Outer Continental Shelf Environmental Assessment Program

Final Reports of Principal Investigators

Volume 54 **February 1987**

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Ocean Service
Office of Oceanography and Marine Assessment
Ocean Assessments Division
Alaska Office

U.S. DEPARTMENT OF THE INTERIOR
Minerals Management Service
OCS Study, MMS 87-0021

"Outer Continental Shelf Environmental Assessment Program Final Reports of Principal Investigators" ("OCSEAP Final Reports") continues the series entitled "Environmental Assessment of the Alaskan Continental Shelf Final Reports of Principal Investigators."

It is suggested that sections of this publication be cited as follows:

Feder, H. M., S. C. Jewett, S. G. McGee, and G. E. M. Matheke. 1981. Distribution, abundance, community structure, and trophic relationships of the benthos of the northeastern Gulf of Alaska from Yakutat Bay to Cross Sound. U.S. Dep. Commer., NOAA, OCSEAP Final Rep. 54(1987):1-206

Cimberg, R. L., T. Gerrodette, and K. Muzik. 1981. Habitat requirements and expected distribution of Alaska coral. U.S. Dep. Commer., NOAA, OCSEAP Final Rep. 54(1987):207-308

Blackburn, J. E., P. B. Jackson, I. M. Warner, and M. H. Dick. 1981. A survey for spawning forage fish on the east side of the Kodiak Archipelago by air and boat during spring and summer 1979. U.S. Dep. Commer., NOAA, OCSEAP Final Rep. 54(1987):309-375

Blackburn, J. E., and P. B. Jackson. 1982. Seasonal composition and abundance of juvenile and adult marine finfish and crab species in the nearshore zone of Kodiak Island's eastside during April 1978 through March 1979. U.S. Dep. Commer., NOAA, OCSEAP Final Rep. 54(1987):377-570

Guzman, J. R., and M. T. Myers. 1982. Ecology and behavior of southern hemisphere shearwaters (Genus Puffinus) when over the outer continental shelf of the Gulf of Alaska and Bering Sea during the Northern summer (1975-1976). U.S. Dep. Commer., NOAA, OCSEAP Final Rep. 54(1987):571-682

OCSEAP Final Reports are published by the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service, Office of Oceanography and Marine Assessment, Ocean Assessments Division, Alaska Office, Anchorage, and primarily funded by the Minerals Management Service, U.S. Department of the Interior, through interagency agreement.

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Anchorage, AK 99513

OUTER CONTINENTAL SHELF

ENVIRONMENTAL ASSESSMENT PROGRAM

FINAL REPORTS OF PRINCIPAL INVESTIGATORS

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Alaska OCS Region
OCS Study, MMS 87-0021

Anchorage, Alaska

The facts, conclusions, and issues appearing in these reports are based on research results of the Outer Continental Shelf Environmental Assessment Program (OCSEAP), which is managed by the National Oceanic and Atmospheric Administration, U.S. Department of Commerce, and funded (wholly or in part) by the Minerals Management Service, U.S. Department of the Interior, through an Interagency Agreement.

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Outer Continental Shelf Environmental Assessment Program

Final Reports of Principal Investigators

VOLUME 54 FEBRUARY 1987

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DISTRIBUTION, ABUNDANCE, COMMUNITY STRUCTURE, AND TROPHIC RELATIONSHIPS OF THE BENTHOS OF THE NORTHEASTERN GULF OF ALASKA FROM YAKUTAT BAY TO CROSS SOUND

by

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Final Report
Outer Continental Shelf Environmental Assessment Program
Research Unit 5

March 1981

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I. SUMMARY OF OBJECTIVES AND CONCLUSIONS

The specific objectives of this investigation were to present: (1) a quantitative inventory of dominant epifaunal invertebrates; (2) a description of spatial distribution patterns of selected epifaunal invertebrates; (3) assess spatial distribution and relative abundance of selected infaunal invertebrate species; and (4) observations of biological interrelationships, emphasizing trophic interactions, between selected segments of the benthic biota.

During 6-25 November, 1979, trawls were made at 42 offshore stations, 33 of which were within an identified high priority area (designated Area 1). Twenty-seven additional offshore stations were surveyed and considered to be untrawlable. A total of 34 van Veen grab stations were sampled; 27 stations in Priority Area 1. Pipe dredge samples were taken from 34 stations, most of which were in Priority Area 1. Dredge samples were mainly used as an aid in identification of stomach contents from various species.

Trawls were made at three stations in Yakutat Bay; eleven additional stations were surveyed and considered to be untrawlable. Grab samples were analyzed from seven stations.

Analysis of the trawl material from offshore stations resulted in a delineation of benthic invertebrates belonging to 10 phyla, 19 classes, 72 families, 100 genera, and 134 species. Yakutat Bay trawl material delineated 4 phyla, 6 classes, 16 families, 19 genera, and 23 species. It is probable that all species with numerical and biomass importance have been collected in the area of investigation and only rare species will be added in future sampling.

Information derived from the grab sampling program indicates that the infauna at most stations was similar to that found in other areas of the northeastern Gulf of Alaska (NEGOA) where there is a soft substrate (Feder and Matheke, 1980). The infauna was dominated by motile deposit-feeding organisms, and the diversity of the fauna was relatively low compared to areas with a more heterogeneous substrate (Feder and Matheke, 1980).

Information on the feeding biology of 20 species from NEGOA (Cross Sound to Yakutat Bay), in conjunction with data collected on other Outer Continental Shelf Environmental Assessment Program (OCSEAP) cruises, should enhance the understanding of benthic trophic relationships for the Gulf of Alaska.

II. INTRODUCTION

GENERAL NATURE AND SCOPE OF STUDY

Operations associated with oil exploration, production, and transportation in the northeast Gulf of Alaska (NEGOA) present a broad spectrum of potential dangers to the marine environment (see Olson and Burgess, 1967; Malins, 1977 for general discussions of marine pollution problems). Adverse effects on the marine environment of this area cannot be assessed nor predicted, unless background data are recorded prior to industrial development.

Insufficient long-term information about an environment, and the basic biology and recruitment of species in that environment, can lead to erroneous interpretations of changes in species which might occur if the area becomes altered (see Nelson-Smith, 1973; Pearson, 1971, 1972, 1975, 1980; Rosenberg, 1973 for general discussions on benthic biological investigations in industrialized marine areas). Populations of marine species may fluctuate over a time span of from a few to 30 years, but such fluctuations are typically unexplainable because of the absence of long-term ecological data (Lewis, 1970).

Benthic organisms (primarily the infauna but also sessile and slow-moving epifauna) are useful as indicator species for a disturbed area because they tend to remain in place, typically react to long-range environmental changes, and, by their presence, generally reflect the nature of the substratum. Consequently, organisms of the infaunal benthos are frequently chosen to monitor long-term pollution effects, and are believed to reflect the biological health of a marine area (see Pearson, 1971, 1972, 1975, 1980; Pearson and Rosenberg, 1978; Rosenberg, 1973 for discussions on long-term usage of benthic organisms for monitoring pollution; and Feder and Matheke, 1980, for data and discussion on the infauna of NEGOA).

The presence of large numbers of epifaunal invertebrates (crabs, shrimps, snails) and finfishes of actual or potential commercial importance in NEGOA further necessitates the understanding of benthic communities since many commercial species feed on infaunal and small epifaunal residents of the benthos (see Zenkevitch, 1963 for a discussion of the interaction of commercial species and the benthos; also see appropriate discussions in Feder and Jewett, 1980a, b; Feder *et al.*, 1980a, b). Changes in density of benthic organisms utilized as food could affect the health and numbers of these commercially-important species.

Experience in pollution-prone areas of England (Smith, 1968); Scotland (Pearson, 1972, 1975, 1980); and California (Straughan, 1971) suggests that at the completion of an initial study, selected stations should be examined regularly on a long-term basis to determine changes in species content, abundance, diversity and biomass. Such long-term data acquisition should make it possible to differentiate between normal ecosystem variation and pollutant-induced biological alteration. Intensive investigations of the benthos of the NEGOA are essential to understand the changes that might take place if oil-related activities are initiated.

The benthic biological program in NEGOA (Jewett and Feder, 1975, unpublished OCSEAP data on file, National Oceanographic Data Center; Feder *et al.*, 1980b) has emphasized the development of an inventory of epifaunal and infaunal species as part of the examination by OCSEAP of the physical, chemical, and biological components of areas slated for oil exploration and drilling activity. In addition, a program designed to quantitatively assess assemblages of infaunal species on the NEGOA shelf has expanded the understanding of patterns of distributions of species there (Feder and Jewett, 1980b; Feder and Matheke, 1980; Matheke *et al.*, 1976). Investigations connected with distribution, abundance, community structure, and trophic relationships of benthic species in Cook Inlet (an embayment of NEGOA) and Kodiak Island waters, have recently been completed (Feder *et al.*, 1980a; Feder and Jewett, 1977, 1980a). Detailed information on the temporal variability of the benthic fauna in NEGOA is sparse.

The project considered in this Final Report was designed to survey the benthic fauna, including feeding interactions, on the shelf of NEGOA

(Yakutat Bay to Cross Sound) in regions of potential oil and gas concentrations. Data were obtained on faunal composition, abundance and biomass to develop baselines to which changes can be compared. Future long-term studies on life histories and trophic interactions of important species should define aspects of communities potentially vulnerable to environmental damage, and should help to assess rates at which damaged environments can recover.

RELEVANCE TO PROBLEMS OF PETROLEUM DEVELOPMENT

Lack of an adequate data base on responses of NEGOA species to oil makes it difficult to predict the effects of oil-related activity on the subtidal benthos of NEGOA. However, OCSEAP-sponsored research activities on the shelf should ultimately point to species or areas that might bear closer scrutiny once industrial activity is initiated. It must be emphasized that an extended time frame is needed to comprehend long-term fluctuations of benthic species; short-term research programs cannot be expected to provide predictive capabilities. Assessment of the environment must be conducted on a continuing basis.

As indicated previously, infaunal organisms tend to remain in place and, consequently, have been useful as indicator species for disturbed areas. Thus, critical examination of stations with substantial complements of infaunal species is warranted (see Feder and Mueller, 1975; Feder and Matheke, 1980; Matheke *et al* , 1976; NODC data on file for examples of such stations). Changes in the environment at stations with relatively large numbers of species might be reflected by a decrease in diversity with increased dominance of a few species (see Nelson-Smith, 1973 for further discussion of oil-related changes in diversity). The potential effect of the loss of species from the trophic structure on the NEGOA shelf can be better addressed through the benthic feeding studies from recent OCSEAP projects (Feder and Jewett, 1977, 1978, 1980a, b; Smith *et al* , 1978).

Data indicating the effect of oil on subtidal benthic invertebrates are accumulating (see Boesch *et al.*, 1974; Malins, 1977; Nelson-Smith, 1973; Kineman *et al.*, 1980 for reviews; Baker, 1976 for a general review of marine ecology and oil pollution), but virtually no data are available for the

NEGOA shelf. Snow (Tanner) crab (*Chionoecetes bairdi*) are conspicuous members of the shallow shelf of the Gulf of Alaska, and this species supports a commercial fishery of considerable importance. Laboratory experiments with this species have shown that postmolt individuals lose most of their legs after exposure to Prudhoe Bay crude oil (Karinen and Rice, 1974). This aspect of the biology of the snow crab must be considered in the continuing study of this species. Mecklenburg *et al.* (1976) examined the effects of Cook Inlet crude oil water soluble fractions on survival and molting of king crab (*Paralithodes camtschatica*) and coonstripe shrimp (*Pandalus hypsinotus*) larvae. Molting was permanently inhibited by exposing larvae of both species for 72 hours to a concentration of 0.8 to 0.9 ppm of crude oil. Larvae that failed to molt died in seven days, although the contaminated water had been replaced with clean water. Although high concentrations of oil killed larvae in 96 hours, lower concentrations disrupted swimming and molting in the same period and ultimately resulted in death. Little other direct data based on laboratory experiments are available for subtidal benthic species from NEGOA. Experimentation on toxic effects of oil on other common members of the subtidal benthos should be encouraged in future OCSEAP programs.

A direct relationship between trophic structure (feeding type) and bottom stability has been demonstrated by Rhoads (see Rhoads, 1974 for review). A diesel fuel spill resulted in oil becoming absorbed on sediment particles with resultant mortality of many deposit feeders on sublittoral muds. Bottom stability was altered with the death of these organisms, and a new complex of species became established in the altered substratum. The most common members of the infauna of the Gulf of Alaska and the Bering Sea are deposit feeders; thus, oil-related mortality of these species could result in a changed near-bottom sedimentary regime with subsequent alteration of species composition.

As suggested above, upon completion of initial baseline studies in pollution prone areas, selected stations should be examined regularly on a long-term basis. Also, intensive examination of the biology (e.g., age, growth, condition, reproduction, recruitment, feeding habits and altered physiological and biochemical activity) of selected species should provide indications of environmental alteration, should it occur.

III. CURRENT STATE OF KNOWLEDGE

Little was known about the biology of the invertebrate benthos of the northeast Gulf of Alaska (NEGOA) at the time OCS (Outer Continental Shelf) studies were initiated there. A compilation of some relevant data on the area was presented by Rosenberg (1972). Bakus and Chamberlain (1975) added some benthic biological data for a specific area of NEGOA south of the Bering Glacier; similar data were reported by Feder and Mueller (1975) and Feder and Matheke (1980) in their OCS investigations.

In late 1961 and early 1962 otter trawls were used by the Bureau of Commercial Fisheries (now National Marine Fisheries Service) in conjunction with the International Pacific Halibut Commission to survey the shellfishes and bottomfishes on the continental shelf and upper continental slope, in the Gulf of Alaska (Hitz and Rathjen, 1965). Invertebrates taken in these trawls were of secondary importance and only major groups and/or species were recorded, although they comprised 27 percent of the total catch. These invertebrates were grouped into the following categories: heart urchins (Echinoidea); snow crab (*Chionoecetes bairdi*); sea stars (Asteroidea); Dungeness crab (*Cancer magister*); scallop (*Pecten caurinus*); shrimps (*Pandalus borealis, P. platyceros, Pandalopsis dispar*); king crab (*Paralithodes camtschatica*); and miscellaneous invertebrates (shells, sponges, etc.). Heart urchins accounted for about 50 percent of the invertebrate catch and snow crab ranked second, representing about 22 percent. Approximately 20 percent of the total catch of invertebrates was composed of sea stars. Additional data on commercially important shellfish are available in Ronholt *et al.* (1976).

Ronholt *et al.* (1978) presented a historical review of the demersal fish and shellfish resources of the Gulf of Alaska from Cape Spencer to Unimak Pass (1948-1976). The International Pacific Halibut Commission conducts surveys in the Gulf of Alaska annually and records selected commercially-important invertebrates; noncommercial species are not considered.

The benthic investigations of Feder and Matheke (1980), Feder and Mueller (1975), Jewett and Feder (1976) and Matheke *et al.* (1976) were the first intensive qualitative and quantitative examinations of the benthic infauna and epifauna of the Gulf of Alaska. These studies also represented the first examinations of trophic relationships involving some of the species in the area.

The present report represents an extension of the above NEGOA investigations eastward to a region where invertebrates have not been properly assessed. A determination of the distribution, relative abundance, and biomass of benthic infauna and epifauna, as well as observations on food habits of selected species, is presented.

IV. STUDY AREA

Sampling was conducted in the region of the northeastern Gulf of Alaska from Icy Bay to Cross Sound, extending outward to approximately the 300 m isobath. Stations were established on a grid (Fig. 1), which was an eastward extension of the stations used by Jewett and Feder (1975, unpublished OCSEAP data on file, National Oceanographic Data Center). The area surrounding each station, usually a rectangle 11 x 14 km, was designated as the station block. If bottom conditions prevented trawling at the predesignated station location, a trawl was attempted from any suitable location within the block. Special attention was given to stations within the proposed sale lease area No. 55 (Priority Area 1) (Fig. 2) and to a limited number of stations in Yakutat Bay (Fig. 3). Those stations peripheral to northwest and southwest of the lease area (Priority Area 2) were of secondary importance (Fig. 2). The stations of least importance were located in the region toward Cross Sound (Priority Area 3) (Fig. 2).

A second grid system was constructed for Yakutat Bay (Fig. 3). North-south lines at every five minutes of longitude were established. Stations were located along each of these lines at every 2.5 minutes of latitude. On alternate longitudinal lines, stations were shifted by 1.25 minutes of latitude from those of adjacent lines. For example, the mid-point of Station 1A was located at 59°41.0'N and 140°12.5'W. The surrounding station blocks were approximately 4.7 x 4.6 km.

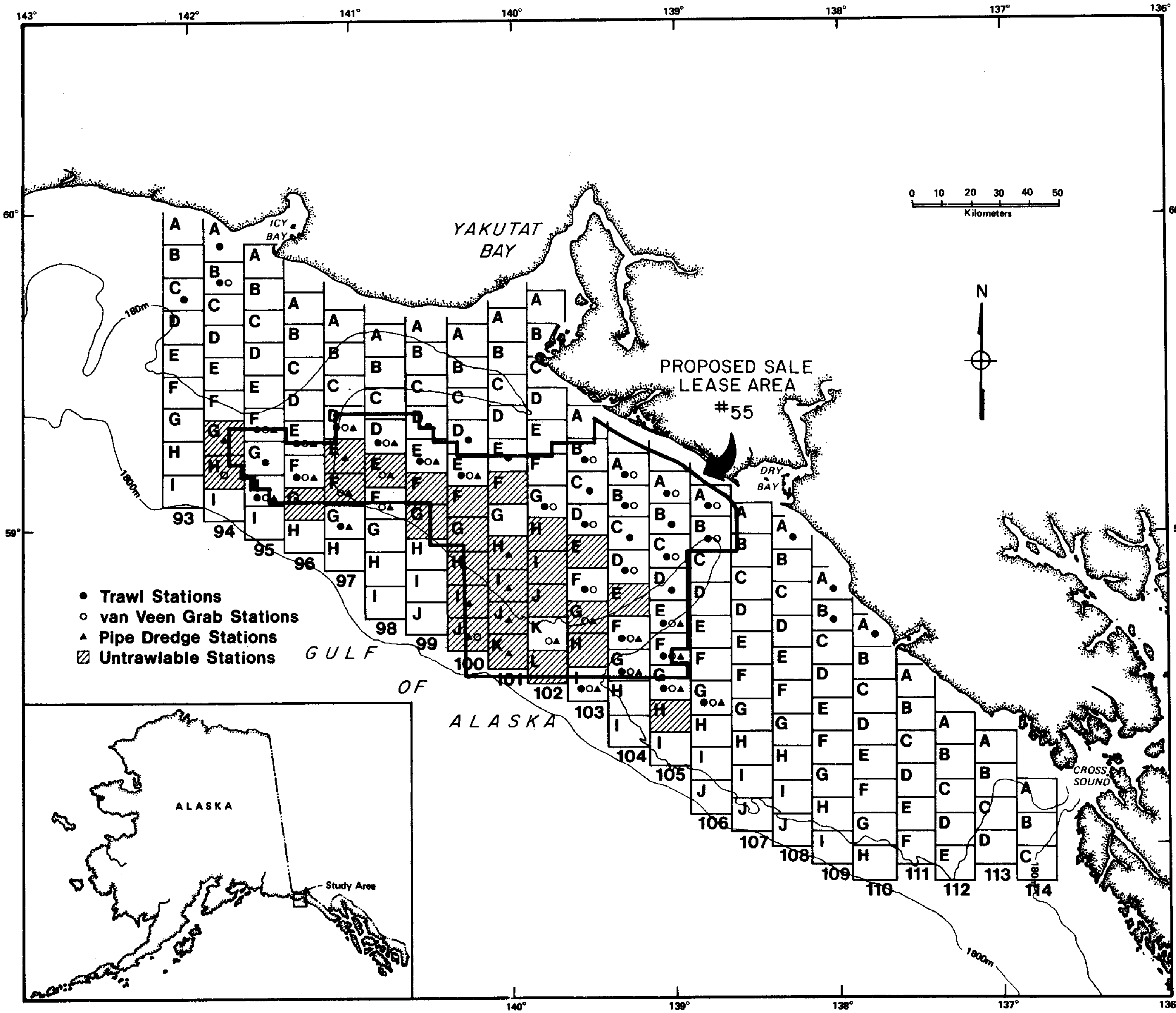

Figure 1. Northeastern Gulf of Alaska station grid occupied by the NOAA ship *Miller Freeman*, November 1979.

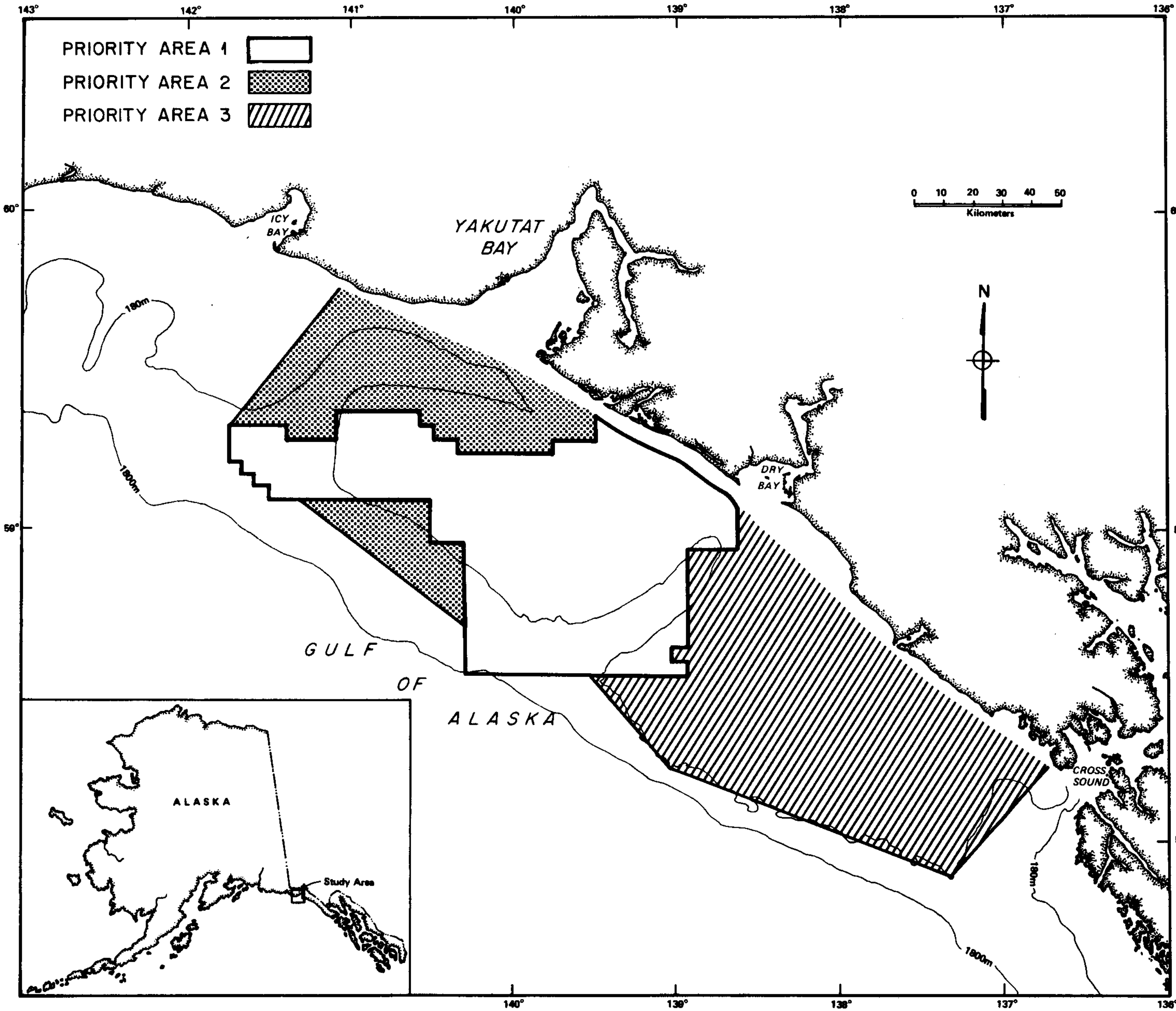

Figure 2. Priority sampling areas established in the northeastern Gulf of Alaska. Priority Area 1 represents the proposed lease area.

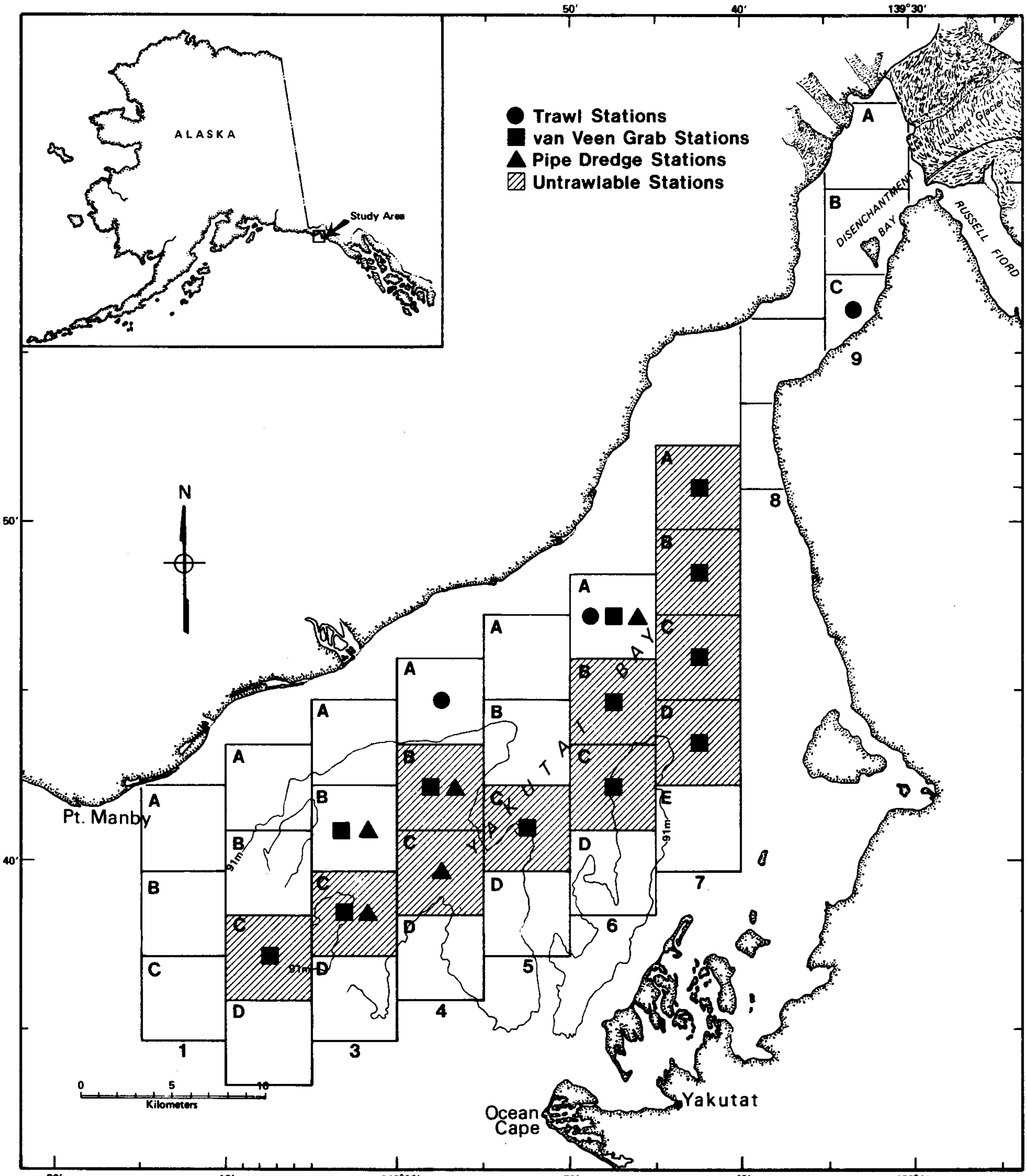

Figure 3. Yakutat station grid occupied by the NOAA ship *Miller Freeman*, November 1979.

V. SOURCES, METHODS AND RATIONALE OF DATA COLLECTION

Specimens were collected onboard the NOAA Ship *Miller Freeman* from 6-25 November 1979.

Usually, one-half-hour tows were made at predetermined stations using a commercial-size 400-mesh Eastern otter trawl with a 12.2 m horizontal opening. The lengths of some tows were shortened to no less than 15 minutes due to marginal bottom conditions. All catches were sorted, weighed, counted, and given tentative identifications onboard ship, according to methodology developed in previous OCS investigations (Feder, *et al* , 1980b). Aliquot samples of species of invertebrates were preserved in 10 percent neutral buffered formalin and labeled for verification at the Institute of Marine Science, University of Alaska. Tabulations of stomach contents from selected species of invertebrates and fishes were also carried out onboard. Contents of stomachs, or entire stomachs from some species, were preserved in 10 percent neutral buffered formalin, and returned to the University of Alaska for more detailed analysis. Feeding data were examined in the laboratory using the frequency of occurrence method. In the discussion on food habits, species used as food are summarized based on the literature and data of this study; all food species are listed in decreasing order of importance, except where noted otherwise.

Samples of infaunal and small epifaunal invertebrates were taken from selected stations by van Veen grab and pipe dredge according to methodology developed by Feder and Matheke (1980) and Feder *et al.* (1980a, b). Infaunal samples were usually collected by pipe dredge at successfully trawled stations as an aid in stomach analysis of various species and to provide additional information on small epifaunal species not obtained by trawl. Pipe dredge and van Veen grab samples were also taken from some untrawlable stations in Priority Area 1 to permit characterization of three stations. Five replicate grabs were usually taken at all stations. Pipe dredge and grab samples were washed over a 1-mm mesh screen to remove fine sediment, and preserved in 10 percent neutral buffered formalin for later examination in the laboratory in Fairbanks.

At Fairbanks, samples were washed through a 1-mm mesh screen to remove the formalin and any remaining sediment, and rough sorted using a magnifying sorting lamp. Specimens were identified using a *Wild* dissection microscope at 60x to 500x magnifications. A compound microscope of 100x to 1000x magnifications was used, as needed, to assist in identifications. A wet weight was taken of all specimens using a Mettler balance. Samples were recombined, catalogued, and stored. A voucher collection containing representatives of each species was deposited at the California Academy of Science.

Pipe dredge samples were examined qualitatively in the laboratory.

NUMERICAL ANALYSIS OF VAN VEEN GRABS

Station groups and species assemblages were identified using cluster analysis. Cluster analysis can be divided into three basic steps.

1. Calculation of a measure of similarity or dissimilarity between entities to be classified.
2. Sorting through a matrix of similarity coefficients to arrange the entities in a hierarchy or dendrogram.
3. Recognition of classes within the hierarchy.

Data reduction prior to calculation of similarity coefficients consisted of elimination of taxa that could not be identified to genus.

The coefficient used to calculate similarity matrices for cluster analysis routines was the Czekanowski coefficient[1]

Czekanowski Coefficient

$$Cs_{1,2} = \frac{2W}{A + B}$$

where A = the sum of the measures of attributes of entity one

B = the sum of the measures of attributes of entity two

W = the sum of the lesser measures of attributes shared by entities one and two.

[1]The Czekanowski coefficient is synonymous with the Motyka (Mueller-Dombois and Ellenberg, 1974), and Bray-Curtis (Clifford and Stephenson, 1975) coefficients.

The Czekanowski coefficient has been used effectively in marine benthic studies by Field and MacFarlane (1968), Field (1969, 1970 and 1971), Day *et al.* (1971), Stephenson and Williams (1971), and Stephenson *et al.* (1972). This coefficient emphasizes the effect of dominant species on the classification, and is often used with some form of transformation. The Czekanowski coefficient was used to calculate similarity matrices for normal cluster analysis (with sites as the entities to be classified and species as their attributes) and inverse cluster analysis (with species as entities and sites as attributes) using both untransformed and natural logarithm transformed abundance data (individuals/m^2). The natural logarithm transformation, $Y = ln(X+1)$, reduces the influence that dominant species have on the similarity determination.

Dendrogams were constructed from the similarity matrices using a group-average agglomerative hierarchical cluster analysis (Lance and Williams, 1966). Two-way coincidence tables comparing site groups formed by normal analysis and species groups formed by inverse analysis were constructed as an aid in the interpretation of dendrograms formed by cluster analyses (Stephenson *et al.*, 1972). In each table the original species x stations data matrix was rearranged (based on the results of both normal and inverse analysis) so that the stations and species with the highest similarities were adjacent to each other.

Principal coordinate analysis (Gower, 1967, 1969) was used as an aid in interpreting the results of the cluster analyses (Stephenson and Williams, 1971; Boesch, 1973) and identifying misclassifications of stations by cluster analysis. Misclassifications in an agglomerative cluster analysis can occur by the early fusion of two stations and their subsequent incorporation into a group whose stations have a high similarity to only one member of the original pair (Boesch, 1973). In principal coordinate analysis an interstation similarity matrix is generated as in normal cluster analysis. The similarity matrix generated can be conceived of as a multidimensional space, in which, the stations are arranged in such a way that they are separated from one another according to their similarities. An ordination is then performed on the matrix to extract axes from this multidimensional space. The first axis extracted coincides with the longest axis, and accounts for the largest amount of variation in the similarity matrix. Subsequent axes account for successively smaller amounts of variation in the data. The Czekanowksi similarity coefficient was used to calculate the similarity matrices used in principal coordinate analysis. Both the Czekanowski and the Canberra "metric" similarity coefficients were used to calculate the similarity matrices used in principal coordinate analysis. The Canberra "metric" coefficient defines the similarity of two entities as:

$$Cs_{1,2} = 1 - \frac{1}{n} \sum_{i}^{n} \frac{|X_{1i} - X_{2i}|}{(X_{1i} + X_{2i})}$$

where X_{1i} = the measure of the i^{th} attribute in entity one
X_{2i} = the measure of the i^{th} attribute in entity two

Because the Canberra "metric" coefficient is a series of fractions, it gives a more equal weighting to all species and reduces the effect of the dominant species on the analysis. It was used as a means of comparison with the results of analyses using the Czekanowski coeffcient which emphasizes dominant species.

DIVERSITY OF VAN VEEN GRABS

Species diversity can be thought of as a measurable attribute of a collection or a natural assemblage of species, and consists of two components: the number of species or "species richness" and the relative abundance of each species or "evenness". The two most widely used measures of diversity which include species richness and evenness are the Brillouin (Brillouin, 1962) and Shannon (Shannon and Weaver, 1963) information measures of diversity (Nybakken, 1978). There is still disagreement on the applicability of these indices, and the results are often difficult to interpret (Sager and Hasler, 1969; Hurlbert, 1971; Fager 1972; Peet, 1974; Pielou, 1966a, b). Pielou (1966a, b, 1977) has outlined some of the conditions under which these indices are appropriate.

The Shannon function

$$H' = -\sum_i p_i \log p_i \text{ where } p_i = \frac{n_i}{N}$$

where n_i = number of individuals in the i^{th} species

N = total number of individuals

assumes that a random sample has been taken from an infinitely large population whereas the Brillouin function

$$H = \frac{1}{N} \log \frac{N!}{n_1!n_2!\cdots n_s!}$$

is appropriate only if the entire population has been sampled. Thus, if we wish to estimate the diversity of the fauna at a sampling site the Shannon function is appropriate. The Brillouin function is merely a measure of the diversity of the five grab samples taken at each site, and makes no predictions about the diversity of the benthic community that the samples were drawn from. The evenness of samples taken at each site can be calculated using the Brillouin measure of evenness, $J = H/H_{maximum}$, where H = Brillouin diversity function. $H_{maximum}$, the maximum possible diversity for a given number of species, occurs if all species are equally common and is calculated as:

$$H_{maximum} = \frac{1}{N} \log \frac{N!}{[N/s]!^{\,s-r} \; ([N/s]+1)!^{\,r}}$$

where $[N/s]$ = the integer part of N/s

s = number of species in the censused community

$r = N - s[N/s]$

Theoretically, the evenness component of the Shannon function can be calculated from the following:

$$J' = \frac{H'}{\log s^*}$$

where H' = Shannon diversity function

s^* = the total number of species in the randomly sampled community

However, s* is seldom known for benthic infaunal communities. Therefore, the Shannon indices of diversity and evenness were not calculated in the present study. Several investigators (Loya, 1972, Nybakken, 1978; Feder and Matheke, 1980) have demonstrated a close correlation between the Brillouin and Shannon diversity indices.

Species richness (Margalef, 1958) was calculated as:

$$SR = \frac{(S-1)}{ln\ N}$$

where S = the number of species

N = the total number of individuals

VI. RESULTS

BENTHIC EPIFAUNAL PROGRAM

Offshore Stations

A total of 42 offshore stations were sampled by trawl; 33 stations in Priority Area 1; 1 station in Priority Area 2, in addition to 3 stations peripheral to Area 2; and 5 stations in Priority Area 3 (Figs. 1 and 2; Appendix A). Due to the limited number of stations occupied in Areas 2 and 3, data from all areas were combined in taxonomic density and biomass analyses.

Taxonomic analysis delineated 10 phyla, 19 classes, 72 families, 100 genera, and 134 species of epifaunal invertebrates (Table 1). Echinodermata, Arthropoda, and Mollusca were the dominant phyla represented with 51 (36%), 35 (25%) and 26 (19%) species, respectively (Table 1). These three phyla made up 27.4, 26.2, and 21.1 percent of the invertebrate biomass, respectively (Table II).

The mean biomass for all epifaunal species collected was 1.7 g/m^2 (data base on file at the National Oceanographic Data Center, NODC). The biomasses of the major phyla were usually dominated by a few species (Table II). For example, the phylum Cnidaria was dominated by the anemone, *Metridium senile*, (80.5% of the phylum weight). Other species biomass dominants by phylum were: Mollusca-*Pecten caurinus* (scallop) (86.6%); Arthropoda-*Cancer magister* (Dungeness crab) (55.6%) and *Chionoecetes bairdi* (snow crab) (27.4%); and Echinodermata-*Strongylocentrotus* spp. (urchins) (56.6%).

TABLE I

SPECIES OF INVERTEBRATES TAKEN BY TRAWL FROM THE NORTHEASTERN GULF OF ALASKA EXCLUDING YAKUTAT BAY, NOVEMBER, 1979

Phylum Porifera
Unidentified species

Phylum Cnidaria
Class Scyphozoa
Unidentified species

Class Anthozoa
Unidentified species

Order Alcyonacea

Family Nephtheidae
Eunephthya rubiformis (Pallas)
Unidentified species

Family Primnoidae
Primnoa sp.

Family Pennatulidae
Stylatula gracile (Gabb)

Family Actinostolidae
Stomphia coccinea (O. F. Müeller)

Family Actiniidae
Unidentified species

Family Metridiidae
Metridium senile

Phylum Rhynchocoela
Class Anopla

Family Rineidae
Cerebratulus sp.

Phylum Annelida
Class Polychaeta

Family Polynoidae
Eunoë senta (Moore)

Family Euphrosinidae
Euphrosine hortensis Moore

Family Syllidae
Pionosyllis gigantea Moore

Family Nereidae
Cheilonereis cyclurus (Harrington)
Nereis sp.

TABLE I

CONTINUED

Family Ampharetidae
Unidentified species

Family Terebellidae
Pista spp.

Family Serpulidae
Crucigera irregularis Bush

Family Aphroditidae
Aphrodita spp.
Aphrodita japonica Marenzeller
Aphrodita negligens Moore

Class Hirudinea
Notostomobdella spp.

Phylum Mollusca
Class Bivalvia

Family Pectinidae
Chlamys rubida (Hinds)
Pecten caurinus Gould

Family Cardiidae
Clinocardium ciliatum (Fabricius)

Family Veneridae
Compsomyax subdiaphana Carpenter

Family Hiatellidae
Hiatella arctica (Linnaeus)

Family Teredinidae
Bankia setacea Tryon

Class Gastropoda

Family Bathybembix
Lischkeia cidaris (Carpenter)

Family Naticidae
Natica clausa Broderip and Sowerby

Family Cymatiidae
Fusitriton oregonensis (Redfield)

Family Buccinidae
Buccinum spp.
Buccinum polare Gray
Buccinum plectrum Stimpson

TABLE I

CONTINUED

Family Neptuneidae
- *Beringius kennicotti* (Dall)
- *Colus* spp.
- *Neptunea lyrata* (Gmelin)
- *Neptunea pribiloffensis* (Dall)
- *Pyrulofusus harpa* (Mörch)

Family Volutidae
- *Arctomelon sternsii* (Dall)

Family Dorididae
- *Archidoris* spp.

Family Tritoniidae
- *Tritonia exsulans* Bergh

Family Arminidae
- *Armina californica* (Cooper)

Class Cephalopoda

Family Sepiolidae
- *Rossia pacifica* Berry

Family Gonatidae
- *Gonatus magister* Berry

Family Octopodidae
- *Octopus* sp.

Phylum Arthropoda

Class Crustacea

Order Thoracica

Family Balanidae
- *Balanus hesperius* Pilsbry

Order Isopoda

Family Limnoridae
- *Limnoria lignorum* Rathke

Family Aegidae
- *Rocinela belliceps* Stimpson

Order Decapoda

Family Pandalidae
- *Pandalus borealis* Kröyer
- *Pandalus goniurus* Stimpson
- *Pandalus jordani* Rathbun
- *Pandalus montagui tridens* Rathbun
- *Pandalus platyceros* Brandt
- *Pandalus danae* Stimpson
- *Pandalopsis dispar* Rathbun

TABLE I

CONTINUED

Family Hippolytidae
Eualus barbata (Rathbun)

Family Crangonidae
Unidentified species
Crangon dalli (Rathbun)
Crangon communis Rathbun
Crangon resima Rathbun
Argis lar (Owen)
Argis dentata (Rathbun)
Argis ovifer (Rathbun)

Family Paguridae
Pagurus spp.
Pagurus ochotensis (Benedict)
Pagurus aleuticus (Benedict)
Pagurus setosus (Benedict)
Pagurus confragosus (Benedict)
Pagurus cornutus (Benedict)
Elassochirus cavimanus (Dana)
Labidochirus splendescens (Owen)

Family Lithodidae
Acantholithodes hispidus (Stimpson)
Paralithodes platypus Brandt
Lopholithodes foraminatus (Stimpson)

Family Galatheidae
Munida quadrispina Benedict

Family Majidae
Hyas lyratus Dana
Chionoecetes bairdi Rathbun
Scyra acutifrons Dana

Family Cancridae
Cancer magister Dana

Phylum Sipuncula
Unidentified species

Phylum Brachiopoda
Class Articulata

Family Cancellothyrididae
Terebratulina unguicula Carpenter

Family Dallinidae
Laqueus californianus Koch

TABLE I

CONTINUED

Phylum Echinodermata
Class Asteroidea

Family Astropectinidae
Dipsacaster spp.
Dipsacaster borealis Fisher

Family Benthopectinidae
Luidiaster dawsoni (Verrill)

Family Goniasteridae
Ceramaster spp.
Ceramaster patagonicus (Sladen)
Hippasterias spinosa Verrill
Mediaster aequalis Stimpson
Pseudarchaster parelii (Düben and Koren)

Family Luiidae
Luidia foliolata Grube

Family Porcellanasteridae
Ctenodiscus crispatus (Retzius)

Family Echinasteridae
Henricia spp.
Henricia aspera Fisher
Henricia beringiania Djakonov
Henricia derjugini Djakonov
Henricia leviuscula (Stimpson)
Henricia sanguinolenta (O. F. Müller)
Henricia clarki Fisher
Poraniopsis inflata Fisher

Family Pterasteridae
Diplopteraster multipes (Sars)
Pteraster militaris (O. F. Müller)
Pteraster tesselatus Ives

Family Solasteridae
Crossaster borealis (Fisher)
Crossaster papposus (Linnaeus)
Lophaster furcilliger Fisher
Solaster dawsoni Verrill
Solaster endeca (Linné)

Family Asteridae
Leptasterias hylodes Fisher
Leptasterias fisheri Djakonov
Lethasterias nanimemsis (Verrill)
Stylasterias forreri (de Loriol)
Pycnopodia helianthoides (Brandt)

TABLE I

CONTINUED

Class Echinoidea

Family Schizasteridae
Brisaster townsendi (Agassiz)

Family Strongylocentrotidae
Allocentrotus fragilis (Jackson)
Strongylocentrotus spp.
Strongylocentrotus droebachiensis (O. F. Müller)

Class Ophiuroidea

Family Gorgonocephalidae
Gorgonocephalus caryi (Lyman)

Family Ophiacanthidae
Ophiacantha gratiosa Koehler

Family Ophiactidae
Ophiopholis aculeata (Linnaeus)
Ophiopholis bakeri McClendon

Family Ophiuridae
Amphiophiura ponderosa (Lyman)
Ophiura sarsi Lütkin

Class Holothuroidea
Unidentified species

Family Molpadiidae
Molpadia intermedia (Ludwig)

Family Stichopodidae
Parastichopus californicus

Family Synallactidae
Pseudostichopus mollis
Bathyplotes spp.

Class Crinoidea
Unidentified species

Phylum Chordata
Subphylum Urochordata
Unidentified species

Class Ascidiacea

Family Pyuridae
Halocynthia igaboja Oka

TABLE II

NUMBERS, WEIGHTS AND BIOMASS (g/m^2) OF THE MAJOR EPIFAUNAL TAXA OF CNIDARIA, MOLLUSCA, ARTHROPODA, AND ECHINODERMATA FROM THE NORTHEASTERN GULF OF ALASKA, EXCLUDING YAKUTAT BAY, NOVEMBER 1979

Phylum	Percent of total weight	Taxon[1]	Number of organisms	Wet weight (g)	Percent of[2] total weight	Percent of phylum weight	Mean biomass per square meter ($\bar{x}$ g/m^2)
Cnidaria	13.7	Anthozoa	86	37531	1.5	11.2	0.03
		Actiniidae	82	26006	1.0	7.8	0.02
		Metridium senile	790	268800	11.0	80.5	0.19
		Total	948	332337	13.6	99.6	0.23
Mollusca	21.1	*Pecten caurinus*	1960	447060	18.3	86.6	0.31
		Fusitriton oregonensis	513	39523	1.6	7.7	0.03
		Rossia pacifica	119	11056	0.4	2.1	<0.01
		Total	2592	497639	20.4	96.4	0.35
Arthropoda (Crustacea)	26.2	*Pandalus jordani*	1533	13759	0.6	2.2	0.01
		Lopholithodes foraminatus	109	67717	2.8	10.6	0.05
		Chionoecetes bairdi	1377	175244	7.2	27.4	0.12
		Cancer magister	842	355837	14.6	55.6	0.25
		Total	3861	612557	25.1	95.7	0.43
Echinodermata	27.4	*Pycnopodia helianthoides*	88	105722	4.3	15.8	0.07
		Allocentrotus fragilis	1522	75752	3.1	11.3	0.05
		Strongylocentrotus sp.	5019	214230	8.8	32.0	0.15
		Strongylocentrotus droebachiensis	2393	164916	6.7	24.6	0.11
		Total	9022	560620	22.9	83.7	0.39
Grand Total	88.4		16423	2003153	82.0	-	1.40

[1]Species or lowest level of identification.

[2]Total weight of all epifauna = 2444090 g.

Some species were widely distributed while others were relatively localized (Table III and Appendix A). *Chionoecetes bairdi* occurred in 25 widely distributed stations. Highest densities and biomasses of this crab occurred in Priority Area 1 at stations 101E, 103B and D, and 104B and C (Table III: Fig. 1). *Cancer magister* occurred at only five stations and was most important at Station 94A, a station northwest of Priority Area 2. At this station, 195 *C. magister* were caught per kilometer of fishing. *Pecten caurinus* was found at 10 stations which were distributed between Stations 93C and 110A. Stations 93C and 108A, located outside of Priority Area 1, yielded the greatest scallop catches with 590 and 249 individuals/km, respectively. Many scallops were infected by the spionid polychaetes, *Pygospio elegans* and *Polydora ciliata*. These polychaetes burrow into the dorsal valve, weakening it to the point where they are easily broken by trawling. Infection was generally greater among larger individuals. Scallops from Station 108A were the most heavily infected. The urchins, *Allocentrotus fragilis* and *Strongylocentrotus* spp., occurred at 20 and 7 stations, respectively, all of which were distant from shore. Station 98D yielded the greatest density of *Allocentrotus* with 417 individuals/km fished. The greatest density of *Strongylocentrotus* came from Station 102G with 1307 individuals/km fished. The brittlestar, *Ophiura sarsi*, occurred in 7 stations, 96F, 102G, 103D, 103F, 104A, 105A, and 106G, all of which, except the latter, were in Priority Area 1. The density of this brittle star was greatest at Station 104A (3603 individuals/km fished).

Data and discussion on the incidence of commensalism between polychaetes, amphipods and hermit crabs is included in Appendix B.

Yakutat Bay Stations

Due to the rough benthic substrate in Yakutat Bay, only three trawl stations were successfully occupied (Stations 4A, 6A, 9C) (Fig. 3 and Appendix A). Taxonomic analysis yielded 4 phyla, 6 classes, 16 families, 19 genera and 23 species (Table IV). Arthropoda, Echinodermata and Mollusca dominated in species representation and biomass; Arthropoda contributed 13 species and 68.6 percent of the total biomass, Echinodermata — 7 species

TABLE III

STATIONS AT WHICH THE DOMINANT EPIFAUNAL INVERTEBRATE SPECIES OCCURRED IN THE NORTHEASTERN GULF OF ALASKA, EXCLUDING YAKUTAT BAY, NOVEMBER 1979

Species	Station	No./km	g/m^2
Metridium senile	109A	284	7.925
Pecten caurinus	93C	590	11.568
	108A	249	4.375
Pandalus jordani	103C	314	0.231
Cancer magister	94A	195	6.752
Chionoecetes bairdi	101E	52	0.281
	103B	32	1.087
	103D	36	0.424
	104B	78	0.052
	104C	105	0.277
Ctenodiscus crispatus	104F	115	0.054
Ophiura sarsi	104A	3603	0.591
Brisaster townsendi	105D	129	0.469
Allocentrotus fragilis	98D	417	0.443
	99E	99	0.802
	104G	56	0.393
Strongylocentrotus spp.	98D	263	0.134
	99E	126	0.495
	100E	1260	4.904
	102G	1307	7.117

TABLE IV

SPECIES OF INVERTEBRATES TAKEN BY TRAWL FROM YAKUTAT BAY, NOVEMBER 1979

Phylum Cnidaria
- Class Anthozoa
  - Order Alcyonacea
    - Family Pennatulidae
      - *Stylatula gracile* (Gabb)

Phylum Mollusca
- Class Bivalvia
  - Family Pectinidae
    - *Pecten caurinus* Gould
- Class Gastropoda
  - Family Neptuneidae
    - *Neptunea lyrata* (Gmelin)

Phylum Arthropoda
- Class Crustacea
  - Order Decapoda
    - Family Pasiphaeidae
      - *Pasiphaea pacifica* Rathbun
    - Family Pandalidae
      - *Pandalus borealis* Kröyer
      - *Pandalus hypsinotus* Brandt
      - *Pandalus danae* Stimpson
      - *Pandalopsis dispar* Rathbun
    - Family Hippolytidae
      - *Eualus* spp.
    - Family Crangonidae
      - *Crangon dalli* (Rathbun)
    - Family Paguridae
      - *Pagurus aleuticus* (Benedict)
      - *Labidochirus splendescens* (Owen)
    - Family Lithodidae
      - *Paralithodes camtschatica* (Tilesius)
    - Family Majidae
      - *Chionoecetes bairdi* Rathbun
    - Family Cancridae
      - *Cancer magister* Dana

Phylum Echinodermata
- Class Asteroidea
  - Family Goniasteridae
    - *Ceramaster potagonicus* (Sladen)
    - *Mediaster aequalis* Stimpson

and 16.0 percent of the biomass, and Mollusca — 2 species and 14.8 percent of the biomass (Tables IV and V).

The mean biomass for all epifaunal species collected was 1.2 g/m^2 (data base for calculations on file at NODC).

The dominant arthropod was the Dungeness crab (*Cancer magister*) which contributed 88.1 percent of the arthropod biomass and 60.4 percent of the total invertebrate biomass (Table V). *Cancer* came from Stations 4A and 6A; the latter station yielded the greatest catch with 84 crab obtained/km of fishing (Appendix A).

The sea stars, *Ceramaster patagonicus* and *Pycnopodia helianthoides*, made up 94.3 percent of the echinoderm biomass and 15.1 percent of the total invertebrate biomass (Table V). *Pycnopodia* dominated the biomass, although only 9 organisms occurred (Appendix A).

Among the two mollusk species encountered, the scallop *Pecten caurinus* dominated. Station 4A yielded the only catch with 24 scallops/km of fishing (Appendix A).

BENTHIC INFAUNAL PROGRAM

Van Veen Grab

Thirty-four van Veen grab stations were sampled for benthic infauna in the offshore Gulf stations as well as in Yakutat Bay (Figs. 1 and 3). Sediments at these stations were primarily silts and clays (Table VI) and the fauna was dominated by polychaete annelids. The abundance of the infauna at these stations ranged from 32 individuals/m^2 in Station 7A within Yakutat Bay to 1704 individuals/m^2 in Station 103D on the outer shelf (Table VII). Biomass ranged from 1 g/m^2 (wet weight) in Station 7A to 303 g/m^2 in Station 2C (outer Yakutat Bay).

A cluster analysis using natural logarithm transformed abundance data (Fig. 4) delineated 5 station groups at the 35 percent similarity level. Three stations (7A, 106A and 97D) did not join any group. Station Group 1 consisted of 3 stations located in Yakutat Bay, an offshore station to the west of Yakutat Bay, a station off of Icy Bay and 10 stations southeast of

TABLE IV

CONTINUED

Phylum Echinodermata (cont'd)
- Family Porcellanasteridae
  - *Ctenodiscus crispatus* (Retzius)
- Family Echinasteridae
  - *Henricia* spp.
- Family Asteridae
  - *Pycnopodia helianthoides* (Brandt)
- Class Ophiuroidea
  - Family Gorgonocephalidae
    - *Gorgonocephalus caryi* (Lyman)

TABLE V

NUMBERS, WEIGHTS AND BIOMASS (g/m^2) OF THE MAJOR EPIFAUNAL TAXA OF MOLLUSCA, ARTHROPODA, AND ECHINODERMATA FROM YAKUTAT BAY, NOVEMBER 1979

Phylum	Percent of total weight	Taxon	Number of organisms	Wet weight (g)	Percent of[1] total weight	Percent of phylum weight	Mean biomass per square meter ($\bar{x}$ g/m^2)
Mollusca	14.8	*Pecten caurinus*	90	16300	14.8	99.5	0.18
Arthropoda	68.6	*Pandalus borealis*	238	1695	1.5	2.2	0.02
		Pandalopsis dispar	218	2812	2.5	3.7	0.03
		Chionoecetes bairdi	32	2778	2.5	3.7	0.03
		Cancer magister	151	66700	60.4	88.1	0.72
		Total	639	73985	67.0	97.7	0.80
Echinodermata	16.0	*Ceramaster patagonicus*	11	2529	2.3	14.3	0.03
		Pycnopodia helianthoides	9	14100	12.8	79.9	0.15
		Total	20	16629	15.1	94.3	0.18
Grand total	99.4		749	106914	96.8	-	1.15

[1]Total weight of all epifauna = 110450 g.

TABLE VI

STATION LOCATIONS AND SEDIMENT DESCRIPTIONS FOR SAMPLES OF THE BENTHIC INFAUNA COLLECTED BY VAN VEEN GRAB, NOVEMER 1979

Station Number	Depth (m)	Latitude	Longitude	Sediment description
2C	148	59°37.7	140°06.7	Soft gray mud
3C	110	59°38.7	140°02.5	Very soft - almost soupy gray mud
4B	122	59°42.4	139°57.1	Soupy - soft gray mud with rocks mixed in
5C	79	59°41.6	139°53.2	Soupy gray mud with small rocks
6B	47	59°45.1	139°46.4	Soft gray/brown mud with gravel, rocks, and shell mixed in
7A	250	59°51.7	139°42.8	Soupy gray mud with gravel and rocks mixed in
7D	55	59°43.9	139°43.9	Soupy gray mud with very rough edged rocks mixed in
94B	58	59°50.1	141°51.8	Soft gray mud
95F	182	59°21.8	141°32.0	Soft gray mud with sand, gravel, and rocks mixed in
95H	326	59°09.5	141°33.6	Soft gray mud
96E	329	59°20.5	141°14.6	Compact gray mud
96F	347	59°13.5	141°18.6	Compact gray mud
97D	237	59°21.7	141.04.8	Compact gray mud with gravel, sand and small rocks mixed in. Some broken shell also
98D	146	59°19.2	140°47.0	Soft gray mud with sand, gravel, and small rocks mixed in
99E	136	59°17.0	140°33.8	Compact gray mud with gravel and rocks mixed in
100E	126	59°12.4	140°17.6	Compact gray mud with small rocks mixed in

TABLE VI

CONTINUED

Station Number	Depth (m)	Latitude	Longitude	Sediment description
100J	199	58°42.1	140°17.3	Compact gray mud with gravel mixed in
102K	188	58°42.0	139°47.8	Soft gray mud with gravel, rock, and broken, dead sponge mixed in
103B	152	59°17.6	139°32.6	Soft gray mud
103D	113	59°02.2	130°28.0	Compact gray mud
103F	150	58°49.4	139°29.6	Soft gray mud with clay - like lumps, occasional small rocks and dead sponge fragments
103I	261	58°32.2	139°32.6	Soft gray mud
104A	68	59°12.8	139°15.5	Soupy/soft gray mud
104B	91	59°05.1	139°13.5	Soft gray mud
104D	119	58°53.7	139°16.6	Soft gray mud with rocks up to 10 cm diameter
104G	164	58°34.2	139°20.3	Gray/black compact sand
105A	70	59°07.7	139°04.2	Soupy/soft gray mud
105C	146	58°54.6	139°00.9	Soft, but sticky gray mud
105E	228	58°45.2	139°02.5	Soft, gray mud
105F	130	58°38.4	139°02.7	Gray/black compact sand
105G	113	58°31.8	139°02.6	Gray/black compact sand
106A	58	59°05.8	138°47.3	Soupy/soft gray mud with broken shells (Macoma mostly)
106B	155	58°59.3	138°42.5	Soupy/soft gray mud
106G	87	58°30.0	138°54.1	Compact sand (reduced)

TABLE VII

THE ABUNDANCE, BIOMASS AND DIVERSITY OF BENTHIC GRAB SAMPLES ARRANGED BY STATION GROUPS

Station Group	Station	Abundance No/m^2	Biomass gm/m^2	No of Species	Species Richness	Brillouin Diversity	Brillouin Evenness
1	103B	700	139	51	7.63	3.08	0.82
	106B	1092	74	55	7.71	2.41	0.61
	105C	622	187	50	7.61	2.92	0.78
	104B	986	93	60	8.56	2.86	0.72
	103D	1704	56	70	9.27	2.43	0.59
	104D	1072	67	82	11.61	3.06	0.72
	103F	670	46	68	10.29	3.09	0.58
	105E	748	25	53	7.85	3.16	0.83
	98D	316	20	54	9.20	3.37	0.91
	2C	557	303	33	5.06	2.77	0.82
	4B	466	48	62	9.63	3.25	0.83
	3C	484	166	50	7.92	2.59	0.70
	94B	1116	142	91	12.82	2.94	0.68
	105A	942	32	60	8.61	3.17	0.80
	104A	1152	44	71	9.93	3.31	0.80
2	99E	534	41	79	12.42	3.27	0.80
	100E	488	41	82	13.08	3.51	0.85
	95F	466	15	62	9.92	2.71	0.70
	104G	932	29	77	11.12	3.15	0.76
	105F	1028	18	76	10.81	3.03	0.73
	100J	696	28	68	10.23	2.96	0.74
	102K	1278	44	88	12.16	3.11	0.72
3	96E	1395	33	52	7.04	2.36	0.61
	103I	1032	47	62	8.79	2.91	0.73
	95H	440	80	52	8.37	2.75	0.74
	96F	454	9	36	5.72	2.36	0.69
4	6B	144	46	26	5.03	2.53	0.85
	7D	188	22	32	5.92	2.66	0.84
	5F	560	91	62	9.62	3.55	0.83

TABLE VII

CONTINUED

Station Group	Station	Abundance No/m^2	Biomass gm/m^2	No of Species	Species Richness	Brillouin Diversity	Brillouin Evenness
5	105G	674	22	72	10.90	2.95	0.73
	106G	374	53	41	6.75	2.73	0.78
DNC	106A	428	40	41	6.60	2.78	0.79
DNC	7A	32	1	9	2.30	1.41	0.77
DNC	97D	238	15	52	9.31	3.31	0.92

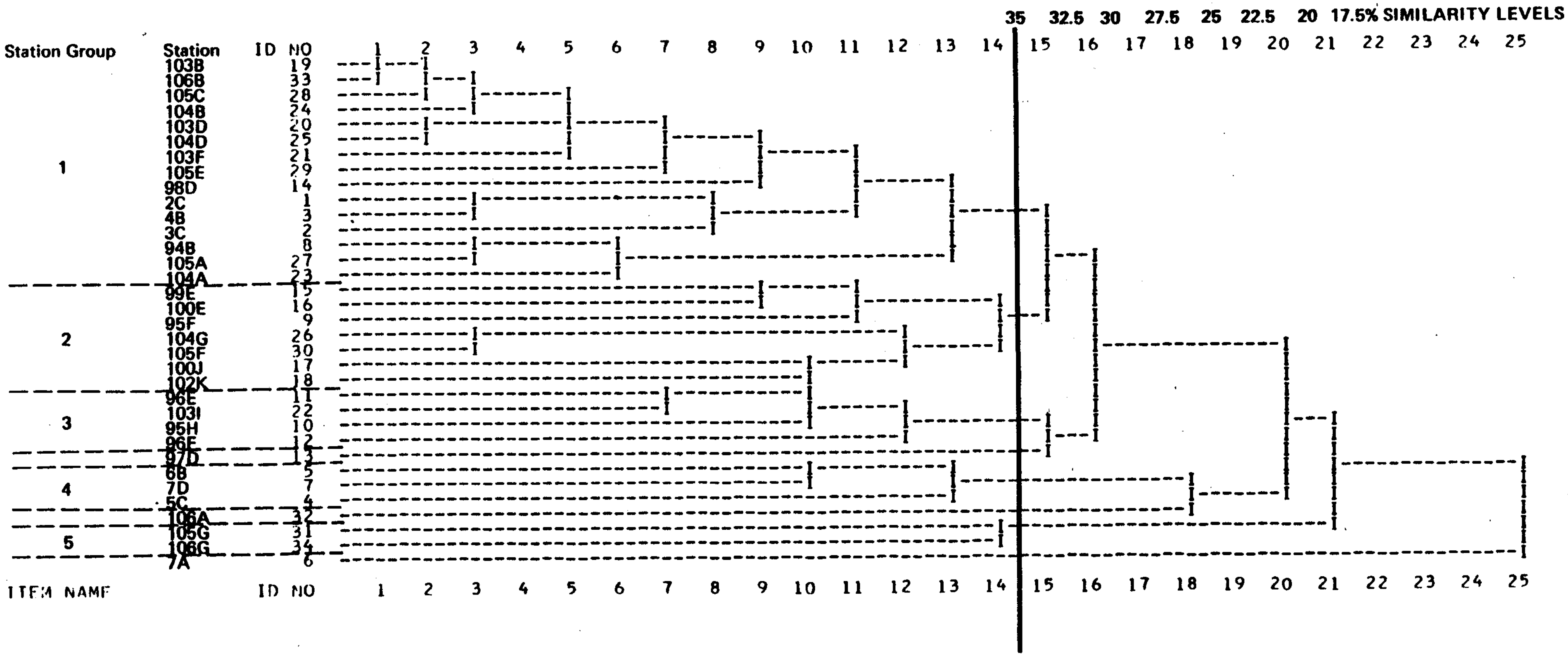

Figure 4. Dendrogram produced by a cluster analysis of *ln* transformed abundance data from benthic grab samples. Stations are linked by vertical bars of progressively lower similarity levels until all stations are joined. Station groups formed at the 35% similarity level (dark vertical line) are separated by dashed lines.

Yakutat Bay (Fig. 5). Station Group 2 consisted of 7 stations, many of which occurred offshore of the stations in Station Group 1. Station Group 3 consisted of 4 stations outside of the 180 m contour; 3 of these stations were located at the mouth of the Yakutat Bay trough and 1 at the mouth of the Dry Bay trough. Station Group 4 consisted of 3 stations in Yakutat Bay and Station Group 5 was composed of 2 offshore stations located south of Dry Bay which had a sandy substrate (Fig. 5; Tables VI and VII). Stations Groups 1 and 2 joined to form a single station group at the 32.5 percent similarity level (Fig. 4) and Station Group 3 plus Station 97D were linked with Station Groups 1 and 2 at the 30 percent similarity level. However, Station Groups 4 and 5 did not join the other station groups until the 20 and 17.5 percent similarity levels, respectively. This indicates that Station Groups 1, 2 and 3, and Station 97D were considerably more similar to each other in terms of these species composition than they were to Station Groups 4 and 5.

An inverse cluster analysis using *ln* transformed abundance data delineated 61 species groups (Table VIII) at the 41 percent similarity level (Fig. 6). Many of the species groups contained species which occurred at only one or two stations and since they have little effect on formation of station groups these will not be discussed here. The largest species group formed, Species Group 17, consisted of species which were present in all station groups and were most abundant in Station Groups 1, 2 and 3. The abundance of species in Species Group 17 was considerably reduced in Station Groups 4 and 5. The primary difference between stations in Station Groups 1 and 2 was the increased abundance of species from Species Group 17 in Station Group 1. Stations in Station Group 2 were also characterized by Species Groups 21 and 22 (Table IX) and they appeared to have a higher species richness than stations in Station Group 1 (Table VII). Station Group 3 was characterized by the presence of species in Species Group 34 as well as those of Species Group 17 (Table IX). Station Group 4 was characterized by species from Species Groups 53 and 54 and Station Group 5 was characterized by species from Species Group 23. Station 97D, which did not join any of the station groups (Fig. 4), was characterized by species from Species Groups 17, 21, 24 and 36. Station 106A was characterized

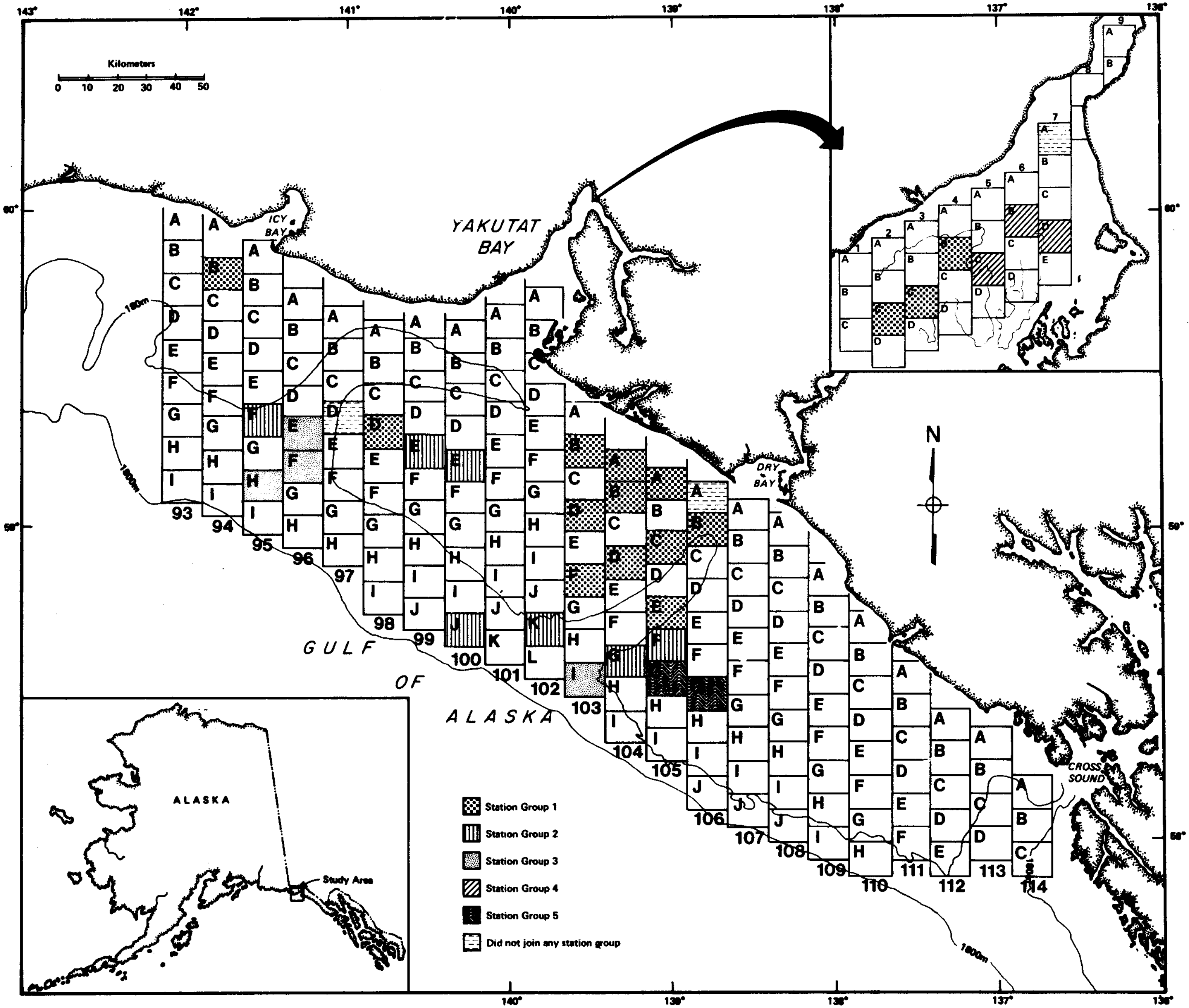

Figure 5. Distribution of stations in station groups formed by a cluster analysis of natural logarithm transformed abundance data from benthic van Veen grab samples.

TABLE VIII

SPECIES GROUPS FORMED BY CLUSTER ANALYSIS OF NATURAL LOGARITHM TRANSFORMED ABUNDANCE DATA FROM BENTHIC GRAB SAMPLES

SPECIES GROUPS	
SPECIES GROUP 1	
	Trophonopsis pacificus
	Leucosyrinx circinata
	Yoldia montereyensis
SPECIES GROUP 2	
	Scalibregma inflatum
	Polinices pallida
SPECIES GROUP 3	
	Capitella capitata
	Epitonium caamanoi
SPECIES GROUP 4	
	Tharyx sp.
	Ampharete acutifrons
SPECIES GROUP 5	
	Nereis zonata
	Yoldia amygdalea
SPECIES GROUP 6	
	Axiothella rubrocincta
	Diastylis alaskensis
	Macoma moesta alaskana
SPECIES GROUP 7	
	Onuphis elegans
	Drilonereis falcata minor
SPECIES GROUP 8	
	Tauberia gracilis
	Ampelisca macrocephala
	Spiophanes cirrata
	Byblis sp.
	Magelona pacifica
	Diastylopsis dawsoni
	Lumbrineris luti

TABLE VIII

CONTINUED

SPECIES GROUPS

SPECIES GROUP 9

Cylichna occulta
Photis sp.
Lumbrineris bicirrata
Lysippe labiata

SPECIES GROUP 10

Nephtys ferruginea
Paraphoxus daubious
Praxillella affinis
Melinna elisabethae

SPECIES GROUP 11

Heteromastus filiformis

SPECIES GROUP 12

Suavodrillia kennicottii
Anonyx nugax
Pista elongata

SPECIES GROUP 13

Alvinia compacta
Anonyx ochoticus
Astarte montagui
Tachyrynchus lacteolus

SPECIES GROUP 14

Asychis disparidentata
Astarte polaris
Oenopota sp.

SPECIES GROUP 15

Asychis similis
Cardiomya planetica

SPECIES GROUP 16

Maldane sarsi

TABLE VIII

CONTINUED

SPECIES GROUPS

SPECIES GROUP 17

Goniada annulata
Laonice cirrata
Odontogena borealis
Ophiura sarsi
Terebellides stroemi
Thyasira flexuosa
Myriochele heeri
Axinopsida serricata
Nucula tenuis
Psephidia lordi
Ninoe gemmea
Diamphiodia craterodmeta
Onuphis iridescens
Axinopsida viridis
Praxillella gracilis
Heterophoxus oculatus
Glycera capitata
Cyclocardia ventricosa
Sternaspis scutata

SPECIES GROUP 18

Cylichna alba
Dentalium sp.
Ammotrypane aulogaster

SPECIES GROUP 19

Solariella obscura

SPECIES GROUP 20

Ctenodiscus crispatus

SPECIES GROUP 21

Aricidea suecica
Notoproctus pacificus
Euchone analis
Owenia fusiformis

SPECIES GROUP 22

Nuculana radiata
Harpiniopsis excavata
Golfingia margaritacea

TABLE VIII

CONTINUED

SPECIES GROUPS

SPECIES GROUP 23

Phascolion strombi

SPECIES GROUP 24

Hanleya hanleyi

SPECIES GROUP 25

Stylatula gracile
Eudorella emarginata

SPECIES GROUP 26

Molpadia intermedia

SPECIES GROUP 27

Cardiomya pectenata

SPECIES GROUP 28

Cerithiopsis sp.
Arctomelon stearnsii
Bittium sp.

SPECIES GROUP 29

Prionospio malmgreni
Chaetozone setosa
Travisia sp.
Cirratulus cirratus
Paraphoxus sp.
Megalomma splendida
Ampelisca birulai

SPECIES GROUP 30

Harmothoe lunulata
Travisia forbesii

SPECIES GROUP 31

Ampharete arctica
Urothoe denticulata
Crenella dessucata

SPECIES GROUP 32

Haploscoloplos elongatus
Aricidea lopezi

TABLE VIII

CONTINUED

SPECIES GROUPS

SPECIES GROUP 33

Eudorella pacifica
Nicippe tumida
Diastylis paraspinulosa

SPECIES GROUP 34

Nuculana conceptionis
Cadulus tolmei
Dacrydium pacificum
Aglaophamus rubella anops
Gnathia trilobata
Axinopsida cf. serricata

SPECIES GROUP 35

Mysella planata

SPECIES GROUP 36

Caryophyllia sp.
Puncturella cooperi
Brisaster townsendi
Chirodota sp.
Pecten caurinus
Terebratalina transversa
Hiatella arctica

SPECIES GROUP 37

Peisidice aspera
Paraphoxus robustus
Golfingia vulgaris
Microporina borealis
Idanthyrsus armatus
Laqueus californianus

SPECIES GROUP 38

Brada villosa
Ischnochiton albus

SPECIES GROUP 39

Glycinde picta
Maera danae
Dentalium dalli

TABLE VIII

CONTINUED

SPECIES GROUPS

SPECIES GROUP 40

Argis dentata

SPECIES GROUP 41

Pista sp.

