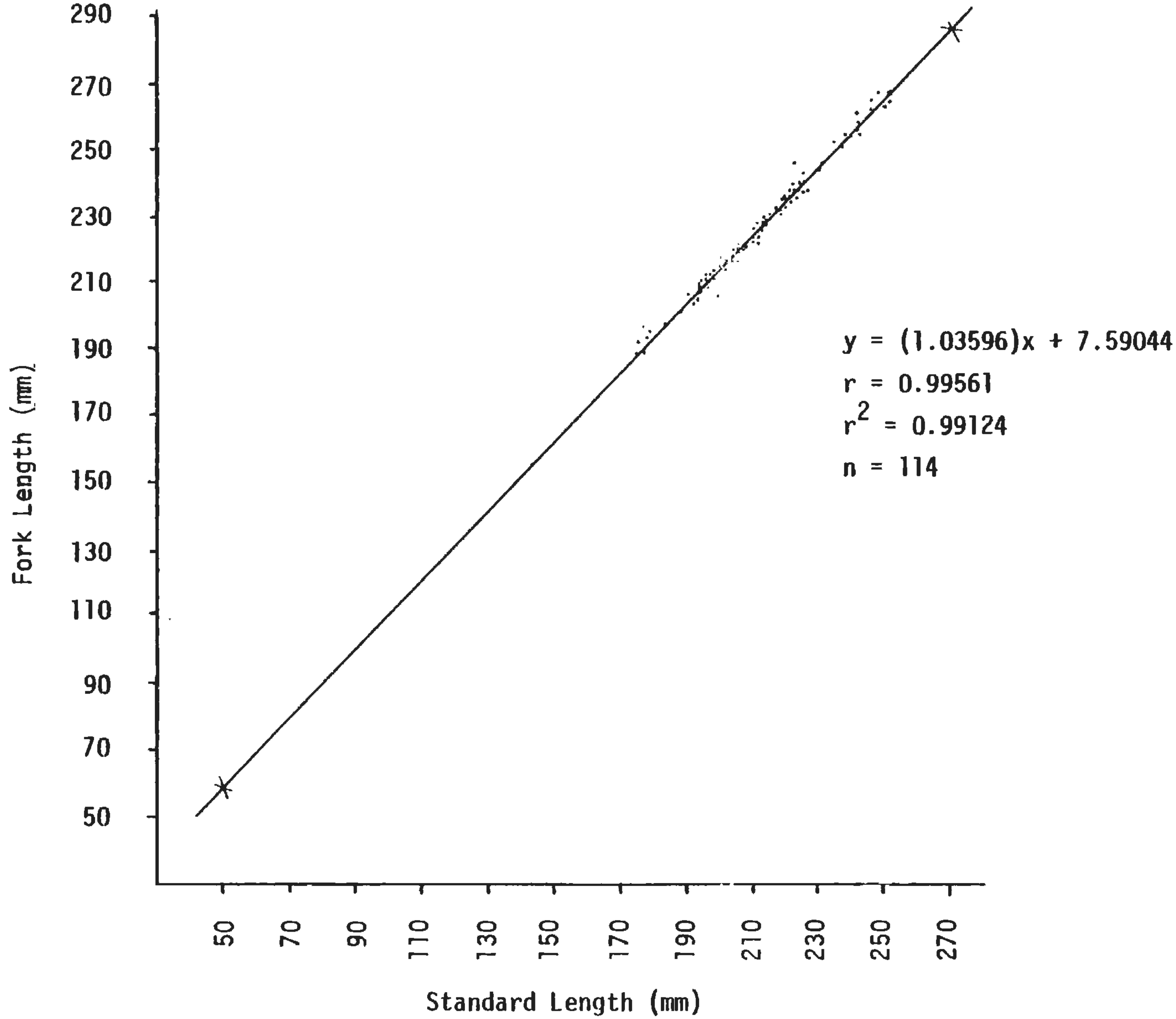


Figure 24. Relationship between fork length and standard length of Pacific herring captured in Golovin Bay June through October, 1977.

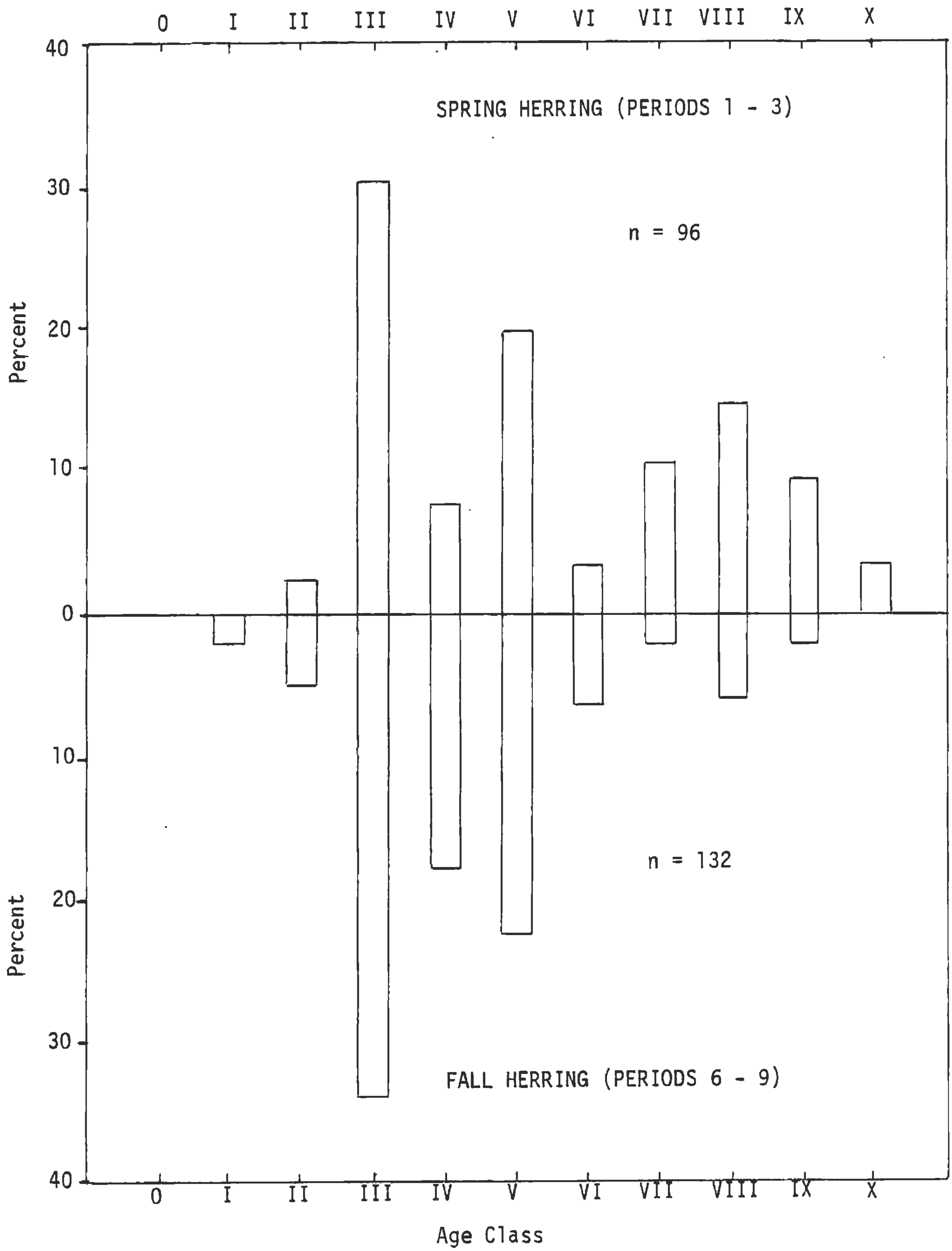


Figure 25. Comparison of percent age composition between spring and fall herring populations in Golovin Bay, 1977.

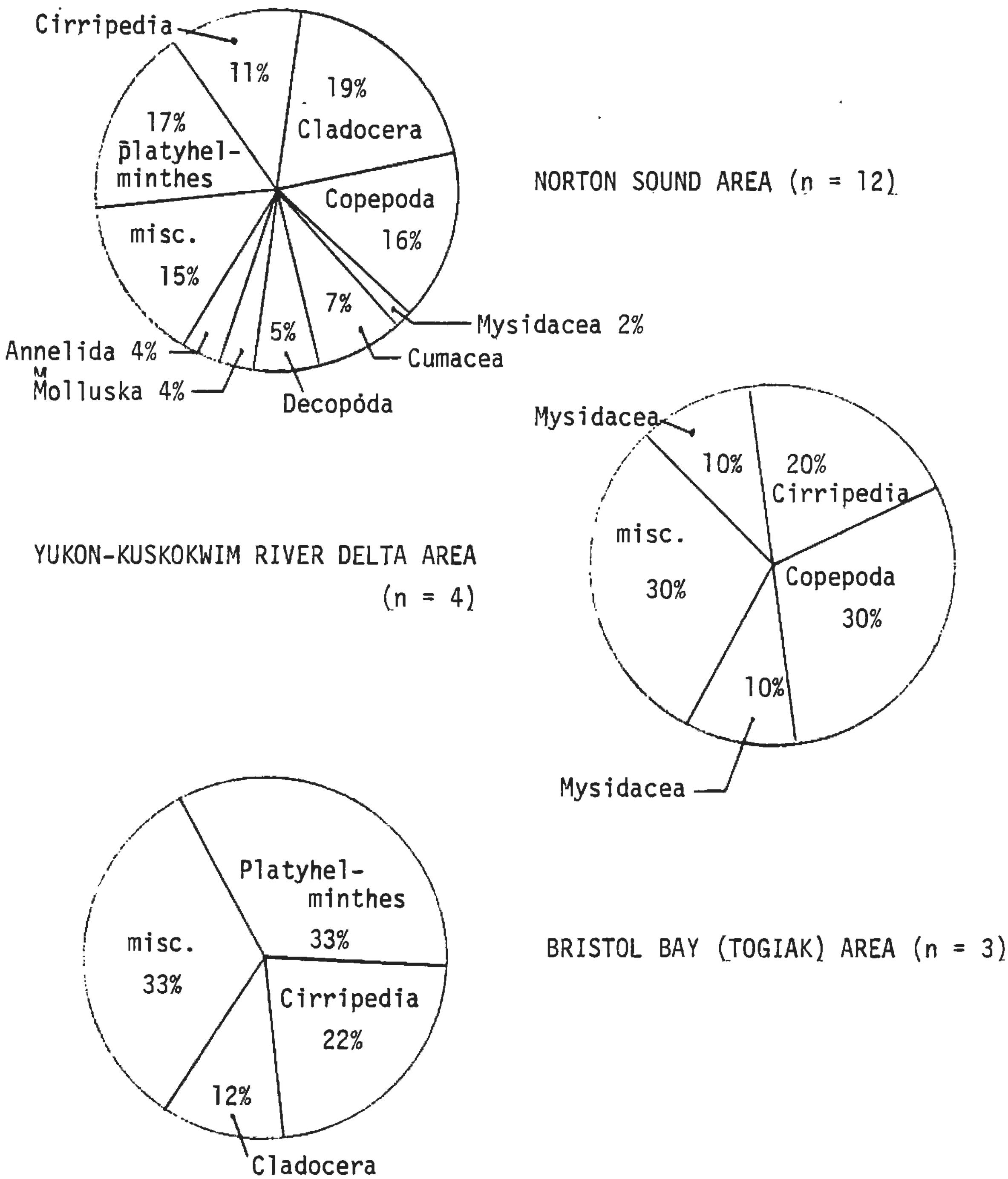


Figure 26. Percent occurrence of the total number of food items in herring stomachs examined along the western Alaska coastline, 1976.

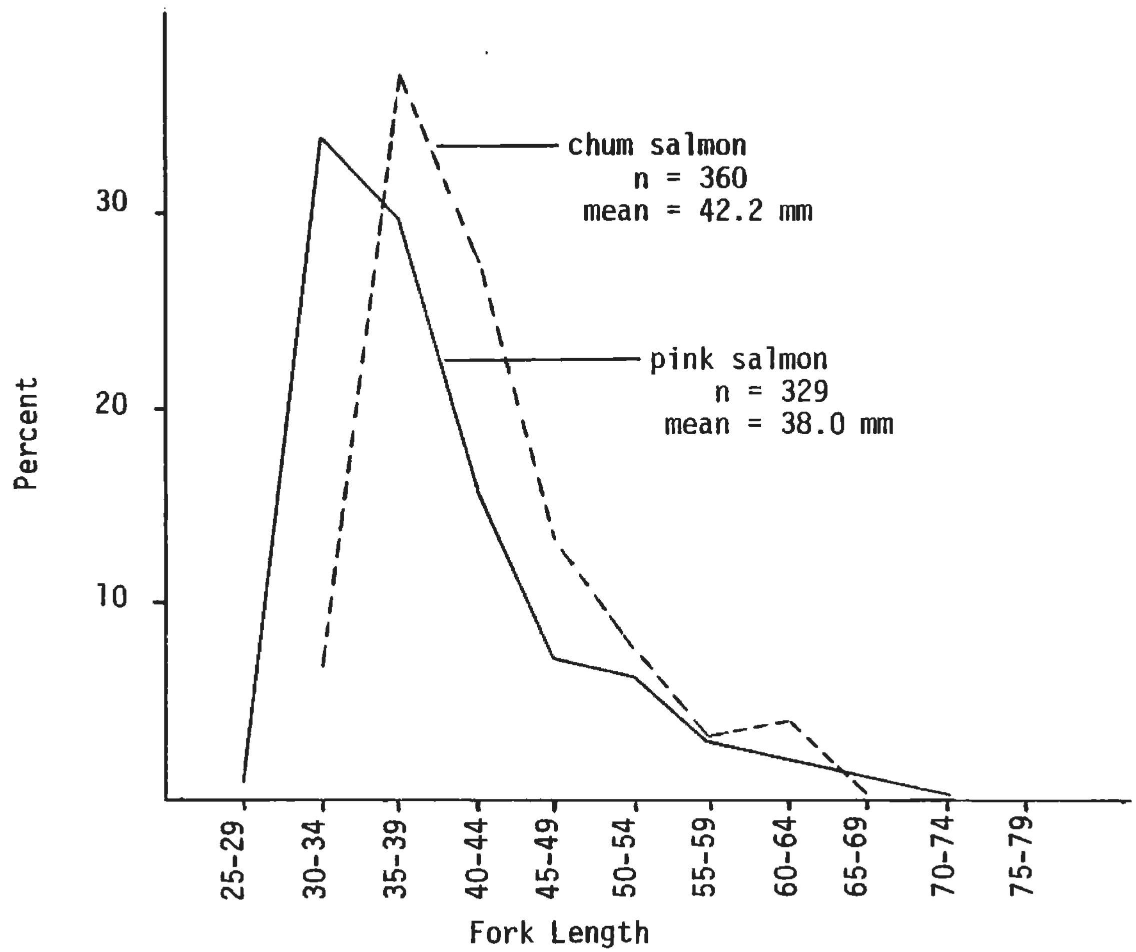


Figure 27. Length frequency (percent) of juvenile pink and chum salmon captured in Golovin Bay June 9 through July 9, 1977.

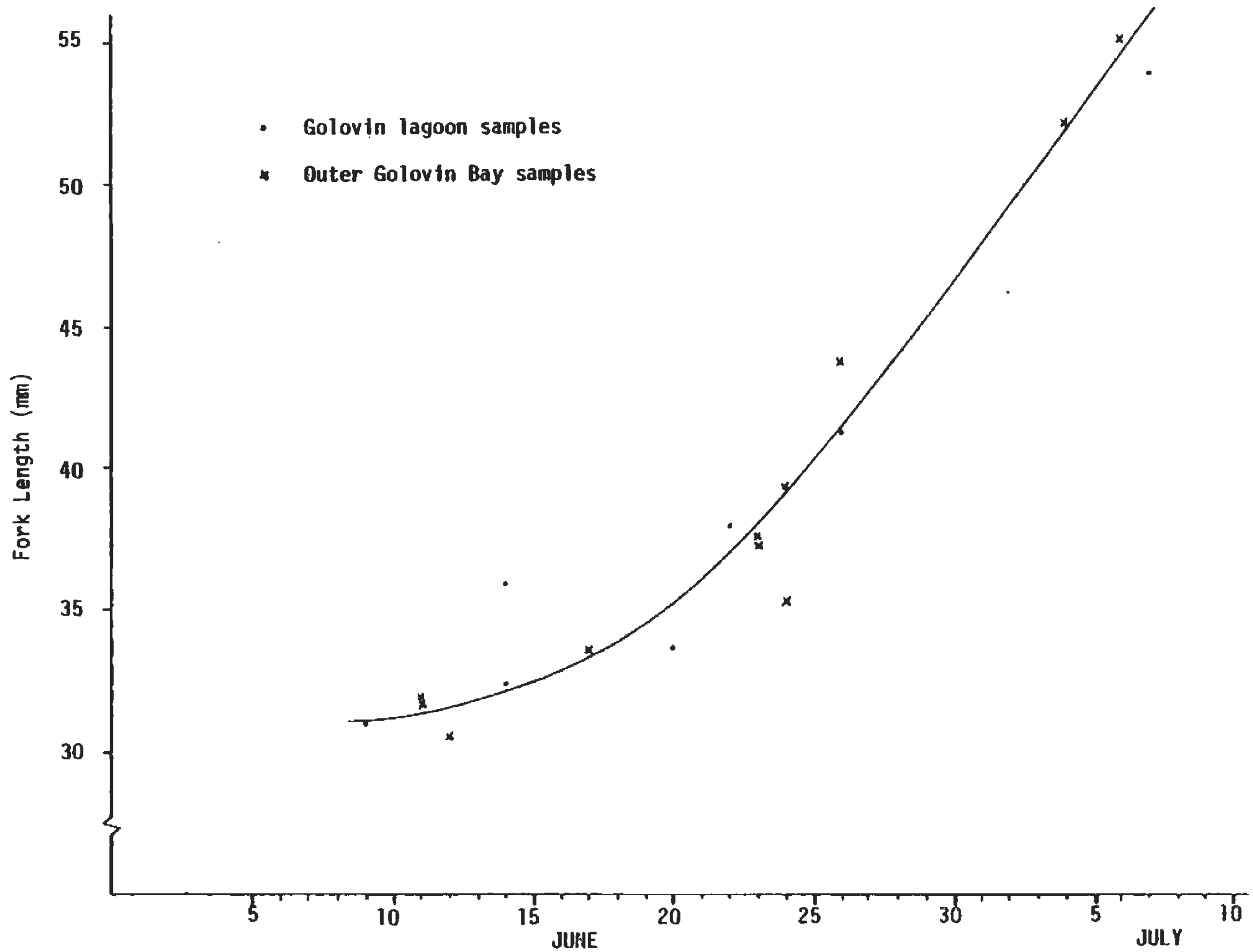


Figure 28. Growth of juvenile pink salmon captured in the nearshore waters of Golovin Bay from June 9 through July 9, 1977.

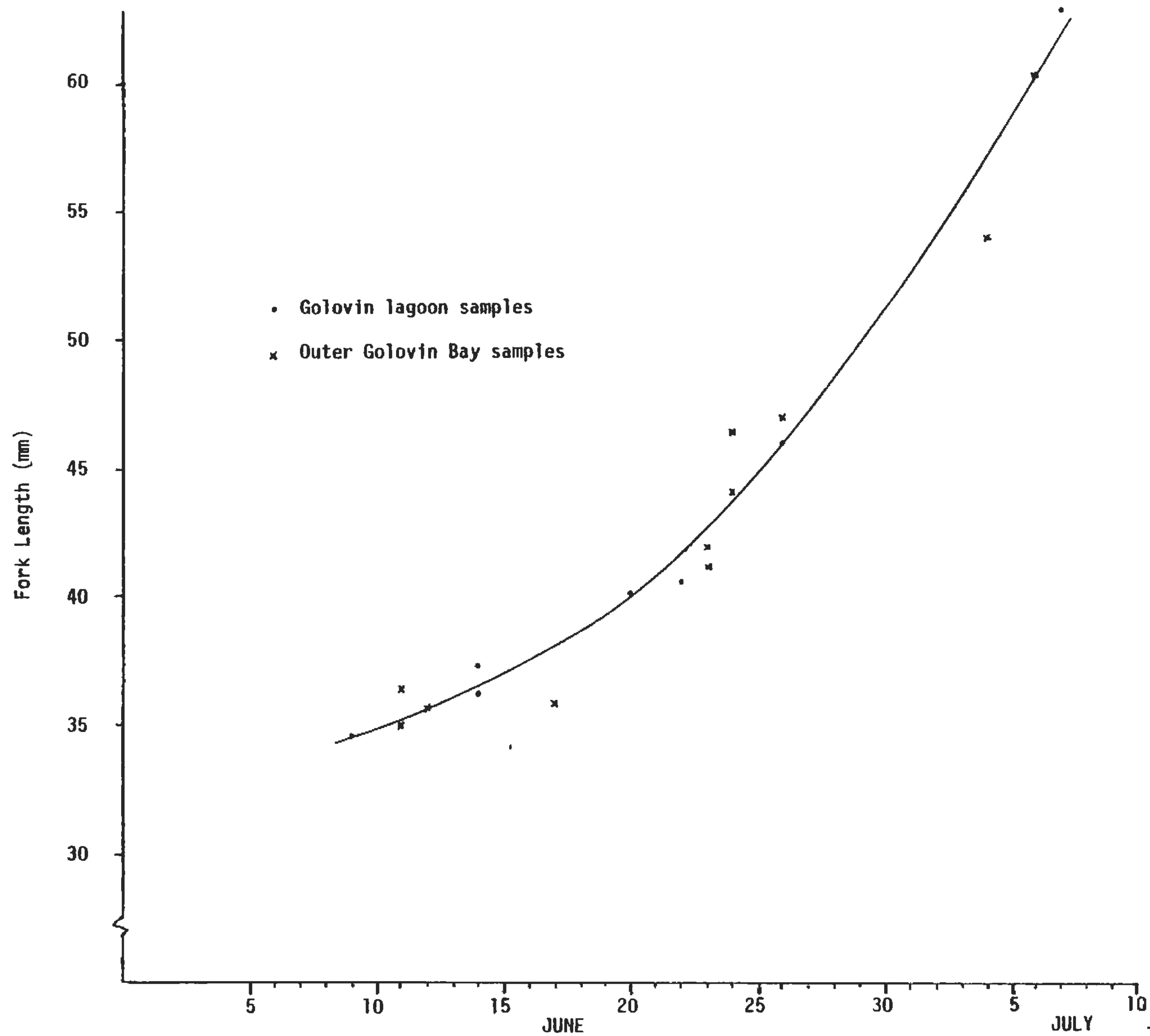


Figure 29. Growth of juvenile chum salmon captured in the nearshore waters of Golovin Bay from June 9 through July 9, 1977.

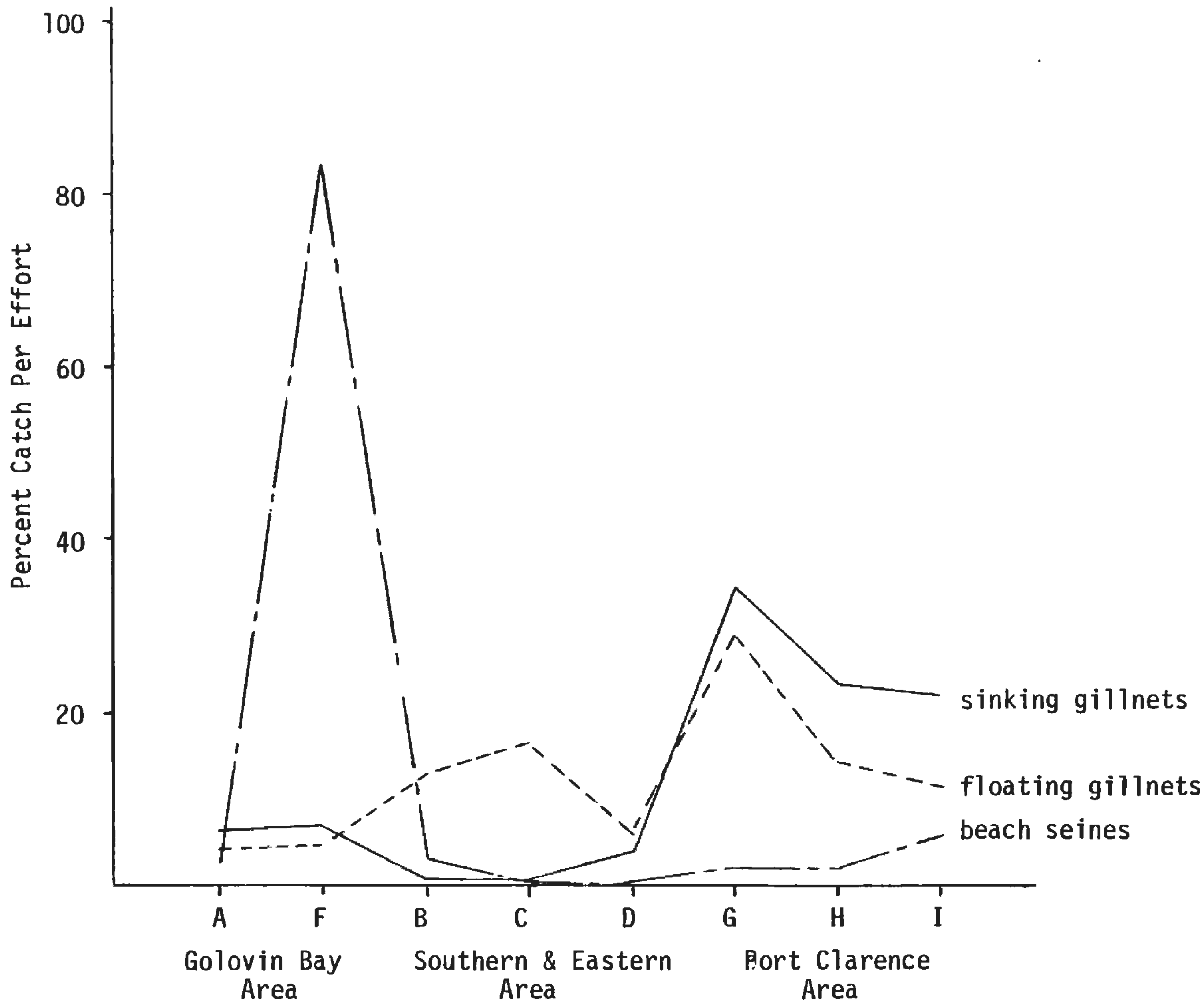


Figure 30. Percent catch per effort for finfish captured in the nearshore waters of Norton Sound from June 7 through October 21, 1977.

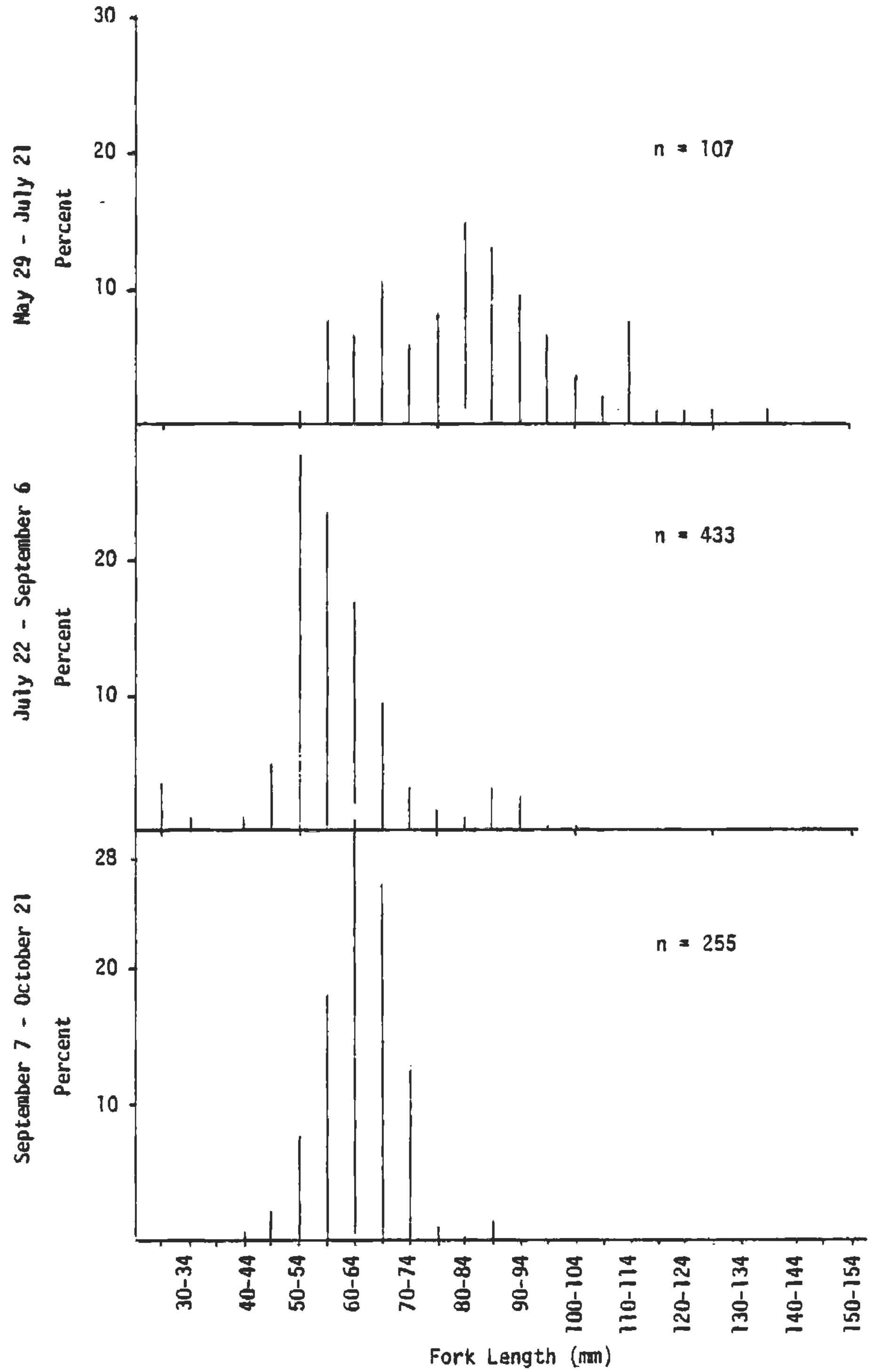


Figure 31. Length frequency (percent) of sand lance captured in Golovin Bay, 1977.