SPECIES GROUP 42

Propebella turricula

SPECIES GROUP 43

Propeamussium alaskense
Anonyx sp.
Onuphis parva
Lumbrineris zonata
Amage anops

SPECIES GROUP 44

Hippomedon sp.
Lycodes brevipes

SPECIES GROUP 45

Leucon nasica
Campylaspis sp.

SPECIES GROUP 46

Amphictene auricoma
Mitrella sp.

SPECIES GROUP 47

Natica clausa

SPECIES GROUP 48

Periploma alaskana
Cadulus sp.

SPECIES GROUP 49

Aphrodita negligens
Paraphoxus oculatus

TABLE VIII

CONTINUED

SPECIES GROUPS

SPECIES GROUP 50

Cerebratulus sp.
Balanus hesperius

SPECIES GROUP 51

Amphissa columbiana

SPECIES GROUP 52

Yoldia myalis
Modiolus modiolus
Pinnixia sp.
Amphissa sp.
Haploops tubicola
Compsomyax subdiaphana
Balanus rostratus

SPECIES GROUP 53

Clinocardium ciliatum
Terebratulina unguicula
Mitrella gouldi

SPECIES GROUP 54

Nephtys punctata
Spiochaetopterus costarum
Melinna cristata
Nuculana fossa

SPECIES GROUP 55

Chaetoderma robusta
Macoma calcarea

SPECIES GROUP 56

Amphicteis gunneri
Turbonilla sp.
Yoldia thraciaeformis

SPECIES GROUP 57

Harmothoe imbricata
Colus halli
Pinnixia schmitti
Lumpenus maculatus

TABLE VIII

CONTINUED

SPECIES GROUPS

SPECIES GROUP 58

Theragra chalcogramma

SPECIES GROUP 59

Nephtys cornuta franciscana
Admete couthouyi

SPECIES GROUP 60

Gattyana sp.
Orchomene sp.
Bathymedon sp.
Ammodytes hexapterus
Westwoodilla sp.
Pandora filosa

SPECIES GROUP 61

Nicomache lumbricalis

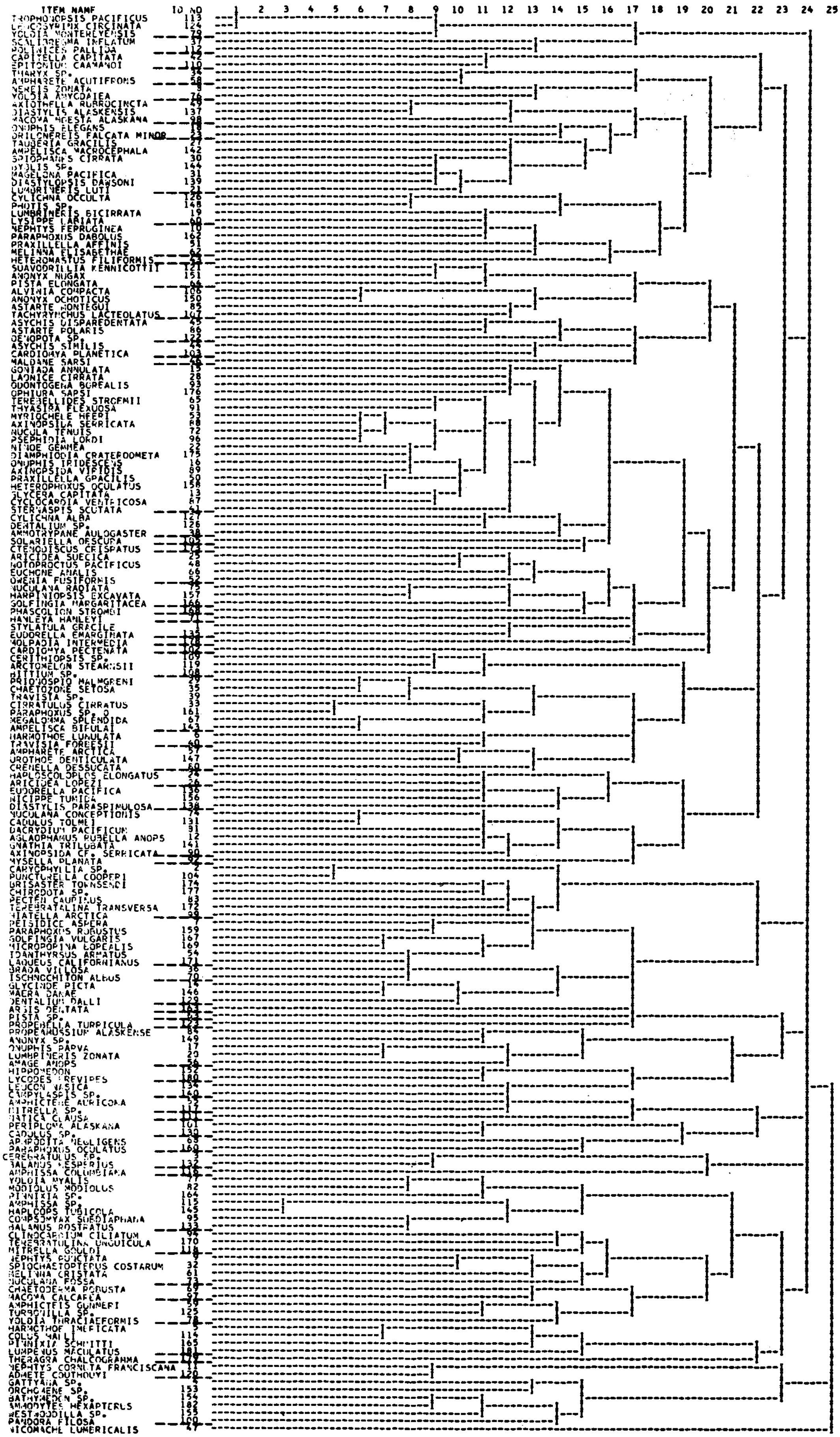

Figure 6. Dendrogram of species groups formed by an inverse cluster analysis of *ln* transformed abundance data.

TABLE IX

TWO WAY COINCIDENCE TABLE OF AVERAGE CELL DENSITY[1] COMPARING THE MAJOR SPECIES GROUPS AND THE STATION GROUPS FORMED BY A CLUSTER ANALYSIS OF *ln* TRANSFORMED ABUNDANCE DATA

Species Group	Station Group 1 (15)[2]	Station Group 2 (7)	Station Group 3 (4)	Station Group 4 (3)	Station Group 5 (2)	Station 106A (1)	Station 97D (1)	Station 7A (1)
8 (7)[2]	6.3	0.9	0.3	0.5	1.0	7.7	1.4	0.0
17 (19)	23.4	14.8	12.7	3.5	2.7	2.2	3.2	0.2
21 (4)	0.8	12.9	1.5	0.0	3.3	0.0	4.5	0.5
23 (1)	0.8	12.9	0.0	0.0	116.0	0.0	0.0	0.0
24 (1)	0.0	3.4	0.0	0.0	0.0	0.0	24.0	0.0
29 (7)	0.0	0.0	0.0	0.0	14.1	0.0	0.0	0.0
34 (6)	1.2	2.7	22.6	0.1	0.3	0.0	2.3	0.0
36 (7)	0.0	0.2	0.1	0.0	0.1	0.0	4.3	0.0
53 (3)	0.6	0.5	0.0	8.8	0.0	0.7	2.0	0.0
54 (4)	12.0	0.9	0.7	18.4	0.0	11.0	0.0	0.0

[1]Average cell density is a total of the abundance of all species in a species group in all stations of a station group divided by the number of stations and species in these groups.

[2]Numbers in parentheses represent the number of stations or species in the group.

by Species Groups 8 and 54 and Station 7A was notable for the low abundance, biomass and diversity of its fauna (Table IX).

A cluster analysis of untransformed abundance data (Figure 7) identified 5 stations groups at the 32 percent similarity level. These groups were quite similar to the station groups formed by a cluster analysis using *ln* transformed abundance data (Table X).

Principal coordinate analyses using the Czekanowski and Canberra "metric" similarity coefficients on both untransformed and *ln* transformed abundance data (Figs. 8, 9, 10 and 11) generally confirmed the results of cluster analyses (Figs. 4 and 7). Stations in the station groups delineated by cluster analyses formed loose groupings on the first and second coordinate axes (Figs. 8a, 9a and 10a) of all plots except Figure 11. Separation between station groups are not as apparent in the principal coordinate analysis using *ln* transformed abundance data and the Canberra "metric" coefficient (Figure 11). The use of the Canberra "metric" coefficient with untransformed abundance data greatly reduces the effect of differences in the abundance of species and stations are distinguished primarily on differences in faunal complement. Station Group 1 formed fairly distinct groupings on the first and second axes (Figs. 8a, 9a and 10a). However, the position (Figs. 8a, 9a, 10a and 11a) of Stations 2C, 3C and 4B (Yakutat Bay) between the majority of the stations in Group 1 and Station Group 4 (Yakutat Bay) indicates that these stations may be transitional between these 2 groups in terms of their fauna. An examination of the species assemblages in Stations 2C, 3C and 4B supports this contention. Stations 2C, 3C and 4B, as well as all stations in Station Group 4, are located in Yakutat Bay.

Pipe Dredge

A total of 34 stations was sampled via the pipe dredge; 29 offshore stations and 5 Yakutat Bay stations (Figs. 1 and 2). Pipe dredge samples from seven untrawlable stations (Stations 94G, 97F, 98F, 100J, 101I and K, and 103G) and one trawled station (Station 98F) were analyzed (identified and enumerated) in the proposed sale lease area (Priority Area 1), and are

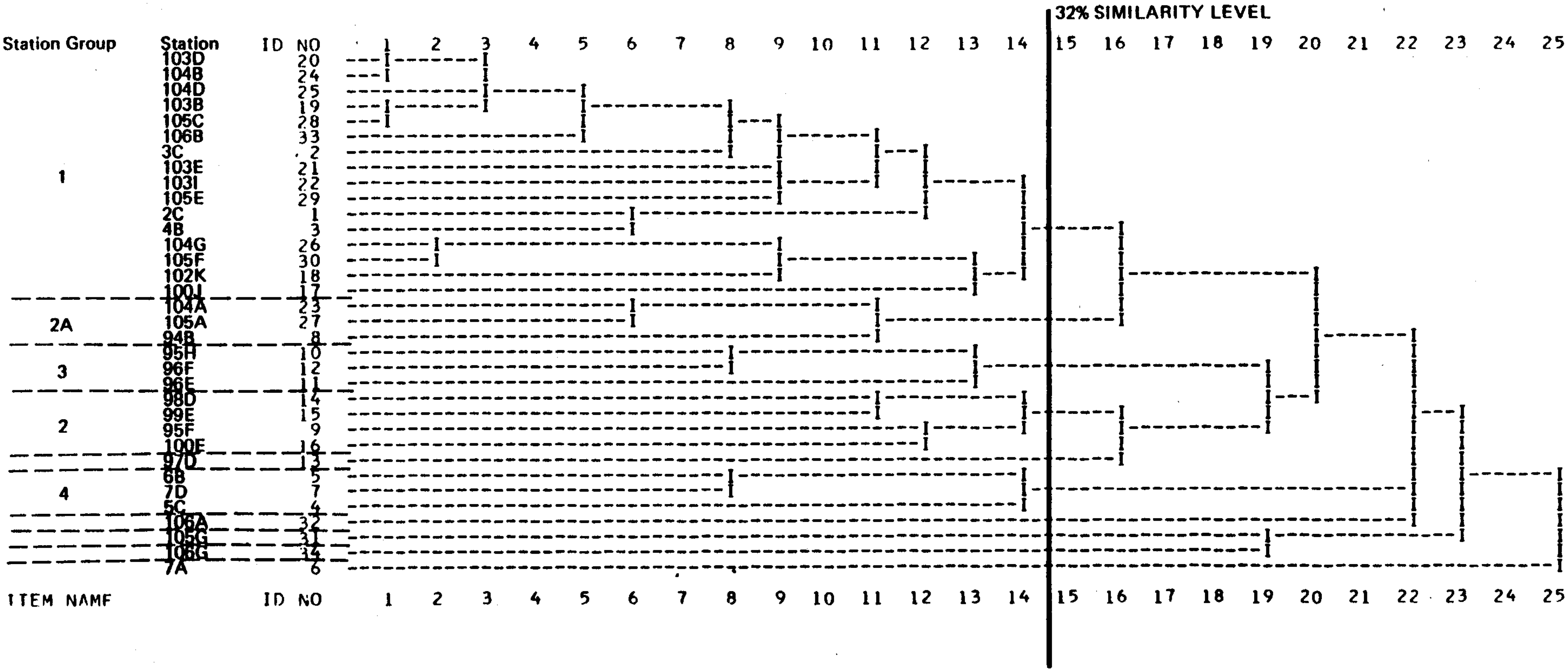

Figure 7. Dendrogram produced by a cluster analysis of untransformed abundance data from benthic grab samples. Station groups delineated at the 32% similarity level (dark vertical line) are separated by dashed lines.

TABLE X

COMPARISON OF STATION GROUPS FORMED BY CLUSTER ANALYSIS USING *ln* TRANSFORMED AND UNTRANSFORMED ABUNDANCE DATA

	ln transformed data	untransformed data
GROUP 1	2C	2C
	3C	3C
	4B	4B
	94B[1]	100J[1]
	98D[1]	102K[1]
	103B	103B
	103D	103D
	103F	103F
	104A	103I[1]
	104B	
	104D	104B
	105A[1]	104D
	105C	104G
	105E	105C
	106B	105E
		105F
		106B
GROUP 2	95F	95F
	99E	98D
	100E	99E
	100J[1]	100E
	102K[1]	
	104G[1]	
	105F[1]	
GROUP 2A		94B
		104A
		105A

TABLE X

CONTINUED

	ln transformed data	untransformed data
GROUP 3	95H	95H
	96E	96E
	96F	96F
	103I[1]	
GROUP 4	5C	5C
	6B	6B
	7D	7D
GROUP 5	105G[1]	
	106G[1]	

[1]Stations which were not classified in the same group by both cluster analysis routines (*ln* transformed and untransformed data).

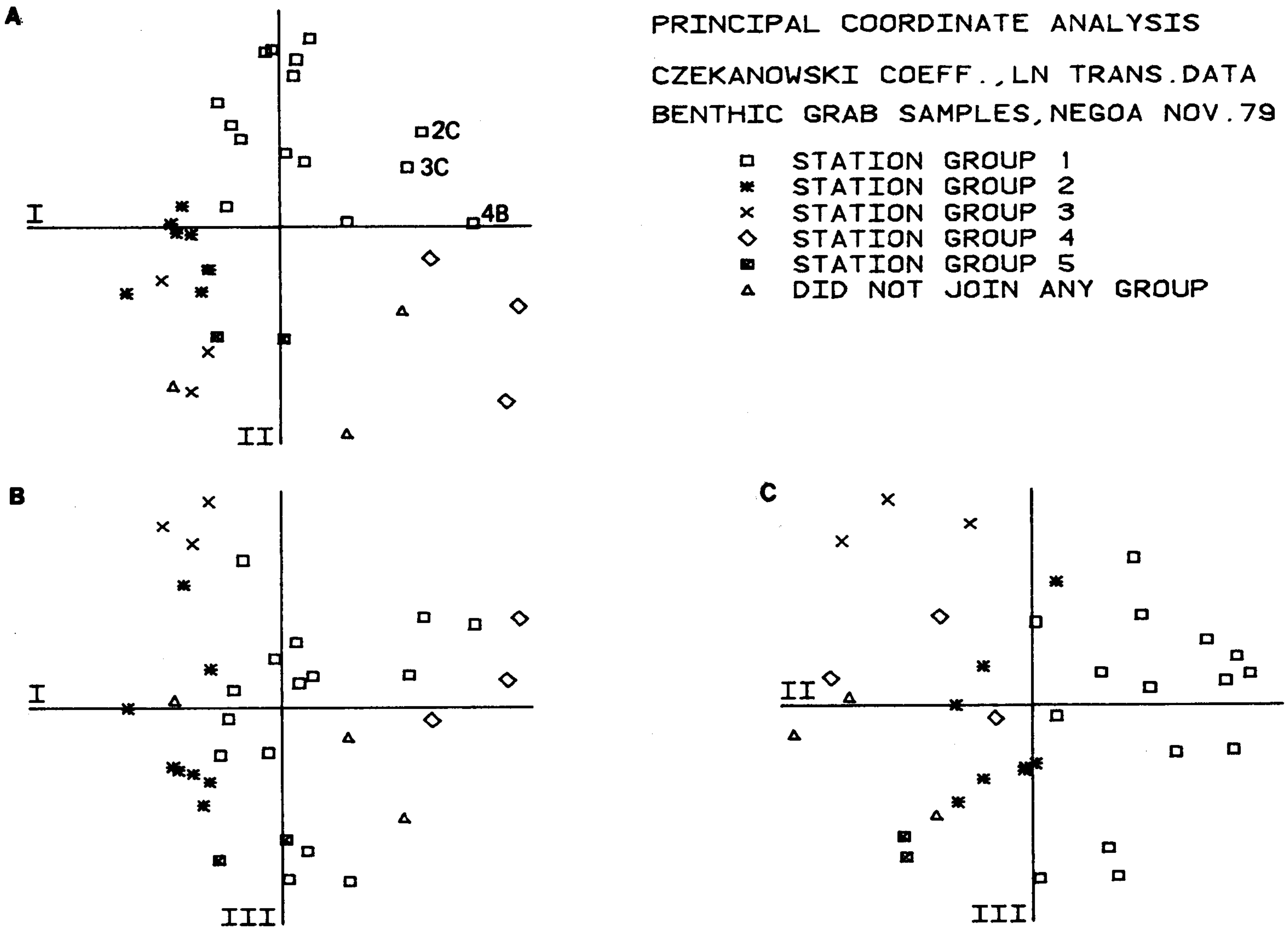

Figure 8. Plots of the first three coordinate axes of a principal coordinate analysis using Czekanowski similarity and *ln* transformed abundance data.

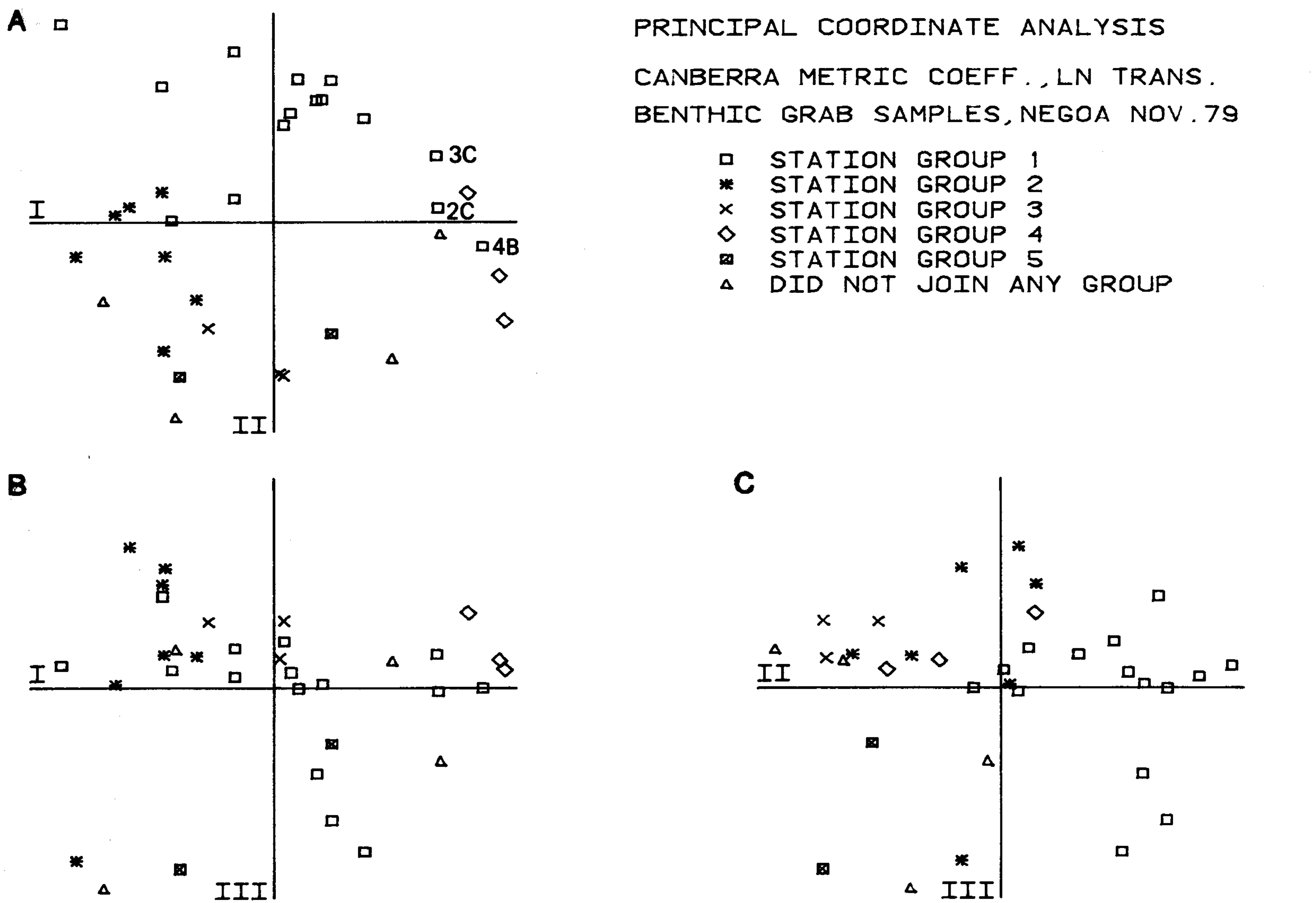

Figure 9. Plots of the first three coordinate axes of a principal coordinate analysis using Canberra metric similarity coefficient and *ln* transformed abundance data.

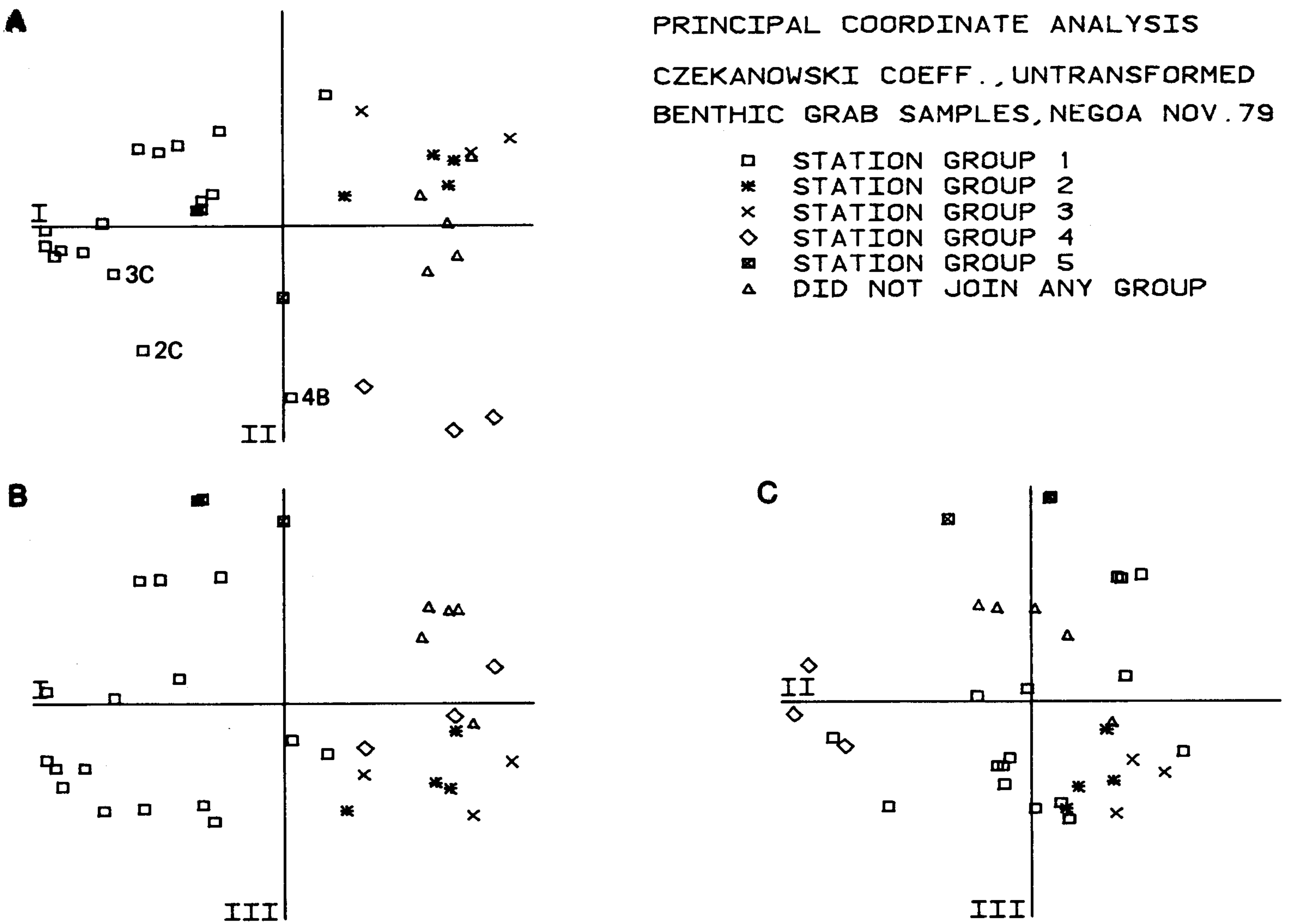

Figure 10. Plots of the first three coordinate axes of a principal coordinate analysis using Czekanowski similarity coefficient and untransformed abundance data.

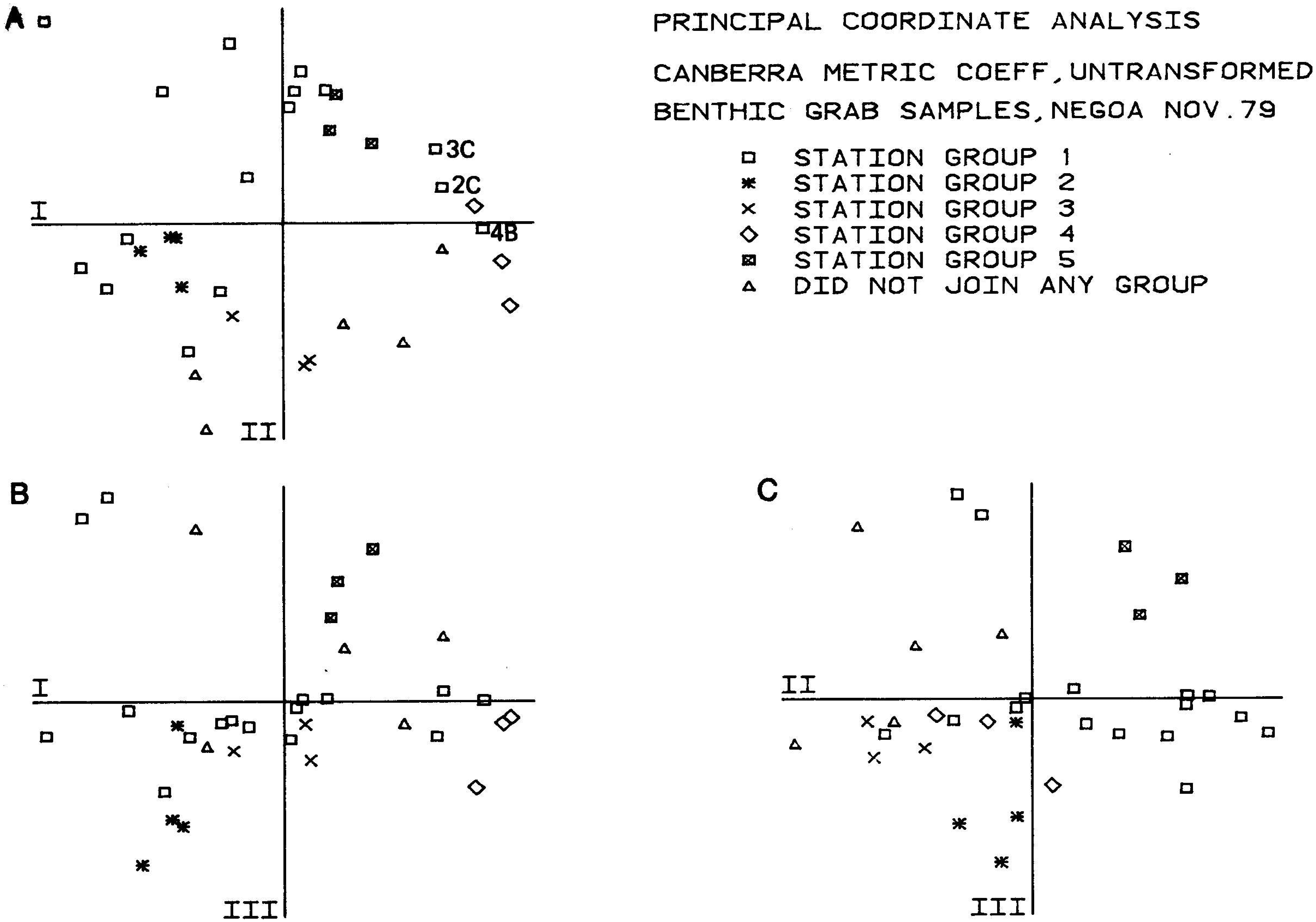

Figure 11. Plots of the first three coordinate axes of a principal coordinate analysis using Canberra metric similarity coefficient and untransformed abundance data.

presented in Appendix C. Four of the stations (97F, 98F, 100J, 103G) had previously been sampled with the van Veen grab. The remainder of the dredge station samples was roughly identified in the field to help characterize the stations. All samples were preserved and archived at the Institute of Marine Science, Fairbanks.

FISHES

Offshore Stations

A total of 64 species of fishes was collected from the offshore stations (Appendix A). Important fish families were Squalidae-sharks (5.9% of total fish biomass), Rajidae-skates (7.1%), Gadidae-cods (12.9%), Anoplopomidae-sablefish (15.7%), and Pleuronectidae-flatfishes (54.3%). Five species made up 71.5 percent of the fish biomass: arrowtooth flounder (*Atheresthes stomias*) — 31.5 percent of the total fish biomass; sablefish (*Anoplopoma fimbria*) — 15.7 percent; walleye pollock (*Theragra chalcogramma*) — 10.1 percent; Pacific halibut (*Hippoglossus stenolepis*) — 8.3 percent; and spiny dogfish (*Squalus acanthias*) — 5.9 percent (Table XI).

Arrowtooth flounder occurred in 40 of the 42 trawl stations. Stations 94A and 105B did not yield this flatfish species. Stations yielding the highest biomass came from the extreme ends of the proposed sale lease area; Stations 95F-H to the west and Stations 103I, 104G, and 105E to the east. These six stations yielded 59.4 percent of the arrowtooth flounder biomass. Station 104G produced the greatest catch with 2370 individuals (1638.5 kg) in a 30 minute tow or 800 fish per kilometer of fishing.

Sablefish (black cod) occurred in 34 (81%) of the offshore trawl stations. Stations 104G and 105F yielded 75.5 percent of the sablefish biomass. At Station 105F, 832 sablefish were caught per kilometer of fishing. The mean fish weight at Station 105F was 0.8 kg.

Walleye pollock occurred in 36 (85.7%) of the offshore trawl stations. Highest biomass stations were 95G and 96E; 83.2 percent of the total walleye pollock biomass. At Station 96E, 1018 individuals per kilometer of fishing were obtained. The mean fish weight at Station 96E was 0.4 kg.

TABLE XI

NUMBERS, WEIGHTS AND BIOMASS (g/m^2) OF THE MAJOR FISHES FROM THE OFFSHORE REGION OF THE NORTHEASTERN GULF OF ALASKA AND YAKUTAT BAY, NOVEMBER 1979

Taxon	Number of fishes		Wet weight (kg)		% of weight wet		$\bar{x}$ g/m^2	
	offshore	Yakutat	offshore	Yakutat	offshore[1]	Yakutat[2]	offshore[3]	Yakutat[4]
Squalus acanthias	610	44	1051.699	57.600	5.9	25.5	0.73	0.62
Raja binoculata	123	2	270.600	1.400	1.5	0.6	0.19	0.02
Raja rhina	61	3	275.677	11.400	1.6	5.0	0.19	0.12
Raja stellulata	221	12	536.143	95.300	3.0	42.2	0.37	1.03
Microgadus proximus	2457	42	327.072	2.030	1.8	0.9	0.23	0.02
Theragra chalcogramma	4502	78	1794.438	2.973	10.1	1.3	1.25	0.03
Anoplopoma fimbria	3332	2	2782.815	1.120	15.7	0.5	1.94	0.01
Atheresthes stomias	11886	21	5578.935	5.070	31.5	2.2	3.89	0.05
Glyptocephalus zachirus	2830	0	414.541	0	2.3	0	0.29	0
Hippoglossoides elassodon	1514	16	551.037	2.944	3.1	1.3	0.38	0.03
Hippoglossus stenolepsis	337	3	1472.567	18.600	8.3	8.2	1.03	0.20
Isopsetta isolepis	3200	26	776.724	5.500	4.4	2.4	0.54	0.06
Lepidopsetta bilineata	490	0	351.402	0	2.0	0	0.25	0
Parophrys vetulus	514	0	257.197	0	1.5	0	0.18	0

[1]Total wet weight - 17689.462 kg
[2]Total wet weight - 225.896 kg
[3]Total area fished - 1434232 m^2
[4]Total area fished - 92598 m^2

Pacific halibut occurred in 33 (78.6%) widely dispersed stations. Highest biomass occurred at Stations 106A and B, 98D, and 93C. These four stations yielded 38.5 percent of the halibut biomass. The mean weight of all halibut caught was 4.3 kg. Station 105F yielded 40 halibut that had an average weight of 2.1 kg.

Spiny dogfish occurred in 33 (78.6%) widely dispersed stations. The high biomass stations of 105G and 109A yielded 56.5 percent of the total spiny dogfish biomass. At Station 105G, 303 individuals were caught in a 30 minute tow. The mean weight at the latter station was 1.4 kg.

Yakutat Bay Stations

A total of 23 fish species was collected in the three Yakutat Bay trawl stations. Elasmobranchs dominated the fish catch yielding 76.8 percent of the fish biomass. Spiny dogfish (*Squalus acanthias*) and starry skate (*Raja stellulata*) dominated. Spiny dogfish occurred at all three stations and made up 25.5 percent of the fish biomass. Starry skate occurred only at Station 4A but accounted for 42.2 percent of the fish biomass in the bay (Table XI).

FEEDING STUDIES

Offshore Stations

An analysis of stomach contents from three species of invertebrates and 20 species of fishes is presented here. Ten of the species of fishes were members of the family Pleuronectidae. The percent frequency of occurrence of food items was calculated for both the total number of stomachs examined and for only those which contained food. Major food groups found in stomachs are listed in Table XII while Table XIII contains all prey items identified to the lowest taxon possible.

The arrowtooth flounder (*Atheresthes stomias*) primarily consumed small fishes such as walleye pollock (*Theragra chalcogramma*) and eulachon (*Thaleichthys pacificus*); shrimps, including *Pandalus* spp., were second in frequency of occurrence as food items among arrowtooth flounders. Rex sole (*Glyptocephalus zachirus*) were found to prey mainly on polychaete worms,

TABLE XII

MAJOR FOOD GROUPS FOUND IN STOMACHS OF SELECTED FISHES AND INVERTEBRATES FROM THE NORTHEASTERN GULF OF ALASKA, EXCLUDING YAKUTAT BAY, NOVEMBER 1979

Numbers in parenthesis are numbers of predators containing that prey item

Stomach contents	Percent frequency of occurrence based on: Stomachs with food	Percent frequency of occurrence based on: Total stomachs	Size (cm)[1] $\bar{x}$ ± S.D.
Fishes			
Atheresthes stomias (Arrowtooth flounder)	N = 120	N = 250	36.6±11.3 (total length)
Empty (130)	-	52.0	
Pisces (76)	63.3	30.4	
Shrimp (35)	29.2	14.0	
Other Crustacea (12)	10.0	4.8	
Glyptocephalus zachirus (Rex sole)	N = 195	N = 218	28.2±5.9 (total length)
Polychaeta (142)	72.8	65.1	
Amphipoda (66)	33.8	30.3	
Shrimp (40)	20.5	18.4	
Other Crustacea (25)	12.8	11.5	
Empty (23)	-	10.5	
Bivalves (16)	8.2	7.3	
Hippoglossoides elassodon (Flathead sole)	N = 96	N = 168	32.5±8.4 (total length)
Empty (72)	-	42.9	
Ophiuroidea (62)	64.6	36.9	
Shrimp (31)	32.3	18.5	
Other Crustacea (15)	15.6	8.9	
Pisces (8)	8.3	4.8	
Isopsetta isolepis (Butter sole)	N = 53	N = 97	28.5±4.2 (total length)
Empty (44)	-	45.5	
Ophiuroidea (31)	58.5	32.0	
Polychaeta (13)	24.5	13.4	
Crustacea (11)	20.8	11.3	
Parophrys vetulus (English sole)	N = 67	N = 92	27.7±7.5 (total length)
Polychaeta (50)	74.6	54.4	
Empty (25)	-	27.2	
Ophiuroidea (19)	28.4	20.7	
Crustacea (12)	17.9	13.0	
Bivalves (7)	10.4	7.6	

TABLE XII

CONTINUED

Stomach contents	Percent frequency of occurrence based on: Stomachs with food	Percent frequency of occurrence based on: Total stomachs	Size (cm)[1] $\bar{x}$ ± S.D.
Microstomus pacificus (Dover sole)	N = 74	N = 89	37.9±6.1 (total length)
Ophiuroidea (66)	89.2	74.2	
Mollusca (34)	46.0	38.2	
Polychaeta (33)	44.6	37.1	
Empty (14)	-	15.7	
Crustacea (13)	17.6	14.6	
Hippoglossus stenolepis (Pacific halibut)	N = 49	N = 74	53.2±12.0 (total length)
Pisces (29)	49.2	39.2	
Empty (25)	-	33.8	
Chionoecetes bairdi (18)	36.7	24.3	
Other Crustacea (11)	22.5	14.9	
Ophiuroidea (5)	10.2	6.8	
Cephalopoda (5)	10.2	6.8	
Platichthys stellatus (Starry flounder)	N = 22	N = 31	44.9±5.9 (total length)
Ophiuroidea (20)	90.9	64.5	
Empty (9)	40.9	29.0	
Mollusca (2)	9.1	6.5	
Unid. remains (1)	4.5	3.2	
Lepidopsetta bilineata (Rock sole)	N = 26	N = 32	30.1±7.6 (total length)
Crustacea (10)	38.5	31.3	
Ophiuroidea (9)	34.6	28.1	
Polychaeta (6)	23.1	18.8	
Empty (6)	23.1	18.8	
Pisces (4)	15.4	12.5	
Psettichthys melanostictus (Sand sole)	N = 4	N = 10	31.3±3.7 (total length)
Empty	-	60.0	
Pisces	100.0	40.0	

TABLE XII

CONTINUED

Stomach contents	Percent frequency of occurrence based on: Stomachs with food	Total stomachs	Size (cm)[1] $\bar{x}$ ± S.D.
Anoplopoma fimbria (Sablefish)	N = 57	N = 90	47.9±7.6 (fork length)
Empty (33)	-	36.7	
Pisces (20)	35.1	22.2	
Scyphozoa (15)	26.3	16.7	
Amphipoda (14)	24.6	15.6	
Other Crustacea (9)	15.8	10.0	
Cephalopoda (6)	10.5	6.7	
Theragra chalcogramma (Walleye pollock)	N = 39	N = 70	39.4±5.7 (total length)
Empty (31)	-	44.3	
Shrimp (22)	56.4	31.4	
Amphipoda (13)	33.3	18.6	
Other Crustacea (8)	20.5	11.4	
Pisces (5)	12.8	7.1	
Gadus macrocephalus (Pacific cod)	N = 15	N = 15	66.2±6.9 (total length)
Shrimp (12)	80.0		
Chionoecetes bairdi (9)	60.0		
Cephalopoda (9)	60.0		
Other Crustacea (8)	53.3		
Pisces (3)	20.0		
Sebastolobus alascanus (Shortspine thornyhead)	N = 41	N = 50	29.4±4.8 (total length)
Shrimp (37)	90.2	74.0	
Empty (9)	-	18.0	
Polychaeta (6)	14.6	12.0	
Pisces (6)	14.6	12.0	
Other Crustaceans (5)	12.2	10.0	
Sebastes aleutianus (Rougheye rockfish)	N = 8	N = 10	35.6±5.9 (total length)
Shrimp (6)	75.0	60.0	
Pisces (4)	50.0	40.0	
Empty (2)	-	20.0	

TABLE XII

CONTINUED

Stomach contents	Percent frequency of occurrence based on		Size (cm)[1]
	Stomachs with food	Total stomachs	$\bar{x}$ ± S.D.
Sebastes alutus (Pacific Ocean perch)	N = 10	N = 10	37.8±6.2 (total length)
Empty (10)	100.0		
Sebastes paucispinis (Bocaccio)	N = 5	N = 6	40.0±3.4 (total length)
Unid. remains (5)	100.0	83.3	
Empty (1)	-	16.7	
Squalus acanthias (Spiny dogfish)	N = 25	N = 43	71.3±5.1 (total length)
Pisces (19)	76.0	44.2	
Empty (18)	-	41.9	
Shrimp (13)	52.0	30.2	
Other (7)	28.0	16.3	
Dasycottus setiger (Spinyhead sculpin)	N = 57	N = 60	9.42±3.4 (total length)
Crustacea (55)	96.5		
Polychaeta (16)	28.1		
Pisces (7)	12.3		
Unknown material (4)	7.0		
empty (2)	3.5		
Malacocottus kincaidi (Blackfin sculpin)	N = 40	N = 40	10.3±2.5 (total length)
Crustacea (40)	100.0		
Polychaeta (27)	67.5		
Porifera (9)	22.5		
Cnidaria (7)	17.5		
Foraminifera (3)	7.5		
Mollusca (3)	7.5		
Pisces (2)	5.0		

TABLE XII

CONTINUED

Stomach contents	Percent frequency of occurrence based on		Size (cm)[1]
	Stomachs with food	Total stomachs	$\bar{x}$ ± S.D.
Invertebrates			
Pycnopodia helianthoides (Sunflower sea star)	N = 36	N = 61	
Empty (25)	-		
Gastropoda (18)	50.0	29.5	
Ophiuroidea (18)	50.0	29.5	
Bivalves (16)	44.4	26.2	
Unid. remains (6)	16.7	9.8	
Crustacea (6)	16.7	9.8	
Cancer magister (Dungeness crab)	N = 14	N = 20	13.8±1.1 (carapace width)
Bivalves (14)	100.0	70.0	
Hydrozoa (10)	71.4	50.0	
Ophiuroidea (8)	57.1	40.0	
Polychaeta (7)	50.0	35.0	
Crustacea (6)	42.9	30.0	
Empty (6)	-	30.0	
Chionoecetes bairdi (Snow crab)	N = 120	N = 140	3.2±1.6 (carapace width)
Polychaeta (105)	87.5	75.0	
Mollusca (94)	78.3	67.1	
Foraminifera (80)	66.7	57.1	
Crustacea (77)	64.2	55.0	
Ophiuroidea (64)	53.3	45.7	
Diatoms (54)	45.0	38.6	
Sponge spicules (43)	35.8	30.7	
Unid. material (30)	25.0	21.4	
Empty (20)	-	14.3	

[1]Based on total stomachs examined.

TABLE XIII

INDIVIDUAL TAXA FOUND IN STOMACHS OF SELECTED FISHES AND INVERTEBRATES FROM THE NORTHEASTERN GULF OF ALASKA, EXCLUDING YAKUTAT BAY, NOVEMBER 1979

Numbers in parenthesis are number of predators containing that prey item

Stomach contents[1]	Percent frequency of occurrence based on: Stomachs with food	Total stomachs
Fishes		
Atheresthes stomias (Arrowtooth flounder)	N = 120	N = 250
Empty (130)	-	52.0
Pisces (55)	45.8	22.0
Shrimp (21)	17.5	8.4
Theragra chalcogramma (walleye pollock) (19)	15.8	7.6
Euphausiacea (krill) (9)	7.5	3.6
Pandalidae (shrimps) (6)	5.0	2.4
Polychaeta (segmented worms) (3)	2.5	1.2
Chionoecetes bairdi (snow crab) (2)	1.7	0.8
Pandalus goniurus (humpy shrimp) (2)	1.7	0.8
Thaleichthys pacificus (eulachon) (2)	1.7	0.8
Pandalus jordani (ocean pink shrimp) (2)	1.7	0.8
Unid. remains (2)	1.7	0.8
Pandalus borealis (pink shrimp) (1)	0.8	0.4
Pandalopsis dispar (sidestripe shrimp) (1)	0.8	0.4
Eualus macrophthalma (shrimp) (1)	0.8	0.4
Crustacea (1)	0.8	0.4
Octopus sp. (1)	0.8	0.4
Rocks (1)	0.8	0.4
Glyptocephalus zachirus (Rex sole)	N = 195	N = 218
Polychaeta (130)	66.7	59.6
Amphipoda (61)	31.3	28.0
Empty (23)	11.8	10.5
Shrimp (22)	11.3	10.1
Pandalidae (14)	7.2	6.4
Chionoecetes bairdi (12)	6.1	5.5
Unid. remains (9)	4.6	4.1
Bivalves (8)	4.1	3.7
Nucula tenuis (bivalve) (6)	3.1	2.8
Crangonidae (6)	3.1	2.8
Ophiuroidea (brittle stars) (4)	2.1	1.8
Aphrodita sp. (polychaete) (4)	2.1	1.8
Mysidae (4)	2.1	1.8

TABLE XIII

CONTINUED

Stomach contents[1]	Percent frequency of occurrence based on: Stomachs with food	Total stomachs
Glyptocephalus zachirus (cont'd)		
Sipuncula (peanut worms) (3)	1.5	1.4
Golfingia sp. (Sipuncula) (3)	1.5	1.4
Ampeliscidae (Amphipoda) (3)	1.5	1.4
Crustacea (3)	1.5	1.4
Cumacea (3)	1.5	1.4
Sternaspis scutata (polychaete) (2)	1.0	0.9
Terebellides stroemi (polychaete) (1)	0.5	0.5
Goniada annulata (polychaete) (1)	0.5	0.5
Travesia sp. (polychaete) (1)	0.5	0.5
Neohella sp. (amphipod) (1)	0.5	0.5
Anonyx sp. (amphipod) (1)	0.5	0.5
Isopoda (1)	0.5	0.5
Crangon septemspinosa (1)	0.5	0.5
Pinnixa sp. (pea crab) (1)	0.5	0.5
Pagurus ochotensis (hermit crab) (1)	0.5	0.5
Delolepis gigantea (giant wry mouth) (1)	0.5	0.5
Psephidia lordi (bivalve) (1)	0.5	0.5
Yoldia sp. (bivalve) (1)	0.5	0.5
Ophiura sarsi (1)	0.5	0.5
Hippoglossoides elassodon (Flathead sole)	N = 96	N = 168
Empty (72)	-	42.9
Ophiura sarsi (52)	54.2	31.0
Pandalidae (17)	17.7	10.1
Shrimp (12)	12.5	7.1
Ophiuroidea (12)	12.5	7.1
Chionoecetes bairdi (8)	8.3	4.8
Euphausiacea (6)	6.3	3.6
Stichaeidae (pricklebacks) (5)	5.2	3.0
Pisces (2)	2.1	1.2
Hippolytidae (2)	2.1	1.2
Pandalopsis dispar (1)	1.0	0.6
Lumpenus maculatus (daubed shanny) (1)	1.0	0.6
Caprellidae (amphipod) (1)	1.0	0.6
Gastropoda (1)	1.0	0.6
Yoldia sp. (1)	1.0	0.6
Amphipoda (1)	1.0	0.6

TABLE XIII

CONTINUED

Stomach contents[1]	Percent frequency of occurrence based on: Stomachs with food	Total stomachs
Isopsetta isolepis (Butter sole)	N = 53	N = 97
Empty (44)	-	45.4
Ophiura sarsi (23)	43.4	23.7
Polychaeta (12)	22.6	12.4
Ophiuroidea (7)	13.2	7.2
Chionoecetes bairdi (5)	9.4	5.2
Unid. remains (3)	5.7	3.1
Amphipoda (2)	3.8	2.1
Pisces (2)	3.8	2.1
Diamphiodia periercta (ophiuroid) (1)	1.9	1.0
Aphrodita sp. (polychaete) (1)	1.9	1.0
Echiurus sp. (spoon worm) (1)	1.9	1.0
Crustacea (1)	1.9	1.0
Shrimp (1)	1.9	1.0
Isopoda (1)	1.9	1.0
Pagurus sp. (hermit crab) (1)	1.9	1.0
Nuculana fossa (bivalve) (1)	1.9	1.0
Lyonsia arenosa (bivalve) (1)	1.9	1.0
Parophrys vetulus (English sole)	N = 67	N = 92
Polychaeta (51)	76.1	55.4
Empty (25)	-	27.2
Ophiuroidea (18)	37.3	19.6
Ophiura sarsi (13)	19.4	14.1
Amphipoda (12)	17.9	13.0
Unid. remains (6)	9.0	6.5
Bivalves (3)	4.5	3.2
Macoma sp. (1)	1.5	1.1
Psephidia lordi (1)	1.5	1.1
Nucula tenuis (1)	1.5	1.1
Yoldia sp. (1)	1.5	1.1
Crangon sp. (shrimp) (1)	1.5	1.1
Microstomus pacificus (Dover sole)	N = 74	N = 89
Ophiuroidea (52)	70.3	58.4
Polychaeta (24)	32.4	27.0

TABLE XIII

CONTINUED

Stomach contents[1]	Percent frequency of occurrence based on: Stomachs with food	Total stomachs
Microstomus pacificus (cont'd)		
Yoldia sp. (16)	21.6	18.0
Empty (15)	-	17.0
Amphipoda (11)	14.9	12.4
Ophiura sarsi (9)	12.2	10.1
Scaphapoda (9)	12.2	10.1
Nucula tenuis (8)	10.8	9.0
Diamphiodia craterodmeta (ophiuroid) (7)	9.5	7.9
Bivalves (6)	8.1	6.7
Sternaspis scutata (polychaete) (5)	6.8	5.6
Periploma alaskana (bivalve) (4)	5.4	4.5
Cadulus sp. (scaphapod) (4)	5.4	4.5
Nephtys sp. (polychaete) (3)	4.1	3.4
Polynoidae (polychaete) (3)	4.1	3.4
Owenia fusiformis (polychaete) (3)	4.1	3.4
Pista cristata (polychaete) (2)	2.7	2.3
Goniada annulata (polychaete) (2)	2.7	2.3
Lumbrineris sp. (polychaete) (2)	2.7	2.3
Yoldia myalis (2)	2.7	2.3
Caprellidae (2)	2.7	2.3
Ophiopholis aculeata (ophiuroid) (1)	1.4	1.1
Asychis dispanidentata (polychaete) (1)	1.4	1.1
Nicomachinae (polychaete) (1)	1.4	1.1
Myriochele heeri (polychaete) (1)	1.4	1.1
Ammotrypane alogaster (polychaete) (1)	1.4	1.1
Glyceridae (polychaete) (1)	1.4	1.1
Ampharitidae (polychaete) (1)	1.4	1.1
Nephtys cornuta franciscana (polychaete) (1)	1.4	1.1
Etone longa (polychaete) (1)	1.4	1.1
Onuphis iridescens (polychaete) (1)	1.4	1.1
Chone cincta (polychaete) (1)	1.4	1.1
Terebellides stroemi (polychaete) (1)	1.4	1.1
Pectinidae (polychaete) (1)	1.4	1.1
Onuphis sp. (1)	1.4	1.1
Brada sp. (polychaete) (1)	1.4	1.1
Glycinde sp. (polychaete) (1)	1.4	1.1
Amphictene auricoma (polychaete) (1)	1.4	1.1
Prionospio malmgreni (polychaete) (1)	1.4	1.1
Sabellidae (polychaete) (1)	1.4	1.1

TABLE XIII

CONTINUED

Stomach contents[1]	Percent frequency of occurrence based on: Stomachs with food	Total stomachs
Microstomus pacificus (cont'd)		
Golfingia sp. (1)	1.4	1.1
Rhyncocoela (proboscis worm) (1)	1.4	1.1
Nuculana fossa (1)	1.4	1.1
Odontogena borealis (bivalve) (1)	1.4	1.1
Cardiomya sp. (bivalve) (1)	1.4	1.1
Psephidia lordi (1)	1.4	1.1
Shrimp (1)	1.4	1.1
Crangonidae (1)	1.4	1.1
Diastylis sp. (cumacea) (1)	1.4	1.1
Heterophoxis occulatus (amphipod) (1)	1.4	1.1
Lysianassidae (amphipod) (1)	1.4	1.1
Ampeliscidae (amphipod) (1)	1.4	1.1
Velutina velutina (gastropod) (1)	1.4	1.1
Harpiniopsis excavata (amphipod) (1)	1.4	1.1
Byblis sp. (Amphipoda) (1)	1.4	1.1
Oedicerotidae (Amphipoda) (1)	1.4	1.1
Chionoecetes bairdi (1)	1.4	1.1
Foraminifera (1)	1.4	1.1
Holothuroidea (1)	1.4	1.1
Ctenodiscus sp. (sea star) (1)	1.4	1.1
Anemone (1)	1.4	1.1
Nudibranchia (1)	1.4	1.1
Hippoglossus stenolepis (Pacific halibut)	N = 49	N = 74
Empty (25)	-	33.8
Chionoecetes bairdi (18)	36.7	24.3
Pisces (14)	28.6	18.9
Pleuronectidae (flat fishes) (8)	10.2	6.8
Octopus sp. (4)	8.2	5.4
Ammodytes hexapterus (Pacific sand lance) (3)	6.1	4.1
Gamaridae (amphipod) (3)	6.1	4.1
Ophiura sarsi (3)	6.1	4.1
Ophiuroidea (2)	4.1	2.7
Cottidae (sculpins) (1)	2.0	1.4
Glyptocephalus zachirus (1)	2.0	1.4
Elassochirus sp. (hermit crab) (1)	2.0	1.4
Pagurus ochotensis (hermit crab) (1)	2.0	1.4

TABLE XIII

CONTINUED

Stomach contents[1]	Percent frequency of occurrence based on: Stomachs with food	Total stomachs
Hippoglossus stenolepis (cont'd)		
Hyas sp. (crab) (1)	2.0	1.4
Munida quadrispina (crab) (1)	2.0	1.4
Crangonidae (1)	2.0	1.4
Pandalus sp. (1)	2.0	1.4
Pandalus platyceros (spot shrimp) (1)	2.0	1.4
Isopoda (1)	2.0	1.4
Squid (1)	2.0	1.4
Actiniaria (sea anemone) (1)	2.0	1.4
Platichthys stellatus (Starry flounder)	N = 22	N = 31
Ophiuroidea (10)	45.5	32.3
Ophiura sarsi (10)	45.5	32.3
Empty (9)	-	29.0
Unid. remains (1)	4.5	3.2
Gastropoda (1)	4.5	3.2
Buccinum sp. (gastropod) (1)	4.5	3.2
Theragra chalcogramma (1)	4.5	3.2
Lepidopsetta bilineata (Rock sole)	N = 26	N = 32
Empty (6)	-	18.8
Ophiura sarsi (5)	19.2	15.6
Ophiuroidea (4)	15.4	12.5
Chionoecetes bairdi (4)	15.4	12.5
Gammariidae (3)	11.5	9.4
Pisces (3)	11.5	9.4
Amphipoda (2)	7.7	6.3
Crangonidae (2)	7.7	6.3
Unid. remains (2)	7.7	6.3
Ammodytes hexapterus (1)	3.8	3.1
Travesia sp. (polychaete) (1)	3.8	3.1
Glycera capitata (polychaete) (1)	3.8	3.1
Spionidae (polychaete) (1)	3.8	3.1
Onuphis sp. (1)	3.8	3.1
Aphrodita sp. (1)	3.8	3.1
Polychaeta (1)	3.8	3.1
Rhynchocoela (1)	3.8	3.1
Anonyx sp. (1)	3.8	3.1

TABLE XIII

CONTINUED

Stomach contents[1]	Percent frequency of occurrence based on: Stomachs with food	Total stomachs
Psettichthys melanostictus (Sand sole)	N = 4	N = 10
Empty (6)	-	60.0
Pisces (3)	75.0	30.0
Atheresthes stomias (1)	25.0	10.0
Anoplopoma fimbria (Sablefish)	N = 57	N = 90
Empty (33)	-	36.7
Pisces (15)	26.3	16.7
Scyphozoa (jelly fish) (15)	26.3	16.7
Amphipoda (12)	21.0	13.3
Shrimp (10)	17.5	11.1
Euphausiacea (7)	12.3	7.8
Squid (3)	5.3	3.3
Hippoglossoides elassodon (2)	3.5	2.2
Pleuronectidae (2)	3.5	2.2
Gamariidae (2)	3.5	2.2
Gonatus sp. (cephalopod) (2)	3.5	2.2
Unid. remains (2)	3.5	2.2
Clupea harengus (herring) (1)	1.8	1.1
Theragra chalcogramma (1)	1.8	1.1
Pandalidae (1)	1.8	1.1
Pandalus goniurus (1)	1.8	1.1
Euphausia pacifica (krill) (1)	1.8	1.1
Thysanoessa inermis (krill) (1)	1.8	1.1
Cumacea (1)	1.8	1.1
Munida quadrispina (1)	1.8	1.1
Octopus sp. (1)	1.8	1.1
Ophiuroidea (1)	1.8	1.1
Theragra chalcogramma (Walleye pollock)	N = 39	N = 70
Empty (31)	-	44.3
Shrimp (17)	43.6	24.3
Amphipoda (13)	33.3	18.6
Pisces (5)	12.8	7.1
Euphausiacea (5)	12.8	7.1
Pandalidae (3)	7.7	4.3

TABLE XIII

CONTINUED

Stomach contents[1]	Percent frequency of occurrence based on: Stomachs with food	Total stomachs
Theragra chalcogramma (cont'd)		
Eualus sp. (shrimp) (2)	5.1	2.9
Parathemisto pacifica (amphipod) (2)	5.1	2.9
Cumacea (2)	5.1	2.9
Unid. remains (2)	5.1	2.9
Thysanoessa sp. (1)	2.6	1.4
Gadus macrocephalus (Pacific cod)	N = 15	N = 15
Shrimp (11)	73.3	
Rocks (11)	73.3	
Chionoecetes bairdi (9)	60.0	
Munida quadrispina (6)	40.0	
Squid (5)	33.3	
Octopus sp. (4)	26.7	
Pisces (3)	20.0	
Crangonidae (2)	13.3	
Pandalus montagui (1)	6.6	
Hyas sp. (1)	6.6	
Rocinela sp. (isopod) (1)	6.6	
Echinodermata (1)	6.6	
Algae (1)	6.6	
Sebastolobus alascanus (Shortspine thornyhead)	N = 41	N = 50
Shrimp (23)	56.1	46.0
Empty (9)	-	18.0
Pandalidae (8)	19.5	16.0
Eualus sp. (5)	12.2	10.0
Polychaeta (5)	12.2	10.0
Hippolytidae (2)	4.9	4.0
Stichaeidae (2)	4.9	4.0
Zoarchidae (eel pouts) (2)	4.9	4.0
Pandalus borealis (1)	2.4	2.0
Pandalopsis dispar (1)	2.4	2.0
Eualus macrophthalma (1)	2.4	2.0
Cumacea (1)	2.4	2.0
Mysidae (1)	2.4	2.0
Neohella sp. (1)	2.4	2.0
Chionoecetes bairdi (1)	2.4	2.0

TABLE XIII

CONTINUED

Stomach contents[1]	Percent frequency of occurrence based on: Stomachs with food	Total stomachs
Sebastolobus alascanus (cont'd)		
Polynoidae (1)	2.4	2.0
Yoldia sp. (1)	2.4	2.0
Octopus sp. (1)	2.4	2.0
Pisces (1)	2.4	2.0
Pleuronectidae (1)	2.4	2.0
Unid. material (1)	2.4	2.0
Crab (1)	2.4	2.0
Sebastes aleutianus (Rougheye rockfish)	N = 8	N = 10
Shrimp (6)	75.0	60.0
Pisces (4)	50.0	40.0
Empty (2)	-	20.0
Mysidacea (1)	12.5	10.0
Squid (1)	12.5	10.0
Sebastes alutus (Pacific Ocean perch)		N = 10
Empty (10)		100.0
Sebastes paucispinis (Bocaccio)	N = 5	N = 6
Unid. remains (5)	100.0	83.3
Empty (1)	-	16.7
Squalus acanthias (Spiny dogfish)	N = 25	N = 43
Empty (18)	-	41.9
Pisces (10)	40.0	23.3
Pandalus jordani (4)	16.0	9.3
Thaleichthys pacificus (4)	16.0	9.3
Pleuronectidae (3)	12.0	7.0
Pandalidae (3)	12.0	7.0
Unid. remains (3)	12.0	7.0
Stichaeidae (2)	8.0	4.6
Atheresthes stomias (2)	8.0	4.6
Shrimp (2)	8.0	4.6
Hippolytidae (shrimp) (2)	8.0	4.6

TABLE XIII

CONTINUED

Stomach contents[1]	Percent frequency of occurrence based on	
	Stomachs with food	Total stomachs
Squalus acanthias (cont'd)		
Chionoecetes bairdi (2)	8.0	4.6
Octopus sp. (2)	8.0	4.6
Spirontocarus sp. (shrimp) (1)	4.0	2.3
Crangonidae (1)	4.0	2.3
Dasycottus setiger (Spinyhead sculpin)	N = 57	N = 58
Natantia (shrimp) (21)	36.8	36.2
Crustacea (18)	31.6	31.0
Polynoidae (polychaete) (15)	26.3	25.9
Mysidacea (15)	26.3	25.9
Amphipoda (10)	17.5	17.2
Pandalidae (8)	14.0	13.8
Crangonidae (6)	10.5	10.3
Osteichthyes (fish) (5)	8.8	8.6
Crangon septemspinosa (shrimp) (4)	7.0	6.8
Pandalus montagui tridens (shrimp) (4)	7.0	6.8
Chionoecetes bairdi (4)	7.0	6.8
Unknown material (4)	7.0	6.8
Pandalus sp. (3)	5.3	5.2
Anonyx sp. (amphipod) (3)	5.3	5.2
Crangon sp. (shrimp) (3)	5.3	5.2
Rhachotropis oculata (isopod) (2)	3.5	3.4
Orchomene sp. (amphipod) (1)	1.8	1.7
Polychaeta (1)	1.8	1.7
Nuculana sp. (bivalve) (1)	1.8	1.7
Cumacea (1)	1.8	1.7
Isopoda (1)	1.8	1.7
Crangon dalli	1.8	1.7
Argis alaskensis (shrimp) (1)	1.8	1.7
Lebbeus washingtonianus (shrimp) (1)	1.8	1.7
Pandalus jordani (1)	1.8	1.7
Reptantia (crab) (1)	1.8	1.7
Ophiuroidea (1)	1.8	1.7
Ammodytes hexapterus (fish) (1)	1.8	1.7
Cottidae (fish) (1)	1.8	1.7
Empty (1)	1.8	1.7

TABLE XIII

CONTINUED

Stomach contents	Percent frequency of occurrence based on	
	Stomachs with food	Total stomachs
Malacocottus kincaidi (Blackfin sculpin)	N = 40	N = 40
Rocks or sand (21)	52.5	
Polynoidae (19)	47.5	
Pandalidae (15)	37.5	
Crustacea (14)	35.0	
Natantia (shrimp) (14)	35.0	
Mysidacea (13)	32.5	
Diastylis sp. (cumacean) (11)	27.5	
Porifera (9)	22.5	
Plastic line (8)	20.0	
Meterythrops robusta (mysid) (7)	17.5	
Sertulariidae (Cnidaria) (6)	15.0	
Polychaeta (6)	15.0	
Lysianassidae (amphipod) (6)	15.0	
Unknown annual tissue (6)	15.0	
Rhachotropis sp. (amphipod) (5)	12.5	
Caprellidae (amphipod) (5)	12.5	
Amphipoda (4)	10.0	
Orchomene sp. (amphipod) (4)	10.0	
Pandalus sp. (4)	10.0	
Formainifera (3)	7.5	
Aphrodita sp. (3)	7.5	
Anonyx sp. (amphipod) (3)	7.5	
Melphidippidae (amphipod) (3)	7.5	
Stegocephalidae (amphipod) (3)	7.5	
Stenothoidae (amphipod) (3)	7.5	
Hydrozoa (2)	5.0	
Ampharetidae (polychaete) (2)	5.0	
Trochidae (gastropod) (2)	5.0	
Pseudomma truncata (mysid) (2)	5.0	
Cumacea (2)	5.0	
Gammaridae (2)	5.0	
Westwoodilla caecula (amphipod) (2)	5.0	
Hippolytidae (2)	5.0	
Heptacarpus sp. (shrimp) (2)	5.0	
Osteichthyes (fish) (2)	5.0	
Antinoella macrolepida (polychaete) (1)	2.5	
Cirratulidae (polychaete) (1)	2.5	
Glyceridae (polychaete) (1)	2.5	

TABLE XIII

CONTINUED

Stomach contents[1]	Percent frequency of occurrence based on: Stomachs with food	Total stomachs
Malacocottus kincaidi (cont'd)		
Goniada annulata (polychaete) (1)	2.5	
Glycera capitata (polychaete) (1)	2.5	
Pelecypoda (1)	2.5	
Pycnogonida (1)	2.5	
Gaetanus sp. (copepod) (1)	2.5	
Acanthomysis (mysid) (1)	2.5	
Holmesiella anomala (mysid) (1)	2.5	
Neomysis sp. (mysid) (1)	2.5	
Piastylidae (cumacean) (1)	2.5	
Leptostylis sp. (cumacean) (1)	2.5	
Isopoda (1)	2.5	
Bopyridae (isopod) (1)	2.5	
Gnathiidae (isopod) (1)	2.5	
Eusirus sp. (amphipod) (1)	2.5	
Anonyx nugax pacifica (amphipod) (1)	2.5	
Prachynella lodo (amphipod) (1)	2.5	
Hippomedon sp. (amphipod) (1)	2.5	
Socarnes bidenticulatus (amphipod) (1)	2.5	
Valettiopsis pentatus (amphipod) (1)	2.5	
Pardaliscidae (amphipod) (1)	2.5	
Nicippe tumida (amphipod) (1)	2.5	
Euphausia sp. (amphipod) (1)	2.5	
Decapoda (1)	2.5	
Crangonidae (1)	2.5	
Heptacarpus moseri (shrimp) (1)	2.5	
Reptantia (crab) (1)	2.5	
Unid. eggs (1)	2.5	
Plant material (1)	2.5	
<u>Invertebrates</u>		
Pycnopodia helianthoides (Sunflower sea star)	N = 37	N = 61
Empty (24)	-	39.3
Nuculana sp. (11)	29.7	18.0
Ophiuroidea (10)	27.0	16.4
Ophiura sarsi (9)	24.3	14.8
Unid. remains (6)	16.2	9.8
Mitrella gouldi (gastropod) (4)	10.8	6.6
Clinocardium ciliatum (bivalve) (4)	10.8	6.6

TABLE XIII

CONTINUED

Stomach contents[1]	Percent frequency of occurrence based on	
	Stomachs with food	Total stomachs
Pycnopodia helianthoides (cont'd)		
Buccinum polare (gastropod) (3)	8.1	4.9
Natica clausa (gastropod) (3)	8.1	4.9
Clinocardium californiense (3)	8.1	4.9
Aphrodita sp. (3)	8.1	4.9
Colus halli (gastropod) (2)	5.4	3.3
Neptunea lyrata (gastropod) (2)	5.4	3.3
Propebela sp. (gastropod) (2)	5.4	3.3
Chionoecetes bairdi (2)	5.4	3.3
Gastropoda (1)	2.7	1.6
Neptunea sp. (1)	2.7	1.6
Natica sp. (1)	2.7	1.6
Polinices pallida (gastropod) (1)	2.7	1.6
Pandora grandis (bivalve) (1)	2.7	1.6
Bivalve (1)	2.7	1.6
Musculus niger (bivalve) (1)	2.7	1.6
Clinocardium sp. (1)	2.7	1.6
Macoma sp. (1)	2.7	1.6
Amphipoda (1)	2.7	1.6
Cancer sp. (1)	2.7	1.6
Pagurus ochotensis (1)	2.7	1.6
Holothuroidea (1)	2.7	1.6
Crangon sp. (1)	2.7	1.6
Plant material (1)	2.7	1.6
Cancer magister (Dungeness crab)	N = 14	N = 20
Bivalve (14)	100.0	70.0
Sediment (14)	100.0	70.0
Hydroids (10)	71.4	50.0
Ophiuroidea (9)	64.3	45.0
Empty (6)	42.9	30.0
Polychaeta (5)	35.7	25.0
Crustacea (3)	21.4	15.0
Unid. animal tissue (3)	21.4	15.0
Crab (3)	21.4	15.0
Plant material (3)	21.4	15.0
Amphipoda (2)	14.3	10.0

TABLE XIII

CONTINUED

Stomach contents[1]	Percent frequency of occurrence based on: Stomachs with food	Total stomachs
Cancer magister (cont'd)		
Isopoda (3)	21.4	15.0
Pisces (2)	14.3	10.0
Lumbrineridae (polychaete) (2)	14.3	10.0
Polyplacophora (chiton) (1)	7.1	5.0
Polynoidae (1)	7.1	5.0
Ampharetidae (polychaete) (1)	7.1	5.0
Spionidae (polychaete) (1)	7.1	5.0
Chionoecetes bairdi (Snow crab)	N = 120	N = 140
Foraminifera (80)	66.7	57.1
Ophiuriodea (63)	52.5	45.0
Bivalvia (56)	46.7	40.0
Polychaeta (54)	45.0	38.6
Cosinodisceae (diatom) (52)	43.3	37.1
Sponge spicules (43)	35.8	30.7
Maldanidae (polychaete) (43)	35.8	30.7
Crustacea (42)	35.0	30.0
Nucula sp. (39)	32.5	27.9
Nephthyidae (polychaete) (32)	26.7	22.9
Capitellidae (polychaete) (32)	26.7	22.9
Crab fragments (31)	25.8	22.1
Sabellidae (polychaete) (30)	25.0	21.4
Spionidae (polychaete) (39)	24.2	20.7
Lumbrineridae (polychaete) (26)	21.7	18.6
Empty (20)		14.3
Pisces (19)	15.8	13.6
Trochidae (18)	15.0	12.9
Unid. organic debris (18)	15.0	12.9
Gastropoda (15)	12.5	10.9
Unid. animal tissue (13)	10.8	9.3
Nematoda (11)	9.2	7.9
Onuphidae (polychaete) (10)	8.3	7.1
Polynoidae (polychaete) (9)	7.5	6.4
Scaphopoda (8)	6.7	5.7
Psephidia lordi (7)	5.8	5.0
Unid. plat material (7)	5.8	5.0
Amphipoda (6)	5.0	4.3

TABLE XIII

CONTINUED

Stomach contents[1]	Percent frequency of occurrence based on	
	Stomachs with food	Total stomachs
Chionoecetes bairdi (cont'd)		
Rhizosolenia sp. (diatom) (4)	3.3	2.9
Lumbrineris sp. (4)	3.3	2.9
Chionoecetes bairdi (4)	3.3	2.9
Nucula tenuis (3)	2.5	2.1
Unid. material (3)	2.5	2.1
Gramatophora sp. (diatom) (2)	1.7	1.4
Nereidae (2)	1.7	1.4
Goniadidae (2)	1.7	1.4
Goniada annulata (2)	1.7	1.4
Onuphis sp. (2)	1.7	1.4
Pennate diatoms (1)	0.8	0.7
Melosira sp. (diatom) (1)	0.8	0.7
Stephanopyxis sp. (diatom) (1)	0.8	0.7
Aphrodita sp. (1)	0.8	0.7
Nereis sp. (1)	0.8	0.7
Nephtys sp. (1)	0.8	0.7
Glyceridae (1)	0.8	0.7
Glycera capitata (1)	0.8	0.7
Scalibregmidae (polychaete) (1)	0.8	0.7
Pectinariidae (polychaete) (1)	0.8	0.7
Ampharetidae (polychaete) (1)	0.8	0.7
Terebellidae (polychaete) (1)	0.8	0.7
Solariella sp. (1)	0.8	0.7
Chiton (1)	0.8	0.7
Axinopsida sp. (1)	0.8	0.7
Cardiomya sp. (1)	0.8	0.7
Dentalium sp. (1)	0.8	0.7
Copepoda (1)	0.8	0.7
Nicippe tumida (Amphipod) (1)	0.8	0.7
Shrimp fragments (1)	0.8	0.7
Ophiura sarsi (1)	0.8	0.7
Holothurian plates (1)	0.8	0.7
Avian feathers (1)	0.8	0.7
Unid. eggs (1)	0.8	0.7

[1]Stomach contents are lowest level of identification.

including *Aphrodita* sp. and *Sternaspis scutata*; gammarid amphipods were second in frequency of occurrence. The brittle star (*Ophiura sarsi*) was the most frequent prey of flathead sole (*Hippoglossoides elassodon*); pandalid shrimps and other Crustacea, including snow crab, were secondary in occurrence. Butter sole (*Isopsetta isolepis*) mainly consumed *O. sarsi*. Unidentified polychaetes were second in frequency of occurrence in stomachs from the latter species. Polychaetes were also found to be the most frequent prey of English sole (*Parophrys vetulus*). Ophiuroids, including *O. sarsi*, were second in frequency of occurrence in stomachs from this species. Brittle stars, including *O. sarsi*, were also the most frequent prey of dover sole (*Microstomus pacificus*); bivalves, including *Yoldia* sp. and *Nucula tenuis*, and scaphopods, including *Cadulus* sp. were secondary in occurrence. Pacific halibut (*Hippoglossus stenolepis*) preyed mainly on small fishes, including other pleuronectids, sculpins (Cottidae), and the Pacific sand lance (*Ammodytes hexapterus*); second in frequency of occurrence among Pacific halibut were snow crab (*Chionoecetes bairdi*). The starry flounder (*Platichthys stellatus*) was also found to prey almost entirely on ophiuroids, including *O. sarsi*; gastropods and unidentified remains were of secondary importance. Rock sole (*Lepidopsetta bilineata*) preyed primarily on crustaceans, including snow crab and gammarid amphipods; brittle stars and polychaetes were second and third in frequency of occurrence, respectively. Sand sole (*Psettichthys melanostictus*) primarily consumed small fishes, including arrowtooth flounders. The sablefish (*Anoplopoma fimbria*) also preyed primarily on other fishes (including pleuronectids, herring [*Clupea harengus pallasi*] and walleye pollock) and on jellyfishes (Scyphozoa). The sable fish (15) that contained jellyfishes seldom contained other prey. Also, all 15 stomachs were full of this unlikely prey. Amphipods and other crustaceans were also important prey in sablefish. Walleye pollock consumed mainly unidentifiable shrimp, with amphipods and other small crustaceans occurring secondarily. Pacific cod (*Gadus macrocephalus*) consumed mainly unidentified shrimps, with snow crab and cephalopods occurring slightly less frequently. The shortspine thornhead (*Sebastolobus alascanus*) preyed almost entirely on shrimps, including Pandalidae and Hippolytidae. Rougheye rockfish (*Sebastes aleutianus*) also preyed primarily on unidentified shrimps.

Unidentified fishes were second in frequency of occurrence in stomachs from rougheye rockfish. All Pacific ocean perch (*Sebastes alutus*) examined were empty. Bocaccio (*Sebastes paucispinis*) contained unidentifiable animal remains; many were empty. Spiny dogfish (*Squalus acanthias*) also preyed mainly on fishes, including pleuronectids, eulachon, and pricklebacks (Stichaeidae). Pandalid and other shrimps were second in frequency of occurrence in spiny dogfish. The two sculpins, *Dasycottus setiger* and *Malacocottus kincaidi*, consumed mainly crustaceans, including shrimps, mysids, and amphipods; polychaetes, particularly polynoids were also important prey.

There was some tendency toward a spacial distribution in range and food habits for some of the species mentioned above. Rock sole, flathead sole, and English sole, occurring at stations farther from shore, consumed mainly ophiuroids. At more near-shore stations these same species consumed a much greater diversity of prey, including amphipods, polychaetes, shrimp and small bivalves. Butter sole, English sole, and starry flounders occurred more frequently at near-shore stations, while dover sole were generally found in deeper water (Feder and Jewett, unpub. OCSEAP data).

Yakutat Bay Stations

Two species of invertebrates and four species of fishes were analyzed for stomach contents from the three Yakutat Bay trawl stations (Table XIV).

Ten flathead sole from Station 4A were examined; four contained food. Two of the fish contained unidentifiable shrimp, one contained the side-stripe shrimp (*Pandalopsis dispar*), and one contained the protobranch clam (*Nuculana* sp.). Among the 20 butter sole examined only one contained food — a polychaete and a snail (*Mitrella gouldi*). Six starry flounder were examined but only one contained food. The food was unidentifiable. The seven out of nine spinyhead sculpin (*Dasycottus setiger*) with food in stomachs mainly contained shrimp.

Among the five out of nine sunflower sea stars (*Pycnopodia helianthoides*) with stomach contents, sediment was found in three of the individuals. *Mitrella gouldi* and the basket star (*Gorgonocephalus caryi*) occurred as food once.

TABLE XIV

INDIVIDUAL TAXA FOUND IN STOMACHS OF SELECTED FISHES AND INVERTEBRATES FROM YAKUTAT BAY, NOVEMBER 1979

Stomach contents	Percent frequency of occurrence based on: Stomachs with food	Total stomachs	Size (cm)[1] $\bar{x} \pm$ S.D.
Fishes			
Hippoglossoides elassodon (Flathead sole)	N = 4	N = 10	27.8±5.1 (total length)
Empty (6)	-	60.0	
Shrimp (2)	50.0	20.0	
Nuculana sp. (1)	25.0	10.0	
Pandalopsis dispar (1)	25.0	10.0	
Isopsetta isolepis (Butter sole)	N = 1	N = 20	27.98±4.6 (total length)
Empty (19)	-	95.0	
Polychaeta (1)	100.0	5.0	
Mitrella gouldi (1)	100.0	5.0	
Platichthys stellatus (Starry flounder)	N = 1	N = 6	43.7±5.2 (total length)
Unid. remains (1)	100.0	16.7	
Empty (5)	-	83.3	
Dasycottus setiger (Spinyhead sculpin)	N = 7	N = 9	11.0±3.3 (total length)
Shrimp (2)	28.6	22.2	
Empty (2)	28.6	22.2	
Polynoidea (1)	14.3	11.1	
Orchomene sp. (1)	14.3	11.1	
Pandalus borealis (1)	14.3	11.1	
Pandalidae (1)	14.3	11.1	
Crangon communis (1)	14.3	11.1	
Chionoecetes bairdi (1)	14.3	11.1	
Crustacea (1)	14.3	11.1	
Invertebrates			
Pycnopodia helianthoides (Sunflower sea star)	N = 5	N = 9	
Empty (4)	-	44.4	
Sediment (3)	75.0	33.3	
Mitrella gouldi (1)	20.0	11.1	
Gorgonocephalus caryi (1)	20.0	11.1	
Unid. material (1)	20.0	11.1	

TABLE XIV

CONTINUED

Stomach contents	Percent frequency of occurrence based on: Stomachs with food	Percent frequency of occurrence based on: Total stomachs	Size (cm)[1] $\bar{x}$ ± S.D.
Cancer magister (Dungeness crab)	N = 55	N = 57	14.1±2.1 (total length)
Sediment (55)	100.0	96.5	
Centric diatoms (40)	72.7	70.2	
Nuculana sp. (30)	54.5	52.6	
Yoldia sp. (21)	38.2	36.8	
Bivalvia (18)	32.7	31.6	
Unid. organic debris (16)	29.1	28.1	
Nephtyidae (14)	25.5	24.6	
Unid. animal tissue (12)	21.8	21.1	
Gastropoda (8)	14.5	14.0	
Foraminifera (6)	10.9	10.5	
Pennate diatoms (5)	9.1	8.8	
Polychaeta (5)	9.1	8.8	
Crab (5)	9.1	8.8	
Pisces (5)	9.1	8.8	
Shrimp (4)	7.3	7.0	
Capitellidae (Polychaeta) (4)	7.3	7.0	
Nematoda (3)	5.5	5.3	
Flagellates (3)	5.5	5.3	
Plant material (2)	3.6	3.5	
Empty (2)	3.6	3.5	
Lumbrineridae (1)	1.8	1.8	
Amphipoda (1)	1.8	1.8	
Pandalidae (1)	1.8	1.8	
Kinorhyncha (1)	1.8	1.8	
Mitrella sp. (1)	1.8	1.8	
Pinnixa sp. (1)	1.8	1.8	
Clinocardium sp. (1)	1.8	1.8	
Crangonidae (1)	1.8	1.8	
Tindaria sp. (bivalve) (1)	1.8	1.8	
Cephalopoda (1)	1.8	1.8	
Pagurus sp. (1)	1.8	1.8	

[1]Based on total stomachs examined.

The largest number of stomachs examined was from the Dungeness crab (*Cancer magister*) at Stations 4A and 6A. Fifty-seven (57) crab were examined, and 55 contained food. Sediment occurred in 100 percent of the feeding crab. Other items frequently found were centric diatoms (72.7%), *Nuculana* sp. (54.5%), *Yoldia* sp. (38.2%), and unidentifiable bivalves (32.7%) (Table XIV).

POLLUTANTS ON THE BOTTOM

The frequency of occurrence of man-made debris in trawls from the northeastern Gulf of Alaska is listed in Table XV. Fragments of plastic, probably from refuse bags, were the most common items found.

VII. DISCUSSION

BENTHIC EPIFAUNAL PROGRAM

Offshore Stations

The overall mean biomass of 1.7 g/m^2 was generally less than values obtained in previous offshore OCSEAP studies for more western areas of the Gulf of Alaska and the southeastern Bering Sea. The biomass for the NEGOA region from Montague Island to Yakutat Bay, taken in 1975, was 2.6 g/m^2 (Jewett and Feder, 1975, unpublished OCSEAP data on file, National Oceanographic Data Center). The biomass value for the Kodiak shelf area in 1978-79 was 2.5 g/m^2 (Feder and Jewett, 1980a). Values for the southeastern Bering Sea ranged from 3.3 to 5.0 g/m^2 for similar studies in 1975 and 1976, respectively (Feder and Jewett, 1980b). Thus, there appears to be an overall decrease in the epifaunal biomass of the Bering Sea and Gulf of Alaska from west to east.

An apparent tendency for decrease in species richness of offshore epifauna from west to east is observable. The southeastern Bering Sea had the greatest richness with 233 species (Feder and Jewett, 1980b). The NEGOA region from Montague Island to Yakutat Bay yielded 168 epifaunal species (Jewett and Feder, 1975, unpublished OCSEAP data on file, National Oceanographic Data Center). Species richness in the offshore region of the present study was 134 species. Localized regions of the Kodiak shelf had only 35 to 53 species, depending on the particular area examined (Feder and

TABLE XV

FREQUENCY OF OCCURRENCE OF MAN-MADE DEBRIS ON THE NORTHEASTERN GULF OF ALASKA SEA FLOOR

Type of debris	Number of trawls in which debris was found	Percent of total N = 45
All types	11	24%
Metal	1	2%
Glass	1	2%
Plastic	10	22%
Rubber	1	2%

Jewett, 1980a). The few species characteristic of the Kodiak shelf reflect the larger catches of snow and king crab in this region.

The biomasses of Arthropoda, Echinodermata, and Mollusca from the offshore region of the present study were relatively similar, i.e., 26.2, 27.4, and 21.1 percent, respectively. In contrast, values for the region of the Gulf of Alaska west of the study area (Montague Island to Yakutat Bay) showed Arthropoda with 71.4 percent of the total biomass, Echinodermata with 19.8 percent and Mollusca with 4.6 percent of the total biomass (Jewett and Feder, 1976). Biomass values for Arthropoda, Echinodermata, and Mollusca from the Kodiak shelf region were 77.4, 8.3, and 8.5 percent of the total biomass, respectively (Feder and Jewett, 1980a). The biomass from the southeastern Bering Sea was also dominated by Arthropoda (59.4%); with Echinodermata (18.9%) and Mollusca (5.5%) next in importance (Feder and Jewett, 1980b). The dominance of Arthropoda in previous studies resulted from an abundance of the snow crab *Chionoecetes bairdi*. Jewett and Feder (1975, unpublished OCSEAP data on file, National Oceanographic Data Center) found *C. bairdi* responsible for 66.2 percent of the total biomass from the northeastern Gulf of Alaska. However, in the present study, this species accounted for only 7.0 percent of the total biomass. *Cancer magister* was the major crab species present in the study reported here, but accounted for only 16.6 percent of the total biomass. *Chionoecetes bairdi* approaches the southern limit of its range in the Yakutat area (Ronholt *et al.*, 1976).

The biomass of mollusks was considerably higher for the present study than for previous studies in the Gulf of Alaska or the southeastern Bering sea (Jewett and Feder, (1975, unpublished OCSEAP data on file, National Oceanographic Data Center; Feder and Jewett, 1980a, b). This was due to the high biomass of weathervane scallop (*Pecten caurinus*) at near-shore station in the vicinities of Icy Bay, Dry Bay and Yakutat Bay. *Pecten caurinus* contributed 18.3 percent of the overall biomass. These areas coincide with historical commercial exploitation (Ronholt *et al.*, 1978).

Yakutat Bay Stations

Based on the present study in Yakutat Bay and previous near-shore OCSEAP studies, there also appears to be a tendency for epifaunal biomass and species richness to decrease from west to east in embayments. Ugak and Alitak

Bay (Kodiak Island) epifaunal biomass and species richness were 3.5-6.2 g/m^2 and 79-84 species, respectively (Feder and Jewett, 1977). Izhut and Kiluida Bay (Kodiak Island) epifaunal biomass and species richness were 1.6-9.5 g/m^2 and 101-153 species, respectively (Feder and Jewett, 1980a). The epifaunal biomass and species richness of Cook Inlet, an embayment of the northern Gulf of Alaska, were 2.4 g/m^2 and nearly 300 species, respectively (Feder *et al.*, 1980b). The biomass and number of species in three bays in Prince William Sound were 0.3-1.2 g/m^2 and 39-86 species, respectively (Feder and Hoberg, 1981). The present study in Yakutat Bay yielded an epifaunal biomass of 1.2 g/m^2 from 23 species. Presumably the richness recorded in the Cook Inlet study is a reflection of the smaller trawling gear used in that study. Small trawls typically collect small epifaunal species not taken by large trawls with an increase in species resulting.

The limited number of trawl stations in Yakutat Bay precluded meaningful comparison of dominant species with other OCSEAP bay studies.

BENTHIC INFAUNAL PROGRAM

Van Veen Grab

The bulk of the stations sampled in this study (Station Groups 1, 2 and 3; Table IX) contained fine grained sediments (Table VI), and their fauna was similar to that of stations located in areas with fine sediments throughout the northeastern Gulf of Alaska (Feder and Matheke, 1980). The fauna in these stations was dominated by deposit feeding organisms.

Stations located in Yakutat Bay, Stations 2C, 3C and 4B of Station Group 1 and Stations in Station Group 4, differed slightly in their species composition from the bulk of the stations in this study, perhaps responding to changes in some environmental parameters in Yakutat Bay. Stations 2C, 3C and 4B appear to be transitional in terms of their fauna between the remainder of stations in Station Group 1 and Station Group 4.

Stations in Station Group 5 and Station 7A, which were located in areas with a sandy substrate, were notable for the low abundance, biomass and diversity of their fauna.

Pipe Dredge

The pipe dredge is a qualitative sampling device, and can be used to effectively supplement species composition data collected quantitatively with sampling devices like grabs and trawls.

The pipe dredge functioned well to (1) provide a benthic sample at stations where grab and trawling sampling was not possible, (2) allow qualitative comparisons of the pipe dredge organisms with those obtained *via* grabs, and (3) identify organisms that are potential prey for benthic invertebrates and demersal fishes.

In general, the seven dredge stations analyzed were similar to most grab stations in that they were dominated by polychaetes, bivalves, and ophiuroids. Stations 101I and 103G also contained several amphipods (Appendix C). Stations at which species were found in the pipe dredge but not in the grabs were: 97F - *Pandalus* sp. and *Capheira mollis*; 98F - *Allocentrotus fragilis* and Crinoidea; 103G - *Paraonis gracilis* and *Nebalia* sp; and 100J - *Thelepus cincinnatus*, *Psolus chitinoides*, Crinoidea, and *Ascidia* spp.

The data obtained at stations where only pipe dredges were used (94G, 101I, 101K) was similar to data in adjacent stations where grabs were used.

FISHES

Offshore Stations

Flatfishes, family Pleuronectidae, dominated the fishes in the present study (54.3% of the total fish biomass), as well as in the 1976 NEGOA study from Yakutat Bay to Cape Cleare (53%) (Ronholt *et al.*, 1976). The single dominant species in each study was the arrowtooth flounder (*Atheresthes stomias*). *Atheresthes* accounted for a larger percent of the total fish biomass (31.5%) and total flatfish (58%) in the present study than the total fish biomass (24%) and the total flatfish (44%) in the 1976 study (Ronholt *et al.*, 1976). In the 1976 study the overall mean biomass of arrowtooth flounder increased from west (0.8 g/m^2) to east (2.0 g/m^2). The mean biomass continued to increase eastward in the present study, i.e., 3.9 g/m^2 for the entire offshore study area. In a summary of the overall foreign fish catch in the Yakutat and southeast Alaska region in 1978, arrowtooth flounder was the second-most important species (Pacific Ocean perch was most important), in terms of biomass (Smith and Hadley, 1979). The arrowtooth flounder catch was highest during October through December when the mean catch per unit effort (CPUE) was 868.4 kg/hr. Most of the catch as this time was south of Yakutat Bay and Icy Bay in 220-318 m of water.

Catches of the Pacific halibut (*Hippoglossus stenolepis*) were also greater in the present study than in the 1976 survey. Pacific halibut made up 3 percent of the total fish biomass and 7 percent of the flatfish biomass in the 1976 survey (Ronholt *et al.*, 1976), whereas, in the present study this species accounted for 8.3 percent of the total fish biomass and 15.3 percent of the flatfish biomass. The overall biomass of the Pacific halibut in the 1976 survey was 0.2 g/m^2, whereas, the overall biomass in the present study was 1.0 g/m^2.

Sablefish (*Anaplopoma fimbria*) in the present study also had a higher mean biomass (1.9 g/m^2) then overall mean sablefish biomass from Yakutat Bay to Cape Cleare in 1976 (0.1 g/m^2) (Ronholt *et al.*, 1976). Sablefish was included in a summary of overall foreign catch statistics from Yakutat and southeast Alaska in 1978 (Smith and Hadley, 1979). The highest CPUE (52.1 kg/hr) was reported for the final quarter of 1978, October-December.

Walleye pollock (*Theragra chalcogramma*) in the present study had a similar mean biomass (1.2 g/m^2) to the pollock catch in the 1976 survey (1.4 g/m^2) (Ronholt *et al.*, 1976). A summary of foreign fish catch observed in the Yakutat and southeast Alaska region revealed walleye pollock as the third-most important fish species throughout most of 1978 catches (Smith and Hadley, 1979). The CPUE was highest (702.3 kg/hr) during October through December.

The overall mean biomass of spiny dogfish in the present study (0.7 g/m^2) was greater than the overall mean biomass of spiny dogfish from the 1976 survey from Yakutat Bay to Cape Cleare (0.01 g/m^2) (Ronholt *et al.*, 1976). The biomass did however increase from west to east in the 1976 survey.

FEEDING STUDIES

Arrowtooth flounder (*Atheresthes stomias*)

Feder and Jewett (1980a) found fishes to be the main prey of arrowtooth flounder from the Kodiak Island area. Simenstad (1977) reported mysids and fishes in stomachs of this species also near Kodiak Island. Smith *et al.* (1978) found fishes and crustaceans as the most frequently occurring prey of this species from the northeastern Gulf of Alaska. Fishes, shrimps and other crustaceans were also the most important prey of the arrowtooth flounder examined for the present study.

Rex sole (*Glyptocephalus zachirus*)

Stomachs of rex sole examined for the present study contained mainly polychaetes, with amphipods, shrimps and other crustaceans occurring secondarily. Smith *et al.* (1978) also found polychaetes to be the primary food of rex sole. Pelecypods and crustaceans were next in importance. The results of the present study are consistent with those of Smith *et al.* (1978), and indicate that the rex sole from the northeastern Gulf of Alaska preys mainly on polychaete annelids.

Flathead sole (*Hippoglossoides elassodon*)

Ophiuriods, (especially *Ophiura sarsi*), shrimps, and other crustaceans were the most important prey of flathead sole from the northeastern Gulf of Alaska in the present study. This agrees, in general, with Smith *et al.* (1978); who found euphausiids and *Ophiura sarsi* to be the main prey of flathead sole from other areas in the northeastern Gulf of Alaska. The few flathead sole that were examined from Cook Inlet were mainly feeding on ophiuroids and crangonid shrimps (Feder *et al.*, 1980b). Rogers *et al.* (1979) found *Pandalus borealis* to be the most important prey of flathead sole from waters near Kodiak Island. Simenstad (1977) reported mysids, shrimps and fishes were important prey, in decreasing frequency of occurrence, in flathead sole near Kodiak Island.

Butter sole (*Isopsetta isolepis*)

Over half the butter sole examined for this study were empty. Those which were feeding contained mainly ophiuroids (primarily *Ophiura sarsi*), polychaetes, and crustaceans. Simenstad (1977) found polychaetes, bivalves and gastropods in stomachs of this species near Kodiak Island. Hart (1973) listed the food of butter sole from Washington state waters as chaetopod marine worms, young herring, shrimps, and sand dollars (no order of importance was given). In general, these results are in agreement as to the major groups of food utilized by butter sole. Specific differences are probably attributable to geographic variation in the distribution of prey.

English sole (*Parophrys vetulus*)

The English sole examined for this study contained mainly polychaetes, with ophiuriods, crustaceans and bivalves occurring less frequently. Hart (1973) listed clams, other mollusks, marine worms, small crabs and shrimps, and brittle stars as the prey of English sole (no order of importance was given). In general, these results are in agreement as to the major groups of food utilized by English sole.

Dover sole (*Microstomus pacificus*)

Smith *et al.* (1978) reported polychaetes, ophiuroids, pelecypods and crustaceans as the dominant food of dover sole from stations in the northeastern Gulf of Alaska. Simenstad (1977) found gammarid amphipods, polychaetes, and shrimp, in decreasing order of importance, in stomachs from this species near Kodiak Island. In the present study, ophiuroids, mollusks, and polychaetes were the most frequent prey of this species. Thus, feeding habits of dover sole appear, in general, to be uniform throughout the northeastern Gulf of Alaska.

Pacific halibut (*Hippoglossus stenolepsis*)

The items most frequently consumed by Pacific halibut in the present study (53 cm in length) were fishes, snow crab, and other crustaceans. Reports from the International Pacific Halibut Commission (IPHC) state that fishes become the predominant food of individuals over 10 inches (25 cm) in length (IPHC Rept. No. 28, 1960). Novikov (1968) found that Pacific halibut less than 30 cm fed primarily on crustaceans while those from 30 to 60 cm consumed mainly fishes, with crustaceans second in frequency of occurrence. Feder *et al.* (1980b) found unidentifiable fishes, snow crab, and miscellaneous crabs, shrimps and fishes as the most frequently found prey in Pacific halibut in Cook Inlet. Rosenthal (1978) reported crabs (*Cancer branneri* and *Pugettia gracilis*) were most frequently found in stomachs of this species from the northeastern Gulf of Alaska. Gray (1964) found Dungeness, king and snow crabs to be important food items in Pacific halibut near Kodiak Island. In general, Pacific halibut food habits are similar throughout their range.

Starry flounder (*Platichthys stellatus*)

Jewett and Feder (1975, unpublished OCSEAP data on file, National Oceanographic Data Center) found that starry flounder, collected from the northeastern Gulf of Alaska (principally collected adjacent to Icy Bay) in June, fed exclusively on clams. In the present study, in November, one third of the starry flounder examined were empty and the remainder contained mainly ophiuroids. Starry flounder examined in Cook Inlet in October were mainly feeding on the clam *Spisula polynyma* (Feder *et al.*, 1980b). Rosenthal (1978) reported herring eggs, brown algae and eelgrass were most frequently found from stomachs of this species in Prince William Sound. Ophiuroids were also a major source of food for starry flounders in the northeastern Bering Sea (Feder and Jewett, 1978, Jewett and Feder, 1980). Starry flounder from Washington fed mainly on priapulids, nemerteans, polychaetes, and lamellibranchs (Miller, 1967). The starry flounder exhibits seasonal variation in feeding (Jewett and Feder, 1976). It ceases feeding in winter, and does not begin again until about June. From the present study, it appears that consumption of food may taper off by mid-November.

Rock sole (*Lepidopsetta bilineata*)

Crustaceans, ophiuroids, and polychaetes were the main prey of the rock sole examined for this study. In general, food of rock sole from the northeastern Gulf of Alaska in the present study was similar to that described by other authors (Feder and Jewett, 1980a; Feder *et al.*, 1980b; Smith *et al.*, 1978; Rogers *et al.*, 1979; Simenstad, 1977). Rosenthal (1978) reported herring eggs and sand lance (*Ammodytes hexapterus*) as frequent prey in stomachs of this species in Prince William Sound.

Sand sole (*Psettichthys melanostictus*)

Miller (1967) found sand sole to feed primarily on fishes, with mysids, shrimps and squids playing less important roles. Four of the ten sand sole examined for the present study contained food, and contained the remains of fishes in their stomachs.

Sablefish (*Anaplopoma fimbria*)

The most frequently found prey in stomachs of sablefish examined for this study were fishes, jellyfishes, amphipods and shrimps. Feder and Jewett (1980a) reported sablefish from the Kodiak Island area to feed exclusively on Pacific sand lance (*Ammodytes hexapterus*). Rogers *et al.* (1979) reported fishes, primarily osmerids, and euphausiids as the primary food of sablefish. Thus, with the exception of jellyfishes, food of sablefish is generally similar throughout the Gulf of Alaska.

Walleye Pollock (*Theragra chalcogramma*)

Walleye pollock examined for the present study contained mainly shrimps, amphipods (probably *Parathemisto*) and euphausiids. Smith *et al.* (1978) found euphausiids to be the predominant prey of walleye pollock from another area in the northeastern Gulf of Alaska. The walleye pollock examined in Cook Inlet mainly contained crangonid and pandalid shrimps and unidentified Crustacea (Feder *et al.*, 1980b). Rogers *et al.* (1979) and Simenstad (1977) found mainly shrimp, euphausiids, and fishes in walleye pollock near Kodiak Island. Pink shrimp (*Pandalus borealis*) and euphausiids were the major prey of walleye pollock examined by Feder and Jewett (1980a), also from waters near Kodiak Island. Feder and Paul (1977) report the amphipod *Parathemisto* and the pink shrimp as dominant prey for walleye pollock in Prince William Sound.

Pacific cod (*Gadus macrocephalus*)

Jewett (1978) and Feder and Jewett (1980a) found fishes, snow crab, shrimps, and amphipods to be the most important prey of Pacific cod, near Kodiak Island, Alaska. Simenstad (1977) found euphausiids, shrimps and fishes as the most important prey in Pacific cod, also near Kodiak Island. Miller *et al.* (1978) found shrimp to be the main prey of this species in Port Townsend Bay, Washington. Feder *et al.* (1980b) found snow crab and crangonid shrimp to be most frequently found prey in Pacific cod from Cook Inlet. The present study yielded similar results i.e., shrimps, snow crab and cephalopods were the most frequently consumed prey.

Rockfishes (*Sebastes* spp.)

Little is known about the food or feeding habits of the Scorpaenidae. Of the four species examined for this study (shortspine thornyhead, Pacific Ocean perch, rougheye rockfish, and bocaccio) Hart (1973) listed food of only bocaccio. Five of the six bocaccio examined for this study contained unidentifiable remains. Small fishes were considered by Hart (1973) and Feder *et al.* (1974) as the main prey of this species. Crabs, squid and octopus also form part of the diet for California representatives of the latter species (Feder *et al.*, 1974).

Rosenthal (1978) examined stomach contents of four species of rockfishes from the northeastern Gulf of Alaska. Quillback rockfish (*Sebastes maliger*) preyed on gammarid amphipods, mysids, cumaceans, and caridean shrimps. China rockfish (*Sebastes nebulosus*) consumed mainly the ophiuroid *Ophiopholis aculeata* and small crabs, including *Pugettia gracilis* and *Cancer oregonensis*. Black rockfish (*Sebastes melanops*) contained mainly pelagic organisms including jellyfishes, fishes, amphipods, and swimming polychaetes. Two yelloweye rockfish (*Sebastes ruberimus*) examined by Rosenthal contained the lithodid crab *Placetron wosenssenskii*. Hart (1973) reported crustaceans and lingcod eggs as food for this species. Pereyra *et al.* (1969) reported the food of yellowtail rockfish (*Sebastes flavidus*) from Washington state to be northern lampfish (*Stenobrachius leucopsarus*), crustaceans, and squid. In near-shore waters, this species consumed mainly amphipods (Miller *et al.*, 1976).

All Pacific Ocean perch (*Sebastes alutus*) examined for this study were empty; probably the result of regurgitation due to barotrauma. Carlson (1976) found that small Pacific ocean perch fed primarily on copepods and euphausiids. Larger fish consumed larger prey, including pandalid shrimps and fishes. Somerton (1978) also found Pacific ocean perch to prey mainly on planktonic crustaceans; especially the euphausiid *Thysanoessa spinifera*.

Rougheye rockfish from the present study preyed mainly on shrimps and small fishes. Shortspine thornyheads were also found to prey mainly on shrimps. No record of feeding habits for these two species was found.

Spiny dogfish (*Squalus acanthias*)

Fishes and shrimps were the most frequent prey of spiny dogfish examined for this study from the northeastern Gulf of Alaska. Hart (1973) listed fishes, euphausiids and other crustaceans, including shrimp as the principal prey of this shark (no order of importance was given). Spiny dogfish were considered by Hart to be opportunistic feeders. Thus, the type of prey utilized probably depends on the prey species present in a particular area.

Sculpins (Cottidae)

Both blackfin (*Malacocottus kincaidi*) and spinyhead sculpins (*Dasycottus setiger*) examined for this study preyed predominantly on crustaceans, especially shrimps, mysids, and amphipods and on polynoid polychaetes. No previous reports of feeding habits for these species have been reported. Two larger species of sculpins in Kodiak waters, *Myoxocephalus* spp. and *Hemilepidotus jordani*, were shown to feed primarily on crabs, including *Chionoecetes bairdi* and *Hyas lyratus*, with a variety of other organisms occurring secondarily (Jewett and Powell, 1979). Rosenthal (1978) reported antlered sculpins

(*Enophrys diceraus*) most frequently feed on the green urchin (*Strongylocentrotus droebachiensis*), limpets, and hermit crabs in the northeastern Gulf of Alaska. *Myoxocephalus* sp. consumed mainly brachyuran crabs, pacific herring (*Clupea harengus pallasi*), and herring eggs. Simenstad (1977) found *Myoxocephalus* spp. near Kodiak Island and Cook Inlet feeding primarily on pandalid shrimps, fishes and euphausiids. Thus, sculpins appear to be voracious benthic predators, consuming a wide variety of organisms opportunistically.

Sunflower sea star (*Pycnopodia helianthoides*)

Pycnopodia helianthoides examined for the present study, consumed primarily gastropods, ophiuroids, and bivalves. The gastropods included *Mitrella gouldi*, *Natica* sp., *Buccinum polare*, and *Neptunea* sp. *Nuculana* sp. was the most common bivalve and *Ophiura sarsi* was the common ophiuroid. Jewett and Feder (1975, unpublished OCSEAP data on file, National Oceanographic Data Center; Feder *et al.*, 1980) also found mollusks and echinoderms to be the dominant prey of *P. helianthoides* from the northeastern Gulf of Alaska with the echinoderms *Ctenodiscus crispatus* and *Ophiura sarsi* the most frequent items encountered. The gastropods *Colus halli*, *Mitrella gouldi*, *Solariella obscura*, *Natica clausa* and *Oenopota* sp., and the bivalves *Serripes groenlandicus* and *Clinocardium ciliatum* were also common. Feder and Hoberg (1981) also found gastropods and bivalves as the main prey of *P. helianthoides* from Prince William Sound.

Paul and Feder (1975) found *P. helianthoides* from intertidal and subtidal areas in Prince William Sound feeding mainly on small bivalves, especially *Mytilus edulis* in the former area and *Nuculana fossa* in the latter. Prey in excess of 30 mm was rarely taken.

Thus, *P. helianthoides* is an opportunistic generalist in feeding habits. Its diet is probably determined by the relative abundance of suitable prey species.

Dungeness crab (*Cancer magister*)

Dungeness crab examined in the present study fed mainly on bivalves, with crustaceans and polychaetes occurring less frequently. *Nuculana* spp. and *Yoldia* spp. were the bivalves most often found in stomachs. Both of these genera occurred commonly in van Veen grabs. Some items such as diatoms, Foraminifera, and Hydrozoa were probably consumed inadvertently, along with sediment, while the crab was foraging for food.

Feder and Paul (1980) also found small bivalves to be the most common prey of *C. magister* from stations in Cook Inlet, Alaska. In this case, juvenile *Spisula polynyma* was most frequently utilized. However, since juveniles of this bivalve species did not occur commonly in benthic samples from these stations, the high incidence of predation on them was probably a reflection of preferential selection of prey by size (Feder and Paul, 1980).

In general, the Dungeness crab appears to be opportunistic in feeding habits, preying selectively on small bivalves. Utilization of particular species probably depends on size as well as abundance.

Snow crab (*Chionoecetes bairdi*)

Snow crab examined for this study preyed predominantly on polychaetes, mollusks, small crustaceans and brittle stars. Other common items such as Foraminifera, diatoms and sponge spicules were probably consumed inadvertently with sediment during feeding. Adult *C. bairdi* from the southeastern Bering Sea fed mainly on polychaetes while juveniles fed mainly on crustaceans, polychaetes and mollusks (Tarverdieva, 1976). Paul *et al.* (1979) and Feder *et al.* (1980b) examined stomachs of *C. bairdi* from lower Cook Inlet and found the main food to be clams (*Macoma* spp., *Spisula polynyma*, and *Nucula tenuis*), hermit crabs (*Pagurus* spp.), barnacles (*Balanus* spp.) and sediment. *Chionoecetes bairdi* from Port Valdez contained polychaetes, clams, young *C. bairdi*, other crustaceans and detrital material (Feder, unpublished data). Snow crab with carapace widths < 40 mm, from waters near Kodiak Island, consumed mainly mollusks, crustaceans, polychaetes, and foraminiferans, while those > 40 mm contained crustaceans, fishes, mollusks and polychaetes (Feder and Jewett, 1980a).

Snow crab from lower Cook Inlet apparently fed on organisms in proportion to their abundance in a particular area (Paul *et al.*, 1979; Feder *et al.*, 1980b). However, Feder and Jewett (1980a) suggested that the organisms preyed upon in Kodiak waters were not necessarily the dominant benthic species present. *Chionoecetes bairdi* appeared to have preferences for certain prey. The general food-groups utilized by *Chionoecetes* spp. were shown to be similar throughout the range of these crab (Feder and Jewett, 1980a). Thus, *C. bairdi* probably selected items belonging to specific food-groups which were also relatively abundant in the area.

POLLUTANTS ON THE BOTTOM

A variety of materials, including plastic refuse bags, were reported from the northeastern Gulf of Alaska by Jewett (1976). Fifty-seven percent of trawls from this area contained refuse. Feder *et al.* (1978) also reported man-made debris in 41 percent of trawls from the Bering Sea in 1976. Similar materials were found in 24 percent of trawls from the present study. Since all stations from which refuse was found were within approximately 45 km of shore, this material was either deposited well within the 50 mile limit or represented debris from an onshore movement of refuse originally deposited at a greater distance from shore.

VIII. CONCLUSIONS

Trawl data and feeding data that have been analyzed to date broaden our knowledge of various aspects of the distribution, abundance, and general biology of the more important invertebrate components of the NEGOA shelf. Implicit in the current study is the vast amount of the survey region that could not be sampled by trawl, grab and/or dredge.

Trawl data were obtained from 42 offshore and 3 Yakutat Bay stations. Van Veen grab data were obtained from 27 offshore and 7 Yakutat Bay stations. Data were mainly obtained in Priority Area 1. These stations represent a reasonable nucleus around which a monitoring program can be developed.

The phyla Cnidaria, Mollusca, Arthropoda, and Echinodermata made up 88.4 percent of the invertebrate biomass of the offshore stations. Important taxa within each phylum were *Metridium senile* (Cnidaria), *Pecten caurinus* (Mollusca), *Cancer magister* (Arthropoda), and *Strongylocentrotus* spp. (Echinodermata), respectively.

The feeding data compiled for numerous benthic species in this report, in conjunction with similar data compiled for these species from other areas investigated by OCSEAP, should contribute to an understanding of the trophic role of these organisms.

IX. NEEDS FOR FURTHER STUDY

Many of the species encountered in trawling operations undergo seasonal migrations. For this reason, it is important to obtain seasonal data on the distribution, abundance and biomass of these organisms, as well as their trophic relationships. As a result of the current study, a data base for the designated area was established for the month of November 1979. If disturbances to the environment occur during other months, no data are available for comparison. Therefore, if further study is conducted within the study area, a seasonal approach is strongly advised. In addition, studies on the toxic effects of hydrocarbons on the biology of many of the commercially-important and ecologically-important species should be initiated prior to petroleum exploration and development.

X. PROBLEMS ENCOUNTERED

During the November 1979 NEGOA cruise, aboard the NOAA ship *Miller Freeman*, problems were encountered with gear inadequacy. The research proposal stated that "at least three 400-mesh Eastern otter trawls" be supplied by OCSEAP. Subsequent phone conversations with OCSEAP-Juneau verified that two <u>new</u> trawl nets would be supplied by the National Marine Fisheries Service. Once the cruise began, it was realized that only two <u>well-worn</u> nets had been supplied, rather than <u>new</u> ones. The used nets were easily torn and trawling on marginal bottom was precluded. As a result, many of the 26 stations deemed untrawlable might have been trawled if proper gear had been available.

Only a limited number (7) of the pipe dredge samples were analyzed due to time constraints.

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APPENDIX A

TRAWL DATA

NORTHEAST GULF OF ALASKA

NOAA SHIP *MILLER FREEMAN*

Cruise No. 795, November 1979

CRUSE #	STAT #	TOW #	GEAR CODE	DATE YYMMDD	TIME HHMM	START LATITUDE DEG MIN	START LONGITUDE DEG MIN	FINISH LATITUDE DEG MIN	FINISH LONGITUDE DEG MIN	MIDPOINT LATITUDE DEG MIN	MIDPOINT LONGITUDE DEG MIN	TIME FISH MINS	DIST FISHED (KM)	DEPTH FISHED (METERS) MIN	MAX	AVG
FN795	106G	1	OTB	791106	0759	58 29.6N	138 56.3W	58 30.1N	138 53.3W			30	2.78	86.0 -	91.5	88.8

TAXON CODE	TAXONOMIC NAME	COUNTS RAW	%	/KM	/M SQ	WEIGHT (GRAMS) RAW	%	/KM	/M SQ
INVERTEBRATES									
5333110302	ELASSOCHIRUS CAVIMANUS	1	0.4	0.4	0.00003	2.0	0.4	0.7	0.00006
6801040501	MEDIASTER AEQUALIS	1	0.4	0.4	0.00003	4.0	0.8	1.4	0.00012
6803090611	OPHIURA SARSI	250	99.2	89.9	0.00737	480.0	98.8	172.7	0.01415
	TOTAL			90.6	0.00743			174.8	0.01433
VERTEBRATES									
7602050201	SQUALUS ACANTHIAS	3	4.3	1.1	0.00009	7300.0	20.3	2625.9	0.21524
7917020102	ATHERESTHES STOMIAS	10	14.5	3.6	0.00029	170.0	0.5	61.2	0.00501
7917020701	HIPPOGLOSSUS STENOLEPIS	13	18.8	4.7	0.00038	17200.0	47.8	6187.1	0.50714
7917020901	LEPIDOPSETTA BILINEATA	43	62.3	15.5	0.00127	11300.0	31.4	4064.7	0.33318
	TOTAL			24.8	0.00203			12938.8	1.06056

COMMENTS

STOMACHS: 20 ROCK SOLE; 4 DOGFISH SHARK; 11 HALIBUT. ALL HALIBUT WERE CAUGHT ON 9 NOVEMBER WHILE TRAWLING FOR LOST CTD. ELASSOCHIRUS CAVIMANUS IN BUCCINUM SP. SHELL.

BOTTOM WATER TEMPERATURE °C = 10.4

CRUSE #	STAT #	TOW #	GEAR CODE	DATE YYMMDD	TIME HHMM	START LATITUDE DEG MIN	START LONGITUDE DEG MIN	FINISH LATITUDE DEG MIN	FINISH LONGITUDE DEG MIN	MIDPOINT LATITUDE DEG MIN	MIDPOINT LONGITUDE DEG MIN	TIME FISH MINS	DIST FISHED (KM)	DEPTH FISHED (METERS) MIN	MAX	AVG
FN795	105G	2	OTB	791106	1036	58 33.1N	139 0.3W	58 32.2N	139 2.4W			30	2.22	111.6 -	113.5	112.6

TAXON CODE	TAXONOMIC NAME	COUNTS RAW	%	/KM	/M SQ	WEIGHT (GRAMS) RAW	%	/KM	/M SQ
INVERTEBRATES									
3200000000	PORIFERA					15.0	0.1	6.8	0.00055
3302000000	SCYPHOZOA	1	0.2	0.5	0.00004	330.0	3.1	148.6	0.01218
3303000000	ANTHOZOA	1	0.2	0.5	0.00004	8.0	0.1	3.6	0.00030
4801700201	CRUCIGERA IRREGULARIS	100	19.2	45.0	0.00369	100.0	0.9	45.0	0.00369
4904080102	CHLAMYS RUBIDA	4	0.8	1.8	0.00015	80.0	0.7	36.0	0.00295
4905290101	FUSITRITON OREGONENSIS	11	2.1	5.0	0.00041	840.0	7.9	378.4	0.03101
4905320128	BUCCINUM PLECTRUM	7	1.3	3.2	0.00026	62.0	0.6	27.9	0.00229
4905330202	BERINGIUS KENNICOTTI	7	1.3	3.2	0.00026	620.0	5.8	279.3	0.02289
4905330801	NEPTUNEA LYRATA	7	1.3	3.2	0.00026	295.0	2.8	132.9	0.01089
4907010101	ROSSIA PACIFICA	20	3.8	9.0	0.00074	765.0	7.2	344.6	0.02825
4907120200	OCTOPUS	2	0.4	0.9	0.00007	5.0	0.0	2.3	0.00018
5333060107	CRANGON DALLI	2	0.4	0.9	0.00007	1.0	0.0	0.5	0.00004
5333060301	ARGIS LAR	7	1.3	3.2	0.00026	10.0	0.1	4.5	0.00037
5333110206	PAGURUS SETOSUS	6	1.1	2.7	0.00022	75.0	0.7	33.8	0.00277
5333110216	PAGURUS CONFRAGOSUS	11	2.1	5.0	0.00041	1145.0	10.7	515.8	0.04228
5333110302	ELASSOCHIRUS CAVIMANUS	14	2.7	6.3	0.00052	187.0	1.8	84.2	0.00690
5333121002	LOPHOLITHODES FORAMINATUS	1	0.2	0.5	0.00004	508.0	4.8	228.8	0.01876
5333170201	HYAS LYRATUS	3	0.6	1.4	0.00011	95.0	0.9	42.8	0.00351
6702050301	LAQUEUS CALIFORNIANUS	110	21.1	49.5	0.00406	35.0	0.3	15.8	0.00129
6801020100	DIPSACASTER SPP.	6	1.1	2.7	0.00022	25.0	0.2	11.3	0.00092
6801040104	CERAMASTER PATAGONICUS	8	1.5	3.6	0.00030	215.0	2.0	96.8	0.00794
6801040501	MEDIASTER AEQUALIS	65	12.5	29.3	0.00240	1425.0	13.3	641.9	0.05261
6801040602	PSEUDARCHASTER PARELII	48	9.2	21.6	0.00177	753.0	7.0	339.2	0.02780
6801080105	HENRICIA LEVIUSCULA	2	0.4	0.9	0.00007	6.0	0.1	2.7	0.00022
6801110103	CROSSASTER PAPPOSUS	46	8.8	20.7	0.00170	563.0	5.3	253.6	0.02079
6801120408	LEPTASTERIAS HYLODES	8	1.5	3.6	0.00030	25.0	0.2	11.3	0.00092
6801120901	LETHASTERIAS NANIMENSIS	19	3.6	8.6	0.00070	285.0	2.7	128.4	0.01052
6802040101	ALLOCENTROTUS FRAGILIS	1	0.2	0.5	0.00004	9.0	0.1	4.1	0.00033
7203030402	HALOCYNTHIA IGABOJA	5	1.0	2.3	0.00018	200.0	1.9	90.1	0.00738
9111111111	UNIDENTIFIED ANIMAL MATERIAL					2000.0	18.7	900.9	0.07384
	TOTAL			235.1	0.01927			4811.7	0.39440
VERTEBRATES									
7602050201	SQUALUS ACANTHIAS	303	33.6	136.5	0.01119	438200.0	87.6	197387.4	16.17929
7903010201	CLUPEA HARENGUS PALLASI	1	0.1	0.5	0.00004	115.0	0.0	51.8	0.00425
7909020701	THERAGRA CHALCOGRAMMA	43	4.8	19.4	0.00159	376.0	0.1	169.4	0.01388
7915043001	PSYCHROLUTES PARADOXUS	1	0.1	0.5	0.00004	10.0	0.0	4.5	0.00037
7915043101	RADULINUS ASPRELLUS	2	0.2	0.9	0.00007	20.0	0.0	9.0	0.00074
7915044103	TRIGLOPS MACELLUS	20	2.2	9.0	0.00074	197.0	0.0	88.7	0.00727
7915050401	ASTEROTHECA ALASCANA	3	0.3	1.4	0.00011	30.0	0.0	13.5	0.00111
7917020102	ATHERESTHES STOMIAS	419	46.4	188.7	0.01547	11100.0	2.2	5000.0	0.40984
7917020501	GLYPTOCEPHALUS ZACHIRUS	76	8.4	34.2	0.00281	3800.0	0.8	1711.7	0.14030
7917020601	HIPPOGLOSSOIDES ELASSODON	1	0.1	0.5	0.00004	810.0	0.2	364.9	0.02991
7917020701	HIPPOGLOSSUS STENOLEPIS	25	2.8	11.3	0.00092	43100.0	8.6	19414.4	1.59135
7917020901	LEPIDOPSETTA BILINEATA	5	0.6	2.3	0.00018	2371.0	0.5	1068.0	0.08754

TAXON CODE	TAXONOMIC NAME	COUNTS RAW	COUNTS %	COUNTS /KM	COUNTS /M SQ	WEIGHT (GRAMS) RAW	WEIGHT (GRAMS) %	WEIGHT (GRAMS) /KM	WEIGHT (GRAMS) /M SQ
7917021301	MICROSTOMUS PACIFICUS	4	0.4	1.8	0.00015	85.0	0.0	38.3	0.00314
	TOTAL			406.8	0.03334			225321.6	18.46899

COMMENTS

ARGIS SP.: 3 W/AQUA EGGS. HYAS LYRATAS: 2 MALES, 1 FEMALE W/ORANGE EGGS. STOMACHS: 20 DOGFISH; 20 PACIFIC HALIBUT; 3 ROCK SOLE.

CRUSE #	STAT #	TOW #	GEAR CODE	DATE YYMMDD	TIME HHMM	START LATITUDE DEG MIN	START LONGITUDE DEG MIN	FINISH LATITUDE DEG MIN	FINISH LONGITUDE DEG MIN	MIDPOINT LATITUDE DEG MIN	MIDPOINT LONGITUDE DEG MIN	TIME FISH MINS	DIST FISHED (KM)	DEPTH FISHED (METERS) MIN	MAX	AVG
FN795	105F	3	OTB	791106	1257	58 38.5N	139 2.2W	58 37.0N	139 3.3W			29	2.59	146.4	- 146.4	146.4

TAXON CODE	TAXONOMIC NAME	COUNTS RAW	%	/KM	/M SQ	WEIGHT (GRAMS) RAW	%	/KM	/M SQ
INVERTEBRATES									
5333121002	LOPHOLITHODES FORAMINATUS	2	100.0	0.8	0.00006	4594.0	100.0	1773.7	0.14539
	TOTAL			0.8	0.00006			1773.7	0.14539
VERTEBRATES									
7602050201	SQUALUS ACANTHIAS	16	0.7	6.2	0.00051	26400.0	1.3	10193.1	0.83550
7909020401	GADUS MACROCEPHALUS	8	0.3	3.1	0.00025	49800.0	2.4	19227.8	1.57605
7915030101	ANOPLOPOMA FIMBRIA	2154	87.6	831.7	0.06817	1736400.0	84.3	670424.7	54.95284
7917020102	ATHERESTHES STOMIAS	154	6.3	59.5	0.00487	123400.0	6.0	47644.8	3.90531
7917020501	GLYPTOCEPHALUS ZACHIRUS	58	2.4	22.4	0.00184	13600.0	0.7	5251.0	0.43041
7917020701	HIPPOGLOSSUS STENOLEPIS	40	1.6	15.4	0.00127	86200.0	4.2	33281.9	2.72802
7917020901	LEPIDOPSETTA BILINEATA	2	0.1	0.8	0.00006	1800.0	0.1	695.0	0.05697
7917021401	PAROPHRYS VETULUS	26	1.1	10.0	0.00082	22600.0	1.1	8725.9	0.71524
	TOTAL			949.0	0.07779			795444.0	65.20033

COMMENTS

STOMACHS: 20 BLACK COD; 13 ENGLISH SOLE; 15 PACIFIC HALIBUT.

CRUSE #	STAT #	TOW #	GEAR CODE	DATE YYMMDD	TIME HHMM	START LATITUDE DEG MIN	START LONGITUDE DEG MIN	FINISH LATITUDE DEG MIN	FINISH LONGITUDE DEG MIN	MIDPOINT LATITUDE DEG MIN	MIDPOINT LONGITUDE DEG MIN	TIME FISH MINS	DIST FISHED (KM)	DEPTH FISHED (METERS) MIN	MAX	AVG
FN795	105E	4	OTB	791106	1610	58 46.5N	139 4.4W	58 45.0N	139 3.9W			30	2.78	223.3 -	241.6	232.5

TAXON CODE	TAXONOMIC NAME	COUNTS RAW	COUNTS %	COUNTS /KM	COUNTS /M SQ	WEIGHT (GRAMS) RAW	WEIGHT %	WEIGHT /KM	WEIGHT /M SQ
INVERTEBRATES									
4905290101	FUSITRITON OREGONENSIS	28	21.7	10.1	0.00083	2346.0	51.0	843.9	0.06917
5333040103	PANDALUS JORDANI	44	34.1	15.8	0.00130	356.0	7.7	128.1	0.01050
5333040204	PANDALOPSIS DISPAR	15	11.6	5.4	0.00044	316.0	6.9	113.7	0.00932
5333170302	CHIONOECETES BAIRDI	3	2.3	1.1	0.00009	143.0	3.1	51.4	0.00422
6801040501	MEDIASTER AEQUALIS	4	3.1	1.4	0.00012	138.0	3.0	49.6	0.00407
6801040602	PSEUDARCHASTER PARELII	4	3.1	1.4	0.00012	52.0	1.1	18.7	0.00153
6801060101	CTENODISCUS CRISPATUS	24	18.6	8.6	0.00071	150.0	3.3	54.0	0.00442
6801121201	PYCNOPODIA HELIANTHOIDES	1	0.8	0.4	0.00003	503.0	10.9	180.9	0.01483
6802030101	BRISASTER TOWNSENDI	4	3.1	1.4	0.00012	154.0	3.3	55.4	0.00454
6802040101	ALLOCENTROTUS FRAGILIS	2	1.6	0.7	0.00006	442.0	9.6	159.0	0.01303
	TOTAL			46.4	0.00380			1654.7	0.13563
VERTEBRATES									
7602050201	SQUALUS ACANTHIAS	35	3.3	12.6	0.00103	54000.0	7.1	19424.5	1.59217
7603020106	RAJA KINCAIDI	5	0.5	1.8	0.00015	3600.0	0.5	1295.0	0.10614
7903010201	CLUPEA HARENGUS PALLASI	1	0.1	0.4	0.00003	144.0	0.0	51.8	0.00425
7904020302	OSMERUS MORDAX	7	0.7	2.5	0.00021	280.0	0.0	100.7	0.00826
7909020701	THERAGRA CHALCOGRAMMA	23	2.2	8.3	0.00068	6000.0	0.8	2158.3	0.17691
7915010101	SEBASTES ALEUTIANUS	1	0.1	0.4	0.00003	500.0	0.1	179.9	0.01474
7915010127	SEBASTES PAUCISPINUS	1	0.1	0.4	0.00003	900.0	0.1	323.7	0.02654
7915010201	SEBASTOLOBUS ALASCANUS	32	3.0	11.5	0.00094	17700.0	2.3	6366.9	0.52188
7915030101	ANOPLOPOMA FIMBRIA	22	2.1	7.9	0.00065	34900.0	4.6	12554.0	1.02901
7917020102	ATHERESTHES STOMIAS	765	72.1	275.2	0.02256	542500.0	71.6	195143.9	15.99540
7917020501	GLYPTOCEPHALUS ZACHIRUS	21	2.0	7.6	0.00062	4100.0	0.5	1474.8	0.12089
7917020601	HIPPOGLOSSOIDES ELASSODON	122	11.5	43.9	0.00360	59000.0	7.8	21223.0	1.73959
7917020701	HIPPOGLOSSUS STENOLEPIS	7	0.7	2.5	0.00021	13600.0	1.8	4892.1	0.40099
7917020901	LEPIDOPSETTA BILINEATA	19	1.8	6.8	0.00056	20900.0	2.8	7518.0	0.61623
	TOTAL			381.7	0.03128			272706.5	22.35299

COMMENTS

SPONGE GROWING ON FUSITRITON (3) 12 PANDALOPSIS DISPAR FEMALES W/AMBER EGGS ON PLEOPODS; 22 PANDALUS JORDANI FEMALES W/BLUEISH EGGS ON PLEOPODS. STOMACHS: 10 ARROWTOOTH FLOUNDER; 10 FLATHEAD SOLE.

CRUSE #	STAT #	TOW #	GEAR CODE	DATE YYMMDD	TIME HHMM	START LATITUDE DEG MIN	START LONGITUDE DEG MIN	FINISH LATITUDE DEG MIN	FINISH LONGITUDE DEG MIN	MIDPOINT LATITUDE DEG MIN	MIDPOINT LONGITUDE DEG MIN	TIME FISH MINS	DIST FISHED (KM)	DEPTH FISHED (METERS) MIN	MAX	AVG
FN795	104G	5	OTB	791107	0739	58 34.1N	139 21.4W	58 35.0N	139 18.9W			30	2.96	164.7 -	166.5	165.6

TAXON CODE	TAXONOMIC NAME	COUNTS RAW	COUNTS %	COUNTS /KM	COUNTS /M SQ	WEIGHT (GRAMS) RAW	WEIGHT %	WEIGHT /KM	WEIGHT /M SQ
INVERTEBRATES									
4905290101	FUSITRITON OREGONENSIS	15	6.0	5.1	0.00042	1469.7	9.0	496.5	0.04070
4907010101	ROSSIA PACIFICA	3	1.2	1.0	0.00008	24.2	0.1	8.2	0.00067
5333110203	PAGURUS ALEUTICUS	3	1.2	1.0	0.00008	72.7	0.4	24.6	0.00201
5333110302	ELASSOCHIRUS CAVIMANUS	6	2.4	2.0	0.00017	106.1	0.7	35.8	0.00294
5333170302	CHIONOECETES BAIRDI	9	3.6	3.1	0.00025	42.4	0.3	14.3	0.00117
6801040602	PSEUDARCHASTER PARELII	42	16.7	14.3	0.00117	354.5	2.2	119.8	0.00982
6801060101	CTENODISCUS CRISPATUS	3	1.2	1.0	0.00008	3.0	0.0	1.0	0.00008
6802040101	ALLOCENTROTUS FRAGILIS	167	65.5	56.3	0.00462	14197.0	87.2	4796.3	0.39314
6803060102	OPHIOPHOLIS BAKERI	6	2.4	2.0	0.00017	3.0	0.0	1.0	0.00008
	TOTAL			86.0	0.00705			5497.5	0.45062
VERTEBRATES									
7602050201	SQUALUS ACANTHIAS	12	0.4	4.1	0.00034	10909.1	0.5	3685.5	0.30209
7603020106	RAJA KINCAIDI	9	0.3	3.1	0.00025	5454.5	0.2	1842.8	0.15105
7909020701	THERAGRA CHALCOGRAMMA	12	0.4	4.1	0.00034	793.9	0.0	268.2	0.02199
7915010100	SEBASTES SPP.	3	0.1	1.0	0.00008	448.5	0.0	151.5	0.01242
7915030101	ANOPLOPOMA FIMBRIA	424	12.6	143.3	0.01175	364242.4	15.8	123054.9	10.08647
7915042200	MYOXOCEPHALUS SPP.	3	0.1	1.0	0.00008	54.5	0.0	18.4	0.00151
7917020102	ATHERESTHES STOMIAS	2370	70.2	800.6	0.06562	1638484.8	71.2	553542.2	45.37231
7917020501	GLYPTOCEPHALUS ZACHIRUS	394	11.7	133.1	0.01091	119697.0	5.2	40438.2	3.31460
7917020601	HIPPOGLOSSOIDES ELASSODON	100	3.0	33.8	0.00277	82424.2	3.6	27846.0	2.28246
7917020701	HIPPOGLOSSUS STENOLEPIS	15	0.4	5.1	0.00042	45454.5	2.0	15356.3	1.25871
7917020901	LEPIDOPSETTA BILINEATA	27	0.8	9.2	0.00076	26060.6	1.1	8804.3	0.72166
7917021401	PAROPHRYS VETULUS	6	0.2	2.0	0.00017	6969.7	0.3	2354.6	0.19300
	TOTAL			1140.5	0.09348			777362.8	63.71826

COMMENTS

2 FUSITRITON HAVE GASTROPOD EGGS AND SERPULID TUBES ON OUTSIDE OF SHELL. 1 FUSITRITON COVERED W/SPONGE. ELASSOCHIRUS CAVIMANUS ARE FEMALE WITH BLACKISH COLORED EGGS.
STOMACHS: 10 REX SOLE;
10 BLACK COD; 9 DOVER SOLE; 3 HALIBUT; 10 FLATHEAD SOLE;
10 ARROWTOOTH FLOUNDER. 2 OPHIUROIDEA LIVING IN THE SHELL OF ELASSOCHIRUS CAVIMANUS.

BOTTOM WATER TEMPERATURE °C = 6.0

CRUSE #	STAT #	TOW #	GEAR CODE	DATE YYMMDD	TIME HHMM	START LATITUDE DEG MIN	START LONGITUDE DEG MIN	FINISH LATITUDE DEG MIN	FINISH LONGITUDE DEG MIN	MIDPOINT LATITUDE DEG MIN	MIDPOINT LONGITUDE DEG MIN	TIME FISH MINS	DIST FISHED (KM)	DEPTH FISHED (METERS) MIN	MAX	AVG
FN795	104F	6	OTB	791107	1019	58 42.3N	139 17.1W	58 41.6N	139 19.6W			30	2.96	247.1 -	247.1	247.1

TAXON CODE	TAXONOMIC NAME		COUNTS RAW	COUNTS %	COUNTS /KM	COUNTS /M SQ	WEIGHT (GRAMS) RAW	WEIGHT %	WEIGHT /KM	WEIGHT /M SQ
INVERTEBRATES										
4801740101	APHRODITA JAPONICA		5	0.8	1.7	0.00014	60.0	0.7	20.3	0.00166
4801740102	APHRODITA NEGLIGENS		4	0.6	1.4	0.00011	50.0	0.6	16.9	0.00138
4905290101	FUSITRITON OREGONENSIS		17	2.6	5.7	0.00047	1210.0	13.8	408.8	0.03351
4905330300	COLUS SPP.		1	0.2	0.3	0.00003	7.0	0.1	2.4	0.00019
4905330801	NEPTUNEA LYRATA		5	0.8	1.7	0.00014	354.0	4.0	119.6	0.00980
5333040103	PANDALUS JORDANI		113	17.3	38.2	0.00313	921.0	10.5	311.1	0.02550
5333040204	PANDALOPSIS DISPAR		32	4.9	10.8	0.00089	490.0	5.6	165.5	0.01357
5333060000	CRANGONIDAE		1	0.2	0.3	0.00003	1.0	0.0	0.3	0.00003
5333110216	PAGURUS CONFRAGOSUS		2	0.3	0.7	0.00006	48.0	0.5	16.2	0.00133
5333170302	CHIONOECETES BAIRDI		3	0.5	1.0	0.00008	12.0	0.1	4.1	0.00033
6801040602	PSEUDARCHASTER PARELII		21	3.2	7.1	0.00058	260.0	3.0	87.8	0.00720
6801060101	CTENODISCUS CRISPATUS		342	52.4	115.5	0.00947	1941.0	22.2	655.7	0.05375
6802030101	BRISASTER TOWNSENDI		106	16.2	35.8	0.00294	3273.0	37.4	1105.7	0.09063
6803040201	GORGONOCEPHALUS CARYI		1	0.2	0.3	0.00003	134.0	1.5	45.3	0.00371
		TOTAL			220.6	0.01808			2959.8	0.24261
VERTEBRATES										
7602050201	SQUALUS ACANTHIAS		13	3.5	4.4	0.00036	20400.0	7.4	6891.9	0.56491
7904020402	SPIRINCHUS THALEICHTHYS		36	9.6	12.2	0.00100	1589.0	0.6	536.8	0.04400
7909020701	THERAGRA CHALCOGRAMMA		25	6.7	8.4	0.00069	19600.0	7.2	6621.6	0.54276
7915010101	SEBASTES ALEUTIANUS		28	7.5	9.5	0.00078	22200.0	8.1	7500.0	0.61475
7915010105	SEBASTES BABCOCKI		1	0.3	0.3	0.00003	2100.0	0.8	709.5	0.05815
7915010127	SEBASTES PAUCISPINUS		2	0.5	0.7	0.00006	900.0	0.3	304.1	0.02492
7915010201	SEBASTOLOBUS ALASCANUS		65	17.3	22.0	0.00180	29900.0	10.9	10101.4	0.82798
7915030101	ANOPLOPOMA FIMBRIA		7	1.9	2.4	0.00019	15000.0	5.5	5067.6	0.41537
7915042200	MYOXOCEPHALUS SPP.		1	0.3	0.3	0.00003	8.0	0.0	2.7	0.00022
7916110000	STICHAEIDAE		1	0.3	0.3	0.00003	4.0	0.0	1.4	0.00011
7917020102	ATHERESTHES STOMIAS		76	20.3	25.7	0.00210	85300.0	31.1	28817.6	2.36210
7917020501	GLYPTOCEPHALUS ZACHIRUS		14	3.7	4.7	0.00039	504.0	0.2	170.3	0.01396
7917020601	HIPPOGLOSSOIDES ELASSODON		103	27.5	34.8	0.00285	53300.0	19.5	18006.8	1.47596
7917020701	HIPPOGLOSSUS STENOLEPIS		2	0.5	0.7	0.00006	22200.0	8.1	7500.0	0.61475
7917020901	LEPIDOPSETTA BILINEATA		1	0.3	0.3	0.00003	900.0	0.3	304.1	0.02492
		TOTAL			126.7	0.01038			92535.5	7.58487

COMMENTS

SNAIL EGG CASES ON 1 NEPTUNEA LYRATA. STOMACHS: 10 TURBOT; 10 FLATHEAD SOLE; 10 ROUGH-EYED ROCKFISH, 10 IDIOTS. PANDALOPSIS DISPAR FEMALES WITH AMBER EGGS; PANDALUS JORDANI FEMALES WITH BLUEISH-GREEN EGGS.

CRUSE #	STAT #	TOW #	GEAR CODE	DATE YYMMDD	TIME HHMM	START LATITUDE DEG MIN	START LONGITUDE DEG MIN	FINISH LATITUDE DEG MIN	FINISH LONGITUDE DEG MIN	MIDPOINT LATITUDE DEG MIN	MIDPOINT LONGITUDE DEG MIN	TIME FISH MINS	DIST FISHED (KM)	DEPTH FISHED (METERS) MIN	MAX	AVG
FN795	103G	7	OTB	791107	1225	58 44.7N	139 33.2W	58 44.4N	139 34.8W			20	2.00	166.5 -	166.5	166.5

COMMENTS TRAWL RIPPED.

CRUSE #	STAT #	TOW #	GEAR CODE	DATE YYMMDD	TIME HHMM	START LATITUDE DEG MIN	START LONGITUDE DEG MIN	FINISH LATITUDE DEG MIN	FINISH LONGITUDE DEG MIN	MIDPOINT LATITUDE DEG MIN	MIDPOINT LONGITUDE DEG MIN	TIME FISH MINS	DIST FISHED (KM)	DEPTH FISHED (METERS) MIN	MAX	AVG
FN795	1031	8	OTB	791107	1613	58 31.6N	139 33.1W	58 32.5N	139 31.9W			30	2.04	261.7 -	263.5	262.6

TAXON CODE	TAXONOMIC NAME	COUNTS RAW	%	/KM	/M SQ	WEIGHT (GRAMS) RAW	%	/KM	/M SQ
INVERTEBRATES									
3303000000	ANTHOZOA	2	1.6	1.0	0.00008	35.0	0.8	17.2	0.00141
4905290101	FUSITRITON OREGONENSIS	11	8.5	5.4	0.00044	1307.0	30.5	640.7	0.05252
4905360101	ARCTOMELLON STEARNSII	1	0.8	0.5	0.00004	38.0	0.9	18.6	0.00153
4905660101	TRITONIA EXSULANS	10	7.8	4.9	0.00040	465.0	10.8	227.9	0.01868
5333040103	PANDALUS JORDANI	32	24.8	15.7	0.00129	316.0	7.4	154.9	0.01270
5333040204	PANDALOPSIS DISPAR	24	18.6	11.8	0.00096	468.0	10.9	229.4	0.01880
5333110216	PAGURUS CONFRAGOSUS	1	0.8	0.5	0.00004	3.0	0.1	1.5	0.00012
6801030201	LUIDIASTER DAWSONI	8	6.2	3.9	0.00032	244.0	5.7	119.6	0.00980
6801040602	PSEUDARCHASTER PARELII	9	7.0	4.4	0.00036	101.0	2.4	49.5	0.00406
6801060101	CTENODISCUS CRISPATUS	23	17.8	11.3	0.00092	109.0	2.5	53.4	0.00438
6801100101	DIPLOPTERASTER MULTIPES	1	0.8	0.5	0.00004	302.0	7.0	148.0	0.01213
6602030101	BRISASTER TOWNSENDI	3	2.3	1.5	0.00012	153.0	3.6	75.0	0.00615
6802040101	ALLOCENTROTUS FRAGILIS	4	3.1	2.0	0.00016	750.0	17.5	367.6	0.03014
	TOTAL			63.2	0.00518			2103.4	0.17241
VERTEBRATES									
7602050201	SQUALUS ACANTHIAS	6	0.6	2.9	0.00024	15400.0	1.9	7549.0	0.61877
7603020106	RAJA KINCAIDI	5	0.5	2.5	0.00020	7700.0	1.0	3774.5	0.30939
7904020302	OSMERUS MORDAX	18	1.8	8.8	0.00072	647.0	0.1	317.2	0.02600
7909020701	THERAGRA CHALCOGRAMMA	26	2.6	12.7	0.00104	17700.0	2.2	8676.5	0.71119
7915010102	SEBASTES ALUTUS	3	0.3	1.5	0.00012	359.0	0.0	176.0	0.01442
7915010106	SEBASTES BREVISPINIS	1	0.1	0.5	0.00004	1400.0	0.2	686.3	0.05625
7915010201	SEBASTOLOBUS ALASCANUS	52	5.2	25.5	0.00209	12300.0	1.5	6029.4	0.49421
7915030101	ANOPLOPOMA FIMBRIA	68	6.8	33.3	0.00273	103900.0	13.1	50931.4	4.17470
7915040000	COTTIDAE	1	0.1	0.5	0.00004	8.0	0.0	3.9	0.00032
7917020102	ATHERESTHES STOMIAS	322	32.4	157.8	0.01294	357400.0	45.0	175196.1	14.36033
7917020501	GLYPTOCEPHALUS ZACHIRUS	177	17.8	86.8	0.00711	37200.0	4.7	18235.3	1.49470
7917020601	HIPPOGLOSSOIDES ELASSODON	27	2.7	13.2	0.00108	12200.0	1.5	5980.4	0.49020
7917020901	LEPIDOPSETTA BILINEATA	288	29.0	141.2	0.01157	228600.0	28.8	112058.8	9.18515
	TOTAL			487.3	0.03994			389614.7	31.93563

COMMENTS

PANDALOPSIS DISPAR FEMALES WITH AMBER EGGS; PANDALUS JORDANI FEMALES WITH BLUE-GREEN EGGS; 1 DEAD YOLDIA SP.
STOMACHS: 10 DOVER SOLE; 10 SHORTSPINE THORNYHEAD; 10 FLATHEAD SOLE.
BOTTOM WATER TEMPERATURE °C = 5.8

CRUSE #	STAT #	TOW #	GEAR CODE	DATE YYMMDD	TIME HHMM	START LATITUDE DEG MIN	START LONGITUDE DEG MIN	FINISH LATITUDE DEG MIN	FINISH LONGITUDE DEG MIN	MIDPOINT LATITUDE DEG MIN	MIDPOINT LONGITUDE DEG MIN	TIME FISH MINS	DIST FISHED (KM)	DEPTH FISHED (METERS) MIN	MAX	AVG
FN795	102K	9	OTB	791108	0919	58 41.9N	139 47.1W	58 41.8N	139 46.4W			5	0.	181.2 -	183.0	182.1

COMMENTS

ROUGH BOTTOM, QUALITATIVE STATION SHORT TOW DURATION.
SPONGE HAD HIATELLA ARCTICA AND SMALL POLYCHAETES LIVING WITHIN IT.

CRUSE #	STAT #	TOW #	GEAR CODE	DATE YYMMDD	TIME HHMM	START LATITUDE DEG MIN	START LONGITUDE DEG MIN	FINISH LATITUDE DEG MIN	FINISH LONGITUDE DEG MIN	MIDPOINT LATITUDE DEG MIN	MIDPOINT LONGITUDE DEG MIN	TIME FISH MINS	DIST FISHED (KM)	DEPTH FISHED (METERS) MIN	MAX	AVG
FN795	1011	10	OTB	791109	0752	58 51.6N	140 5.4W	58 51.3N	140 3.8W			15	1.00	170.2 -	170.2	170.2

COMMENTS

NET RIPPED. LARGE ROCK IN COD END. NO DATA OBTAINED.

125

CRUSE #	STAT #	TOW #	GEAR CODE	DATE YYMMDD	TIME HHMM	START LATITUDE DEG MIN	START LONGITUDE DEG MIN	FINISH LATITUDE DEG MIN	FINISH LONGITUDE DEG MIN	MIDPOINT LATITUDE DEG MIN	MIDPOINT LONGITUDE DEG MIN	TIME FISH MINS	DIST FISHED (KM)	DEPTH FISHED (METERS) MIN	MAX	AVG
FN795	100H	11	OTB	791109	1559	58 54.1N	140 15.6W	58 54.1N	140 15.7W			1	0.	170.2 -	170.2	170.2

COMMENTS

UNTRAWLABLE, NET HUNG UP ON BOTTOM; ONLY 1 MINUTE ON BOTTOM.

CRUSE #	STAT #	TOW #	GEAR CODE	DATE YYMMDD	TIME HHMM	START LATITUDE DEG MIN	START LONGITUDE DEG MIN	FINISH LATITUDE DEG MIN	FINISH LONGITUDE DEG MIN	MIDPOINT LATITUDE DEG MIN	MIDPOINT LONGITUDE DEG MIN	TIME FISH MINS	DIST FISHED (KM)	DEPTH FISHED (METERS) MIN	MAX	AVG
FN795	96F	12	OTB	791110	1156	59 12.8N	141 20.0W	59 13.8N	141 17.4W			30	2.96	351.4	- 351.4	351.4

TAXON CODE	TAXONOMIC NAME	COUNTS RAW	COUNTS %	COUNTS /KM	COUNTS /M SQ	WEIGHT (GRAMS) RAW	WEIGHT %	WEIGHT /KM	WEIGHT /M SQ
INVERTEBRATES									
4907050202	GONATUS MAGISTER	8	44.4	2.7	0.00022	2700.0	82.2	912.2	0.07477
5333040204	PANDALOPSIS DISPAR	4	22.2	1.4	0.00011	50.0	1.5	16.9	0.00138
6801020102	DIPSACASTER BOREALIS	2	11.1	0.7	0.00006	440.0	13.4	148.6	0.01218
6801040501	MEDIASTER AEQUALIS	1	5.6	0.3	0.00003	22.0	0.7	7.4	0.00061
6801060101	CTENODISCUS CRISPATUS	1	5.6	0.3	0.00003	10.0	0.3	3.4	0.00028
6802040101	ALLOCENTROTUS FRAGILIS	1	5.6	0.3	0.00003	52.0	1.6	17.6	0.00144
6803090611	OPHIURA SARSI	1	5.6	0.3	0.00003	10.0	0.3	3.4	0.00028
	TOTAL			6.1	0.00050			1109.5	0.09094
VERTEBRATES									
7909020701	THERAGRA CHALCOGRAMMA	91	35.1	30.7	0.00252	52600.0	20.4	17770.3	1.45658
7915010102	SEBASTES ALUTUS	6	2.3	2.0	0.00017	1527.0	0.6	515.9	0.04229
7915010201	SEBASTOLOBUS ALASCANUS	32	12.4	10.8	0.00089	9500.0	3.7	3209.5	0.26307
7915030101	ANOPLOPOMA FIMBRIA	4	1.5	1.4	0.00011	10000.0	3.9	3378.4	0.27692
7916090103	BATHYMASTER SIGNATUS	1	0.4	0.3	0.00003	169.0	0.1	57.1	0.00468
7917020102	ATHERESTHES STOMIAS	75	29.0	25.3	0.00208	102000.0	39.6	34459.5	2.82455
7917020501	GLYPTOCEPHALUS ZACHIRUS	5	1.9	1.7	0.00014	1400.0	0.5	473.0	0.03877
7917020701	HIPPOGLOSSUS STENOLEPIS	8	3.1	2.7	0.00022	56300.0	21.9	19020.3	1.55904
7917020901	LEPIDOPSETTA BILINEATA	37	14.3	12.5	0.00102	24000.0	9.3	8108.1	0.66460
	TOTAL			87.5	0.00717			86991.9	7.13048

COMMENTS

STOMACHS: 10 TURBOT; 10 DOVER SOLE; 10 WALLEYE POLLOCK; 10 SHORTSPINE THORNYHEAD.