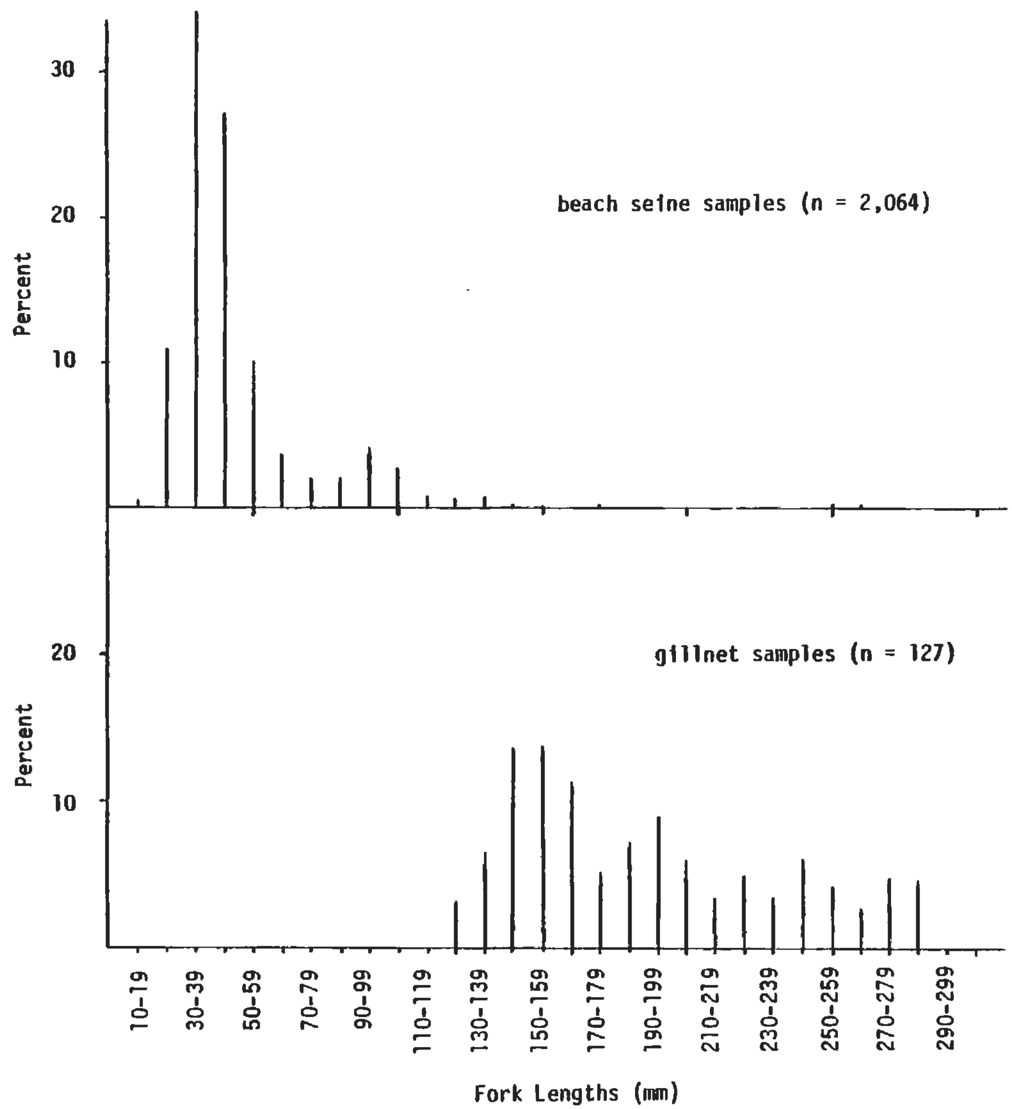


Figure 32. Length frequency (percent) of boreal smelt by gear type captured in nearshore waters of Norton Sound from June through October, 1977.

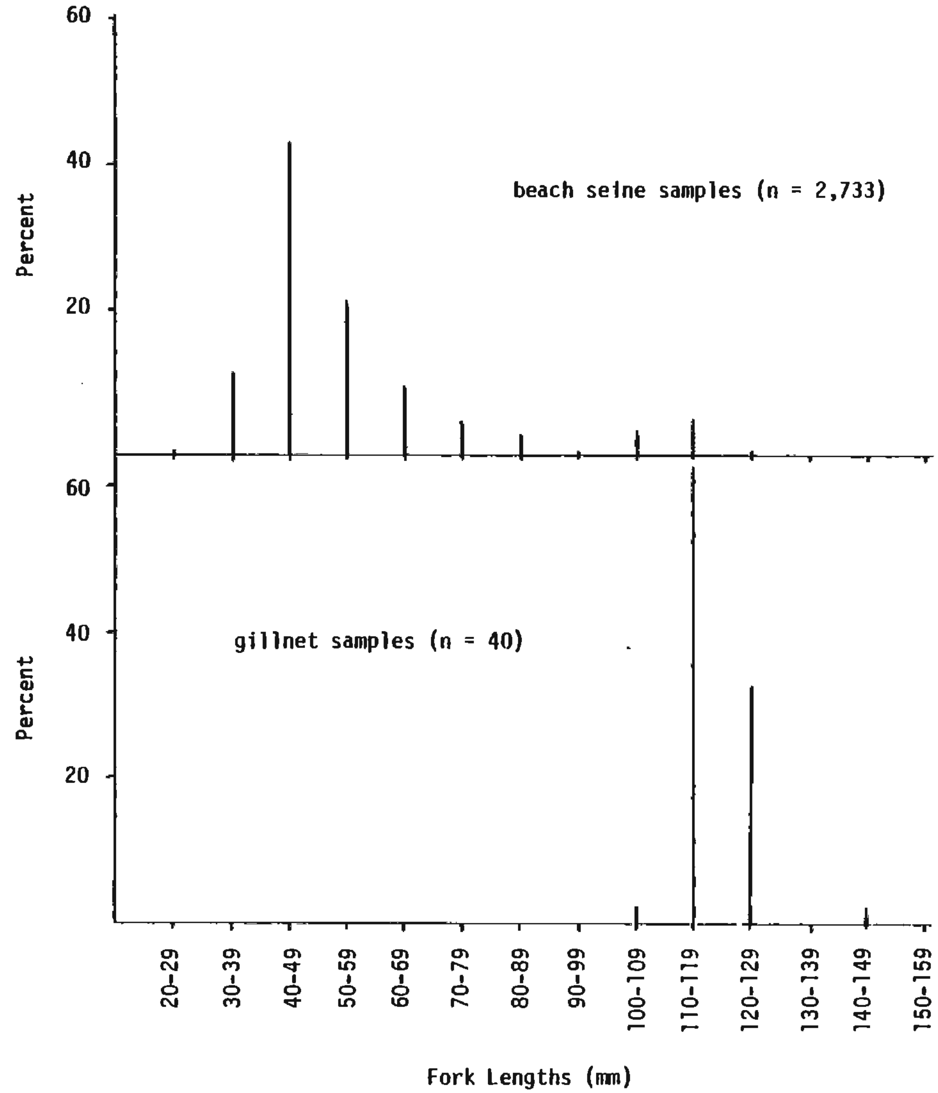


Figure 33. Length frequency (percent) of pond smelt by gear type captured in nearshore waters of Norton Sound from June through October, 1977.

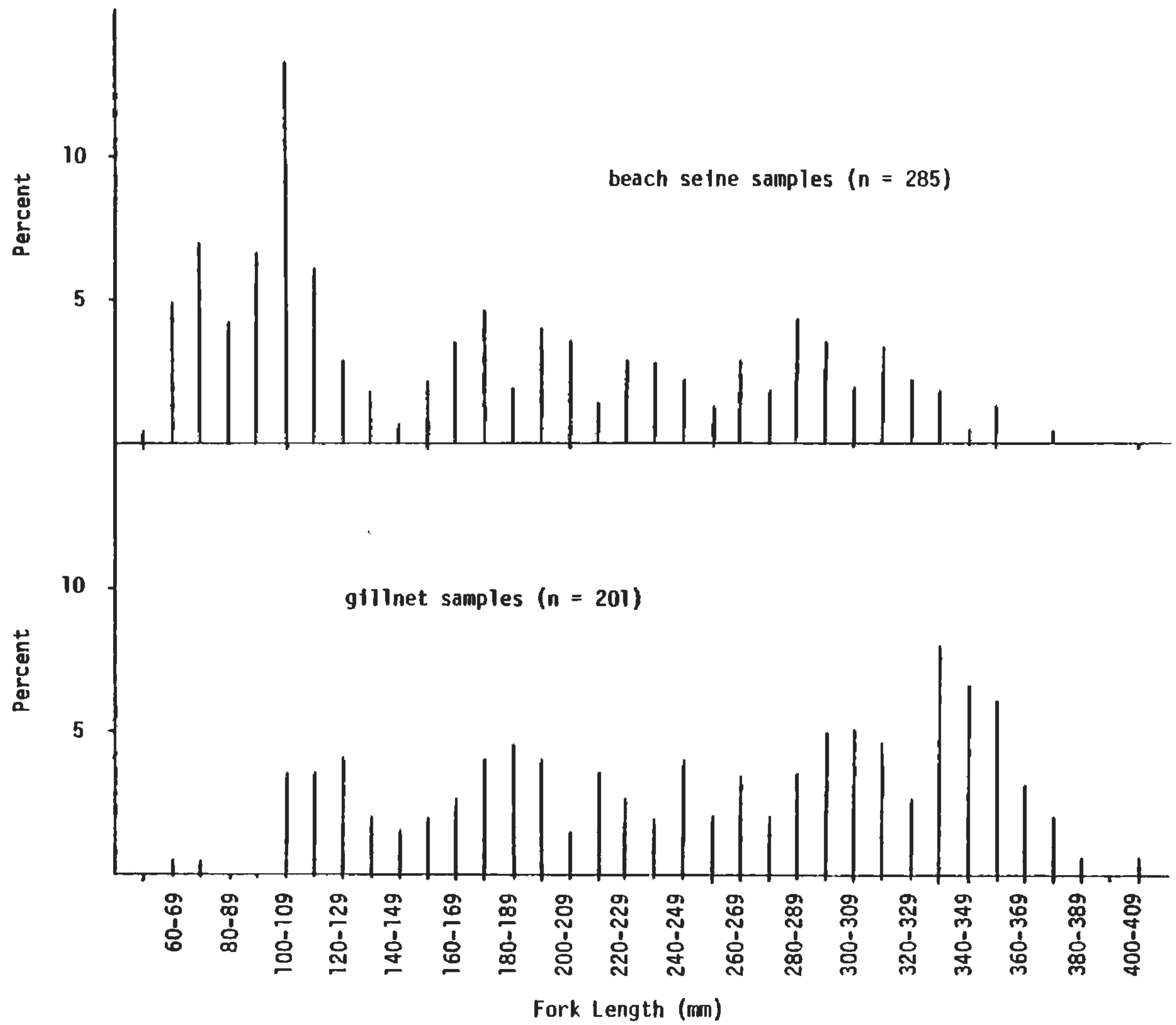


Figure 34. Length frequency (percent) of Bering cisco by gear type captured in nearshore waters of Norton Sound from June through October, 1977.

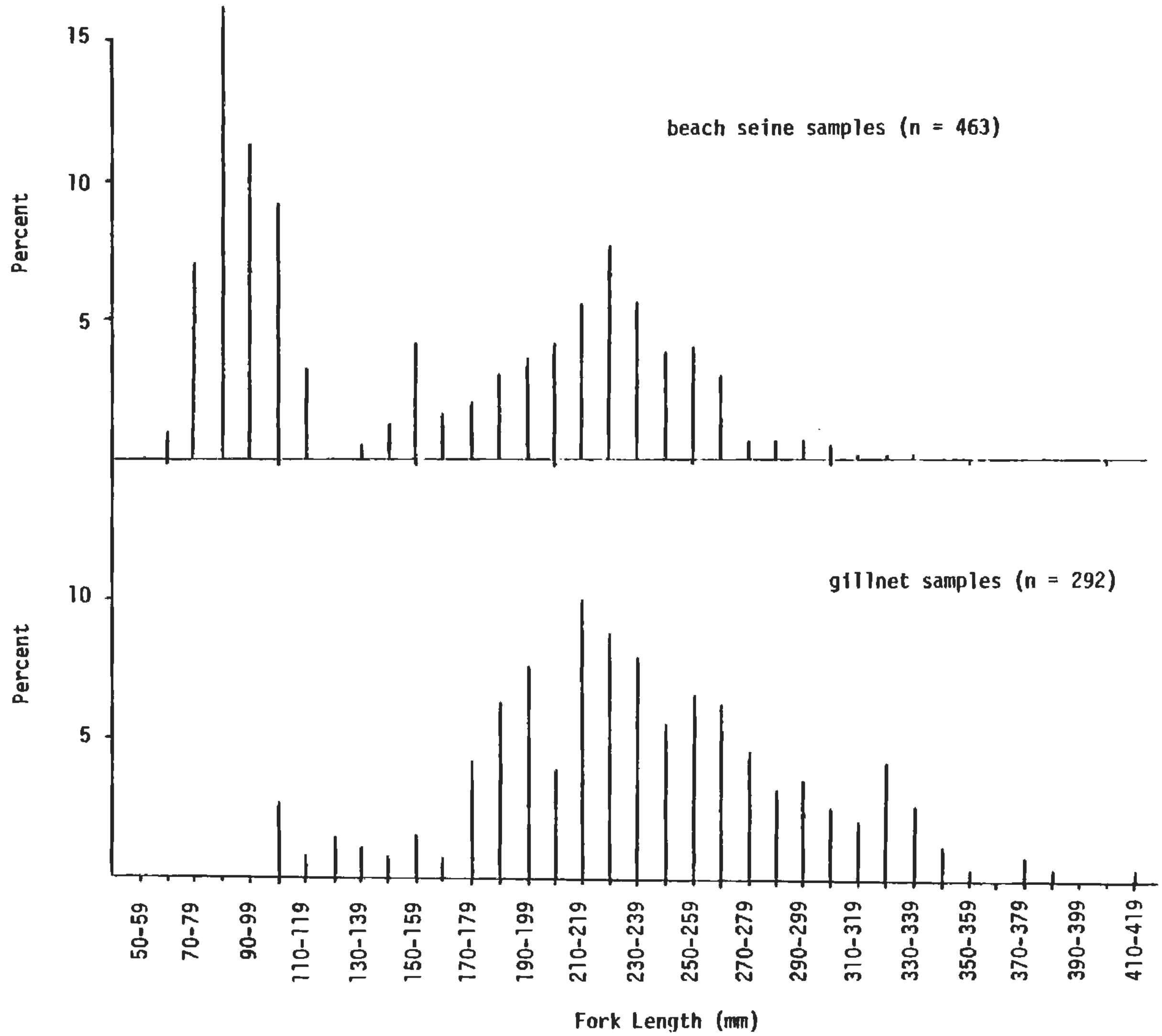


Figure 35. Length frequency (percent) of least cisco by gear type captured in nearshore waters of Norton Sound from June through October, 1977.

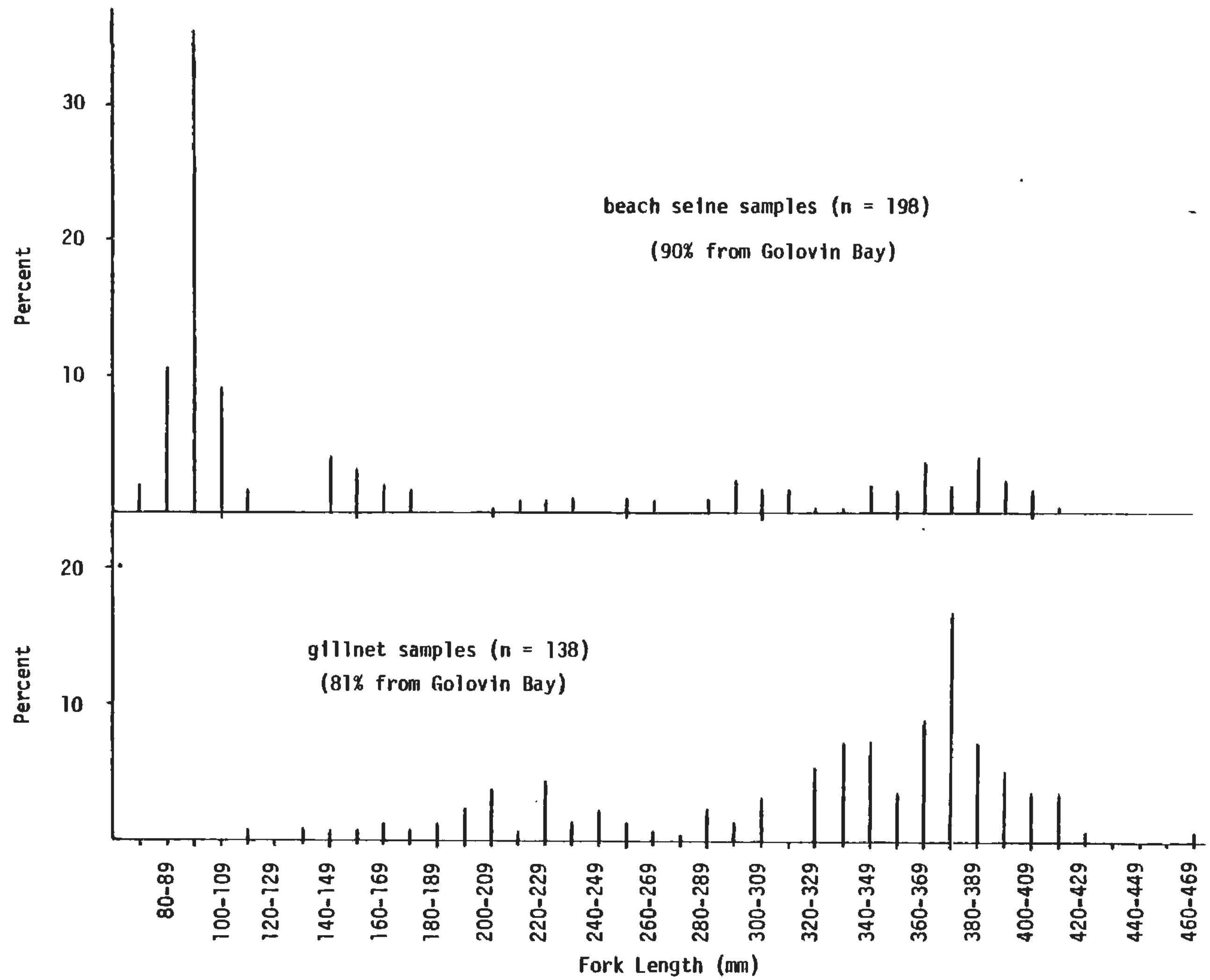


Figure 36. Length frequency (percent) of humpback whitefish by gear type captured in nearshore waters of Norton Sound from June through October, 1977.

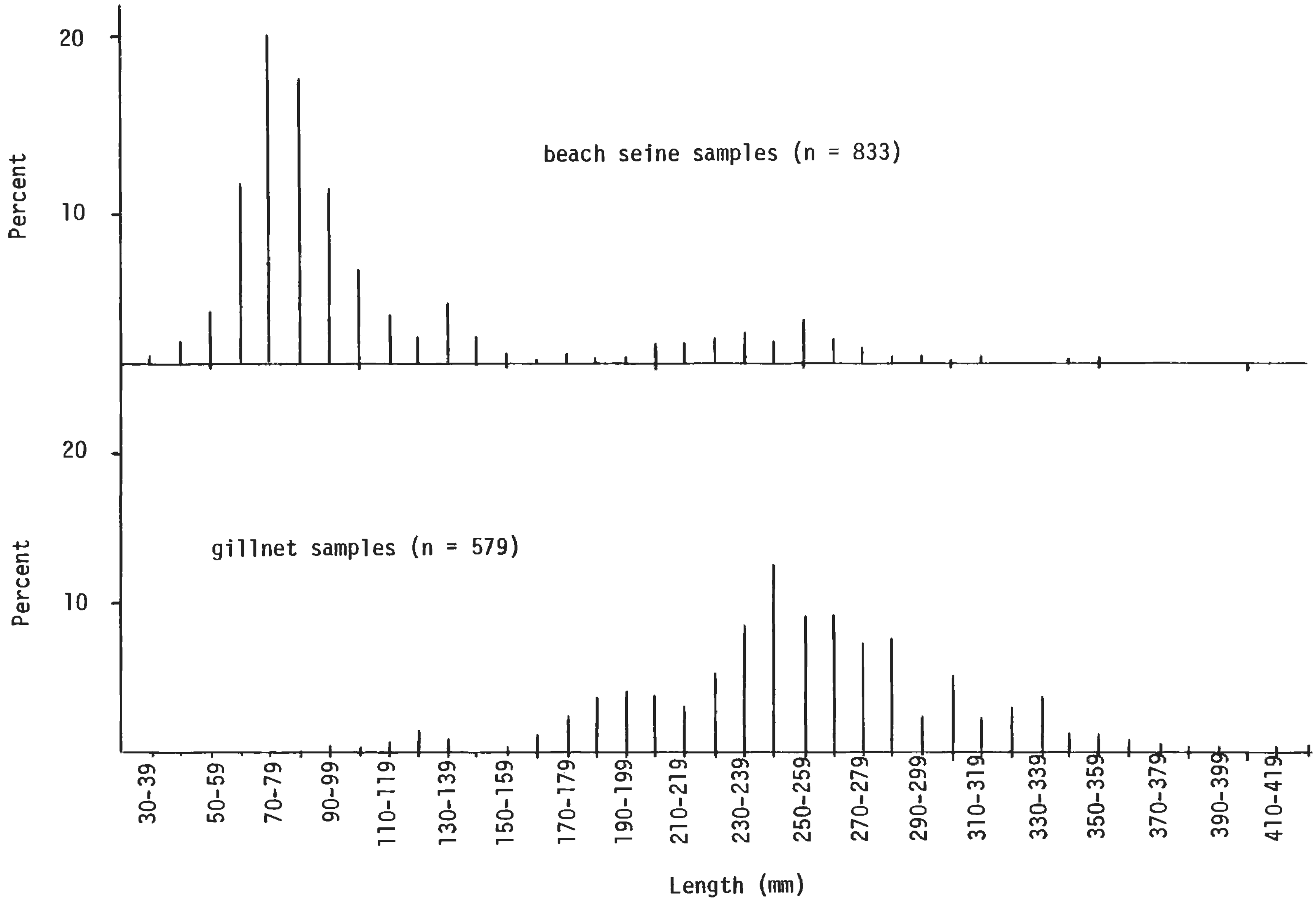


Figure 37. Length frequency (percent) of saffron cod captured in beach seines and gillnets in the near-shore waters of Norton Sound, 1977.

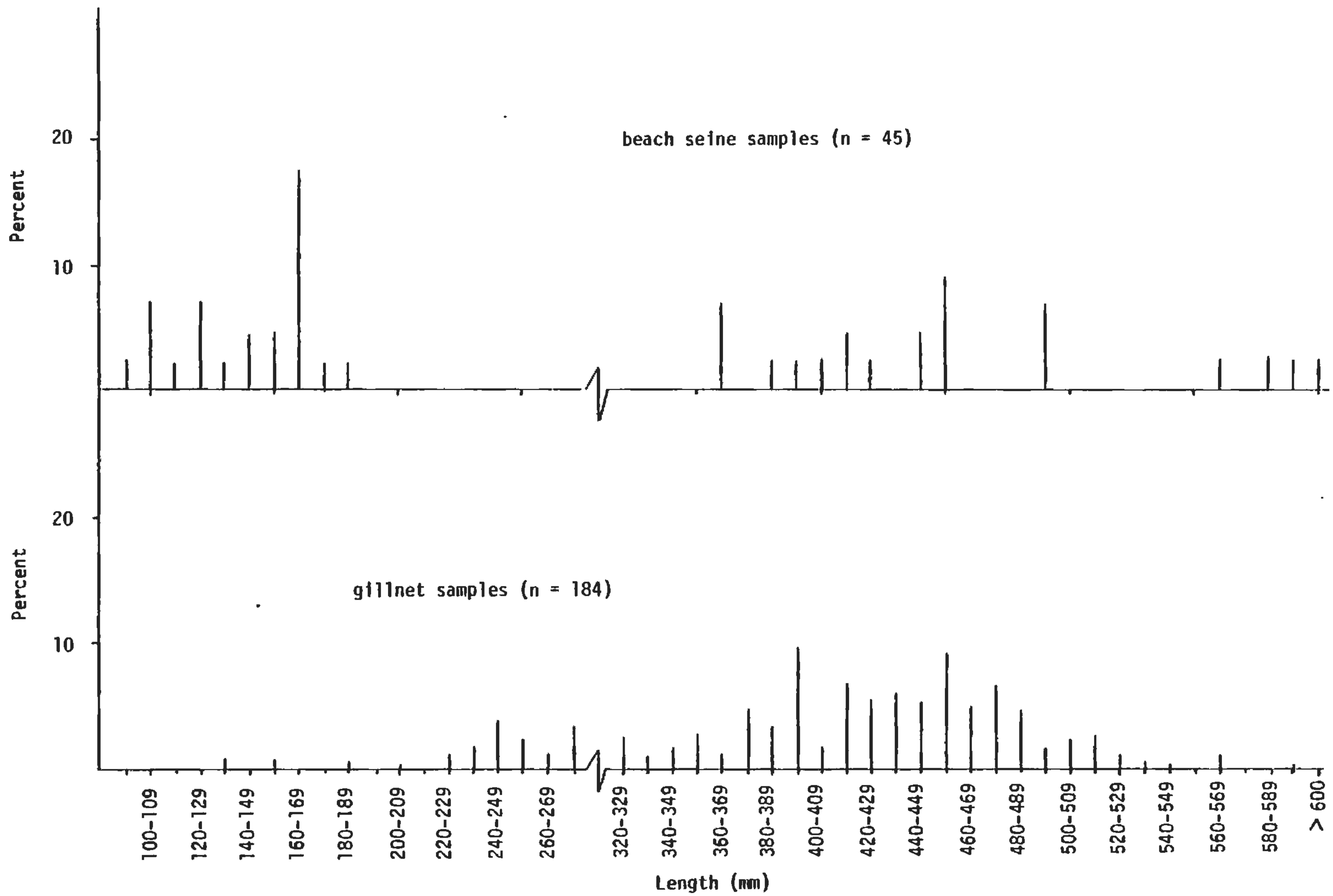


Figure 38. Length frequency (percent) of Arctic char by gear type captured in nearshore waters of Norton Sound from June through October, 1977.

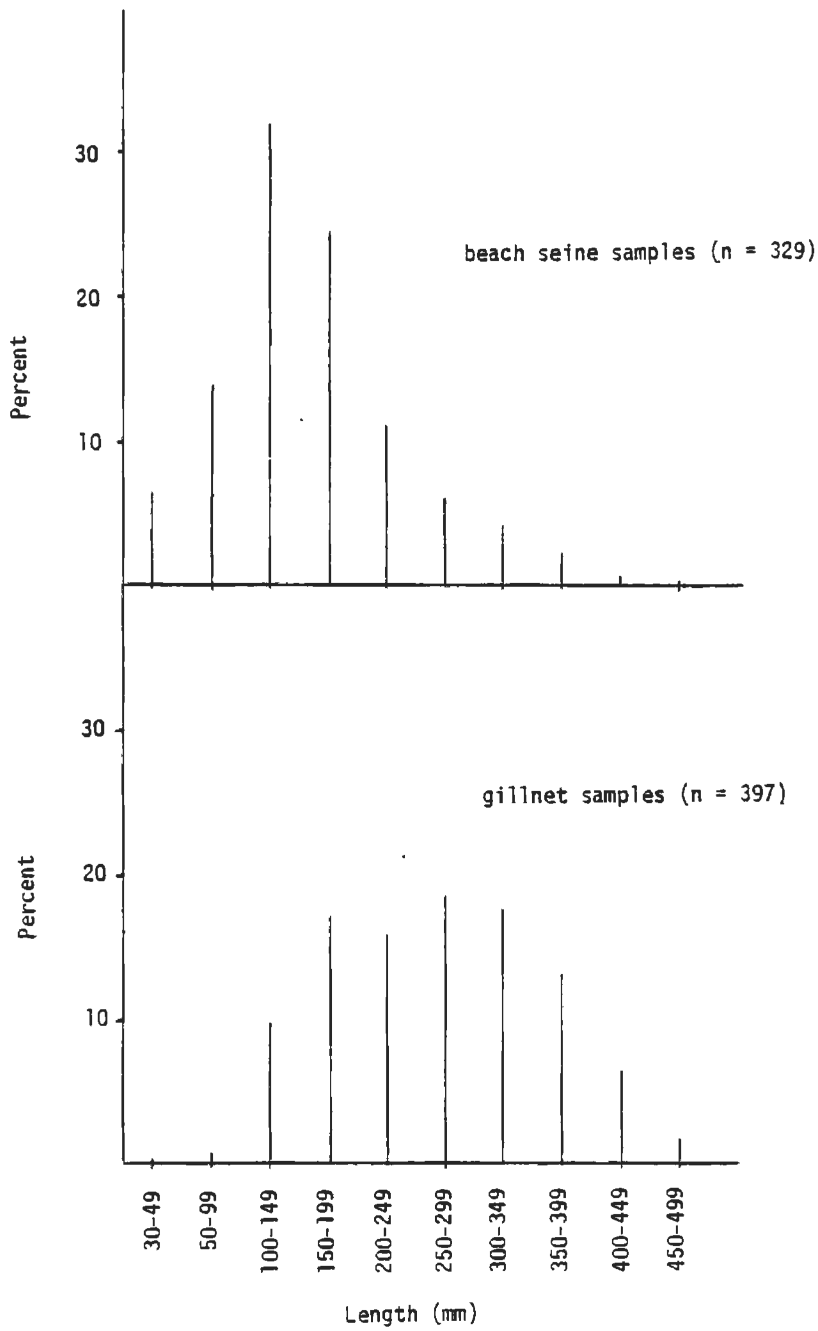


Figure 39. Length frequency (percent) of starry flounder by gear type captured in near-shore waters of Norton Sound from June through October, 1977.

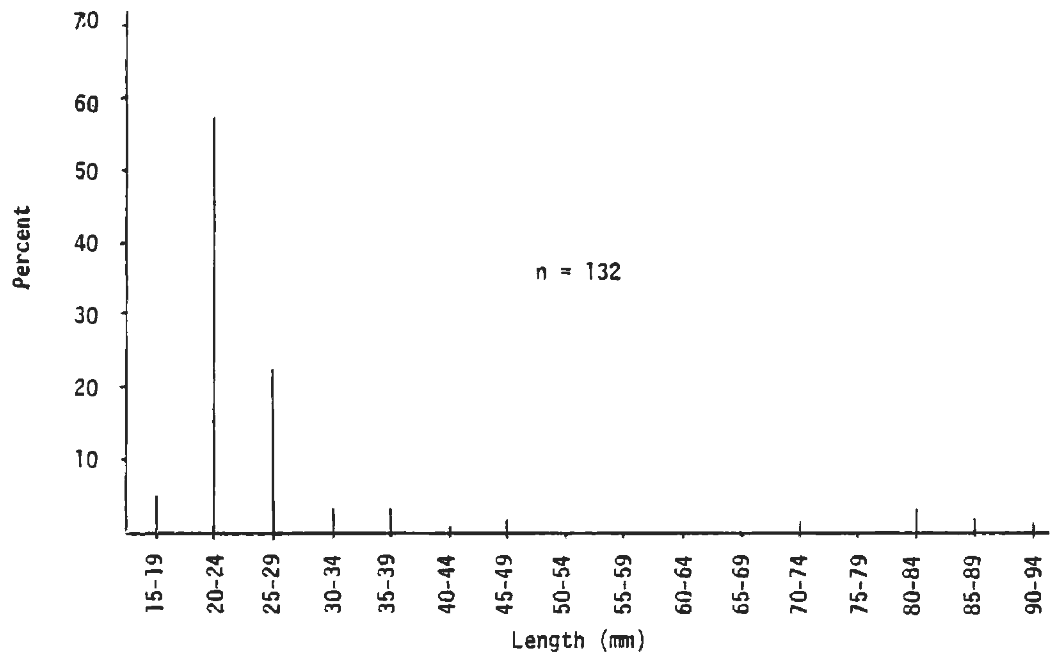


Figure 40. Length frequency (percent) of threespine stickleback captured in the nearshore waters of Norton Sound, 1977.