BOTTOM WATER TEMPERATURE °C = 5.4

CRUSE #	STAT #	TOW #	GEAR CODE	DATE YYMMDD	TIME HHMM	START LATITUDE DEG MIN	START LONGITUDE DEG MIN	FINISH LATITUDE DEG MIN	FINISH LONGITUDE DEG MIN	MIDPOINT LATITUDE DEG MIN	MIDPOINT LONGITUDE DEG MIN	TIME FISH MINS	DIST FISHED (KM)	DEPTH FISHED (METERS) MIN	MAX	AVG
FN795	97G	13	OTB	791111	0929	59 2.0N	141 3.6W	59 1.7N	141 2.5W			15	1.67	347.7 -	347.7	347.7

TAXON CODE	TAXONOMIC NAME	COUNTS RAW	COUNTS %	COUNTS /KM	COUNTS /M SQ	WEIGHT (GRAMS) RAW	WEIGHT %	WEIGHT /KM	WEIGHT /M SQ
INVERTEBRATES									
3200000000	PORIFERA					130600.0	94.9	78203.6	6.41013
3303330100	PRIMNOA SPP.	1	0.1	0.6	0.00005	100.0	0.1	59.9	0.00491
3303470201	STYLATULA GRACILE	1	0.1	0.6	0.00005	74.0	0.1	44.3	0.00363
4801010504	EUNOE SENTA	1	0.1	0.6	0.00005	2.0	0.0	1.2	0.00010
4801100104	EUPHROSINE HORTENSIS	50	4.2	29.9	0.00245	100.0	0.1	59.9	0.00491
4801230400	NEREIS SPP.	1	0.1	0.6	0.00005	10.0	0.0	6.0	0.00049
4904290201	HIATELLA ARCTICA	500	42.3	299.4	0.02454	500.0	0.4	299.4	0.02454
4905290101	FUSITRITON OREGONENSIS	3	0.3	1.8	0.00015	213.0	0.2	127.5	0.01045
4905360101	ARCTOMELON STEARNSII	1	0.1	0.6	0.00005	48.0	0.0	28.7	0.00236
4907120200	OCTOPUS	1	0.1	0.6	0.00005	11.0	0.0	6.6	0.00054
5333040102	PANDALUS GONIURUS	6	0.5	3.6	0.00029	27.0	0.0	16.2	0.00133
5333040105	PANDALUS PLATYCEROS	3	0.3	1.8	0.00015	185.0	0.1	110.8	0.00908
5333120101	ACANTHOLITHODES HISPIDUS	2	0.2	1.2	0.00010	71.0	0.1	42.5	0.00348
5333121002	LOPHOLITHODES FORAMINATUS	1	0.1	0.6	0.00005	77.0	0.1	46.1	0.00378
5333170701	SCYRA ACUTIFRONS	1	0.1	0.6	0.00005	1.0	0.0	0.6	0.00005
6801020102	DIPSACASTER BOREALIS	2	0.2	1.2	0.00010	426.0	0.3	255.1	0.02091
6801040104	CERAMASTER PATAGONICUS	3	0.3	1.8	0.00015	84.0	0.1	50.3	0.00412
6801040403	HIPPASTERIAS SPINOSA	2	0.2	1.2	0.00010	404.0	0.3	241.9	0.01983
6801080101	HENRICIA ASPERA	2	0.2	1.2	0.00010	66.0	0.0	39.5	0.00324
6801080103	HENRICIA BERINGIANIA	2	0.2	1.2	0.00010	180.0	0.1	107.8	0.00883
6801080105	HENRICIA LEVIUSCULA	15	1.3	9.0	0.00074	144.0	0.1	86.2	0.00707
6801080201	PORANIOPSIS INFLATA	1	0.1	0.6	0.00005	1.0	0.0	0.6	0.00005
6801100101	DIPLOPTERASTER MULTIPES	6	0.5	3.6	0.00029	474.0	0.3	283.8	0.02326
6801110201	LOPHASTER FURCILLIGER	1	0.1	0.6	0.00005	1.0	0.0	0.6	0.00005
6803050115	OPHIACANTHA GRATIOSA	160	13.5	95.8	0.00785	480.0	0.3	287.4	0.02356
6803060101	OPHIOPHOLIS ACULEATA	330	27.9	197.6	0.01620	960.0	0.7	574.9	0.04712
6803090101	AMPHIOPHIURA PONDEROSA	2	0.2	1.2	0.00010	47.0	0.0	28.1	0.00231
6804070101	PSEUDOSTICHOPUS MOLLIS	35	3.0	21.0	0.00172	1094.0	0.8	655.1	0.05370
6804070400	BATHYPLOTES SPP.	40	3.4	24.0	0.00196	840.0	0.6	503.0	0.04123
7203030402	HALOCYNTHIA IGABOJA	10	0.8	6.0	0.00049	390.0	0.3	233.5	0.01914
	TOTAL			708.4	0.05806			82401.2	6.75420
VERTEBRATES									
7602050201	SQUALUS ACANTHIAS	2	0.5	1.2	0.00010	5900.0	1.7	3532.9	0.28958
7603020111	RAJA STELLULATA	1	0.3	0.6	0.00005	900.0	0.3	538.9	0.04417
7909020401	GADUS MACROCEPHALUS	1	0.3	0.6	0.00005	6400.0	1.8	3832.3	0.31413
7909020701	THERAGRA CHALCOGRAMMA	19	4.8	11.4	0.00093	7700.0	2.2	4610.8	0.37793
7915010101	SEBASTES ALEUTIANUS	2	0.5	1.2	0.00010	900.0	0.3	538.9	0.04417
7915010102	SEBASTES ALUTUS	181	45.8	108.4	0.00868	154700.0	44.6	92634.7	7.59301
7915010105	SEBASTES BABCOCKI	5	1.3	3.0	0.00025	2300.0	0.7	1377.2	0.11289
7915010106	SEBASTES BREVISPINIS	9	2.3	5.4	0.00044	19000.0	5.5	11377.2	0.93256
7915010118	SEBASTES HELVOMACULATUS	19	4.8	11.4	0.00093	5900.0	1.7	3532.9	0.28958
7915010127	SEBASTES PAUCISPINUS	65	16.5	38.9	0.00319	75300.0	21.7	45089.8	3.69589
7915010136	SEBASTES VARIEGATUS	2	0.5	1.2	0.00010	900.0	0.3	538.9	0.04417
7915010201	SEBASTOLOBUS ALASCANUS	10	2.5	6.0	0.00049	2300.0	0.7	1377.2	0.11289

TAXON CODE	TAXONOMIC NAME	COUNTS RAW	COUNTS %	COUNTS /KM	COUNTS /M SQ	WEIGHT (GRAMS) RAW	WEIGHT (GRAMS) %	WEIGHT (GRAMS) /KM	WEIGHT (GRAMS) /M SQ
7915030101	ANOPLOPOMA FIMBRIA	4	1.0	2.4	0.00020	4500.0	1.3	2694.6	0.22087
7915041901	MALACOCOTTUS KINCAIDI	21	5.3	12.6	0.00103	1100.0	0.3	658.7	0.05399
7916090103	BATHYMASTER SIGNATUS	8	2.0	4.8	0.00039	1175.0	0.3	703.6	0.05767
7916150101	ZAPRORA SILENUS	1	0.3	0.6	0.00005	546.0	0.2	326.9	0.02680
7917020101	ATHERESTHES EVERMANNI	25	6.3	15.0	0.00123	11300.0	3.3	6766.5	0.55463
7917020501	GLYPTOCEPHALUS ZACHIRUS	17	4.3	10.2	0.00083	5900.0	1.7	3532.9	0.28958
7917020701	HIPPOGLOSSUS STENOLEPIS	3	0.8	1.8	0.00015	40400.0	11.6	24191.6	1.98292
	TOTAL			236.5	0.01939			207856.9	17.03745

COMMENTS

APPROXIMATELY FOUR SPECIES OF SPONGE WITH TWO SPECIES OF BRITTLE STARS FOUND IN THE INCURRENT/EXCURRENT PORES. HIATELLA ARCTICA NOTED AS LIVING IN ONE OF THE SPONGE SPECIES.
STOMACHS: 10 PACIFIC OCEAN PERCH; 10 POLLOCK; 10 REX SOLE; 10 TURBOT; 6 BOCACCIO; 21 BLACKFIN SCULPIN.

BOTTOM WATER TEMPERATURE °C = 5.5

CRUSE #	STAT #	TOW #	GEAR CODE	DATE YYMMDD	TIME HHMM	START LATITUDE DEG MIN	START LONGITUDE DEG MIN	FINISH LATITUDE DEG MIN	FINISH LONGITUDE DEG MIN	MIDPOINT LATITUDE DEG MIN	MIDPOINT LONGITUDE DEG MIN	TIME FISH MINS	DIST FISHED (KM)	DEPTH FISHED (METERS) MIN	MAX	AVG
FN795	95H	14	OTB	791111	1329	59 8.6N	141 33.2W	59 10.0N	141 33.8W			29	2.78	325.7	- 325.7	325.7

TAXON CODE	TAXONOMIC NAME	COUNTS RAW	COUNTS %	COUNTS /KM	COUNTS /M SQ	WEIGHT (GRAMS) RAW	WEIGHT %	WEIGHT /KM	WEIGHT /M SQ
INVERTEBRATES									
3303120000	ALCYONACEA NEPHTHEIDAE					21.0	0.2	7.6	0.00062
3303550000	ACTINIIDAE	2	2.8	0.7	0.00006	56.0	0.5	20.1	0.00165
4905290101	FUSITRITON OREGONENSIS	3	4.2	1.1	0.00009	440.0	3.7	158.3	0.01297
4905330202	BERINGIUS KENNICOTTI	1	1.4	0.4	0.00003	90.0	0.8	32.4	0.00265
4907010101	ROSSIA PACIFICA	16	22.5	5.8	0.00047	9100.0	75.9	3273.4	0.26831
5333040204	PANDALOPSIS DISPAR	2	2.8	0.7	0.00006	35.0	0.3	12.6	0.00103
6801020102	DIPSACASTER BOREALIS	3	4.2	1.1	0.00009	41.0	0.3	14.7	0.00121
6801080103	HENRICIA BERINGIANIA	1	1.4	0.4	0.00003	103.0	0.9	37.1	0.00304
6801080112	HENRICIA CLARKI	1	1.4	0.4	0.00003	17.0	0.1	6.1	0.00050
6802030101	BRISASTER TOWNSENDI	1	1.4	0.4	0.00003	12.0	0.1	4.3	0.00035
6802040101	ALLOCENTROTUS FRAGILIS	2	2.8	0.7	0.00006	193.0	1.6	69.4	0.00569
6803040201	GORGONOCEPHALUS CARYI	1	1.4	0.4	0.00003	212.0	1.8	76.3	0.00625
6803090101	AMPHIOPHIURA PONDEROSA	16	22.5	5.8	0.00047	242.0	2.0	87.1	0.00714
6804000000	HOLOTHUROIDEA	22	31.0	7.9	0.00065	1434.0	12.0	515.8	0.04228
	TOTAL			25.5	0.00209			4315.1	0.35370
VERTEBRATES									
7909020701	THERAGRA CHALCOGRAMMA	159	21.7	57.2	0.00469	78500.0	21.5	28237.4	2.31454
7915010102	SEBASTES ALUTUS	8	1.1	2.9	0.00024	4500.0	1.2	1618.7	0.13268
7915010118	SEBASTES HELVOMACULATUS	1	0.1	0.4	0.00003	500.0	0.1	179.9	0.01474
7915010127	SEBASTES PAUCISPINUS	1	0.1	0.4	0.00003	900.0	0.2	323.7	0.02654
7915010201	SEBASTOLOBUS ALASCANUS	40	5.4	14.4	0.00118	8200.0	2.2	2949.6	0.24177
7915030101	ANOPLOPOMA FIMBRIA	18	2.5	6.5	0.00053	21800.0	6.0	7841.7	0.64276
7915041901	MALACOCOTTUS KINCAIDI	8	1.1	2.9	0.00024	574.0	0.2	206.5	0.01692
7915044201	ULCA BOLINI	1	0.1	0.4	0.00003	5000.0	1.4	1798.6	0.14742
7917020101	ATHERESTHES EVERMANNI	450	61.3	161.9	0.01327	210500.0	57.6	75719.4	6.20651
7917020501	GLYPTOCEPHALUS ZACHIRUS	14	1.9	5.0	0.00041	2300.0	0.6	827.3	0.06781
7917020701	HIPPOGLOSSUS STENOLEPIS	4	0.5	1.4	0.00012	18600.0	5.1	6690.6	0.54841
7917020901	LEPIDOPSETTA BILINEATA	30	4.1	10.8	0.00088	14100.0	3.9	5071.9	0.41573
	TOTAL			264.0	0.02164			131465.5	10.77586

COMMENTS

STOMACHS: 10 POLLOCK; 10 REX SOLE; 10 TURBOT; 10 IDIOT; 10 DOVER SOLE; 10 SABLE FISH; 8 BLACK FIN SCULPIN.

BOTTOM WATER TEMPERATURE °C = 6.3

CRUSE #	STAT #	TOW #	GEAR CODE	DATE YYMMDD	TIME HHMM	START LATITUDE DEG MIN	START LONGITUDE DEG MIN	FINISH LATITUDE DEG MIN	FINISH LONGITUDE DEG MIN	MIDPOINT LATITUDE DEG MIN	MIDPOINT LONGITUDE DEG MIN	TIME FISH MINS	DIST FISHED (KM)	DEPTH FISHED (METERS) MIN	MAX	AVG
FN795	95G	15	OTB	791112	0706	59 15.8N	141 30.8W	59 17.1N	141 30.1W			30	2.59	334.9	- 338.6	336.8

TAXON CODE	TAXONOMIC NAME	COUNTS RAW	COUNTS %	COUNTS /KM	COUNTS /M SQ	WEIGHT (GRAMS) RAW	WEIGHT %	WEIGHT /KM	WEIGHT /M SQ
INVERTEBRATES									
4803010100	NOTOSTOMOBDELLA SPP.	1	3.6	0.4	0.00003	1.0	0.0	0.4	0.00003
4907050202	GONATUS MAGISTER	4	14.3	1.5	0.00013	1763.0	32.2	680.7	0.05579
5333040204	PANDALOPSIS DISPAR	4	14.3	1.5	0.00013	96.0	1.8	37.1	0.00304
5333120702	PARALITHODES PLATYPUS	1	3.6	0.4	0.00003	1131.0	20.6	436.7	0.03579
6801020102	DIPSACASTER BOREALIS	15	53.6	5.8	0.00047	2162.0	39.4	834.7	0.06842
6801110101	CROSSASTER BOREALIS	1	3.6	0.4	0.00003	189.0	3.4	73.0	0.00598
6802040101	ALLOCENTROTUS FRAGILIS	2	7.1	0.8	0.00006	141.0	2.6	54.4	0.00446
	TOTAL			10.8	0.00089			2117.0	0.17352
VERTEBRATES									
7603020111	RAJA STELLULATA	5	1.1	1.9	0.00016	10400.0	2.0	4015.4	0.32913
7909020701	THERAGRA CHALCOGRAMMA	309	64.9	119.3	0.00978	174600.0	32.9	67413.1	5.52567
7915010127	SEBASTES PAUCISPINUS	1	0.2	0.4	0.00003	700.0	0.1	270.3	0.02215
7915010136	SEBASTES VARIEGATUS	1	0.2	0.4	0.00003	200.0	0.0	77.2	0.00633
7915010201	SEBASTOLOBUS ALASCANUS	28	5.9	10.8	0.00089	8600.0	1.6	3320.5	0.27217
7915030101	ANOPLOPOMA FIMBRIA	19	4.0	7.3	0.00060	24900.0	4.7	9613.9	0.78802
7917020101	ATHERESTHES EVERMANNI	80	16.8	30.9	0.00253	214000.0	40.3	82625.5	6.77258
7917020501	GLYPTOCEPHALUS ZACHIRUS	7	1.5	2.7	0.00022	900.0	0.2	347.5	0.02848
7917020701	HIPPOGLOSSUS STENOLEPIS	9	1.9	3.5	0.00028	82100.0	15.5	31698.8	2.59827
7917020901	LEPIDOPSETTA BILINEATA	17	3.6	6.6	0.00054	14500.0	2.7	5598.5	0.45889
	TOTAL			183.8	0.01506			204980.7	16.80170

COMMENTS

4 PANDALOPSIS DISPAR: 3 WITH LIGHT BROWN EGGS. STOMACHS: 10 POLLOCK; 10 DOVER SOLE; 10 TURBOT; 10 BLACK COD; 10 IDIOTS.

BOTTOM WATER TEMPERATURE °C = 4.3

CRUSE #	STAT #	TOW #	GEAR CODE	DATE YYMMDD	TIME HHMM	START LATITUDE DEG MIN	START LONGITUDE DEG MIN	FINISH LATITUDE DEG MIN	FINISH LONGITUDE DEG MIN	MIDPOINT LATITUDE DEG MIN	MIDPOINT LONGITUDE DEG MIN	TIME FISH MINS	DIST FISHED (KM)	DEPTH FISHED (METERS) MIN	MAX	AVG
FN795	95F	16	OTB	791112	1306	59 21.8N	141 30.8W	59 21.4N	141 33.3W			30	2.41	184.8 -	186.7	185.8

TAXON CODE	TAXONOMIC NAME	COUNTS RAW	%	/KM	/M SQ	WEIGHT (GRAMS) RAW	%	/KM	/M SQ
INVERTEBRATES									
3200000000	PORIFERA					136000.0	77.0	56431.5	4.62554
3303330100	PRIMNOA SPP.					50.0	0.0	20.7	0.00170
3303540101	STOMPHIA COCCINEA	1	0.1	0.4	0.00003	105.0	0.1	43.6	0.00357
3303550000	ACTINIIDAE	61	4.1	25.3	0.00207	24950.0	14.1	10352.7	0.84858
4801230400	NEREIS SPP.	100	6.7	41.5	0.00340	200.0	0.1	83.0	0.00680
4801740100	APHRODITA SPP.	2	0.1	0.8	0.00007	27.0	0.0	11.2	0.00092
4904290201	HIATELLA ARCTICA	500	33.7	207.5	0.01701	500.0	0.3	207.5	0.01701
4905290101	FUSITRITON OREGONENSIS	15	1.0	6.2	0.00051	1722.0	1.0	714.5	0.05857
4905330202	BERINGIUS KENNICOTTI	4	0.3	1.7	0.00014	547.0	0.3	227.0	0.01860
5333040103	PANDALUS JORDANI	150	10.1	62.2	0.00510	1500.0	0.8	622.4	0.05102
5333110203	PAGURUS ALEUTICUS	1	0.1	0.4	0.00003	25.0	0.0	10.4	0.00085
5333121002	LOPHOLITHODES FORAMINATUS	3	0.2	1.2	0.00010	1450.0	0.8	601.7	0.04932
5333170201	HYAS LYRATUS	2	0.1	0.8	0.00007	85.0	0.0	35.3	0.00289
5333170302	CHIONOECETES BAIRDI	2	0.1	0.8	0.00007	100.0	0.1	41.5	0.00340
6702030101	TEREBRATULINA UNGUICULA	10	0.7	4.1	0.00034	5.0	0.0	2.1	0.00017
6702050301	LAQUEUS CALIFORNIANUS	50	3.4	20.7	0.00170	100.0	0.1	41.5	0.00340
6801020102	DIPSACASTER BOREALIS	4	0.3	1.7	0.00014	392.0	0.2	162.7	0.01333
6801060101	CTENODISCUS CRISPATUS	1	0.1	0.4	0.00003	5.0	0.0	2.1	0.00017
6801080104	HENRICIA DERJUGINI	1	0.1	0.4	0.00003	77.0	0.0	32.0	0.00262
6801080105	HENRICIA LEVIUSCULA	1	0.1	0.4	0.00003	50.0	0.0	20.7	0.00170
6801080201	PORANIOPSIS INFLATA	2	0.1	0.8	0.00007	273.0	0.2	113.3	0.00929
6801100101	DIPLOPTERASTER MULTIPES	25	1.7	10.4	0.00085	2750.0	1.6	1141.1	0.09353
6801100306	PTERASTER TESSELATUS	6	0.4	2.5	0.00020	995.0	0.6	412.9	0.03384
6801110201	LOPHASTER FURCILLIGER	4	0.3	1.7	0.00014	150.0	0.1	62.2	0.00510
6801110302	SOLASTER ENDECA	1	0.1	0.4	0.00003	297.0	0.2	123.2	0.01010
6802040101	ALLOCENTROTUS FRAGILIS	8	0.5	3.3	0.00027	1790.0	1.0	742.7	0.06088
6802040201	STRONGYLOCENTROTUS DROEBACHIENSIS	1	0.1	0.4	0.00003	50.0	0.0	20.7	0.00170
6803040201	GORGONOCEPHALUS CARYI	8	0.5	3.3	0.00027	1336.0	0.8	554.4	0.04544
6803060101	OPHIOPHOLIS ACULEATA	500	33.7	207.5	0.01701	500.0	0.3	207.5	0.01701
6804000000	HOLOTHUROIDEA	1	0.1	0.4	0.00003	60.0	0.0	24.9	0.00204
6804060101	PARASTICHOPUS CALIFORNICUS	1	0.1	0.4	0.00003	38.0	0.0	15.8	0.00129
7203030402	HALOCYNTHIA IGABOJA	20	1.3	8.3	0.00068	580.0	0.3	240.7	0.01973
	TOTAL			616.2	0.05051			73323.2	6.01010
VERTEBRATES									
7602050201	SQUALUS ACANTHIAS	11	0.4	4.6	0.00037	22700.0	2.3	9419.1	0.77206
7603020106	RAJA KINCAIDI	13	0.5	5.4	0.00044	4100.0	0.4	1701.2	0.13945
7904020402	SPIRINCHUS THALEICHTHYS	87	3.5	36.1	0.00296	2720.0	0.3	1128.6	0.09251
7909020401	GADUS MACROCEPHALUS	6	0.2	2.5	0.00020	7700.0	0.8	3195.0	0.26189
7909020701	THERAGRA CHALCOGRAMMA	41	1.6	17.0	0.00139	15900.0	1.6	6597.5	0.54078
7915010101	SEBASTES ALEUTIANUS	5	0.2	2.1	0.00017	5000.0	0.5	2074.7	0.17006
7915010102	SEBASTES ALUTUS	28	1.1	11.6	0.00095	24000.0	2.4	9958.5	0.81627
7915010105	SEBASTES BABCOCKI	3	0.1	1.2	0.00010	900.0	0.1	373.4	0.03061
7915010106	SEBASTES BREVISPINIS	1	0.0	0.4	0.00003	700.0	0.1	290.5	0.02381
7915010127	SEBASTES PAUCISPINUS	9	0.4	3.7	0.00031	7700.0	0.8	3195.0	0.26189

TAXON CODE	TAXONOMIC NAME	COUNTS RAW	COUNTS %	COUNTS /KM	COUNTS /M SQ	WEIGHT (GRAMS) RAW	WEIGHT (GRAMS) %	WEIGHT (GRAMS) /KM	WEIGHT (GRAMS) /M SQ
7915010201	SEBASTOLOBUS ALASCANUS	2	0.1	0.8	0.00007	700.0	0.1	290.5	0.02381
7915020201	OPHIODON ELONGATUS	3	0.1	1.2	0.00010	3200.0	0.3	1327.8	0.10884
7915030101	ANOPLOPOMA FIMBRIA	222	8.9	92.1	0.00755	224500.0	22.5	93153.5	7.63554
7916090103	BATHYMASTER SIGNATUS	140	5.6	58.1	0.00476	26300.0	2.6	10912.9	0.89450
7916150101	ZAPRORA SILENUS	3	0.1	1.2	0.00010	1800.0	0.2	746.9	0.06122
7917020102	ATHERESTHES STOMIAS	1152	46.0	478.0	0.03918	352400.0	35.3	146224.1	11.98558
7917020501	GLYPTOCEPHALUS ZACHIRUS	165	6.6	68.5	0.00561	31800.0	3.2	13195.0	1.08156
7917020601	HIPPOGLOSSOIDES ELASSODON	563	22.5	233.6	0.01915	193700.0	19.4	80373.4	6.58799
7917020701	HIPPOGLOSSUS STENOLEPIS	21	0.8	8.7	0.00071	61200.0	6.1	25394.2	2.08149
7917021301	MICROSTOMUS PACIFICUS	28	1.1	11.6	0.00095	10900.0	1.1	4522.8	0.37072
	TOTAL			1038.6	0.08513			414074.7	33.94055

COMMENTS

HYAS HYRATUS: 1 MALE; 1 FEMALE W/ORANGE EGGS.
STOMACHS: 10 DOVER SOLE; 10 POLLOCK; 10 TURBOT; 10 REX SOLE; 15 HALIBUT; 10 FLATHEAD SOLE.

BOTTOM WATER TEMPERATURE °C = 6.0

CRUSE #	STAT #	TOW #	GEAR CODE	DATE YYMMDD	TIME HHMM	START LATITUDE DEG MIN	START LONGITUDE DEG MIN	FINISH LATITUDE DEG MIN	FINISH LONGITUDE DEG MIN	MIDPOINT LATITUDE DEG MIN	MIDPOINT LONGITUDE DEG MIN	TIME FISH MINS	DIST FISHED (KM)	DEPTH FISHED (METERS) MIN	MAX	AVG
FN795	96E	17	OTB	791112	1642	59 20.0N	141 13.8W	59 21.6N	141 14.1W			30	2.96	311.1	318.4	314.8

TAXON CODE	TAXONOMIC NAME	COUNTS RAW	%	/KM	/M SQ	WEIGHT (GRAMS) RAW	%	/KM	/M SQ
INVERTEBRATES									
4907050202	GONATUS MAGISTER	36	85.7	12.2	0.00100	2876.0	90.5	971.6	0.07964
5333040204	PANDALOPSIS DISPAR	2	4.8	0.7	0.00006	38.0	1.2	12.8	0.00105
6802030101	BRISASTER TOWNSENDI	2	4.8	0.7	0.00006	36.0	1.1	12.2	0.00100
6802040101	ALLOCENTROTUS FRAGILIS	2	4.8	0.7	0.00006	228.0	7.2	77.0	0.00631
	TOTAL			14.2	0.00116			1073.6	0.08800
VERTEBRATES									
7909020701	THERAGRA CHALCOGRAMMA	3014	91.6	1018.2	0.08346	1318600.0	86.2	445473.0	36.51418
7915010201	SEBASTOLOBUS ALASCANUS	50	1.5	16.9	0.00138	15400.0	1.0	5202.7	0.42645
7915030101	ANOPLOPOMA FIMBRIA	18	0.5	6.1	0.00050	20800.0	1.4	7027.0	0.57599
7917020102	ATHERESTHES STOMIAS	64	1.9	21.6	0.00177	46200.0	3.0	15608.1	1.27935
7917020501	GLYPTOCEPHALUS ZACHIRUS	60	1.8	20.3	0.00166	16400.0	1.1	5540.5	0.45414
7917020601	HIPPOGLOSSOIDES ELASSODON	30	0.9	10.1	0.00083	15400.0	1.0	5202.7	0.42645
7917020701	HIPPOGLOSSUS STENOLEPIS	8	0.2	2.7	0.00022	60800.0	4.0	20540.5	1.68365
7917021301	MICROSTOMUS PACIFICUS	48	1.5	16.2	0.00133	35400.0	2.3	11959.5	0.98028
	TOTAL			1112.2	0.09116			516554.1	42.34050

COMMENTS

STOMACHS: 10 POLLOCK; 10 DOVER SOLE; 10 FLATHEAD SOLE; 10 REX SOLE.
BOTTOM WATER TEMPERATURE °C = 4.7

CRUSE #	STAT #	TOW #	GEAR CODE	DATE YYMMDD	TIME HHMM	START LATITUDE DEG MIN	START LONGITUDE DEG MIN	FINISH LATITUDE DEG MIN	FINISH LONGITUDE DEG MIN	MIDPOINT LATITUDE DEG MIN	MIDPOINT LONGITUDE DEG MIN	TIME FISH MINS	DIST FISHED (KM)	DEPTH FISHED (METERS) MIN	MAX	AVG
FN795	97D	18	OTB	791113	0721	59 23.9N	141 6.0W	59 22.9N	141 6.9W			25	2.04	283.6 -	283.6	283.6

TAXON CODE	TAXONOMIC NAME	COUNTS RAW	%	/KM	/M SQ	WEIGHT (GRAMS) RAW	%	/KM	/M SQ
INVERTEBRATES									
3200000000	PORIFFRA					561.0	13.4	284.8	0.02334
3303550000	ACTINIIDAE	19	28.8	9.3	0.00076	1000.0	23.1	490.2	0.04018
4905360101	ARCTOMELON STEARNSII	2	3.0	1.0	0.00008	146.0	3.4	71.6	0.00587
4907050202	GONATUS MAGISTER	7	10.6	3.4	0.00028	666.0	15.4	326.5	0.02676
5333040204	PANDALOPSIS DISPAR	17	25.8	8.3	0.00068	330.0	7.6	161.8	0.01326
5333110213	PAGURUS CORNUTUS	1	1.5	0.5	0.00004	18.0	0.4	8.8	0.00072
5333110302	ELASSOCHIRUS CAVIMANUS	1	1.5	0.5	0.00004	20.0	0.5	9.8	0.00080
6801040602	PSEUDARCHASTER PARELII	1	1.5	0.5	0.00004	20.0	0.5	9.8	0.00080
6801060101	CTENODISCUS CRISPATUS	1	1.5	0.5	0.00004	2.0	0.0	1.0	0.00008
6801100101	DIPLOPTERASTER MULTIPES	3	4.5	1.5	0.00012	634.0	14.7	310.8	0.02547
6801110101	CROSSASTER BOREALIS	1	1.5	0.5	0.00004	18.0	0.4	8.8	0.00072
6801110201	LOPHASTER FURCILLIGER	2	3.0	1.0	0.00008	33.0	0.8	16.2	0.00133
6801121201	PYCNOPODIA HELIANTHOIDES	1	1.5	0.5	0.00004	232.0	5.4	113.7	0.00932
6802030101	BRISASTER TOWNSENDI	2	3.0	1.0	0.00008	37.0	0.9	18.1	0.00149
6802040101	ALLOCENTROTUS FRAGILIS	8	12.1	3.9	0.00032	590.0	13.6	289.2	0.02371
	TOTAL			32.4	0.00265			2121.1	0.17386
VERTEBRATES									
7904020402	SPIRINCHUS THALEICHTHYS	17	3.2	8.3	0.00068	594.0	0.2	291.2	0.02387
7909020701	THERAGRA CHALCOGRAMMA	143	26.8	70.1	0.00575	65800.0	26.8	32254.9	2.64384
7915010102	SEBASTES ALUTUS	1	0.2	0.5	0.00004	200.0	0.1	98.0	0.00804
7915010201	SEBASTOLOBUS ALASCANUS	41	7.7	20.1	0.00165	11800.0	4.8	5784.3	0.47412
7915030101	ANOPLOPOMA FIMBRIA	14	2.6	6.9	0.00056	12300.0	5.0	6029.4	0.49421
7915041901	MALACOCOTTUS KINCAIDI	7	1.3	3.4	0.00028	184.0	0.1	90.2	0.00739
7917020102	ATHERESTHES STOMIAS	50	9.4	24.5	0.00201	36300.0	14.8	17794.1	1.45853
7917020501	GLYPTOCEPHALUS ZACHIRUS	104	19.5	51.0	0.00418	30000.0	12.2	14705.9	1.20540
7917020601	HIPPOGLOSSOIDES ELASSODON	103	19.3	50.5	0.00414	51800.0	21.1	25392.2	2.08132
7917021301	MICROSTOMUS PACIFICUS	53	9.9	26.0	0.00213	35800.0	14.6	17549.0	1.43844
7917021401	PAROPHRYS VETULUS	1	0.2	0.5	0.00004	500.0	0.2	245.1	0.02009
	TOTAL			261.8	0.02146			120234.3	9.85527

COMMENTS

STOMACHS: 10 DOVER SOLE; 10 FLATHEAD SOLE; 10 REX SOLE; 10 ARROWTOOTH FLOUNDER; 7 BLACKFIN SCULPIN.

BOTTOM WATER TEMPERATURE °C = 5.4

CRUSE #	STAT #	TOW #	GEAR CODE	DATE YYMMDD	TIME HHMM	START LATITUDE DEG MIN	START LONGITUDE DEG MIN	FINISH LATITUDE DEG MIN	FINISH LONGITUDE DEG MIN	MIDPOINT LATITUDE DEG MIN	MIDPOINT LONGITUDE DEG MIN	TIME FISH MINS	DIST FISHED (KM)	DEPTH FISHED (METERS) MIN	MAX	AVG
FN795	98D	19	OTB	791113	1130	59 18.5N	140 45.7W	59 17.8N	140 43.7W			30	2.22	144.6	146.4	145.5

TAXON CODE	TAXONOMIC NAME	COUNTS RAW	COUNTS %	COUNTS /KM	COUNTS /M SQ	WEIGHT (GRAMS) RAW	WEIGHT %	WEIGHT /KM	WEIGHT /M SQ
INVERTEBRATES									
4905290101	FUSITRITON OREGONENSIS	10	0.6	4.5	0.00037	694.0	3.5	312.6	0.02562
4905331001	PYRULOFUSUS HARPA	3	0.2	1.4	0.00011	445.0	2.2	200.5	0.01643
4907010101	ROSSIA PACIFICA	1	0.1	0.5	0.00004	9.0	0.0	4.1	0.00033
5333040103	PANDALUS JORDANI	5	0.3	2.3	0.00018	50.0	0.3	22.5	0.00185
5333110302	ELASSOCHIRUS CAVIMANUS	2	0.1	0.9	0.00007	50.0	0.3	22.5	0.00185
5333121002	LOPHOLITHODES FORAMINATUS	1	0.1	0.5	0.00004	522.0	2.6	235.1	0.01927
5333170302	CHIONOECETES BAIRDI	5	0.3	2.3	0.00018	170.0	0.9	76.6	0.00628
6702050301	LAQUEUS CALIFORNIANUS	22	1.4	9.9	0.00081	88.0	0.4	39.6	0.00325
6801040501	MEDIASTER AEQUALIS	5	0.3	2.3	0.00018	81.0	0.4	36.5	0.00299
6801080105	HENRICIA LEVIUSCULA	1	0.1	0.5	0.00004	10.0	0.1	4.5	0.00037
6801100101	DIPLOPTERASTER MULTIPES	2	0.1	0.9	0.00007	983.0	4.9	442.8	0.03629
6801110103	CROSSASTER PAPPOSUS	2	0.1	0.9	0.00007	61.0	0.3	27.5	0.00225
6801110201	LOPHASTER FURCILLIGER	7	0.4	3.2	0.00026	357.0	1.8	160.8	0.01318
6802030101	BRISASTER TOWNSENDI	1	0.1	0.5	0.00004	30.0	0.2	13.5	0.00111
6802040101	ALLOCENTROTUS FRAGILIS	925	58.5	416.7	0.03415	12000.0	60.4	5405.4	0.44307
6802040200	STRONGYLOCENTROTUS SPP.	585	37.0	263.5	0.02160	3630.0	18.3	1635.1	0.13403
6803040201	GORGONOCEPHALUS CARYI	2	0.1	0.9	0.00007	608.0	3.1	273.9	0.02245
7203030402	HALOCYNTHIA IGABOJA	2	0.1	0.9	0.00007	79.0	0.4	35.6	0.00292
	TOTAL			712.2	0.05837			8949.1	0.73353
VERTEBRATES									
7602050201	SQUALUS ACANTHIAS	6	0.8	2.7	0.00022	10400.0	2.5	4684.7	0.38399
7603020106	RAJA KINCAIDI	5	0.7	2.3	0.00018	5900.0	1.4	2657.7	0.21784
7904020402	SPIRINCHUS THALEICHTHYS	98	13.4	44.1	0.00362	3342.0	0.8	1505.4	0.12339
7909020401	GADUS MACROCEPHALUS	1	0.1	0.5	0.00004	3600.0	0.9	1621.6	0.13292
7909020701	THERAGRA CHALCOGRAMMA	7	1.0	3.2	0.00026	3200.0	0.8	1441.4	0.11815
7915010102	SEBASTES ALUTUS	9	1.2	4.1	0.00033	1800.0	0.4	810.8	0.06646
7915030101	ANOPLOPOMA FIMBRIA	101	13.8	45.5	0.00373	83100.0	20.2	37432.4	3.06823
7916090103	BATHYMASTER SIGNATUS	12	1.6	5.4	0.00044	1963.0	0.5	884.2	0.07248
7917020102	ATHERESTHES STOMIAS	395	54.0	177.9	0.01458	127600.0	31.0	57477.5	4.71127
7917020501	GLYPTOCEPHALUS ZACHIRUS	63	8.6	28.4	0.00233	14500.0	3.5	6531.5	0.53537
7917020601	HIPPOGLOSSOIDES ELASSODON	22	3.0	9.9	0.00081	9100.0	2.2	4099.1	0.33599
7917020701	HIPPOGLOSSUS STENOLEPIS	8	1.1	3.6	0.00030	146763.0	35.6	66109.5	5.41881
7917021301	MICROSTOMUS PACIFICUS	4	0.5	1.8	0.00015	900.0	0.2	405.4	0.03323
	TOTAL			329.3	0.02699			185661.3	15.21814

COMMENTS

ELASSOCHIRUS CAVIMANUS: 1 FEMALE WITH DARK PURPLE EGGS.
PANDALUS JORDANI: 4 WITH AQUA BLUE EGGS. POLLUTANTS: 1 PIECE
OF PLASTIC BAG.
STOMACHS: 10 REX SOLE; 10 FLATHEAD SOLE; 10 BLACKCOD; 9 TURBOT.
BOTTOM WATER TEMPERATURE °C = 6.3

CRUSE #	STAT #	TOW #	GEAR CODE	DATE YYMMDD	TIME HHMM	START LATITUDE DEG MIN	START LONGITUDE DEG MIN	FINISH LATITUDE DEG MIN	FINISH LONGITUDE DEG MIN	MIDPOINT LATITUDE DEG MIN	MIDPOINT LONGITUDE DEG MIN	TIME FISH MINS	DIST FISHED (KM)	DEPTH FISHED (METERS) MIN	MAX	AVG
FN795	6A	20	OTB	791114	1323	59 46.2N	139 49.0W	59 47.7N	139 49.3W			15	1.48	43.9 -	56.7	50.3

TAXON CODE	TAXONOMIC NAME	COUNTS RAW	%	/KM	/M SQ	WEIGHT (GRAMS) RAW	%	/KM	/M SQ
INVERTEBRATES									
4905330301	NEPTUNEA LYRATA	1	0.3	0.7	0.00006	83.0	0.2	56.1	0.00460
5333010101	PASIPHAEA PACIFICA	1	0.3	0.7	0.00006	5.0	0.0	3.4	0.00028
5333040101	PANDALUS BOREALIS	73	23.7	49.3	0.00404	311.0	0.6	210.1	0.01722
5333040107	PANDALUS DANAE	1	0.3	0.7	0.00006	10.0	0.0	6.8	0.00055
5333050400	EUALUS SPP.	1	0.3	0.7	0.00006	2.0	0.0	1.4	0.00011
5333060107	CRANGON DALLI	103	33.4	69.6	0.00570	504.0	0.9	340.5	0.02791
5333110203	PAGURUS ALEUTICUS	1	0.3	0.7	0.00006	25.0	0.0	16.9	0.00138
5333120701	PARALITHODES CAMTSCHATICA	1	0.3	0.7	0.00006	900.0	1.7	608.1	0.04984
5333180104	CANCER MAGISTER	124	40.3	83.8	0.00687	51300.0	96.4	34662.2	2.84116
6801040104	CERAMASTER PATAGONICUS	1	0.3	0.7	0.00006	73.0	0.1	49.3	0.00404
6801040501	MEDIASTER AEQUALIS	1	0.3	0.7	0.00006	23.0	0.0	15.5	0.00127
	TOTAL			208.1	0.01706			35970.3	2.94838
VERTEBRATES									
7602050201	SQUALUS ACANTHIAS	24	6.2	16.2	0.00133	31300.0	67.1	21148.6	1.73350
7603020103	RAJA BINOCULATA	2	0.5	1.4	0.00011	1400.0	3.0	945.9	0.07754
7904020402	SPIRINCHUS THALEICHTHYS	296	76.9	200.0	0.01639	2275.0	4.9	1537.2	0.12600
7909020601	MICROGADUS PROXIMUS	42	10.9	28.4	0.00233	1733.0	3.7	1170.9	0.09598
7915041801	LEPTOCOTTUS ARMATUS	1	0.3	0.7	0.00006	170.0	0.4	114.9	0.00942
7917020601	HIPPOGLOSSOIDES ELASSODON	2	0.5	1.4	0.00011	200.0	0.4	135.1	0.01108
7917020801	ISOPSETTA ISOLEPIS	12	3.1	8.1	0.00066	2300.0	4.9	1554.1	0.12738
7917021501	PLATICHTHYS STELLATUS	6	1.6	4.1	0.00033	7300.0	15.6	4932.4	0.40430
	TOTAL			260.1	0.02132			31539.2	2.58518

COMMENTS

PANDALUS BOREALIS: 15 W/AQUA EGGS. CRANGON DALLI: NO EGGS.
CANCER MAGISTER: 122 MALES; 2 FEMALES. STOMACHS: 37 MALE
DUNGENESS CRABS; 6 STARRY FLOUNDERS; 10 BUTTER SOLE.

BOTTOM WATER TEMPERATURE °C = 10.0

CRUSE #	STAT #	TOW #	GEAR CODE	DATE YYMMDD	TIME HHMM	START LATITUDE DEG MIN	START LONGITUDE DEG MIN	FINISH LATITUDE DEG MIN	FINISH LONGITUDE DEG MIN	MIDPOINT LATITUDE DEG MIN	MIDPOINT LONGITUDE DEG MIN	TIME FISH MINS	DIST FISHED (KM)	DEPTH FISHED (METERS) MIN	MAX	AVG
FN795	99D	21	OTB	791115	0729	59 24.9N	140 34.1W	59 24.9N	140 37.0W			30	2.96	139.1 -	142.7	140.9

TAXON CODE	TAXONOMIC NAME	COUNTS RAW	COUNTS %	COUNTS /KM	COUNTS /M SQ	WEIGHT (GRAMS) RAW	WEIGHT %	WEIGHT /KM	WEIGHT /M SQ
INVERTEBRATES									
3303540101	STOMPHIA COCCINEA	1	0.5	0.3	0.00003	35.0	0.2	11.8	0.00097
4904290201	HIATELLA ARCTICA	2	0.9	0.7	0.00006	2.0	0.0	0.7	0.00006
4904310101	BANKIA SETACEA	11	5.0	3.7	0.00030	10.0	0.1	3.4	0.00028
4905290101	FUSITRITON OREGONENSIS	28	12.8	9.5	0.00078	2361.0	12.5	797.6	0.06538
4905320128	BUCCINUM PLECTRUM	1	0.5	0.3	0.00003	21.0	0.1	7.1	0.00058
4905331001	PYRULOFUSUS HARPA	6	2.7	2.0	0.00017	727.0	3.9	245.6	0.02013
4905360101	ARCTOMELON STEARNSII	2	0.9	0.7	0.00006	228.0	1.2	77.0	0.00631
4907010101	ROSSIA PACIFICA	4	1.8	1.4	0.00011	60.0	0.3	20.3	0.00166
5330040101	LIMNORIA LIGNOSUM	3	1.4	1.0	0.00008	1.0	0.0	0.3	0.00003
5333040102	PANDALUS GONIURUS	4	1.8	1.4	0.00011	27.0	0.1	9.1	0.00075
5333040103	PANDALUS JORDANI	15	6.8	5.1	0.00042	170.0	0.9	57.4	0.00471
5333110200	PAGURUS SPP.	10	4.6	3.4	0.00028	153.0	0.8	51.7	0.00424
5333110302	ELASSOCHIRUS CAVIMANUS	14	6.4	4.7	0.00039	376.0	2.0	127.0	0.01041
5333121002	LOPHOLITHODES FORAMINATUS	11	5.0	3.7	0.00030	4100.0	21.8	1385.1	0.11354
5333170201	HYAS LYRATUS	19	8.7	6.4	0.00053	915.0	4.9	309.1	0.02534
5333170302	CHIONOECETES BAIRDI	22	10.0	7.4	0.00061	908.0	4.8	306.8	0.02514
5333180104	CANCER MAGISTER	3	1.4	1.0	0.00008	932.0	4.9	314.9	0.02581
6801040104	CERAMASTER PATAGONICUS	4	1.8	1.4	0.00011	265.0	1.4	89.5	0.00734
6801040501	MEDIASTER AEQUALIS	1	0.5	0.3	0.00003	75.0	0.4	25.3	0.00208
6801040602	PSEUDARCHASTER PARELII	1	0.5	0.3	0.00003	50.0	0.3	16.9	0.00138
6801080101	HENRICIA ASPERA	8	3.7	2.7	0.00022	76.0	0.4	25.7	0.00210
6801080105	HENRICIA LEVIUSCULA	3	1.4	1.0	0.00008	62.0	0.3	20.9	0.00172
6801080111	HENRICIA SANGUINOLENTA	7	3.2	2.4	0.00019	120.0	0.6	40.5	0.00332
6801100101	DIPLOPTERASTER MULTIPES	12	5.5	4.1	0.00033	3817.0	20.3	1289.5	0.10570
6801110103	CROSSASTER PAPPOSUS	1	0.5	0.3	0.00003	13.0	0.1	4.4	0.00036
6801110201	LOPHASTER FURCILLIGER	9	4.1	3.0	0.00025	315.0	1.7	106.4	0.00872
6801120901	LETHASTERIAS NANIMENSIS	1	0.5	0.3	0.00003	181.0	1.0	61.1	0.00501
6802040101	ALLOCENTROTUS FRAGILIS	8	3.7	2.7	0.00022	2527.0	13.4	853.7	0.06998
6804070400	BATHYPLOTES SPP.	7	3.2	2.4	0.00019	278.0	1.5	93.9	0.00770
7200000000	UROCHORDATA	1	0.5	0.3	0.00003	35.0	0.2	11.8	0.00097
	TOTAL			74.0	0.00606			6364.9	0.52171
VERTEBRATES									
7602050201	SQUALUS ACANTHIAS	1	0.2	0.3	0.00003	1400.0	0.6	473.0	0.03877
7603020106	RAJA KINCAIDI	10	2.1	3.4	0.00028	3600.0	1.7	1216.2	0.09969
7904020501	THALEICHTHYS PACIFICUS	26	5.5	8.8	0.00072	899.0	0.4	303.7	0.02489
7909020401	GADUS MACROCEPHALUS	5	1.0	1.7	0.00014	17300.0	8.0	5844.6	0.47907
7909020701	THERAGRA CHALCOGRAMMA	10	2.1	3.4	0.00028	1805.0	0.8	609.8	0.04998
7915030101	ANOPLOPOMA FIMBRIA	58	12.2	19.6	0.00161	51800.0	24.0	17500.0	1.43443
7915041801	LEPTOCOTTUS ARMATUS	3	0.6	1.0	0.00008	900.0	0.4	304.1	0.02492
7915042200	MYOXOCEPHALUS SPP.	3	0.6	1.0	0.00008	28.0	0.0	9.5	0.00078
7916090103	BATHYMASTER SIGNATUS	1	0.2	0.3	0.00003	117.0	0.1	39.5	0.00324
7917020102	ATHERESTHES STOMIAS	264	55.3	89.2	0.00731	95800.0	44.4	32364.9	2.65286
7917020501	GLYPTOCEPHALUS ZACHIRUS	76	15.9	25.7	0.00210	16300.0	7.6	5506.8	0.45137
7917020601	HIPPOGLOSSCIDES ELASSODON	10	2.1	3.4	0.00028	5400.0	2.5	1824.3	0.14953

TAXON CODE	TAXONOMIC NAME	COUNTS RAW	COUNTS %	COUNTS /KM	COUNTS /M SQ	WEIGHT (GRAMS) RAW	WEIGHT (GRAMS) %	WEIGHT (GRAMS) /KM	WEIGHT (GRAMS) /M SQ
7917020701	HIPPOGLOSSUS STENOLEPIS	9	1.9	3.0	0.00025	19500.0	9.0	6587.8	0.53999
7917021501	PLATICHTHYS STELLATUS	1	0.2	0.3	0.00003	900.0	0.4	304.1	0.02492
	TOTAL			161.1	0.01321			72888.2	5.97444

COMMENTS

HYAS LYRATUS: 7 MALES; 10 FEMALES, 9 WITH ORANGE EGGS.
CHIONOECETES BAIRDI: ALL JUVENILES. BANKIA SP. PRESENT IN WOOD.
STOMACHS: 10 SABLEFISH; 5 PACIFIC COD; 10 FLATHEAD SOLE; 10 TURBOT; 10 REX SOLE.
BOTTOM WATER TEMPERATURE °C = 6.3

CRUSE #	STAT #	TOW #	GEAR CODE	DATE YYMMDD	TIME HHMM	START LATITUDE DEG MIN	START LONGITUDE DEG MIN	FINISH LATITUDE DEG MIN	FINISH LONGITUDE DEG MIN	MIDPOINT LATITUDE DEG MIN	MIDPOINT LONGITUDE DEG MIN	TIME FISH MINS	DIST FISHED (KM)	DEPTH FISHED (METERS) MIN	MAX	AVG
FN795	99E	22	OTB	791115	0925	59 18.3N	140 34.1W	59 19.8N	140 34.5W			30	2.78	133.6 -	137.3	135.5

TAXON CODE	TAXONOMIC NAME	COUNTS RAW	%	/KM	/M SQ	WEIGHT (GRAMS) RAW	%	/KM	/M SQ
INVERTEBRATES									
3303000000	ANTHOZOA	1	0.1	0.4	0.00003	39.0	0.1	14.0	0.00115
4905290101	FUSITRITON OREGONENSIS	53	6.7	19.1	0.00156	4100.0	7.1	1474.8	0.12089
4905331001	PYRULOFUSUS HARPA	1	0.1	0.4	0.00003	101.0	0.2	36.3	0.00298
4905360101	ARCTOMELON STEARNSII	4	0.5	1.4	0.00012	445.0	0.8	160.1	0.01312
4907010101	ROSSIA PACIFICA	8	1.0	2.9	0.00024	142.0	0.2	51.1	0.00419
5333110216	PAGURUS CONFRAGOSUS	8	1.0	2.9	0.00024	302.0	0.5	108.6	0.00890
5333110302	ELASSOCHIRUS CAVIMANUS	6	0.8	2.2	0.00018	216.0	0.4	77.7	0.00637
5333121002	LOPHOLITHODES FORAMINATUS	9	1.1	3.2	0.00027	6400.0	11.0	2302.2	0.18870
5333170201	HYAS LYRATUS	4	0.5	1.4	0.00012	344.0	0.6	123.7	0.01014
5333170302	CHIONOECETES BAIRDI	4	0.5	1.4	0.00012	205.0	0.4	73.7	0.00604
6801030201	LUIDIASTER DAWSONI	1	0.1	0.4	0.00003	125.0	0.2	45.0	0.00369
6801040100	CERAMASTER SPP.	5	0.6	1.8	0.00015	159.0	0.3	57.2	0.00469
6801040501	MEDIASTER AEQUALIS	5	0.6	1.8	0.00015	120.0	0.2	43.2	0.00354
6801080100	HENRICIA SPP.	3	0.4	1.1	0.00009	72.0	0.1	25.9	0.00212
6801080101	HENRICIA ASPERA	1	0.1	0.4	0.00003	10.0	0.0	3.6	0.00029
6801080105	HENRICIA LEVIUSCULA	1	0.1	0.4	0.00003	10.0	0.0	3.6	0.00029
6801080201	PORANIOPSIS INFLATA	1	0.1	0.4	0.00003	41.0	0.1	14.7	0.00121
6801110103	CROSSASTER PAPPOSUS	15	1.9	5.4	0.00044	215.0	0.4	77.3	0.00634
6801110201	LOPHASTER FURCILLIGER	26	3.3	9.4	0.00077	510.0	0.9	183.5	0.01504
6801110301	SOLASTER DAWSONI	1	0.1	0.4	0.00003	16.0	0.0	5.8	0.00047
6801121101	STYLASTERIAS FORRERI	1	0.1	0.4	0.00003	39.0	0.1	14.0	0.00115
6802040101	ALLOCENTROTUS FRAGILIS	275	34.9	98.9	0.00811	27200.0	46.8	9784.2	0.80198
6802040201	STRONGYLOCENTROTUS DROEBACHIENSIS	350	44.5	125.9	0.01032	16800.0	28.9	6043.2	0.49534
6803040201	GORGONOCEPHALUS CARYI	1	0.1	0.4	0.00003	431.0	0.7	155.0	0.01271
7203030402	HALOCYNTHIA IGABOJA	3	0.4	1.1	0.00009	95.0	0.2	34.2	0.00280
	TOTAL			283.1	0.02320			20912.6	1.71415
VERTEBRATES									
7602050201	SQUALUS ACANTHIAS	2	0.3	0.7	0.00006	2700.0	1.1	971.2	0.07961
7603020103	RAJA BINOCULATA	1	0.2	0.4	0.00003	32200.0	13.2	11582.7	0.94940
7603020106	RAJA KINCAIDI	1	0.2	0.4	0.00003	1400.0	0.6	503.6	0.04128
7904020402	SPIRINCHUS THALEICHTHYS	44	7.0	15.8	0.00130	1512.0	0.6	543.9	0.04458
7909020401	GADUS MACROCEPHALUS	3	0.5	1.1	0.00009	14500.0	5.9	5215.8	0.42753
7909020701	THERAGRA CHALCOGRAMMA	8	1.3	2.9	0.00024	1410.0	0.6	507.2	0.04157
7915010102	SEBASTES ALUTUS	2	0.3	0.7	0.00006	324.0	0.1	116.5	0.00955
7915030101	ANOPLOPOMA FIMBRIA	19	3.0	6.8	0.00056	15900.0	6.5	5719.4	0.46881
7916090103	BATHYMASTER SIGNATUS	8	1.3	2.9	0.00024	980.0	0.4	352.5	0.02889
7917020102	ATHERESTHES STOMIAS	479	76.5	172.3	0.01412	132100.0	54.2	47518.0	3.89492
7917020501	GLYPTOCEPHALUS ZACHIRUS	44	7.0	15.8	0.00130	5000.0	2.0	1798.6	0.14742
7917020601	HIPPOGLOSSOIDES ELASSODON	9	1.4	3.2	0.00027	5000.0	2.0	1798.6	0.14742
7917020701	HIPPOGLOSSUS STENOLEPIS	6	1.0	2.2	0.00018	30900.0	12.7	11115.1	0.91107
	TOTAL			225.2	0.01846			87743.2	7.19206

COMMENTS

HYAS LYRATUS: 2 MALES; 2 FEMALES WITH LIGHT ORANGE EGGS.
CHIONOECETES BAIRDI: 1 MALE; 3 FEMALES WITH ORANGE EGGS, FULL
CLUTCH. POLLUTANTS: ONE PLASTIC BAG.
STOMACHS: 10 BLACK COD; 10 FLATHEAD SOLE; 10 REX SOLE; 10
ARROWTOOTH FLOUNDER; 3 PACIFIC COD.

BOTTOM WATER TEMPERATURE °C = 6.8

CRUSE #	STAT #	TOW #	GEAR CODE	DATE YYMMDD	TIME HHMM	START LATITUDE DEG MIN	START LONGITUDE DEG MIN	FINISH LATITUDE DEG MIN	FINISH LONGITUDE DEG MIN	MIDPOINT LATITUDE DEG MIN	MIDPOINT LONGITUDE DEG MIN	TIME FISH MINS	DIST FISHED (KM)	DEPTH FISHED (METERS) MIN	MAX	AVG
FN795	100E	23	OTB	791115	1303	59 11.6N	140 14.7W	59 10.7N	140 17.3W			30	3.52	122.6 -	126.3	124.5

TAXON CODE	TAXONOMIC NAME	COUNTS RAW	COUNTS %	COUNTS /KM	COUNTS /M SQ	WEIGHT (GRAMS) RAW	WEIGHT %	WEIGHT /KM	WEIGHT /M SQ
INVERTEBRATES									
4905060701	LISCHKEIA CIDARIS	22	0.5	6.3	0.00051	194.0	0.1	55.1	0.00452
4905290101	FUSITRITON OREGONENSIS	42	0.9	11.9	0.00098	2414.0	1.1	685.8	0.05621
4905330202	BERINGIUS KENNICOTTI	4	0.1	1.1	0.00009	168.0	0.1	47.7	0.00391
4907010101	ROSSIA PACIFICA	16	0.3	4.5	0.00037	220.0	0.1	62.5	0.00512
5333040104	PANDALUS MONTAGUI TRIDENS	18	0.4	5.1	0.00042	52.0	0.0	14.8	0.00121
5333110206	PAGURUS SETOSUS	2	0.0	0.6	0.00005	30.0	0.0	8.5	0.00070
5333110302	ELASSOCHIRUS CAVIMANUS	22	0.5	6.3	0.00051	392.0	0.2	111.4	0.00913
5333121002	LOPHOLITHODES FORAMINATUS	2	0.0	0.6	0.00005	1340.0	0.6	380.7	0.03120
5333170201	HYAS LYRATUS	16	0.3	4.5	0.00037	994.0	0.4	282.4	0.02315
6801040104	CERAMASTER PATAGONICUS	22	0.5	6.3	0.00051	1708.0	0.8	485.2	0.03977
6801040501	MEDIASTER AEQUALIS	10	0.2	2.8	0.00023	224.0	0.1	63.6	0.00522
6801080101	HENRICIA ASPERA	4	0.1	1.1	0.00009	96.0	0.0	27.3	0.00224
6801100302	PTERASTER MILITARIS	4	0.1	1.1	0.00009	340.0	0.2	96.6	0.00792
6801110103	CROSSASTER PAPPOSUS	16	0.3	4.5	0.00037	180.0	0.1	51.1	0.00419
6801110301	SOLASTER DAWSONI	2	0.0	0.6	0.00005	40.0	0.0	11.4	0.00093
6801120901	LETHASTERIAS NANIMENSIS	2	0.0	0.6	0.00005	100.0	0.0	28.4	0.00233
6802040101	ALLOCENTROTUS FRAGILIS	48	1.0	13.6	0.00112	2200.0	1.0	625.0	0.05123
6802040200	STRONGYLOCENTROTUS SPP.	4434	94.6	1259.7	0.10325	210600.0	95.2	59829.5	4.90406
	TOTAL			1331.3	0.10912			62867.0	5.15304
VERTEBRATES									
7602050201	SQUALUS ACANTHIAS	20	3.0	5.7	0.00047	30800.0	10.9	8750.0	0.71721
7904020501	THALEICHTHYS PACIFICUS	88	13.4	25.0	0.00205	3076.0	1.1	873.9	0.07163
7909020401	GADUS MACROCEPHALUS	14	2.1	4.0	0.00033	61800.0	21.9	17556.8	1.43908
7909020701	THERAGRA CHALCOGRAMMA	24	3.7	6.8	0.00056	316.0	0.1	89.8	0.00736
7915010102	SEBASTES ALUTUS	6	0.9	1.7	0.00014	400.0	0.1	113.6	0.00931
7915020201	OPHIODON ELONGATUS	4	0.6	1.1	0.00009	1800.0	0.6	511.4	0.04192
7915030101	ANOPLOPOMA FIMBRIA	4	0.6	1.1	0.00009	2800.0	1.0	795.5	0.06520
7915044103	TRIGLOPS MACELLUS	10	1.5	2.8	0.00023	646.0	0.2	183.5	0.01504
7916090103	BATHYMASTER SIGNATUS	88	13.4	25.0	0.00205	10000.0	3.5	2840.9	0.23286
7917020102	ATHERESTHES STOMIAS	368	56.1	104.5	0.00857	104400.0	37.0	29659.1	2.43107
7917020501	GLYPTOCEPHALUS ZACHIRUS	16	2.4	4.5	0.00037	2800.0	1.0	795.5	0.06520
7917020601	HIPPOGLOSSOIDES ELASSODON	6	0.9	1.7	0.00014	2800.0	1.0	795.5	0.06520
7917020701	HIPPOGLOSSUS STENOLEPIS	8	1.2	2.3	0.00019	60800.0	21.5	17272.7	1.41580
	TOTAL			186.4	0.01528			80238.1	6.57689

COMMENTS

STRONGYLOCENTROTUS MEAN WT. 95 GM PER 2 INDIVIDUALS;
ALLOCENTROTUS ALSO 2 PER 95 GM.
HYAS LYRATUS: 1 MALE; 7 FEMALES WITH ORANGE EGGS. STOMACHS: 10
ARROWTOOTH FLOUNDER; 7 PACIFIC COD. 1 SLIME STAR PRESERVED.
2 SLIM SCULPIN PRESERVED.

BOTTOM WATER TEMPERATURE °C = 6.5

CRUSE #	STAT #	TOW #	GEAR CODE	DATE YYMMDD	TIME HHMM	START LATITUDE DEG MIN	START LONGITUDE DEG MIN	FINISH LATITUDE DEG MIN	FINISH LONGITUDE DEG MIN	MIDPOINT LATITUDE DEG MIN	MIDPOINT LONGITUDE DEG MIN	TIME FISH MINS	DIST FISHED (KM)	DEPTH FISHED (METERS) MIN	MAX	AVG
FN795	100D	24	OTB	791115	1521	59 21.9N	140 17.9W	59 20.4N	140 17.9W			30	2.78	135.4 -	150.0	142.7

TAXON CODE	TAXONOMIC NAME	COUNTS RAW	COUNTS %	COUNTS /KM	COUNTS /M SQ	WEIGHT (GRAMS) RAW	WEIGHT %	WEIGHT /KM	WEIGHT /M SQ
INVERTEBRATES									
3200000000	PORIFERA					1593.0	12.7	573.0	0.04697
4905290101	FUSITRITON OREGONENSIS	10	5.0	3.6	0.00029	834.0	6.7	300.0	0.02459
4905360101	ARCTOMLLON STEARNSII	1	0.5	0.4	0.00003	216.0	1.7	77.7	0.00637
5333040103	PANDALUS JORDANI	94	47.0	33.8	0.00277	1052.0	8.4	378.4	0.03102
5333040204	PANDALOPSIS DISPAR	3	1.5	1.1	0.00009	116.0	0.9	41.7	0.00342
5333110206	PAGURUS SETOSUS	1	0.5	0.4	0.00003	30.0	0.2	10.8	0.00088
5333110216	PAGURUS CONFRAGOSUS	1	0.5	0.4	0.00003	30.0	0.2	10.8	0.00088
5333121002	LOPHOLITHODES FORAMINATUS	5	2.5	1.8	0.00015	4100.0	32.7	1474.8	0.12089
5333170302	CHIONOECETES BAIRDI	35	17.5	12.6	0.00103	760.0	6.1	273.4	0.02241
6801040104	CERAMASTER PATAGONICUS	12	6.0	4.3	0.00035	966.0	7.7	347.5	0.02848
6801040501	MEDIASTER AEQUALIS	14	7.0	5.0	0.00041	510.0	4.1	183.5	0.01504
6801040602	PSEUDARCHASTER PARELII	4	2.0	1.4	0.00012	90.0	0.7	32.4	0.00265
6801080100	HENRICIA SPP.	1	0.5	0.4	0.00003	10.0	0.1	3.6	0.00029
6801080101	HENRICIA ASPERA	1	0.5	0.4	0.00003	10.0	0.1	3.6	0.00029
6801080105	HENRICIA LEVIUSCULA	1	0.5	0.4	0.00003	10.0	0.1	3.6	0.00029
6801100101	DIPLOPTERASTER MULTIPES	2	1.0	0.7	0.00006	953.0	7.6	342.8	0.02810
6801110301	SOLASTER DAWSONI	2	1.0	0.7	0.00006	170.0	1.4	61.2	0.00501
6802040101	ALLOCENTROTUS FRAGILIS	8	4.0	2.9	0.00024	661.0	5.3	237.8	0.01949
7203030402	HALOCYNTHIA IGABOJA	5	2.5	1.8	0.00015	430.0	3.4	154.7	0.01268
	TOTAL			71.9	0.00590			4511.2	0.36977
VERTEBRATES									
7602050201	SQUALUS ACANTHIAS	5	0.5	1.8	0.00015	10900.0	5.6	3920.9	0.32138
7603020106	RAJA KINCAIDI	5	0.5	1.8	0.00015	5900.0	3.0	2122.3	0.17396
7904020501	THALEICHTHYS PACIFICUS	283	27.5	101.8	0.00834	6156.0	3.2	2214.4	0.18151
7909020701	THERAGRA CHALCOGRAMMA	8	0.8	2.9	0.00024	1213.0	0.6	436.3	0.03576
7909041110	LYCODES PALEARIS	1	0.1	0.4	0.00003	200.0	0.1	71.9	0.00590
7915010201	SEBASTOLOBUS ALASCANUS	55	5.3	19.8	0.00162	21300.0	10.9	7661.9	0.62802
7915030101	ANOPLOPOMA FIMBRIA	4	0.4	1.4	0.00012	3200.0	1.6	1151.1	0.09435
7915044201	ULCA BOLINI	1	0.1	0.4	0.00003	30.0	0.0	10.8	0.00088
7917020102	ATHERESTHES STOMIAS	521	50.6	187.4	0.01536	128900.0	66.2	46366.9	3.80057
7917020501	GLYPTOCEPHALUS ZACHIRUS	115	11.2	41.4	0.00339	12700.0	6.5	4568.3	0.37445
7917020601	HIPPOGLOSSOIDES ELASSODON	28	2.7	10.1	0.00083	3600.0	1.8	1295.0	0.10614
7917021301	MICROSTOMUS PACIFICUS	3	0.3	1.1	0.00009	500.0	0.3	179.9	0.01474
	TOTAL			370.1	0.03034			69999.6	5.73768

COMMENTS

PANDALUS JORDANI: 75% WITH AQUA EGGS. CHIONECETES BAIRDI:
17 MALES; 18 FEMALES.
STOMACHS: 10 FLATHEAD SOLE; 10 REX SOLE; 10 ARROWTOOTH FLOUNDER.
POLLUTANTS: 1 PLASTIC BAG; 1 5 GAL. FUEL CAN.
BOTTOM WATER TEMPERATURE °C = 6.6

CRUSE #	STAT #	TOW #	GEAR CODE	DATE YYMMDD	TIME HHMM	START LATITUDE DEG MIN	START LONGITUDE DEG MIN	FINISH LATITUDE DEG MIN	FINISH LONGITUDE DEG MIN	MIDPOINT LATITUDE DEG MIN	MIDPOINT LONGITUDE DEG MIN	TIME FISH MINS	DIST FISHED (KM)	DEPTH FISHED (METERS) MIN	MAX	AVG
FN795	101E	25	OTB	791115	1745	59 16.1N	140 0.7W	59 17.7N	140 1.5W			30	3.33	139.1 -	146.4	142.8

TAXON CODE	TAXONOMIC NAME	COUNTS RAW	%	/KM	/M SQ	WEIGHT (GRAMS) RAW	%	/KM	/M SQ
INVERTEBRATES									
4905290101	FUSITRITON OREGONENSIS	2	1.1	0.6	0.00005	181.0	1.3	54.4	0.00446
5333040204	PANDALOPSIS DISPAR	2	1.1	0.6	0.00005	47.0	0.3	14.1	0.00116
5333050401	EUALUS BARBATA	1	0.5	0.3	0.00002	14.0	0.1	4.2	0.00034
5333121002	LOPHOLITHODES FORAMINATUS	1	0.5	0.3	0.00002	932.0	6.5	279.9	0.02294
5333170302	CHIONOECETES BAIRDI	174	93.0	52.3	0.00428	11400.0	79.9	3423.4	0.28061
6801040403	HIPPASTERIAS SPINOSA	1	0.5	0.3	0.00002	217.0	1.5	65.2	0.00534
6801060101	CTENODISCUS CRISPATUS	1	0.5	0.3	0.00002	16.0	0.1	4.8	0.00039
6801110301	SOLASTER DAWSONI	4	2.1	1.2	0.00010	607.0	4.3	182.3	0.01494
6801121201	PYCNOPODIA HELIANTHOIDES	1	0.5	0.3	0.00002	862.0	6.0	258.9	0.02122
	TOTAL			56.2	0.00460			4287.1	0.35140
VERTEBRATES									
7603020106	RAJA KINCAIDI	15	4.4	4.5	0.00037	21300.0	8.1	6396.4	0.52429
7603020108	RAJA RHINA	18	5.3	5.4	0.00044	113000.0	43.2	33933.9	2.78147
7904010206	ONCORHYNCHUS TSHAWYTSCHA	1	0.3	0.3	0.00002	574.0	0.2	172.4	0.01413
7904020501	THALEICHTHYS PACIFICUS	24	7.0	7.2	0.00059	830.0	0.3	249.2	0.02043
7909020701	THERAGRA CHALCOGRAMMA	21	6.1	6.3	0.00052	1800.0	0.7	540.5	0.04431
7915010102	SEBASTES ALUTUS	1	0.3	0.3	0.00002	100.0	0.0	30.0	0.00246
7915010201	SEBASTOLOBUS ALASCANUS	24	7.0	7.2	0.00059	14500.0	5.5	4354.4	0.35691
7915030101	ANOPLOPOMA FIMBRIA	2	0.6	0.6	0.00005	1400.0	0.5	420.4	0.03446
7915040901	DASYCOTTUS SETIGER	1	0.3	0.3	0.00002	31.0	0.0	9.3	0.00076
7917020102	ATHERESTHES STOMIAS	225	65.8	67.6	0.00554	96300.0	36.8	28918.9	2.37040
7917020501	GLYPTOCEPHALUS ZACHIRUS	7	2.0	2.1	0.00017	900.0	0.3	270.3	0.02215
7917020701	HIPPOGLOSSUS STENOLEPIS	3	0.9	0.9	0.00007	10900.0	4.2	3273.3	0.26830
	TOTAL			102.7	0.00842			78569.1	6.44009

COMMENTS

STOMACHS: 20 JUVENILE SNOW CRAB. SNOW CRABS: 71 FEMALES; 103 MALES.
BOTTOM WATER TEMPERATURE °C = 6.3

CRUSE #	STAT #	TOW #	GEAR CODE	DATE YYMMDD	TIME HHMM	START LATITUDE DEG MIN	START LONGITUDE DEG MIN	FINISH LATITUDE DEG MIN	FINISH LONGITUDE DEG MIN	MIDPOINT LATITUDE DEG MIN	MIDPOINT LONGITUDE DEG MIN	TIME FISH MINS	DIST FISHED (KM)	DEPTH FISHED (METERS) MIN	MAX	AVG
FN795	9C	26	OTB	791116	1433	59 57.5N	139 34.8W	59 56.2N	139 35.7W			30	2.41	239.7 -	243.4	241.6

TAXON CODE	TAXONOMIC NAME		COUNTS RAW	%	/KM	/M SQ	WEIGHT (GRAMS) RAW	%	/KM	/M SQ
INVERTEBRATES										
3303000000	ANTHOZOA		2	2.0	0.8	0.00007	510.0	37.8	211.6	0.01735
3303470201	STYLATULA GRACILE		2	2.0	0.8	0.00007	184.0	13.6	76.3	0.00626
5333040101	PANDALUS BOREALIS		40	39.6	16.6	0.00136	176.0	13.1	73.0	0.00599
5333040204	PANDALOPSIS DISPAR		50	49.5	20.7	0.00170	75.0	5.6	31.1	0.00255
5333060107	CRANGON DALLI		1	1.0	0.4	0.00003	5.0	0.4	2.1	0.00017
5333110401	LABIDOCHIRUS SPLENDESCENS		1	1.0	0.4	0.00003	16.0	1.2	6.6	0.00054
5333170302	CHIONOECETES BAIRDI		3	3.0	1.2	0.00010	216.0	16.0	89.6	0.00735
6801080100	HENRICIA SPP.		1	1.0	0.4	0.00003	90.0	6.7	37.3	0.00306
6803040201	GORGONOCEPHALUS CARYI		1	1.0	0.4	0.00003	76.0	5.6	31.5	0.00258
		TOTAL			41.9	0.00344			559.3	0.04585
VERTEBRATES										
7602050201	SQUALUS ACANTHIAS		11	12.5	4.6	0.00037	15900.0	73.6	6597.5	0.54078
7903010201	CLUPEA HARENGUS PALLASI		9	10.2	3.7	0.00031	590.0	2.7	244.8	0.02007
7904020201	MALLOTUS VILLOSUS		1	1.1	0.4	0.00003	19.0	0.1	7.9	0.00065
7909020701	THERAGRA CHALCOGRAMMA		58	65.9	24.1	0.00197	2230.0	10.3	925.3	0.07585
7915040901	DASYCOTTUS SETIGER		2	2.3	0.8	0.00007	256.0	1.2	106.2	0.00871
7917020102	ATHERESTHES STOMIAS		4	4.5	1.7	0.00014	970.0	4.5	402.5	0.03299
7917020601	HIPPOGLOSSOIDES ELASSODON		2	2.3	0.8	0.00007	444.0	2.1	184.2	0.01510
7917021501	PLATICHTHYS STELLATUS		1	1.1	0.4	0.00003	1183.0	5.5	490.9	0.04024
		TOTAL			36.5	0.00299			8959.3	0.73437

COMMENTS

NUMEROUS ROCKS-APPROX. 1850 KG. CHIONOECETES BAIRDI: 1 FEMALE; 1 MALE; 1 UNKNOWN. POLLUTANTS: ONE PLASTIC BAG.

BOTTOM WATER TEMPERATURE °C = 5.7

CRUSE #	STAT #	TOW #	GEAR CODE	DATE YYMMDD	TIME HHMM	START LATITUDE DEG MIN	START LONGITUDE DEG MIN	FINISH LATITUDE DEG MIN	FINISH LONGITUDE DEG MIN	MIDPOINT LATITUDE DEG MIN	MIDPOINT LONGITUDE DEG MIN	TIME FISH MINS	DIST FISHED (KM)	DEPTH FISHED (METERS) MIN	MAX	AVG
FN795	103B	27	OTB	791117	1116	59 16.6N	139 32.6W	59 18.0N	139 33.3W			30	3.15	150.1	- 161.0	155.6

TAXON CODE	TAXONOMIC NAME	COUNTS RAW	%	/KM	/M SQ	WEIGHT (GRAMS) RAW	%	/KM	/M SQ
INVERTEBRATES									
3303000000	ANTHOZOA	1	0.5	0.3	0.00003	121.0	0.3	38.4	0.00315
4905290101	FUSITRITON OREGONENSIS	1	0.5	0.3	0.00003	99.0	0.2	31.4	0.00258
4905330305	NEPTUNEA PRIBILOFFENSIS	1	0.5	0.3	0.00003	98.0	0.2	31.1	0.00255
4905660101	TRITONIA EXSULANS	1	0.5	0.3	0.00003	50.0	0.1	15.9	0.00130
4907120200	OCTOPUS	1	0.5	0.3	0.00003	60.0	0.1	19.0	0.00156
5333040101	PANDALUS BOREALIS	50	26.5	15.9	0.00130	405.0	0.9	128.6	0.01054
5333040204	PANDALOPSIS DISPAR	19	10.1	6.0	0.00049	400.0	0.9	127.0	0.01041
5333110203	PAGURUS ALEUTICUS	1	0.5	0.3	0.00003	20.0	0.0	6.3	0.00052
5333110216	PAGURUS CONFRAGOSUS	1	0.5	0.3	0.00003	10.0	0.0	3.2	0.00026
5333170302	CHIONOECETES BAIRDI	101	53.4	32.1	0.00263	41800.0	93.3	13269.8	1.08769
6801060101	CTENODISCUS CRISPATUS	10	5.3	3.2	0.00026	121.0	0.3	38.4	0.00315
6801121201	PYCNOPODIA HELIANTHOIDES	2	1.1	0.6	0.00005	1599.0	3.6	507.6	0.04161
	TOTAL			60.0	0.00492			14216.8	1.16531
VERTEBRATES									
7602050201	SQUALUS ACANTHIAS	8	4.8	2.5	0.00021	14100.0	13.3	4476.2	0.36690
7603020106	RAJA KINCAIDI	9	5.4	2.9	0.00023	9500.0	9.0	3015.9	0.24720
7603020108	RAJA RHINA	1	0.6	0.3	0.00003	8600.0	8.1	2730.2	0.22378
7909041110	LYCODES PALEARIS	1	0.6	0.3	0.00003	100.0	0.1	31.7	0.00260
7915010102	SEBASTES ALUTUS	2	1.2	0.6	0.00005	900.0	0.8	285.7	0.02342
7915040901	DASYCOTTUS SETIGER	10	6.0	3.2	0.00026	500.0	0.5	158.7	0.01301
7915044201	ULCA BOLINI	1	0.6	0.3	0.00003	2700.0	2.5	857.1	0.07026
7917020102	ATHERESTHES STOMIAS	136	81.0	43.2	0.00354	69500.0	65.6	22063.5	1.80848
	TOTAL			53.3	0.00437			33619.0	2.75566

COMMENTS

PANDALOPSIS DISPAR: 10 WITH TAN EGGS. PANDALUS BOREALIS: 15 WITH AQUA EGGS. LOGS RIDDLED WITH BANKIA SETACEA. CHIONOECETES BAIRDI: 63 MALES, 38 FEMALES-ALL OLD HARD SHELLS. STOMACHS: 10 FLATHEAD SOLE; 10 TURBOT; 20 SNOW CRAB. POLLUTANTS: 5 PLASTIC BAGS, 1 RUBBER GLOVE.