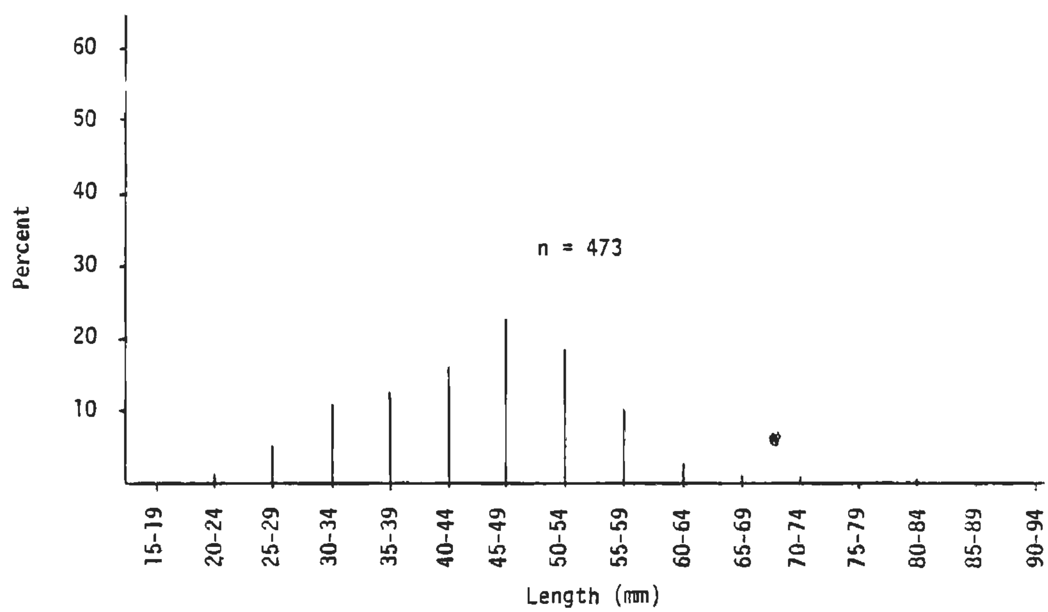


Figure 41. Length frequency (percent) of ninespine stickleback captured in the nearshore waters of Norton Sound, 1977.

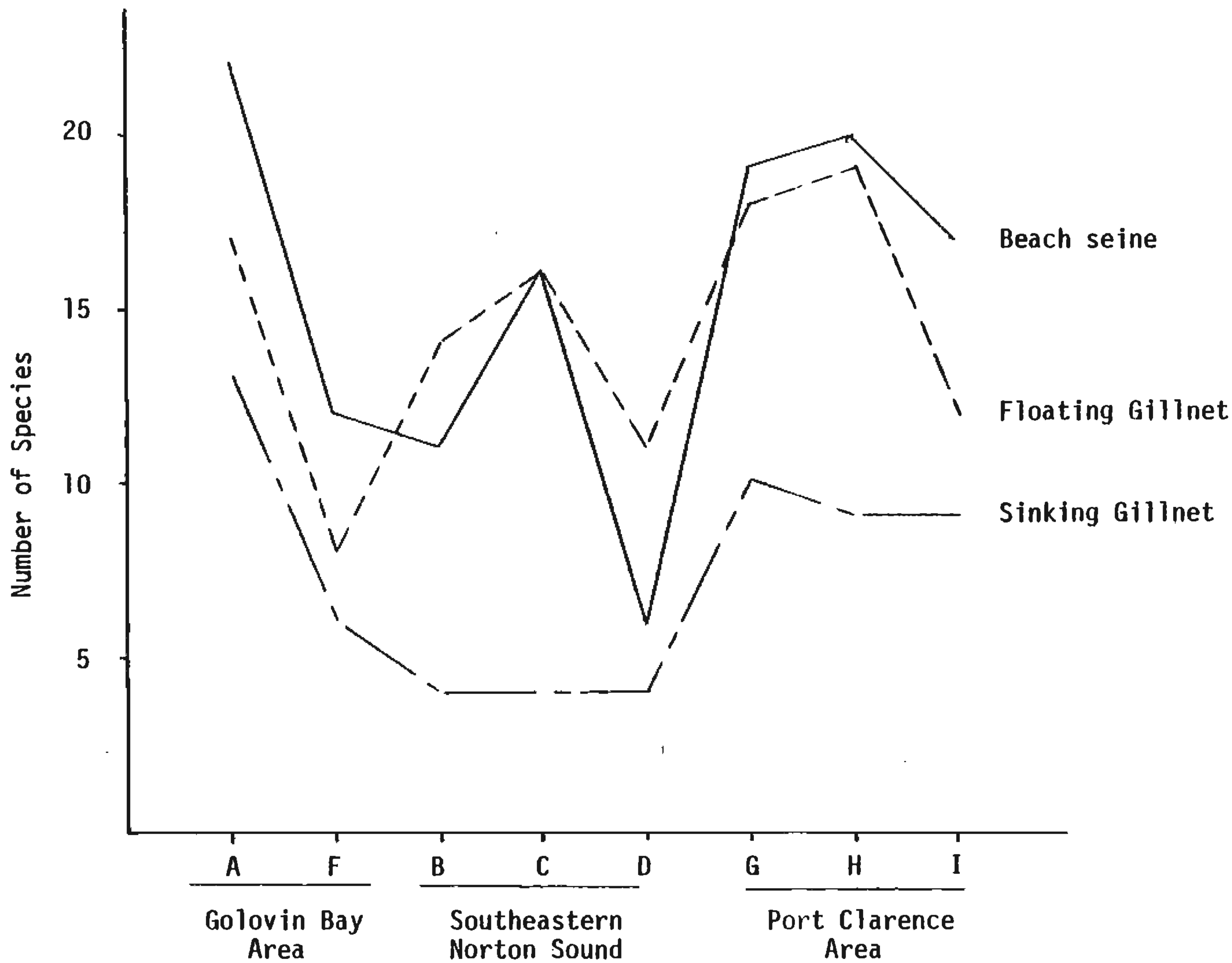


Figure 42. Species diversity by gear type of fish captured in the nearshore waters of Norton Sound from June through October, 1976-77.

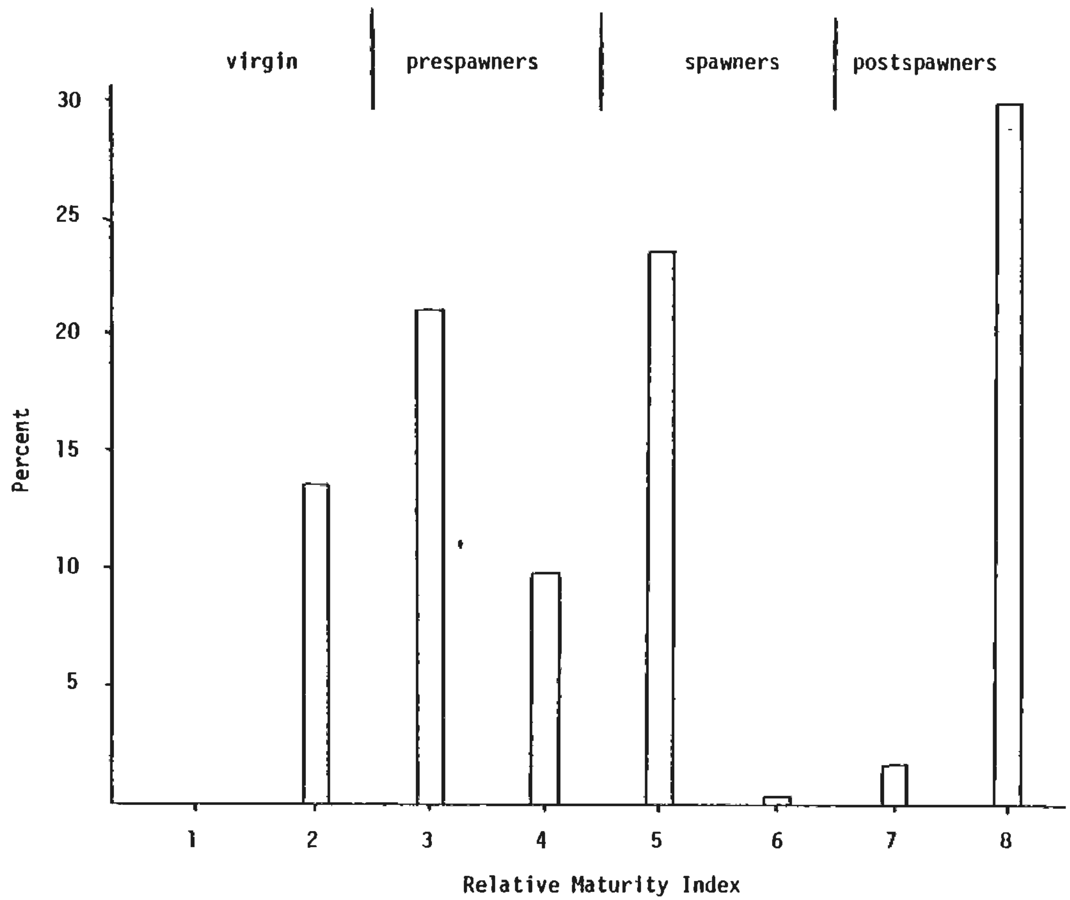


Figure 43. Relative maturity of herring captured in the offshore surface waters of Norton Sound from June 22 through July 12, 1977.

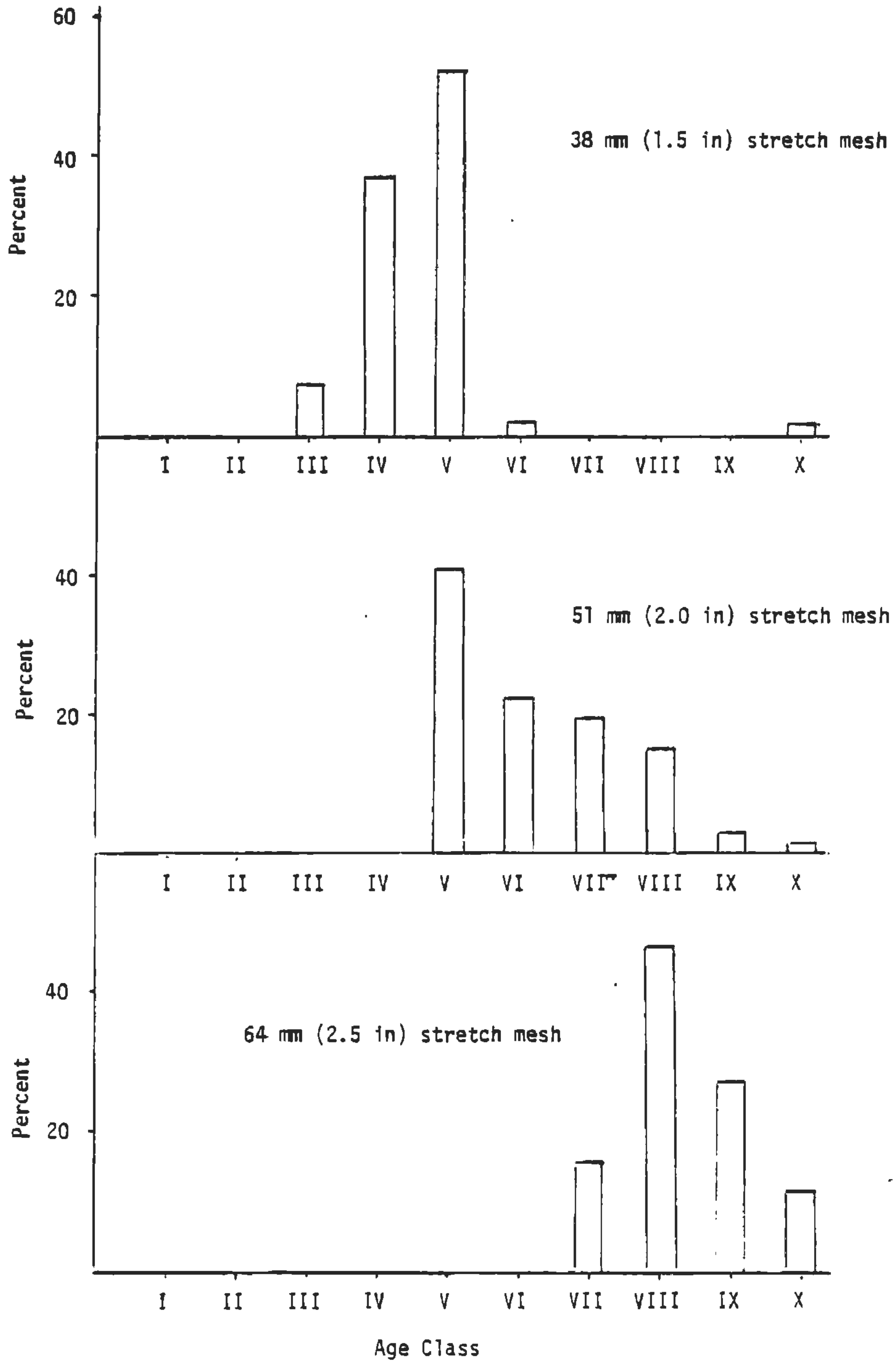


Figure 44. Mesh selectivity of gillnets to age classes of herring captured in the offshore waters of Norton Sound from June 22 through July 12, 1977.

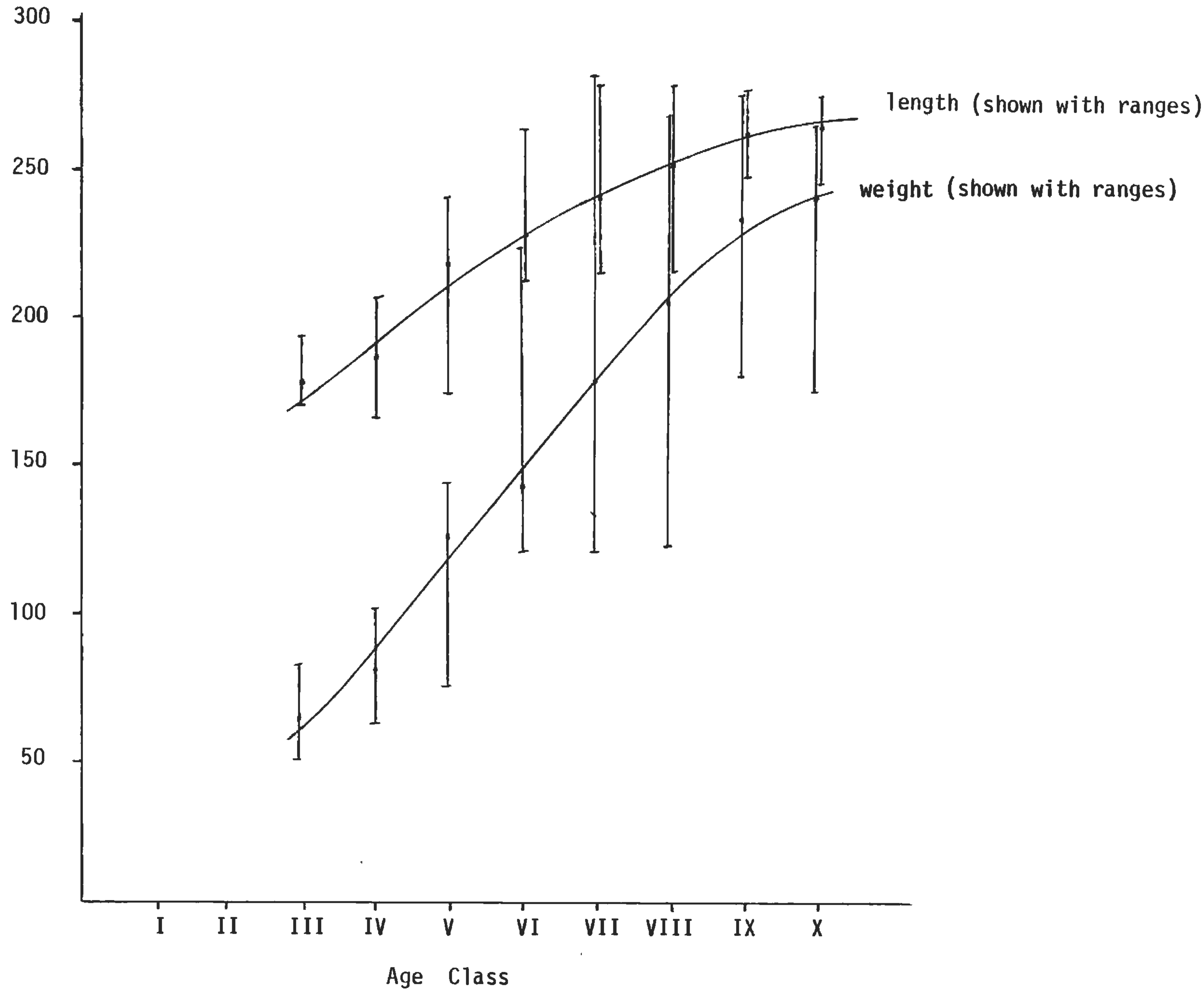


Figure 45. Mean length and weight-at-age for herring collected in the offshore surface waters of Norton Sound from June 22 through July 9, 1977.

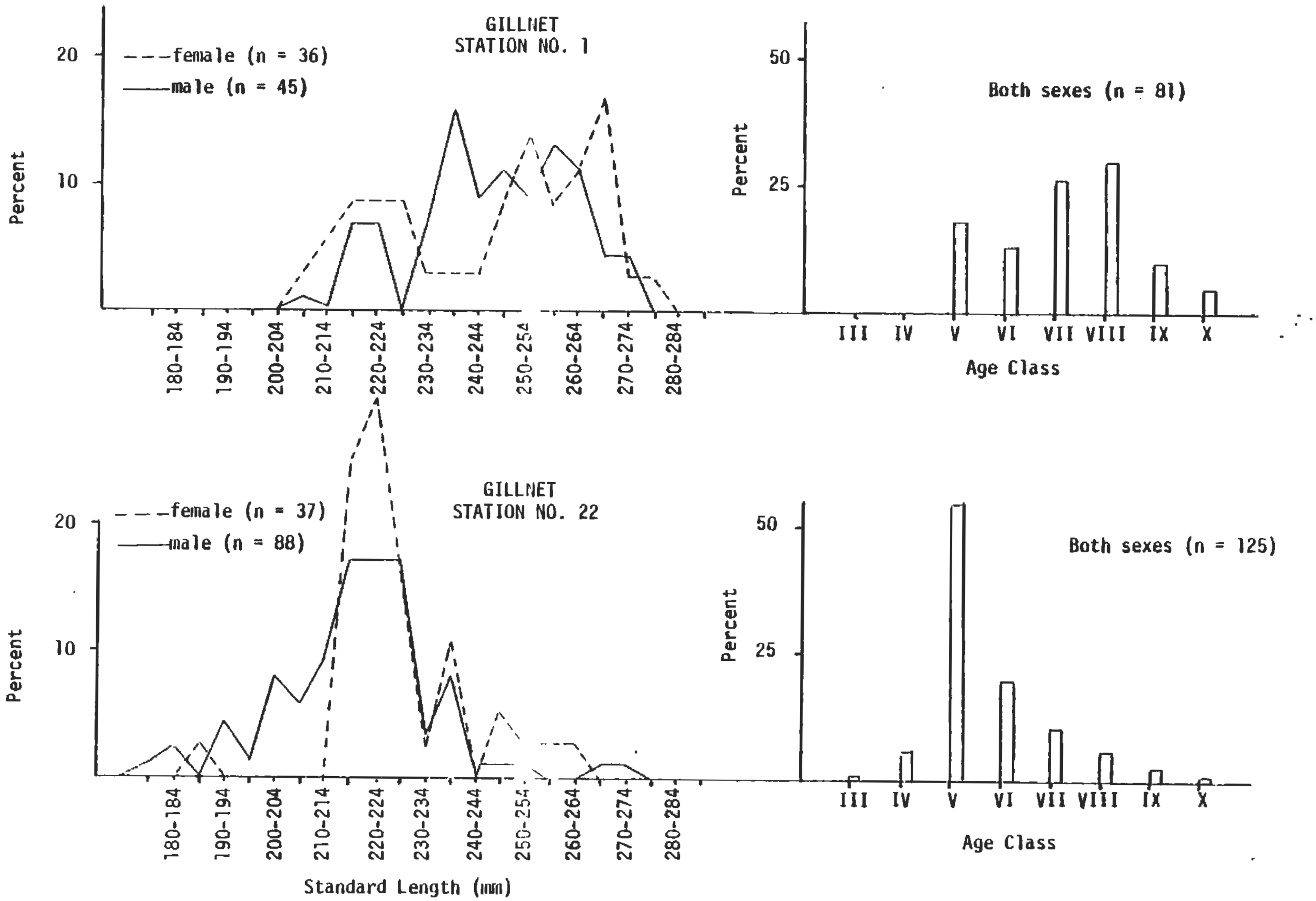


Figure 46. Length frequency and percent age composition of herring captured at stations 1 and 20 in Norton Sound during the M/V Royal Atlantic cruise from June 22 through July 12, 1977.

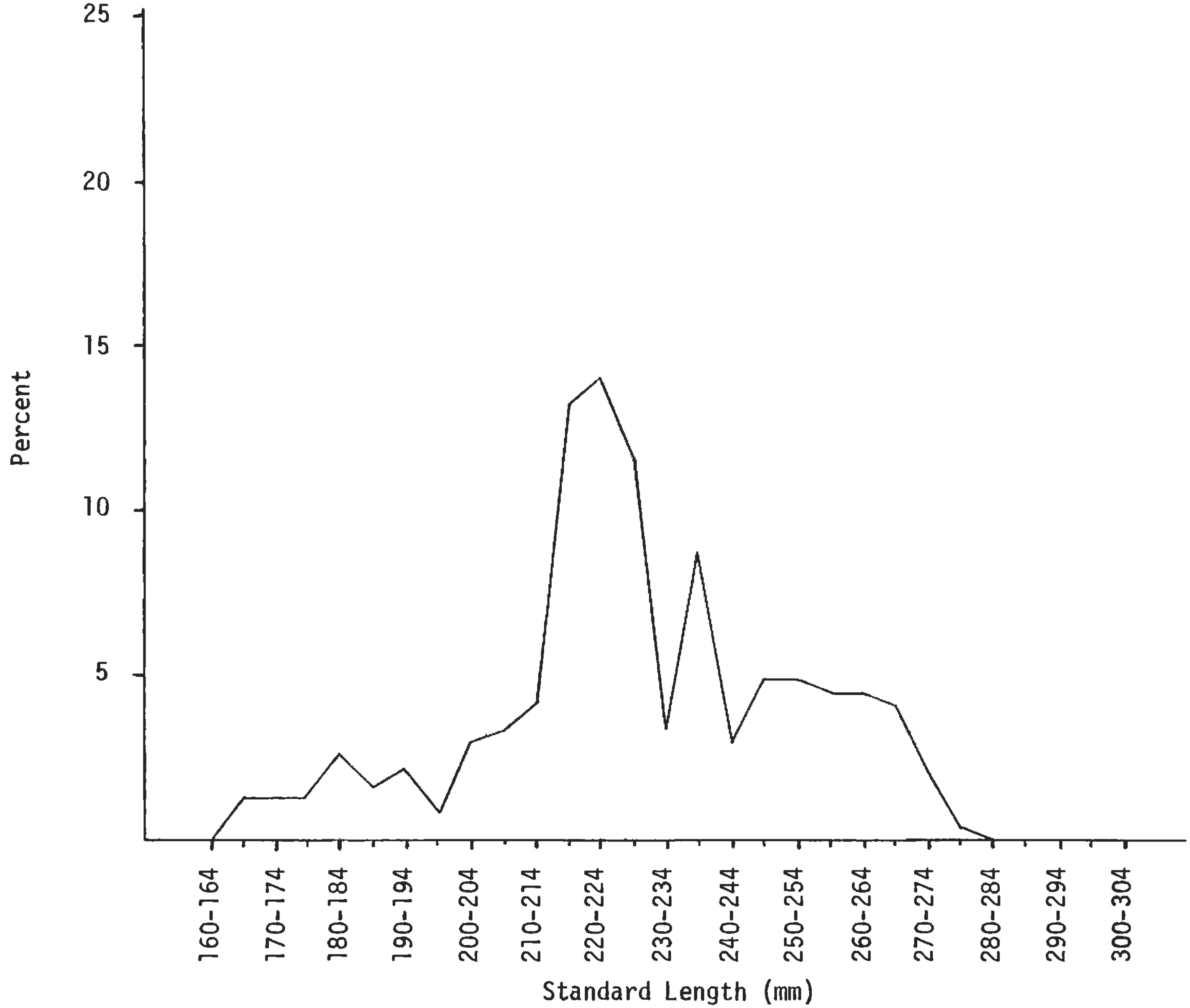


Figure 47. Length frequency (percent) of herring sampled in offshore surface waters of Norton Sound from June 22 through July 12, 1977.

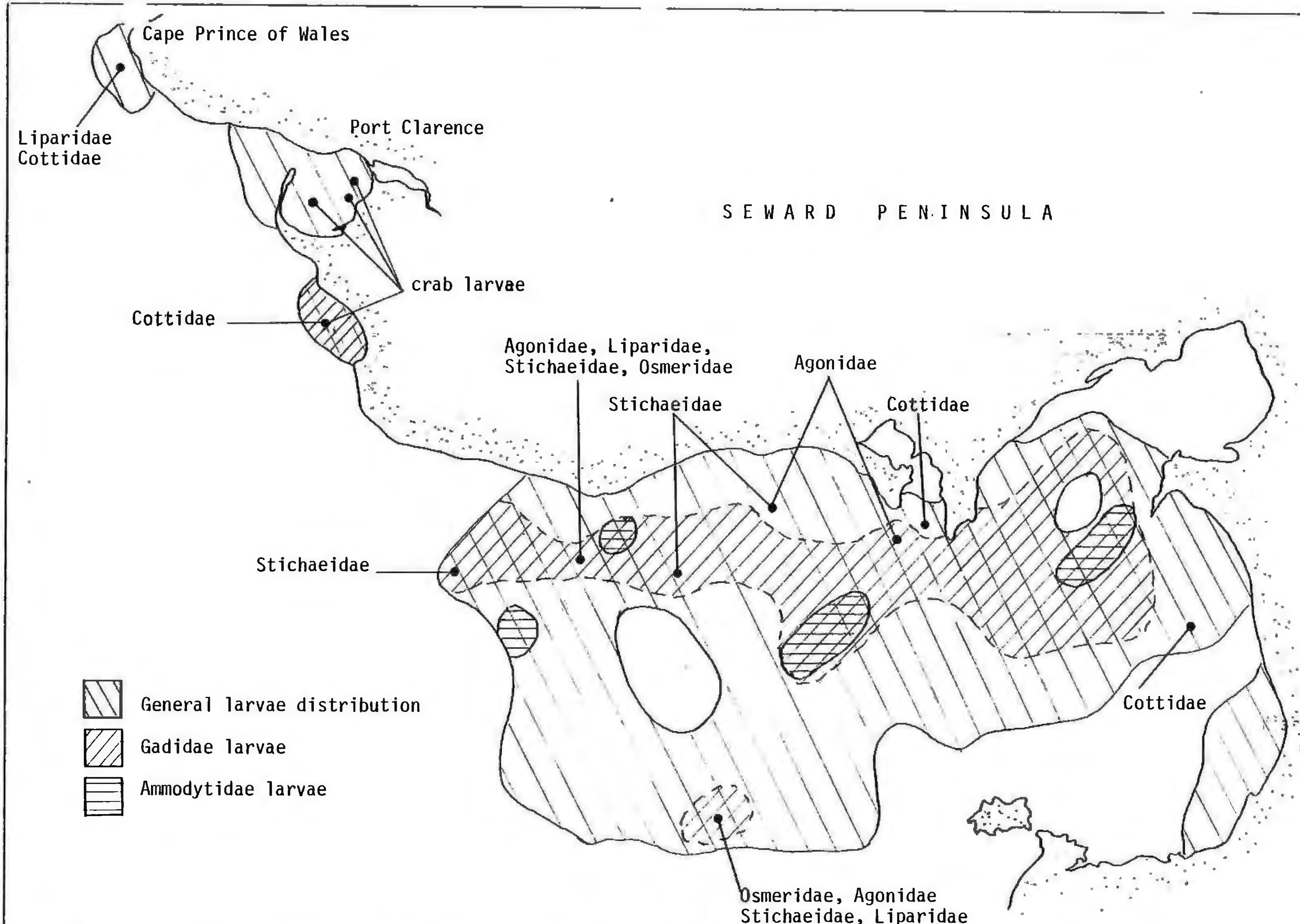


Figure 48. Larvae distribution in the offshore surface waters of Norton Sound June 22 through July 7, 1977.

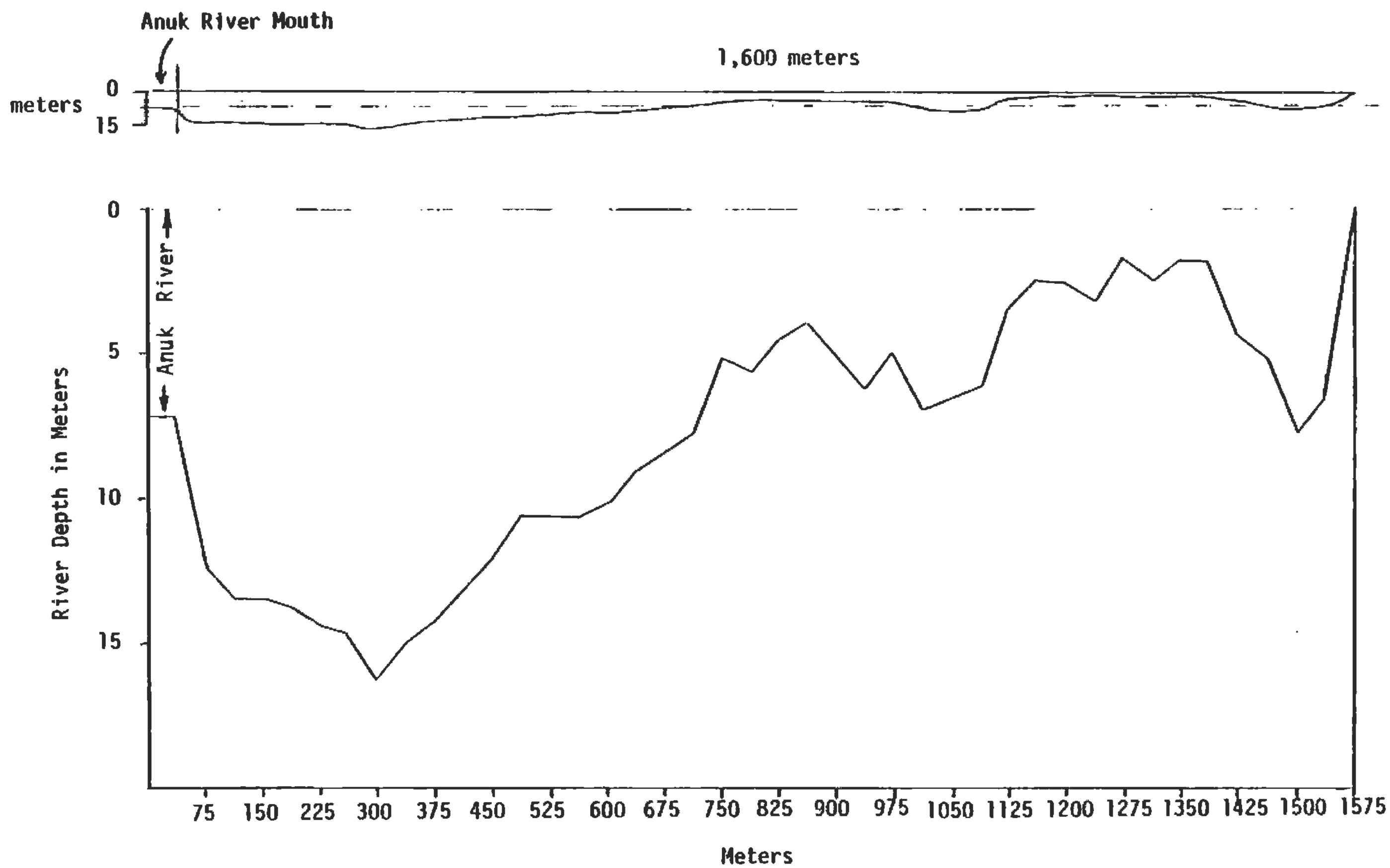


Figure 49. Exaggerated profile of the Yukon River 101 kilometers upriver from Flat Island, 1977. This site was location for smolting studies.

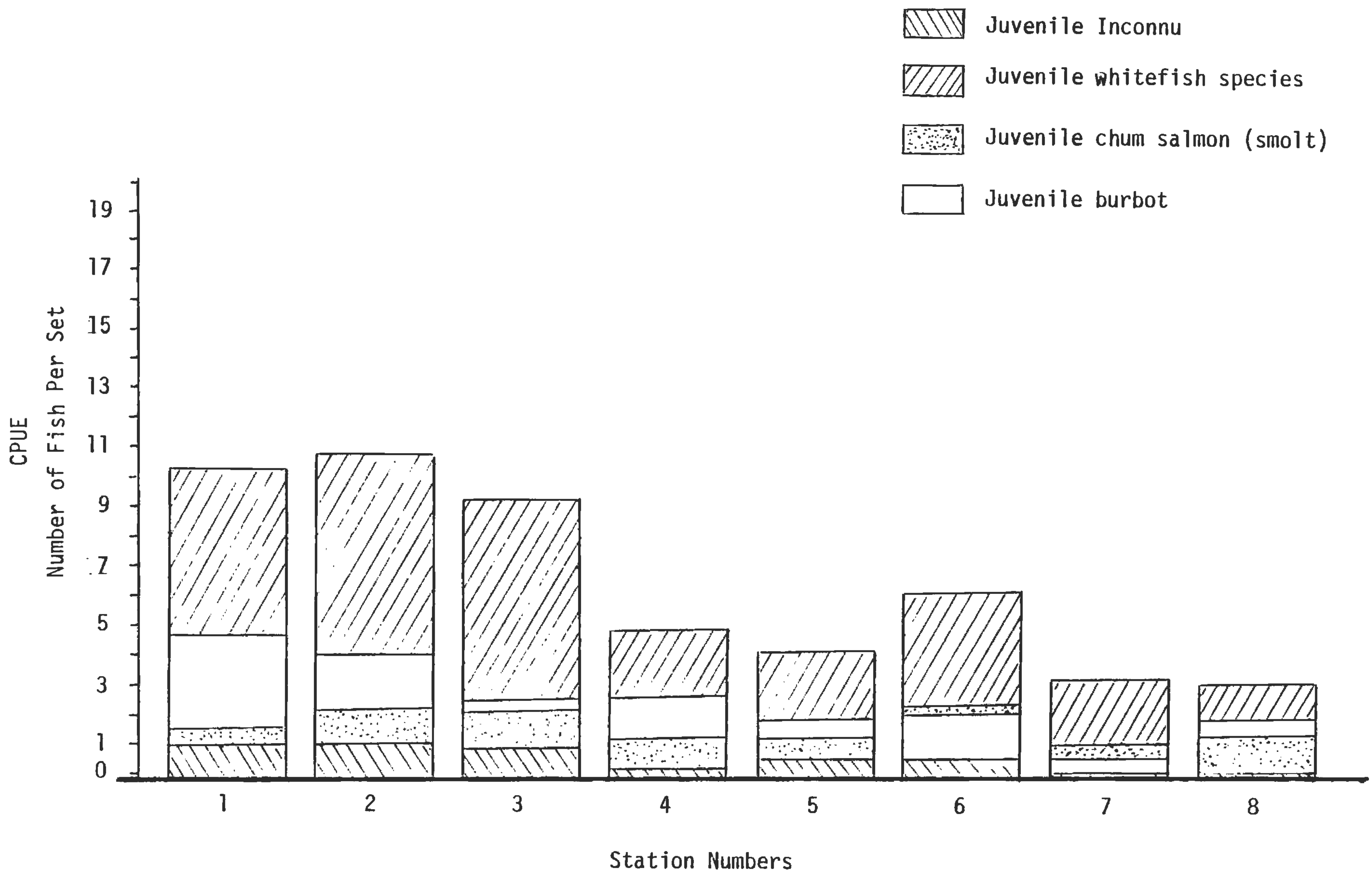


Figure 50. Catch per unit effort for four fish groups by station number captured in the Yukon River from June 7 through July 7, 1977. Site location was at the confluence of the Anuk River.

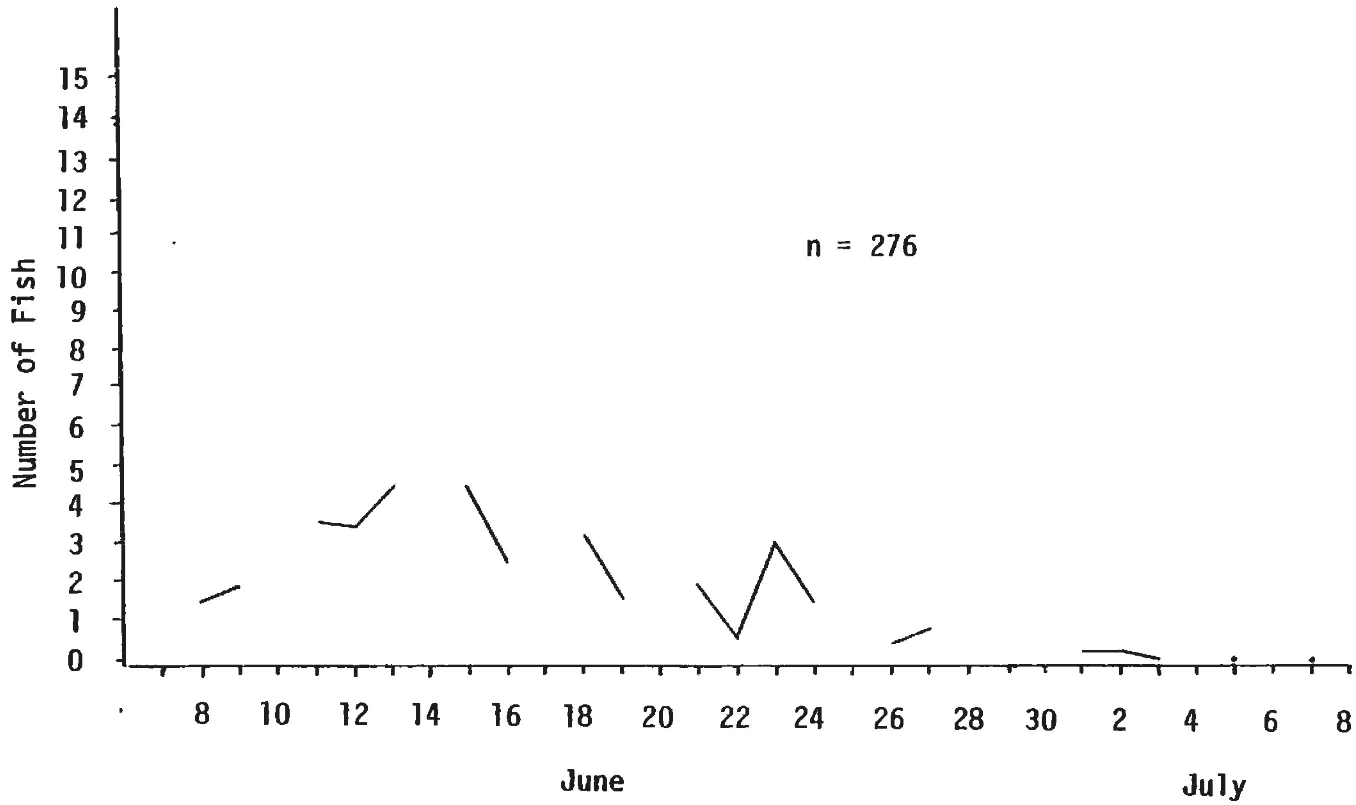


Figure 51. Timing and abundance of chum salmon smolt down the Yukon River 101 kilometers upriver from Flat Island in June, 1977.

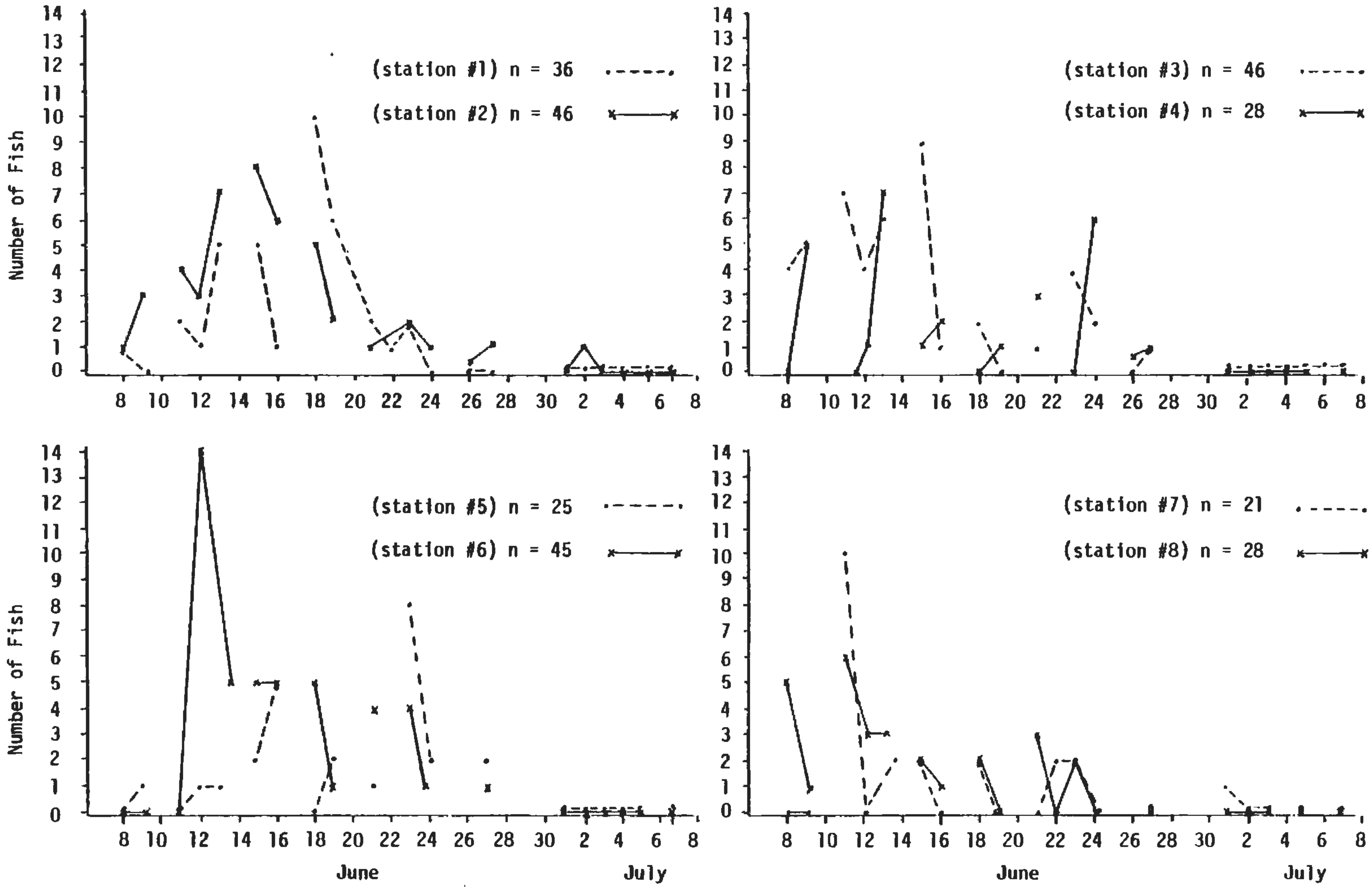


Figure 52. Spatial and temporal distribution of chum salmon smolt in the Yukon River 101 kilometers upriver from Flat Island in June, 1977.

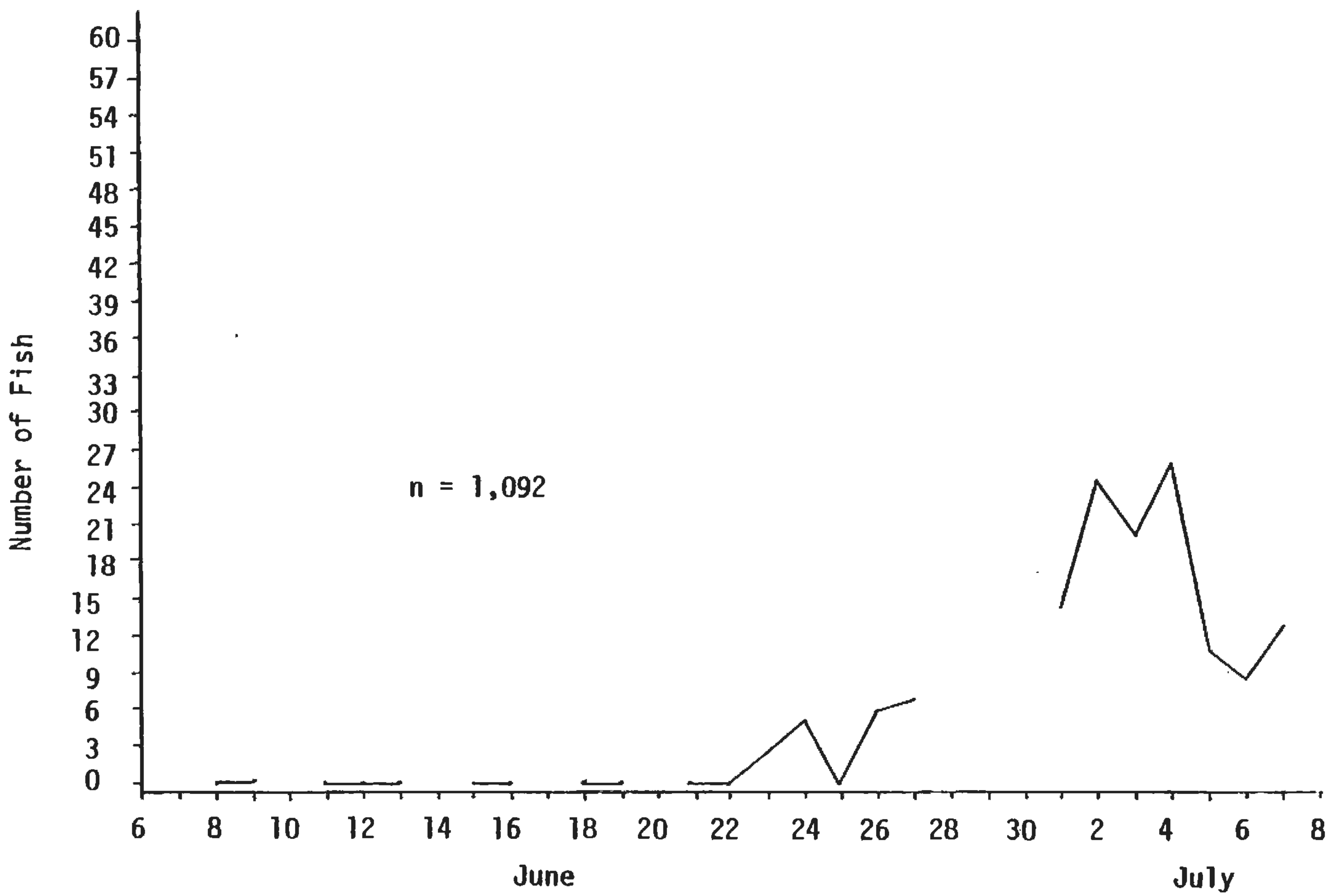


Figure 53. Timing and abundance of juvenile whitefish species down the Yukon River 101 kilometers upriver from Flat Island in June, 1977.

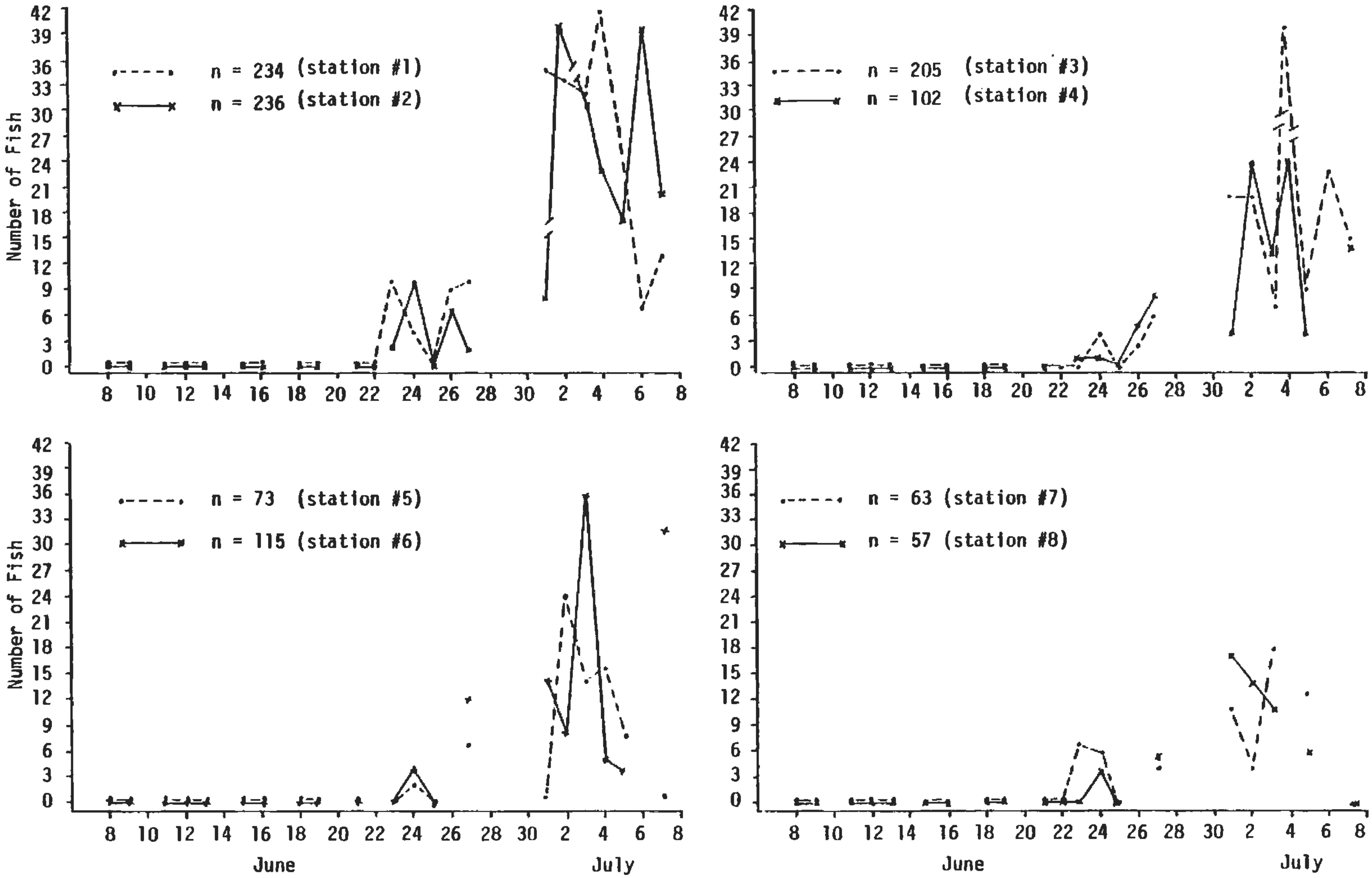


Figure 54. Spatial and temporal distribution of juvenile whitefish species down the Yukon River 101 kilometers upriver from Flat Island in June, 1977.

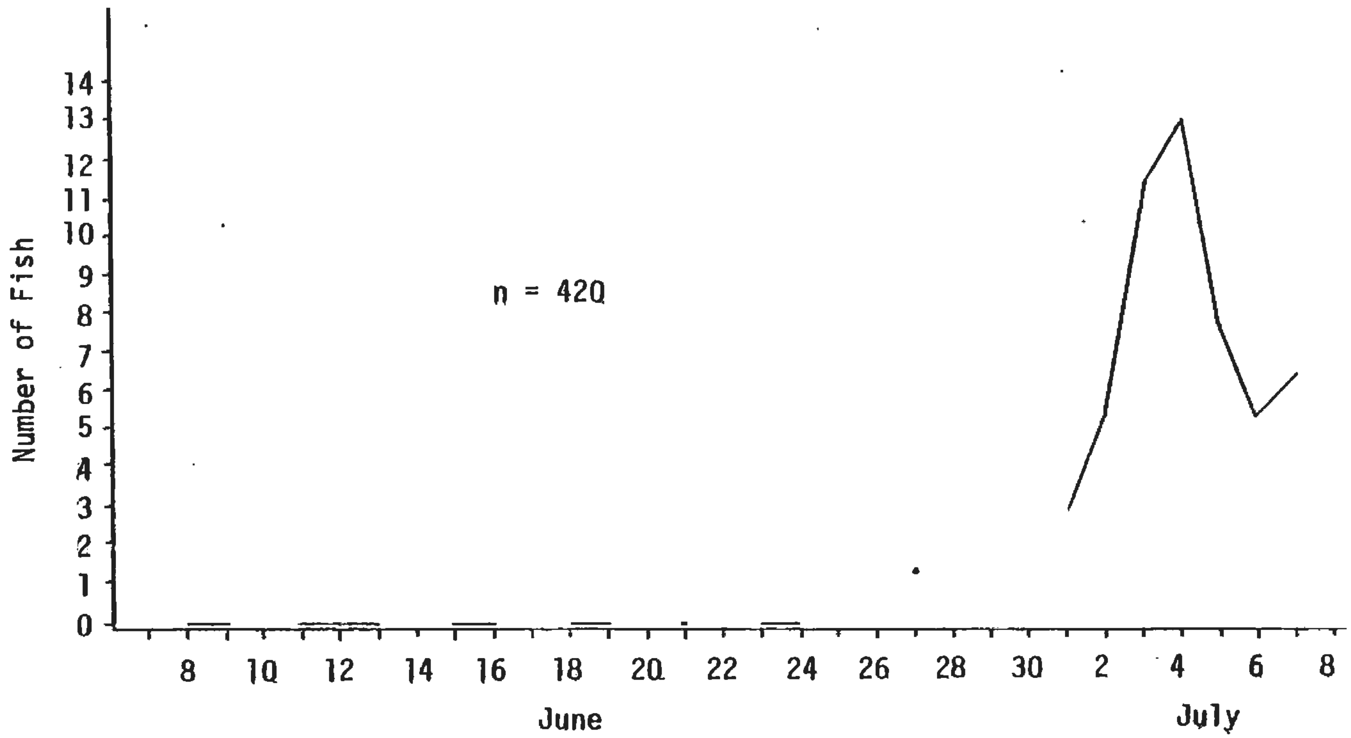


Figure 55. Timing and abundance of juvenile burbot down the Yukon River 101 kilometers upriver from Flat Island in June, 1977.

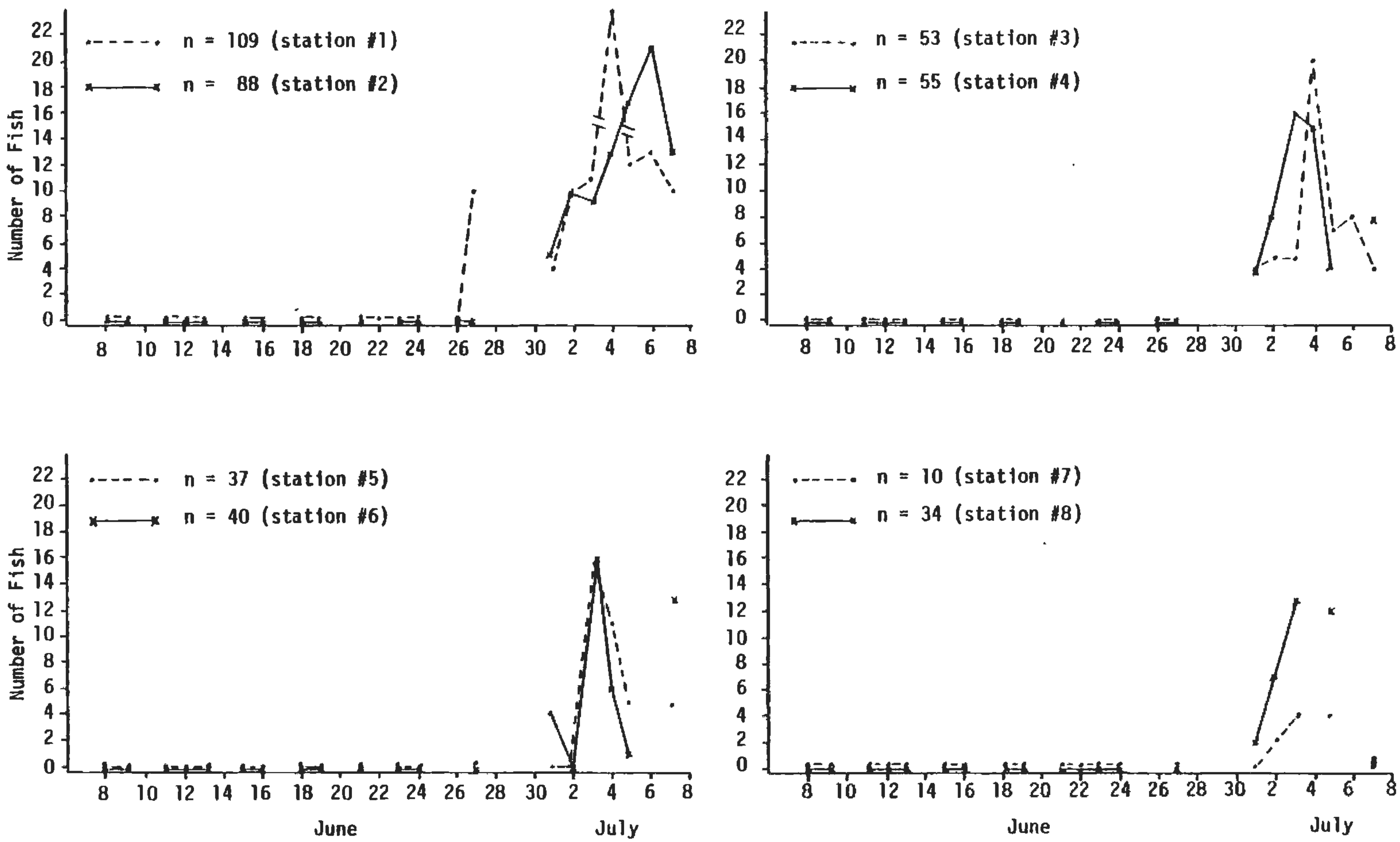


Figure 56. Spatial and temporal distribution of juvenile burbot down the Yukon River 101 kilometers upriver from Flat Island in June, 1977.

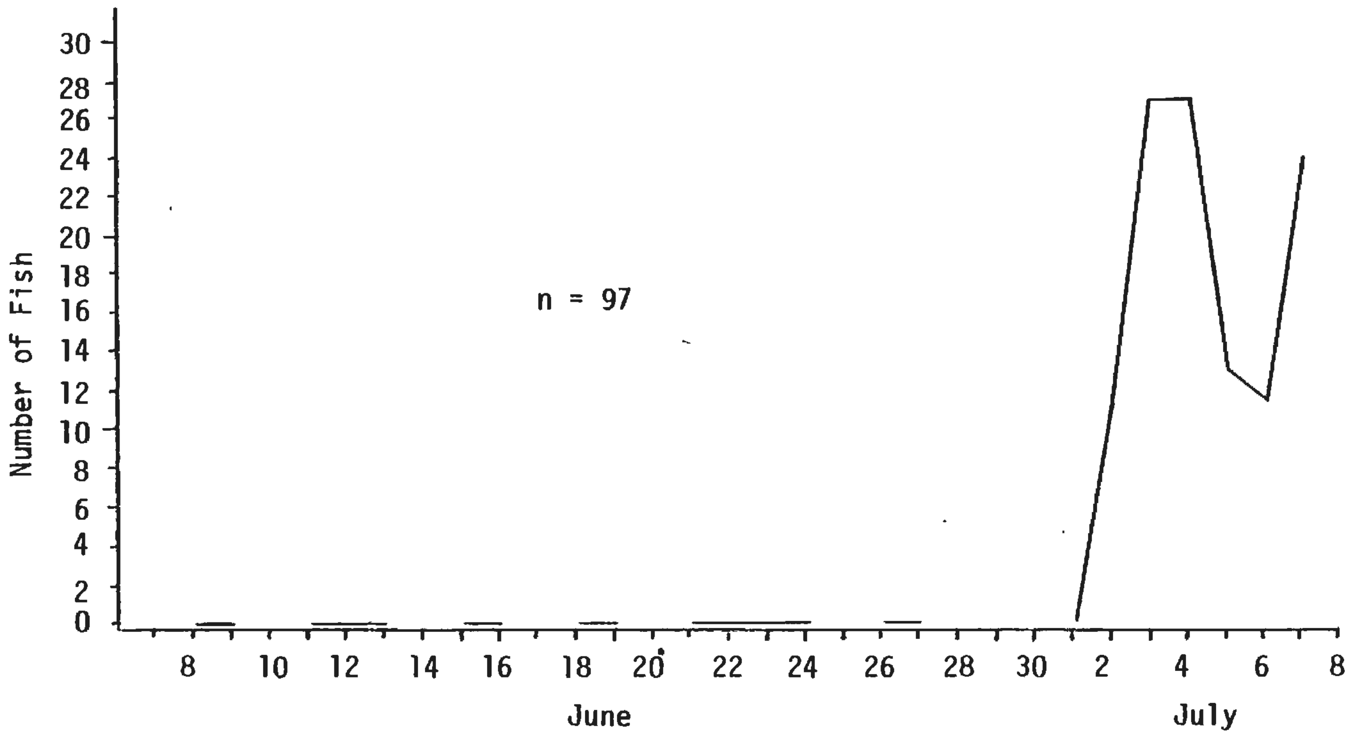


Figure 57 . Timing and abundance of juvenile sheefish (Inconnu) down the Yukon River 101 kilometers upriver from Flat Island in June, 1977.