BOTTOM WATER TEMPERATURE °C = 7.4

CRUSE #	STAT #	TOW #	GEAR CODE	DATE YYMMDD	TIME HHMM	START LATITUDE DEG MIN	START LONGITUDE DEG MIN	FINISH LATITUDE DEG MIN	FINISH LONGITUDE DEG MIN	MIDPOINT LATITUDE DEG MIN	MIDPOINT LONGITUDE DEG MIN	TIME FISH MINS	DIST FISHED (KM)	DEPTH FISHED (METERS) MIN	MAX	AVG
FN795	103C	28	OTB	791117	1346	59 5.3N	139 30.6W	59 6.3N	139 28.3W			30	2.96	115.3	117.1	116.2

TAXON CODE	TAXONOMIC NAME	COUNTS RAW	%	/KM	/M SQ	WEIGHT (GRAMS) RAW	%	/KM	/M SQ
INVERTEBRATES									
3200000000	PORIFERA					200.0	1.1	67.6	0.00554
4905290101	FUSITRITON OREGONENSIS	6	0.6	2.0	0.00017	380.0	2.1	128.4	0.01052
4907010101	ROSSIA PACIFICA	16	1.5	5.4	0.00044	216.0	1.2	73.0	0.00598
5333040103	PANDALUS JORDANI	931	87.3	314.5	0.02578	8358.0	46.7	2823.6	0.23145
5333050401	EUALUS BARBATA	25	2.3	8.4	0.00069	250.0	1.4	84.5	0.00692
5333060107	CRANGON DALLI	15	1.4	5.1	0.00042	75.0	0.4	25.3	0.00208
5333110203	PAGURUS ALEUTICUS	1	0.1	0.3	0.00003	23.0	0.1	7.8	0.00064
5333110216	PAGURUS CONFRAGOSUS	1	0.1	0.3	0.00003	23.0	0.1	7.8	0.00064
5333121002	LOPHOLITHODES FORAMINATUS	2	0.2	0.7	0.00006	2300.0	12.8	777.0	0.06369
5333170302	CHIONOECETES BAIRDI	68	6.4	23.0	0.00188	5842.0	32.6	1973.6	0.16177
6801060101	CTENODISCUS CRISPATUS	1	0.1	0.3	0.00003	15.0	0.1	5.1	0.00042
6802040101	ALLOCENTROTUS FRAGILIS	1	0.1	0.3	0.00003	221.0	1.2	74.7	0.00612
	TOTAL			360.5	0.02955			6048.3	0.49576
VERTEBRATES									
7602050201	SQUALUS ACANTHIAS	9	0.9	3.0	0.00025	13200.0	5.4	4459.5	0.36553
7603020106	RAJA KINCAIDI	25	2.4	8.4	0.00069	29100.0	11.9	9831.1	0.80583
7603020108	RAJA RHINA	3	0.3	1.0	0.00008	12300.0	5.0	4155.4	0.34061
7904020501	THALEICHTHYS PACIFICUS	325	31.3	109.8	0.00900	815.0	0.3	275.3	0.02257
7909020701	THERAGRA CHALCOGRAMMA	219	21.1	74.0	0.00606	4468.0	1.8	1509.5	0.12373
7909041110	LYCODES PALEARIS	24	2.3	8.1	0.00066	986.0	0.4	333.1	0.02730
7915010101	SEBASTES ALEUTIANUS	7	0.7	2.4	0.00019	1926.0	0.8	650.7	0.05333
7915030101	ANOPLOPOMA FIMBRIA	3	0.3	1.0	0.00008	2700.0	1.1	912.2	0.07477
7917020102	ATHERESTHES STOMIAS	377	36.3	127.4	0.01044	144800.0	59.0	48918.9	4.00975
7917020501	GLYPTOCEPHALUS ZACHIRUS	18	1.7	6.1	0.00050	1800.0	0.7	608.1	0.04984
7917020601	HIPPOGLOSSOIDES ELASSODON	24	2.3	8.1	0.00066	2300.0	0.9	777.0	0.06369
7917020701	HIPPOGLOSSUS STENOLEPIS	4	0.4	1.4	0.00011	30900.0	12.6	10439.2	0.85567
	TOTAL			350.7	0.02874			82869.9	6.79262

COMMENTS

CRYPTONISCIDAE PARASITES ON PANDALUS JORDANI. GASTROPOD EGG CASES.
CHIONOECETES BAIRDI: 33 MALES; 35 FEMALES.
STOMACHS: 10 REX SOLE; 10 TURBOT; 68 SNOW CRAB; 10 FLATHEAD
SOLE; 20 SPINYHEAD SCULPIN.
PANDALUS JORDANI:
W/ AQUA OVARY 63
W/ ISOPOD PARASITES 42
W/ EGGS 331
NEITHER OF ABOVE 493

BOTTOM WATER TEMPERATURE °C = 7.9

CRUSE #	STAT #	TOW #	GEAR CODE	DATE YYMMDD	TIME HHMM	START LATITUDE DEG MIN	START LONGITUDE DEG MIN	FINISH LATITUDE DEG MIN	FINISH LONGITUDE DEG MIN	MIDPOINT LATITUDE DEG MIN	MIDPOINT LONGITUDE DEG MIN	TIME FISH MINS	DIST FISHED (KM)	DEPTH FISHED (METERS) MIN	MAX	AVG
FN795	104A	29	OTB	791117	1406	59 12.1N	139 15.0W	59 13.7N	139 16.0W			30	3.15	64.1 -	67.7	65.9

TAXON CODE	TAXONOMIC NAME	COUNTS RAW	%	/KM	/M SQ	WEIGHT (GRAMS) RAW	%	/KM	/M SQ
INVERTEBRATES									
4801230201	CHEILONEREIS CYCLURUS	1	0.0	0.3	0.00003	10.0	0.0	3.2	0.00026
4801740101	APHRODITA JAPONICA	91	0.8	28.9	0.00237	3902.0	6.4	1238.7	0.10154
4904080401	PECTEN CAURINUS	32	0.3	10.2	0.00083	9100.0	14.9	2888.9	0.23679
4905320128	BUCCINUM PLECTRUM	20	0.2	6.3	0.00052	100.0	0.2	31.7	0.00260
5333040107	PANDALUS DANAE	1	0.0	0.3	0.00003	10.0	0.0	3.2	0.00026
5333110202	PAGURUS OCHOTENSIS	30	0.3	9.5	0.00078	1060.0	1.7	336.5	0.02758
5333170302	CHIONOECETES BAIRDI	5	0.0	1.6	0.00013	2700.0	4.4	857.1	0.07026
6801050101	LUIDIA FOLIOLATA	25	0.2	7.9	0.00065	6800.0	11.2	2158.7	0.17695
6801121201	PYCNOPODIA HELIANTHOIDES	12	0.1	3.8	0.00031	14500.0	23.8	4603.2	0.37731
6803090611	OPHIURA SARSI	11350	98.1	3603.2	0.29534	22700.0	37.3	7206.3	0.59068
	TOTAL			3672.1	0.30099			19327.6	1.58423
VERTEBRATES									
7602050201	SQUALUS ACANTHIAS	11	0.9	3.5	0.00029	16800.0	3.1	5333.3	0.43716
7603020103	RAJA BINOCULATA	122	9.5	38.7	0.00317	238400.0	44.4	75682.5	6.20349
7603020108	RAJA RHINA	1	0.1	0.3	0.00003	4500.0	0.8	1428.6	0.11710
7909020601	MICROGADUS PROXIMUS	440	34.4	139.7	0.01145	61300.0	11.4	19460.3	1.59511
7915030101	ANOPLOPOMA FIMBRIA	3	0.2	1.0	0.00008	92.0	0.0	29.2	0.00239
7915051301	AGONUS ACIPENSERINUS	4	0.3	1.3	0.00010	124.0	0.0	39.4	0.00323
7916080201	TRICHODON TRICHODON	3	0.2	1.0	0.00008	215.0	0.0	68.3	0.00559
7917020102	ATHERESTHES STOMIAS	23	1.8	7.3	0.00060	10900.0	2.0	3460.3	0.28363
7917020501	GLYPTOCEPHALUS ZACHIRUS	173	13.5	54.9	0.00450	10900.0	2.0	3460.3	0.28363
7917020701	HIPPOGLOSSUS STENOLEPIS	26	2.0	8.3	0.00068	52700.0	9.8	16730.2	1.37132
7917020801	ISOPSETTA ISOLEPIS	442	34.6	140.3	0.01150	126200.0	23.5	40063.5	3.28389
7917021401	PAROPHRYS VETULUS	24	1.9	7.6	0.00062	2700.0	0.5	857.1	0.07026
7917021501	PLATICHTHYS STELLATUS	7	0.5	2.2	0.00018	12300.0	2.3	3904.8	0.32006
	TOTAL			406.0	0.03328			170517.8	13.97687

COMMENTS

1 DEAD CLINOCARDIUM CILIATUM. OPHIURA SARSI STOMACHS. 950G;
5 @ 10G. STOMACHS: APPROX. 475 OPHIURA SARSI; 7 STARRY FLOUNDER;
10 REX SOLE; 10 ENGLISH SOLE; 10 BUTTER SOLE. POLLUTANTS:
5 16OZ GLASS JARS.
20 BIG SKATE CASES EACH W/ 1-2 YOUNG W/ ATTACHED YOLK SACS.
BANKIA SETAE IN WOOD.

BOTTOM WATER TEMPERATURE °C = 9.8

CRUSE #	STAT #	TOW #	GEAR CODE	DATE YYMMDD	TIME HHMM	START LATITUDE DEG MIN	START LONGITUDE DEG MIN	FINISH LATITUDE DEG MIN	FINISH LONGITUDE DEG MIN	MIDPOINT LATITUDE DEG MIN	MIDPOINT LONGITUDE DEG MIN	TIME FISH MINS	DIST FISHED (KM)	DEPTH FISHED (METERS) MIN	MAX	AVG
FN795	104B	30	OTB	791117	1810	59 4.5N	139 12.8W	59 5.7N	139 14.2W			30	2.59	89.7 -	91.5	90.6

TAXON CODE	TAXONOMIC NAME	COUNTS RAW	%	/KM	/M SQ	WEIGHT (GRAMS) RAW	%	/KM	/M SQ
INVERTEBRATES									
4801740100	APHRODITA SPP.	59	14.9	22.8	0.00187	2183.0	19.1	842.9	0.06909
4904080401	PECTEN CAURINUS	8	2.0	3.1	0.00025	1400.0	12.2	540.5	0.04431
4905320128	BUCCINUM PLECTRUM	4	1.0	1.5	0.00013	65.0	0.6	25.1	0.00206
4905330801	NEPTUNEA LYRATA	2	0.5	0.8	0.00006	120.0	1.0	46.3	0.00380
4905660101	TRITONIA EXSULANS	7	1.8	2.7	0.00022	760.0	6.6	293.4	0.02405
4905670101	ARMINIA CALIFORNICA	2	0.5	0.8	0.00006	5.0	0.0	1.9	0.00016
4907010101	ROSSIA PACIFICA	8	2.0	3.1	0.00025	100.0	0.9	38.6	0.00316
4907120200	OCTOPUS	2	0.5	0.8	0.00006	83.0	0.7	32.0	0.00263
5333040101	PANDALUS BOREALIS	46	11.6	17.8	0.00146	426.0	3.7	164.5	0.01348
5333060111	CRANGON COMMUNIS	17	4.3	6.6	0.00054	47.0	0.4	18.1	0.00149
5333060303	ARGIS OVIFER	1	0.3	0.4	0.00003	5.0	0.0	1.9	0.00016
5333110202	PAGURUS OCHOTENSIS	20	5.0	7.7	0.00063	498.0	4.4	192.3	0.01576
5333110203	PAGURUS ALEUTICUS	2	0.5	0.8	0.00006	17.0	0.1	6.6	0.00054
5333110216	PAGURUS CONFRAGOSUS	2	0.5	0.8	0.00006	30.0	0.3	11.6	0.00095
5333121002	LOPHOLITHODES FORAMINATUS	5	1.3	1.9	0.00016	2300.0	20.1	888.0	0.07279
5333170201	HYAS LYRATUS	4	1.0	1.5	0.00013	213.0	1.9	82.2	0.00674
5333170302	CHIONOECETES BAIRDI	203	51.1	78.4	0.00642	1661.0	14.5	641.3	0.05257
6801040501	MEDIASTER AEQUALIS	2	0.5	0.8	0.00006	150.0	1.3	57.9	0.00475
6801060101	CTENODISCUS CRISPATUS	1	0.3	0.4	0.00003	10.0	0.1	3.9	0.00032
6801121201	PYCNOPODIA HELIANTHOIDES	2	0.5	0.8	0.00006	1356.0	11.9	523.6	0.04291
	TOTAL			153.3	0.01256			4412.7	0.36170
VERTEBRATES									
7602050201	SQUALUS ACANTHIAS	9	6.1	3.5	0.00028	10400.0	22.1	4015.4	0.32913
7603020106	RAJA KINCAIDI	1	0.7	0.4	0.00003	341.0	0.7	131.7	0.01079
7603020108	RAJA RHINA	2	1.4	0.8	0.00006	1835.0	3.9	708.5	0.05807
7903010201	CLUPEA HARENGUS PALLASI	2	1.4	0.8	0.00006	143.0	0.3	55.2	0.00453
7904020501	THALEICHTHYS PACIFICUS	2	1.4	0.8	0.00006	78.0	0.2	30.1	0.00247
7909020601	MICROGADUS PROXIMUS	1	0.7	0.4	0.00003	44.0	0.1	17.0	0.00139
7909020701	THERAGRA CHALCOGRAMMA	62	41.9	23.9	0.00196	2080.0	4.4	803.1	0.06583
7909041110	LYCODES PALEARIS	5	3.4	1.9	0.00016	540.0	1.1	208.5	0.01709
7915030101	ANOPLOPOMA FIMBRIA	2	1.4	0.8	0.00006	269.0	0.6	103.9	0.00851
7915040901	DASYCOTTUS SETIGER	5	3.4	1.9	0.00016	292.0	0.6	112.7	0.00924
7915043101	RADULINUS ASPRELLUS	2	1.4	0.8	0.00006	10.0	0.0	3.9	0.00032
7915050401	ASTEROTHECA ALASCANA	1	0.7	0.4	0.00003	5.0	0.0	1.9	0.00016
7917020102	ATHERESTHES STOMIAS	38	25.7	14.7	0.00120	14100.0	29.9	5444.0	0.44623
7917020501	GLYPTOCEPHALUS ZACHIRUS	9	6.1	3.5	0.00028	1267.0	2.7	489.2	0.04010
7917020701	HIPPOGLOSSUS STENOLEPIS	4	2.7	1.5	0.00013	15000.0	31.8	5791.5	0.47471
7917020801	ISOPSETTA ISOLEPIS	2	1.4	0.8	0.00006	660.0	1.4	254.8	0.02089
7917020901	LEPIDOPSETTA BILINEATA	1	0.7	0.4	0.00003	70.0	0.1	27.0	0.00222
	TOTAL			57.1	0.00468			18198.5	1.49168

COMMENTS

SERPULIDAE AND SPONGE ON PECTEN CAURINUS DORSAL VALVE.
PANDALUS BOREALIS.: 90% W/ AQUA EGGS.
STOMACHS: 2 PYCNOPODIA HELIANTHOIDES; 35 CHIONOECETES BAIRDI;
5 DASYCOTTUS SETIGER. CRANGON SP.: 17 PRESERVED, 4/17
W/APOCROBOPYRUS SP. HYAS LYRATUS: 1 FEMALE W/ ORANGE EGGS.
BOTTOM WATER TEMPERATURE °C = 10.0

CRUSE #	STAT #	TOW #	GEAR CODE	DATE YYMMDD	TIME HHMM	START LATITUDE DEG MIN	START LONGITUDE DEG MIN	FINISH LATITUDE DEG MIN	FINISH LONGITUDE DEG MIN	MIDPOINT LATITUDE DEG MIN	MIDPOINT LONGITUDE DEG MIN	TIME FISH MINS	DIST FISHED (KM)	DEPTH FISHED (METERS) MIN	MAX	AVG
FN795	106B	31	OTB	791118	0655	58 58.5N	138 41.5W	58 59.8N	138 43.7W			30	3.15	151.9 -	151.9	151.9

TAXON CODE	TAXONOMIC NAME	COUNTS RAW	COUNTS %	COUNTS /KM	COUNTS /M SQ	WEIGHT (GRAMS) RAW	WEIGHT %	WEIGHT /KM	WEIGHT /M SQ
INVERTEBRATES									
4904080401	PECTEN CAURINUS	9	1.7	2.9	0.00023	1620.0	1.9	514.3	0.04215
4905290101	FUSITRITON OREGONENSIS	7	1.3	2.2	0.00018	556.0	0.7	176.5	0.01447
4905330801	NEPTUNEA LYRATA	11	2.1	3.5	0.00029	830.0	1.0	263.5	0.02160
4905660101	TRITONIA EXSULANS	10	1.9	3.2	0.00026	247.0	0.3	78.4	0.00643
4907120200	OCTOPUS	1	0.2	0.3	0.00003	33.0	0.0	10.5	0.00086
5333040101	PANDALUS BOREALIS	250	47.8	79.4	0.00651	2300.0	2.8	730.2	0.05985
5333040204	PANDALOPSIS DISPAR	22	4.2	7.0	0.00057	500.0	0.6	158.7	0.01301
5333110203	PAGURUS ALEUTICUS	35	6.7	11.1	0.00091	1207.0	1.4	383.2	0.03141
5333121002	LOPHOLITHODES FORAMINATUS	1	0.2	0.3	0.00003	545.0	0.7	173.0	0.01418
5333170302	CHIONOECETES BAIRDI	132	25.2	41.9	0.00343	74900.0	90.0	23777.8	1.94900
6801040602	PSEUDARCHASTER PARELII	3	0.6	1.0	0.00008	54.0	0.1	17.1	0.00141
6801060101	CTENODISCUS CRISPATUS	40	7.6	12.7	0.00104	356.0	0.4	113.0	0.00926
6801120901	LETHASTERIAS NANIMENSIS	1	0.2	0.3	0.00003	54.0	0.1	17.1	0.00141
6804050101	MOLPADIA INTERMEDIA	1	0.2	0.3	0.00003	40.0	0.0	12.7	0.00104
	TOTAL			166.0	0.01361			26426.0	2.16607
VERTEBRATES									
7602050201	SQUALUS ACANTHIAS	5	0.5	1.6	0.00013	5900.0	1.4	1873.0	0.15353
7603020106	RAJA KINCAIDI	11	1.1	3.5	0.00029	12300.0	3.0	3904.8	0.32006
7603020108	RAJA RHINA	2	0.2	0.6	0.00005	13600.0	3.3	4317.5	0.35389
7903010201	CLUPEA HARENGUS PALLASI	13	1.3	4.1	0.00034	500.0	0.1	158.7	0.01301
7904010206	ONCORHYNCHUS TSHAWYTSCHA	2	0.2	0.6	0.00005	6400.0	1.6	2031.7	0.16654
7904020501	THALEICHTHYS PACIFICUS	1	0.1	0.3	0.00003	100.0	0.0	31.7	0.00260
7909020701	THERAGRA CHALCOGRAMMA	10	1.0	3.2	0.00026	2300.0	0.6	730.2	0.05985
7915010101	SEBASTES ALEUTIANUS	4	0.4	1.3	0.00010	535.0	0.1	169.8	0.01392
7915010201	SEBASTOLOBUS ALASCANUS	1	0.1	0.3	0.00003	446.0	0.1	141.6	0.01161
7915030101	ANOPLOPOMA FIMBRIA	8	0.8	2.5	0.00021	5500.0	1.3	1746.0	0.14312
7915040901	DASYCOTTUS SETIGER	9	0.9	2.9	0.00023	758.0	0.2	240.6	0.01972
7915051301	AGONUS ACIPENSERINUS	1	0.1	0.3	0.00003	37.0	0.0	11.7	0.00096
7917020102	ATHERESTHES STOMIAS	641	64.6	203.5	0.01668	161200.0	39.2	51174.6	4.19464
7917020501	GLYPTOCEPHALUS ZACHIRUS	34	3.4	10.8	0.00088	5000.0	1.2	1587.3	0.13011
7917020601	HIPPOGLOSSOIDES ELASSODON	247	24.9	78.4	0.00643	24500.0	6.0	7777.8	0.63752
7917020701	HIPPOGLOSSUS STENOLEPIS	3	0.3	1.0	0.00008	172580.0	41.9	54787.3	4.49076
	TOTAL			314.9	0.02581			130684.4	10.71184

COMMENTS

PANDALUS BOREALIS: 80% WITH AQUA EGGS. PANDALOPSIS DISPAR: 50 WITH TAN EGGS. PAGURUS ALEUTICUS: 1 W/ PARASITIC BARNACLES; 15 W/BLACK EGGS. BANKIA SETACEA PRESENT. STOMACHS: 20 SNOW CRABS; 9 SPINYGHEAD SCULPIN; 10 REX SOLE; 10 TURBOT; 10 FLATHEAD SOLE.
POLLUTANTS: 2 PIECES OF PLASTIC.

BOTTOM WATER TEMPERATURE °C = 6.3

CRUSE #	STAT #	TOW #	GEAR CODE	DATE YYMMDD	TIME HHMM	START LATITUDE DEG MIN	START LONGITUDE DEG MIN	FINISH LATITUDE DEG MIN	FINISH LONGITUDE DEG MIN	MIDPOINT LATITUDE DEG MIN	MIDPOINT LONGITUDE DEG MIN	TIME FISH MINS	DIST FISHED (KM)	DEPTH FISHED (METERS) MIN	MAX	AVG
FN795	106A	32	OTB	791118	0825	59 6.2N	138 49.3W	59 6.7N	138 52.6W			30	3.33	54.9 -	56.7	55.8

TAXON CODE	TAXONOMIC NAME	COUNTS RAW	%	/KM	/M SQ	WEIGHT (GRAMS) RAW	%	/KM	/M SQ
INVERTEBRATES									
4801740100	APHRODITA SPP.	2	2.2	0.6	0.00005	152.0	5.8	45.6	0.00374
4905320126	BUCCINUM POLARE	4	4.3	1.2	0.00010	47.0	1.8	14.1	0.00116
4905330801	NEPTUNEA LYRATA	1	1.1	0.3	0.00002	103.0	3.9	30.9	0.00254
5333040101	PANDALUS BOREALIS	50	53.8	15.0	0.00123	900.0	34.5	270.3	0.02215
5333110202	PAGURUS OCHOTENSIS	36	38.7	10.8	0.00089	1407.0	53.9	422.5	0.03463
	TOTAL			27.9	0.00229			783.5	0.06422
VERTEBRATES									
7602050201	SQUALUS ACANTHIAS	2	0.2	0.6	0.00005	2300.0	0.5	690.7	0.05661
7603020108	RAJA RHINA	5	0.6	1.5	0.00012	54900.0	13.0	16486.5	1.35135
7603020111	RAJA STELLULATA	59	6.9	17.7	0.00145	90800.0	21.5	27267.3	2.23502
7904020501	THALEICHTHYS PACIFICUS	44	5.1	13.2	0.00108	887.0	0.2	266.4	0.02183
7909020601	MICROGADUS PROXIMUS	451	52.4	135.4	0.01110	24500.0	5.8	7357.4	0.60306
7909020701	THERAGRA CHALCOGRAMMA	4	0.5	1.2	0.00010	73.0	0.0	21.9	0.00180
7909041110	LYCODES PALEARIS	1	0.1	0.3	0.00002	95.0	0.0	28.5	0.00234
7915020201	OPHIODON ELONGATUS	1	0.1	0.3	0.00002	17700.0	4.2	5315.3	0.43568
7915040901	DASYCOTTUS SETIGER	1	0.1	0.3	0.00002	38.0	0.0	11.4	0.00094
7915051301	AGONUS ACIPENSERINUS	27	3.1	8.1	0.00066	841.0	0.2	252.6	0.02070
7916080201	TRICHODON TRICHODON	1	0.1	0.3	0.00002	57.0	0.0	17.1	0.00140
7917020102	ATHERESTHES STOMIAS	19	2.2	5.7	0.00047	5000.0	1.2	1501.5	0.12307
7917020501	GLYPTOCEPHALUS ZACHIRUS	46	5.3	13.8	0.00113	5500.0	1.3	1651.7	0.13538
7917020701	HIPPOGLOSSUS STENOLEPIS	15	1.7	4.5	0.00037	126478.0	30.0	37981.4	3.11323
7917020801	ISOPSETTA ISOLEPIS	89	10.3	26.7	0.00219	31300.0	7.4	9399.4	0.77044
7917021401	PAROPHRYS VETULUS	43	5.0	12.9	0.00106	4300.0	1.0	1291.3	0.10584
7917021501	PLATICHTHYS STELLATUS	51	5.9	15.3	0.00126	57200.0	13.5	17177.2	1.40797
7917021801	PSETTICHTHYS MELANOSTICTUS	1	0.1	0.3	0.00002	240.0	0.1	72.1	0.00591
	TOTAL			258.3	0.02117			126789.5	10.39258

COMMENTS

PANDALUS BOREALIS: 50% W/AQUA EGGS.
STOMACHS: 10 ENGLISH SOLE; 10 STARRY FLOUNDERS; 10 BUTTER SOLE; 10 REX SOLE.

BOTTOM WATER TEMPERATURE °C = 10.5

CRUSE #	STAT #	TOW #	GEAR CODE	DATE YYMMDD	TIME HHMM	START LATITUDE DEG MIN	START LONGITUDE DEG MIN	FINISH LATITUDE DEG MIN	FINISH LONGITUDE DEG MIN	MIDPOINT LATITUDE DEG MIN	MIDPOINT LONGITUDE DEG MIN	TIME FISH MINS	DIST FISHED (KM)	DEPTH FISHED (METERS) MIN	MAX	AVG
FN795	105A	33	OTB	791118	0949	59 8.0N	139 5.7W	59 8.9N	139 8.7W			30	3.33	69.5 -	71.4	70.4

TAXON CODE	TAXONOMIC NAME	COUNTS RAW	COUNTS %	COUNTS /KM	COUNTS /M SQ	WEIGHT (GRAMS) RAW	WEIGHT %	WEIGHT /KM	WEIGHT /M SQ
INVERTEBRATES									
4905320126	BUCCINUM POLARE	2	3.6	0.6	0.00005	26.0	0.8	7.8	0.00064
5333110202	PAGURUS OCHOTENSIS	1	1.8	0.3	0.00002	25.0	0.8	7.5	0.00062
6801121201	PYCNOPODIA HELIANTHOIDES	2	3.6	0.6	0.00005	3000.0	95.2	900.9	0.07384
6803090611	OPHIURA SARSI	50	90.9	15.0	0.00123	100.0	3.2	30.0	0.00246
	TOTAL			16.5	0.00135			946.2	0.07756
VERTEBRATES									
7602050201	SQUALUS ACANTHIAS	23	3.9	6.9	0.00057	29500.0	16.4	8858.9	0.72614
7603020111	RAJA STELLULATA	9	1.5	2.7	0.00022	5500.0	3.1	1651.7	0.13538
7904010206	ONCORHYNCHUS TSHAWYTSCHA	1	0.2	0.3	0.00002	900.0	0.5	270.3	0.02215
7904020501	THALEICHTHYS PACIFICUS	4	0.7	1.2	0.00010	142.0	0.1	42.6	0.00350
7909020401	GADUS MACROCEPHALUS	1	0.2	0.3	0.00002	3600.0	2.0	1081.1	0.08861
7909020601	MICROGADUS PROXIMUS	59	9.9	17.7	0.00145	10000.0	5.6	3003.0	0.24615
7909020701	THERAGRA CHALCOGRAMMA	23	3.9	6.9	0.00057	399.0	0.2	119.8	0.00982
7909041110	LYCODES PALEARIS	14	2.3	4.2	0.00034	1225.0	0.7	367.9	0.03015
7915051301	AGONUS ACIPENSERINUS	3	0.5	0.9	0.00007	106.0	0.1	31.8	0.00261
7916080201	TRICHODON TRICHODON	8	1.3	2.4	0.00020	363.0	0.2	109.0	0.00894
7917020101	ATHERESTHES EVERMANNI	96	16.1	28.8	0.00236	7300.0	4.1	2192.2	0.17969
7917020501	GLYPTOCEPHALUS ZACHIRUS	49	8.2	14.7	0.00121	4100.0	2.3	1231.2	0.10092
7917020601	HIPPOGLOSSOIDES ELASSODON	3	0.5	0.9	0.00007	422.0	0.2	126.7	0.01039
7917020701	HIPPOGLOSSUS STENOLEPIS	19	3.2	5.7	0.00047	28600.0	15.9	8588.6	0.70398
7917020801	ISOPSETTA ISOLEPIS	255	42.8	76.6	0.00628	77600.0	43.2	23303.3	1.91011
7917021401	PAROPHRYS VETULUS	29	4.9	8.7	0.00071	10000.0	5.6	3003.0	0.24615
	TOTAL			179.0	0.01467			53981.1	4.42468

COMMENTS

STOMACHS: 2 PYCNOPODIA HELIANTHOIDES; 10 REX SOLE; 9 ENGLISH SOLE; 10 BUTTER SOLE; 10 ARROWTOOTH FLOUNDER.

BOTTOM WATER TEMPERATURE °C = 9.7

CRUSE #	STAT #	TOW #	GEAR CODE	DATE YYMMDD	TIME HHMM	START LATITUDE DEG MIN	START LONGITUDE DEG MIN	FINISH LATITUDE DEG MIN	FINISH LONGITUDE DEG MIN	MIDPOINT LATITUDE DEG MIN	MIDPOINT LONGITUDE DEG MIN	TIME FISH MINS	DIST FISHED (KM)	DEPTH FISHED (METERS) MIN	MAX	AVG
FN795	105B	34	OTB	791118	1137	59 3.8N	138 59.6W	59 3.9N	139 2.7W			30	3.33	84.2 -	84.2	84.2

TAXON CODE	TAXONOMIC NAME	COUNTS RAW	COUNTS %	COUNTS /KM	COUNTS /M SQ	WEIGHT (GRAMS) RAW	WEIGHT %	WEIGHT /KM	WEIGHT /M SQ
INVERTEBRATES									
3303470201	STYLATULA GRACILE	1	3.7	0.3	0.00002	46.0	0.5	13.8	0.00113
4801740100	APHRODITA SPP.	3	11.1	0.9	0.00007	262.0	3.0	78.7	0.00645
4905290101	FUSITRITON OREGONENSIS	1	3.7	0.3	0.00002	47.0	0.5	14.1	0.00116
4905330801	NEPTUNEA LYRATA	3	11.1	0.9	0.00007	207.0	2.4	62.2	0.00510
5333110202	PAGURUS OCHOTENSIS	9	33.3	2.7	0.00022	400.0	4.6	120.1	0.00985
5333121002	LOPHOLITHODES FORAMINATUS	2	7.4	0.6	0.00005	2340.0	26.8	702.7	0.05760
5333170302	CHIONOECETES BAIRDI	4	14.8	1.2	0.00010	64.0	0.7	19.2	0.00158
6801121201	PYCNOPODIA HELIANTHOIDES	4	14.8	1.2	0.00010	5373.0	61.5	1613.5	0.13226
	TOTAL			8.1	0.00066			2624.3	0.21511
VERTEBRATES									
7904020501	THALEICHTHYS PACIFICUS	18	13.5	5.4	0.00044	897.0	11.5	269.4	0.02208
7909020601	MICROGADUS PROXIMUS	4	3.0	1.2	0.00010	350.0	4.5	105.1	0.00862
7909020701	THERAGRA CHALCOGRAMMA	51	38.3	15.3	0.00126	2024.0	25.9	607.8	0.04982
7909041110	LYCODES PALEARIS	41	30.8	12.3	0.00101	1925.0	24.7	578.1	0.04738
7915010101	SEBASTES ALEUTIANUS	1	0.8	0.3	0.00002	100.0	1.3	30.0	0.00246
7915030101	ANOPLOPOMA FIMBRIA	3	2.3	0.9	0.00007	598.0	7.7	179.6	0.01472
7917020601	HIPPOGLOSSOIDES ELASSODON	15	11.3	4.5	0.00037	1910.0	24.5	573.6	0.04701
	TOTAL			39.9	0.00327			2343.5	0.19209

COMMENTS

CHIONOECETES BAIRDI: 2 MALES; 2 FEMALES.
STOMACHS: 10 FLATHEAD SOLE; 10 TURBOT; 10 REX SOLE; 9 BUTTER SOLE;
4 PYCNOPODIA HELIANTHOIDES. POLLUTANTS: 1 PIECE PLASTIC.
BOTTOM WATER TEMPERATURE °C = 9.9

CRUSE #	STAT #	TOW #	GEAR CODE	DATE YYMMDD	TIME HHMM	START LATITUDE DEG MIN	START LONGITUDE DEG MIN	FINISH LATITUDE DEG MIN	FINISH LONGITUDE DEG MIN	MIDPOINT LATITUDE DEG MIN	MIDPOINT LONGITUDE DEG MIN	TIME FISH MINS	DIST FISHED (KM)	DEPTH FISHED (METERS) MIN	MAX	AVG
FN795	105C	35	OTB	791118	1345	58 53.3N	139 2.4W	58 54.5N	139 1.3W			30	3.33	148.2 -	151.9	150.1

TAXON CODE	TAXONOMIC NAME	COUNTS RAW	COUNTS %	COUNTS /KM	COUNTS /M SQ	WEIGHT (GRAMS) RAW	WEIGHT %	WEIGHT /KM	WEIGHT /M SQ
INVERTEBRATES									
4904080401	PECTEN CAURINUS	31	12.8	9.3	0.00076	7300.0	31.4	2192.2	0.17969
4905290101	FUSITRITON OREGONENSIS	47	19.3	14.1	0.00116	3052.0	13.1	916.5	0.07512
4905330801	NEPTUNEA LYRATA	1	0.4	0.3	0.00002	53.0	0.2	15.9	0.00130
4907010101	ROSSIA PACIFICA	2	0.8	0.6	0.00005	41.0	0.2	12.3	0.00101
5330050202	ROCINELA BELLICEPS	1	0.4	0.3	0.00002	1.0	0.0	0.3	0.00002
5333040101	PANDALUS BOREALIS	20	8.2	6.0	0.00049	161.0	0.7	48.3	0.00396
5333040204	PANDALOPSIS DISPAR	9	3.7	2.7	0.00022	133.0	0.6	39.9	0.00327
5333110202	PAGURUS OCHOTENSIS	2	0.8	0.6	0.00005	57.0	0.2	17.1	0.00140
5333110203	PAGURUS ALEUTICUS	8	3.3	2.4	0.00020	364.0	1.6	109.3	0.00896
5333110216	PAGURUS CONFRAGOSUS	42	17.3	12.6	0.00103	810.0	3.5	243.2	0.01994
5333121002	LOPHOLITHODES FORAMINATUS	4	1.6	1.2	0.00010	1898.0	8.2	570.0	0.04672
5333170302	CHIONOECETES BAIRDI	39	16.0	11.7	0.00096	2481.0	10.7	745.0	0.06107
6801040104	CERAMASTER PATAGONICUS	5	2.1	1.5	0.00012	47.0	0.2	14.1	0.00116
6801040602	PSEUDARCHASTER PARELII	2	0.8	0.6	0.00005	40.0	0.2	12.0	0.00098
6801060101	CTENODISCUS CRISPATUS	2	0.8	0.6	0.00005	13.0	0.1	3.9	0.00032
6801121201	PYCNOPODIA HELIANTHOIDES	4	1.6	1.2	0.00010	2318.0	10.0	696.1	0.05706
6802040101	ALLOCENTROTUS FRAGILIS	24	9.9	7.2	0.00059	4500.0	19.3	1351.4	0.11077
	TOTAL			73.0	0.00598			6987.7	0.57276
VERTEBRATES									
7602050201	SQUALUS ACANTHIAS	8	1.0	2.4	0.00020	8600.0	2.8	2582.6	0.21169
7603020106	RAJA KINCAIDI	24	2.9	7.2	0.00059	28100.0	9.0	8438.4	0.69168
7603020108	RAJA RHINA	7	0.9	2.1	0.00017	4500.0	1.4	1351.4	0.11077
7603020111	RAJA STELLULATA	1	0.1	0.3	0.00002	500.0	0.2	150.2	0.01231
7904020501	THALEICHTHYS PACIFICUS	41	5.0	12.3	0.00101	1516.0	0.5	455.3	0.03732
7909020701	THERAGRA CHALCOGRAMMA	5	0.6	1.5	0.00012	1800.0	0.6	540.5	0.04431
7909041110	LYCODES PALEARIS	30	3.7	9.0	0.00074	1207.0	0.4	362.5	0.02971
7915010101	SEBASTES ALEUTIANUS	6	0.7	1.8	0.00015	2033.0	0.7	610.5	0.05004
7915030101	ANOPLOPOMA FIMBRIA	7	0.9	2.1	0.00017	4500.0	1.4	1351.4	0.11077
7916080201	TRICHODON TRICHODON	1	0.1	0.3	0.00002	110.0	0.0	33.0	0.00271
7916110000	STICHAEIDAE	1	0.1	0.3	0.00002	154.0	0.0	46.2	0.00379
7917020101	ATHERESTHES EVERMANNI	649	79.2	194.9	0.01597	246100.0	79.0	73903.9	6.05770
7917020501	GLYPTOCEPHALUS ZACHIRUS	19	2.3	5.7	0.00047	2300.0	0.7	690.7	0.05661
7917020601	HIPPOGLOSSOIDES ELASSODON	7	0.9	2.1	0.00017	3200.0	1.0	961.0	0.07877
7917020701	HIPPOGLOSSUS STENOLEPIS	3	0.4	0.9	0.00007	3200.0	1.0	961.0	0.07877
7917021301	MICROSTOMUS PACIFICUS	10	1.2	3.0	0.00025	3600.0	1.2	1081.1	0.08861
	TOTAL			245.9	0.02016			93519.5	7.66553

COMMENTS

CHIONOECETES BAIRDI: 24FEMALES, 15 MALES;1 FEMALE W/ORGANGE EGGS.
PANDALUS BOREALIS: 90% WITH AQUA EGGS. 2 PAGURUS ALEUTICUS W/ 15
PARASITIC BARANCLE; 2 FEMALES W/ BLACK EGGS.
SOTMACHS: 10 REX SOLE; 10 TURBOT; 10 DOVER SOLE.
PAGURUS CONFRAGOSUS: 6 FEMALES W/ BLACK EGGS.

BOTTOM WATER TEMPERATURE °C = 6.4

CRUSE #	STAT #	TOW #	GEAR CODE	DATE YYMMDD	TIME HHMM	START LATITUDE DEG MIN	START LONGITUDE DEG MIN	FINISH LATITUDE DEG MIN	FINISH LONGITUDE DEG MIN	MIDPOINT LATITUDE DEG MIN	MIDPOINT LONGITUDE DEG MIN	TIME FISH MINS	DIST FISHED (KM)	DEPTH FISHED (METERS) MIN	MAX	AVG
FN795	105D	36	OTB	791118	1722	58 50.1N	138 59.2W	58 49.5N	138 57.3W			30	2.22	208.6	- 208.6	208.6

TAXON CODE	TAXONOMIC NAME	COUNTS RAW	COUNTS %	COUNTS /KM	COUNTS /M SQ	WEIGHT (GRAMS) RAW	WEIGHT %	WEIGHT /KM	WEIGHT /M SQ
INVERTEBRATES									
4801740100	APHRODITA SPP.	4	0.7	1.8	0.00015	70.0	0.3	31.5	0.00258
4905290101	FUSITRITON OREGONENSIS	104	17.4	46.8	0.00384	7700.0	32.5	3468.5	0.28430
4905320126	BUCCINUM POLARE	1	0.2	0.5	0.00004	20.0	0.1	9.0	0.00074
4905330801	NEPTUNEA LYRATA	7	1.2	3.2	0.00026	415.0	1.8	186.9	0.01532
4905330805	NEPTUNEA PRIBILOFFENSIS	1	0.2	0.5	0.00004	78.0	0.3	35.1	0.00288
5333040204	PANDALOPSIS DISPAR	7	1.2	3.2	0.00026	139.0	0.6	62.6	0.00513
5333110203	PAGURUS ALEUTICUS	8	1.3	3.6	0.00030	321.0	1.4	144.6	0.01185
5333170302	CHIONOECETES BAIRDI	11	1.8	5.0	0.00041	170.0	0.7	76.6	0.00628
6801040602	PSEUDARCHASTER PARELII	9	1.5	4.1	0.00033	143.0	0.6	64.4	0.00528
6801060101	CTENODISCUS CRISPATUS	154	25.7	69.4	0.00569	1154.0	4.9	519.8	0.04261
6802030101	BRISASTER TOWNSENDI	287	47.9	129.3	0.01060	12712.0	53.7	5726.1	0.46935
6802040101	ALLOCENTROTUS FRAGILIS	3	0.5	1.4	0.00011	647.0	2.7	291.4	0.02389
6604050101	MOLPADIA INTERMEDIA	3	0.5	1.4	0.00011	124.0	0.5	55.9	0.00458
	TOTAL			269.8	0.02212			10672.5	0.87480
VERTEBRATES									
7602050201	SQUALUS ACANTHIAS	2	0.8	0.9	0.00007	1800.0	1.2	810.8	0.06646
7603020106	RAJA KINCAIDI	7	2.8	3.2	0.00026	7300.0	4.8	3288.3	0.26953
7603020108	RAJA RHINA	5	2.0	2.3	0.00018	29100.0	19.1	13108.1	1.07444
7904020501	THALEICHTHYS PACIFICUS	12	4.8	5.4	0.00044	535.0	0.4	241.0	0.01975
7909020701	THERAGRA CHALCOGRAMMA	22	8.8	9.9	0.00081	1590.0	1.0	716.2	0.05871
7915010101	SEBASTES ALEUTIANUS	4	1.6	1.8	0.00015	3200.0	2.1	1441.4	0.11815
7915010201	SEBASTOLOBUS ALASCANUS	5	2.0	2.3	0.00018	2700.0	1.8	1216.2	0.09969
7915030101	ANOPLOPOMA FIMBRIA	6	2.4	2.7	0.00022	5900.0	3.9	2657.7	0.21784
7917020101	ATHERESTHES EVERMANNI	166	66.7	74.8	0.00613	92200.0	60.6	41531.5	3.40422
7917020501	GLYPTOCEPHALUS ZACHIRUS	7	2.8	3.2	0.00026	135.0	0.1	60.8	0.00498
7917020601	HIPPOGLOSSOIDES ELASSODON	10	4.0	4.5	0.00037	3600.0	2.4	1621.6	0.13292
7917020701	HIPPOGLOSSUS STENOLEPIS	2	0.8	0.9	0.00007	3600.0	2.4	1621.6	0.13292
7917021301	MICROSTOMUS PACIFICUS	1	0.4	0.5	0.00004	500.0	0.3	225.2	0.01846
	TOTAL			112.2	0.00919			68540.5	5.61808

COMMENTS

SNAIL EGG CASES. CHIONOECETES BAIRDI: 10 FEMALES; 1 MALE.
PAGURUS ALEUTICUS: 7 MALES; 1 FEMALE.
POLLUTANT: 1 PLASTIC FRAGMENT.
BOTTOM WATER TEMPERATURE °C = 6.5

CRUSE #	STAT #	TOW #	GEAR CODE	DATE YYMMDD	TIME HHMM	START LATITUDE DEG MIN	START LONGITUDE DEG MIN	FINISH LATITUDE DEG MIN	FINISH LONGITUDE DEG MIN	MIDPOINT LATITUDE DEG MIN	MIDPOINT LONGITUDE DEG MIN	TIME FISH MINS	DIST FISHED (KM)	DEPTH FISHED (METERS) MIN	MAX	AVG
FN795	4A	37	OTB	791119	0815	59 42.8N	139 57.4W	59 44.2N	139 54.8W			30	3.70	87.8	104.3	96.1

TAXON CODE	TAXONOMIC NAME	COUNTS RAW	COUNTS %	COUNTS /KM	COUNTS /M SQ	WEIGHT (GRAMS) RAW	WEIGHT %	WEIGHT /KM	WEIGHT /M SQ
INVERTEBRATES									
4904060401	PECTEN CAURINUS	90	16.3	24.3	0.00199	16300.0	29.2	4405.4	0.36110
5333040101	PANDALUS BOREALIS	125	22.6	33.8	0.00277	1208.0	2.2	326.5	0.02676
5333040106	PANDALUS HYPSINOTUS	1	0.2	0.3	0.00002	28.0	0.1	7.6	0.00062
5333040204	PANDALOPSIS DISPAR	168	30.4	45.4	0.00372	2737.0	4.9	739.7	0.06063
5333110203	PAGURUS ALEUTICUS	7	1.3	1.9	0.00016	243.0	0.4	65.7	0.00538
5333110401	LABIDOCHIRUS SPLENDESCENS	4	0.7	1.1	0.00009	23.0	0.0	6.2	0.00051
5333170302	CHIONOECETES BAIRDI	29	5.2	7.8	0.00064	2562.0	4.6	692.4	0.05676
5333180104	CANCER MAGISTER	27	4.9	7.3	0.00060	15400.0	27.6	4162.2	0.34116
6801040104	CERAMASTER PATAGONICUS	10	1.8	2.7	0.00022	2456.0	4.4	663.8	0.05441
6801060101	CTENODISCUS CRISPATUS	82	14.8	22.2	0.00182	748.0	1.3	202.2	0.01657
6801121201	PYCNOPODIA HELIANTHOIDES	9	1.6	2.4	0.00020	14100.0	25.2	3810.8	0.31236
6803040201	GORGONOCEPHALUS CARYI	1	0.2	0.3	0.00002	61.0	0.1	16.5	0.00135
	TOTAL			149.5	0.01225			15098.9	1.23762
VERTEBRATES									
7602050201	SQUALUS ACANTHIAS	9	6.8	2.4	0.00020	10400.0	6.6	2810.8	0.23039
7603020106	RAJA KINCAIDI	11	8.3	3.0	0.00024	7700.0	4.9	2081.1	0.17058
7603020108	RAJA RHINA	3	2.3	0.8	0.00007	11400.0	7.2	3081.1	0.25255
7603020111	RAJA STELLULATA	12	9.0	3.2	0.00027	95300.0	60.5	25756.8	2.11121
7903010201	CLUPEA HARENGUS PALLASI	1	0.8	0.3	0.00002	47.0	0.0	12.7	0.00104
7904020201	MALLOTUS VILLOSUS	1	0.8	0.3	0.00002	10.0	0.0	2.7	0.00022
7909020601	MICROGADUS PROXIMUS	5	3.8	1.4	0.00011	297.0	0.2	80.3	0.00658
7909020701	THERAGRA CHALCOGRAMMA	20	15.0	5.4	0.00044	743.0	0.5	200.8	0.01646
7909041103	LYCODES BREVIPES	2	1.5	0.5	0.00004	25.0	0.0	6.8	0.00055
7909041110	LYCODES PALEARIS	5	3.8	1.4	0.00011	485.0	0.3	131.1	0.01074
7915010101	SEBASTES ALEUTIANUS	2	1.5	0.5	0.00004	289.0	0.2	78.1	0.00640
7915030101	ANOPLOPOMA FIMBRIA	2	1.5	0.5	0.00004	1120.0	0.7	302.7	0.02481
7915040901	DASYCOTTUS SETIGER	9	6.8	2.4	0.00020	571.0	0.4	154.3	0.01265
7915051301	AGONUS ACIPENSERINUS	2	1.5	0.5	0.00004	41.0	0.0	11.1	0.00091
7917020102	ATHERESTHES STOMIAS	17	12.8	4.6	0.00038	4100.0	2.6	1108.1	0.09083
7917020601	HIPPOGLOSSOIDES ELASSODON	12	9.0	3.2	0.00027	2300.0	1.5	621.6	0.05095
7917020701	HIPPOGLOSSUS STENOLEPIS	3	2.3	0.8	0.00007	18600.0	11.8	5027.0	0.41205
7917020801	ISOPSETTA ISOLEPIS	14	10.5	3.8	0.00031	3200.0	2.0	864.9	0.07089
7917021301	MICROSTOMUS PACIFICUS	2	1.5	0.5	0.00004	243.0	0.2	65.7	0.00538
7917021501	PLATICHTHYS STELLATUS	1	0.8	0.3	0.00002	755.0	0.5	204.1	0.01673
	TOTAL			35.9	0.00295			42601.6	3.49194

COMMENTS

CHIONOECETES BAIRDI: 14 MALES; 15 FEMALES. 1 PANDALUS HYPSINOTUS W/ BLUE EGGS. CANCER MAGISTER: 11 MALES; 16 FEMALES; 20 PANDALUS BOREALIS: 95% W/WHITE OR AQUA EGGS.
STOMACHS: 9 PYCNOPODIA HELIANTHOIDES; 10 FLATHEAD SOLE; 10 BUTTER SOLE; 9 SPINYHEAD SCULPIN; 20 CANCER MAGISTER.
BOTTOM WATER TEMPERATURE °C = 10.0

CRUSE #	STAT #	TOW #	GEAR CODE	DATE YYMMDD	TIME HHMM	START LATITUDE DEG MIN	START LONGITUDE DEG MIN	FINISH LATITUDE DEG MIN	FINISH LONGITUDE DEG MIN	MIDPOINT LATITUDE DEG MIN	MIDPOINT LONGITUDE DEG MIN	TIME FISH MINS	DIST FISHED (KM)	DEPTH FISHED (METERS) MIN	MAX	AVG
FN795	94A	38	OTB	791123	0654	59 52.9N	141 51.3W	59 52.3N	141 48.8W			30	4.26	27.5 -	29.3	28.4

TAXON CODE	TAXONOMIC NAME	COUNTS RAW	COUNTS %	COUNTS /KM	COUNTS /M SQ	WEIGHT (GRAMS) RAW	WEIGHT %	WEIGHT /KM	WEIGHT /M SQ
INVERTEBRATES									
3303000000	ANTHOZOA	3	0.3	0.7	0.00006	34.0	0.0	8.0	0.00065
3303120101	EUNEPHTHYA RUBIFORMIS					68.0	0.0	16.0	0.00131
4904080401	PECTEN CAURINUS	2	0.2	0.5	0.00004	260.0	0.1	61.0	0.00500
5318020108	BALANUS HESPERIUS	50	5.3	11.7	0.00096	50.0	0.0	11.7	0.00096
5333040107	PANDALUS DANAE	51	5.4	12.0	0.00098	571.0	0.2	134.0	0.01099
5333060107	CRANGON DALLI	4	0.4	0.9	0.00008	10.0	0.0	2.3	0.00019
5333110202	PAGURUS OCHOTENSIS	3	0.3	0.7	0.00006	134.0	0.0	31.5	0.00258
5333180104	CANCER MAGISTER	833	88.1	195.5	0.01603	350900.0	99.7	82370.9	6.75171
	TOTAL			222.1	0.01820			82635.4	6.77340
VERTEBRATES									
7602050201	SQUALUS ACANTHIAS	7	2.0	1.6	0.00013	10400.0	43.3	2441.3	0.20011
7603020111	RAJA STELLULATA	9	2.6	2.1	0.00017	933.0	3.9	219.0	0.01795
7904020501	THALEICHTHYS PACIFICUS	1	0.3	0.2	0.00002	70.0	0.3	16.4	0.00135
7909020601	MICROGADUS PROXIMUS	280	80.0	65.7	0.00539	5125.0	21.3	1203.1	0.09861
7915041402	HEMILEPIDOTUS HEMILEPIDOTUS	2	0.6	0.5	0.00004	255.0	1.1	59.9	0.00491
7915050903	OCCELLA VERRUCOSA	3	0.9	0.7	0.00006	25.0	0.1	5.9	0.00048
7915051301	AGONUS ACIPENSERINUS	4	1.1	0.9	0.00008	138.0	0.6	32.4	0.00266
7917020801	ISOPSETTA ISOLEPIS	26	7.4	6.1	0.00050	4100.0	17.1	962.4	0.07889
7917021100	LIOPSETTA SPP.	2	0.6	0.5	0.00004	32.0	0.1	7.5	0.00062
7917021301	MICROSTOMUS PACIFICUS	14	4.0	3.3	0.00027	260.0	1.1	61.0	0.00500
7917021501	PLATICHTHYS STELLATUS	2	0.6	0.5	0.00004	2700.0	11.2	633.8	0.05195
	TOTAL			82.2	0.00673			5642.7	0.46252

COMMENTS

PANDALUS DANAE: 95% WITH AQUA EGGS, ALL COLLECTED FOR FOOD ANALYSIS. CANCER MAGISTER: 6 FEMALES, 1 W/ ORANGE EGGS; 827 MALES. STOMACHS: 20 DUNGENESS CRAB; 10 BUTTER SOLE.

BOTTOM WATER TEMPERATURE °C = 9.4

CRUSE #	STAT #	TOW #	GEAR CODE	DATE YYMMDD	TIME HHMM	START LATITUDE DEG MIN	START LONGITUDE DEG MIN	FINISH LATITUDE DEG MIN	FINISH LONGITUDE DEG MIN	MIDPOINT LATITUDE DEG MIN	MIDPOINT LONGITUDE DEG MIN	TIME FISH MINS	DIST FISHED (KM)	DEPTH FISHED (METERS) MIN	MAX	AVG
FN795	94B	39	OTB	791123	0814	59 49.9N	141 52.4W	59 49.4N	141 50.2W			30	2.22	58.6 -	58.6	58.6

TAXON CODE	TAXONOMIC NAME	COUNTS RAW	%	/KM	/M SQ	WEIGHT (GRAMS) RAW	%	/KM	/M SQ
INVERTEBRATES									
3303000000	ANTHOZOA	46	22.4	20.7	0.00170	22300.0	47.1	10045.0	0.82336
4801740100	APHRODITA SPP.	30	14.6	13.5	0.00111	1815.0	3.8	817.6	0.06701
4904020401	PECTEN CAURINUS	1	0.5	0.5	0.00004	110.0	0.2	49.5	0.00406
4904200101	CLINOCARDIUM CILIATUM	1	0.5	0.5	0.00004	17.0	0.0	7.7	0.00063
4905290101	FUSITRITON OREGONENSIS	1	0.5	0.5	0.00004	18.0	0.0	8.1	0.00066
4905330801	NEPTUNEA LYRATA	1	0.5	0.5	0.00004	14.0	0.0	6.3	0.00052
5333040107	PANDALUS DANAE	58	28.3	26.1	0.00214	640.0	1.4	288.3	0.02363
5333110202	PAGURUS OCHOTENSIS	52	25.4	23.4	0.00192	1500.0	3.2	675.7	0.05538
5333110401	LABIDOCHIRUS SPLENDESCENS	2	1.0	0.9	0.00007	10.0	0.0	4.5	0.00037
5333170201	HYAS LYRATUS	1	0.5	0.5	0.00004	27.0	0.1	12.2	0.00100
6801121201	PYCNOPODIA HELIANTHOIDES	12	5.9	5.4	0.00044	20900.0	44.1	9414.4	0.77167
	TOTAL			92.3	0.00757			21329.3	1.74830
VERTEBRATES									
7602050201	SQUALUS ACANTHIAS	9	1.3	4.1	0.00033	18600.0	7.4	8378.4	0.68675
7603020111	RAJA STELLULATA	59	8.7	26.6	0.00218	174300.0	69.7	78513.5	6.43553
7903010201	CLUPEA HARENGUS PALLASI	1	0.1	0.5	0.00004	20.0	0.0	9.0	0.00074
7904010206	ONCORHYNCHUS TSHAWYTSCHA	1	0.1	0.5	0.00004	861.0	0.3	387.8	0.03179
7904020501	THALEICHTHYS PACIFICUS	5	0.7	2.3	0.00018	166.0	0.1	74.8	0.00613
7909020601	MICROGADUS PROXIMUS	475	70.4	214.0	0.01754	10442.0	4.2	4703.6	0.38554
7915030101	ANOPLOPOMA FIMBRIA	1	0.1	0.5	0.00004	109.0	0.0	49.1	0.00402
7915041801	LEPTOCOTTUS ARMATUS	2	0.3	0.9	0.00007	554.0	0.2	249.5	0.02045
7915050000	AGONIDAE	26	3.9	11.7	0.00096	538.0	0.2	242.3	0.01986
7916090103	BATHYMASTER SIGNATUS	3	0.4	1.4	0.00011	220.0	0.1	99.1	0.00812
7917020102	ATHERESTHES STOMIAS	1	0.1	0.5	0.00004	84.0	0.0	37.8	0.00310
7917020601	HIPPOGLOSSOIDES ELASSODON	1	0.1	0.5	0.00004	53.0	0.0	23.9	0.00196
7917020701	HIPPOGLOSSUS STENOLEPIS	5	0.7	2.3	0.00018	13600.0	5.4	6126.1	0.50214
7917020801	ISOPSETTA ISOLEPIS	49	7.3	22.1	0.00181	7300.0	2.9	3288.3	0.26953
7917021100	LIOPSETTA SPP.	2	0.3	0.9	0.00007	50.0	0.0	22.5	0.00185
7917021301	MICROSTOMUS PACIFICUS	1	0.1	0.5	0.00004	15.0	0.0	6.8	0.00055
7917021401	PAROPHRYS VETULUS	16	2.4	7.2	0.00059	1800.0	0.7	810.8	0.06646
7917021501	PLATICHTHYS STELLATUS	18	2.7	8.1	0.00066	21300.0	8.5	9594.6	0.78644
	TOTAL			304.1	0.02492			112618.0	9.23099

COMMENTS

PANDALUS DANAE - 60% FEMALES WITH EGGS.
STOMACHS: 10 BUTTER SOLE; 10 STARRY FLOUNDER; 10 ENGLISH SOLE;
12 PYCNOPODIA.

BOTTOM WATER TEMPERATURE °C = 11.0

CRUSE #	STAT #	TOW #	GEAR CODE	DATE YYMMDD	TIME HHMM	START LATITUDE DEG MIN	START LONGITUDE DEG MIN	FINISH LATITUDE DEG MIN	FINISH LONGITUDE DEG MIN	MIDPOINT LATITUDE DEG MIN	MIDPOINT LONGITUDE DEG MIN	TIME FISH MINS	DIST FISHED (KM)	DEPTH FISHED (METERS) MIN	MAX	AVG
FN795	93C	40	OTB	791123	1001	59 50.3N	142 0.9W	59 50.1N	141 58.1W			30	1.85	65.9 -	65.9	65.9

TAXON CODE	TAXONOMIC NAME	COUNTS RAW	COUNTS %	COUNTS /KM	COUNTS /M SQ	WEIGHT (GRAMS) RAW	WEIGHT %	WEIGHT /KM	WEIGHT /M SQ
INVERTEBRATES									
3303000000	ANTHOZOA	9	0.7	4.9	0.00040	4100.0	1.4	2216.2	0.18166
4801740100	APHRODITA SPP.	56	4.6	30.3	0.00248	2253.0	0.7	1217.8	0.09982
4904080401	PECTEN CAURINUS	1093	89.3	590.8	0.04843	261100.0	86.3	141135.1	11.56845
4904210301	COMPSOMYAX SUBDIAPHANA	1	0.1	0.5	0.00004	40.0	0.0	21.6	0.00177
5333040107	PANDALUS DANAE	3	0.2	1.6	0.00013	47.0	0.0	25.4	0.00208
5333110202	PAGURUS OCHOTENSIS	25	2.0	13.5	0.00111	1203.0	0.4	650.3	0.05330
6801050101	LUIDIA FOLIOLATA	16	1.3	8.6	0.00071	2598.0	0.9	1404.3	0.11511
6801121201	PYCNOPODIA HELIANTHOIDES	21	1.7	11.4	0.00093	31300.0	10.3	16918.9	1.38680
	TOTAL			661.6	0.05423			163589.7	13.40899
VERTEBRATES									
7602050201	SQUALUS ACANTHIAS	9	4.4	4.9	0.00040	14100.0	5.7	7621.6	0.62472
7603020111	RAJA STELLULATA	35	17.0	18.9	0.00155	86700.0	35.3	46864.9	3.84138
7909020601	MICROGADUS PROXIMUS	71	34.5	38.4	0.00315	1753.0	0.7	947.6	0.07767
7909020701	THERAGRA CHALCOGRAMMA	1	0.5	0.5	0.00004	75.0	0.0	40.5	0.00332
7915030101	ANOPLOPOMA FIMBRIA	3	1.5	1.6	0.00013	443.0	0.2	239.5	0.01963
7915040901	DASYCOTTUS SETIGER	1	0.5	0.5	0.00004	70.0	0.0	37.8	0.00310
7915041801	LEPTOCOTTUS ARMATUS	1	0.5	0.5	0.00004	250.0	0.1	135.1	0.01108
7915050000	AGONIDAE	1	0.5	0.5	0.00004	20.0	0.0	10.8	0.00089
7915051301	AGONUS ACIPENSERINUS	11	5.3	5.9	0.00049	300.0	0.1	162.2	0.01329
7917020102	ATHERESTHES STOMIAS	4	1.9	2.2	0.00018	296.0	0.1	160.0	0.01311
7917020501	GLYPTOCEPHALUS ZACHIRUS	9	4.4	4.9	0.00040	408.0	0.2	220.5	0.01808
7917020701	HIPPOGLOSSUS STENOLEPIS	4	1.9	2.2	0.00018	120892.0	49.3	65347.0	5.35631
7917020801	ISOPSETTA ISOLEPIS	50	24.3	27.0	0.00222	12700.0	5.2	6864.9	0.56269
7917021401	PAROPHRYS VETULUS	2	1.0	1.1	0.00009	555.0	0.2	300.0	0.02459
7917021501	PLATICHTHYS STELLATUS	4	1.9	2.2	0.00018	6800.0	2.8	3675.7	0.30128
	TOTAL			111.4	0.00913			132628.1	10.87116

COMMENTS

STOMACHS: 4 STARRY FLOUNDER; 10 BUTTER SOLE; 21 PYCNOPODIA.
BOTTOM WATER TEMPERATURE °C = 9.7

CRUSE #	STAT #	TOW #	GEAR CODE	DATE YYMMDD	TIME HHMM	START LATITUDE DEG MIN	START LONGITUDE DEG MIN	FINISH LATITUDE DEG MIN	FINISH LONGITUDE DEG MIN	MIDPOINT LATITUDE DEG MIN	MIDPOINT LONGITUDE DEG MIN	TIME FISH MINS	DIST FISHED (KM)	DEPTH FISHED (METERS) MIN	MAX	AVG
FN795	94A	41	OTB	791123	1043	59 52.7N	141 52.1W	59 53.8N	141 52.5W			60	5.00	29.3 -	32.9	31.1

COMMENTS GUALITATIVE TOW.

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CRUSE #	STAT #	TOW #	GEAR CODE	DATE YYMMDD	TIME HHMM	START LATITUDE DEG MIN	START LONGITUDE DEG MIN	FINISH LATITUDE DEG MIN	FINISH LONGITUDE DEG MIN	MIDPOINT LATITUDE DEG MIN	MIDPOINT LONGITUDE DEG MIN	TIME FISH MINS	DIST FISHED (KM)	DEPTH FISHED (METERS) MIN	MAX	AVG
FN795	102G	42	OTB	791124	0735	59 5.2N	139 48.5W	59 5.9N	139 49.4W			15	1.48	115.3	- 115.3	115.3

TAXON CODE	TAXONOMIC NAME	COUNTS RAW	%	/KM	/M SQ	WEIGHT (GRAMS) RAW	%	/KM	/M SQ
INVERTEBRATES									
4002020300	CEREBRATULUS SPP.	2	0.1	1.4	0.00011	24.0	0.0	16.2	0.00133
4905060701	LISCHKEIA CIDARIS	3	0.1	2.0	0.00017	25.0	0.0	16.9	0.00138
4905290101	FUSITRITON OREGONENSIS	29	1.2	19.6	0.00161	1739.0	1.2	1175.0	0.09631
4905331001	PYRULOFUSUS HARPA	1	0.0	0.7	0.00006	164.0	0.1	110.8	0.00908
4905570300	ARCHIDORIS SPP.	4	0.2	2.7	0.00022	240.0	0.2	162.2	0.01329
4907010101	ROSSIA PACIFICA	10	0.4	6.8	0.00055	124.0	0.1	83.8	0.00687
5333040103	PANDALUS JORDANI	4	0.2	2.7	0.00022	27.0	0.0	18.2	0.00150
5333040104	PANDALUS MONTAGUI TRIDENS	8	0.3	5.4	0.00044	29.0	0.0	19.6	0.00161
5333060111	CRANGON COMMUNIS	7	0.3	4.7	0.00039	17.0	0.0	11.5	0.00094
5333060118	CRANGON RESIMA	3	0.1	2.0	0.00017	3.0	0.0	2.0	0.00017
5333110206	PAGURUS SETOSUS	3	0.1	2.0	0.00017	33.0	0.0	22.3	0.00183
5333110216	PAGURUS CONFRAGOSUS	2	0.1	1.4	0.00011	34.0	0.0	23.0	0.00188
5333110302	ELASSOCHIRUS CAVIMANUS	3	0.1	2.0	0.00017	34.0	0.0	23.0	0.00188
5333121002	LOPHOLITHODES FORAMINATUS	3	0.1	2.0	0.00017	1315.0	0.9	888.5	0.07283
5333130101	MUNIDA QUADRISPINA	3	0.1	2.0	0.00017	15.0	0.0	10.1	0.00083
5333170201	HYAS LYRATUS	8	0.3	5.4	0.00044	471.0	0.3	318.2	0.02609
5333170302	CHIONOECETES BAIRDI	6	0.3	4.1	0.00033	84.0	0.1	56.8	0.00465
5333180104	CANCER MAGISTER	1	0.0	0.7	0.00006	396.0	0.3	267.6	0.02193
5900000000	SIPUNCULIDA	1	0.0	0.7	0.00006	20.0	0.0	13.5	0.00111
6702050301	LAQUEUS CALIFORNIANUS	18	0.8	12.2	0.00100	60.0	0.0	40.5	0.00332
6801040104	CERAMASTER PATAGONICUS	5	0.2	3.4	0.00028	343.0	0.2	231.8	0.01900
6801040501	MEDIASTER AEQUALIS	7	0.3	4.7	0.00039	326.0	0.2	220.3	0.01805
6801080100	HENRICIA SPP.	4	0.2	2.7	0.00022	113.0	0.1	76.4	0.00626
6801080101	HENRICIA ASPERA	2	0.1	1.4	0.00011	25.0	0.0	16.9	0.00138
6801110103	CROSSASTER PAPPOSUS	28	1.2	18.9	0.00155	432.0	0.3	291.9	0.02393
6801110201	LOPHASTER FURCILLIGER	3	0.1	2.0	0.00017	76.0	0.1	51.4	0.00421
6801110301	SOLASTER DAWSONI	3	0.1	2.0	0.00017	63.0	0.0	42.6	0.00349
6801120901	LETHASTERIAS NANIMENSIS	2	0.1	1.4	0.00011	340.0	0.2	229.7	0.01883
6802040201	STRONGYLOCENTROTUS DROEBACHIENSIS	1934	82.1	1306.8	0.10711	128500.0	89.9	86824.3	7.11675
6803090611	OPHIURA SARSI	7	0.3	4.7	0.00039	10.0	0.0	6.8	0.00055
6804070400	BATHYPLOTES SPP.	191	8.1	129.1	0.01058	7651.0	5.4	5169.6	0.42374
6805000000	CRINOIDEA	51	2.2	34.5	0.00282	127.0	0.1	85.8	0.00703
	TOTAL			1591.9	0.13048			96527.0	7.91205
VERTEBRATES									
7602050201	SQUALUS ACANTHIAS	5	1.9	3.4	0.00028	8600.0	12.8	5810.8	0.47630
7603020106	RAJA KINCAIDI	1	0.4	0.7	0.00006	1400.0	2.1	945.9	0.07754
7903010201	CLUPEA HARENGUS PALLASI	6	2.3	4.1	0.00033	650.0	1.0	439.2	0.03600
7904020501	THALEICHTHYS PACIFICUS	1	0.4	0.7	0.00006	20.0	0.0	13.5	0.00111
7909020701	THERAGRA CHALCOGRAMMA	41	15.9	27.7	0.00227	1343.0	2.0	907.4	0.07438
7915010102	SEBASTES ALUTUS	2	0.8	1.4	0.00011	370.0	0.5	250.0	0.02049
7915030101	ANOPLOPOMA FIMBRIA	9	3.5	6.1	0.00050	7300.0	10.8	4932.4	0.40430
7915040901	DASYCOTTUS SETIGER	2	0.8	1.4	0.00011	30.0	0.0	20.3	0.00166
7915041706	ICELUS SPINIGER	1	0.4	0.7	0.00006	10.0	0.0	6.8	0.00055
7915041901	MALACOCOTTUS KINCAIDI	3	1.2	2.0	0.00017	50.0	0.1	33.8	0.00277

TAXON CODE	TAXONOMIC NAME	COUNTS RAW	COUNTS %	COUNTS /KM	COUNTS /M SQ	WEIGHT (GRAMS) RAW	WEIGHT (GRAMS) %	WEIGHT (GRAMS) /KM	WEIGHT (GRAMS) /M SQ
7915044103	TRIGLOPS MACELLUS	3	1.2	2.0	0.00017	30.0	0.0	20.3	0.00166
7915050401	ASTEROTHECA ALASCANA	2	0.8	1.4	0.00011	10.0	0.0	6.8	0.00055
7916090103	BATHYMASTER SIGNATUS	6	2.3	4.1	0.00033	626.0	0.9	423.0	0.03467
7917020102	ATHERESTHES STOMIAS	142	55.0	95.9	0.00786	24100.0	35.8	16283.8	1.33474
7917020501	GLYPTOCEPHALUS ZACHIRUS	12	4.7	8.1	0.00066	631.0	0.9	426.4	0.03495
7917020601	HIPPOGLOSSOIDES ELASSODON	2	0.8	1.4	0.00011	590.0	0.9	398.6	0.03268
7917020701	HIPPOGLOSSUS STENOLEPIS	14	5.4	9.5	0.00078	21300.0	31.6	14391.9	1.17966
7917021301	MICROSTOMUS PACIFICUS	6	2.3	4.1	0.00033	239.0	0.4	161.5	0.01324
	TOTAL			174.3	0.01429			45472.3	3.72724

COMMENTS

STOMACHS: 10 TURBOT; 3 BLACKFIN SCULPIN; 2 SPINYHEAD SCULPIN.
CHIONOECETES BAIRDI: 4 FEMALES; 2 MALES.
BOTTOM WATER TEMPERATURE °C = 9.6

CRUSE #	STAT #	TOW #	GEAR CODE	DATE YYMMDD	TIME HHMM	START LATITUDE DEG MIN	START LONGITUDE DEG MIN	FINISH LATITUDE DEG MIN	FINISH LONGITUDE DEG MIN	MIDPOINT LATITUDE DEG MIN	MIDPOINT LONGITUDE DEG MIN	TIME FISH MINS	DIST FISHED (KM)	DEPTH FISHED (METERS) MIN	MAX	AVG
FN795	103D	43	OTB	791124	0914	59 2.4N	139 30.1W	59 1.4N	139 27.6W			30	2.96	113.5	115.3	114.4

TAXON CODE	TAXONOMIC NAME	COUNTS RAW	COUNTS %	COUNTS /KM	COUNTS /M SQ	WEIGHT (GRAMS) RAW	WEIGHT %	WEIGHT /KM	WEIGHT /M SQ
INVERTEBRATES									
3200000000	PORIFERA					50.0	0.2	16.9	0.00138
4905290101	FUSITRITON OREGONENSIS	4	2.3	1.4	0.00011	166.0	0.8	56.1	0.00460
4907010101	ROSSIA PACIFICA	4	2.3	1.4	0.00011	64.0	0.3	21.6	0.00177
5333040103	PANDALUS JORDANI	22	12.6	7.4	0.00061	152.0	0.7	51.4	0.00421
5333110216	PAGURUS CONFRAGOSUS	11	6.3	3.7	0.00030	117.0	0.6	39.5	0.00324
5333121002	LOPHOLITHODES FORAMINATUS	6	3.4	2.0	0.00017	4396.0	20.8	1485.1	0.12173
5333170201	HYAS LYRATUS	1	0.6	0.3	0.00003	161.0	0.8	54.4	0.00446
5333170302	CHIONOECETES BAIRDI	106	60.6	35.8	0.00294	15310.0	72.5	5172.3	0.42396
6702050301	LAQUEUS CALIFORNIANUS	3	1.7	1.0	0.00008	14.0	0.1	4.7	0.00039
6801040104	CERAMASTER PATAGONICUS	1	0.6	0.3	0.00003	100.0	0.5	33.8	0.00277
6801040501	MEDIASTER AEQUALIS	1	0.6	0.3	0.00003	27.0	0.1	9.1	0.00075
6801080101	HENRICIA ASPERA	1	0.6	0.3	0.00003	25.0	0.1	8.4	0.00069
6801110103	CROSSASTER PAPPOSUS	2	1.1	0.7	0.00006	37.0	0.2	12.5	0.00102
6801110301	SOLASTER DAWSONI	1	0.6	0.3	0.00003	35.0	0.2	11.8	0.00097
6801120901	LETHASTERIAS NANIMENSIS	1	0.6	0.3	0.00003	170.0	0.8	57.4	0.00471
6802040201	STRONGYLOCENTROTUS DROEBACHIENSIS	1	0.6	0.3	0.00003	66.0	0.3	22.3	0.00183
6803090611	OPHIURA SARSI	3	1.7	1.0	0.00008	10.0	0.0	3.4	0.00028
6804070400	BATHYPLOTES SPP.	7	4.0	2.4	0.00019	219.0	1.0	74.0	0.00606
	TOTAL			59.1	0.00485			7134.8	0.58482
VERTEBRATES									
7602050201	SQUALUS ACANTHIAS	5	1.4	1.7	0.00014	12300.0	10.4	4155.4	0.34061
7603020106	RAJA KINCAIDI	9	2.5	3.0	0.00025	10000.0	8.4	3378.4	0.27692
7603020108	RAJA RHINA	1	0.3	0.3	0.00003	1400.0	1.2	473.0	0.03877
7603020111	RAJA STELLULATA	2	0.6	0.7	0.00006	11800.0	10.0	3986.5	0.32676
7903010201	CLUPEA HARENGUS PALLASI	1	0.3	0.3	0.00003	115.0	0.1	38.9	0.00318
7904020501	THALEICHTHYS PACIFICUS	48	13.6	16.2	0.00133	1971.0	1.7	665.9	0.05458
7909020701	THERAGRA CHALCOGRAMMA	8	2.3	2.7	0.00022	464.0	0.4	156.8	0.01285
7909041110	LYCODES PALEARIS	15	4.2	5.1	0.00042	1636.0	1.4	552.7	0.04530
7915010101	SEBASTES ALEUTIANUS	11	3.1	3.7	0.00030	4440.0	3.7	1500.0	0.12295
7915020201	OPHIODON ELONGATUS	1	0.3	0.3	0.00003	286.0	0.2	96.6	0.00792
7915030101	ANOPLOPOMA FIMBRIA	1	0.3	0.3	0.00003	504.0	0.4	170.3	0.01396
7915040901	DASYCOTTUS SETIGER	5	1.4	1.7	0.00014	106.0	0.1	35.8	0.00294
7915041801	LEPTOCOTTUS ARMATUS	1	0.3	0.3	0.00003	195.0	0.2	65.9	0.00540
7915050000	AGONIDAE	2	0.6	0.7	0.00006	16.0	0.0	5.4	0.00044
7917020102	ATHERESTHES STOMIAS	208	58.9	70.3	0.00576	58100.0	49.0	19628.4	1.60888
7917020501	GLYPTOCEPHALUS ZACHIRUS	20	5.7	6.8	0.00055	1227.0	1.0	414.5	0.03398
7917020601	HIPPOGLOSSOIDES ELASSODON	8	2.3	2.7	0.00022	2030.0	1.7	685.8	0.05621
7917020701	HIPPOGLOSSUS STENOLEPIS	4	1.1	1.4	0.00011	11800.0	10.0	3986.5	0.32676
7917021301	MICROSTOMUS PACIFICUS	3	0.8	1.0	0.00008	193.0	0.2	65.2	0.00534
	TOTAL			119.3	0.00978			40061.8	3.28376

COMMENTS

PANDALUS JORDANI: 4 W/AQUA EGGS; 3 W/ PARASITIC ISOPOD.
CHIONOECETES BAIRDI: 56 MALES; 50 FEMALES. STOMACHS: 10
TURBOT; 10 REX SOLE; 5 SPINYHEAD SCULPIN.
POLLUTANTS: 1 GREEN PLASTIC BAG.