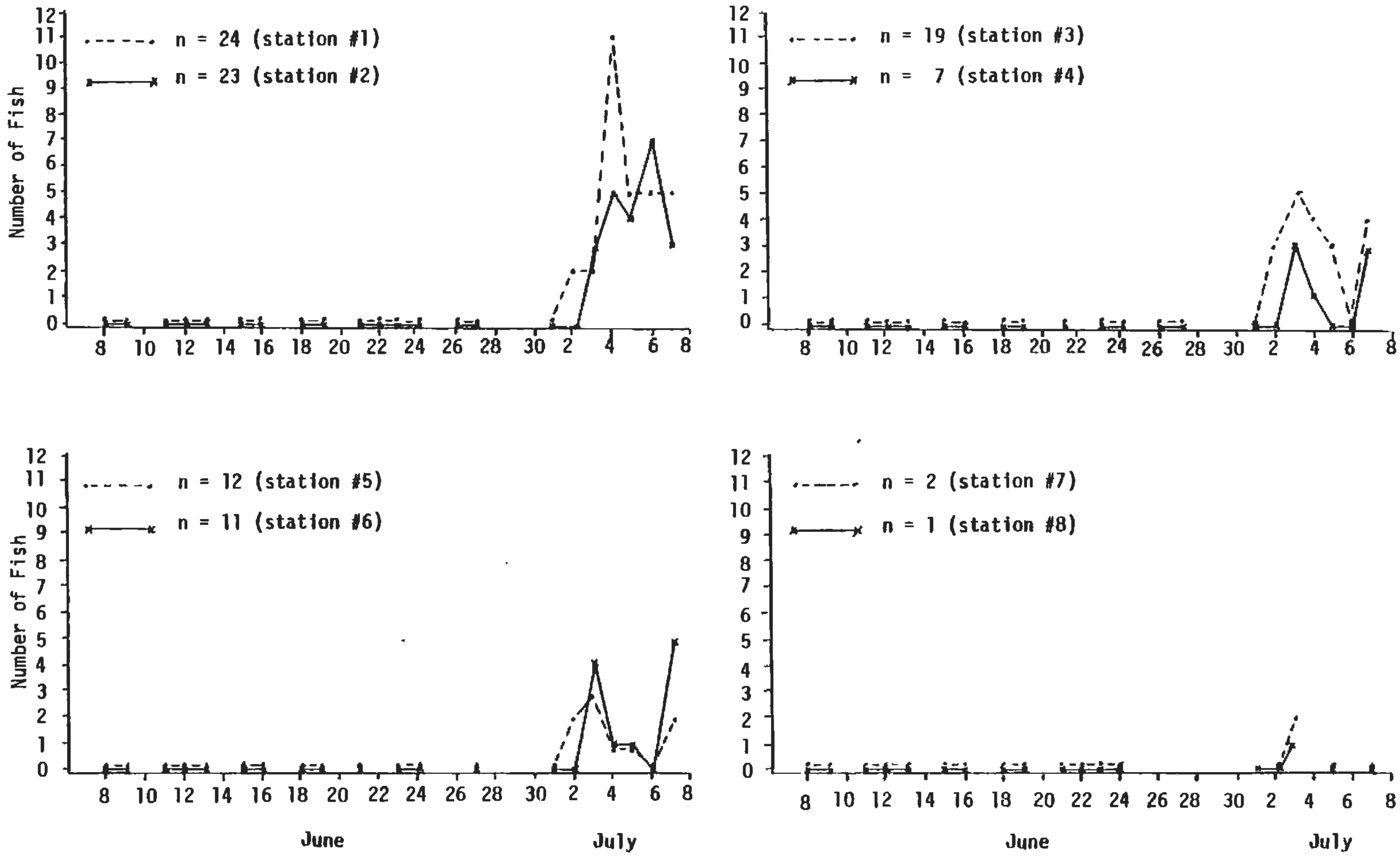


Figure 58. Spatial and temporal distribution of juvenile sheefish (Inconnu) down the Yukon River 101 kilometers upriver from Flat Island in June, 1977.

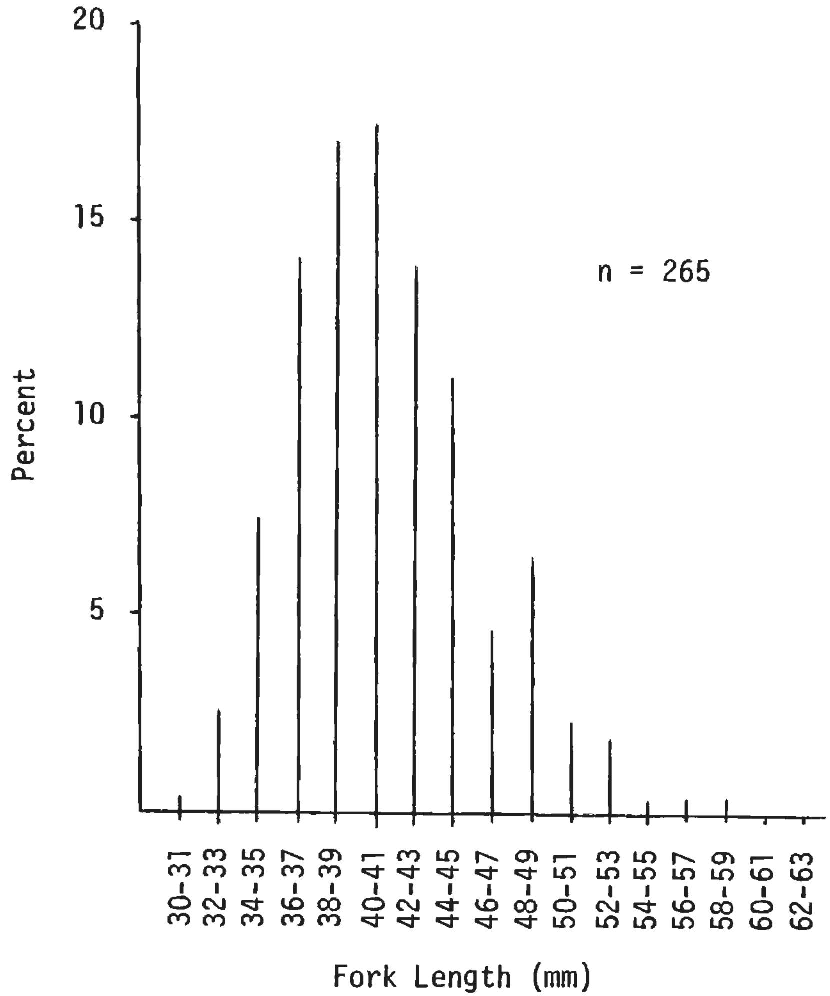


Figure 59. Length frequency (percent) of chum salmon smolt captured in the Yukon River 101 kilometers upriver from Flat Island, June 1977.

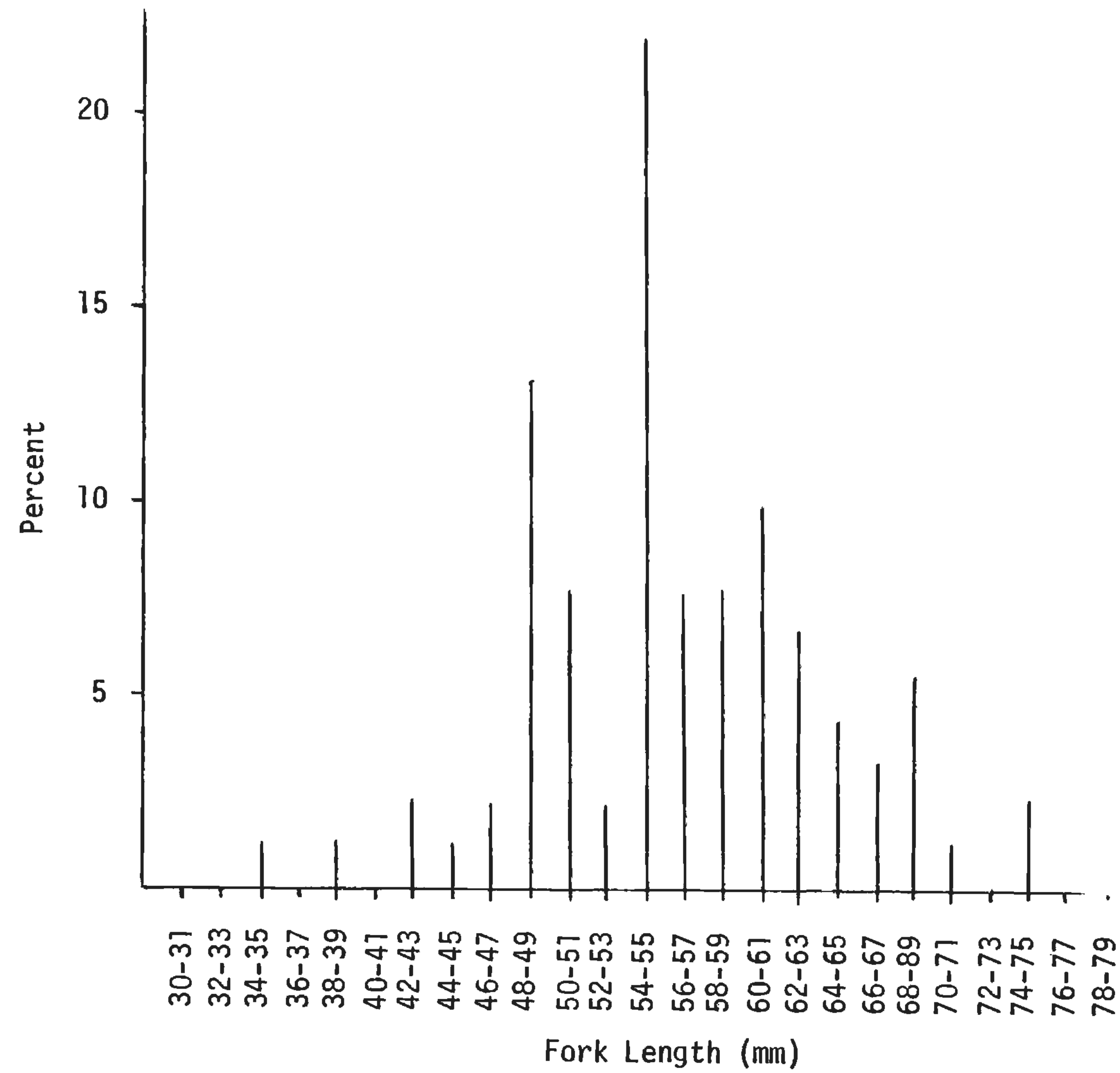


Figure 60. Length frequency (percent) of juvenile sheefish (Inconnu) captured in the Yukon River 101 kilometers upriver from Flat Island, June 1977.

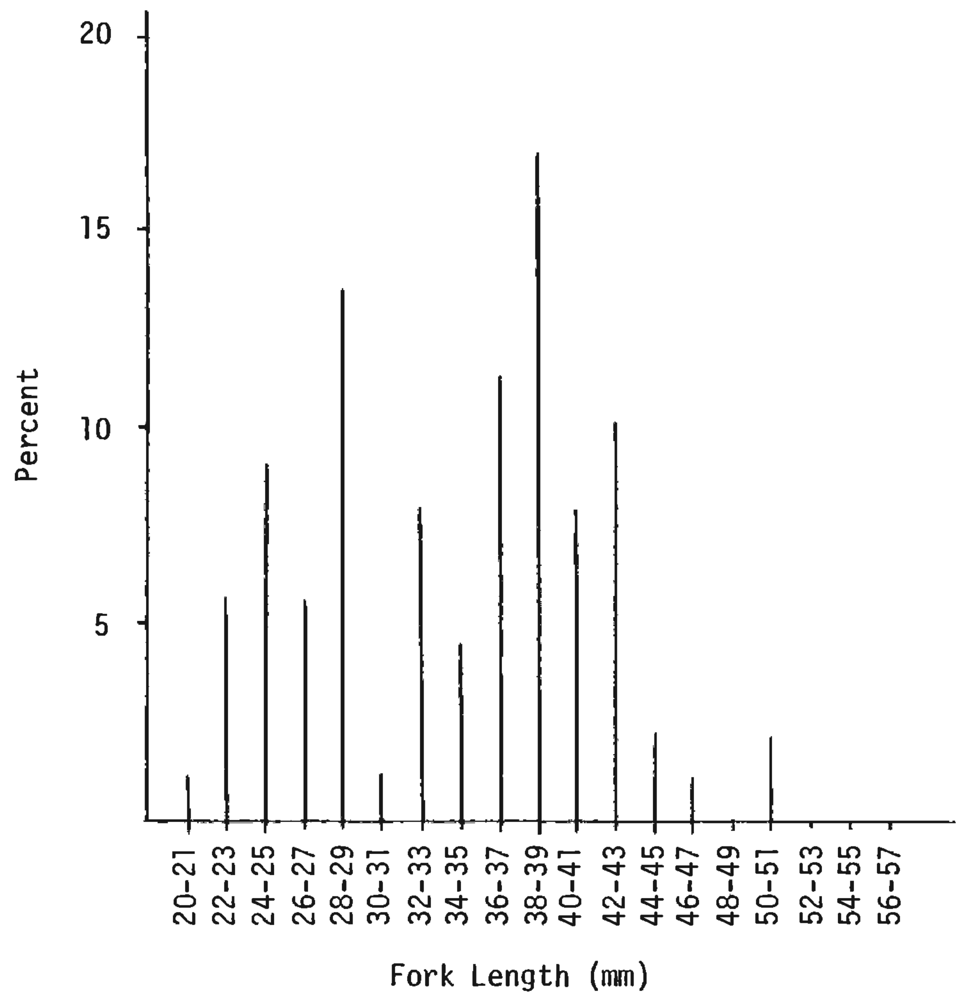


Figure 61. Length frequency (percent) of juvenile whitefish species captured in the Yukon River 101 kilometers upriver from Flat Island, June 1977.

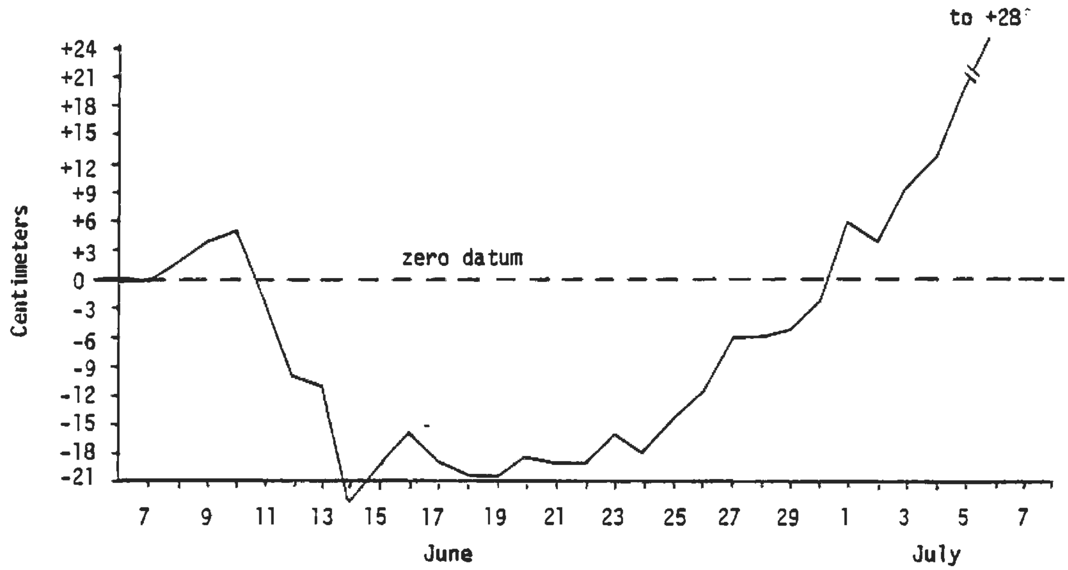


Figure 62. Water level fluctuations in the Anuk River one mile upriver from its confluence with the Yukon River, June 1977.

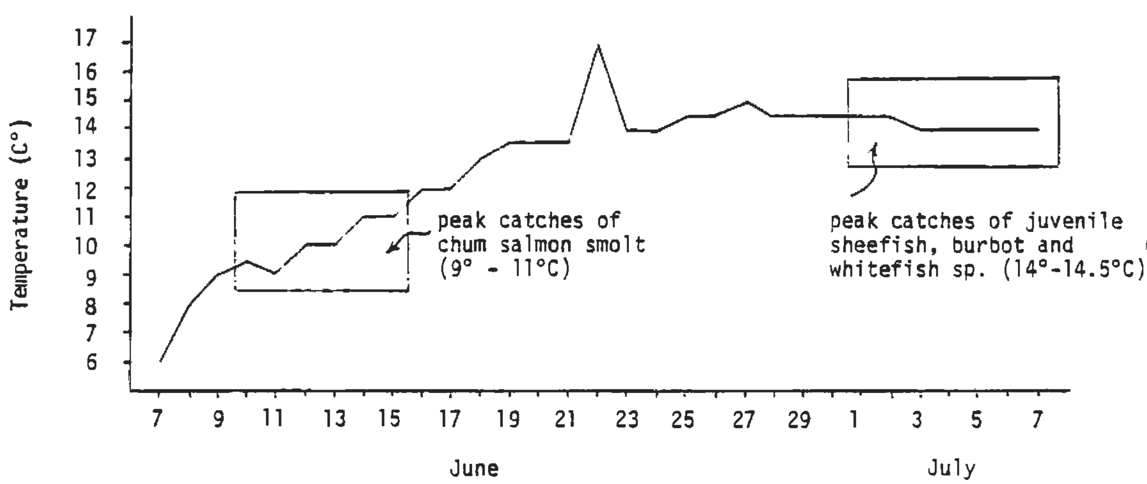


Figure 63. Yukon River surface water temperatures 101 kilometers upriver from Flat Island, June 1977.

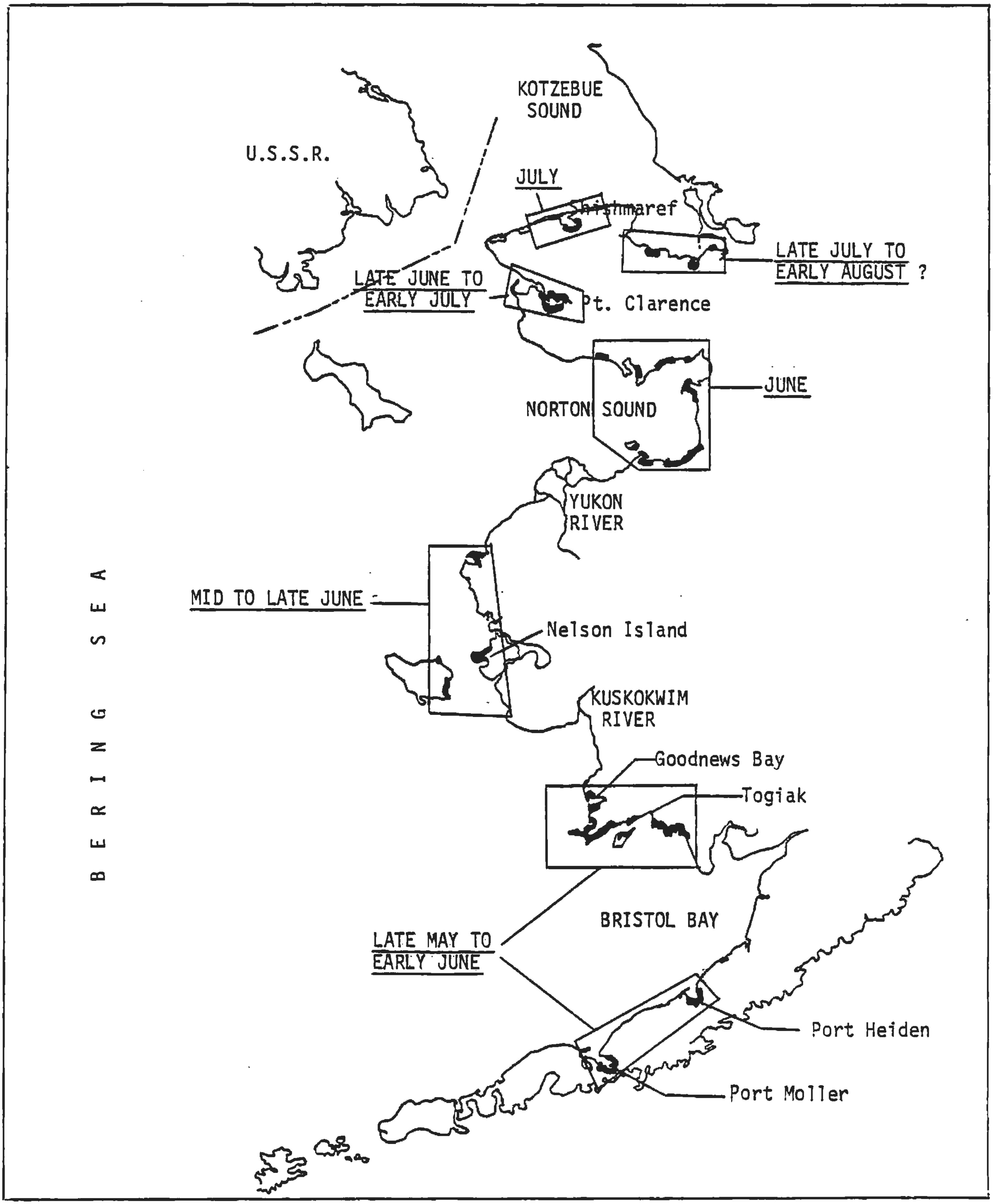


Figure 64 . Timing and distribution of Pacific herring spawning in the eastern Bering Sea.

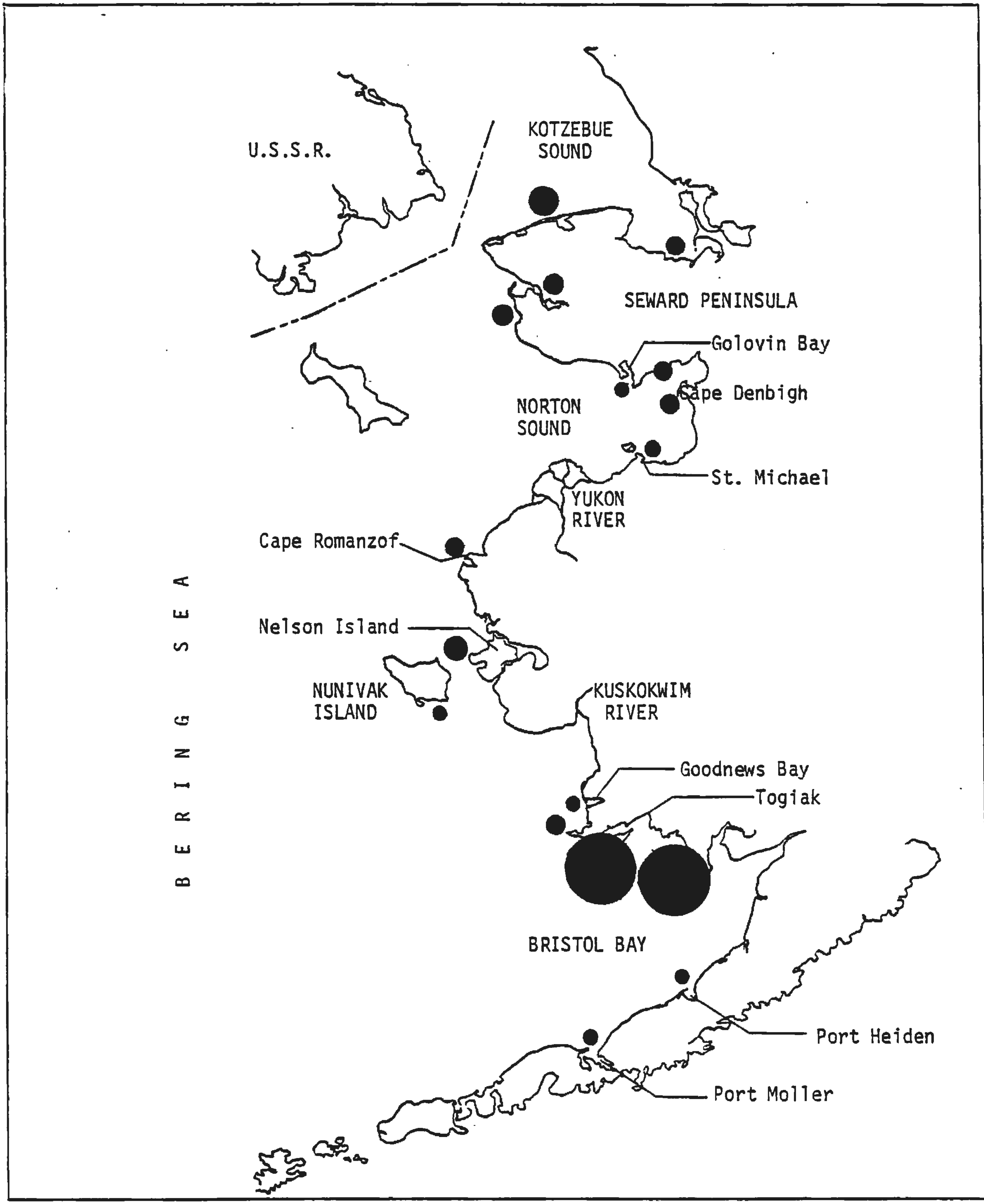


Figure 65. Relative abundance of Pacific herring based upon peak count surface area estimates of schools observed during aerial surveys, 1976 and 1977.

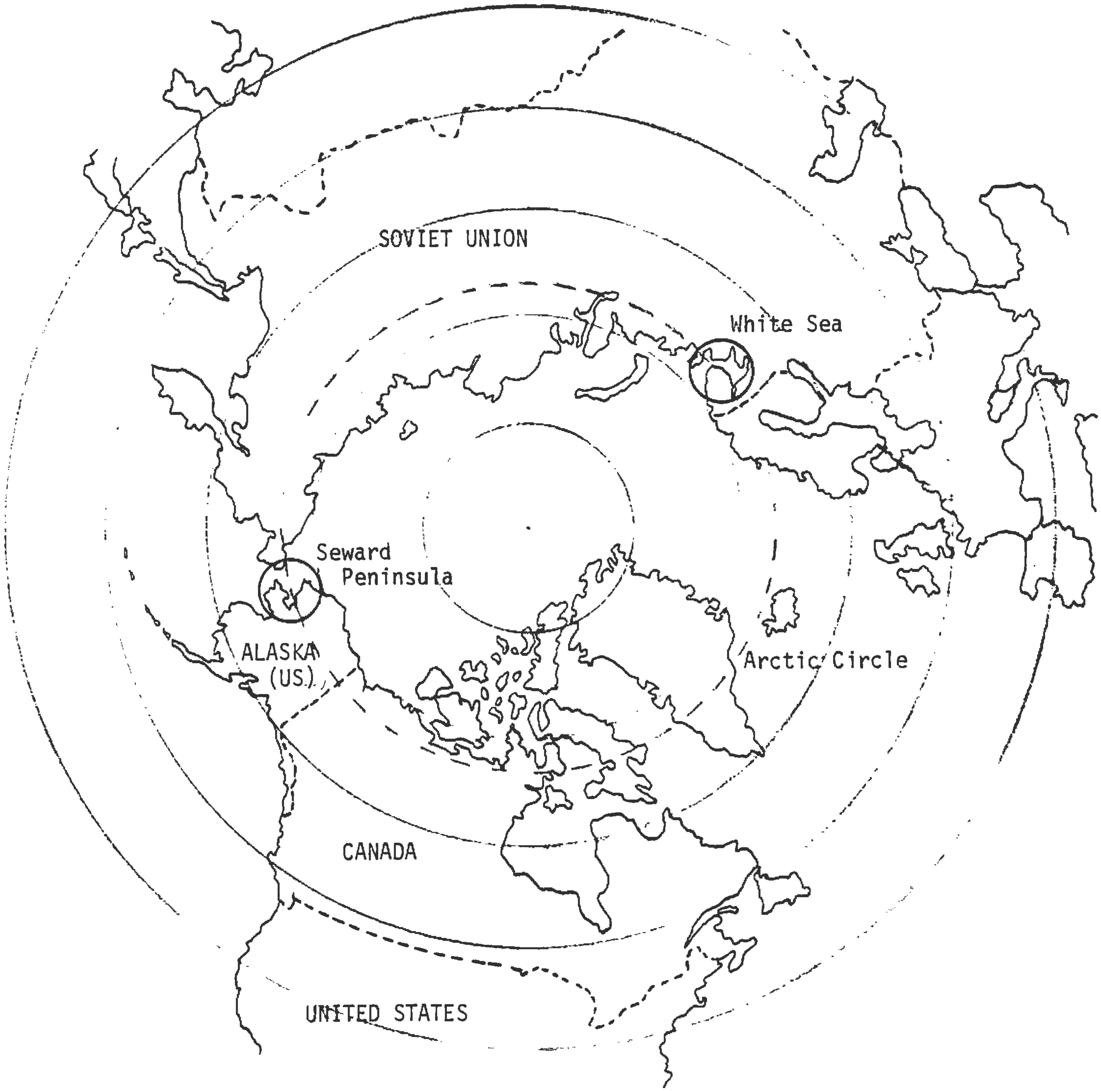


Figure 66. Comparative latitude of the Seward Peninsula and Kotzebue Sound with the White Sea.

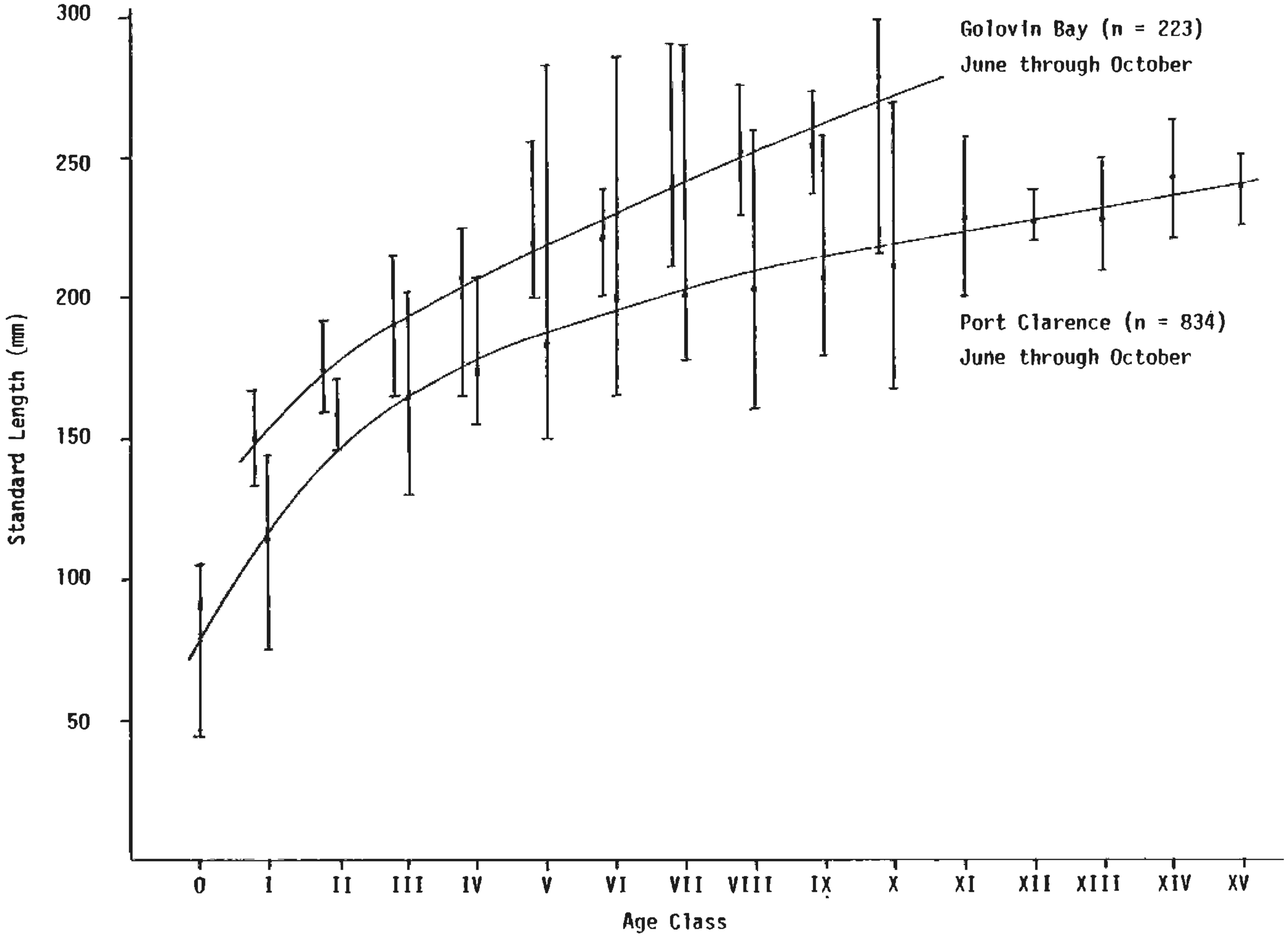


Figure 67. Comparison of mean lengths-at-age for herring sampled in Golovin Bay and the Port Clarence area in 1977. Mean lengths are shown with ranges.

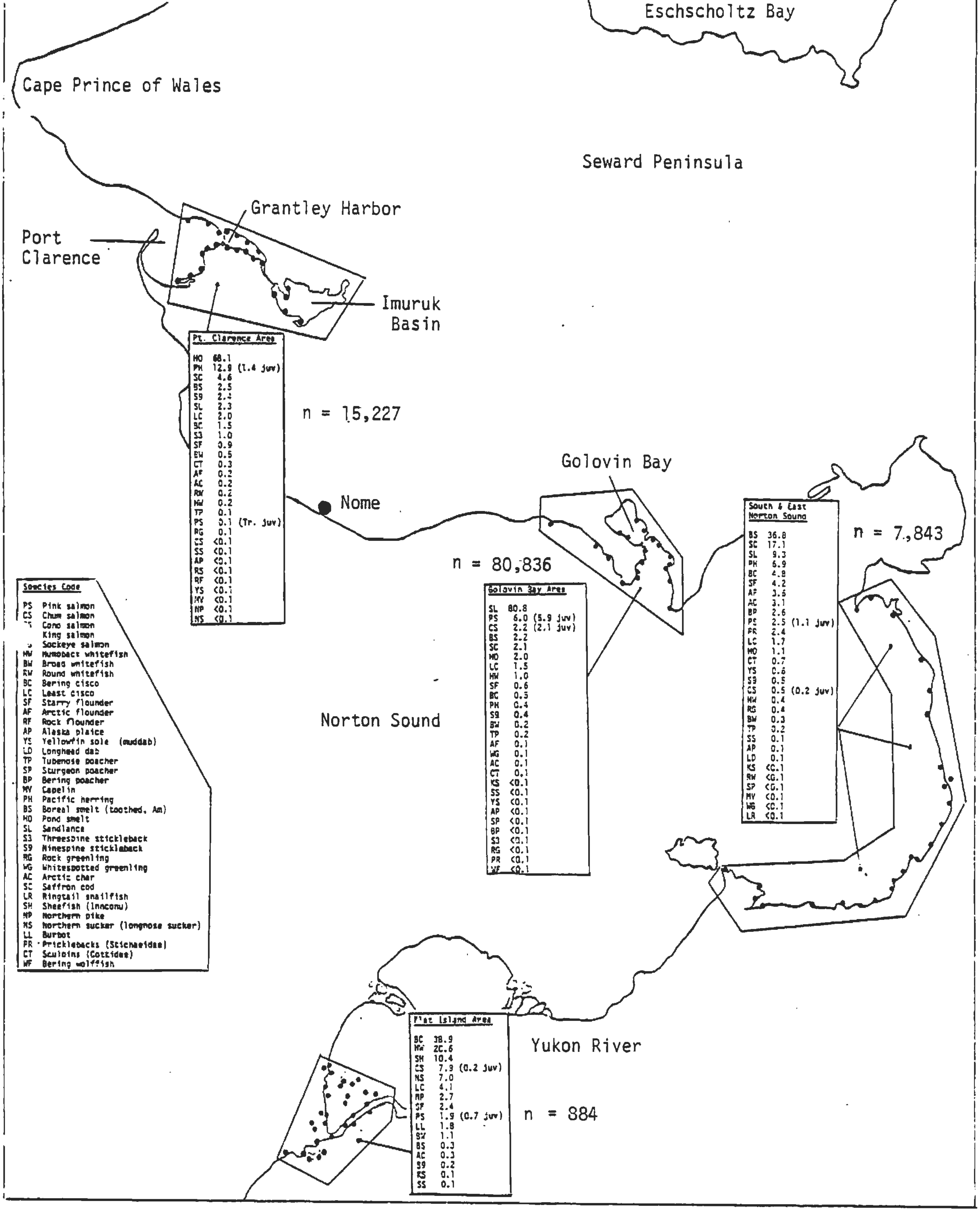


Figure 68. Relative abundance in percent composition of finfish captured throughout the nearshore waters of Norton Sound, 1976-77.

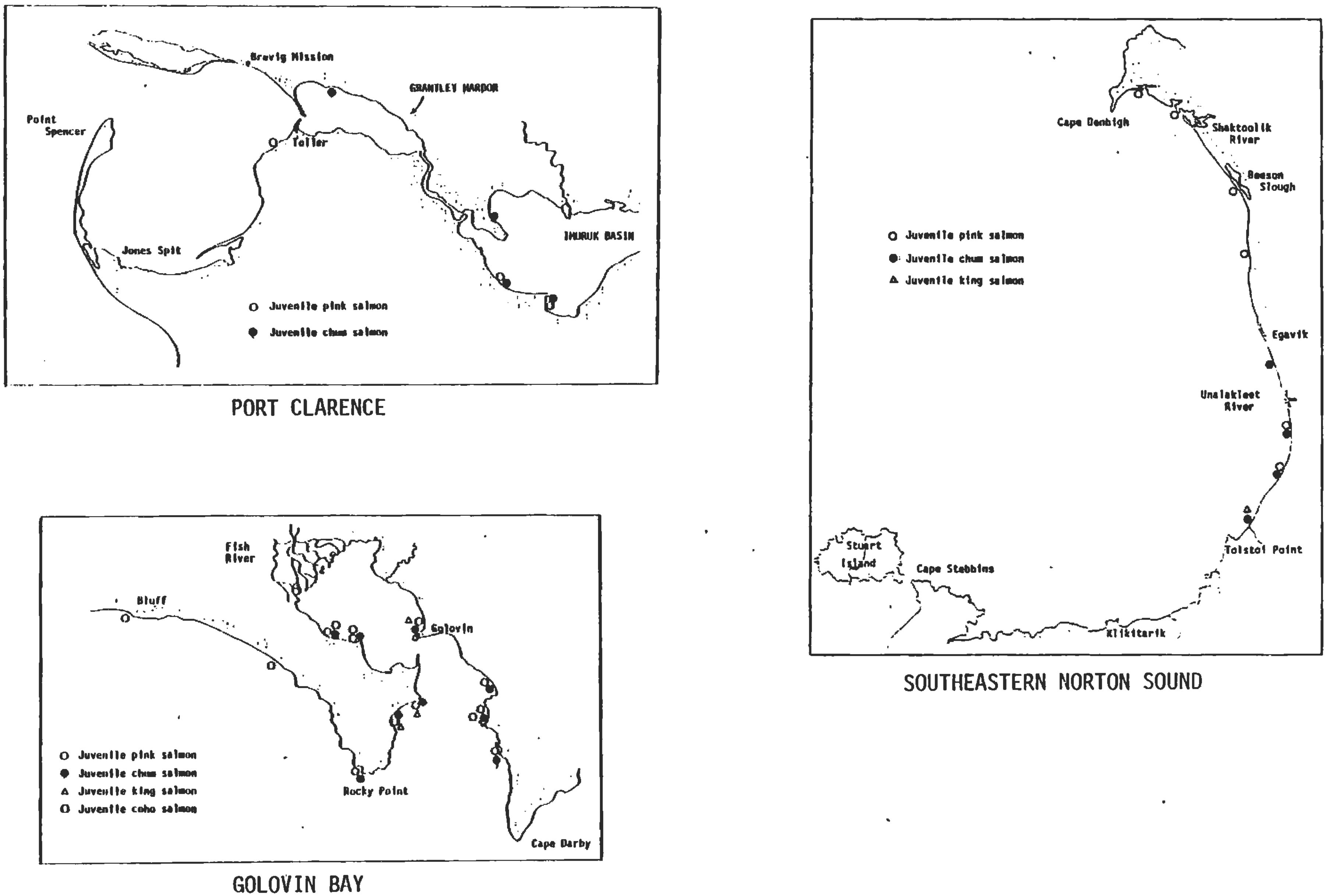
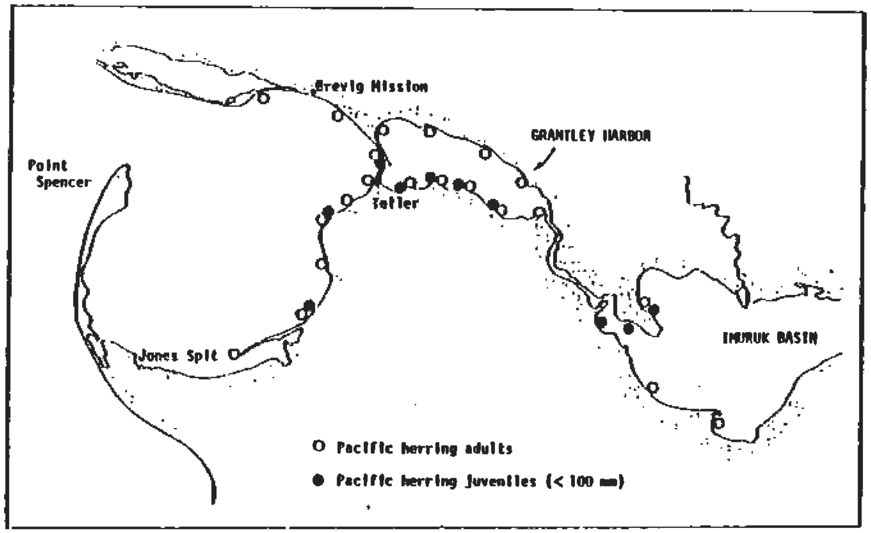
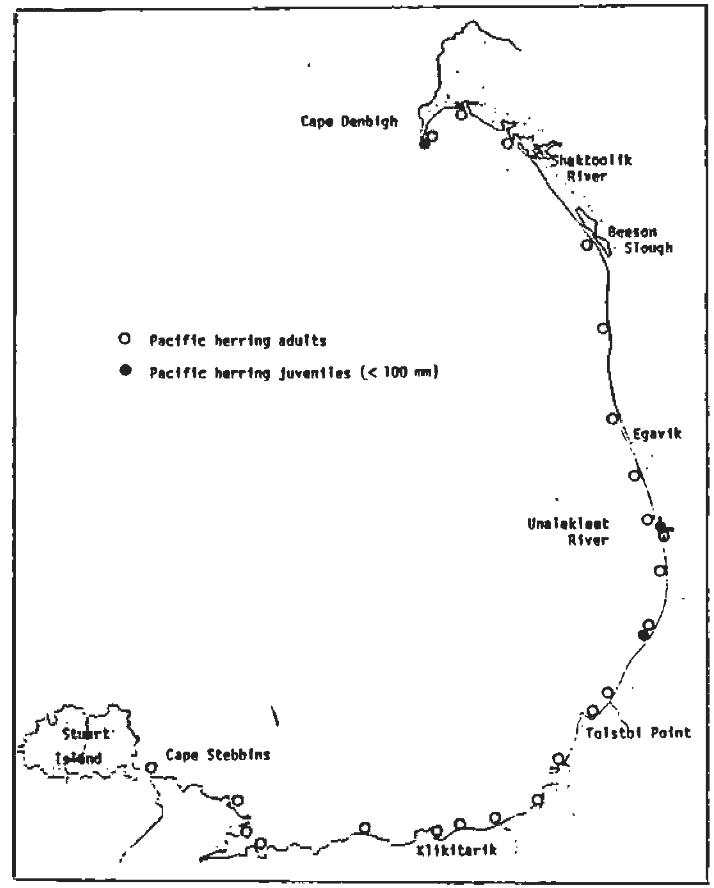


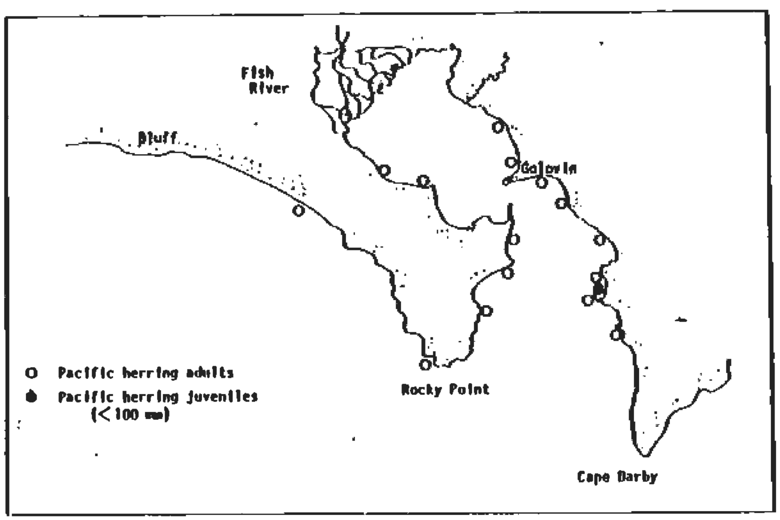
Figure 69. Distribution of juvenile salmon within the study area, 1976-77.



PORT CLARENCE



SOUTHEASTERN NORTON SOUND



GOLOVIN BAY

Figure 70. Distribution of Pacific herring within the study area, 1976-77.

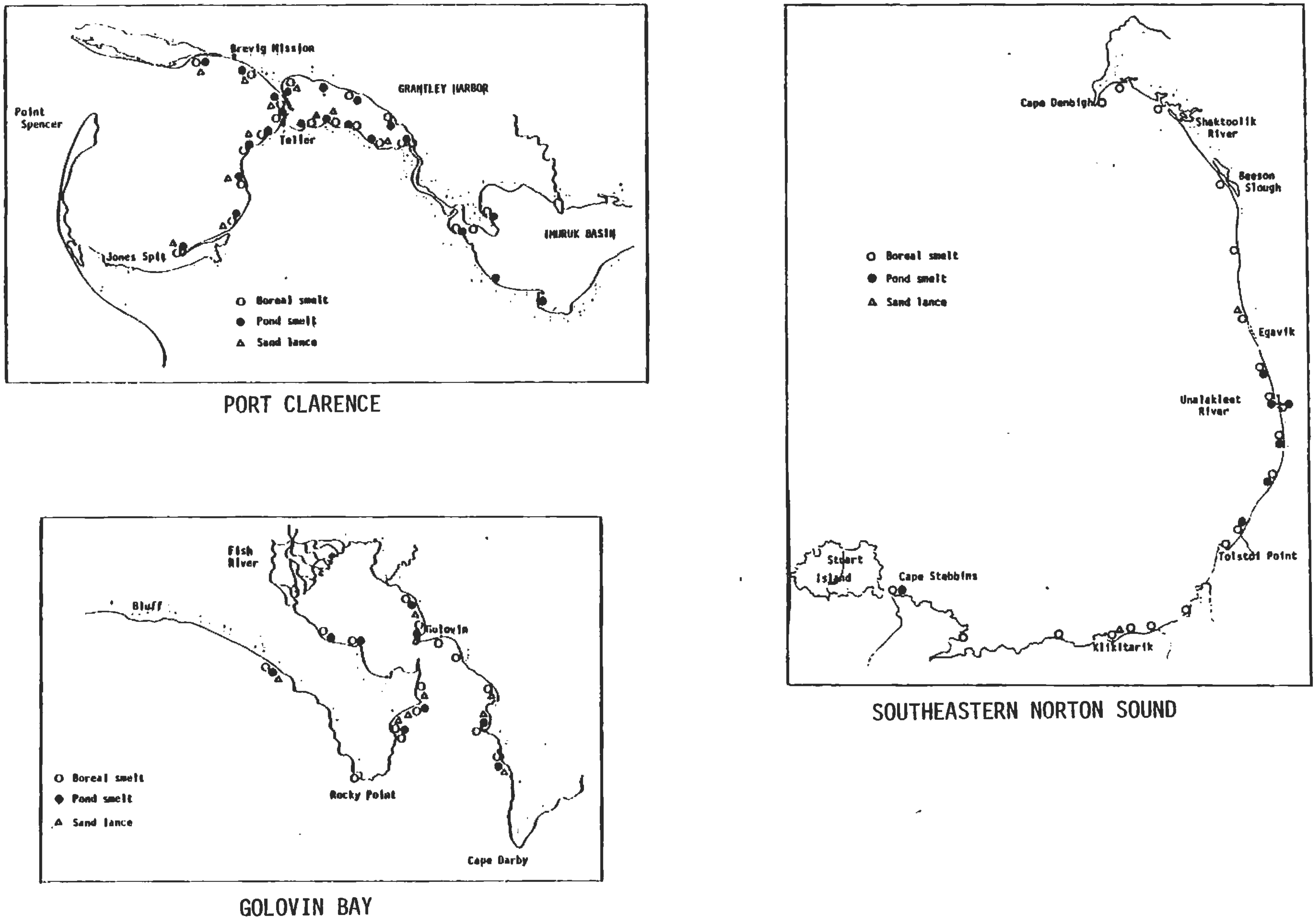


Figure 71. Distribution of boreal and pond smelt and sand lance within the study area, 1976-77.

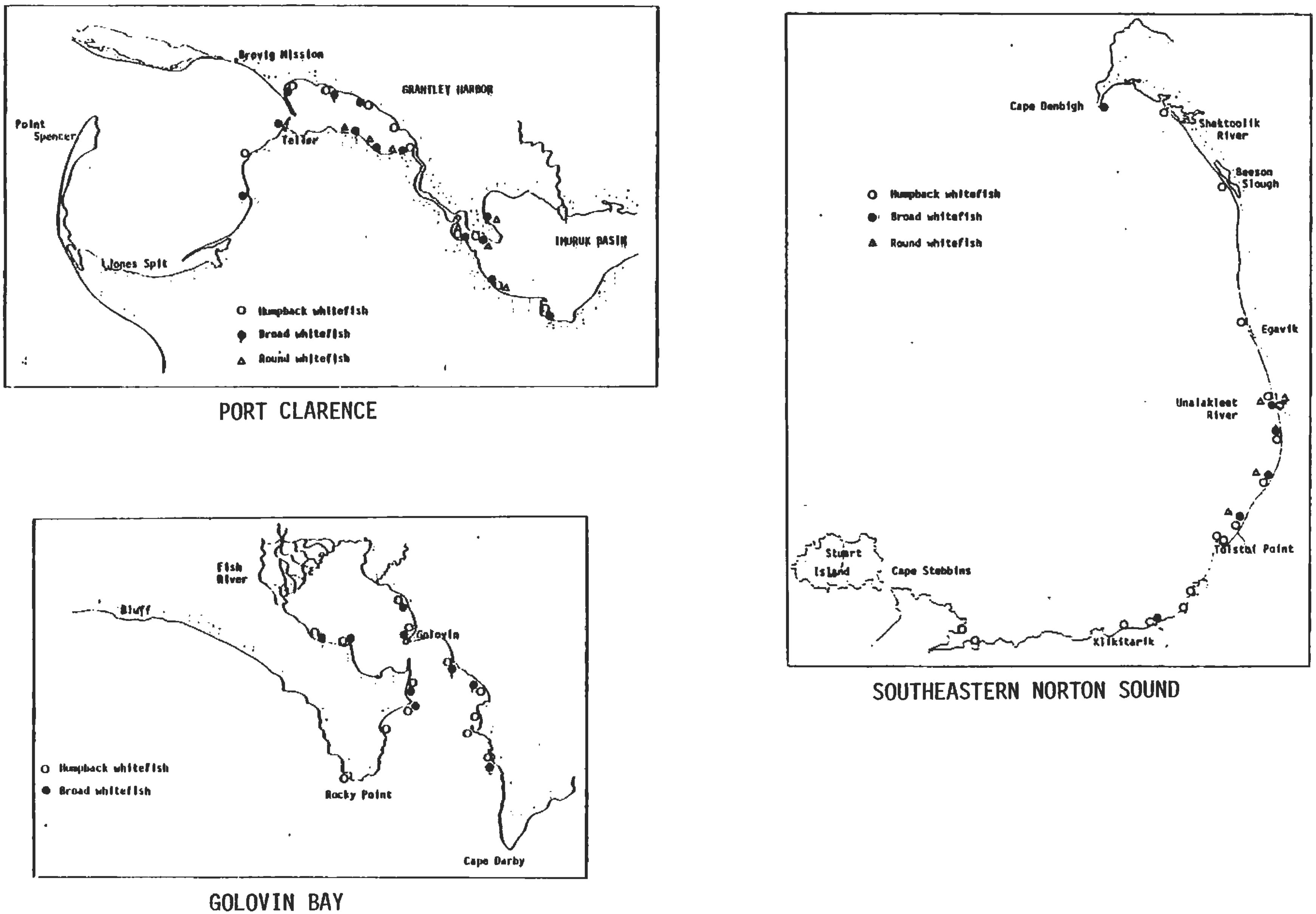


Figure 72. Distribution of humpback, broad and round whitefish within the study area, 1976-77.

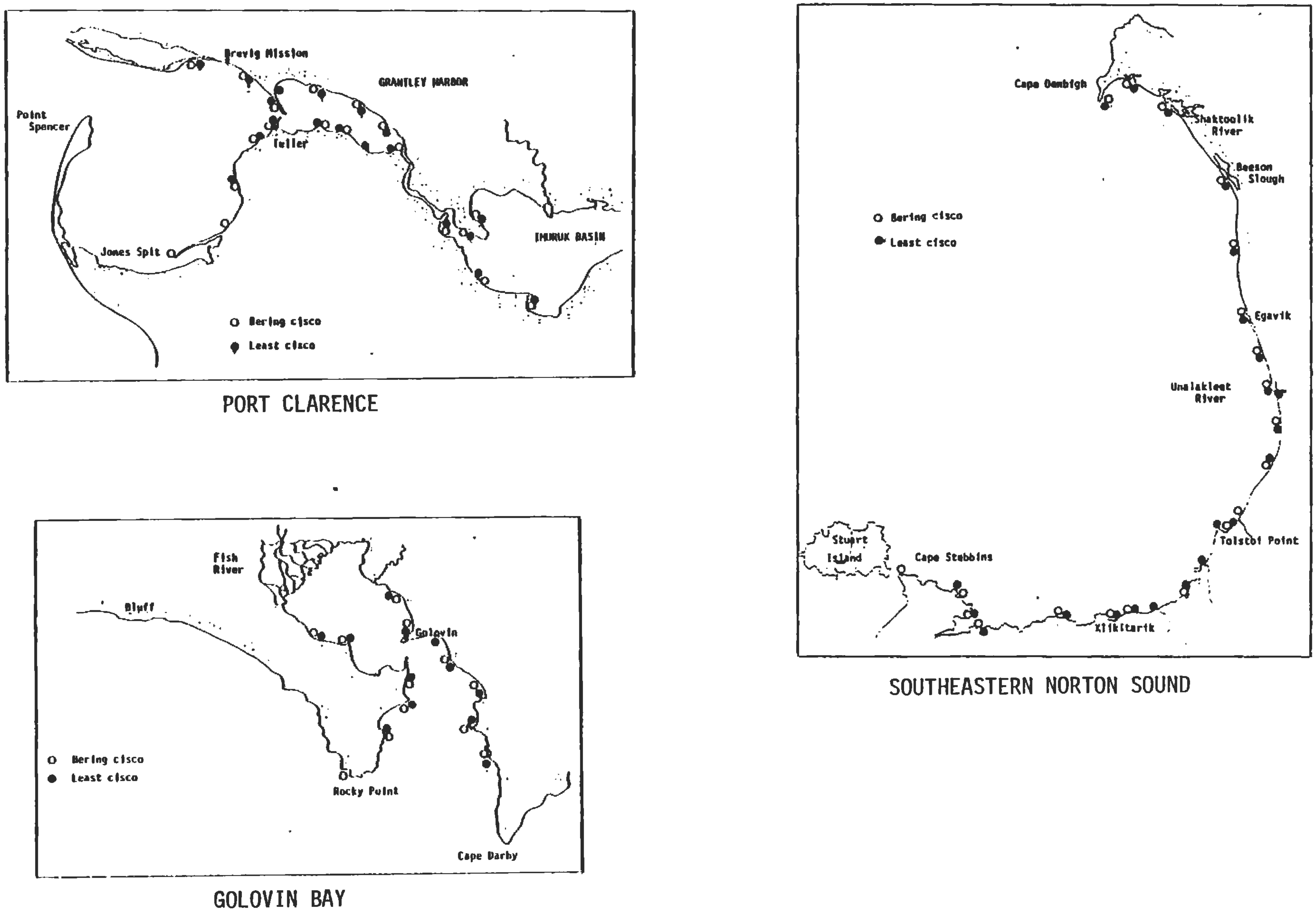
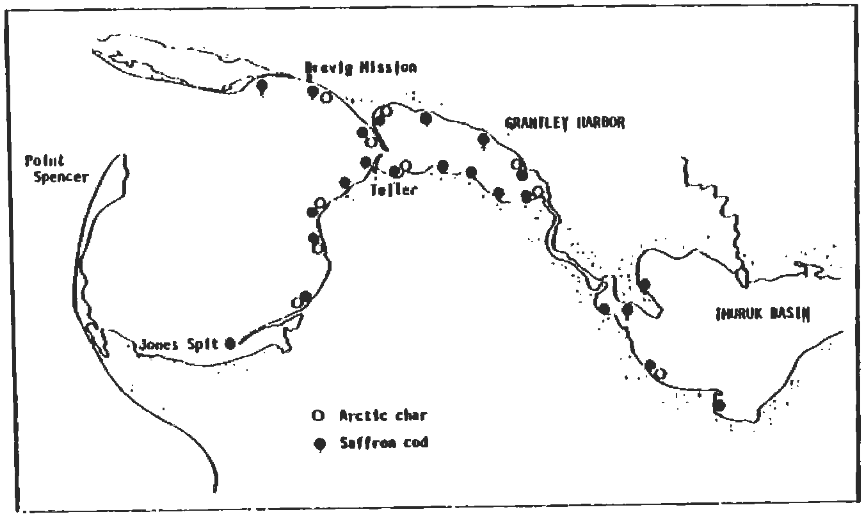
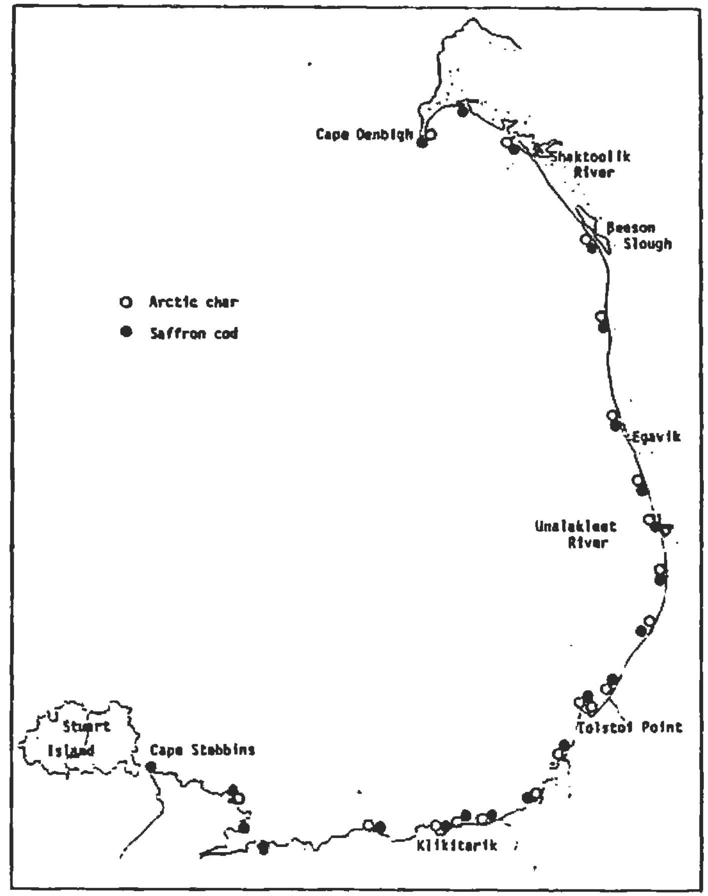


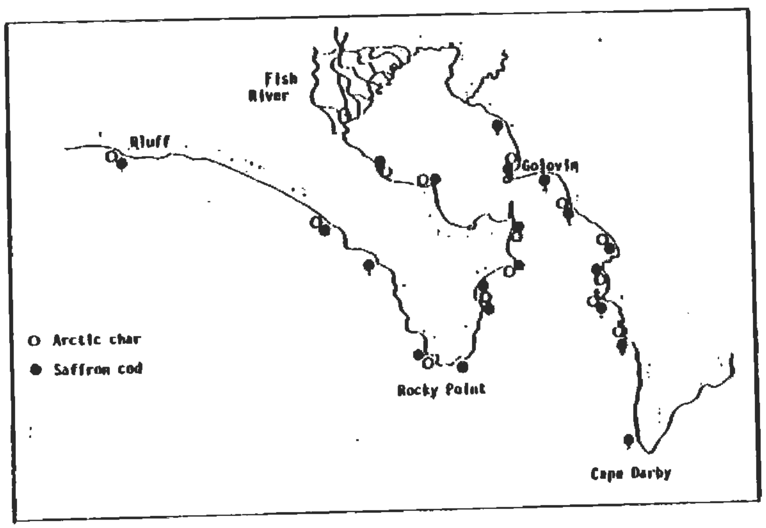
Figure 73. Distribution of Bering and least cisco within the study area, 1976-77.



PORT CLARENCE

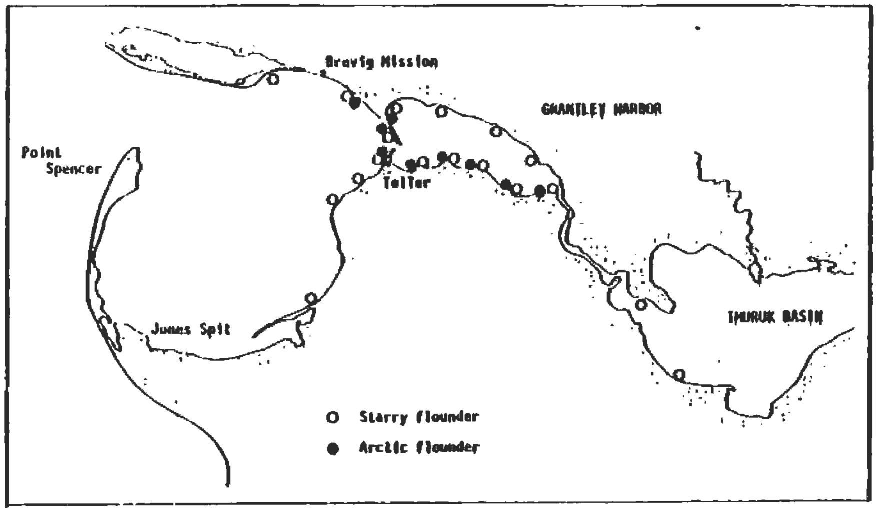


SOUTHEASTERN NORTON SOUND



GOLOVIN BAY

Figure 74 . Distribution of Arctic char and saffron cod within the study area, 1976-77.