BOTTOM WATER TEMPERATURE °C = 8.9

CRUSE #	STAT #	TOW #	GEAR CODE	DATE YYMMDD	TIME HHMM	START LATITUDE DEG MIN	START LONGITUDE DEG MIN	FINISH LATITUDE DEG MIN	FINISH LONGITUDE DEG MIN	MIDPOINT LATITUDE DEG MIN	MIDPOINT LONGITUDE DEG MIN	TIME FISH MINS	DIST FISHED (KM)	DEPTH FISHED (METERS) MIN	MAX	AVG
FN795	103F	44	OTB	791124	1254	58 51.7N	139 36.0W	58 50.8N	139 33.6W			30	3.70	142.7 -	146.4	144.6

TAXON CODE	TAXONOMIC NAME	COUNTS RAW	COUNTS %	COUNTS /KM	COUNTS /M SQ	WEIGHT (GRAMS) RAW	WEIGHT %	WEIGHT /KM	WEIGHT /M SQ
INVERTEBRATES									
3200000000	PORIFERA					1524.0	3.7	411.9	0.03376
4801220201	PIONOSYLLIS GIGANTEA	1	0.3	0.3	0.00002	1.0	0.0	0.3	0.00002
4801650000	AMPHARETIDAE	1	0.3	0.3	0.00002	1.0	0.0	0.3	0.00002
4801660700	PISTA SPP.	1	0.3	0.3	0.00002	1.0	0.0	0.3	0.00002
4905290101	FUSITRITON OREGONENSIS	13	3.4	3.5	0.00029	1022.0	2.5	276.2	0.02264
4907010101	ROSSIA PACIFICA	5	1.3	1.4	0.00011	80.0	0.2	21.6	0.00177
5333040103	PANDALUS JORDANI	104	26.9	28.1	0.00230	730.0	1.8	197.3	0.01617
5333050401	EUALUS BAREATA	1	0.3	0.3	0.00002	2.0	0.0	0.5	0.00004
5333110216	PAGURUS CONFRAGOSUS	3	0.8	0.8	0.00007	102.0	0.3	27.6	0.00226
5333121002	LOPHOLITHODES FORAMINATUS	23	5.9	6.2	0.00051	13600.0	33.4	3675.7	0.30128
5333170302	CHIONOECETES BAIRDI	47	12.1	12.7	0.00104	3731.0	9.2	1008.4	0.08265
6801040501	MEDIASTER AEQUALIS	1	0.3	0.3	0.00002	24.0	0.1	6.5	0.00053
6801040602	PSEUDARCHASTER PARELII	1	0.3	0.3	0.00002	20.0	0.0	5.4	0.00044
6801110103	CROSSASTER PAPPOSUS	1	0.3	0.3	0.00002	5.0	0.0	1.4	0.00011
6801121101	STYLASTERIAS FORRERI	2	0.5	0.5	0.00004	95.0	0.2	25.7	0.00210
6802040201	STRONGYLOCENTROTUS DROEBACHIENSIS	107	27.6	28.9	0.00237	19500.0	47.9	5270.3	0.43199
6803040201	GORGONOCEPHALUS CARYI	2	0.5	0.5	0.00004	178.0	0.4	48.1	0.00394
6803060101	OPHIOPHOLIS ACULEATA	40	10.3	10.8	0.00089	40.0	0.1	10.8	0.00089
6803090611	OPHIURA SARSI	34	8.8	9.2	0.00075	71.0	0.2	19.2	0.00157
	TOTAL			104.6	0.00857			11007.3	0.90224
VERTEBRATES									
7602050201	SQUALUS ACANTHIAS	16	1.6	4.3	0.00035	21300.0	9.5	5756.8	0.47187
7603020106	RAJA KINCAIDI	9	0.9	2.4	0.00020	8200.0	3.7	2216.2	0.18166
7603020108	RAJA RHINA	8	0.8	2.2	0.00018	18200.0	8.2	4918.9	0.40319
7904020501	THALEICHTHYS PACIFICUS	495	48.2	133.8	0.01097	16300.0	7.3	4405.4	0.36110
7909020701	THERAGRA CHALCOGRAMMA	6	0.6	1.6	0.00013	806.0	0.4	217.8	0.01786
7909041110	LYCODES PALEARIS	2	0.2	0.5	0.00004	59.0	0.0	15.9	0.00131
7915010101	SEBASTES ALEUTIANUS	4	0.4	1.1	0.00009	1443.0	0.6	390.0	0.03197
7915010201	SEBASTOLOBUS ALASCANUS	1	0.1	0.3	0.00002	1267.0	0.6	342.4	0.02807
7915020201	OPHIODON ELONGATUS	1	0.1	0.3	0.00002	10000.0	4.5	2702.7	0.22153
7915030101	ANOPLOPOMA FIMBRIA	9	0.9	2.4	0.00020	7300.0	3.3	1973.0	0.16172
7915040901	DASYCOTTUS SETIGER	4	0.4	1.1	0.00009	217.0	0.1	58.6	0.00481
7917020102	ATHERESTHES STOMIAS	405	39.4	109.5	0.00897	133000.0	59.6	35945.9	2.94639
7917020501	GLYPTOCEPHALUS ZACHIRUS	42	4.1	11.4	0.00093	1400.0	0.6	378.4	0.03101
7917020601	HIPPOGLOSSOIDES ELASSODON	23	2.2	6.2	0.00051	3600.0	1.6	973.0	0.07975
7917021301	MICROSTOMUS PACIFICUS	2	0.2	0.5	0.00004	139.0	0.1	37.6	0.00308
	TOTAL			277.6	0.02275			60332.7	4.94530

COMMENTS

PANDALUS JORDANI: 75% W/ AQUA EGGS. CHIONOECETES BAIRDI: 34 MALES; 13 FEMALES. STOMACHS: 10 TURBUT; 10 FLATHEAD SOLE; 10 DOG FISH; 4 SPINYHEAD SCULPIN. GLASS SPONGE WITH SEVERAL SPECIES OF BRITTLE STAR IN INCURRENT/EXCURRENT PORES; HIATELLA ARTICA, LAQUEUS CALIFORNIANUS, SERPULIDAE WORMS; 2 POLYCHAETES.

BOTTOM WATER TEMPERATURE °C = 7.6

CRUSE #	STAT #	TOW #	GEAR CODE	DATE YYMMDD	TIME HHMM	START LATITUDE DEG MIN	START LONGITUDE DEG MIN	FINISH LATITUDE DEG MIN	FINISH LONGITUDE DEG MIN	MIDPOINT LATITUDE DEG MIN	MIDPOINT LONGITUDE DEG MIN	TIME FISH MINS	DIST FISHED (KM)	DEPTH FISHED (METERS) MIN	MAX	AVG
FN795	104D	45	OTB	791124	1459	58 53.2N	139 15.9W	58 54.1N	139 18.7W			30	3.15	118.9	118.9	118.9

TAXON CODE	TAXONOMIC NAME	COUNTS RAW	%	/KM	/M SQ	WEIGHT (GRAMS) RAW	%	/KM	/M SQ
INVERTEBRATES									
3303470201	STYLATULA GRACILE	1	0.5	0.3	0.00003	147.0	0.9	46.7	0.00383
4801740100	APHRODITA SPP.	1	0.5	0.3	0.00003	20.0	0.1	6.3	0.00052
4905290101	FUSITRITON OREGONENSIS	31	16.5	9.8	0.00081	2950.0	18.0	936.5	0.07676
4905320126	BUCCINUM POLARE	1	0.5	0.3	0.00003	8.0	0.0	2.5	0.00021
4905331001	PYRULOFUSUS HARPA	1	0.5	0.3	0.00003	88.0	0.5	27.9	0.00229
4905660101	TRITONIA EXSULANS	1	0.5	0.3	0.00003	52.0	0.3	16.5	0.00135
4907010101	ROSSIA PACIFICA	3	1.6	1.0	0.00008	71.0	0.4	22.5	0.00185
5333040103	PANDALUS JORDANI	19	10.1	6.0	0.00049	127.0	0.8	40.3	0.00330
5333110216	PAGURUS CONFRAGOSUS	2	1.1	0.6	0.00005	44.0	0.3	14.0	0.00114
5333121002	LOPHOLITHODES FORAMINATUS	15	8.0	4.8	0.00039	6800.0	41.4	2158.7	0.17695
5333170302	CHIONOECETES BAIRDI	61	32.4	19.4	0.00159	1398.0	8.5	443.8	0.03638
6702030101	TEREBRATULINA UNGUICULA	22	11.7	7.0	0.00057	12.0	0.1	3.8	0.00031
6702050301	LAQUEUS CALIFORNIANUS	2	1.1	0.6	0.00005	4.0	0.0	1.3	0.00010
6801060101	CTENODISCUS CRISPATUS	5	2.7	1.6	0.00013	22.0	0.1	7.0	0.00057
6801110301	SOLASTER DAWSONI	1	0.5	0.3	0.00003	77.0	0.5	24.4	0.00200
6802040101	ALLOCENTROTUS FRAGILIS	21	11.2	6.7	0.00055	4500.0	27.4	1428.6	0.11710
6803040201	GORGONOCEPHALUS CARYI	1	0.5	0.3	0.00003	110.0	0.7	34.9	0.00286
	TOTAL			59.7	0.00489			5215.9	0.42753
VERTEBRATES									
7602050201	SQUALUS ACANTHIAS	8	1.9	2.5	0.00021	10900.0	19.0	3460.3	0.28363
7603020106	RAJA KINCAIDI	1	0.2	0.3	0.00003	1800.0	3.1	571.4	0.04684
7603020108	RAJA RHINA	2	0.5	0.6	0.00005	142.0	0.2	45.1	0.00370
7904020501	THALEICHTHYS PACIFICUS	36	8.7	11.4	0.00094	1236.0	2.2	392.4	0.03216
7909020701	THERAGRA CHALCOGRAMMA	2	0.5	0.6	0.00005	184.0	0.3	58.4	0.00479
7909041110	LYCODES PALEARIS	3	0.7	1.0	0.00008	60.0	0.1	19.0	0.00156
7915010101	SEBASTES ALEUTIANUS	1	0.2	0.3	0.00003	253.0	0.4	80.3	0.00658
7915010102	SEBASTES ALUTUS	1	0.2	0.3	0.00003	200.0	0.3	63.5	0.00520
7915040901	DASYCOTTUS SETIGER	1	0.2	0.3	0.00003	20.0	0.0	6.3	0.00052
7915041901	MALACOCOTTUS KINCAIDI	1	0.2	0.3	0.00003	10.0	0.0	3.2	0.00026
7915051301	AGONUS ACIPENSERINUS	1	0.2	0.3	0.00003	26.0	0.0	8.3	0.00068
7916090103	BATHYMASTER SIGNATUS	1	0.2	0.3	0.00003	180.0	0.3	57.1	0.00468
7917020102	ATHERESTHES STOMIAS	291	70.3	92.4	0.00757	37700.0	65.7	11968.3	0.98100
7917020501	GLYPTOCEPHALUS ZACHIRUS	53	12.8	16.8	0.00138	2700.0	4.7	857.1	0.07026
7917020601	HIPPOGLOSSOIDES ELASSODON	11	2.7	3.5	0.00029	1265.0	2.2	401.6	0.03292
7917021401	PAROPHRYS VETULUS	1	0.2	0.3	0.00003	732.0	1.3	232.4	0.01905
	TOTAL			131.4	0.01077			18224.8	1.49383

COMMENTS

CHIONOECETES BAIRDI: 31 FEMALES, 566G; 30 MALES, 832G.
STOMACHS: 10 TURBUT; 10 REX SOLE; 1 BLACKFIN SCULPIN;
1 DASYCOTTUS SETIGER; 61 SNOW CRAB.

BOTTOM WATER TEMPERATURE °C = 8.7

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CRUSE #	STAT #	TOW #	GEAR CODE	DATE YYMMDD	TIME HHMM	START LATITUDE DEG MIN	START LONGITUDE DEG MIN	FINISH LATITUDE DEG MIN	FINISH LONGITUDE DEG MIN	MIDPOINT LATITUDE DEG MIN	MIDPOINT LONGITUDE DEG MIN	TIME FISH MINS	DIST FISHED (KM)	DEPTH FISHED (METERS) MIN	MAX	AVG
FN795	104C	46	OTB	791124	1659	58 59.6N	139 19.5W	58 58.1N	139 18.4W			30	2.96	107.9 -	111.6	109.8

TAXON CODE	TAXONOMIC NAME	COUNTS RAW	%	/KM	/M SQ	WEIGHT (GRAMS) RAW	%	/KM	/M SQ
INVERTEBRATES									
4905290101	FUSITRITON OREGONENSIS	21	5.1	7.1	0.00058	1662.0	5.8	561.5	0.04602
4905330301	NEPTUNEA LYRATA	1	0.2	0.3	0.00003	52.0	0.2	17.6	0.00144
4905331001	PYRULOFUSUS HARPA	1	0.2	0.3	0.00003	128.0	0.4	43.2	0.00354
4907010101	ROSSIA PACIFICA	2	0.5	0.7	0.00006	18.0	0.1	6.1	0.00050
5333110203	PAGURUS ALEUTICUS	2	0.5	0.7	0.00006	50.0	0.2	16.9	0.00138
5333110216	PAGURUS CONFRAGOSUS	27	6.5	9.1	0.00075	586.0	2.0	198.0	0.01623
5333110302	ELASSOCHIRUS CAVIMANUS	3	0.7	1.0	0.00008	26.0	0.1	8.8	0.00072
5333121002	LOPHOLITHODES FORAMINATUS	12	2.9	4.1	0.00033	8200.0	28.4	2770.3	0.22707
5333170302	CHIONOECETES BAIRDI	312	75.4	105.4	0.00864	10000.0	34.6	3378.4	0.27692
6801040602	PSEUDARCHASTER PARELII	1	0.2	0.3	0.00003	14.0	0.0	4.7	0.00039
6801060101	CTENODISCUS CRISPATUS	2	0.5	0.7	0.00006	12.0	0.0	4.1	0.00033
6801110301	SOLASTER DAWSONI	1	0.2	0.3	0.00003	122.0	0.4	41.2	0.00338
6801121201	PYCNOPODIA HELIANTHOIDES	1	0.2	0.3	0.00003	3200.0	11.1	1081.1	0.08861
6802040101	ALLOCENTROTUS FRAGILIS	13	3.1	4.4	0.00036	2904.0	10.0	981.1	0.08042
6803040201	GORGONOCEPHALUS CARYI	15	3.6	5.1	0.00042	1923.0	6.7	649.7	0.05325
	TOTAL			139.9	0.01146			9762.5	0.80020
VERTEBRATES									
7603020106	RAJA KINCAIDI	2	0.9	0.7	0.00006	1653.0	2.4	558.4	0.04577
7603020108	RAJA RHINA	6	2.6	2.0	0.00017	13600.0	20.1	4594.6	0.37661
7903010201	CLUPEA HARENGUS PALLASI	2	0.9	0.7	0.00006	161.0	0.2	54.4	0.00446
7909020701	THERAGRA CHALCOGRAMMA	19	8.2	6.4	0.00053	1154.0	1.7	389.9	0.03196
7909041110	LYCODES PALEARIS	2	0.9	0.7	0.00006	43.0	0.1	14.5	0.00119
7915010102	SEBASTES ALUTUS	3	1.3	1.0	0.00008	320.0	0.5	108.1	0.00886
7915040901	DASYCOTTUS SETIGER	4	1.7	1.4	0.00011	293.0	0.4	99.0	0.00811
7917020102	ATHERESTHES STOMIAS	170	73.3	57.4	0.00471	45400.0	67.2	15337.8	1.25720
7917020501	GLYPTOCEPHALUS ZACHIRUS	18	7.8	6.1	0.00050	1272.0	1.9	429.7	0.03522
7917020601	HIPPOGLOSSOIDES ELASSODON	3	1.3	1.0	0.00008	427.0	0.6	144.3	0.01182
7917020701	HIPPOGLOSSUS STENOLEPIS	2	0.9	0.7	0.00006	3200.0	4.7	1081.1	0.08861
7917021301	MICROSTOMUS PACIFICUS	1	0.4	0.3	0.00003	65.0	0.1	22.0	0.00180
	TOTAL			78.4	0.00642			22833.8	1.87162

COMMENTS

CHIONOECETES BAIRDI: 157 FEMALES; 155 MALES. STOMACHS: 20
FEMALE SNOW CRABS; 20 MALE SNOW CRABS; 4 SPINYHEAD SCULPIN;
1 PYCNOPODIA-EMPTY.
POLLUTANTS: PLASTIC BLEACH BOTTLE FULL OF MUD.

BOTTOM WATER TEMPERATURE °C = 8.8

CRUSE #	STAT #	TOW #	GEAR CODE	DATE YYMMDD	TIME HHMM	START LATITUDE DEG MIN	START LONGITUDE DEG MIN	FINISH LATITUDE DEG MIN	FINISH LONGITUDE DEG MIN	MIDPOINT LATITUDE DEG MIN	MIDPOINT LONGITUDE DEG MIN	TIME FISH MINS	DIST FISHED (KM)	DEPTH FISHED (METERS) MIN	MAX	AVG
FN795	108A	47	OTB	791125	0640	58 59.5N	138 23.3W	58 58.2N	138 21.3W			30	2.96	62.2 -	65.8	64.C

TAXON CODE	TAXONOMIC NAME	COUNTS RAW	COUNTS %	COUNTS /KM	COUNTS /M SQ	WEIGHT (GRAMS) RAW	WEIGHT %	WEIGHT /KM	WEIGHT /M SQ
INVERTEBRATES									
3303000000	ANTHOZOA	21	2.6	7.1	0.00058	10000.0	5.4	3378.4	0.27692
4904080401	PECTEN CAURINUS	736	90.2	248.6	0.02038	158000.0	84.9	53378.4	4.37528
4905250201	NATICA CLAUSA	1	0.1	0.3	0.00003	1.0	0.0	0.3	0.00003
4905320100	BUCCINUM SPP.	2	0.2	0.7	0.00006	11.0	0.0	3.7	0.00030
4905330202	BERINGIUS KENNICOTTI	1	0.1	0.3	0.00003	85.0	0.0	28.7	0.00235
5333040101	PANDALUS BOREALIS	2	0.2	0.7	0.00006	16.0	0.0	5.4	0.00044
5333110200	PAGURUS SPP.	1	0.1	0.3	0.00003	1.0	0.0	0.3	0.00003
5333110202	PAGURUS OCHOTENSIS	19	2.3	6.4	0.00053	105.0	0.1	35.5	0.00291
5333110206	PAGURUS SETOSUS	1	0.1	0.3	0.00003	2.0	0.0	0.7	0.00006
5333110216	PAGURUS CONFRAGOSUS	2	0.2	0.7	0.00006	7.0	0.0	2.4	0.00019
5333110401	LABIDOCHIRUS SPLENDESCENS	1	0.1	0.3	0.00003	5.0	0.0	1.7	0.00014
5333170302	CHIONOECETES BAIRDI	10	1.2	3.4	0.00028	298.0	0.2	100.7	0.00825
5333180104	CANCER MAGISTER	1	0.1	0.3	0.00003	9.0	0.0	3.0	0.00025
6801040501	MEDIASTER AEQUALIS	1	0.1	0.3	0.00003	20.0	0.0	6.8	0.00055
6801050101	LUIDIA FOLIOLATA	3	0.4	1.0	0.00008	311.0	0.2	105.1	0.00861
6801121201	PYCNOPODIA HELIANTHOIDES	14	1.7	4.7	0.00039	17300.0	9.3	5844.6	0.47907
	TOTAL			275.7	0.02260			62895.6	5.15538
VERTEBRATES									
7602050201	SQUALUS ACANTHIAS	3	0.6	1.0	0.00008	5000.0	2.9	1689.2	0.13846
7603020111	RAJA STELLULATA	9	1.7	3.0	0.00025	25900.0	14.9	8750.0	0.71721
7904020501	THALEICHTHYS PACIFICUS	2	0.4	0.7	0.00006	60.0	0.0	20.3	0.00166
7909020401	GADUS MACROCEPHALUS	1	0.2	0.3	0.00003	2300.0	1.3	777.0	0.06369
7909020601	MICROGADUS PROXIMUS	31	6.0	10.5	0.00086	1776.0	1.0	600.0	0.04918
7909020701	THERAGRA CHALCOGRAMMA	23	4.4	7.8	0.00064	4812.0	2.8	1625.7	0.13325
7909041110	LYCODES PALEARIS	14	2.7	4.7	0.00039	1880.0	1.1	635.1	0.05206
7915030101	ANOPLOPOMA FIMBRIA	8	1.5	2.7	0.00022	2700.0	1.6	912.2	0.07477
7915040901	DASYCOTTUS SETIGER	1	0.2	0.3	0.00003	26.0	0.0	8.8	0.00072
7917020102	ATHERESTHES STOMIAS	25	4.8	8.4	0.00069	2000.0	1.2	675.7	0.05538
7917020501	GLYPTOCEPHALUS ZACHIRUS	95	18.3	32.1	0.00263	6800.0	3.9	2297.3	0.18830
7917020601	HIPPOGLOSSOIDES ELASSODON	10	1.9	3.4	0.00028	10400.0	6.0	3513.5	0.28799
7917020701	HIPPOGLOSSUS STENOLEPIS	31	6.0	10.5	0.00086	41800.0	24.1	14121.6	1.15751
7917020801	ISOPSETTA ISOLEPIS	211	40.7	71.3	0.00584	53100.0	30.6	17939.2	1.47043
7917020901	LEPIDOPSETTA BILINEATA	20	3.9	6.8	0.00055	6800.0	3.9	2297.3	0.18830
7917021001	LIMANDA ASPERA	1	0.2	0.3	0.00003	2300.0	1.3	777.0	0.06369
7917021301	MICROSTOMUS PACIFICUS	2	0.4	0.7	0.00006	110.0	0.1	37.2	0.00305
7917021401	PAROPHRYS VETULUS	31	6.0	10.5	0.00086	5900.0	3.4	1993.2	0.16338
	TOTAL			175.0	0.01434			58670.3	4.80904

COMMENTS

CHIONOECETES BAIRDI: 7 MALES; 3 FEMALES.
STOMACHS: 14 PYCNOPODIA HELIANTHOIDES; 10 REX SOLE; 9 BUTTER SOLE;
9 ROCK SOLE; 10 FLATHEAD SOLE; 10 ENGLISH SOLE.
PECTEN CCURINUS: DORSAL VALVES DETERICRATING. AGENT NOT KNOWN.
APPROXIMATELY 100% OF SPECIMENS CAUGHT INFESTED.
BOTTOM WATER TEMPERATURE °C = 9.3

CRUSE #	STAT #	TOW #	GEAR CODE	DATE YYMMDD	TIME HHMM	START LATITUDE DEG MIN	START LONGITUDE DEG MIN	FINISH LATITUDE DEG MIN	FINISH LONGITUDE DEG MIN	MIDPOINT LATITUDE DEG MIN	MIDPOINT LONGITUDE DEG MIN	TIME FISH MINS	DIST FISHED (KM)	DEPTH FISHED (METERS) MIN	MAX	AVG
FN795	109A	48	OTB	791125	0839	58 49.2N	138 6.2W	58 50.5N	138 7.9W			30	2.78	109.8 -	117.1	113.5

TAXON CODE	TAXONOMIC NAME	COUNTS RAW	%	/KM	/M SQ	WEIGHT (GRAMS) RAW	%	/KM	/M SQ
INVERTEBRATES									
3303470201	STYLATULA GRACILE	1	0.1	0.4	0.00003	100.0	0.0	36.0	0.00295
3303570101	METRIDIUM SENILE	790	96.7	284.2	0.02329	268800.0	98.3	96690.6	7.92546
5333110202	PAGURUS OCHOTENSIS	7	0.9	2.5	0.00021	60.0	0.0	21.6	0.00177
5333170201	HYAS LYRATUS	1	0.1	0.4	0.00003	22.0	0.0	7.9	0.00065
5333170302	CHIONOECETES BAIRDI	1	0.1	0.4	0.00003	16.0	0.0	5.8	0.00047
6801040501	MEDIASTER AEQUALIS	2	0.2	0.7	0.00006	44.0	0.0	15.8	0.00130
6801050101	LUIDIA FOLIOLATA	13	1.6	4.7	0.00038	2183.0	0.8	785.3	0.06436
6801120416	LEPTASTERIAS FISHERI	1	0.1	0.4	0.00003	23.0	0.0	8.3	0.00068
6801121201	PYCNOPODIA HELIANTHOIDES	1	0.1	0.4	0.00003	2300.0	0.8	827.3	0.06781
	TOTAL			293.9	0.02409			98398.6	8.06546
VERTEBRATES									
7602050201	SQUALUS ACANTHIAS	11	0.3	4.0	0.00032	156390.0	12.9	56255.4	4.61110
7603020111	RAJA STELLULATA	25	0.7	9.0	0.00074	92510.0	7.7	33277.0	2.72762
7904020501	THALEICHTHYS PACIFICUS	28	0.8	10.1	0.00083	1249.0	0.1	449.3	0.03683
7909020601	MICROGADUS PROXIMUS	465	13.8	167.3	0.01371	187220.0	15.5	67345.3	5.52011
7909020701	THERAGRA CHALCOGRAMMA	2	0.1	0.7	0.00006	1467.0	0.1	527.7	0.04325
7915030101	ANOPLOPOMA FIMBRIA	3	0.1	1.1	0.00009	469.0	0.0	168.7	0.01383
7915040901	DASYCOTTUS SETIGER	4	0.1	1.4	0.00012	360.0	0.0	129.5	0.01061
7915051301	AGONUS ACIPENSERINUS	16	0.5	5.8	0.00047	446.0	0.0	160.4	0.01315
7915061200	LIPARIS SPP.	1	0.0	0.4	0.00003	22.0	0.0	7.9	0.00065
7917020102	ATHERESTHES STOMIAS	89	2.6	32.0	0.00262	83700.0	6.9	30107.9	2.46786
7917020501	GLYPTOCEPHALUS ZACHIRUS	300	8.9	107.9	0.00885	12300.0	1.0	4424.5	0.36266
7917020601	HIPPOGLOSSOIDES ELASSODON	11	0.3	4.0	0.00032	1085.0	0.1	390.3	0.03199
7917020701	HIPPOGLOSSUS STENOLEPIS	10	0.3	3.6	0.00029	6800.0	0.6	2446.0	0.20050
7917020801	ISOPSETTA ISOLEPIS	2067	61.3	743.5	0.06094	462200.0	38.3	166259.0	13.62779
7917021301	MICROSTOMUS PACIFICUS	22	0.7	7.9	0.00065	448.0	0.0	161.2	0.01321
7917021401	PAROPHRYS VETULUS	301	8.9	108.3	0.00887	196040.0	16.2	70518.0	5.78016
7917021801	PSETTICHTHYS MELANOSTICTUS	15	0.4	5.4	0.00044	5000.0	0.4	1798.6	0.14742
	TOTAL			1212.2	0.09936			434426.6	35.60874

COMMENTS

STOMACH: 1 PYCNOPODIA-EMPTY; 10 HALIBUT; 10 BUTTER SOLE; 10 ENGLISH SOLE; 4 SPINYHEAD SCULPIN.
BOTTOM WATER TEMPERATURE °C = 9.3

CRUSE #	STAT #	TOW #	GEAR CODE	DATE YYMMDD	TIME HHMM	START LATITUDE DEG MIN	START LONGITUDE DEG MIN	FINISH LATITUDE DEG MIN	FINISH LONGITUDE DEG MIN	MIDPOINT LATITUDE DEG MIN	MIDPOINT LONGITUDE DEG MIN	TIME FISH MINS	DIST FISHED (KM)	DEPTH FISHED (METERS) MIN	MAX	AVG
FN795	109B	49	OTB	791125	1014	58 43.9N	138 1.4W	58 44.9N	138 3.5W			30	2.78	84.2 -	84.2	84.2

TAXON CODE	TAXONOMIC NAME	COUNTS RAW	COUNTS %	COUNTS /KM	COUNTS /M SQ	WEIGHT (GRAMS) RAW	WEIGHT %	WEIGHT /KM	WEIGHT /M SQ
INVERTEBRATES									
3303000000	ANTHOZOA	2	6.7	0.7	0.00006	894.0	27.2	321.6	0.02636
3303470201	STYLATULA GRACILE	4	13.3	1.4	0.00012	178.0	5.4	64.0	0.00525
4801740100	APHRODITA SPP.	1	3.3	0.4	0.00003	22.0	0.7	7.9	0.00065
4904080401	PECTEN CAURINUS	2	6.7	0.7	0.00006	470.0	14.3	169.1	0.01386
4905660101	TRITONIA EXSULANS	3	10.0	1.1	0.00009	151.0	4.6	54.3	0.00445
4907010101	ROSSIA PACIFICA	1	3.3	0.4	0.00003	22.0	0.7	7.9	0.00065
5333040101	PANDALUS BOREALIS	2	6.7	0.7	0.00006	11.0	0.3	4.0	0.00032
5333110202	PAGURUS OCHOTENSIS	1	3.3	0.4	0.00003	6.0	0.2	2.2	0.00018
5333170201	HYAS LYRATUS	1	3.3	0.4	0.00003	18.0	0.5	6.5	0.00053
5333170302	CHIONOECETES BAIRDI	10	33.3	3.6	0.00029	474.0	14.4	170.5	0.01398
6801040501	MEDIASTER AEQUALIS	2	6.7	0.7	0.00006	60.0	1.8	21.6	0.00177
6801121201	PYCNOPODIA HELIANTHOIDES	1	3.3	0.4	0.00003	979.0	29.8	352.2	0.02887
	TOTAL			10.8	0.00088			1181.7	0.09686
VERTEBRATES									
7602050201	SQUALUS ACANTHIAS	25	3.3	9.0	0.00074	34100.0	21.1	12266.2	1.00543
7603020111	RAJA STELLULATA	7	0.9	2.5	0.00021	35900.0	22.2	12913.7	1.05850
7904020501	THALEICHTHYS PACIFICUS	106	13.9	38.1	0.00313	3789.0	2.3	1362.9	0.11172
7909020601	MICROGADUS PROXIMUS	139	18.2	50.0	0.00410	21362.0	13.2	7684.2	0.62985
7909020701	THERAGRA CHALCOGRAMMA	19	2.5	6.8	0.00056	1359.0	0.8	488.8	0.04007
7909041110	LYCODES PALEARIS	6	0.8	2.2	0.00018	653.0	0.4	234.9	0.01925
7915010121	SEBASTES MELANOPS	2	0.3	0.7	0.00006	4500.0	2.8	1618.7	0.13268
7915020201	OPHIODON ELONGATUS	1	0.1	0.4	0.00003	13600.0	8.4	4892.1	0.40099
7915030101	ANOPLOPOMA FIMBRIA	2	0.3	0.7	0.00006	289.0	0.2	104.0	0.00852
7915040000	COTTIDAE	1	0.1	0.4	0.00003	179.0	0.1	64.4	0.00528
7915040901	DASYCOTTUS SETIGER	5	0.7	1.8	0.00015	198.0	0.1	71.2	0.00584
7915050000	AGONIDAE	1	0.1	0.4	0.00003	56.0	0.0	20.1	0.00165
7915051301	AGONUS ACIPENSERINUS	2	0.3	0.7	0.00006	51.0	0.0	18.3	0.00150
7917020102	ATHERESTHES STOMIAS	46	6.0	16.5	0.00136	12300.0	7.6	4424.5	0.36266
7917020501	GLYPTOCEPHALUS ZACHIRUS	349	45.6	125.5	0.01029	22000.0	13.6	7913.7	0.64866
7917020601	HIPPOGLOSSOIDES ELASSODON	8	1.0	2.9	0.00024	541.0	0.3	194.6	0.01595
7917020701	HIPPOGLOSSUS STENOLEPIS	2	0.3	0.7	0.00006	4100.0	2.5	1474.8	0.12089
7917020801	ISOPSETTA ISOLEPIS	9	1.2	3.2	0.00027	1564.0	1.0	562.6	0.04611
7917021301	MICROSTOMUS PACIFICUS	1	0.1	0.4	0.00003	57.0	0.0	20.5	0.00168
7917021401	PAROPHRYS VETULUS	34	4.4	12.2	0.00100	5100.0	3.2	1834.5	0.15037
	TOTAL			275.2	0.02256			58164.7	4.76760

COMMENTS

STOMACHS: 10 ENGLISH SOLE; 10 REX SOLE; 10 DOGFISH; 1 PYCNOPODIA;
5 SPINYHEAD SCULPIN. CHIONOECETES BAIRDI: 6 MALES; 4 FEMALES.
BOTTOM WATER TEMPERATURE °C = 9.4

CRUSE #	STAT #	TOW #	GEAR CODE	DATE YYMMDD	TIME HHMM	START LATITUDE DEG MIN	START LONGITUDE DEG MIN	FINISH LATITUDE DEG MIN	FINISH LONGITUDE DEG MIN	MIDPOINT LATITUDE DEG MIN	MIDPOINT LONGITUDE DEG MIN	TIME FISH MINS	DIST FISHED (KM)	DEPTH FISHED (METERS) MIN	MAX	AVG
FN795	110A	50	OTB	791125	1159	58 40.2N	137 51.9W	58 41.4N	137 53.4W			30	2.59	58.6 -	60.4	59.5

TAXON CODE	TAXONOMIC NAME	COUNTS RAW	%	/KM	/M SQ	WEIGHT (GRAMS) RAW	%	/KM	/M SQ
INVERTEBRATES									
3303470201	STYLATULA GRACILE	6	9.2	2.3	0.00019	204.0	1.5	78.8	0.00646
4904080401	PECTEN CAURINUS	46	70.8	17.8	0.00146	7700.0	58.0	2973.0	0.24369
5333110202	PAGURUS OCHOTENSIS	1	1.5	0.4	0.00003	9.0	0.1	3.5	0.00028
5333170302	CHIONOECETES BAIRDI	4	6.2	1.5	0.00013	575.0	4.3	222.0	0.01820
5333180104	CANCER MAGISTER	4	6.2	1.5	0.00013	3600.0	27.1	1390.0	0.11393
6801050101	LUIDIA FOLIOLATA	4	6.2	1.5	0.00013	1184.0	8.9	457.1	0.03747
	TOTAL			25.1	0.00206			5124.3	0.42003
VERTEBRATES									
7903010201	CLUPEA HARENGUS PALLASI	1	0.2	0.4	0.00003	95.0	0.2	36.7	0.00301
7904020501	THALEICHTHYS PACIFICUS	59	12.2	22.8	0.00187	2700.0	4.3	1042.5	0.08545
7909020601	MICROGADUS PROXIMUS	36	7.4	13.9	0.00114	3200.0	5.1	1235.5	0.10127
7909020701	THERAGRA CHALCOGRAMMA	2	0.4	0.8	0.00006	126.0	0.2	48.6	0.00399
7909041110	LYCODES PALEARIS	3	0.6	1.2	0.00009	130.0	0.2	50.2	0.00411
7915030101	ANOPLOPOMA FIMBRIA	102	21.0	39.4	0.00323	12700.0	20.1	4903.5	0.40192
7915041801	LEPTOCOTTUS ARMATUS	6	1.2	2.3	0.00019	2514.0	4.0	970.7	0.07956
7915051301	AGONUS ACIPENSERINUS	2	0.4	0.8	0.00006	75.0	0.1	29.0	0.00237
7917020102	ATHERESTHES STOMIAS	96	19.8	37.1	0.00304	15000.0	23.8	5791.5	0.47471
7917020501	GLYPTOCEPHALUS ZACHIRUS	144	29.7	55.6	0.00456	15000.0	23.8	5791.5	0.47471
7917020601	HIPPOGLOSSOIDES ELASSODON	7	1.4	2.7	0.00022	580.0	0.9	223.9	0.01836
7917021301	MICROSTOMUS PACIFICUS	1	0.2	0.4	0.00003	62.0	0.1	23.9	0.00196
7917021501	PLATICHTHYS STELLATUS	2	0.4	0.8	0.00006	3200.0	5.1	1235.5	0.10127
7917021801	PSETTICHTHYS MELANOSTICTUS	24	4.9	9.3	0.00076	7700.0	12.2	2973.0	0.24369
	TOTAL			187.3	0.01535			24356.0	1.99639

COMMENTS

CHIONOECETES BAIRDI: 3 FEMALES; 1 MALE.
STOMACHS: 10 ENGLISH SOLE; 10 BUTTER SOLE; 10 SAND SOLE.
BOTTOM WATER TEMPERATURE °C = 9.5

APPENDIX B

POLYCHAETES AND AMPHIPODS AS COMMENSALS WITH HERMIT CRABS FROM THE NORTHEASTERN GULF OF ALASKA

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and

S. G. McGee

INTRODUCTION

Numerous commensal associations involving polychaetes have been reported previously. These associations involve Paguridae, Opistobranchia, Echiura, Asteroidea, Stichopidae, Solasteridae, Gastropoda, Pelecypoda, and other Polychaeta (Andrews, 1891; Harrington, 1897; Hartman, 1948; Pettibone, 1953; Nicol, 1960; Hatfield, 1965; MacGinitie and MacGinitie 1968; Ricketts and Calvin, 1968). Most of this literature has dealt primarily with interactions between polychaetes and sea stars, sea cucumbers, gastropods, pelecypods, or echiuroids with relatively little information on hermit crab - polychaete associations. Much of the information available on associations between polychaetes and pagurid crabs is from original discriptions of the polychaetes from papers on specific aspects of pagurid or polychaete biology or in general discussions from invertebrate textbooks (see Barrington, 1967; Barnes, 1980). Although associations involving *Cheiloneres cyclurus* (Harrington, 1897) and *Polydora commensalis* (Andrews, 1891) with specific pagurids have been well documented (Hatfield, 1965; Seaborn, 1975), relationships involving other species have not.

The present study represents the first comprehensive examination of commensal relationships involving hermit crabs from the northeastern Gulf of Alaska.

METHODS AND MATERIALS

Invertebrates were collected during November, 1979, on board the NOAA Ship *Miller Freeman*, using a standard 400 mesh Eastern otter trawl. Gastropod shells containing hermit crabs were broken to expose the crab and possible symbionts. All specimens were sorted and given tentative identifications in the field. Representative specimens were preserved in 10% neutral buffered formalin or 70% isoproponol for later confirmation at the Institute of Marine Science, Fairbanks, Alaska.

RESULTS

The shells of the gastropods *Fusitriton oregonensis* and *Neptunea lyrata* were the most frequent habitat of the following hermit crabs: *Pagurus* *confragosus; Pagurus setosus; Pagurus ochotensis; Pagurus aleuticus;* and *Elassochirus cavimanus*. Shells from *Beringius kennicotti; Arctomelon stearnsi; Buccinum plectrum; Natica clausa*, and the sponge *Subrites ficus* were utilized occasionally (Table I). The following five species of polychaetes were found cohabiting the same shells: *Eunoe depressa* (Polynoidae); *Cheilonereis cyclurus* (Nereidae); *Polydora commensalis* (Spionidae); *Eusyllis blomstrandi* (Syllidae); and *Crucigera zygophora* (Serpulidae) (Table I). The following amphipods were also found in association with the above hermit crabs: *Melita* sp. (Gammariidae), *Podoceropsis* sp., and a species from the family Pleustidae.

Commensals occurred with 40.9% of all pagurids collected during this study (Table II). Frequency and percent frequency of occurrence for all commensals with each of the five species of pagurids are presented by station. The percent frequencies for individual species are presented in Table III. Amphipods alone, particularly *Melita* sp., were associated with hermit crabs in 16.7% of all symbioses. In four instances, both amphipods and polychaetes were found with the same crab. Rarely (6.4%) did more than one commensal occur with the same crab.

Eunoe depressa and *Melita* were the dominant commensals associated with *Pagurus confragosus* (Table III). Both symbionts were always located in the spire of the gastropod shell. *Eunoe depressa*, *Eusyllis blomstrandi* and *Melita* sp. were each found once in association with *Pagurus setosus* (Table III). *Polydora commensalis* was located within the columella, while the others were in the spire of the shell. *Eunoe depressa*, *Cheilonereis cyclurus* and *P. commensalis* were the commensals most frequently associated with *Pagurus ochotensis* (Table III). *Polydora commensalis* was again located within the columella; the others in the spire were *Eunoe depressa*, *P. commensalus* and *Melita* sp. were most often associated with *Pagurus aleuticus*. *Polydora commensalis* and *Melita* sp. were the species most often found with *Elassochirus cavimanus*. These commensals were always positioned in their characteristic locations within the shell.

TABLE I

Numbers of commensals occurring with five species of hermit crabs in seven species of shells from the northeastern Gulf of Alaska, November 1979.

	Hermit crab					
Shell	*Pagurus confragosus*	*Pagurus setosus*	*Pagurus ochotensis*	*Pagurus aleuticus*	*Elassochirus cavimanus*	Totals
Fusitriton oregonensis	27	3	6	11	13	60
Neptunea lyrata	13		59	1	1	74
Beringius kennicotti	1					1
Subrites ficus		1	1			2
Arctomelon stearnsi					1	1
Buccinum plectrum			5			5
Natica clausa			13			13
TOTALS	41	4	84	12	15	156

TABLE II

Numbers of hermit crabs with commensals/total number of crabs from stations in the northeastern Gulf of Alaska, November 1979.

Station	*Pagurus confragosus*	*Pagurus setosus*	*Pagurus ochotensis*	*Pagurus aleuticus*	*Elassochirus cavimanus*	Totals
104 G				0/3	1/6	1/9
104 F	1/2					1/2
99 D					1/14	1/14
99 E	2/8				3/6	5/14
100 E		1/2			8/22	9/24
100 D	1/1	0/1				1/2
104 B	0/2		1/20	0/2		1/24
106 B				8/35		8/35
106 A			24/36			24/36
105 A			1/1			1/1
105 B			7/9			7/9
105 C	12/42		1/2	3/8		16/52
94 B			17/52			17/52
93 C			20/25			20/25
102 G	1/2	2/3			1/3	4/8
103 D	4/11					4/11
104 D	1/2					1/2
104 C	19/27			1/2	1/3	21/32
108 A	0/2	1/1	9/19			10/22
109 A			4/17			4/17
TOTALS	4/99 (41.4%)	4/7 (57.1%)	84/171 (49.1%)	12/50 (24.0%)	15/54 (27.8%)	156/381 (40.9%)

TABLE III

Percent frequency of occurrence of commensals with five species of hermit crabs. Numbers in parentheses are for crabs with commensals only.

Commensal	*Pagurus confragosus* N = 99 (41)	*Pagurus setosus* N = 7 (4)	*Pagurus ochotensis* N = 171 (84)	*Pagurus aleuticus* N = 50 (12)	*Elassochirus cavimanus* N = 54 (15)	Totals N = 381 (156)
Eunoe depressa	20.2 (48.8)	14.3 (25.0)	27.5 (56.0)	12.0 (50.0)	1.9 (6.7)	19.7 (48.1)
Polydora commensalis	1.0 (2.4)	14.3 (25.0)	2.9 (6.0)	8.0 (33.3)	7.4 (26.7)	3.9 (9.6)
Eusyllis blomstrandi	2.0 (4.9)	14.3 (25.0)	1.8 (3.6)			1.6 (3.9)
Cheilonereis cyclurus	4.0 (9.8)		17.5 (35.7)	2.0 (8.3)		9.2 (22.4)
Melita sp.	16.2 (39.0)	14.3 (25.0)	0.6 (1.2)	4.0 (16.7)	16.7 (60.0)	7.6 (18.6)
Pleustidae	1.0 (2.4)		0.6 (1.2)		1.9 (6.7)	0.8 (1.9)
Podoceropsis sp.				2.0 (8.3)		0.3 (0.6)

Crucigera zygophora was recovered from a single *N. lyrata* shell containing a *Pagurus confragosus*. This worm formed a calcareous tube within the columella of the gastropod.

DISCUSSION

Paguridae are primarily opportunistic omnivores with tendencies toward scavenger/predator habits (Warner, 1977). Most of the commensal polychaetes have similar feeding habits as Pagurid crabs (Fauchald and Jumars, 1979). Thus, food would be readily available to the symbiont during the feeding processes of the crab.

Moore (1905, 1908) and Hartman (1948) described *Eunoe depressa* as a commensal "messmate" of unspecified hermit crabs and as a symbiont in the branchial chamber of the King crab, *Paralithodes camtschatica*. These worms were located in the spire of the gastropod shell, just behind and above the carapace of the hermit crab. In the present study, *E. depressa* was by far the most frequently found commensal; occurring with 19.7% of all hermit crabs examined and with 47.8% of those with symbionts. It occurred with all five species of crabs. Occurrences as high as this have not been reported previously.

Polydora commensalis was originally described by Andrews (1891) from the shells of *Ilyanassa obsoleta* inhabited by *Pagurus longicarpus*. Hatfield (1965) reported this species from the east coast in the shells of *Lunatia heros; Polinices duplicatus; Busycon canaliculatum* and *Buccinum undatum* all inhabited by *Pagurus pollicaris*. It has also been reported from British Columbia in shells of *Thais lamellosa* inhabited by *Pagurus granosimanus*; Berkeley and Berkeley, 1936). The present report extends its range to the northeastern Gulf of Alaska and the list of possible symbionts to five additional pagurid species in three additional types of shells. *Polydora commensalis* has a calcareous tube in the terminal spire of the gastropod shell with an opening through the columella into the aperture (Hatfield, 1965). The tube is never visible unless the shell is broken. The worm is capable of extending itself out through the aperture for feeding (Andrews, 1891; Hatfield, 1965).

Cheilonereis cyclurus was first described by Harrington (1897) as emerging from the aperture and proceeding to the mouth parts of the hermit crab. Harrington found this species in Puget Sound with *Pagurus armatus* and *Pagurus tenuimanus* in shells of *Lunatia* sp., *Natica* sp. and *Pterenotus* sp. Seaborn (1975) reported *C. cyclurus* with *Pagurus aleuticus* and several unspecified pagurids from the same area. He suggested *P. aleuticus* was the preferred host. In this study, however, *C. cyclurus* was most often associated with *P. ochotensis*.

Eusyllis blomstrandi has not been previously described as a commensal with hermit crabs. Its low prevalence with three species of hermit crabs probably indicates a more facultative relationship. *Eusyllis blomstraudi* has been reported in the sponge *Ectyodoryx parasitica* growing on shells of *Pecten hindsi* (Berkeley and Berkeley, 1948). Pettibone (1954) reported this species on female *Hyas coarctatus alutaceus* from Point Barrow, Alaska.

Serpulids have not been previously reported as symbionts. They are generally filter-feeders, and although permanent association with a hermit crab might provide an abundance of food, the presence of a single *Crucigera zygophora* within a shell occupied by a *P. confragosus* was probably accidental.

The only report found for a commensal relationship involving amphipods and pagurids was that of Jackson (1913). He sights *Podoceropsis excavata* as "infesting the dirt at the bottom of shells" inhabited by pagurids. Only one specimen of *Podoceropsis* sp. was recovered during this study. Specimens of *Melita* sp., however, were present in 7.6% of all hermit crabs examined and made up 18.6% of those with commensals. Another species, from the family Pleustidae, was found three times, with three different pagurids. No known commensal relationships have been previously reported, and it is possible that the presence of these amphipods was accidental.

Research on the role of chemical factors in mediating host-commensal interactions has been reported by Davenport (1950, 1953, 1966); Davenport and Hickok (1951); Dimock and Davenport (1971); and Seaborn (1975). These authors have demonstrated that chemoreception is used by commensal polychaetes to locate potential hosts. In associations involving pagurids, the size of the aperture of the shell may be a factor in determining successful entry once the polychaete has located the host by chemoreception (Seaborn, 1975). Seaborn found commensal *C. cyclurus* more frequently in shells with an aperture width greater than 2.2 cm.

Pagurids tend to inhabit the largest, most abundant shells present in their habitat (Reese, 1962). Thus, commensals would be expected to do the same. In the northeastern Gulf of Alaska, the shells of *Fusitriton oregonensis* and *Neptunea lyrata* were most frequently utilized by hermit crabs. These are relatively large shells and therefore were expected to more frequently contain commensals as well.

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APPENDIX C

PIPE DREDGE DATA
NORTHEAST GULF OF ALASKA
NOAA SHIP *MILLER FREEMAN*
Cruise No. 795, November 1979

APPENDIX TABLE C.1

Station: 97F
Sample date: 10 November 1979
Latitude: 59°09.3'
Latitude: 141°02.2'
Depth: 188 m

Taxon	Count No.	Count PCT
Porifera	1.0	1.8
Annelida		
Glycera capitata	1.0	1.8
Ninve gemmea	1.0	1.8
Notomastus spp.	1.0	1.8
Maldanidae	1.0	1.8
Owenia fusiformis	1.0	1.8
Myriochele heeri	17.0	29.8
Pista cristata	3.0	5.3
Sabellidae	1.0	1.8
Megalomma splendida	2.0	3.5
Serpulidae	1.0	1.8
Mollusca (Gastropoda)		
Puncturella cooperi	1.0	1.8
Natica clausa	1.0	1.8
Arthropoda		
Heterophoxus oculatus	1.0	1.8
Pandalus spp.	1.0	1.8
Sipuncula		
Golfingia margaritacea	1.0	1.8
Phascolion strombi	1.0	1.8
Ectoprocta		
Microporina borealis	1.0	1.8
Brachiopoda		
Terebratulina unguicula	6.0	10.5

APPENDIX TABLE C.1

CONTINUED

Taxon	Count No.	Count PCT
Echinodermata		
Ctenodiscus crispatus	2.0	3.5
Brisaster townsendi	2.0	3.5
Diamphiodia craterodmeta	2.0	3.5
Ophiura sarsi	5.0	8.8
Molpadia intermedia	1.0	1.8
Capheira mollis	1.0	1.8
Urochordata		
Ascidia spp.	1.0	1.8

Comments

Dead and drilled: 1 *Natica clausa*, 1 *Neptunea Lyrata*, 1 *Admete couthouyi*.

APPENDIX TABLE C.2

Station: 98F
Sample date: 10 November 1979
Latitude: 59°06.4'
Longitude: 140°53.3'
Depth: 176 m

Taxon	Count No.	Count PCT
Annelida		
Onuphis iridescens	1.0	2.7
Lumbrinereis spp.	2.0	5.4
Ninve gemmea	1.0	2.7
Maldanella robusta	1.0	2.7
Notoproctus pacificus	1.0	2.7
Praxillella gracilis	2.0	5.4
Pista cristata	1.0	2.7
Mollusca		
Nucula tenuis	1.0	2.7
Yoldia thraciaeformis	1.0	2.7
Cyclocardia ventricosa	1.0	2.7
Axinopsida serricata	2.0	5.4
Odontogena borealis	1.0	2.7
Arthropoda		
Heterophoxus oculatus	1.0	2.7
Echinodermata		
Ctenodiscus crispatus	5.0	13.5
Allocentrotus fragilis	1.0	2.7
Diamphiodia craterodmeta	13.0	35.1
Ophiura sarsi	1.0	2.7
Crinoidea	1.0	2.7

APPENDIX TABLE C.3

Station: 94G
Sample date: 12 November 1979
Latitude: 59°20.2'
Longitude: 141°53.6'
Depth: 199 m

Taxon	Count No.	PTC
Porifera	1.0	7.1
Cnidaria		
Anthozoa	1.0	7.1
Annelida		
Maldanidae	2.0	14.3
Myriochele heeri	4.0	28.6
Sabellidae	2.0	14.3
Arthropoda		
Ampelisca birulai		
Echinodermata		
Brisaster townsendi	1.0	7.1
Diamphiodia craterodmeta	1.0	7.1
Ophiura sarsi	1.0	7.1
Molpadia intermedia	1.0	7.1

Comments

Dead and drilled: Hydroids, 1 *Macoma* sp., 2 *Astarte* sp., 1 *Puncturella galeata*, 1 *Chlamys* sp., 1 *Balanus* sp., 2 *Lima* sp.

APPENDIX TABLE C.4

Station: 103G
Sample date: 9 November 1979
Latitude: 58°44.2'
Longitude: 139°33.2'
Depth: 166.5 m

Taxon	Count No.	Count PCT
Sarcodina		
Sarcodina rhizopodea	41.0	17.5
Annelida		
Polychaeta	1.0	0.4
Anaitides spp.	1.0	0.4
Nephtys punctata	2.0	0.9
Glycera capitata	3.0	1.3
Goniada annulata	2.0	0.9
Onuphis iridescens	4.0	1.7
Lumbrinereis spp.	4.0	1.7
Ninve gemmea	23.0	9.8
Driloneries longa	1.0	0.4
Paraonis gracilis	2.0	0.9
Laonice cirrata	2.0	0.9
Spiochaetopterus costarum	1.0	0.4
Maldanidae	1.0	0.4
Praxillella gracilis	8.0	3.4
Owenia fusiformis	19.0	8.1
Myriochele heeri	32.0	13.7
Amage anops	1.0	0.4
Ampharete spp.	1.0	0.4
Melinna cristata	1.0	0.4
Melinna elisabethae	1.0	0.4
Pista cristata	2.0	0.9
Mollusca		
Pelecypoda	1.0	0.4
Nucula tenuis	7.0	3.0
Nuculana radiata	1.0	0.4
Dacrydium pacificum	1.0	0.4
Cyclocardia ventricosa	1.0	0.4
Axinopsida serricata	23.0	9.8
Thyasira flexuosa	1.0	0.4
Odontogena borealis	2.0	0.9
Psephidia lordi	2.0	0.9
Natica clausa	1.0	0.4
Dentalium spp.	2.0	0.9

APPENDIX TABLE C.4

CONTINUED

Taxon	Count No.	Count PCT
Arthropoda		
Nebalia sp.	1.0	0.4
Diastylis paraspinulosa	1.0	0.4
Ampelisca spp.	1.0	0.4
Haploops tubicula	1.0	0.4
Orchomene spp.	1.0	0.4
Harpiniopsis excavata	6.0	2.6
Heterophoxus oculatus	1.0	0.4
Syrrhoe longifrons	1.0	0.4
Sipuncula		
Golfingia margaritacea	5.0	2.1
Golfingia vulgaris	5.0	2.1
Echinodermata		
Diamphiodia craterodmeta	7.0	3.0
Molpodia intermedia	3.0	1.3

Comments

Dead and drilled: *Dentalium* sp., 2 *Yoldia* sp., 2 *Cyclocardia ventricosa*, 1 *natica clausa*, 1 *Nuculana*, 1 *Oenopota* sp., 1 *Pandora* sp., *Terebratulina unquicula*.

APPENDIX TABLE C.5

Station: 101I
Sample date: 9 November 1979
Latitude: 58°51.1'
Longitude: 140°02.6'
Depth: 170.2 m

Taxon	Count No.	Count PCT
Annelida		
Goniada annulata	1.0	1.9
Onuphis parva		
Lumbrineries spp.	2.0	3.8
Lumbrinereis bicirrata	1.0	1.9
Ninve gemmae	3.0	5.7
Laonice cirrata	1.0	1.9
Maldanidae	1.0	1.9
Owenia fusiformis	4.0	7.5
Myriochele heeri	8.0	15.1
Pista cristata	2.0	3.8
Megalomma splendida	1.0	1.9
Mollusca		
Pelecypoda	2.0	3.8
Nucula tenuis	3.0	5.7
Nuculana radiata	1.0	1.9
Yoldia spp.	2.0	3.8
Pectinidae	1.0	1.9
Astarte spp.	1.0	1.9
Thyasira flexuosa	1.0	1.9
Odontogena borealis	4.0	7.5
Gastropoda	1.0	1.9
Amphissa spp.	1.0	1.9
Arthropoda		
Leucon nasica	1.0	1.9
Amphipoda	1.0	1.9
Nicippe tumida	1.0	1.9
Harpiniopsis excavata	1.0	1.9
Heterophoxus oculatus	1.0	1.9
Paraphoxus oculatus	1.0	1.9
Sipuncula		
Phascolion strombi	1.0	1.9
Brachiopoda		
Laqueus californianus	1.0	1.9
Echinodermata		
Ctenodiscus crispatus	2.0	3.8
Diamphiodia craterodmeta	1.0	1.9
Ophiura sarsi	1.0	1.9

APPENDIX TABLE C.6

Station: 100J
Sample date: 9 November 1979
Latitude: 58°41.5'
Longitude: 140°16.5'
Depth: 204 m

Taxon	Count No.	Count PCT
Sarcodina		
Sarcodina rhizopodea	5.0	10.2
Porifera	16.0	33.3
Cnidaria		
Hydrozoa	1.0	2.0
Anthozoa	1.0	2.0
Rhynchocoela	1.0	2.0
Annelida		
Lepidonotus squamatus	1.0	2.0
Typosyllis alternata	1.0	2.0
Typosyllis armillaris	1.0	2.0
Onuphis parva	1.0	2.0
Spiochaetopterus costarum	1.0	2.0
Thelepus cincinnatus	1.0	2.0
Sabellidae	1.0	2.0
Mollusca		
Hanleya hanleyi	3.0	6.1
Pelecypoda	1.0	2.0
Propeamussium alaskense	1.0	2.0
Arthropoda		
Bylisis spp.	1.0	2.0
Ectoprota		
Brachiopoda		
Terebratulina unguicula	2.0	4.1
Echinodermata		
Ophiuroidea	1.0	2.0
Psolus chitinoides	1.0	2.0
Crinoidea	1.0	2.0
Chordata		
Ascidia spp.	5.0	10.2

Comments

Dead and drilled: 1 *Cyclocardia ventricosa*, 1 gastropod.

APPENDIX TABLE C.7

Station: 101K
Sample date: 9 November 1979
Latitude: 58°38.9'
Longitude: 140°01.8'
Depth: 190 m

Taxon	Count No.	Count PCT
Cnidaria		
Hydrozoa	2.0	9.5
Anthozoa	4.0	19.0
Annelida		
Goniadidae	1.0	4.8
Laonice cirrata	1.0	4.8
Myriochele heeri	1.0	4.8
Megalomma splendida	2.0	9.5
Sipuncula		
Sipuncula	1.0	4.8
Phascolion strombi	2.0	9.5
Brachiopoda		
Terebratulina unguicula	2.0	9.5
Echinodermata		
Ophiuroidea	1.0	4.8
Diamphiodia craterodmeta	4.0	19.0

Comments

Dead and drilled: 1 *Astarte* sp., 1 *Propeamussium alaskense*, 2 *Spiochaetopterus* tubes (empty).

HABITAT REQUIREMENTS AND EXPECTED DISTRIBUTION OF ALASKA CORAL

by

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Final Report
Outer Continental Shelf Environmental Assessment Program
Research Unit 601

October 1981

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I. INTRODUCTION

Proposed leasing of Alaskan Outer Continental Shelf (OCS) areas for oil and gas exploration and development has resulted in the need to gather and synthesize information which can be used by the Bureau of Land Management (BLM) to make decisions necessary for protection of the marine environment. One particular aspect of the marine environment that BLM has been required by law to protect is the coral resource (OCS Lands Act of 1953; Public Law 94-265; Fisheries Conservation and Management Act of 1976; and Federal Register Notes 43 CFR 6224, Protection and Preservation of National Values). In addition, during the past ten years a commercial coral industry has developed in Alaska. These corals are harvested by fishermen who either selectively seek them out or make incidental catches while fishing for other commercial species.

The objectives of this study are to provide the Alaskan OCS office of the Bureau of Land Management with: 1) a compilation and synthesis of information from the literature and other sources regarding the distribution, abundance, habitat requirements, and probable locations of corals along the Alaskan OCS waters; 2) a discussion of the potential effects of oil and gas exploration and development on corals; and 3) recommendations for further studies of corals and the effects of oil and gas exploration and development on these organisms.

All Alaskan OCS waters are reviewed in this report. Areas within the Gulf of Alaska are emphasized for two reasons. One, this region is the first area of Alaska available for oil and gas exploration and development, and two, most of the commercial harvesting of coral takes place in this area. This study will focus on specific areas within the Gulf of Alaska proposed for oil and gas development (Lower Cook Inlet, Shelikof Strait, Kodiak Island, and Northeast Gulf of Alaska), as well as the inland waters of southeast Alaska. The latter region is presently not contemplated for oil development, but includes areas rich in commercial coral and thereby provides a major source of coral information.

The following chapter (Chapter II) presents a review of coral taxonomy, life history, and ecology which may assist in understanding subsequent portions of the report. Chapters III-V address specific objectives of the study, while Chapter VI presents a summary of information generated in the report.

II. BACKGROUND REVIEW

The term "coral" is applied to several diverse orders within the Phylum Coelenterata (Table 1). This study covers those orders of Coelenterates having corals found in Alaska. These include the orders Alcyonacea (soft corals), Gorgonacea (sea fans or horny corals), and Scleractinia (cup corals, stony corals, or hard corals) in the class Anthozoa, and the order Stylasterina (hydrocorals) in the class Hydrozoa.

The morphology of corals varies. The living tissues are composed of polyps, each with a mouth surrounded by tentacles. Some species are composed of a single polyp, others are colonies of many polyps. Certain corals are upright and display varying degrees of branching, while others are low growing, encrusting forms. Corals vary in size from less than 1 cm to over 1 m. The skeletons of corals consist of spicules which are embedded within or are deposited outside the living tissues. The chemical composition (hardness) and size of the skeleton are important in determining the commercial value of each species.

Sexual reproduction usually takes place between individual polyps or colonies, since sexes in most corals are separate (Lacaze-Duthiers 1864; Bayer and Weinheimer 1974; Grigg 1977; Weinberg and Weinberg 1979). Female colonies harbor the eggs, which are fertilized by sperm from male colonies. Fertilized eggs develop within the female polyps into planula larvae.

The planula larva of many species has never been observed (Stimson 1978); those that have been studied are usually large (between 0.5 and 2.5 mm long), pink, ciliated, and slightly negatively buoyant (Sevens 1981). The larvae usually live between 2 and 10 days (Lacaze-Duthiers 1864; Gohar 1940; Kinzie 1973; Grigg 1977; Weinberg and Weinberg 1979) although some have been reported to survive up to 90 days in the laboratory (Vaughan and Wells 1943; Grigg 1979).

Table 1. Coelenterate Systematics. Orders covered in this study are asterisked (*).

Phylum Coelenterata	Common Name; Distribution
Class Anthozoa	
Subclass Octocorallia (Alcyonaria)	
* Order Alcyonacea	Soft corals, sea strawberries; found in Alaska.
Order Coenothecalia	Blue coral; found in tropical Pacific reefs.
* Order Gorgonacea	Sea fans, fan coral; found in Alaska.
Order Pennatulacea	Sea pens, sea pansies; found in Alaska.
Subclass Hexacorallia (Zoantharia)	
Order Actinaria	Sea anemones; found in Alaska.
Order Antipatharia	Th^rny corals, black coral; found in tropics, subtropics.
Order Ceriantharia	Cerianthids; possibly in Alaska[1].
* Order Scleractinia (=Madreporaria)	Stony corals, cup corals; found in Alaska.
Order Zoanthidae	Zoanthids; not in Alaska.
Class Hydrozoa	
Order Hydroida	Hydroids and jelly fish; found in Alaska.
Order Milleporina	Fire coral, millepores; not found in Alaska.
Order Siphonophora	Jellyfish; found in Alaska.
* Order Stylasterina	Hydrocorals, hard corals; found in Alaska.
Order Trachylina	Jellyfish; found in Alaska.
Class Scyphozoa	Jellyfish; found in Alaska.

* Covered in this study
1 Dr. Bruce Wing, personal communication

Planula larvae either swim, crawl, sink and perhaps float after being released. Planula of most corals are not usually dispersed very far from parent colonies (Fritchman 1974; Gerrodette 1981). The larva of one species creeps down the parent colony and settles nearby (Kinzie 1973). Larvae of other species can crawl and settle up to 40 m away (Weinberg and Weinberg 1979). There is one report of planula larvae floating (Butler 1980), but this observation has not been substantiated.

The planulae settle, often on current-swept solid substrates, and undergo metamorphosis into the primary polyp stage. Only a very small fraction of the larvae reach this stage; many are lost by landing on unfavorable substrates, others are eaten by predators, while still others are abraded and smothered by sediment and algae. In colonial species, subsequent budding (asexual reproduction) of the primary polyp stage produces additional polyps, each with a mouth surrounded by tentacles; these polyps form and share a common skeleton. The colony continues to grow by budding more polyps and secreting additional skeletal material. Growth of most corals is believed to be slow and may require over 100 years to reach maximum size.

Causes of adult mortality include physical factors such as smothering by sand (Grigg 1977), toppling of large colonies by storm waves (Birkeland 1974), weakening of skeletons by boring organisms (Dr. Richard Grigg, personal communication), freshwater runoff, and exposure to air during extreme low tides. Biological factors include interspecific competition with other coral species, and predation. Corals compete with each other for space and light by overgrowing one another and/or by digesting adjacent colonies. Coral predators include snails (Kinzie 1973, Birkeland 1974), fish (Randall 1967; Clarke 1968), polychaetes (Dr. R. Kinzie, personal communication), starfish and nudibranchs (Sebens, personal communication). Recently man has caused mortalities as a result of thermal and chemical pollution from power plants, sewage (Smith et al. 1973), and oil and gas exploration and development (Dept. of Commerce 1979; Loya and Rinkevich 1980).

Coral distribution and abundance is affected by substrate size, currents, depth, and temperature. Most coral species require a solid, rocky substrate to survive, however, a few can live on sandy and muddy bottoms. Currents bring food, reduce sedimentation, and may assist in larval dispersal. Depth is important because of its relationship with other factors such as light, temperature, salinity, oxygen, and wave action. Light is necessary to many tropical, reef-building corals harboring commensal algae, which produce the necessary food for the host coral. Temperature is known to control the distribution of reef forming corals and the reproductive activity of certain temperate species (Grigg 1979). Corals are often found in association with other species and can provide a habitat for fish and invertebrates that fish might feed on.

III. DISTRIBUTION, HABITATS AND PROBABLE LOCATIONS

A. Purpose and Methods

The purposes of this section are to describe:

- the corals found in Alaskan coastal waters;
- the commercial value;
- the distribution;
- a habitat profile; and
- areas where these corals are likely to occur.

Information on Alaskan coral distributions was gathered from a number of sources including on line computer searches of the published literature listed in Biological Abstacts; a manual search of Science Citation Index and the Zoological Record using key coral papers and subject titles; contacts with museums regarding Alaskan corals archived in their collections; a search of corals listed in NODC data files; contacts with commercial coral fishermen to discuss distributional information of the Alaskan species; and contacts with State and Federal scientists involved in studies of Alaskan benthic organisms. Finally over 400 Alaskan fishermen were contacted, through mailed questionnaires, to gather site specific distributional information on commercially important corals.

Information regarding physical factors was acquired from NODC files to determine which environmental factors might correspond with and perhaps regulate the distribution of the commercially valuable corals in the Gulf of Alaska. These seasonal data included: temperature, oxygen, and salinity values by depth; and temperature, salinity, and oxygen values on the bottom, throughout the Gulf of Alaska. These oceanographic data were compared with distributional records to determine which parameters corresponded with coral distributions.

B. Results and Discussion

Results of the literature and data search generated a list of 34 species of corals in Alaskan waters. Their scientific and common names are listed in Table 2. This list includes 21 species of octocorals (Class Anthozoa, Subclass Octocorallia), two species of hexacorals (Class Anthozoa, Subclass Hexacorallia), and 11 species of hydrocorals (Class Hydrozoa). A listing of the taxonomic synonymies (previous names used for each species) is provided in Appendix 1.

1. Commercial Species

The commercial value for each species is also indicated in Table 2. This evaluation was based on skeletal composition, size, and abundance. Commercial value was rated as high for corals presently being sold for jewelry, moderate for those species with potential use as jewelry, low for those species which are or could be sold as curios, and no commercial value for those species whose skeleton and/or size are not appropriate for commercial use.

Alaskan corals with high commercial value are limited to certain species of gorgonians. Gorgonians, or sea fans, are colonies of animals composed of individual polyps which deposit a tree-like skeleton that supports the colony. This skeleton, which is composed of both calcium carbonate and a collagen-like protein (gorgonian), is cut and polished for use as jewelry. Two species of gorgonians, *Primnoa resedaeformis* and *P. willeyi*, have skeletons with a metallic golden sheen and are presently being harvested commercially for jewelry in Alaska. The high commercial value of *Primnoa* in Alaska is attributed to its large size (many individuals grow up to 1 meter), high abundance, and luster of the skeleton when polished.

The taxonomy of the commercially valuable coral, *Primnoa*, is in question. Dr. F. Bayer (personal communication) contends there are

Table 2. Systematics of Alaskan corals and their estimated value.

Taxonomy	Common Name	Commercial Value, Use
Class Anthozoa		
Subclass Octocorallia (Alcyonaria)		
Order Alcyonacea		
Family Neptheidae		
1. *Gersemia rubiformis*	soft coral, sea strawberry	No value, lacks hard skeleton
Order Gorgonacea		
Suborder Holaxonia		
Family Isididae		
2. *Keratoisis profunda*	bamboo coral	Moderate value, as jewelry, curio
3. *Lepidisis paucispinosa*	bamboo coral	Moderate value, as jewelry, curio
Family Plexauridae		
4. *Muriceides cylindrica*	sea fan	Low value, as curio
5. *Muriceides nigra*	sea fan	Low value, as curio
6. *Swiftia beringi*	sea fan	Low value, as curio
7. *Swiftia pacifica*	sea fan	Low value, as curio
Family Primnoidae		
Subfamily Calyptrophorinae		
8. *Arthrogorgia kinoshitai*	sea fan	Low value, as curio
9. *Arthrogorgia otsukai*	sea fan	Low value, as curio
Subfamily Primnoinae		
10. *Calligorgia compressa*	sea fan	Moderate value, as jewelry, curio

Table 2. (continued)

Taxonomy	Common Name	Commercial Value, Use
11. Plumarella flabellata	sea fan	Moderate value, as jewelry, curio
12. Plumarella spicata	sea fan	Moderate value, as jewelry, curio
13. Plumarella spinosa	sea fan	Moderate value, as jewelry, curio
14. Primnoa resedaeformis	sea fan	High value, as jewelry
15. Primnoa willeyi	sea fan	High value, as jewelry
16. Thouarella hilgendorfi?	sea fan	Moderate value, as jewelry, curio
17. Thouarella straita	sea fan	Moderate value, as jewelry, curio
Suborder Scleraxonia		
Family Paragorgiidae		
18. Paragorgia sp.	sea fan	Low value, as curio
19. Paragorgia arborea	sea fan	Low value, as curio
20. Paragorgia pacifica	sea fan	Low value, as curio
Subclass Hexacorallia		
Order Scleractinia		
Family Dendrophylliidae		
21. Balanophyllia elegans	cup coral	No value, too small
Family Caryphylliidae		
22. Caryophyllia alaskensis	cup coral	No value, too small

Table 2. (continued)

Taxonomy	Common Name	Commercial Value, Use
Class Hydrozoa		
Order Stylasterina		
Family Stylasteridae		
23. _Allopora campyleca_	hydrocoral	Low value, as curio
24. _Allopora moseleyana_	hydrocoral	Low value, as curio
25. _Allopora papillosa_	hydrocoral	No value, encrusting
26. _Allopora petrogapta_	hydrocoral	No value, encrusting
27. _Allopora polyorchis_	hydrocoral	Low value, as curio
28. _Cyptohelia trophostega_	hydrocoral	Low value, as curio
29. _Distichopora borealis_	hydrocoral	Low value, as curio
30. _Errinopora nanneca_	hydrocoral	Low value, as curio
31. _Errinopora zarhyncha_	hydrocoral	Low value, as curio
32. _Stylaster cancellatus_	hydrocoral	Low value, as curio
33. _Stylaster elassotomus_	hydrocoral	?
34. _Stylaster gemmascens alaskanus_	hydrocoral	Low value, as curio

High value = Presently harvested for jewelry

Moderate value = Might be harvested for jewelry, if abundant

Low value = Could be sold as curio

No value = Lacks commercial value at this time three distinct species of Primnoa in the world, based on examination of the type-specimens of P. willeyi and P. resedaeformis. Two of these species, P. resedaeformis and P. willeyi, occur in Alaska, but are difficult to distinguish in the field. The synonymies for Primnoa are listed in Appendix 1.

Species with moderate commercial value include seven other species of Alaskan gorgonians: Calligorgia compressa, Plumarella flabellata, P. spicata, P. spinosa, Thourella hilgendorfi, and T. straita. These sea fans belong to the same subfamily (Primnoinae) as Primnoa, have similar skeletal characteristics, and therefore have a potential value as jewelry. The realized commercial value of these species depends on their size and abundance. Species must have a large and hard enough skeleton to be cut and polished, and be abundant enough to be harvested economically. Two other species of gorgonian corals (Keratoisis profunda and Lepidisis paucispinosa) have a highly calcified (hard) skeleton, few branches, and are therefore referred to as bamboo corals. These corals have some value as jewelry and as curios.

Species with low commercial value are those corals which have a limited value as jewelry, but could be sold as curios. Included in this category are both fan corals and hydrocorals. These fan corals are found in subfamilies other than Primnoinae and do not possess skeletons valuable for jewelry. They include species in the genera Muriceides, Swiftia, Arthrogorgia, and Paragorgia.