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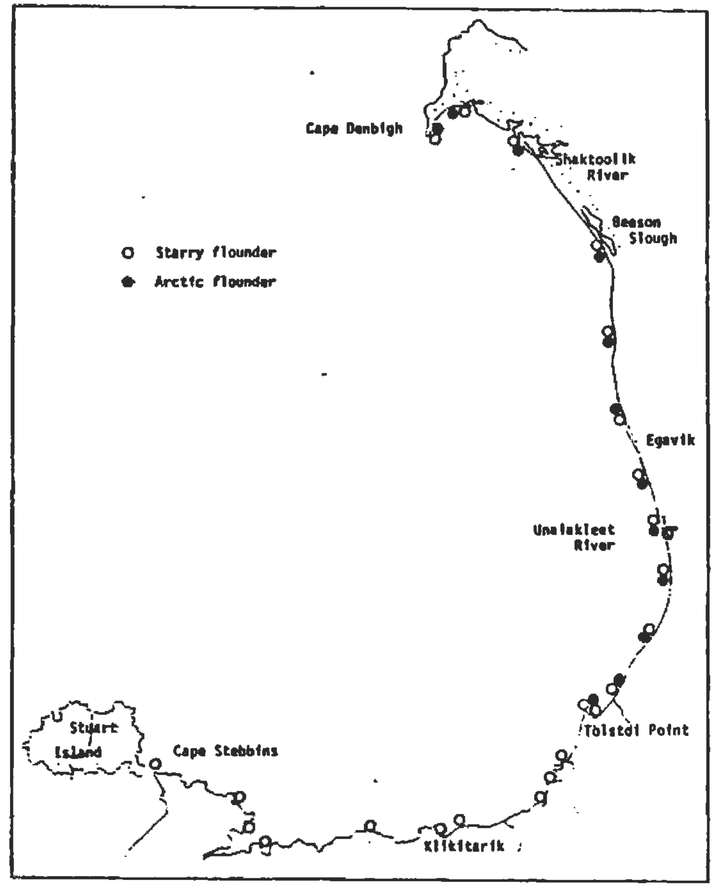
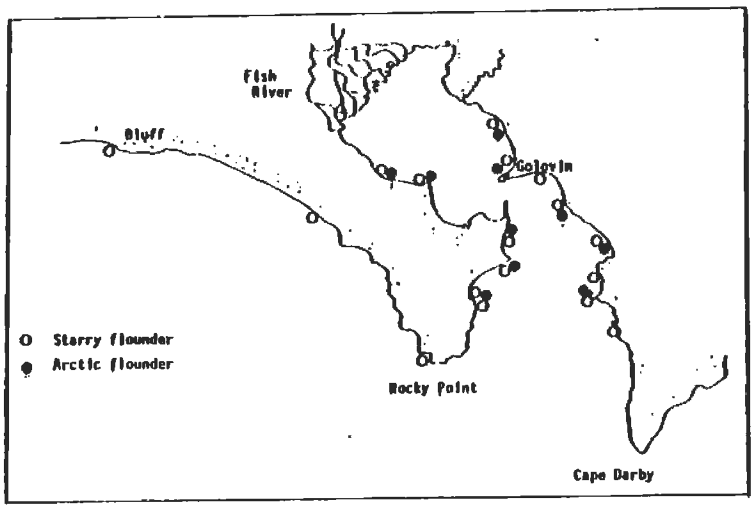
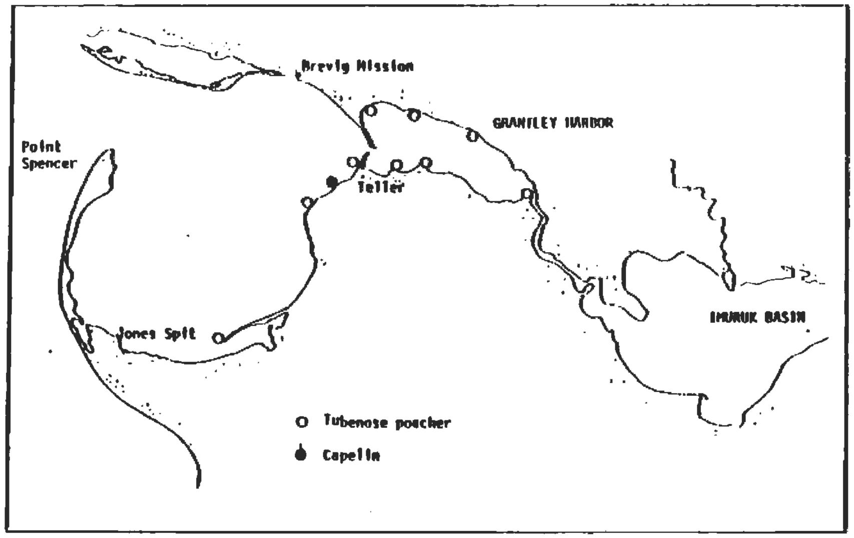


SOUTHEASTERN NORTON SOUND

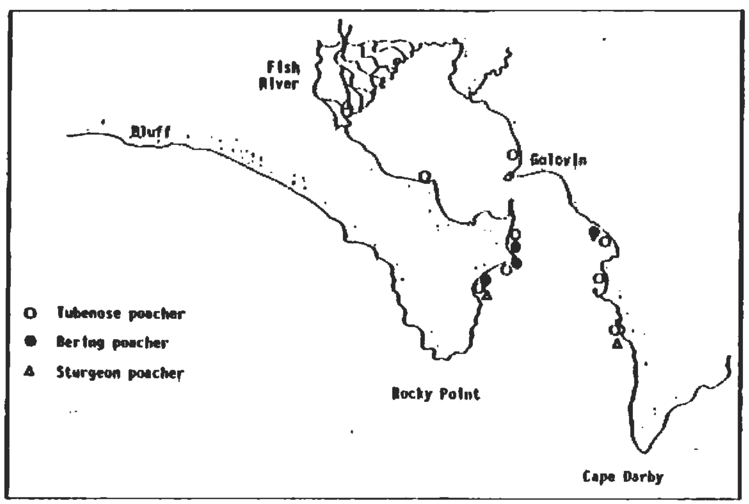


GOLOVIN BAY

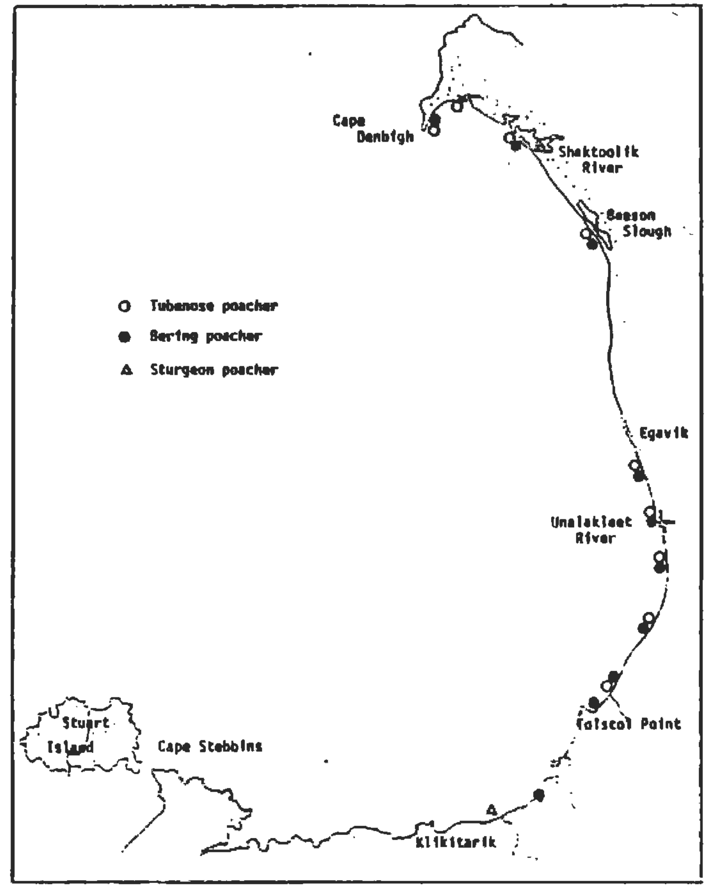
Figure 75. Distribution of starry flounder and Arctic flounder within the study area, 1976-77.



PORT CLARENCE



GOLOVIN BAY



SOUTHEASTERN NORTON SOUND

Figure 76. Distribution of sea poachers within the study area, 1976-77.

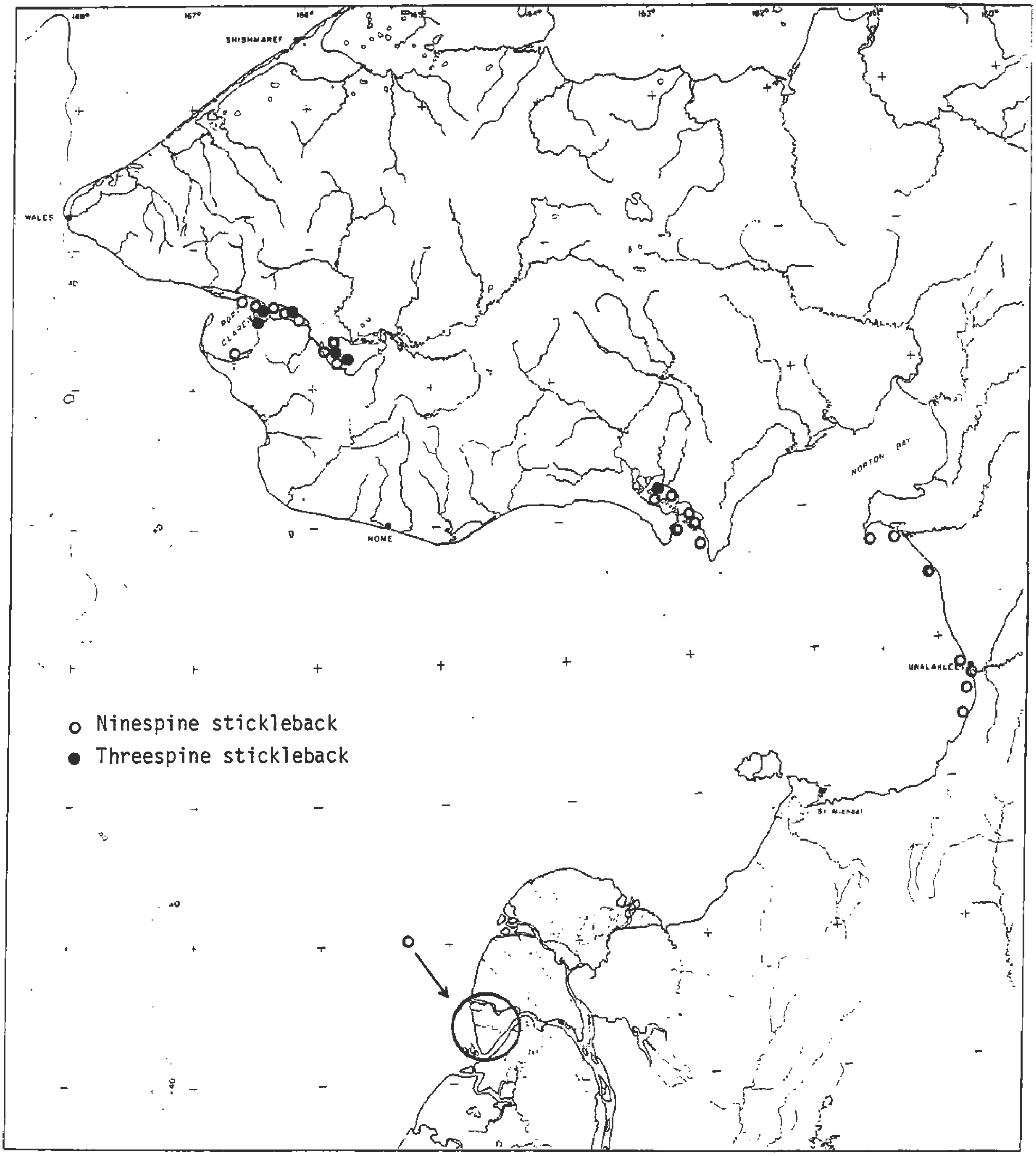


Figure 77. Distribution of ninespine and threespine stickleback within the study area, 1976-77.

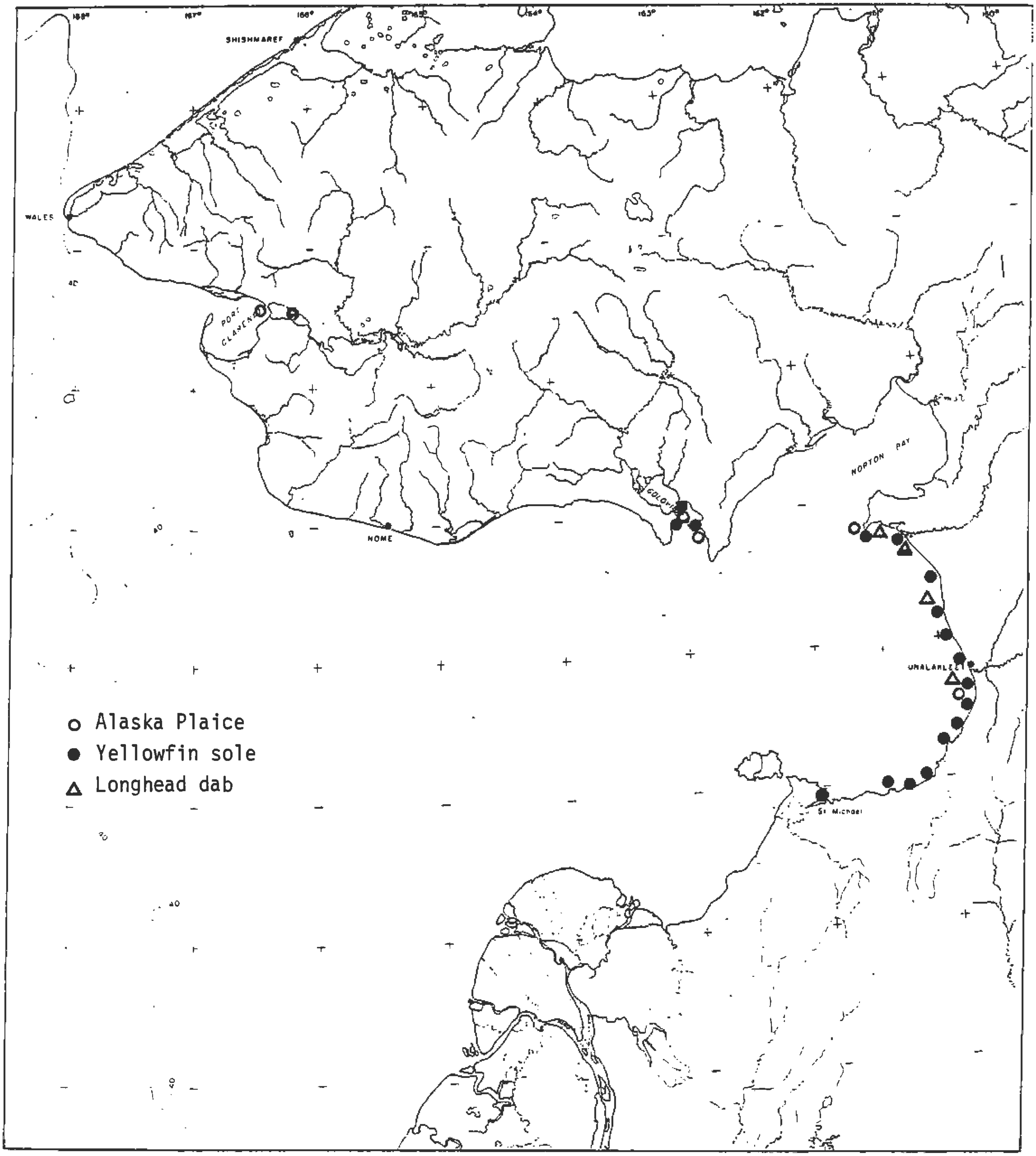


Figure 78. Distribution of Alaska plaice, yellowfin sole and longhead dab within the study area, 1976-77.

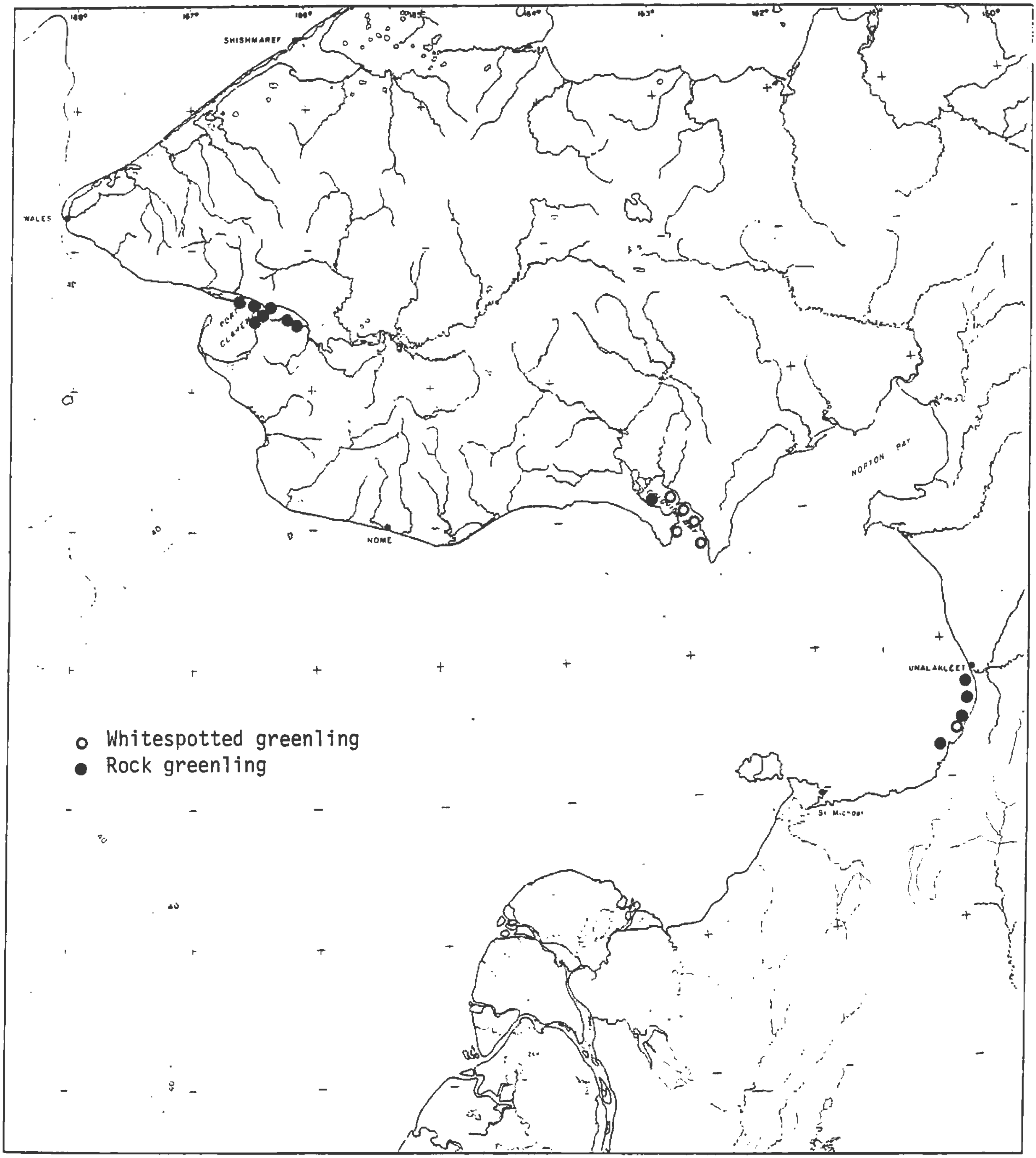


Figure 79. Distribution of whitespotted and rock greenling within the study area, 1976-77.

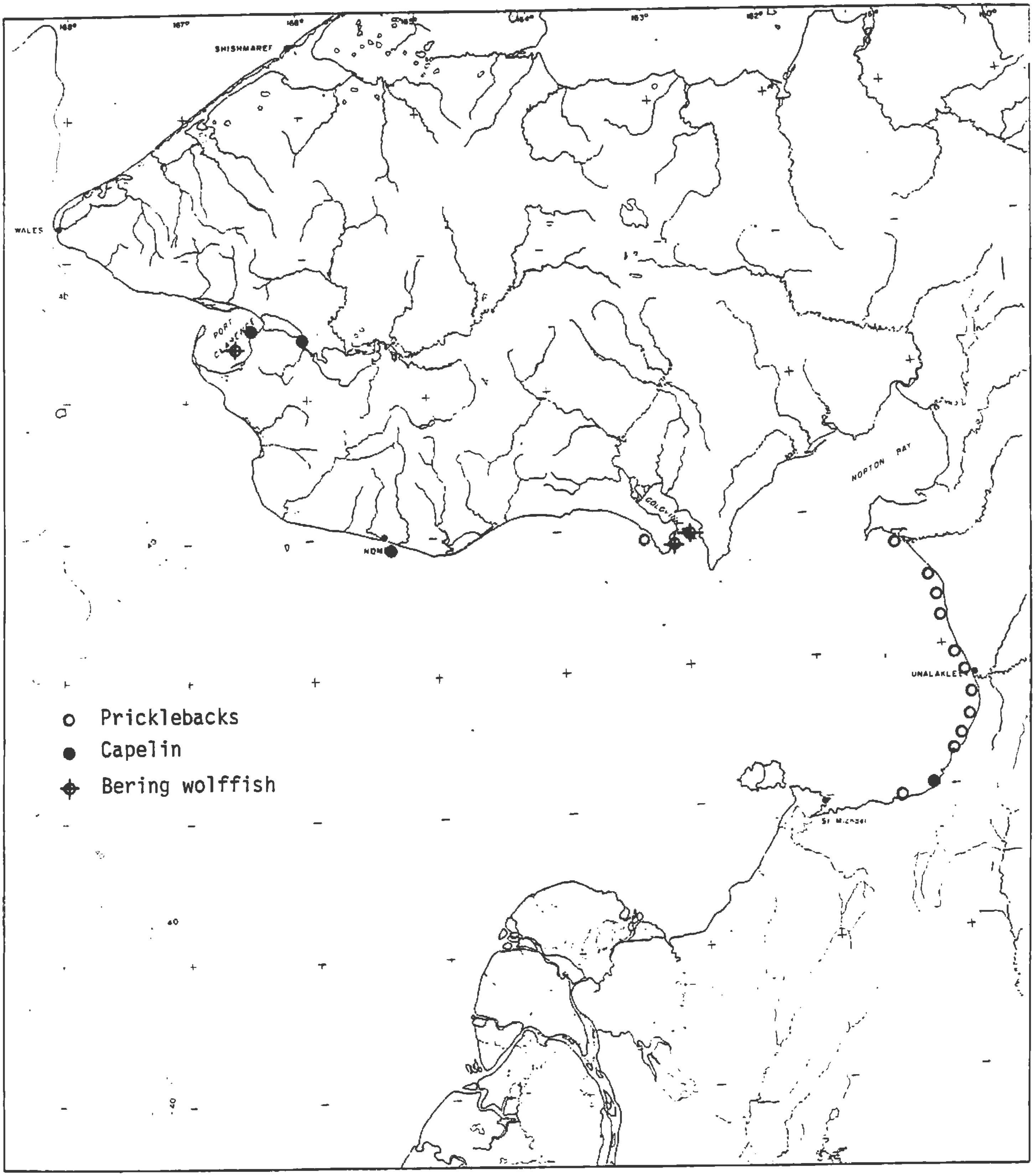


Figure 80. Distribution of pricklebacks, capelin and Bering wolffish within the study area, 1976-77.

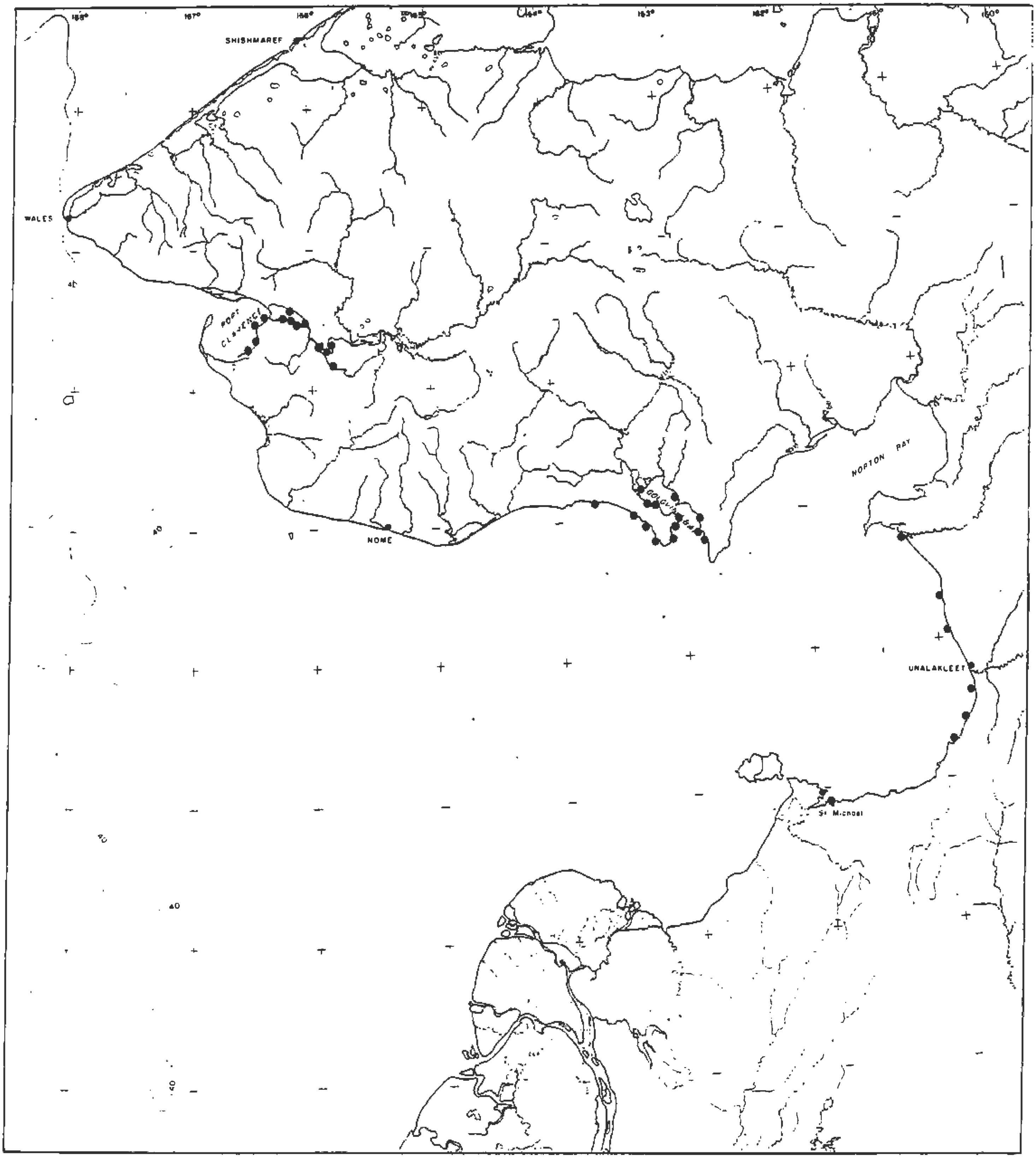


Figure 81. Distribution of larval boreal smelt in coastal waters within the study area, 1976-77.

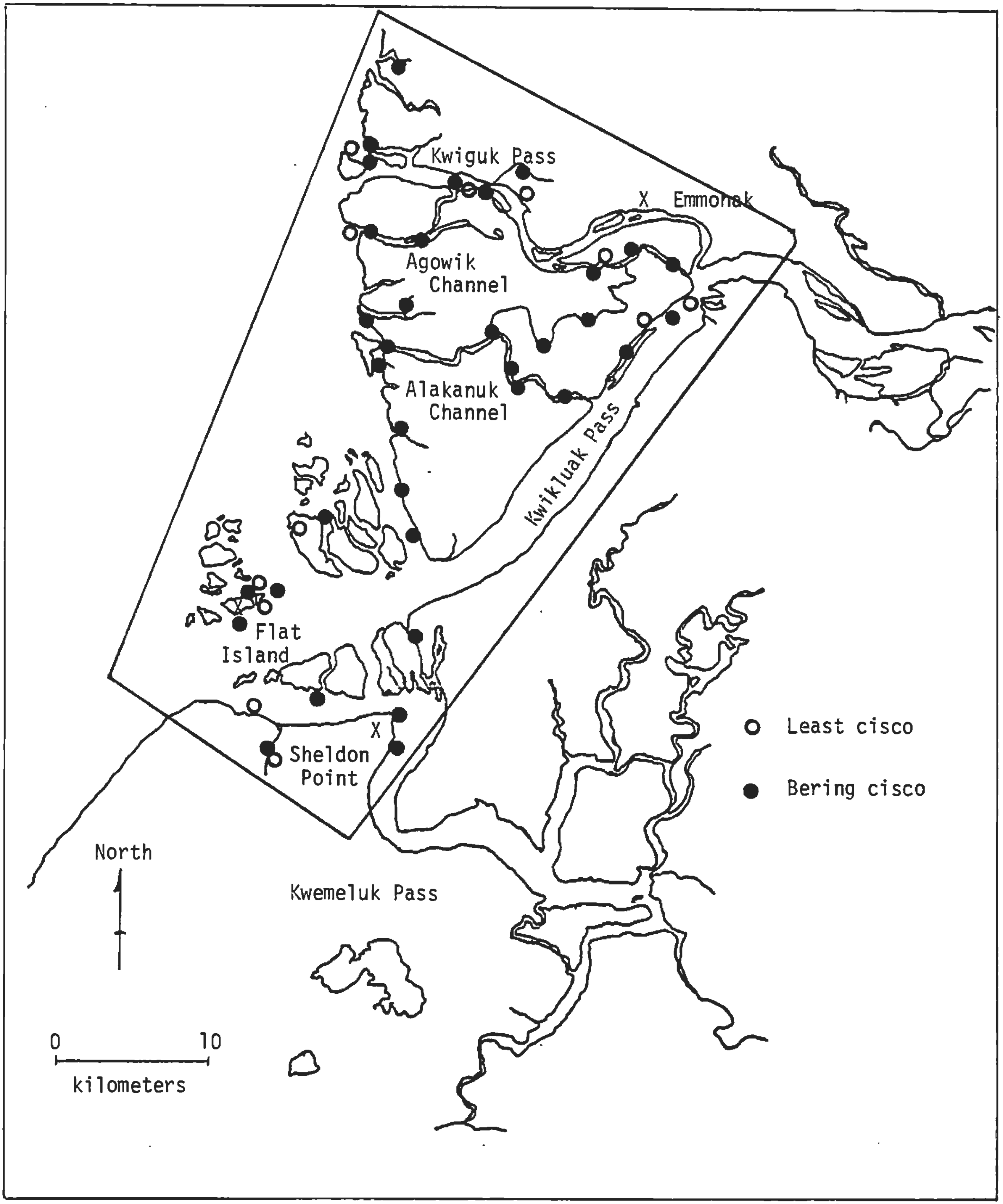


Figure 82. Distribution of least cisco and Bering cisco catches at the south mouth of the Yukon River, June 9 through August 5, 1976.