The hydrocorals (Class Hydrozoa) also have a low commercial value. These species have a rigid calcium carbonate skeleton that does not polish well and is therefore not valuable as jewelry. The shapes and varied colors, including yellow and purple, contribute to the value of these corals. These colors are attributed to the carotenoid pigments that are firmly bonded to the calcium carbonate and are retained even after cleaning (Fox and Wilkie 1970). Species large enough to be valuable as curios are Allopora campyleca, A. polyorchis, A.

museleyana, Stylaster cancellatus, S. elassotomus, and S. gemmascens alaskanus. Allopora (violet coral) is also used in California for jewelry.

A number of species do not have any commercial value at this time due to their growth form (Allopora papillosa grows prostrate on substrates), morphology (Gersemia rubiformis is a soft coral without a rigid skeleton useful for jewelry or as curios), or size (Allopora stejnegeri is probably too small to be used as a curio).

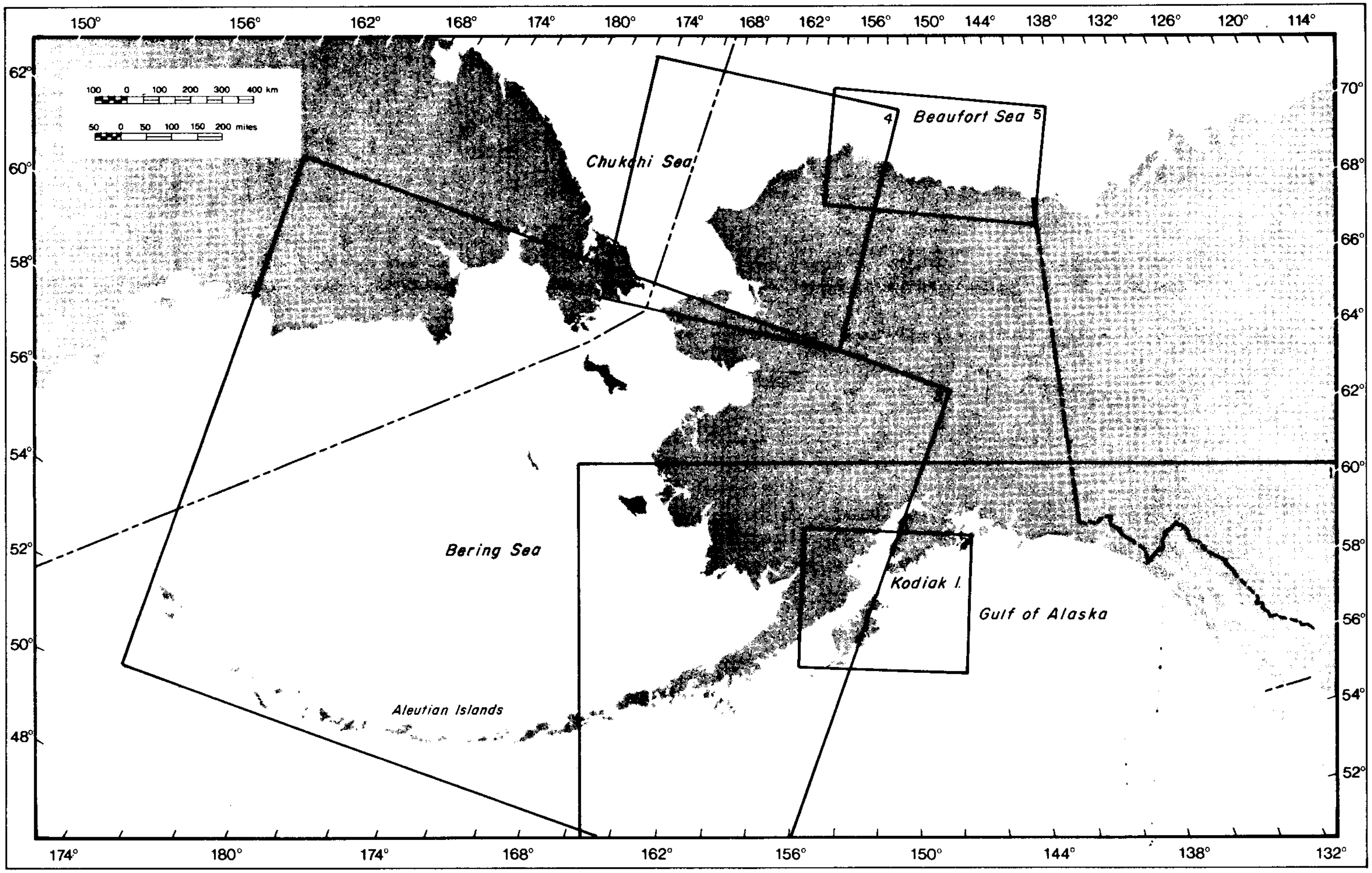
2. Distribution, Abundance, Habitat, and Probable Location

Distributional records for corals reported in Alaska are presented by species in Appendices 2, 3, and 4. Appendix 2 includes species with fewer than ten distributional records. Appendices 3 and 4 present records for Primnoa and Gersemia, respectively. These distributional records were plotted by area (see Figure 1, Index Map) and are discussed in the following pages.

This discussion emphasizes those corals with either a high commercial value or those with sufficient data. In most cases, data are too sparse to treat species individually, therefore, many species are grouped together and treated as a unit. These groupings are: 1) red trees; 2) bamboo corals; 3) other sea fans; 4) cup corals; 5) soft corals; and 6) hydrocorals.

a. Species

Red trees. Primnoa is presently the most important commercial coral in Alaska. These fan corals are also known as red-trees due to the color of the living tissues and gold coral due to the color of the skeleton. The two species, P. resedaeformis and P. willeyi, apparently cannot be distinguished in the field and therefore are treated together.



LEGEND

1 - Gulf of Alaska
2 - Kodiak Island
3 - Bering Sea
4 - Chukchi Sea
5 - Beaufort Sea

ALASKAN CORAL SURVEY

Index Map

vtn

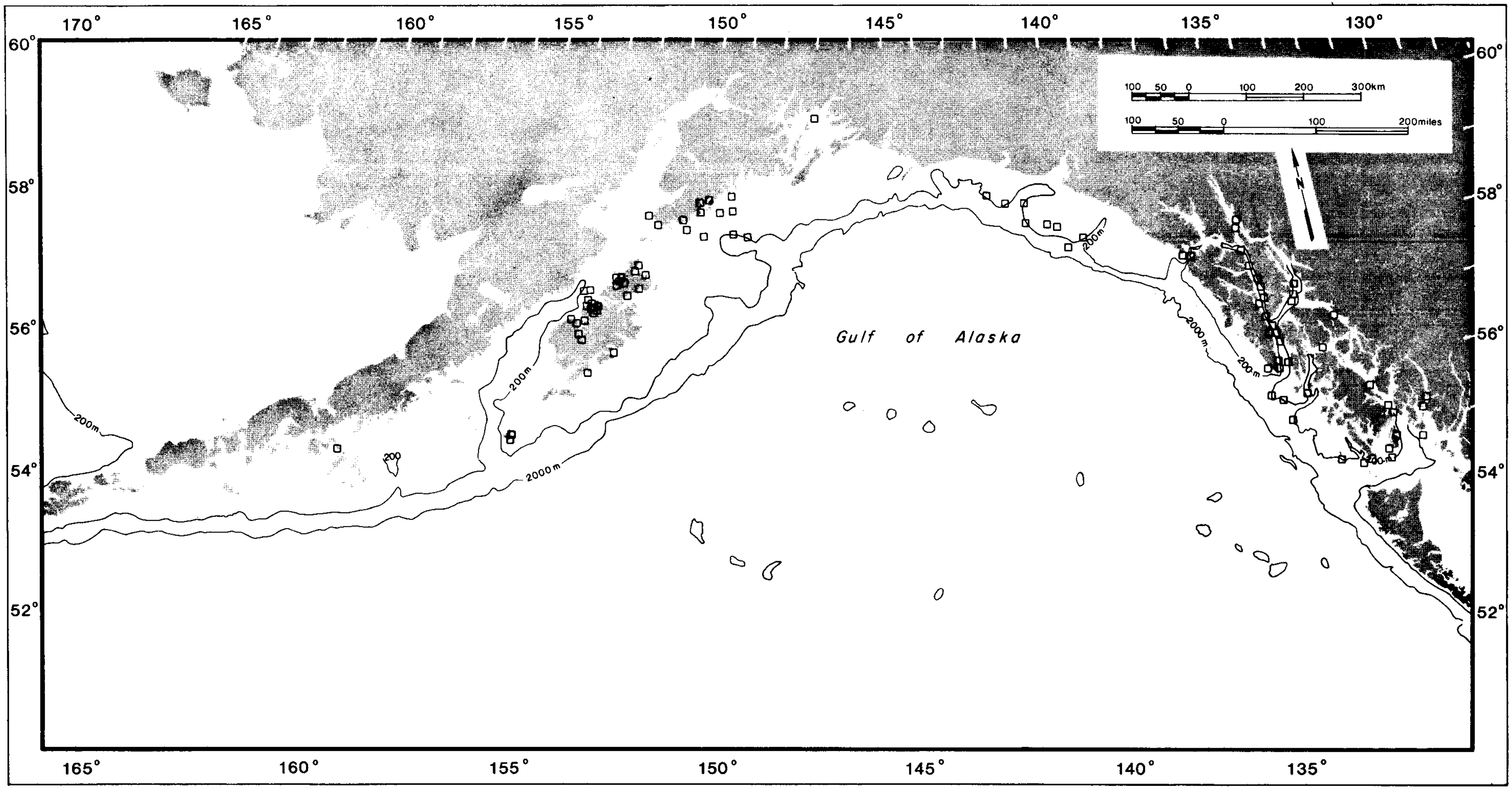
JUNE 1981 | FIGURE 1

Primnoa has been reported in Alaska from Dixon Entrance in S.E. Alaska, to Amchitka in the Aleutian Islands. Records of this coral in the Gulf of Alaska are plotted in Figure 2; a detailed map of the Kodiak Island area is presented in Figure 3. Primnoa is found in the Bering Sea, but is restricted to areas around the Aleutian Islands (Figure 4). There have not been any reports of Primnoa in the Bering Sea north of the Aleutians, or in the Chukchi or Beaufort Seas.

The greatest number of distributional records for Primnoa are from the Gulf of Alaska, in particular in S.E. Alaska (the Inside Passage) and certain bays on the northwest side of Kodiak and Afognak Island (Figure 3). In S.E. Alaska, Primnoa has been frequently reported in Chatham Strait, Frederick Sound, and Behm Canal. The frequency of occurrences increases toward the ocean entrances (Dixon Entrance, Christian Sound, and Cross Sound) and further away from the fjords. This trend could be due to swifter currents in the major channels near the entrances, and/or due to greater turbidity and lower salinities in the fjords. In addition, Primnoa was found more frequently on the west side than the east side of these channels. Areas of highest densities are found in regions where currents are 3-4 knots, such as channel narrows (Dr. Richard Grigg, personal communication).

The Kodiak Island area (Figure 3) has the second largest number of Primnoa records. Nearly all corals were reported from Paramanoff, Uganik, and Uyak Bays on the northwest side of Kodiak and Afognak Islands. There were very few records from the southeast side of these two islands. As was the case in S.E. Alaska, corals were found more frequently along the west side than the east side of these bays.

Other distributional records in the Gulf of Alaska (Figure 2) reported corals in the S.E. Gulf, N.E. Gulf, Northern Gulf, and off the Kenai Peninsula. Isolated records occurred in areas west of Kodiak Island, namely off Chirikof Island (Figure 2) and in the Aleutian Islands (Figure 4). Primnoa was not reported (or limited to a single record)



LEGEND

□ Primnoa ("red-trees")

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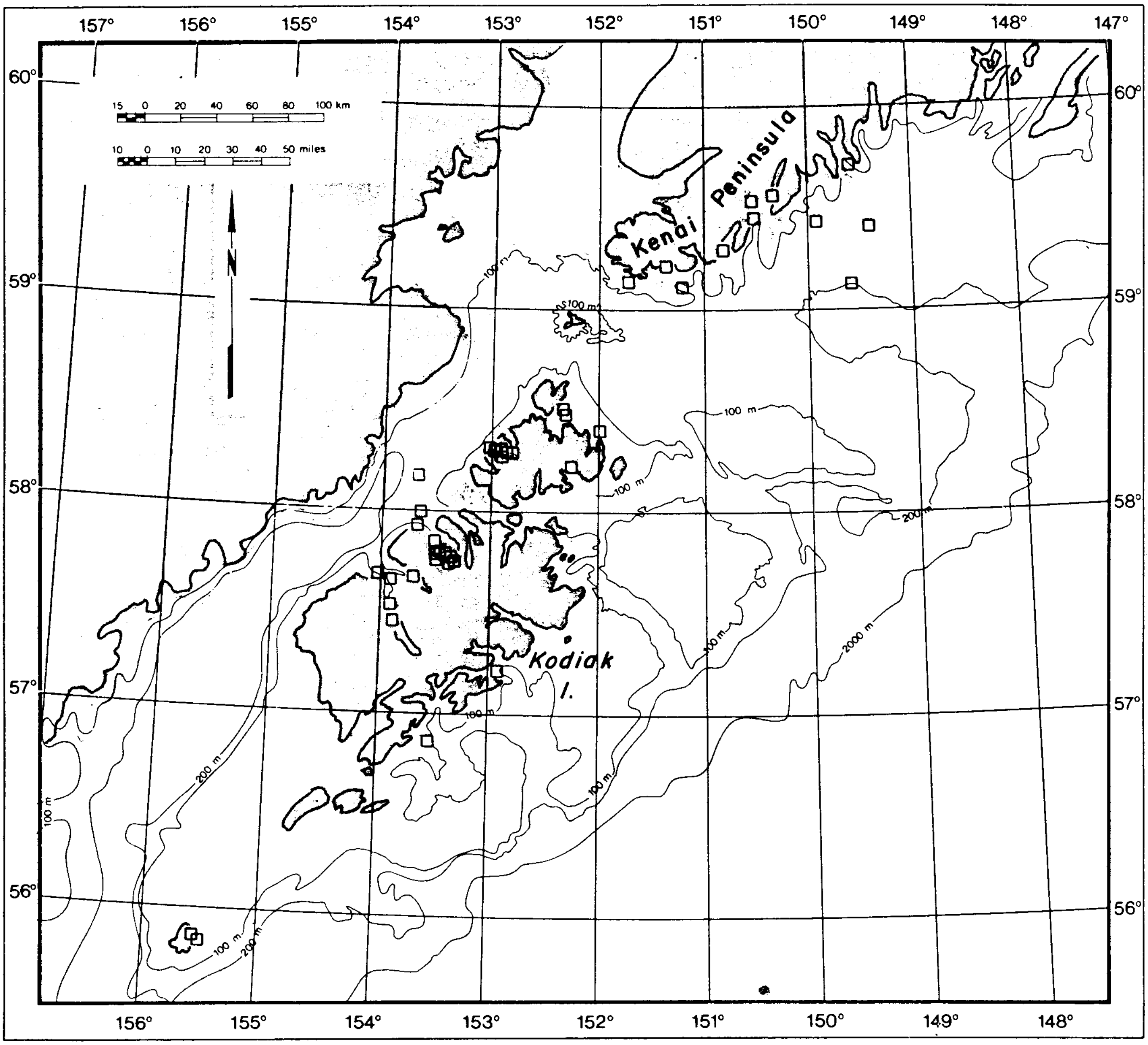
ALASKAN CORAL SURVEY

Distribution of Primnoa in the Gulf of Alaska

MAP: Gulf of Alaska

JUNE 1981

FIGURE 2



LEGEND

□ Primnoa (red-trees)

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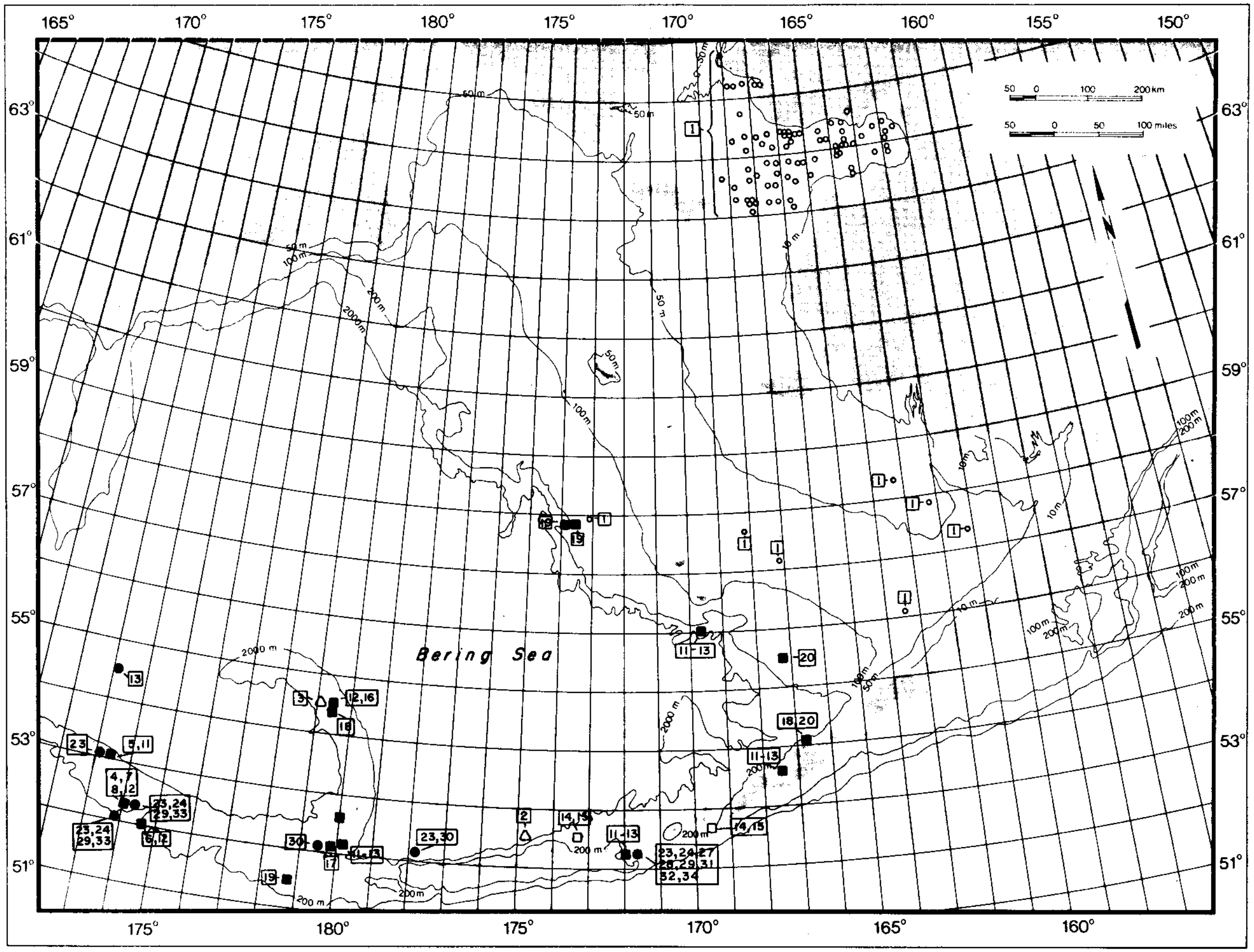
ALASKAN CORAL SURVEY

Distribution of Primnoa near Kodiak Island

Map : Kodiak Island

JUNE 1981	FIGURE 3



LEGEND

- ° Soft coral (Species 1)
- △ Bamboo coral (Species 2-3)
- ■ Fan coral (Species 4 - 20)
  - □ Red-trees (Species 14,15)
- x Cup coral (Species 21-22) - none reported
- ● Hydrocoral (Species 23 - 34)
- [#] Species number, see Table 2

vtn

ALASKAN CORAL SURVEY

Distribution of Coral in the Bering Sea

Map : Bering Sea

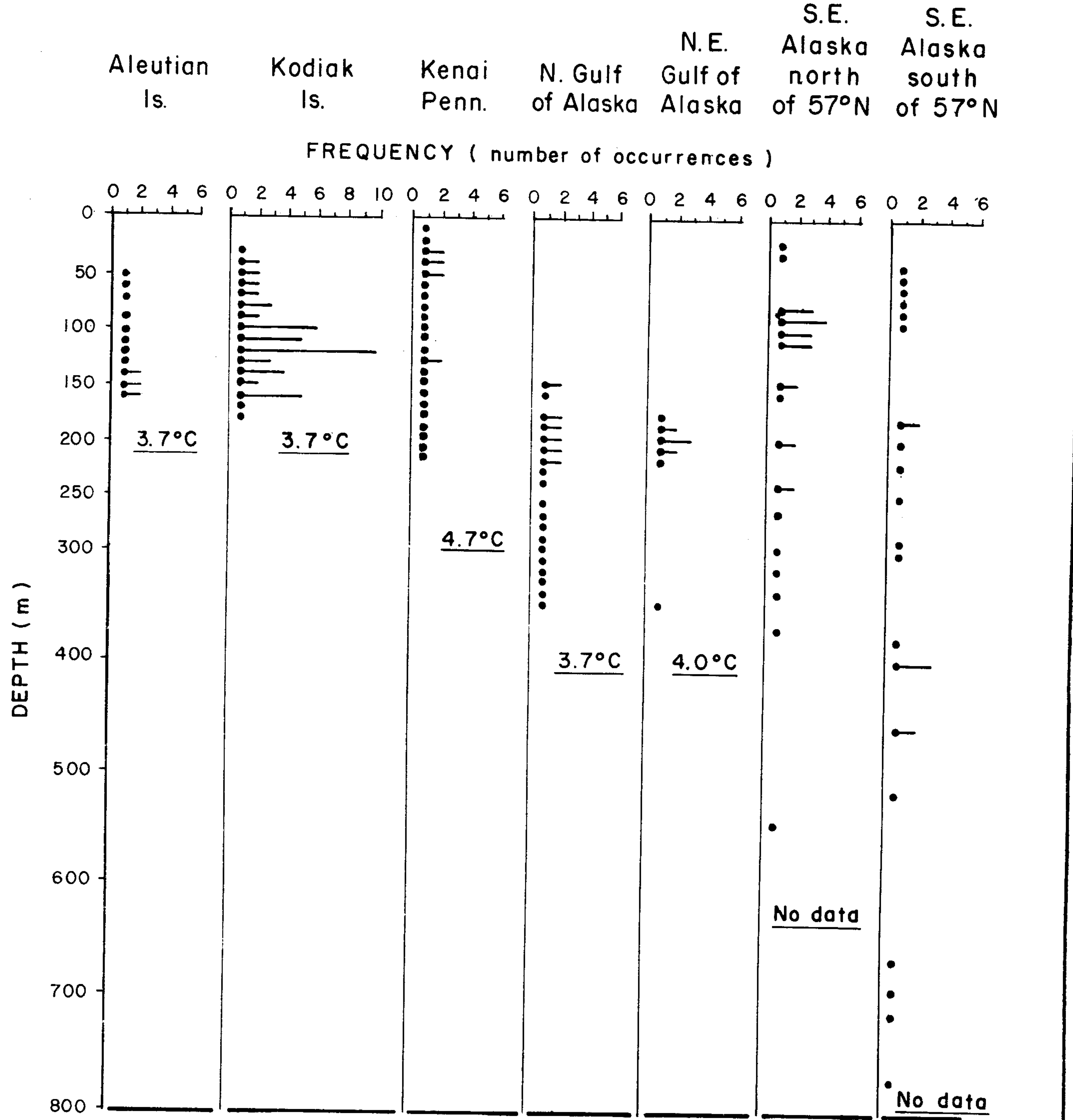
JUNE 1981 | FIGURE 4

in certain regions of the Gulf of Alaska, namely Prince William Sound, the bays on the southeast side of Kodiak and Afognak Islands and the northern portion of Shelikof Strait from lower Cook Inlet to the Aleutian Islands.

The distributional records for Primnoa were analyzed by looking at: 1) the vertical (depth) distribution in each area; and 2) the horizontal (geographic) distribution in the Gulf of Alaska. Primnoa has been reported at depths between 10 and 800 m. The lower depth limit varied in different regions of Alaska (Figure 5), increasing along a geographic gradient from the Aleutian Islands to S.E. Alaska. This phenomenon of equatorial or tropical submergence has been noted in the biogeography of other species including California hydrocorals (Gerrodette 1979). The lower depth limit of Primnoa in each area corresponds with a mean spring temperature of around 3.7°C (Figure 5). These results suggest that the lower depth limit of Primnoa corresponds with the lowest seasonal temperatures to which the corals are usually exposed.

The geographical distribution of Primnoa also corresponds with mean spring bottom temperatures above 3.7°C (Figure 6). Essentially all of the Primnoa records occurred in this temperature range. Even isolated regions in the western part of the Gulf of Alaska with Primnoa populations (such as the northwest side of Kodiak Island) are exposed to this same temperature range due to current patterns and depth. Nearby areas that are colder have no or few Primnoa records. Areas in this temperature range with isolated records or without any reports of Primnoa are Prince William Sound, Lower Cook Inlet and the northern portion of Shelikof Strait. Primnoa probably does not occur abundantly in Prince William Sound or Cook Inlet due to the high turbidity and/or the lack of a hard substrate.

Figure 7 indicates the most likely areas for Primnoa populations, based on analysis of distributional data, bottom temperatures, and suitable



LEGEND

• *Primnoa* distribution records

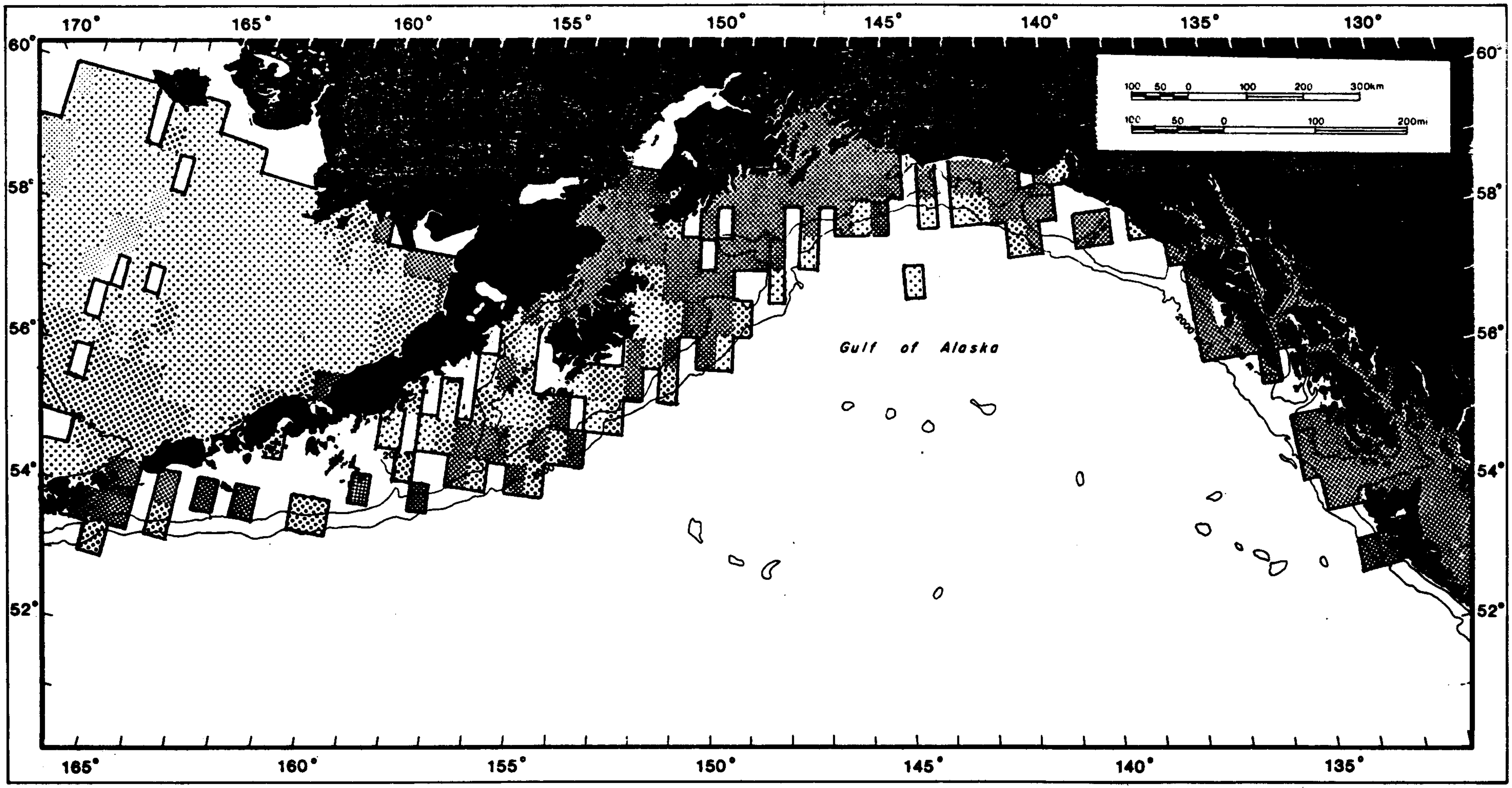
°C Mean spring temperatures at lower depth limit

ALASKAN CORAL SURVEY

Distribution of *Primnoa* with depth

JUNE 1981

FIGURE 5



LEGEND

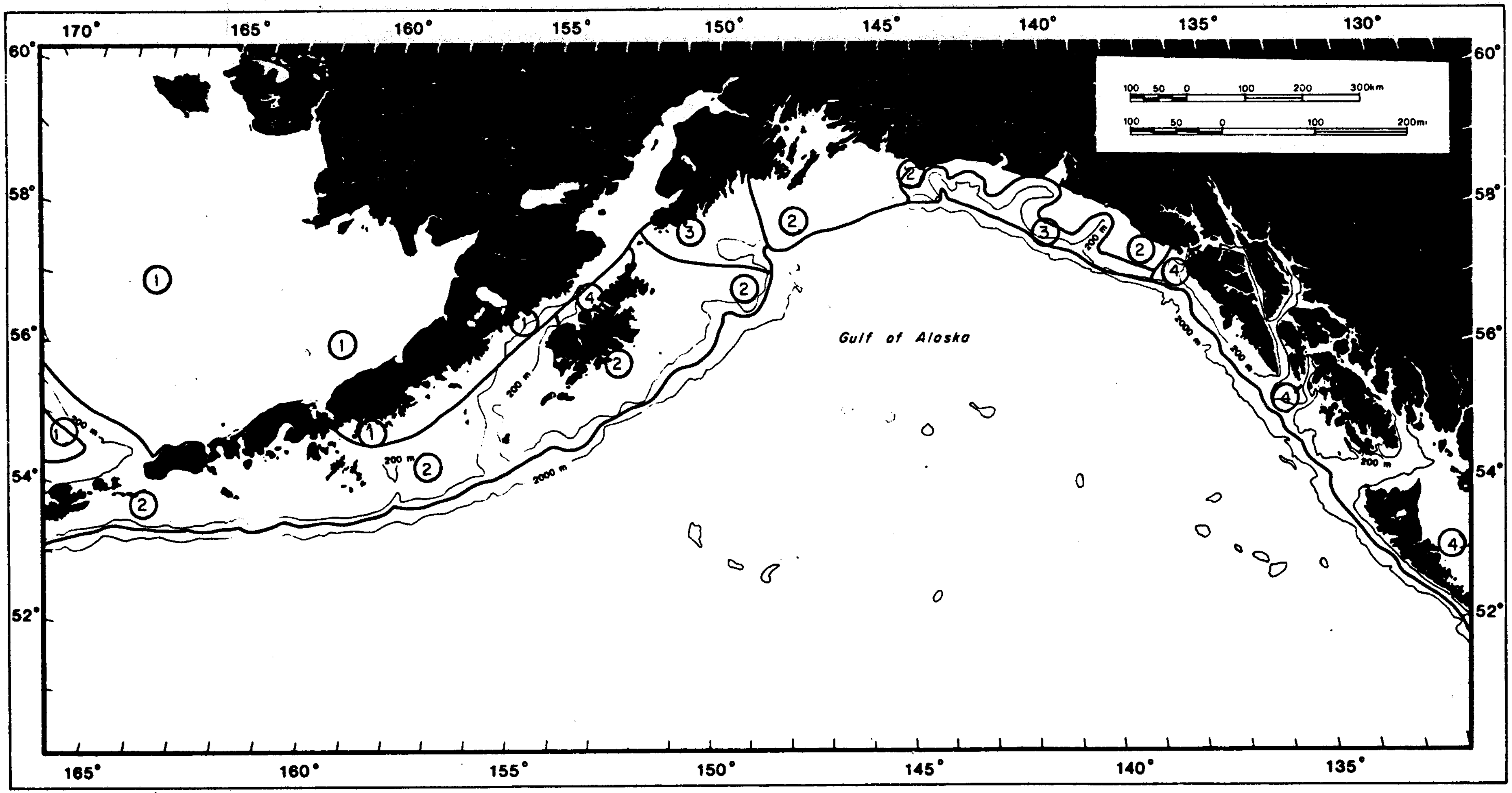
No data	< -1.0°C	-1.0 to 2.9°C	3.0 to 3.6°C	3.7 to 9.0°C

ALASKAN CORAL SURVEY

Mean bottom temperatures from April through June in the Gulf of Alaska

MAP : Gulf of Alaska

JUNE 1981 | FIGURE 6



LEGEND

1 - Very Low Abundance, not present

2 - Low Abundance

3 - Moderate Abundance

4 - High Abundance

VTN

ALASKAN CORAL SURVEY

Predicted distribution of _Primnoa_ in the Gulf of Alaska

MAP : Gulf of Alaska

JUNE 1981

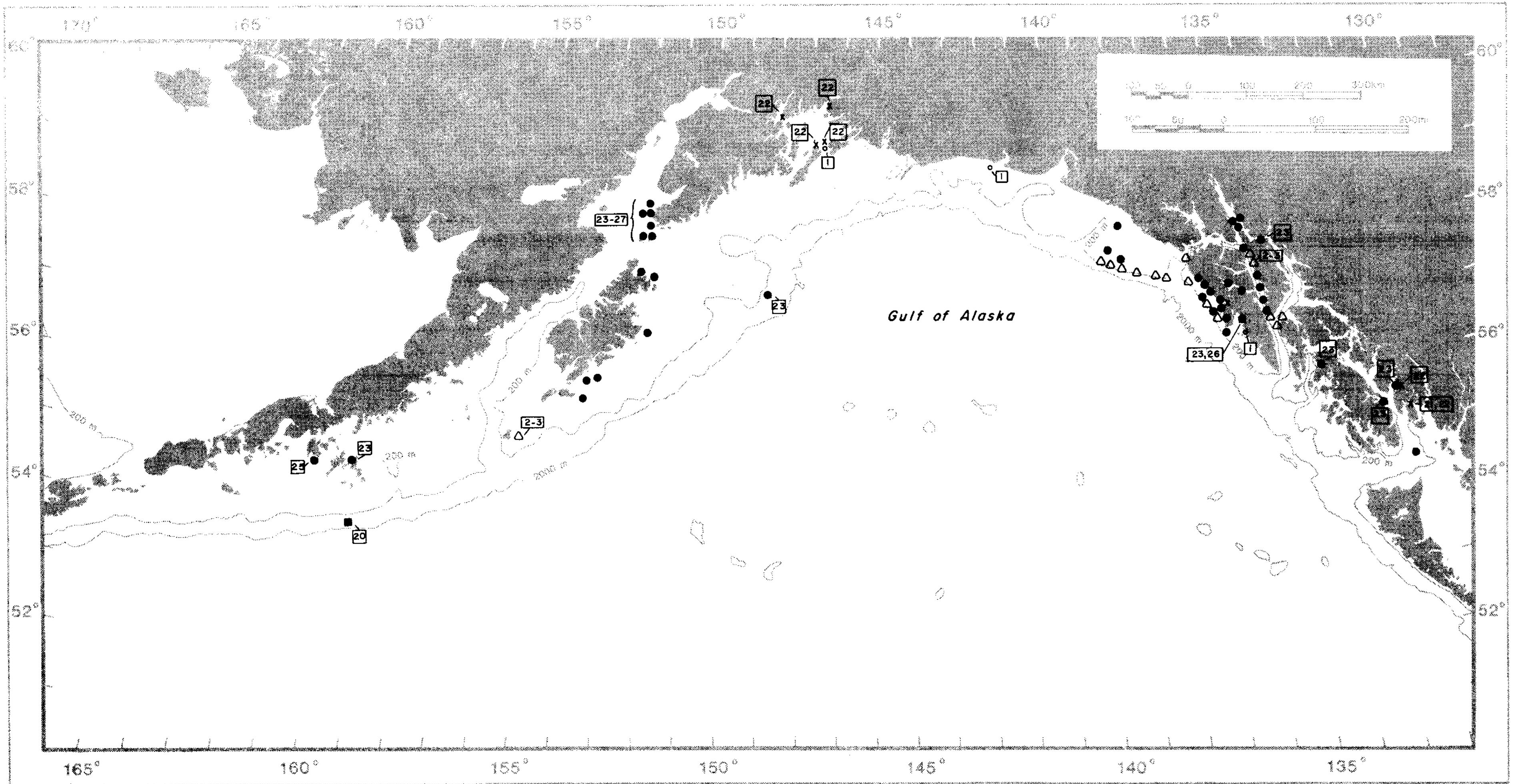
FIGURE 7

substrate. High abundance indicates areas with an acceptable temperature range and where Primnoa has been frequently reported. Moderate abundance indicates areas with the acceptable temperature range, but where Primnoa has been reported less frequently. Low probability represents areas where Primnoa has been reported or that fit the temperature model. Very low probability indicates those areas that fall outside the temperature range and where Primnoa has not been reported or that fall within the temperature model but apparently do not have the proper substrate. Primnoa is probably not present in the northern Bering, Chukchi, or Beaufort Seas due to low temperatures and/or unsuitable substrates.

A habitat profile can therefore be generated for Primnoa based on the above data. The distribution of this species on a geographic scale depends on the proper substrate (large boulders, exposed bedrock), lack of turbidity, and yearly temperatures remaining above 3.7°C.

Bamboo Corals. The distributional records for bamboo corals (Lepedisis and Keratoisis) are listed in Appendix 2 and are plotted in Figures 4 and 8. This coral has been reported in the Bering Sea along the Aleutian Islands and Bowers Bank. The only verified records in the Gulf of Alaska are from Chirikof Island. Fishermen have also reported bamboo corals from the inside passages of S.E. Alaska and in the S.E. Gulf of Alaska. These corals have not been reported from the northern portion of the Bering Sea (above 58°N), or from the Chukchi or Beaufort Seas. Bamboo corals have the deepest distribution (300-3,500 m) of the six groups of Alaskan corals (Figure 9).

A generalized habitat profile for bamboo corals indicates that this group is expected to occur on boulders and bedrock from 300 to 3,500 m. Their northern distribution in the Bering Sea and occurrence in deep waters indicate that these corals can live at temperatures less than 3.0°C. Their distribution also suggests that these corals have a low tolerance for sediments.



LEGEND

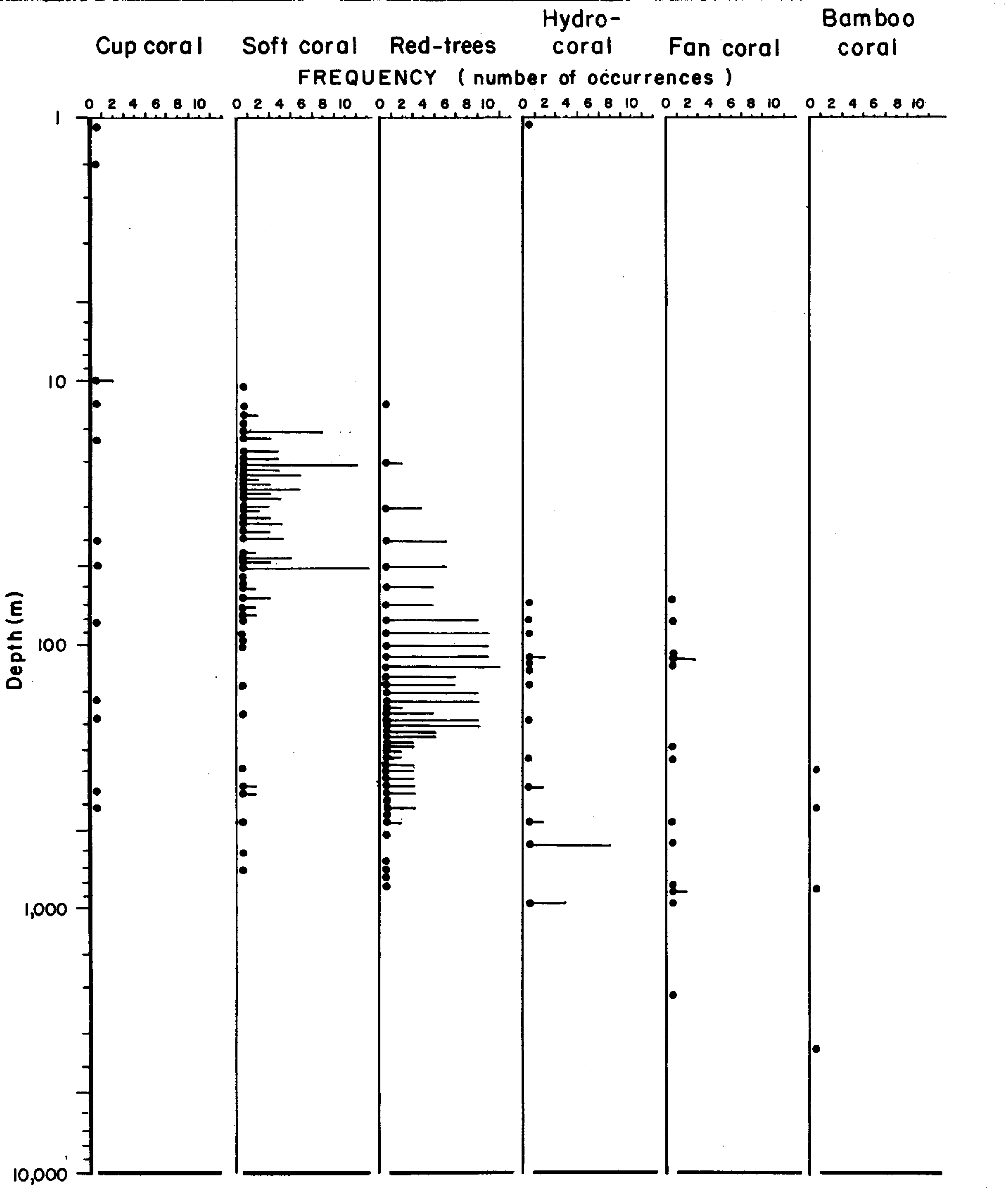
- ◦ Soft coral (Species 1)
- △ Bamboo coral (Species 2-3)
- ■ Fan coral (Species 4-20)
- x Cup coral (Species 21-22)
- ● Hydrocoral (Species 23-34)
- # Species number, see Table 2

ALASKAN CORAL SURVEY

Distribution of Coral in the Gulf of Alaska

MAP Gulf of Alaska

JUNE 1981 | FIGURE 8



LEGEND

• One occurrence

— Two+ occurrences

ALASKAN CORAL SURVEY

Distribution of Corals with depth

JUNE 1981

FIGURE 9

This generalized habitat profile can be used to predict the areas that bamboo corals should be found (Table 3). These corals are expected to occur on stable, rocky substrates at depths between 300 and 3,500 m, around the Aleutian Islands and Bowers Bank (in the southern part of the Bering Sea), in the Gulf of Alaska, and S.E. Alaska. This coral is not expected to occur in the northern portion of the Bering Sea, or in the Chukchi or Beaufort Seas due to the lack of stable, rocky substrates and deep enough depths.

Other Sea Fans. Other species of sea fans (such as *Muriceides*) have been reported from the Aleutian Islands and lower Bering Sea along the continental slope (Figure 4) and in S.E. Alaska. Sea fans were observed, but not identified, in S.E. Alaska during submersible dives as part of NOAA's project Sub-Sea (Dr. William High, personal communication). These corals were found at depths greater than *Primnoa* (10-2,000 m) (Figure 9).

A general habitat profile can be generated for these corals. They should occur on boulders and bedrock from 10 to 2,000 m in areas free of sediment. The distribution of these corals in the Bering Sea and at greater depths than *Primnoa* suggests that these corals can withstand temperatures as low as 3°C and possibly less. This generalized habitat profile can be used to predict the areas in which fan corals should be found (Table 3). These corals are predicted to occur in deep areas (10-2,000 m) in S.E. Alaska, the Gulf of Alaska, the Aleutian Islands, and along the southern Bering Sea slope (54°-58°N).

Cup Corals. The reported records for cup corals (*Balanophyllia* and *Caryophyllia*) are listed in Appendix 2 and are plotted in Figure 8. These two species differ in geographic range and habitat. *Balanophyllia* has only been reported from S.E. Alaska, whereas *Caryophyllia* has been reported from S.E. Alaska and Prince William Sound. Neither has been reported in the Bering, Chukchi, or Beaufort Seas. These species also appear to differ in habitats. *Balanophyllia* is found from

Table 3. Reported and predicted distributions of corals in Alaska, by region.

	Common Name (Species Numbers)	S.E. ALASKA	GULF OF ALASKA: S.E. Gulf	N.E. Gulf	Prince Wm. Sound	N. Gulf	Kenai Peninsula	Cook Inlet	Kodiak	N.W. Gulf	BERING SEA: Aleutian Islands	Bering Sea Shelf	Bering Sea Slope	CHUKCHI SEA	BEAUFORT SEA
REPORTED	Soft coral	0	*	0	**	*	0	0	0	0	0	***	*	***	***
	Bamboo coral	**	**	**	0	0	0	0	0	0	**	0	0	0	0
	Red trees	***	***	**	*	**	**	0	***	*	*	0	0	0	0
	Other sea fans	*	0	0	0	0	0	0	0	*	**	0	*	0	0
	Cup corals	*	*	0	*	0	0	0	0	0	0	0	0	0	0
	Hydrocorals	**	**	**	0	0	**	0	**	*	**	0	0	0	0
PREDICTED	Soft coral	**	**	**	***	**	*	**	**	**	*	***	*	***	***
	Bamboo coral	**	**	**	0	*	*	0	*	*	**	0	*	0	0
	Red trees	***	**	**	*	**	**	0	***	*	*	0	*	0	0
	Other sea fans	**	**	**	*	*	*	*	**	*	***	0	*	0	0
	Cup corals	**	**	**	**	*	*	*	*	*	*	0	0	0	0
	Hydrocorals	**	**	**	*	*	**	*	**	**	**	*	*	0	0

*** Abundant
** Frequent
* Rare
0 None

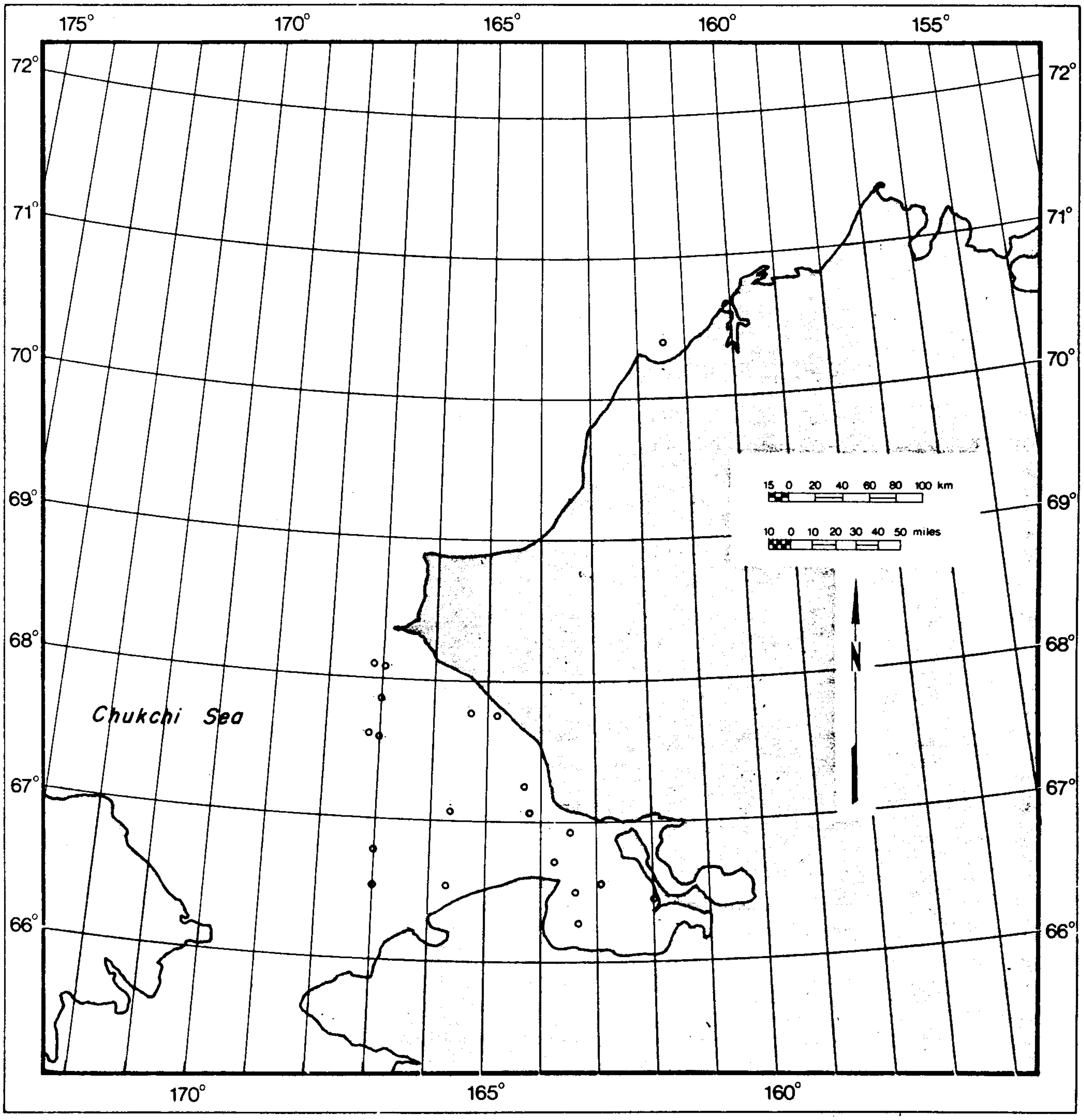
0-12 m and appears to have a low tolerance for sediments. Caryophyllia ranges from 12-420 m and appears to have a greater tolerance for sediments. Depth and geographic distributional data suggest that these species cannot tolerate temperatures less than 4.5°C.

Cup corals are predicted to occur in additional regions of the Gulf of Alaska and S.E. Alaska, from 0-12 m for Balanophyllia and from 12 m to 400 m for Caryophyllia (Table 3). Since these corals do not appear to tolerate temperatures below 4.5°C, their distribution west of Kodiak Island should be infrequent. Cup corals are not expected to occur in the Bering Sea beyond the Aleutian Islands or in the Chukchi or Beaufort Seas.

Soft Corals. The reported records for soft coral (Gersemia) are listed in Appendix 4 and are plotted by area in Figures 4, 8, 10, and 11. This species has the widest geographic range of all Alaskan corals and has been reported from the Gulf of Alaska to the Beaufort Sea. It has been found most frequently in Norton Sound, Bering Sea (Figure 4), Kotzebue Sound, Chukchi Sea (Figure 10), and in the Beaufort Sea east of Point Barrow (Figure 11). This species has also been reported from Prince William Sound in the Gulf of Alaska (Figure 4).

The depth distribution of soft corals is shallow (10 to 800 m) and overlaps with cup corals (Figure 9). They occur on cobble and larger substrates. The distributional range indicates that Gersemia can tolerate temperatures as low as -1.0°C; the distribution in soft sediments suggests that Gersemia has a high tolerance to turbidity.

A generalized habitat profile can be generated from the above information. Gersemia should be found on cobble and larger substrates, from 10 to 800 m, in areas where temperatures range from -1.0°C to above 9.0°C. This species has the widest distributional range, temperature range, and substrate preference of all Alaskan corals.



LEGEND

o Soft coral (Gersemia rubiformis)

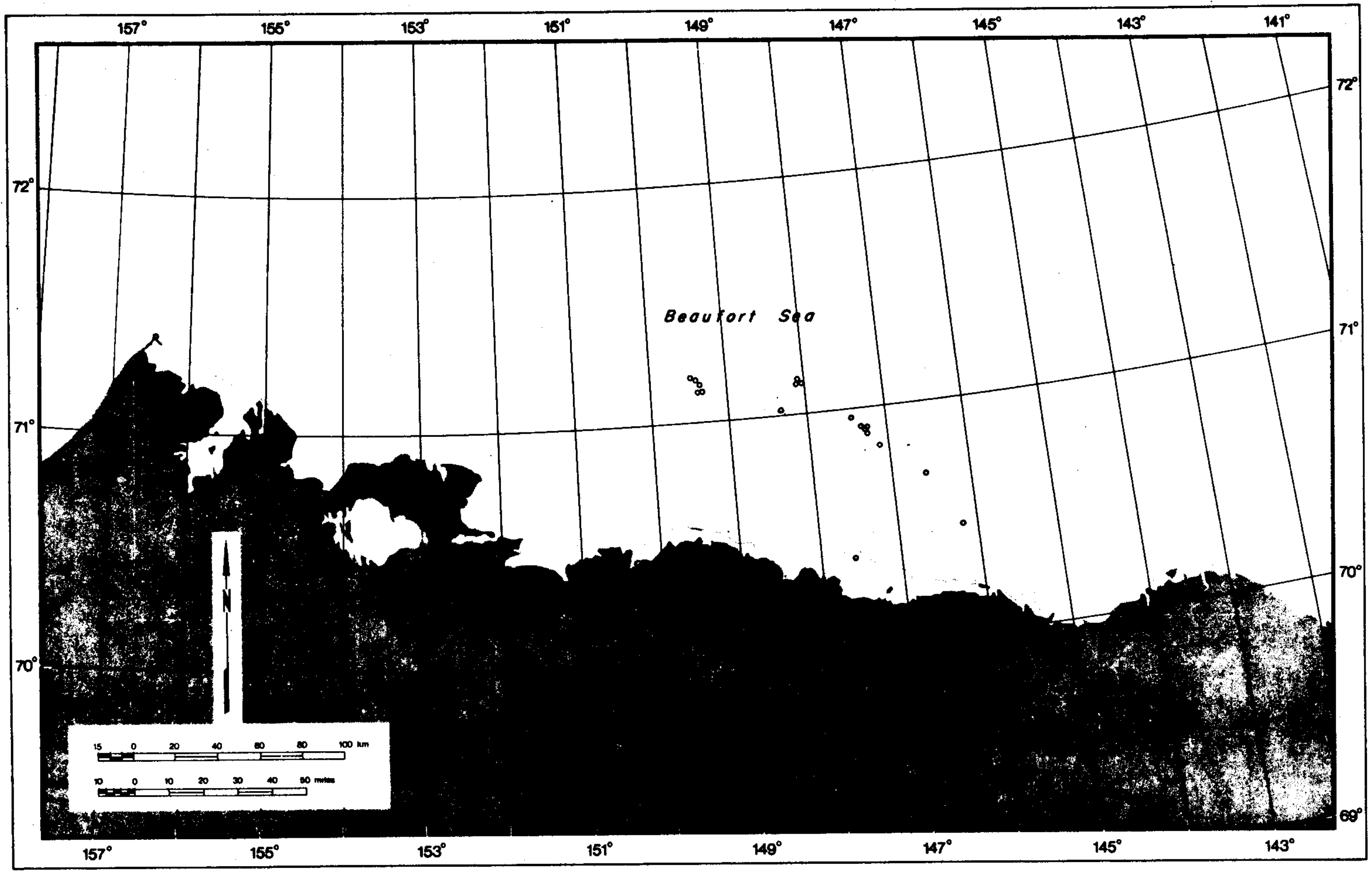
ALASKAN CORAL SURVEY

Distribution of Coral in the Chukchi Sea

Map : Chukchi Sea

JUNE 1981

FIGURE 10



LEGEND

∘ Soft coral (Gersemia rubiformis)

vtn

ALASKAN CORAL SURVEY

Distribution of Coral in the Beaufort Sea

Map : Beaufort Sea

JUNE 1981 | FIGURE 11

This generalized habitat profile can be used to predict areas of Alaska where soft coral should be found (Table 3). Gersemia should occur in all regions of Alaska (Southeast Alaska, Gulf of Alaska, Aleutian Islands, and the Bering, Chukchi and Beaufort Seas), at depths between 10 and 400 m on gravel and larger substrates.

Hydrocorals. The reported records for hydrocoral species (such as Allopora) are listed in Appendix 2 and are plotted in Figures 2, 4 and 8. The greatest number of records occurred in the Aleutian Islands, however, unlike sea fans, hydrocorals were not found along the continental slope in the southern Bering Sea. Other verified records of hydrocorals occurred in portions of the Gulf of Alaska, including the Kenai Peninsula, Shumagin Islands and Chirikof Island. Fishermen and biologists (Dr. Bruce Wing, personal communication) have reported hydrocorals in S.E. Alaska, the southeast and northeast areas of the Gulf of Alaska, and on the eastern side of Kodiak and Afognak Islands. Hydrocorals have not been reported from the Bering Sea (other than the Aleutian Islands), or from the Chukchi or Beaufort Seas. The depth range for these corals (700 to 950 m) is similar to that for sea fans (Figure 9). Biologists have noted that hydrocorals might be shallower in southeast Alaska than in more northern, colder waters (Dr. Bruce Wing, personal communication).

Hydrocorals should occur on cobble and larger rocky substrates. Their distribution on the Aleutian Islands suggest that hydrocorals can tolerate temperatures less than 3°C. They can therefore be expected to occur in additional regions of the Gulf of Alaska as well as the Aleutian Islands (Table 3). This coral is not expected to occur in the northern portion of the Bering Sea, or the Chukchi or Beaufort Seas.

b. Areas

Southeast Alaska. This region probably has the largest number of coral species due to the variety of habitats in terms of depth, substrate size, temperatures, and currents (Table 3). Primnoa is probably more abundant in southeast Alaska than any other region. Other species of fan corals have been observed during submersible dives, but were not collected (Dr. Richard Grigg, personal communication). Bamboo corals, cup corals, soft corals, and hydrocorals have also been observed in this region.

Gulf of Alaska. All six groups of corals discussed in this paper have been reported from the Gulf of Alaska (Table 3). Primnoa has been reported in moderate and low frequencies from the S.E. Gulf, N.E. Gulf, Kenai Peninsula, Kodiak Island, and isolated areas in the western Gulf. Fan corals, other than Primnoa, have been reported in one locality, but are expected to be more common. Bamboo and hydrocorals have been reported by fishermen in the southeast and eastern portions of the Gulf of Alaska, but are probably present in other areas of the Gulf as well. Cup corals should be found in additional areas of the Gulf, particularly east of Prince William Sound. Gersemia should be found in additional areas at depths less than 50 m, on substrates as small as cobble.

Bering Sea. This area can be divided into three regions: the Aleutian Islands, the Bering Sea shelf, and the Bering Sea slope. The Aleutian Islands are characterized by steep rocky slopes. The majority of the sea fans, bamboo corals, and hydrocorals reported during the Albatross expeditions were found here. All groups of corals (Primnoa, bamboo corals, other sea fans, hydrocorals, and soft corals), with the exception of cup corals, should be found here (Table 3). Primnoa should be found where temperatures remain above 3.7°C. The Bering Sea shelf on the other hand is shallow (0-100 m), covered with fine sediments, and exposed to cold winter temperatures. The only species reported in this region and expected to occur is *Gersemia*, the soft coral. The Bering Sea slope is deep (100-200 m) and has more rocky areas than the shelf. Sea fans are the only group of corals reported from this region; other corals are not likely to be found here.

Chukchi Sea. This region is shallow (0-50 m), cold, and dominated by fine sediments. The only species reported and also predicted to occur is the soft coral, *Gersemia rubiformis*.

Beaufort Sea. This region is characterized by a narrow shelf and a steep slope. The only species reported and also predicted to occur is the soft coral, *Gersemia rubiformis*.

IV. IMPACTS OF OIL AND GAS EXPLORATION AND DEVELOPMENT

A. Purpose and Methods

The purpose of this section is to predict impacts of oil and gas exploration and development on Alaskan corals. Since no studies have apparently been conducted on the specific effects of oil and gas exploration and development on Alaskan species, the following discussion is based on impacts on other corals with extrapolations made for Alaskan corals. This section treats both physical and chemical effects. An additional discussion reviews recolonization of potential impacted areas.

B. Results and Discussion

1. Physical Impacts

Physical impacts could occur as a result of surveying, platform and pipeline emplacement, and drilling.

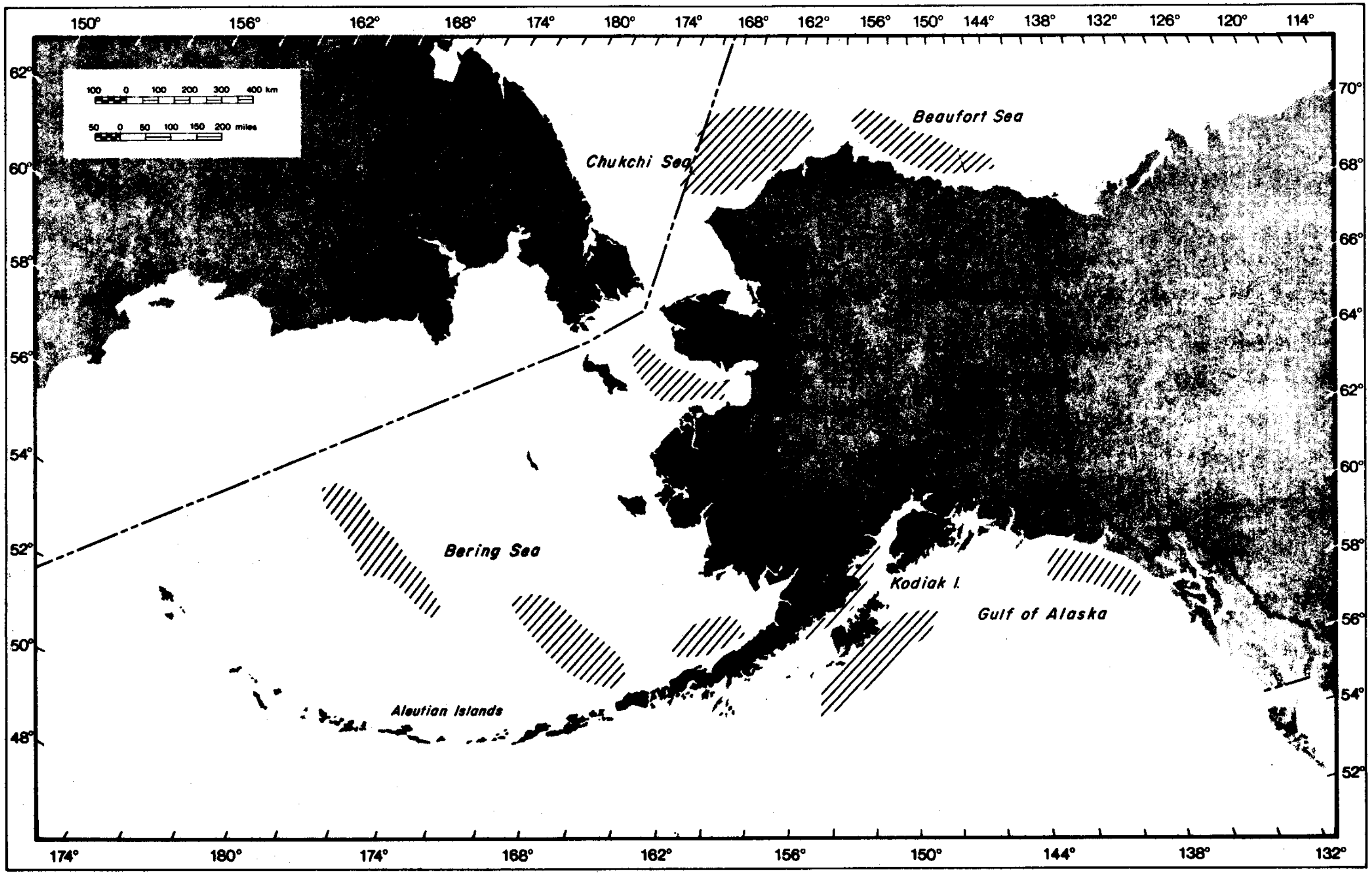
Surveying. Initial geological surveying usually involves topographical mapping using sonar and seismic profiling with explosive charges and hydrophone arrays. Since these charges are detonated in the water column, away from the benthic dwelling corals and since corals do not contain internal air-water boundaries, the impact of geological surveying on Alaskan corals is anticipated to be minimal.

Platform Emplacement. Oil platforms are large structures whose emplacement could result in both localized and general impacts. In the immediate vicinity of the site, the sea bottom will be highly disturbed, not only by the platform itself, but also by anchors, chains, pipelines and moorings. These operations and structures are likely to produce direct mortalities on corals. Platform emplacement can also result in indirect effects over a larger area by re-suspending sediments.

The predicted impacts of platform emplacement on most Alaskan corals would probably be minimal due to: 1) the large-scale geographic differences between most of the reported coral distributions and the location of lease areas; and 2) the small scale differences in coral habitats and platform emplacement. Most of the known distributions of Alaskan corals, and in particular the commercially valuable species, do not occur in the lease areas (Figure 12). The commercially valuable corals (red trees or Primnoa) are found mainly in such non-lease areas as the Inside Passage of S.E. Alaska, the bays along the northwest coasts of Kodiak and Afognak Islands, and the region off the Kenai Peninsula; none of which are present oil lease areas. The greatest area of overlap between dense populations of Primnoa and lease areas occurs in the northeast Gulf of Alaska and perhaps portions of the Cook Inlet/Shelikof Strait region. There is too little distributional data on most of the other species to make similar evaluations. The only species whose known distribution occurs in any substantial amounts in lease areas is Gersemia, the soft coral, found in the North Aleutian Shelf, Norton Basin, and Beaufort Basin lease areas.

Even in lease areas where corals have been reported, the small-scale geographic distribution (habitat) of the corals, in most cases, is not anticipated to occur where platforms are usually placed. Primnoa, bamboo corals, other sea fans, cup corals, and hydrocorals all appear to prefer current-swept hard substrates; such habitats occur on "edges," such as the continental slope. Platforms, on the other hand, tend to be situated on more level areas and therefore would not be placed near most coral habitats. Only Gersemia, which has been reported inhabiting soft substrates, could be affected.

Once in place, an oil platform provides a large area on which marine organisms, including corals, could settle and grow. The marine life on platforms is often abundant, diverse and productive (Wolfson et al. 1979). However, corals are not very abundant on oil platforms in southern California; instead mussels and starfish, which are better



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ALASKAN CORAL SURVEY

Proposed Lease Areas

JUNE 1981 | FIGURE 12

colonizers, are the most dominant organisms (Wolfson et al. 1979). Whether or not Alaskan corals will grow abundantly on offshore oil platforms is not known, but this is not anticipated since corals are considered poor colonizers and grow slowly (see Section IV.B.3.).

Pipeline Emplacement. Pipelines can affect coral populations in a number of manners as reviewed in the Draft EIS on the Proposed Flower Garden Bank Marine Sanctuary (Dept. of Commerce 1979). Direct impacts would occur on a localized basis as a result of direct mechanical damage to populations as the pipeline was being placed on the seabed floor. Indirect impacts could occur due to resuspension of bottom sediments, drilling muds, and cuttings. Such indirect impacts would be greater if the pipelines were buried than if the pipelines were simply placed on the seabed floor.

The predicted impacts on most Alaskan corals would probably be minimal due to the large-scale distribution of corals in relationship to lease areas and the small-scale distribution of corals in relationship to pipeline location. As in the case of platform emplacement, Gersenia (the soft coral) may be the Alaskan coral most affected.

Pipelines, like platforms, may have an enhancement effect on coral populations by providing additional hard substrates available for colonization. However, most Alaskan corals are probably slow colonizers of new or damaged areas (see Section IV.B.3).

Drilling. During drilling operations, an increased sediment load in the water column can be expected. This sediment comes from both the drilling cuttings (solids) brought up from the drill hòle and from the drilling fluids (muds) used in the operation. Since drilling fluids contain valuable chemicals, an attempt is made to recover the muds on the drilling platform and to minimize discharge into the water. The discharge of cuttings and drilling fluids, whether at the surface or at depth, will increase sedimentation in the immediate vicinity of the drilling operation and for some distance around it, depending on hydrographic conditions. The following assessment of the sensitivity of Alaskan corals to sedimentation is based on studies of other marine organisms, particularly tropical corals (see review by Wilber 1971).

Large amounts of sediment are capable of smothering marine organisms, particularly sessile organisms like corals (Smith et al. 1973; Dodge and Vaisnys 1977; Bak 1978). Increased turbidity is believed to decrease the diversity and growth of filter feeders (Rhoads and Young 1970; Aller and Dodge 1974). The lethal dosage of sediment depends on a number of factors, including coral morphology and size of sediment particles.

Some corals are able to clear sediments to a considerable degree (Hubbard and Pocock 1972). Clearing of the sediments requires an expenditure of energy which probably occurs at the expense of other vital functions, such as feeding, growth, or reproduction (Dodge et al. 1974; Dodge and Vaisnys 1977). The effect of sedimentation is probably most severe where conditions for the survival of a species are already marginal, such as near the limits of a species distribution or where organisms are exposed to chronic perturbations and stresses; and therefore, the effects may be synergistic. The deleterious effects of sediment from a drilling operation on corals can be mitigated to a large extent by requiring the fluids and cuttings to be transported to other disposal sites.

The susceptibility of Alaskan corals to smothering by sediment may depend on the size of the organism and the amount of sediment discharged. The smaller corals (cup corals, soft corals, and the crustose hydrocorals) could be covered by a thin (1 cm) layer of sediment, the upright hydrocorals by a 50 cm sediment layer, and the fan and bamboo corals by a sediment layer 1 m thick. In addition, a layer of sediment just several centimenters thick would kill basal sections of corals, which may result in mortalities (Dr. Richard Grigg, personal communication).

Even though sediments can directly or indirectly cause mortalities and sublethal impacts, actual impacts on Alaskan corals may be minimal since the known coral distributions do not occur in lease areas and since the small-scale geographic distribution (habitats) of corals in lease areas would not occur in the same areas as the drill sites. Gersemia, the soft coral, would be the Alaskan coral most exposed to impacts by increased sedimentation, due to its distribution in many lease areas. However, this coral is probably the most sediment tolerant species.

2. Chemical Impacts

The following discussion presents a literature review on the effects of drilling fluids and cuttings and the effects of oil and oil-dispersants on corals. At the end of each of these sections, extrapolations for Alaskan corals will be made.

Effects of Drilling Fluids and Cuttings. Since 1896 offshore drilling for oil in North America involved discharging drill fluids and subsequent drill solids. However, the chemical effects of fluids and cuttings on the environment have only recently been realized.

The specific chemical composition of drilling fluids varies with the precise technical requirements of the drilling project. The composition, functions and performance of these fluids are reviewed by McGlothlin and Krause (1980) and Perricone (1980). In most instances the drilling fluids are composed of a complex suspension of solids in water or diesel oil, along with additives, such as barite, bentonite, lignite, and lignosulfonate (Perricone 1980). The amount of material (fluids and cuttings) discharged at each well site varies.

The following section first covers laboratory investigations, usually involving individual chemical pollutants, and then reviews field studies conducted on discharged pollutants consisting of a mixture of chemicals.

Most of the major components of drilling fluids are relatively non-toxic. However, ferrochrome lignosulfonate (FCLS) has been shown to be highly toxic to marine invertebrates (Thompson and Bright 1977; Gettleson 1978, Krone and Biggs 1980). Laboratory studies indicate a 1,000 ppm concentration of drilling fluids caused mortalitities within 65 hours in three of seven species of tropical corals tested, while a 100 ppm concentration caused increased polyp retraction in five of the seven species. All coral colonies exposed to drilling muds with FCLS withdrew their polyps and increased their rates of respiration and excretion (Krone and Biggs 1980). In some cases bacterial infection and polyp mortality was noted. When exposure to drilling fluids and FCLS was discontinued, colonies returned to normal levels within 48 hours.

Dilutions of the whole muds used by Thompson and Bright (1980) were similar to those that may occur within a km from the discharge site. In the Krone and Biggs experiments, drill muds plus FCLS levels were selected to simulate loads within 200 m of discharge. Gettleson found that FCLS comprised less than 1,000 ppm of the fluids used. Most FCLS in the muds are absorbed onto clay particles, precipitating with the suspended sediment plume to potentially impact underlying benthic communities. Since FCLS is sublethal at 10 ppm and lethal at 100 ppm (Thompson and Bright 1977), Gettleson therefore recommended near-surface discharge of sediments in order to dilute FCLS to levels that would not result in impacts to benthic communities.

Tentative findings in a short-term study (Hudson and Robbin 1980) indicate that heavy concentrations of drilling fluids, applied directly to corals over a 7 1/2 hour period, reduced growth rates. In their long-term growth studies, they found no changes in yearly growth rates in corals, which may have been exposed to drilling fluids over a three-year period. To date there are no reports of studies on long-term sublethal effects of drilling muds and cuttings on reproduction and behavior. In addition, the toxic effects of the large numbers of other additives are not known.

Additional contamination to organisms could result from exposure to the diesel oil associated with oil-based fluids. McMordie (1980) states that oil-based cuttings are not commonly used, and that contaminated cuttings are cleaned carefully by a method "closely monitored to insure hydrocarbon free cuttings." Nevertheless, Grahl-Nielson et al. (1980) found petroleum hydrocarbons in the sediments attributed to possible oil-based drilling muds from nearby sites. In fact, dark-colored and oily smelling sediments were observed in some of their grab samples close to the platform.

There have been fewer field studies than laboratory investigations on impacts of drilling fluids and cuttings. Mariani et al. (1980) found chemical and physical alterations in the benthic environment as a result of drilling discharges in the mid-Atlantic Bight. These chemical changes included increased concentrations of lead, nickel, barium, vanadium and zinc in the sediment, and increased concentrations of barium and nickel and chromium in some species.

Lees and Houghton (1980) found no impacts of drilling fluids on benthic communities at a well site in Lower Cook Inlet. These results could be attributed to a rapid dispersal of fluids and muds via strong tidal currents (Laurie Jarvela, personal communication). Similarly Gettleson (1978), studying the distribution and dispersion of fluids and cuttings in the Flower Gardens off Texas, found no apparent change in the health of nine coral species. However, he reported barium levels in the sediment indicating that drilling fluids were dispersed more than 1,000 m from the drilling site. In the past, barium has been considered non-toxic and useful as a tracer; the results of this study indicate that this metal might undergo bio-accumulation and could cause chronic toxicity in marine organisms.