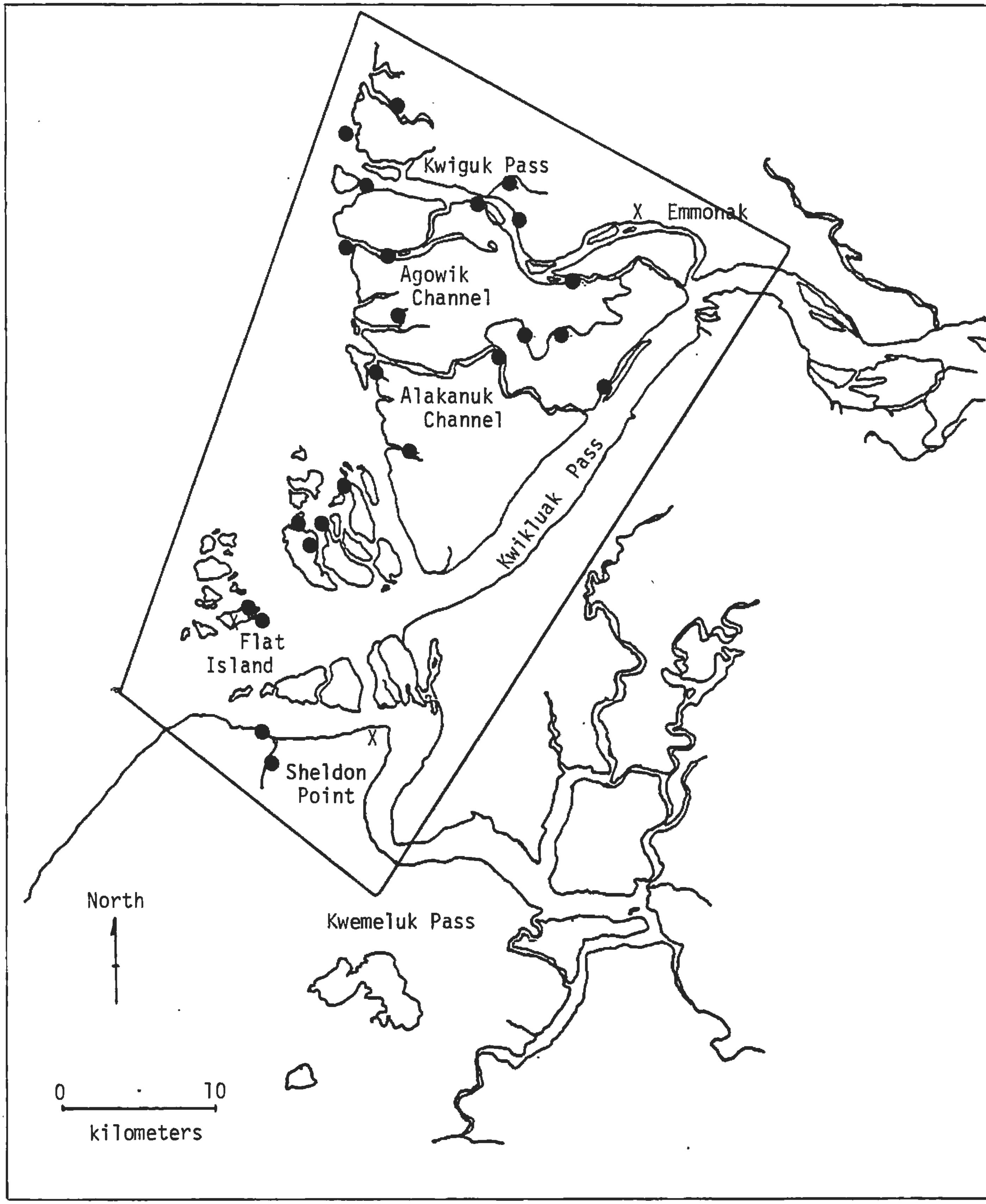


Figure 83. Distribution of humpback whitefish catches at the south mouth of the Yukon River, June 9 through August 5, 1976.

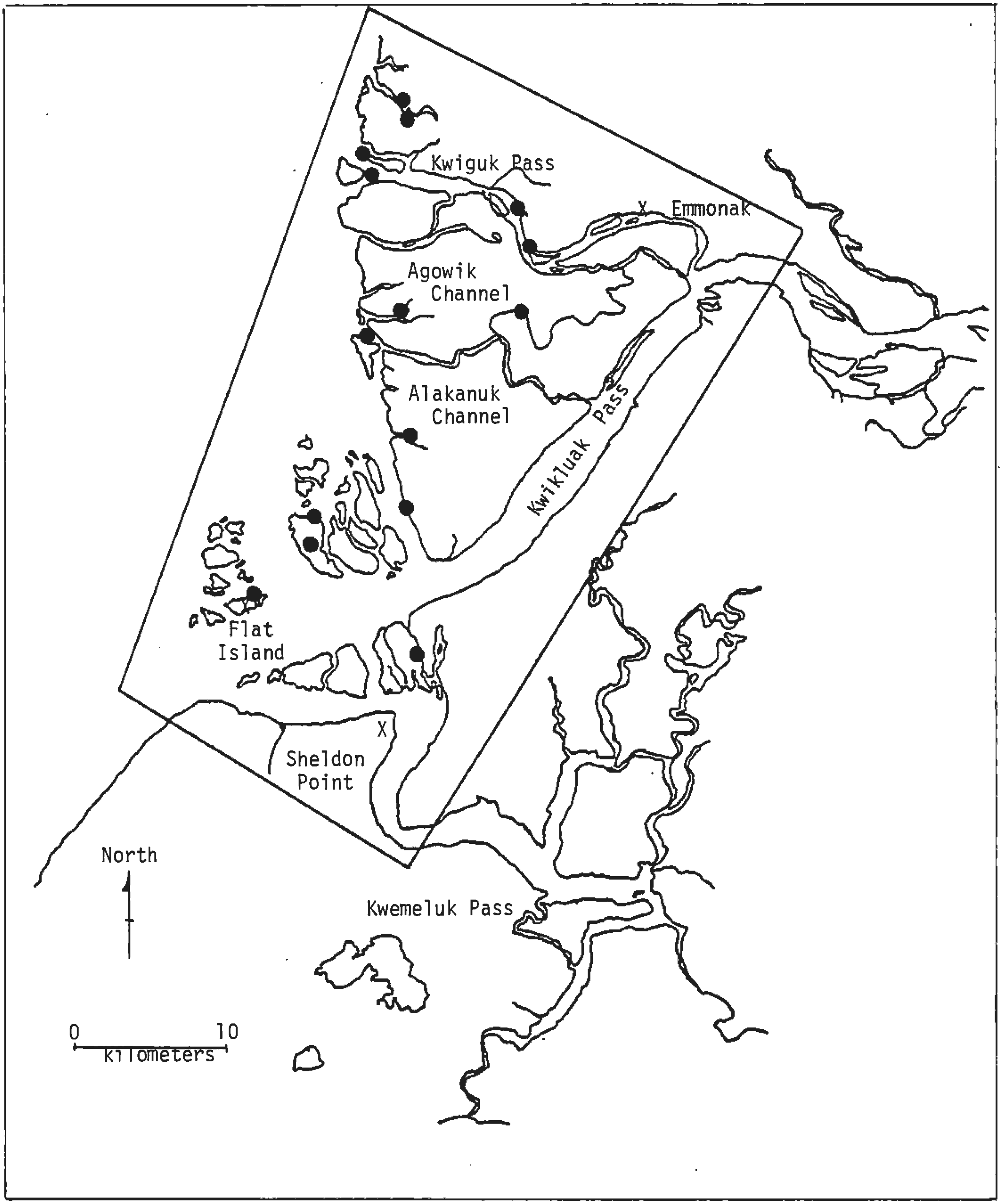


Figure 84. Distribution of sheefish (Inconnu) catches at the south mouth of the Yukon River, June 9 through August 5, 1976.

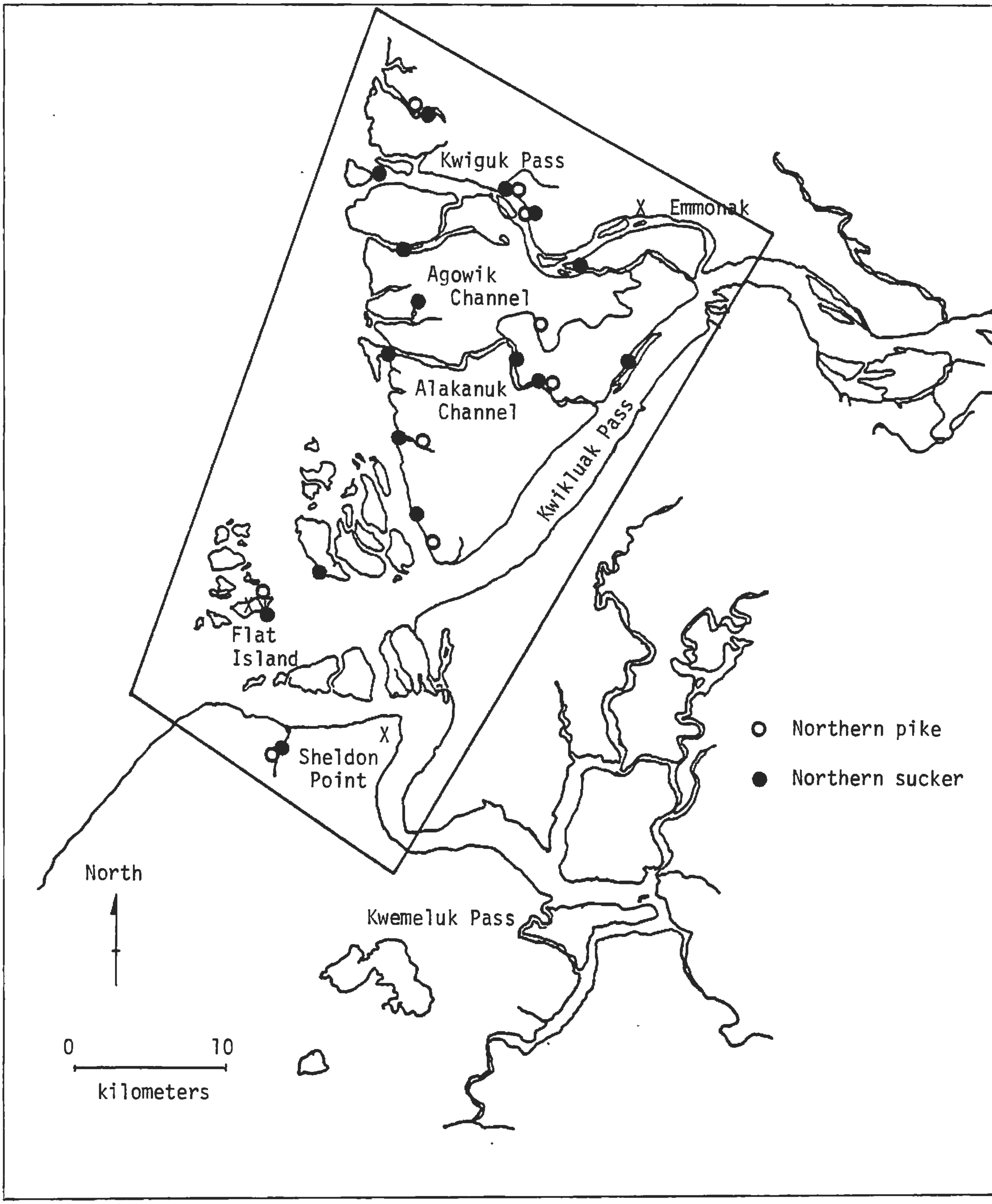


Figure 85. Distribution of northern pike and northern sucker catches at the south mouth of the Yukon River, June 9 through August 5,1976.

APPENDIX PHOTOGRAPHS

1. Norton Sound ice conditions, June 10, 1976. Looking east at Cape Stebbins.

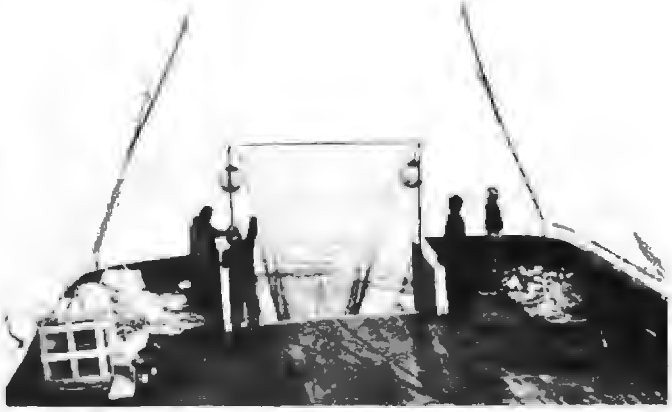
2. Ice conditions at Klikitarik, June 10, 1976. Three weeks of coastal sampling was lost immediately following spring breakup in Norton Sound in 1976 due to a delay in project funding.

3. Norton Sound ice conditions, June 3, 1977. Looking west along southern coast toward Klikitarik.

4. Norton Sound ice conditions, June 3, 1977. Looking north along coast toward Cape Denbigh.

5. Ice conditions in Golovin Bay, June 9, 1977. Field sampling began in this area on June 9.

6. Bering Sea pack ice and pan ice conditions at Cape Epsenberg which blocked entry of the *MV Royal Atlantic* into Kotzebue Sound, July 11, 1977.



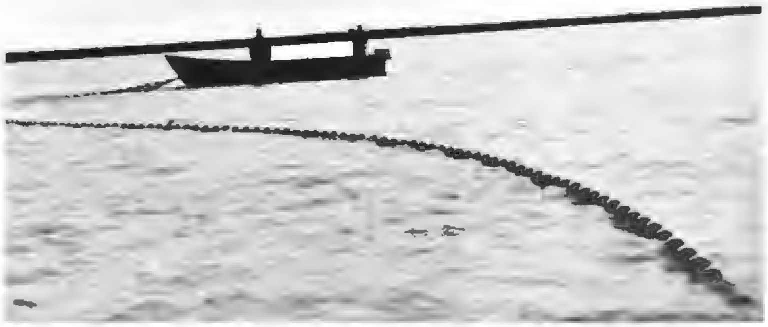
7. Launching the rigid frame surface townet from the MV *Royal Atlantic* near Tin City, July, 1977.

8. Surface tows in Norton Sound were 30 minutes in duration each, and towed at two to three knots.

9. Retrieval of townet. Most catches consisted of larbal Osmerics
larval Osmerids, Clupeids or Gadids.

10. Fishing variable mesh, long line gillnets from the MV *Royal Atlantic* , June, 1977. Overnight soaks of 8 - 10 hours were made daily.

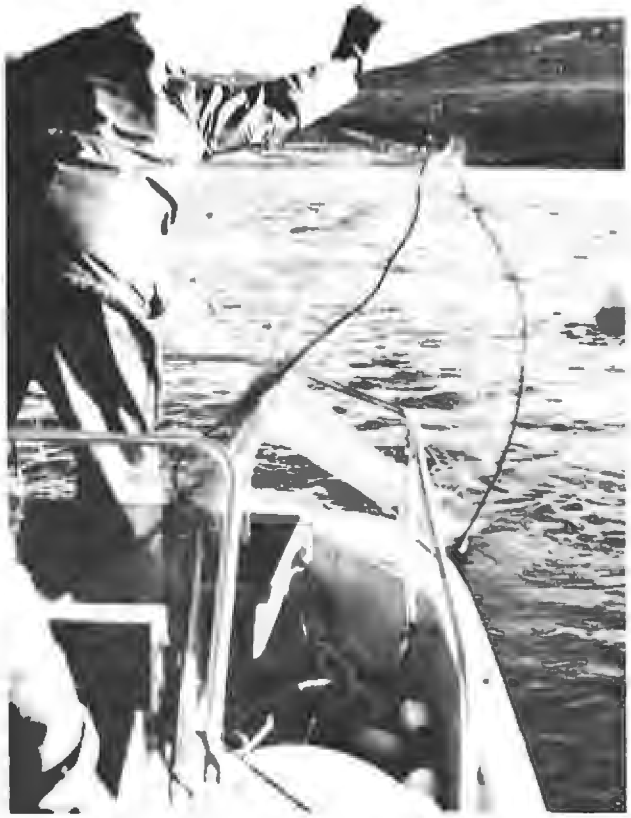
11. Retrieval of variable mesh gillnets aboard the MV *Royal Atlantic*. Catches consisted primarily of Pacific herring.



12. Deployment of 46x7 meters hand purse seine in Yukon River estuary.

13. Retrieval of the hand purse seine used to sample the Yukon River estuary, 1977.

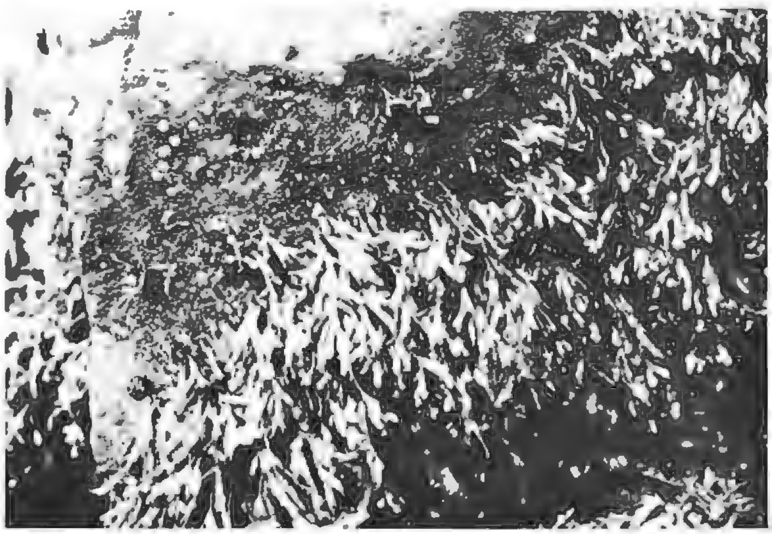
14. Juvenile Coregonids and Salmonids were among the most frequently captured species with the 3 mm hand purse seine in the Yukon River estuary in June, 1977.



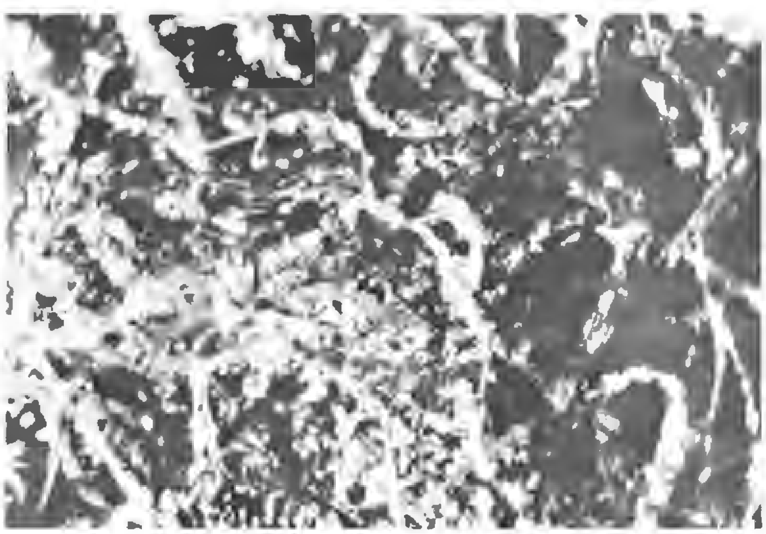
15. Setting one of the many offshore variable mesh gillnets in Golovin Bay, October,1977.

16. Retrieving a floating variable mesh gillnet in Grantley Harbor, July 1977. Catch included more than 600 Pacific herring.

17. Herring spawn on rockweed kelp (*Fucus* sp.). *Fucus* was documented as a major spawning substrate for herring in most areas along the western Alaskan coastline.

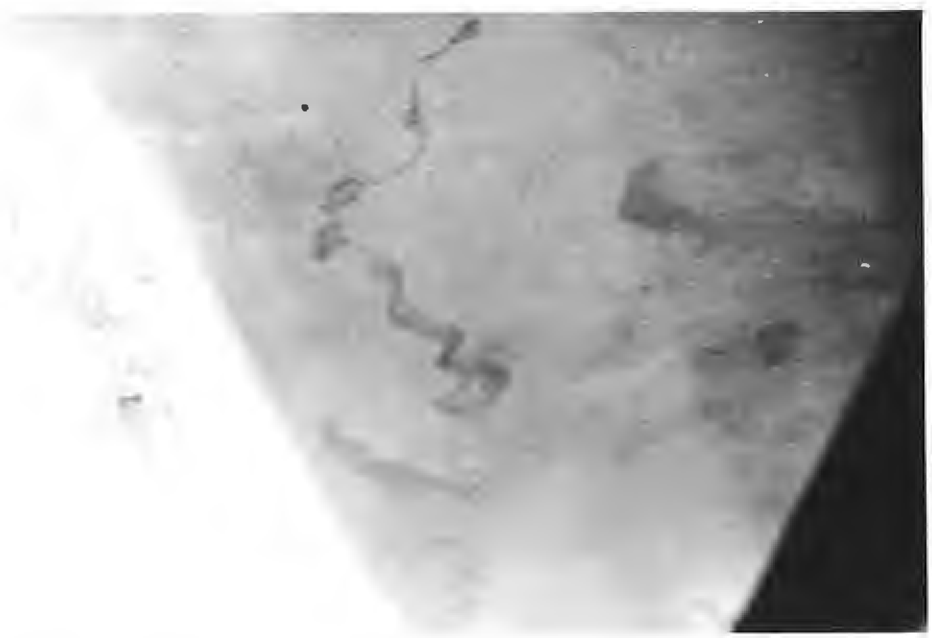


18. *Fucus* on exposed rocks near Klikitarik in southern Norton Sound, June 11, 1977. *Fucus* was common to exposed, rocky headlands and most other rocky coastal areas.

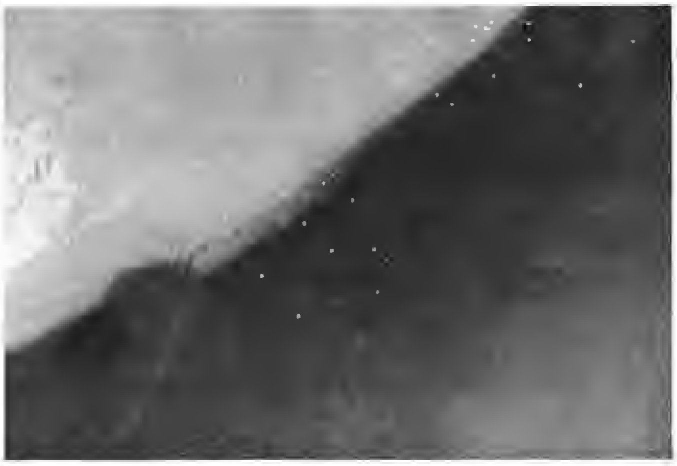


19. A second important spawning substrate for herring was eelgrass (*Zosteria* sp.). Eelgrass was common to most shallow secluded bays and inlets.

20. Schools of herring at Fourmile Point in Grantley Harbor, July 21, 1976. Herring occur in dense schools in deep water giving a dark appearance to individual schools.



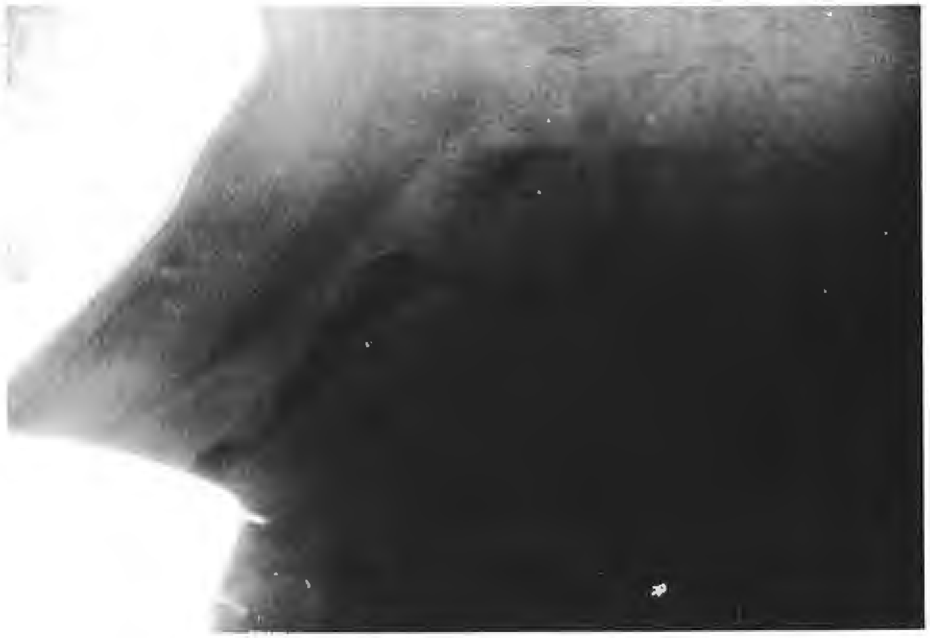
21. Herring schools at Coyote Creek in Grantley Harbor, July 21, 1976. Fish tend to disperse somewhat in shallow water and schools appear lighter in color. Banding is common under such conditions.



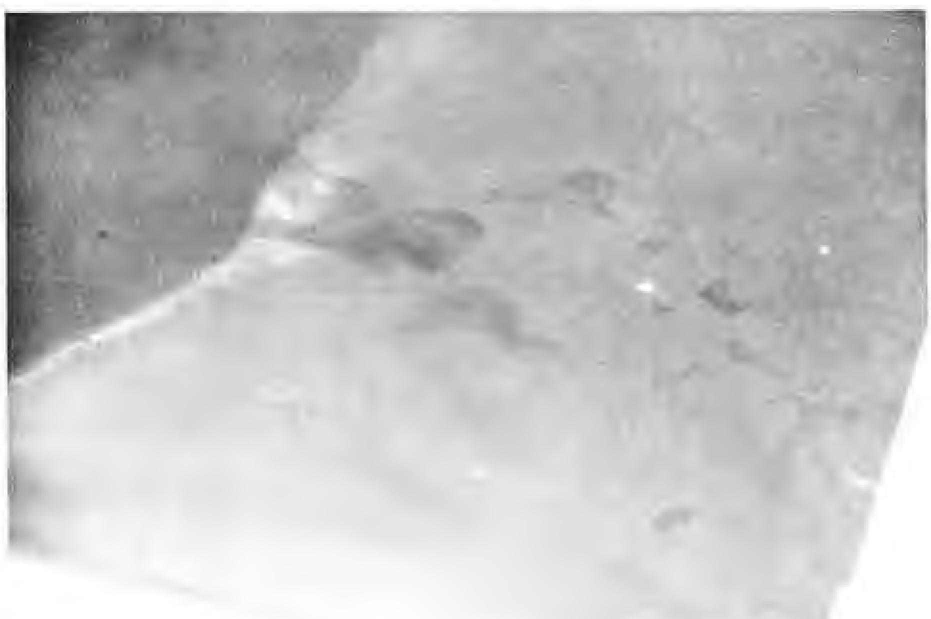
22. School of unidentified fish (believed to be herring) in Shishmaref Inlet, July 21, 1976. Feeding seals and birds were also present.

23. Typical rocky headland characteristic of major herring spawning areas along western Alaska. A white to yellow-white color is produced in the water from milt released by spawning males.

24. A large school of herring entering Shishmaref Inlet, July 1977.



25. Unidentified fish schools (believed to be herring) near Shishmaref, July 1977.



26. Unidentified fish schools in shallow water of Shishmaref Inlet, July 1977.

27. Commercial beach seine deployed at Cape Denbigh, June 1977. Approximately nine metric tons of herring were commercially harvested for sac roe production in Norton Sound in 1977.

28. Ice conditions in the Chukchi Sea in July not only preclude entry of the *MV Royal Atlantic* into Kotzebue Sound but also severely hindered coastal test fishing efforts.

29. A common sampling problem encountered in the early spring. Drifting pan ice often reduced the soak time of many gillnet sets.

30, 31, 32. A typical set and catch with the 61 meter (3 mm mesh) beach seine near Shaktoolik, 1976.

33. A three-year-old herring as indicated by the annual rings on scale. This is generally the earliest that sexual maturity occurs in eastern Bering Sea herring.

34. A five-year-old herring. The 1972 brood year was the dominant spawning age class of herring along most of western Alaska in 1977.

35. A seven-year-old herring; sampled in Grantley Harbor, July 10, 1977.

36. A nine-year-old herring;
sampled in Port Clarence,
July 10, 1977.

37. A fifteen-year-old herring; sampled in Grantley Harbor, July 1, 1977. This was the oldest ageable herring captured in 1977.

38. Sampling beach seine catches became more tedious in the fall months as storms created heavy debris (algae & seaweed) problems in coastal waters.

39. Beach seine sampling in Port Clarence in September, 1977.

40. The most abundant fish captured in Norton Sound in 1976 and 1977 was Pacific sand lance. Young sand lance were tedious to sample; shown here in 3 mm mesh beach seine, Golovin Bay.

41. Herring are often woven into grass strings and allowed to sun-dry for several days. Herring are an important subsistence food item to many coastal residents of western Alaska.

42. An OCS ground crew hand sampling spawning capelin near the village of Tununak, 1976. This is typical of capelin spawning habitats; fine sand and gravel beaches.

43. Spawning capelin at Nelson Island, June 24, 1976. No white water characteristic of herring spawning was observed. Note enlarged anal fin of spawning males.

44. Capelin carcasses left stranded on the beach after the spawning act.

45. The NOAA ship *Miller Freeman* investigated fishery resources in the offshore waters of Norton Sound and Kotzebue Sound in September and October, 1977.

46. Retrieving variable mesh long-line gillnets aboard the NOAA Ship *Miller Freeman*, September 1976.

47. Freeze up of Grantley Harbor occurred overnight in 1977. Photograph shows village of Teller at the outlet of Grantley Harbor on October 16, 1977.

48. Smoke from one of many tundra fires on the Seward Peninsula which hindered aerial surveys in the fall of 1977.

49. Turbid water conditions near Cape Wooley generated by fall storms which hampered aerial surveys.

50. 51. Japanese herring gillnetters in Norton Sound, June, 1968. The first foreign commercial effort for herring in Norton Sound occurred in 1968. Approximately 120 metric tons of herring were harvested by three Japanese vessels positioned about 20 km offshore in the area between St. Michael and Golovin Bay.

52. One of two Japanese gillnetters which were apprehended on June 7, 1969, for fishing within the U. S. contiguous zone in the vicinity of St. Michael. The two vessels had a total of 22 tons of herring aboard consisting of mostly spawned out males. The Japanese operated in Norton Sound in 1969 with a fleet of about 40 ships; peak foreign herring catches were experienced that year which amounted to nearly 1,300 metric tons.