The potential chemical impacts from drilling fluids and cuttings could be substantial if corals were exposed to high enough concentrations of these chemicals. However, since much of the known distributional sites of Alaskan corals do not occur in lease areas, and since drilling would probably not occur near most coral habitats, many of the coral populations would probably not be exposed to high enough concentrations of chemicals to result in deleterious effects. Gersmia (soft coral), which is found in many of the lease areas and near habitats where drilling could occur, is probably the Alaskan coral with the greatest potential exposure to these chemicals.

Effects of Oils and Oil-Dispersants. There are no field or laboratory investigations on the effects of oil on Alaskan corals. The following literature review discusses and summarizes the numerous studies done on other cold water marine invertebrates and on tropical corals, in order to provide a basis for predicting impacts on Alaskan corals. This discussion examines the impacts on each stage of the coral's life history.

Studies on the adult stage indicate that mortalities of reef colonies were four times greater in areas exposed to oil than in control sites (Loya 1975). Species of Panamanian corals survive short exposure (up to 30 minutes) to diesel and bunker oil in the laboratory with no differences noted between oil exposed colonies and controls (Reimer 1975). This effect varied with the type of oil, length of exposure, and individual species. Reimer also noted differences in feeding responses due to oil, which she suggested might affect growth rates.

Adult colonies of corals immersed in high concentrations of Persian crude oil for 96 hours died within 7 days after being transferred to uncontaminated seawater (Eisler 1975b). Experimental animals exposed to concentrations greater than 10,000 ppm of Sinai crude had 60-64% lower polyp pulsation rates than control organisms. Mixtures of crude oil and dispersants are more toxic than either component (Elgershuizen and deKruijf 1976; Eisler 1975b).

Corals also show a significant decrease in reproductive activity (number of female gonads per polyp) after six months of periodic exposure to sublethal concentrations (1,000-10,000 ppm) of Iranian crude oil (Rinkevich and Loya 1979b). In other studies the number of colonies breeding and the number of ovaries with eggs were all found to be lower in areas exposed to oil than in control areas (Loya and Rinkevich 1979). Premature release of larvae occurred in corals exposed to sublethal concentrations (1,000-10,000 ppm) of water soluble fractions of Iranian crude oil (Rinkevich and Loya 1979a) and sublethal concentrations of water soluble fractions of Sinai crude oil (Cohen et al. 1977). Decreased larval viability, such as changes in settlement and subsequent growth, occurred during controlled field studies on reef-forming corals in the Red Sea (Loya 1975).

These effects have been reported from tropical corals. Due to morphological, physiological and biochemical similarities among the corals, similar effects could occur among Alaskan corals. The magnitude of the effects, however, may vary due to: 1) the persistence of toxic aromatic hydrocarbons, which may increase in cold waters due to slower rates of evaporation and degradation; 2) the effect of water temperature on the animal's sensitivity to oil by changing rates of hydrocarbon uptake, metabolism and excretion; 3) the synergistic effect of temperatures and petroleum at extreme cold or warm temperatures (Korn et al. MS cited in prep in Rice et al. 1977); and 4) cold-water invertebrates are considered more sensitive than similar species from warmer climates (Rice et al. 1977). Mitchell and Ducklow (1976) reported that there is a delicate relationship between corals and marine bacteria. When disturbed by low levels of chemical pollutants, corals react by extensive mucus secretion which enhances bacterial growth and eventually leads to death.

In spite of the sensitivity of corals to oil, the most probable impacts of oil on Alaskan corals are not believed to be great due to the location of lease areas in Alaska in relationship to the distribution and life history of coral populations. As previously stated, with the exception of *Gersemia* (soft corals), most of the known distributions of Alaskan corals do not occur in lease areas. Also with the exception of *Gersemia*, most of the corals are found in areas where drilling would not occur. Most of the Alaskan corals, as opposed to the shallow, tropical, reef building (hermatypic) corals, are found in deep water, usually below 100 m. In such deep waters, only a small amount of the oil spilled would come into contact with the Alaskan corals. The light, and often most toxic fractions, would probably not come into contact with the corals since they evaporate and dissolve. The heavier, and usually the less toxic fractions, might sink and represent the major source of oil that would come into direct contact with the corals. The planula larvae, which are probably (physiologically and ecologically) the most vulnerable stages, are believed to be present for a short time, demersal and therefore, would not be susceptible to large impacts from an oil spill.

Therefore, while oil has been reported to be extremely damaging to shallow water, reef-building corals in warm tropical waters, Alaskan corals, found in deeper waters, appear to be less threatened by oil spills due to their distribution, deep habitat, and the brief duration of the demersal planula larval stage.

3. Recolonization

The rate of recolonization of damaged areas depends on the degree of damage, persistence of the pollutant, distance of nearby adult populations, duration of the reproductive season, abundance of larvae, larval settlement, and growth rates. Since very little of this specific information is known about Alaskan corals, pertinent literature on other corals regarding each individual factor will be discussed. A summary of this information is presented at the end of this section regarding rates of recolonization.

The degree of damage to coral populations is important to assess since recovery rates decrease as the degree of damage (intensity and area) increases. If only portions of individual corals (some tissues) are damaged then recovery is quick and involves tissue growth or asexual reproduction. If mortalities occur among some individuals of the population, recovery is slower and dependent upon recruitment via larvae from nearby colonies. However, if mortalities occur among all individuals over a large area, then recolonization should take even longer since potential sources of recruiting larvae would be further away. Therefore, as the degree of damage (perturbation) increases the period for recolonization also increases.

Rates of recolonization should decrease with increasing persistence of the pollutant. In the arctic and subarctic regions of Alaska, hydrocarbons persist longer than at lower latitudes. Degradation of petroleum and other chemicals by microbes is slower due to lower temperatures and seasonal shortage of nitrogen and phosphorus (Atlas 1977). In addition, if pollution is chronic, recolonization may be slower. Recovery of Red Sea corals took place more rapidly on an unpolluted reef than on a reef chronically polluted with oil and minerals (Loya 1976). Loya suggests that the polluted reef might not return to its former conditions due to long-term habitat changes.

Distance from recruiting populations is important since it (along with larval longevity and currents) determines the probability of the larvae reaching a certain site. In general, the further the distance of recruiting populations, the longer the recovery rate. This factor is determined by the geographic scale of the impact in relationship to the distribution of the organism.

Duration and time of reproductive season are important since organisms with a long reproductive season are faster colonizers ("r" selected species). Their larvae are available for recolonization during a longer period of the year. Species closer to the poles, in deeper waters, or with longer generation times usually have limited reproductive periods (Thorson 1950). Primnoa and perhaps other Alaskan species (with the possible exception of the soft corals and the cup corals) are found in deep waters, probably live for over 100 years, and are expected to have limited reproductive periods.

The greater the abundance of larvae released, the greater the probability that one will reach a particular site. Many Alaskan corals appear to be large, slow-growing, long-lived species ("k-selected species"). Although the reproductive season in such species is often short, the number of larvae released per unit time is often great.

Distance of larval dispersal increases with larval longevity, mobility, and water currents. Species closer to the poles and at deeper depths (which applies to most Alaskan species) have more direct development with limited larval dispersal (Thorson 1950). Most coral larvae survive for 2-10 days, and some for as long as 90 days in the laboratory. The planula larvae of some corals settle within 1 meter of the parent colony (Kinzie 1973; Lewis 1974; Gerrodette 1979), although one species settles up to 40 m away (Weinberg and Weinberg 1979). Larvae of one of the Alaskan cup corals (Balanophyllia elegans) settles within 0.4 m of the female colony (Gerrodette 1981) and the larvae of the Alaskan hydrocoral (Allopora petrograpta) crawls (Fritchman 1974). These reports suggest limited dispersal ranges for Alaskan species.

Most marine larvae use chemical and physical cues to detect a substrate on which to settle (Crisp 1974). The presence of residual chemical pollutants and sediments often inhibits settlement.

Growth rates have been measured for only one Alaskan coral, Balanophyllia elegans (0.1-0.2 cm/yr., Gerrodette 1979). In general, growth rates of cold-water corals are low, one to several millimeters per year. Furthermore, growth and development of invertebrates in general may be slower in cold water. Pearse (1969) found that the embryos and larvae of the Antarctic starfish, Odontaster validus, required about 10 times as long to develop as those of tropical starfish. Dayton (1978) was not able to detect changes in size of many marked Antarctic sponges even after 10 years. Low growth rates for Alaskan corals, especially Primnoa, are expected. Growth of Primnoa, a gorgonian with a partly-calcified skeleton, is believed to be slower than the warm-water, reef-growing Plexaura (1-8 cm/yr) (Bayer and Weinheimer 1974), but probably not as slow as the purely calcareous Corallium (0.9 cm/yr) (Hinman et al. 1964). Light, temperature, and the kind of skeleton are all important in determining the growth rates of corals. Since Primnoa is slightly calcified, found in deep, cold, dark waters, the growth rate of this genus is predicted to be approximately 1 cm/yr. Based on this growth rate, a Primnoa colony 1 m high would require at least 100 years to return to the pre-impacted state.

Recolonization of tropical coral communities requires at least several decades to recover from major perturbations (Pearson 1981). Colonization of lava flows by Hawaiian corals took several decades to achieve a diversity of species comparable to undisturbed areas (Grigg and Maragos 1974). In summary, recovery of Alaskan coral communities from damage due to oil and gas exploration and development should be even slower (and require perhaps between 10 to over 100 years) than tropical corals since petroleum degradation is slower, reproductive season of corals probably briefer, and growth rates probably slower.

V. RECOMMENDED STUDIES

The information presented in the preceeding chapters was based solely on existing published and unpublished data. This base of information is therefore limited and partial to certain areas of Alaska as a result of the historical nature of previous studies. Additional information is required, particularly site specific distributions of commercially and ecologically important corals in many of the proposed oil lease areas.

A. Distribution and Taxonomy

Data Limitations. Knowledge of Alaskan corals is sparse and limited to certain areas for a number of reasons. One, little work has been done collecting corals in Alaska. The limited knowledge about Alaskan corals during the past one hundred years has come primarily from the cruises made by the U.S. Fish Commission steamer *Albatross* at the turn of the century, which were limited to certain regions of Alaska. Dredge samples in which corals were collected were subsequently analyzed by octocoral taxonomists (Nutting 1912) and hydrocoral taxonomists (Fisher 1938).

A second reason is that much of the coral collected in Alaska has not been looked at by coral taxonomists. Additional specimens collected during the *Albatross* and other expeditions in the Bering and Beaufort Seas, as well as the Gulf of Alaska, have not been examined at all. Third, many of the identifications of the Alaskan material may be incorrect and in need of review.

Suggested Studies. Study 1 involves examination and analysis of the large amount of material already collected and stored in museums and laboratories. This study would be highly cost effective, would provide a large amount of additional distribution data, and could be specific to certain species and/or specific lease areas. Study 2 involves preservation of corals caught incidentally by fishermen. This material could be sent to respective coral experts for accurate identifications.

Such studies would provide a large data base on the distribution of the commercially and ecologically important species in proposed lease areas. Should sufficient records of commercially and/or ecologically important corals be found in specific lease areas as a result of these studies, then studies 3, 4, and 5 should be conducted in sequence to directly determine the impacts of oil and gas exploration and development.

B. Habitats and Ecology

Data Limitations. Most of the ecological studies on fan corals have been conducted in warm water areas such as the Mediterranean (Theodor 1967a,b; Weinberg 1978, 1979a,b,c), the Caribbean (Cary 1914, 1917; Kinzie 1973; Opresko 1973; Bayer and Weinheimer 1974; Muzik 1980b) and Fiji (Muzik and Wainwright 1977). Studies in the temperate zone have been conducted in California (Grigg 1970, 1972, 1975, 1977, 1979). Studies on soft corals have been conducted by Cary (1917), Gohar (1940), and Suzuki (1971). Ecological studies of deep-water fan corals are limited to the investigation by Lacaze-Duthiers (1864), Grigg (1973a, 1976), Grigg and Bayer (1976), and Muzik (1978, 1980a). Bayer (1957), in his review of deep-water sea fan ecology, suggests that the ecological parameters required by shallow water octocorals are different from those in deep water. No ecological studies have been conducted on Primnoa or on any other commercially or ecologically important Alaskan coral.

Suggested Studies. Study 3 will provide ecological and natural history information on commercially and ecologically important Alaskan corals. These field studies should be performed for each kind of Alaskan coral including the commercially valuable Primnoa, the soft coral Gersemia, a species of hydrocoral, a species of bamboo coral, and a species of cup coral. Studies should determine age, size classes of population, growth rates, and reproductive activity. This information can be used as a basis to more accurately determine coral distributions, abundance, as well as predict the impacts of oil and gas exploration and development.

Study 4 will examine, from laboratory experiments, aspects of the coral's life history that are difficult to determine from field studies. These studies should emphasize larval ecology and, in particular, effects of substrate type, currents, temperature, and turbidity on substrate selection, settlement and metamorphosis. This additional information on critical life history stages will help to define suitable coral habitats as well as to determine the effects of oil and gas exploration and development. This study should be conducted following Study 3 in order to determine which species, areas, and times should be examined.

C. Impacts of Oil and Gas Exploration and Development

Data Limitation. Chemical impacts associated with oil and gas exploration and development on Alaskan corals or many other species have not been investigated either in the field or laboratory. To accurately determine these impacts, information regarding the effects of exposure time, concentration, trace-metal and hydrocarbon composition, bioaccumulation and synergistic action on individual species should be directly tested. In addition, studies should examine lethal and sublethal effects on behavior, growth, and reproduction to recommend effective mitigating procedures.

Proposed Study. Study 5 will involve laboratory studies on the effects of oil and detergents, drilling fluids and cuttings, and sediments on species of Alaskan coral. Species chosen should represent each kind of Alaskan coral (red trees, bamboo corals, hydrocorals, cup corals, and soft corals). Coral responses monitored should include mortalities as well as sublethal effects on feeding rates, reproduction, and larval behavior.

This information will provide estimates of effects of oil and gas exploration and development on Alaskan corals emphasizing comparative effects of different chemicals on different species and life stages.

This laboratory investigation might be conducted together with studies on corals from other OCS areas and/or on other important Alaskan species to be more economical and to provide more useful and comparative results.

VI. SUMMARY

1. A literature review was conducted on the known and predicted distributions, habitats, and commerical value of Alaskan corals, and to assess impacts of oil and gas exploration and development on these organisms. This information was gathered from published articles, museum specimens, computerized data files, records of commercial fishermen, and discussions with university and agency scientists.

2. A total of 34 species of corals have been reported from Alaskan waters including 21 species of sea fans (octocorals), two species of cup corals (hexacorals), and 11 species of hard corals (hydrocorals).

3. An evaluation of these Alaskan corals indicates that: two species of sea fans (commonly referred to as red trees or gold coral) have a high commercial value and are presently being harvested in large quantities; 19 species of sea fans (such as bamboo corals) have moderate commercial value as jewelry and as curios; nine species of hydrocorals have low commercial values as curios; and the remaining three species do not have any apparent commercial value since they are either too small or too soft to be used for jewelry or as curios.

4. Distributional records indicate that the commercial species (red trees or Primnoa) are found in current swept areas in the Gulf of Alaska and southeast Alaska, on large rocky substrates, where ambient temperatures usually do not fall below 3.7°C.

   Most of the other Alaskan corals are usually found on rocky substrates in the southern Bering Sea and in the Gulf of Alaska. Only one species, the soft coral Gersemia rubiformis, is found in all Alaskan waters, including the Chukchi and Beaufort Seas where temperatures fall below -1.5°C. This coral inhabits smaller substrates (including gravel) than any of the other Alaskan species.

5. Habitat profiles were used to generate anticipated distributions of the following coral groups: Primnoa; bamboo corals; other sea fans; cup corals; hydrocorals; and soft corals.

6. Present knowledge regarding the impacts of oil and gas exploration and development on corals has been developed primarily from studies of tropical reef forming corals. These species inhabit shallow waters, usually less than 50 m in depth, and are therefore susceptible to direct contact with oil slicks and water soluble fractions.

7. Alaskan corals are not believed to be as susceptible to the adverse impacts of oil and gas development as tropical corals because: a) most of the known distributions of Alaskan corals do not occur in lease areas; b) platform emplacement will probably not occur in areas of high coral densities; c) most of the corals are deep and would not be exposed to much of the oil from spills; and d) the planula larval stage of corals is believed to be brief, demersal, and therefore not highly susceptible to damage from oil spills.

   The greatest anticipated impact would probably occur as a result of increased sediment fouling and toxicity from drilling fluids and muds. The extent of this damage would depend on the concentration of each individual pollutant and the sensitivity of each species, both of which are not presently known nor can be adequately predicted at this time.

   The most susceptible species is the soft-coral, Gersemia, which is found throughout Alaska in shallow waters, including many lease areas. This species has no apparent commercial value, since the spicules are embedded in the tissues and therefore do not form a hard skeleton.

8. Damaged coral populations in Alaska would probably take longer to recover than tropical corals since Alaskan corals are believed to grow slower and have briefer reproductive seasons.

9. This study was based entirely on existing information and limited because of historical reasons to certain species and certain areas. Therefore, additional information from samples already collected and from specific field studies is desirable for particular lease sales areas to confirm preliminary conclusions generated from the literature. If such studies modify the conclusions in item 7, then studies on the impacts of oil and gas exploration and development may be warranted and should be considered.

VII. ACKNOWLEDGEMENTS

The authors are indebted to a large number of individuals, agencies, and universities for their important contributions throughout this study. These individuals include: Kris Brooks (Oregon State University) for computerized literature searches; George Muller and Nora Foster (University of Alaska), Dr. Gordon Hendler (Smithsonian Institution), Dr. William High (National Marine Fisheries Service), and Dr. Andrew Carey and Eugene Ruff (Oregon State University) for contributing unpublished coral data; Jim Audet, Mike Crane, Dean Dale, and Gary Falk (National Oceanographic Data Center) for access to NODC files; Paul Kaiser (Alaska Commercial Fisheries Entry Commission) for information on fisheries; Dr. Joe Strauch and George Tamm (Science Applications, Inc.) for NOAA/OMPA base maps; Dr. Erich Hochberg (Santa Barbara Museum of Natural History) and Dr. Pat O'Neil (Portland State University) for their helpful comments; and the VTN biologists, graphic artists, and word processors for their support throughout the project.

The authors would like to give particular thanks to: Dr. Richard Grigg (University of Hawaii) for contributing his knowledge regarding Alaskan corals and reviewing the manuscript; Bart and Toni Eaton, Joseph Terry, "Frenchie", and Dick Bishop for sharing their time and knowledge on Alaskan corals; Dr. Bruce Wing (Auke Bay Fisheries Laboratory) for providing unpublished coral data and reviewing the manuscript; Laurie Jarvela, Dr. Herb Bruce, Chris McQuitty, Jody Hilton, and Jane Carlson (NOAA) for their technical assistance on the contract; Dr. Greg McMurray (VTN Oregon) for assistance on distributional data and NODC data files; and Ronald Rathburn (VTN Oregon), Project Manager.

This report is dedicated to those fishermen who were willing to share with us their invaluable knowledge of Alaskan corals.

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IX. APPENDICES

Appendix 1. Taxonomic synonymies for Alaskan corals.

Class Anthozoa

Subclass Octocorallia (Alcyonaria)

Order Alcyonacea Lamouroux 1816

Family Neptheidae Gray 1862

1. Gersemia rubiformis (Ehrenberg) 1834

Lobularia rubiformis Ehrenberg 1834:282

? Halcyonium carncum Agassiz 1850:200 (after Verrill)

Alcyonium rubiforme Verrill 1864:4

Alcyonium carneum Verrill 1864:39

Nannodendron elegans Danielssen 1887:69

Paraspongodes rubra May 1898:393

Alcyonium rubiforme + Paraspongodes globosa + P. rubra May 1900:400

Eunephthya rubiformis Kukenthal 1906a:21; Kukenthal 1907:331

? Lithophytum roseum Nutting 1912:14

Alcyonium gracillimum Nutting 1912:21 (not Kukenthal 1906)

Gersemia rubiformis Molander 1915:51; Molander 1918:4

Gersemia carnea Verrill 1922:22

Gersemia rubiformis Verrill 1922:4

Eunephthya rubiformis Deichmann 1936:63

Gersemia rubiformis Broch 1935:17

Gersemia rubiformis (part) Madsen 1944:26; Madsen 1948

Gersemia rubiformis rubiformis Broch 1956:7

Gersemia rubiformis Utinomi 1961:235

Order Gorgonacea Lamouroux 1816

Suborder Holaxonia Studer 1887

Family Isididae

2. Keratoisis profunda (Wright & Studer) 1889

Bathygorgia profunda Wright & Studer 1889:32

Bathygorgia profunda Nutting 1912:90

Appendix 1. (continued)

3. Lepidisis paucispinosa (Wright & Studer) 1889
   Ceratoisis paucispinosa Wright & Studer 1889:28
   Ceratoisis paucispinosa Nutting 1912:91

Family Plexauridae Gray 1859

4. Muriceides cylindrica Nutting 1912:76
5. Muriceides nigra Nutting 1912:77
6. Swiftia beringi (Nutting) 1912
   Leptogorgia beringi Nutting 1912:95
   Stenogorgia beringi Kukenthal 1919:918
7. Swiftia pacifica (Nutting) 1912
   Callistephanus pacificus Nutting 1912:96
   Allogorgia exserta Verrill 1928:8

Family Primnoidae Gray 1857

Subfamily Calyptrophorinae Gray 1870

8. Arthrogorgia kinoshitai Bayer 1952:64
9. Arthrogorgia otsukai Bayer 1952:65

Subfamily Primnoinae Gray 1857

10 Calligorgia compressa Verrill
   Primnoa compressa Verrill 1865:454
11. Plumarella flabellata Versluys 1906:16
12. Plumarella spicata Nutting 1912:64
13. Plumarella spinosa Kinoshita 1907:11
14. Primnoa resedaeformis (Gunnerus)
   Gorgonia resedaeformis Gunnerus 1763:321,329
   Gorgonia reseda Pallas 1766:204
   Gorgonia lepadifera Linne 1767:1289
   Primnoa lepadifera Lamouroux 1816:442
   Lithoprimnoa arctica Grube 1861:165
   Primnoa reseda Verrill 1866:9
   Primnoa resedaeformis Storm 1901:10
   Primnoa resedaeformis Kukenthal 1919:360; 1924:266

Appendix 1. (continued)

15. Primnoa willeyi Hickson
    Primnoa willeyi Hickson 1915:551
    Primnoa willeyi Kukenthal 1924:267
16. Thouarella hilgendorfi (Studer) 1878
    Plumarella hilgendorfi Studer 1878:648
    Thouarella hilgendorfi Nutting 1912:66
17. Thouarella straita Kukenthal 1907:204

Suborder Scleraxonia Studer 1887

Family Paragorgiidae Kukenthal 1916

18. Paragorgia sp.
    ≠ Paragorgia arborea (Linnaeus) 1758:803
    ? = Paragorgia nodosa Koren & Dan. 1883:13
    = Paragorgia nodosa Nutting 1912:99
19. Paragorgia arborea (Linnaeus) 1758
    Alcyonium arboreum Linnaeus 1758:803
    Paragorgia arborea Kukenthal 1924:28
20. Paragorgia pacifica Verrill 1878
    (Paragorgia arborea pacifica at USNM, unpublished data)

Subclass Hexacorallia

Order Scleractinia

Family Dendrophylliidae

21. Balanophyllia elegans Verrill

Family Caryphylliidae

22. Caryophyllia alaskensis Vaughn

Class Hydrozoa

Order Stylasterina

Family Stylasteridae

23. Allopora campyleca Fisher
24. Allopora moseleyana Fisher
25. Allopora papillosa Dall
26. Allopora petrogapta Fisher

Appendix 1. (continued)

27. Allopora polyorchis Fisher
28. Cyptohelia trophostega Fisher
29. Distichopora borealis Fisher
30. Errinopora nanneca Fisher
31. Errinopora zarhyncha Fisher
32. Stylaster cancellatus Fisher
33. Stylaster elassotomus Fisher
34. Stylaster gemmascens alaskanus Fisher

Appendix 2. Distributional records of Alaskan corals.

Species	Location	Latitude; Longitude	Depth (m)	Method of Collection	Physical and Biological Data	Reference
Class Anthozoa						
Subclass Octocorallia (Alcyonaria)						
Order Alcyonacea						
Family Neptheidae						
1. *Gersemia rubiformis*	(see Appendix 4)					
Order Gorgonacea						
Suborder Holaxonia						
Family Isididae						
2. *Keratoisis profunda*	Albatross #4766; Koniuji Is., S 22.5°W, 27 mi. Aleutian Is.	52°38' N; 174°49' W	3,532	Beam trawl	-	Nutting 1912
3. *Lepidisis paucispinosa*	Albatross #4771; Bowers Bank, Aleutian Is.	54°30' N; 179°17' E	852	Beam trawl	Broken shells	CAS*
?	Chatham St. (AB 62-519), SE Alaska	-	405	-	Sand, mud, gravel	AB*
?	Chirikof Is. (AB 66-60), Gulf of Alaska	-	280-300	-	-	AB*
Family Plexauridae						
4. *Muriceides cylindrica*	Albatross #4781; SE of Agattu Is., Aleutian Is.	52°14'30"N; 174°13' E	964	Beam trawl	Fine gray sand, pebbles; 38.6°F	Nutting 1912
5. *Muriceides nigra*	Albatross #4784; E. Cape, Attu Is., S 18°W, 4 mi. Aleutian Is.	52°55'42"N; 173°26' E	270	Beam trawl	Coarse pebbles	Nutting 1912
6. *Swiftia beringi*	Albatross #4780 Aleutian Is.	52°01' N; 174°38' E	2,092	Beam trawl	Gray mud, sand, pebbles; 35.9°F	Nutting 1912
7. *Swiftia pacifica*	Albatross #4781; S.E. of Agattu Is., Aleutian Is.	52°14'30"N; 174°13' E	964	Beam trawl	Fine gray sand, pebbles; 38.6°F	Nutting 1912

Appendix 2. (continued)

Species	Location	Latitude; Longitude	Depth (m)	Method of Collection	Physical and Biological Data	Reference
Family Primnoidae						
Subfamily Calyptrophorinae						
8. *Arthrogorgia kinoshitai*	Albatross #4781; S.E. of Agattu Is., Aleutian Is.	52°14'30"N; 174°13' E	964	Beam trawl	Fine gray sand, pebbles; 38.6°F	Nutting 1912
9. *Arthrogorgia otsukai*	Between Bowers Bank, Bering Sea and Codfish Banks Aagan River, Kamchatka	-	-	Dredge	-	Bayer 1952
Subfamily Primnoinae						
10. *Calligorgia compressa*				Long line		Verrill 1922
11. *Plumarella flabellata*	Albatross #4784; E. Cape, Attu Is., S 18°W, 4 mi. Aleutian Is.	52°55'42"N; 173°26' E	270	Beam trawl	Coarse pebbles	Nutting 1912
12. *Plumarella spicata*	Albatross #4780; Aleutian Is.	52°01' N; 174°38' E	2,092	Beam trawl	Gray mud, sand, pebbles; 35.9°F	Nutting 1912
?	Albatross #4771; Bowers Bank, Aleutian Is.	54°30' N 179°17' E	852	Beam trawl	Broken shells	Nutting 1912
13. *Plumarella spinosa*	Albatross #4781; S.E. of Agattu Is., Aleutian Is.	52°14'30"N; 174°13' E	964	Beam trawl	Fine gray sand, pebbles; 38.6°F	Nutting 1912
	Albatross #4769; Aleutian Is.	54°30'40"N; 174°14' E	474-488	Beam trawl	Gray sand, green mud	Nutting 1912
**	Albatross #4787; North Point, Copper Is., N79°E, 8.5 mi., Bering Sea	54°51'54"N 167°13'30"E	108-114	Beam trawl	Green sand	Nutting 1912
11-13. *Plumarella* spp.	Albatross #3480; Amukta Pass, Aleutian Is.	52°06' N; 171°45' W	566	Beam trawl	Black sand, coral; rocky	USNM*

Appendix 2. (continued)

Species	Location	Latitude; Longitude	Depth (m)	Method of Collection	Physical and Biological Data	Reference
	Albatross #3500; Bering Sea	56°02' N; 169°30' W	242	Beam trawl	Fine gray sand, gravel; 38.6°F	USNM*
	Albatross #3319; Aleutian Is.	53°40'30"N; 167°30'00"W	118	Beam trawl	Black sand	USNM*
	Albatross #4779; "Petrel" Bank, Bering Sea	52°11' N; 179°57' W	108-112	Beam trawl	Broken shells, pebbles; sand	USNM*
14. Primnoa resedaeformis	Petersburg; SE Alaska (See Appendix 3)	-	-	-	-	USNM*
15. Primnoa willeyi	Prince William Sound;	-	64	-	-	USNM*
	Clarence St., Behm Canal; SE Alaska (See Appendix 3)	-	377-446	-	-	USNM*
16. Thouarella hilgendorfi?	Albatross #4771; Bowers Bank, Aleutian Is.	54°30' N; 179°17' E	852	Beam trawl	Broken shells	CAS*
17. Thouarella straita	Albatross #4778; Semisopochnoi Is. S 45°W, S 12°W, 12 mi. Aleutian Is.	52°12' N; 179°52' E	66-86	Beam trawl	Fine black gravel	Nutting 1912
Suborder Scleraxonia						
Family Paragorgiidae						
18. Paragorgia sp.	Albatross #4776; Aleutian Is.	54°30' N; 179°14' E	688-744	-	Greenish brown sand	USNM*
	Albatross #3315; Aleutian Is.	54°02'40"N; 166°42'00"W	554	Beam trawl	Green muddy sand; 38.5°F	USNM*
19. Paragorgia arborea **	Albatross #4789; Off North Pt Copper Is. Aleutian Is.	54°49'45"N; 167°12'30"E	112	Beam trawl	Green sand	Nutting 1912

Appendix 2. (continued)

Species	Location	Latitude; Longitude	Depth (m)	Method of Collection	Physical and Biological Data	Reference
	Amchitka Is.; Bering Sea (AB 73-19)	51°30' N; 179°00' E	18-20	SCUBA	Vertical bedrock wall	AB*
	Feder #90	57°19'54"N; 173°38'00"W	137-	Otter trawl	52 gms.	NODC*
	Feder #92	57°48'00"N; 173°38'18"W	92	Otter trawl	870 gms.	NODC*
20. <u>Paragorgia pacifica</u>	Albatross #3321; Bering Sea	55°30'30"N; 167°15'40"W	108	Dredge	Dark mud; 41.5°F	USNM*
	Albastross #3315; Bering Sea	54°02'40"N; 166°42'00"W	554	Beam trawl	Green muddy sand; 38.5°F	USNM*
	Albatross #3338; Bering Sea	54°19' N; 159°40' W	1,250	Beam trawl	Green mud and sand; 37.3°F	USNM*
Subclass Hexacorallia Order Scleractinia Family Dendrophylliidae						
21. <u>Balanophyllia elegans</u>	? Pirates Cove	-	Intertidal	Hand	Rocky area	AB*
	? Mountain Pt.; SE Alaska	-	2-12	Hand	Rocky	Kathy Casson Pers. Comm.
	Snipe Bay,	-	0-1	-	Rocky	UA*
Family Caryphylliidae						
22. <u>Caryophyllia alaskensis</u>	Naha Bay; SE Alaska	-	164	-	6.1°C	Vaughn 1941
	Drier Bay; SE Alaska	-	40-50	-	-	Durham 1947
	Yes Bay; SE Alaska	-	-	-	9.7°C	Durham 1947
	Tree Is., Slocum Arm Chichagof Is., (AB 73-158); SE Alaska	57°30' N; 136°00' W	10	-	Bed rock	AB*
	Sumner St.; SE Alaska	-	370-440	-	-	Vaughn 1941

Appendix 2. (continued)

Species	Location	Latitude; Longitude	Depth (m)	Method of Collection	Physical and Biological Data	Reference
	Mountain Pt.; SE Alaska	-	10-14	Hand	Rocky	Kathy Casson Pers. Comm.
	Two Moon Bay; Fort Fidalgo	-	80	-	-	UA*
	Port Wells; Alaska	-	-	-	-	UA*
	Port Valdez; Alaska	-	3-10	-	-	-
	Feder #R23	60°22'24"N; 147°00'00"W	73	-	-	-
	Feder #R4	60°21'30"N; 147°04'00"W	67	-	-	-
Class Hydrozoa Order Stylasterina Family 23. <u>Allopora campyleca</u>	Albatross #3480; Amukta Pass; Aleutian Is.	52°06' N; 171°45' E	566	Beam trawl	Rocky, black sand; 37-38°F	Fisher 1938
	Albatross #2852; Shumagin Is.	55°15' N; 159°37' W	116	Beam trawl	Black sand; 41.8°F	Fisher 1938
	Albatross #2858; Gulf of Alaska	58°17' N; 148°36' W	460	Beam trawl	Blue mud, gravel; 39.8°F	Fisher 1938
	Albatross #3599; Bering Sea	52°05' N; 177°40' W	110	Beam trawl	Rocks, shells, fine sand	Fisher 1938
	Albatross #4230; Vicinity Naha Bay; Behm Canal; (5 mi. from Indian Pt.; N 70°E), SE Alaska	-	216-480	Beam trawl	Rock; 42.4°F	Fisher 1938
	Albatross #4302; Off Shakan, Sumner St.; Pt. Amelius (S. 8 mi; s 80°W), SE Alaska	-	338-424	Beam trawl	Blue mud; 44.2°F	Fisher 1938

Appendix 2. (continued)

Species	Location	Latitude; Longitude	Depth (m)	Method of Collection	Physical and Biological Data	Reference
Allopora campyleca paragea[1]	Albatross #4245; Kasaan Bay; P of Wales Is.; center of Round Is. (4 mi. S 10°W), SE Alaska	-	190-196	Beam trawl	Dark green mud, sand, shells, rocks; 48.9°F	Fisher 1938
	Near Sitka	-	-	Shrimp dredge	-	Fisher 1938
	Near Juneau	-	-	-	-	Fisher 1938
Allopora campyleca trachystoma	Albatross #4784; E. Cape; Allu. Is.; S 18°W, 4 mi., Aleutian Is.	52°55'42"N; 173°26' E	270	Beam trawl	Coarse pebbles	Fisher 1938
Allopora campyleca tylota[2]	Albatross #4781 S.E. of Agattu Is., Aleutian Is.	52°14.5' N; 174°13' E	964	Beam trawl	Fine gray sand, pebbles; 38.6°F	Fisher 1938
24. *Allopora moseleyana*	Albatross #4781 SE of Agattu Is., Aleutian Is.	52°14.5' N; 174°13' E	964	Beam trawl	Fine gray sand, pebbles; 38.6°F	Fisher 1938
Allopora moseleyana forma leptostyla	Albatross #3480; Amukta Pass, Aleutian Is.	52°06' N; 171°45' N	566	Beam trawl	Rocks, black sand; 37-38°F	Fisher 1938
25. *Allopora papillosa*	Unga, Shumagin Is., Gulf of Alaska	-	-	-	-	Dall 1884
26. *Allopora petrogapta*	Kyack Is., Sitka, SE Alaska	-	0	Hand	Forms thin crust on rocks exposed to surf	Fisher 1938
27. *Allopora polyorchis*	Albatross #3480; Amukta Pass, Aleutian Is.	52°06' N; 171°45' W	566	Beam trawl	Rocks, black sand; 37-38°F	Fisher 1938
23-27. *Allopora* spp.	Feder #8	59°00'18"N; 152°11'36"W	117	Pipe dredge	1 specimen/1 gm.	NODC*

Appendix 2. (continued)

Species	Location	Latitude; Longitude	Depth (m)	Method of Collection	Physical and Biological Data	Reference
	Feder #9	59°08'24"N; 152°04'12"W	142	Pipe dredge	1 specimen/10 gms.	NODC*
	Feder #9	59°08'24"N; 152°04'12"W	142	Pipe dredge	1 specimen/10 gms.	NODC*
	Feder #11	59°06'00"N; 152°20'00"W	115	Pipe dredge	-	NODC*
	Feder #14	59°22'36"N; 152°09'24"W	81	Pipe dredge	1 specimen/10 gms.	NODC*
	Feder #29	59°22'36"N; 152°09'24"W	80	Pipe dredge	9 specimens	NODC*
	Feder #47	59°33'06"N; 152°13'42"W	68	Pipe dredge	1 specimen/2 gms.	NODC*
	Feder #71	59°15'30"N; 152°10'42"W	110	Pipe dredge	1 specimen/3 gms.	NODC*
	Albatross #3480; Amukta Pass, Aleutian Is.	52°06' N; 171°45' N	566	Beam trawl	Rocks, black sand; 37-38°F	Fisher 1938 Dall 1884
28. *Cypthelia trophostega*	Albatross #3480; Amukta Pass, Aleutian Is.	52°06' N; 171°45' N	566	Beam trawl	Rocks, black sand; 37-38°F	Fisher 1938 Dall 1884
29. *Distichopora borealis*	Albatross #3480; Amukta Pass, Aleutian Is.	52°06' N; 171°45' N	566	Beam trawl	Rocks, black sand; 37-38°F	Fisher 1938 Dall 1884
	Albatross #4781 S.E. of Agattu Is., Aleutian Is.	52°14.5' N; 174°13' E	964	Beam trawl	Fine gray sand, pebbles; 38.6°F	Fisher 1938
30. *Errinopora nanneca*	Albatross #3599; Bering Sea	52°05' N; 177°40' W	110	Beam trawl	Rocks, shells, fine sand	Fisher 1938
	Albatross #4777; Petrel Bank, Bering Sea	52°11' N 179°49' E	86-104	Beam trawl	Gravel	Fisher 1938

Appendix 2. (continued)

Species	Location	Latitude; Longitude	Depth (m)	Method of Collection	Physical and Biological Data	Reference
31. *Errinopora zarhyncha*	Albatross #3480; Amukta Pass, Aleutian Is.	52°06' N; 171°45' W	566	Beam trawl	Rocks, black sand; 37-38°F	Fisher 1938 Dall 1884
32. *Stylaster cancellatus*	Albatross #3480; Amukta Pass, Aleutian Is.	52°06' N; 171°45' W	566	Beam trawl	Rocks, black sand: 37-38°F	Fisher 1938 Dall 1884
33. *Stylaster elassotomus*	Albatross #4781: S.E. of Agattu Is., Aleutian Is.	52°14.5' N; 174°13' E	964	Beam trawl	Fine gray sand, pebbles; 38.6°F	Fisher 1938
34. *Stylaster gemmascens alaskanus*	Albatross #3480; Amukta Pass, Aleutian Is.	52°06' N; 171°45' N	566	Beam trawl	Rocks, black sand; 37-38°F	Fisher 1938 Dall 1884

* Unpublished records:
- AB - Auke Bay Fisheries Laboratory
- CAS - California Academy of Sciences
- NODC - National Oceanic and Atmospheric Administration Data Center
- UA - University of Alaska
- USNM - United States National Museum

** Location not present on maps

1 A southern, shallow-water race

2 A deep-water race

? Identification uncertain

Appendix 3. Distributional records of red trees (Primnoa).

Location	Latitude; Longitude	Depth (m)	Method of Collection	Physical Data	Biological Data	Reference
Aleutian Islands						
Amchitka	-	-	-	-	-	USNM*
Cape Cheerful	54°04'N; 166°35'W	140-160	Otter trawl	Rocky	Cod, perch	George Fulton Pers. Comm.
Is. of Four Mts.	52°40'N; 169°45'W	50-70	Crab pot	Rocky	Other corals	Stanchfield Pers. Comm.
Seguam Pass	52°10'N; 173°15'W	90-160	Otter trawl	Shale hard	Other corals	Stanchfield Pers. Comm.
Kodiak Island						
Izhut Bay	58°10'N; 152°15'W	180	-	-	-	Joseph Terry Pers. Comm.
Kazakof Bay	58°05'N 152°50'W	160	Beam trawl	Rocky substrate	-	Douglas Hall Pers. Comm.
Kiliuda Bay	57°15'N	120	Drag	-	-	Sam Franklin Pers. Comm.
Paramanoff Bay	58°18'N; 152°56'W	100-140	Shrimp Net	Rocky along steep edges	-	Charles King Pers. Comm.
Paramanoff Bay	58°18'N; 52°54'W	110	Otter trawl	Rocky substrate	Shrimp	James M. Miller Pers. Comm.
Paramanoff Bay	58°20'N; 153° W	100	Otter trawl	Sand, shell	Shrimp	Jim Bell Pers. Comm.
Paramanoff Bay	58°18'N; 152°55'W	120	Bottom trawl	Mud, rocks	King crab, tanner crab, shrimp, cod, herring, flounder, pollock	Mark Chandler Pers. Comm.
Paramanoff Bay	58°18'N; 152°53'W	120	Beam trawl	Rocky substrate	Shrimp, crab	Douglas Hall Pers. Comm.
Paramanoff Bay	58°18'N; 152°55'W	120	Shrimp trawl	-	Shrimp, halibut, candle fish, king crab, tanner crab	Mark Barham Pers. Comm.
Perenosa Bay	58°30'N; 152°20'W	30	-	-	-	Joseph Terry Pers. Comm.

Appendix 3. (continued)

Location	Latitude; Longitude	Depth (m)	Method of Collection	Physical Data	Biological Data	Reference
Kodiak Island (continued)						
Shelikof Strait, near Cape Ugat	58°00'N 153°47'W	240	Drag	-	-	Sam Franklin Pers. Comm.
Shelikof Strait,	58°10'N; 153°45'W	174	-	-	-	Joseph Terry Pers. Comm.
Shuyak Is., southeast of	58°28'N; 152°22'W	142	Drag	-	-	Sam Franklin Pers. Comm.
Two-headed Is. southeast of	56°50'N	100	Drag	-	-	Sam Franklin Pers. Comm.
Tolstoi Pt. (3 mi. off), Tonki Bay	58°30'N; 152° W	160	Long line	Sand bottom	Scallops	Bud Anderson Pers. Comm.
Uganik Bay	57°45'N; 153°22'W	40-160	Otter trawl	Rocky	Shrimp	James M. Miller Pers. Comm.
Uganik Bay	57°45'N; 153°30'W	100	Bottom trawl	Mud and rocks	King and tanner crab, shrimp, herring, cod, pollack, flounder	Mark Chandler Pers. Comm.
Uganik Is., Northeast Arm	57°45'N; 153°22'N	120	Beam trawl	Rocky	Shrimp, crabs	Douglas Hall Pers. Comm.
Uganik Bay	57°45'N; 153°50'W	80	Shrimp trawl	Sand	Shrimp, halibut, candlefish, king and tanner crab	Mark Barham Pers. Comm.
Uganik Bay	57°45'N; 153°23'W	120	Drag	Sand	-	Sam Franklin Pers. Comm.
Uganik Bay, near West Pt.	57°50'N; 153°40'W	-	-	Coarse brown shell, sand, some mud	-	Bart Eaton Pers. Comm.
Uganik Bay, near Miners Pt.	57°55'N;	-	-	-	-	Bart Eaton Pers. Comm.
Uganik Bay	57°45'N	-	-	-	-	Joseph Terry Pers. Comm.

Appendix 3. (continued)

Location	Latitude; Longitude	Depth (m)	Method of Collection	Physical Data	Biological Data	Reference
Kodiak Island (continued)						
Uyak Bay	57°40'N	40-160	Otter trawl	Rocky	Shrimp	James Miller Pers. Comm.
Uyak Bay	57°42'N; 154° W	100-120	Otter trawl	Soft	Shrimp	Jim Bell Pers. Comm.
Uyak Bay	57°30'N; 153°55'W	160	Otter trawl	-	-	Jim Bell Pers. Comm.
Uyak Bay	-	-	-	-	-	Joseph Terry Pers. Comm.
Kenai Peninsula						
Chugach Is., southeast of	59°03'N; 151°13'W	88	-	Mud, gravel	-	Sam Franklin Pers. Comm
Chugach Passage	59°11'N; 151°47'W	110	Otter trawl	Rocky	Crab	Fred Currier Pers. Comm.
Day Harbor (AB 70-270)	58°54'N; 149°10'W	186	-	-	-	Bruce Wing Pers. Comm.
Flat Is., S. to Elizabeth Is.	59°15'N; 152°00'W	34-52	Long line	Rocky, sand, and shell	-	Thurman C. Smith Pers. Comm.
Nuka Bay and Passage (East and North Arm)	-	80-220	Otter trawl	Rocky	Shrimp, fish	Fred Currier Pers. Comm.
Nuka Passage	59°18'N; 150°50'W	-	Otter trawl	Mixed	Shrimp, fish	Fred Currier Pers. Comm.
Nuka Bay (N. Arm)	59°28'N; 150°35'W	-	Otter trawl	-	Shrimp, fish	Fred Currier Pers. Comm.
Nuka Bay (N. Arm)	59°34'N; 150°32'W	-	Otter trawl	-	Shrimp, fish	Fred Currier Pers. Comm.
Rocky Bay	59°14'N; 151°25'W	10-80	-	Rocky	-	Sam Franklin Pers. Comm.
Yolik Bay	59°36'N; 150°18'W	130	Otter trawl	Rocky	Spot shrimp, fish	Fred Currier Pers. Comm.

Appendix 3. (continued)

Location	Latitude; Longitude	Depth (m)	Method of Collection	Physical Data	Biological Data	Reference
Northeast Gulf of Alaska						
Alsek Bay, 60 mi. off	58°35'N; 139°50'W	200-220	Long line	Green mud, black sand, hard	-	Darryl P. Olsen Pers. Comm.
Shelf	58°56'N; 140°02'W	180	Otter trawl	-	-	NMFS*
Shelf	59°36'N; 139°54'W	208	Otter trawl	-	-	NMFS*
Shelf	59°32'N; 142°10'W	200	Otter trawl	-	-	NMFS*
Shelf	59°21'48"N; 141°30'78"W	185	Otter trawl	-	-	NMFS*
Shelf	59°01'42"N; 141°02'30"W	348	Otter trawl	-	-	NMFS*
Yakutat Bay, 60 mi. off	59° N; 141° W	190-200	Long line	Hard	-	Darryl P. Olsen Pers. Comm.
Gulf of Alaska	59°42'N; 149°41'W	256-350	Otter trawl	-	-	NMFS*
Gulf of Alaska	59°08'N; 149°41'W	182-192	Otter trawl	-	-	NMFS*
Gulf of Alaska	59°02'N; 150°23'W	154-160	Otter trawl	-	-	NMFS*
Gulf of Alaska	59°26'N; 149°55'W	180-252	Otter trawl	-	-	NMFS*
Gulf of Alaska	59°26'N; 149°28'W	148-156	Otter trawl	-	-	NMFS*
Southeast Alaska - N. Chatham St.						
Chatham St.	57°40'N; 134°43'W	112	Long line	Rocky	-	John Maher Pers. Comm.
Chatham St., nr. Danger Pt.	57°32'N; 134°38'W	88	Long line	-	-	John Maher Pers. Comm.

Appendix 3. (continued)

Location	Latitude; Longitude	Depth (m)	Method of Collection	Physical Data	Biological Data	Reference
Southeast Alaska - N. Chatham St. (continued)						
Chatham St., nr. Gardener Pt.	57°05'N; 134°40'W	112	Long line	Soft	-	John Maher Pers. Comm.
Chatham St., nr. Pt. Gardner	57°00'N; 134°38'W	300	Long line	Hard	-	John Maher Pers. Comm.
Chatham St., nr. Kelp Bay	57°15'N; 134°48'W	318	Long line	Soft	-	John Maher Pers. Comm.
Chatham St., nr Tenakae Inlet	57°43'N; 134°45'W	200	Long line	Hard	-	John Maher Pers. Comm.
Cross Sound	58°07'N; 136°37'W	266	Long line	Rocky	-	John Maher Pers. Comm.
Cross Sound, in Lisianski Inlet	58°06'N; 136°27'W	240	Long line	-	-	John Maher Pers. Comm.
Frederick Sound	57°10'N; 133°53'W	108	Long line	Hard	-	John Maher Pers. Comm.
Frederick Sound	56°55'N; 134°30'W	338	Long line	Soft	-	John Maher Pers. Comm.
Frederick Sound	56°55'N; 134°35'W	544	Long line	Soft	-	John Maher Pers. Comm.
Frederick Sound, nr. Brothers Is.	57°18'N; 133°56'W	80-100	Trawl	Rocky pinnacle	Pollock	E.G. Westman Pers. Comm.
Frederick Sound, Petersburg area	56°50'N; 132°56'W	21-30	Beam trawl	-	-	USNM*
Icy St.	58°08'N; 135°00'W	200	Long line	-	-	John Maher Pers. Comm.
Stephens Passage, 1-2 mi. N Five Fingers Light	57°18'N; 133°38'W	80-100	Trawl	Rocky pinnacle	Pollock	E.G. Westman, Pers. Comm.

Appendix 3. (continued)

Location	Latitude; Longitude	Depth (m)	Method of Collection	Physical Data	Biological Data	Reference
Southeast Alaska - S. Chatham St.						
Chatham St., nr. Cape Ommaney	56°15'N; 134°35'W	672	Long line	Rocky	Hard coral	J. Svensson Pers. Comm.
Chatham St., nr. Kingsmill Pt.	56°45'N; 134°30'W	718	Long line	-	-	John Maher Pers. Comm.
Chatham St., nr. Kingsmill Pt.	56°45'N; 134°27'W	376	Long line	Hard	-	John Maher Pers. Comm.
Chatham St., nr. Port Alexander	56°15'N; 134°35'W	772	Long line	Rocky	-	John Maher Pers. Comm.
Chatham St., nr. Port Malmsloury	56°16'N; 134°20'W	198	Long line	Hard	-	John Maher Pers. Comm.
Chatham St., nr. Red Bluff Bay	56°50'N; 134°40'W	700	Long line	Soft	Hard coral	J. Svensson Pers. Comm.
Chatham St., nr. Tebenkof Bay	56°30'N; 134°24'W	460	Long line	Sand, gravel, rocky	Hard coral	J. Svensson Pers. Comm.
Southeast Alaska - Dixon Entrance						
Dixon Entrance, nr. Cape Chacon	54°35'N; 132°00'W	300	Long line	Rocky	-	John Maher Pers. Comm.
Dixon Entrance, nr. Cape Muzon	54°37'N; 131°45'W	400	Long line	Rocky	-	John Maher Pers. Comm.
Southeast Alaska - Clarence St.						
Behm Canal, nr. Roe Pt.	55°15'N; 131°05'W	400	Long line	Mud	-	John Maher Pers. Comm.
Behm Canal, nr. Smeaton Is.	55°18'N; 130°58'W	286	Long line	Sticky	-	John Maher Pers. Comm.
Clarence St., nr. Barren Is.	54°44'N; 131°20'W	182	Long line	-	-	John Maher Pers. Comm.
Behm Canal, nr. Roe Pt.	55°15'N; 131°05'W	400	Long line	Mud	-	John Maher Pers. Comm.

Appendix 3. (continued)

Location	Latitude; Longitude	Depth (m)	Method of Collection	Physical Data	Biological Data	Reference
Southeast Alaska - Clarence St. (continued)						
Behm Canal, nr. Smeaton Is.	55°18'N; 130°58'W	286	Long line	-	-	John Maher Pers. Comm.
Clarence St., nr. Barren Is.	54°44'N; 131°20'W	182	Long line	-	-	John Maher Pers. Comm.
Clarence St., nr. Cholmondeley Sd.	55°20'N; 132°00'W	444	Long line	Mud	-	John Maher Pers. Comm.
Clarence St., nr. Kindrick Bay	54°52'N; 131°55'W	222	Long line	Rocky	-	John Maher Pers. Comm.
Clarence St., nr. Lemesumer Pt.	55°15'N; 132°20'W	516	Long line	Sand	-	John Maher Pers. Comm.
Clarence St., nr. Moria Rock	55°12'N; 131°55'W	458	Long line	Sand	-	John Maher Pers. Comm.
Clarence St., East 2/3 of from 55°25'N south to 54°25'N, east to 134°W	-	250-700	Long line	Rocky, sand	-	Fred Athorp Pers. Comm.
Sumner Straits	56°18'N; 133°20'W	50-60	Long line	Rocky	-	Karl Robeck Pers. Comm.
Southeast Alaska - Shelf						
Baranoff Is.	56°30'N; 135°30'W	120-	Long line	Rocky, gravel	-	J. Svensson Pers. Comm.
Coronation Is.	55°55'N; 135°10'W	180	Long line	Rocky, gray sand	-	J. Svensson Pers. Comm.
Forrerster Is.	54°43'N; 133°30'W	178	Long line	Sandy	-	John Maher Pers. Comm.
Iphigenia Bay	55°50'N; 134°05'W	300	Long line	Rock	-	J. Svensson Pers. Comm.

* Unpublished Data:
  NMFS - National Marine Fisheries Service
  USNM - United States National Museum

Appendix 4. Distributional records of soft coral (*Gersemia rubiformis*).

Station Number	Latitude; Longitude	Depth (m)	Method of Collection	Density/ Weight	References
Gulf of Alaska					
R23	60°22'29"N; 147°00' W	73	-	-/2 gms.	Jewett and Feder 1976
-	59'51' N; 141°44' W	60	Otter trawl		Jewett and Feder 1976
Bering Sea					
7	64°20' N; 164°40' W	16	Otter trawl	1/1 gms.	NODC*
11	64°21' N; 166°25' W	26	Otter trawl	2/35 gms.	NODC*
15	64°29' N; 167°17' W	33	Otter trawl	1/5 gms.	NODC*
22	64°44' N; 167°16' W	29	Otter trawl	1/5 gms.	NODC*
23	65°16' N; 166°36' W	13	Otter trawl	2/40 gms.	NODC*
25	65°18' N; 167°11' W	12	Otter trawl	7/150 gms.	NODC*
27	65°16' N; 167°52' W	35	Otter trawl	2/50 gms.	NODC*
29	65°47' N; 168°16' W	50	Otter trawl	22/454 gms.	NODC*
61	64°32' N; 163°04' W	18	Otter trawl	1/10 gms.	NODC*
77	56°03'12"N; 165°28' W	142	Otter trawl	-/30 gms.	NODC*
106	58°19'36"N; 163°13' W	36	Otter trawl	1/50 gms.	NODC*
107	57°50'30"N; 162°13'24"W	45	Otter trawl	1/120 gms.	NODC*
108	57°18'18"N; 161°06'24"W	66	Otter trawl	-/135 gms.	NODC*
112	57°56'12"N; 173°01' W	116	Otter trawl	1/10 gms.	NODC*
114	57°35' N; 168°05'42"W	73	Otter trawl	2/11 gms.	NODC*

Appendix 4. (continued)

Station Number	Latitude; Longitude	Depth (m)	Method of Collection	Density/ Weight		References
179	63°51' N; 161°59' W	20	Otter trawl	20/40	gms.	NODC*
181	64°00'10"N; 161°58' W	20	Otter trawl	10/746	gms.	NODC*
184	63°49' N; 161°58' W	15	Otter trawl	3/50	gms.	NODC*
187	64°20' N; 161°58' W	20	Otter trawl	13/250	gms.	NODC*
188	64°11' N; 161°31' W	19	Otter trawl	68/1,362	gms.	NODC*
190	64°09' N; 161°51' W	22	Otter trawl	3/50	gms.	NODC*
203	63°15' N; 167°37' W	38	Otter trawl	23/454	gms.	NODC*
204	63°14' N; 167°05' W	27	Otter trawl	8/170	gms.	NODC*
205	63°15' N; 166°29' W	26	Otter trawl	8/160	gms.	NODC*
206	63°28' N; 166°28' W	27	Otter trawl	130/1,260	gms.	NODC*
207	63°32' N; 167°06' W	30	Otter trawl	1/5	gms.	NODC*
208	63°29' N; 167°40' W	34	Otter trawl	21/420	gms.	NODC*
209	63°32' N; 168°13' W	32	Otter trawl	1/10	gms.	NODC*
211	63°44' N; 167°06' W	33	Otter trawl	10/200	gms.	NODC*
216	64°02' N; 167°10' W	38	Otter trawl	1/10	gms.	NODC*
218	64°01' N; 163°36' W	35	Otter trawl	48/550	gms.	NODC*
219	63°46' N; 166°33' W	32	Otter trawl	4/70	gms.	NODC*
221	64°00' N; 163°49' W	22	Otter trawl	1/15	gms.	NODC*
222	64°09' N; 164°14' W	23	Otter trawl	7/135	gms.	NODC*
223	64°10' N; 163°29' W	22	Otter trawl	1/35	gms.	NODC*

Appendix 4. (continued)

Station Number	Latitude; Longitude	Depth (m)	Method of Collection	Density/ Weight	References
135	65°16' N; 166°36' W	15	Otter trawl	3/65 gms.	NODC*
136	64°11' N; 166°09' W	15	Otter trawl	10/200 gms.	NODC*
139	63°51' N; 165°40' W	23	Otter trawl	2/40 gms.	NODC*
140	63°51' N; 166°04' W	29	Otter trawl	7/150 gms.	NODC*
141	63°40' N; 166°02' W	29	Otter trawl	1/15 gms.	NODC*
143	63°29'27"N; 166°06' "W	25	Otter trawl	15/300 gms.	NODC*
145	63°11' N; 166°05' W	24	Otter trawl	10/200 gms.	NODC*
146	63°10' N; 165°40' W	24	Otter trawl	25/494 gms.	NODC*
148	63°19' N; 165°45' W	25	Otter trawl	36/725 gms.	NODC*
149	63°32' N; 165°43' W	27	Otter trawl	75/1,508 gms.	NODC*
151	63°30' N; 165°21' W	20	Otter trawl	1/30 gms.	NODC*
153	63°50' N; 165°20' W	20	Otter trawl	8/150 gms.	NODC*
154	63°50' N; 165°02' W	20	Otter trawl	1/20 gms.	NODC*
157	63°34' N; 164°58' W	13	Otter trawl	3/65 gms.	NODC*
161	63°50' N; 164°36' W	18	Otter trawl	7/130 gms.	NODC*
169	64°01' N; 163°26' W	23	Otter trawl	522/10,442 gms.	NODC*
170	64°00' N; 163°03' W	21	Otter trawl	240/4,086 gms.	NODC*
172	63°38' N; 163°10' W	16	Otter trawl	1/5 gms.	NODC*
173	63°31' N; 163°10' W	14	Otter trawl	10/15 gms.	NODC*
177	63°49' N; 162°21' W	20	Otter trawl	2/50 gms.	NODC*

Appendix 4. (continued)

Station Number	Latitude; Longitude	Depth (m)	Method of Collection	Density/ Weight		References
224	64°10'10"N; 162°45' W	22	Otter trawl	1/70	gms.	NODC*
226	64°19' N; 162°18' W	19	Otter trawl	9/225	gms.	NODC*
228	64°10' N; 164°14' W	287	Otter trawl	8/160	gms.	NODC*
231	64°20' N; 163°33' W	22	Otter trawl	3/55	gms.	NODC*
232	64°30' N; 163°32' W	19	Otter trawl	2/60	gms.	NODC*
234	64°30' N; 163°55' W	18	Otter trawl	3/20	gms.	NODC*
239	64°19' N;	22	Otter trawl	-/45	gms.	NODC*
244	63°58' N; 163°50' W	20	Otter trawl	23/450	gms.	NODC*
246	-	-	-	19/728	gms.	NODC*
248	63°59' N; 163°49' W	20	Otter trawl	16/601	gms.	NODC*
249	63°59' N; 163°54' W	21	Otter trawl	15/30	gms.	NODC*
252	64°15' N; 166°34' W	29	Otter trawl	18/360	gms.	NODC*
254	64°16' N; 167°50' W	37	Otter trawl	1/30	gms.	NODC*
260	63°14' N; 167°02' W	26	Otter trawl	37/75	gms.	NODC*
261	63°15' N; 167'03' W	27	Otter trawl	72/145	gms.	NODC*
264	63°14' N; 167°02' W	27	Otter trawl	4/70	gms.	NODC*
265	63°14' N; 167°01' W	26	Otter trawl	1/20	gms.	NODC*
-	64°28'30"N; 165°35' W	22	Dredge	-		Hood et al. 1974
-	64°30'30"N; 165°45' W	19	Dredge	-		Hood et al. 1974
-	64°30' N; 165°58' W	22	Dredge	-		Hood et al. 1974

Appendix 4. (continued)

Station Number	Latitude; Longitude	Depth (m)	Method of Collection	Density/ Weight		References
-	64°24'30"N; 165°34'30"W	32	Grab	-		Hood et al. 1974
-	64°25'30"N; 165°34'30"W	22	Grab	-		Hood et al. 1974
-	64°29' N; 165°50'20"W	16	Grab	-		Hood et al. 1974
-	64°24'30"N; 165°45'20"W	30	Grab	-		Hood et al. 1974
-	64°27'12"N; 165°35'12"W	25	Otter trawl	-		Hood et al. 1974
-	64°28'56"N; 165°38'48"W	20	Otter trawl	-		Hood et al. 1974
-	56°00'00"N; 164°01'00"W	93	Otter trawl	-		Feder and Jewett 1980
-	64°28'30"N; 165°25'00"W	24	Dredge	-		Hood et al 1974
Chukchi Sea						
38	66°29' N; 166°43' W	25	Otter trawl	8/20	gms.	NODC*
53	66°30' N; 162°02' W	15	Otter trawl	1/90	gms.	NODC*
56	66°39' N; 162°58' W	15	Otter trawl	1/120	gms.	NODC*
57	66°22' N; 163°21' W	15	Otter trawl	5/3	gms.	NODC*
62	66°31' N; 163°21' W	21	Otter trawl	1/3	gms.	NODC*
63	66°41' N; 163°47' W	25	Otter trawl	4/130	gms.	NODC*
69	67°02' N; 164°10' W	27	Otter trawl	1/30	gms.	NODC*
73	67°46' N; 164°50' W	18	Otter trawl	113/2,270	gms.	NODC*
79	67°14'28"N; 164°13' W	25	Otter trawl	5/100	gms.	NODC*
86	67°47' N; 165°28' W	42	Otter trawl	222/4,429	gms.	NODC*
90	68°03' N; 168°10' W	61	Otter trawl	227/4,540	gms.	NODC*

Appendix 4. (continued)

Station Number	Latitude; Longitude	Depth (m)	Method of Collection	Density/ Weight		References
91	67°48' N; 166°25' W	63	Otter trawl	23/454	gms.	NODC*
92	67°34' N; 168°09' W	49	Otter trawl	227/454	gms.	NODC*
93	67°34' N; 168°07' W	49	Otter trawl	5/100	gms.	NODC*
94	67°02' N; 166°36' W	38	Otter trawl	5/100	gms.	NODC*
104	68°03' N; 167°11' W	64	Otter trawl	5/100	gms.	NODC*
105	67°49' N; 167°52' W	57	Otter trawl	2/45	gms.	NODC*
115	66°52' N; 163°34' W	20	Otter trawl	2/45	gms.	NODC*
125	66°45' N; 167°58' W	31	Otter trawl	2/25	gms.	NODC*
126	66°31' N; 168°00' W	27	Otter trawl	7/150	gms.	NODC*
Beaufort Sea						
WBS-1-CG1	70°14'06"N; 143°23'30"W	7	Otter trawl	-		OSU*
WBS-2-CG2	70°22'54"N; 143°23'30"W	51	Otter trawl	-		OSU*
WBS-2-CG3	70°27'00"N; 143°14'24"W	48	Smith-McIntyre	-		OSU*
WBS-3-CG4	70°41'00"N; 143°42'48"W	464	Otter trawl	-		OSU*
WBS-3-CG5	70°34'36"N; 143°38'00"W	105	Smith-McIntyre	-		OSU*
WBS-5-CG9	70°34'48"N; 144°23'06"W	71	Otter trawl	-		OSU*
WBS-9-CG15	70°33'00"N; 145°40'00"W	50	Otter trawl	-		OSU*
WBS-10-CG16	70°40'48"N; 145°49'06"W	79	Otter trawl	-		OSU*
-	70°42'24"N; 145°17' W	-	-	-		-
WBS-10-CG17	70°50' N; 147°06'12"W	46	Smith-McIntyre	3/.09	gms.	OSU*

Appendix 4. (continued)

Station Number	Latitude; Longitude	Depth (m)	Method of Collection	Density/ Weight		References
-	70°50' N; 147°06'12"W	46	Smith-McIntyre	42/.23	gms.	OSU*
-	70°50' N; 147°06'12"W	46	Smith-McIntyre	4/.28	gms.	OSU*
-	70°50' N; 147°06'12"W	46	Smith-McIntyre	6/.129	gms.	OSU*
-	70°50' N; 147°06'12"W	46	Smith-McIntyre	1/.01	gms.	OSU*
WB-11-CG17	70°51'30"N; 145°17' "W	357	Otter trawl	-		OUS*
WB-17-CG27	70°56' N; 147°19'56"W	50	Smith-McIntyre	5/.01	gms.	OSU*
WB-17-CG27	70°56' N; 147°19'18"W	50	Smith-McIntyre	3/.46	gms.	OSU*
WB-17-CG27	70°56'12"N; 147°24' W	51	Smith-McIntyre	7/.54	gms.	OSU*
WB-17-CG27	70°56'24"N; 147°17'24"W	50	Smith-McIntyre	2/.04	gms.	OSU*
WB-18-CG28	70°59' N; 147°24' W	91	Smith-McIntyre	2/.04	gms.	OSU*
WB-19-CG29	71°08'30"N; 148°00' W	360	Smith-McIntyre	4/.57	gms.	OSU*
WB-19-CG29	70°08' N; 148°00'24"W	355	Smith-McIntyre	2/.24	gms.	OSU*
WB-19-CG29	71°08'54"N; 148°00'48"W	335	Smith-McIntyre	2/.17	gms.	OSU*
WB-22-CG37	71°05'42"N; 148°41' W	55	Otter trawl	3/-	gms.	OSU*
WB-23-CG44	71°01' N; 148°22'42"W	48	Smith-McIntyre	4/.24	gms.	OSU*
WB-27-CG58	71°14'30"N; 147°19'56"W	48	Smith-McIntyre	2/.12	gms.	OSU*
WB-27-CG58	71°14'12"N; 149°22'18"W	717	Smith-McIntyre	9/1.72	gms.	OSU*
WB-27-CG58	71°14'06"N; 149°21'92"W	603	Smith-McIntyre	11/1.09	gms.	OSU*
WB-28-CG60	71°12' N; 149°15' W	63	Smith-McIntyre	-/.13	gms.	OSU*
WBS-29-CG61	71°10' N; 149°18'54"W	51	Smith-McIntyre	1/.01	gms.	OSU*

Appendix 4. (continued)

Station Number	Latitude; Longitude	Depth (m)	Method of Collection	Density/ Weight		References
WBS-29-CG61	71°10' N; 149°18'54"W	50	Smith-McIntyre	1/-	gms.	OSU*
WBS-29-CG61	71°10' N; 149°18'54"W	50	Smith-McIntyre	2/.20	gms.	OSU*

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* Unpublished Data:

NODC - National Oceanographic and Atmospheric Administration Data Center

OSU - Oregon State University, Benthic Research Group (Drew Carey, personal communication)

A SURVEY FOR SPAWNING FORAGE FISH ON THE EAST SIDE OF THE KODIAK ARCHIPELAGO BY AIR AND BOAT DURING SPRING AND SUMMER 1979

by

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Irving M. Warner, and Matthew H. Dick

Alaska Department of Fish and Game

Final Report
Outer Continental Shelf Environmental Assessment Program
Research Unit 552

October 1981

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INTRODUCTION

General Nature and Scope of Study

This project was designed to study aspects of forage fish biology along the eastside of the Kodiak Archipelago from Afognak Island to Sitkinak Island. The results of the project contribute to the data base necessary for an environmental impact statement required by law prior to Outer Continental Shelf (OCS) lease sales.

Specific Objectives

1. Determine the temporal and spatial distribution of spawning by nearshore pelagic forage fishes. Determine age, weight and length relationships of these fish species.

2. Identify spawning substrate commonly used by herring, capelin and other species encountered.

3. Determine density of herring and capelin spawn on substrate.

Forage fish are here defined as herring (*Clupea harengus*), sand lance (*Ammodytes hexapterus*) and any smelt (*Osmeridae*), which in this area includes the capelin (*Mallotus villosus*), eulachon (*Thaleichthys pacificus*) and surf smelt (*Hypomesus pretiosus*).

Relevance to Problems of Petroleum Development

Concern has been expressed over the impact of petroleum development on all finfish resources in the northern Gulf of Alaska, including the Kodiak shelf. Large scale damage to the major forage fish species would probably affect the ecosystem drastically and adversely. This study was funded primarily to assess forage fish vulnerability during a critical time, the spawning period.

Acknowledgements

The following persons contributed to the project: Nell Tsakrios, Kelly Meeusen and Dora Sigurdsson assisted in all aspects of field work, and Meeusen did tabulation and graphic work; Spencer Shaw, with Flirite Airways, piloted all surveys; Winn Brindel, Superintendent of Lazy Bay Cannery, allowed field personnel use of his facility; Joe Terebaso assisted in many ways on Sitkinak Island; Leroy Blondin contributed eulachon specimens and catch information; Jerry McCrary and Jim Blackburn (ADF&G, Kodiak) and Dr. Bill Arvey (ADF&G, Anchorage) edited the final report; Mr. Duane French provided sand lance information.

STUDY AREA

The study area (Figure 1) lies along the eastern shore of the Kodiak Archipelago, within the western Gulf of Alaska. The archipelago consists of Kodiak, Afognak and ten minor islands, from Shytak at the north to Tugidak at the south, with thousands of small islands and rocks. It extends through 2°20' of latitude and is 260 km long.

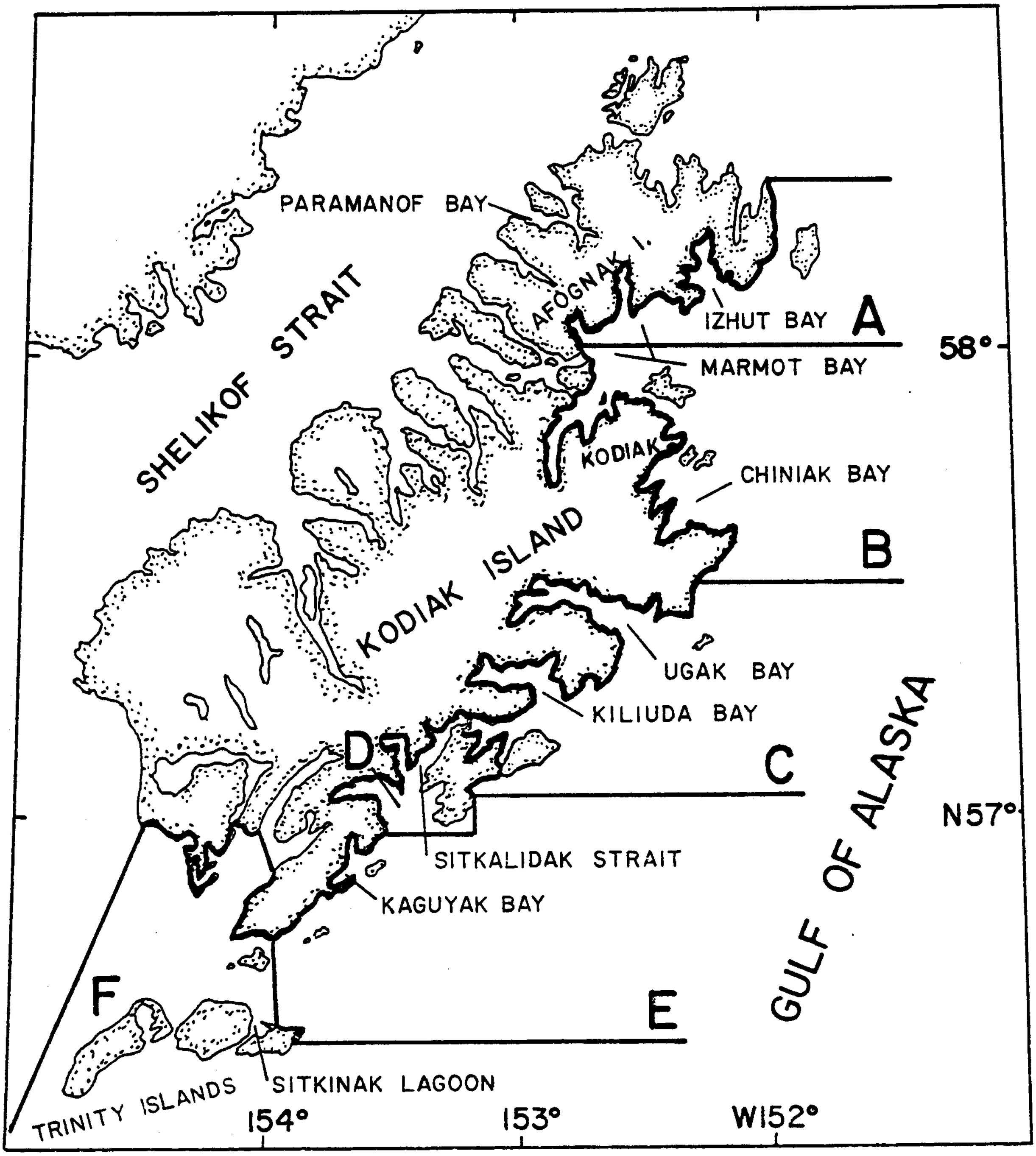

Figure 1. Kodiak Archipelago, Alaska. The study area for the 1979 OCS Forage Fish Project is outlined in black. Letters A-F represent census areas.

The coastline is convoluted with numerous bay systems. The 20 meter (10 fathom) depth contour is generally within 2 - 4 km offshore, although in the Trinity Island group, it extends up to 16 km from shore. In most bays the bottom drops off sharply into troughs which are generally shallower than 200 m. There are numerous sheltered areas, which are advantageous for forage fish spawning. Eelgrass (Zostera marina) beds, common at the estuarine heads of bays throughout the study area, are important as shelter and substrate for spawning herring.

Although the Alaska Stream influences offshore currents, inshore currents along the east side of the archipelago are predominantly tidal, with velocities of 150 cm/sec or more, but with a vector average to the southwest of only 2.5 cm/sec (MacDonald 1979). Tidal amplitudes are in the range of 2 - 4 m. The tide usually floods to the north and ebbs to the south. Storms with high winds are common in the western Gulf of Alaska, especially in winter when sustained velocities can reach 50 to 75 knots (93 - 139 km/hr) with higher gusts. Wave action is severe. The effective fetch to the southwest is on the order of 1,850 km (1,000 nautical miles). Because of the dynamic nature of the water masses adjacent to this area, primary productivity is particularly high, hence conducive to the nurturing of a large biomass of forage fish.

CURRENT STATE OF KNOWLEDGE

Forage fish studies have been conducted by the ADF&G under OCSEAP funding since 1975. Initially the research area consisted of the southern and northeastern Bering Sea. Little was known about any aspect of northeastern Pacific and Bering Sea smelt at that time. In contrast to the smelt, a great deal of information concerning methods, natural history and basic biology existed for Pacific herring. Rounsefell (1929) worked extensively on the biology of herring in the northern Gulf of Alaska. In addition to Rounsefell, there was a wide literature base from three sources: 1) the British Columbia herring fishery, 2) studies in Puget Sound and 3) research and management materials from Southeastern and Southcentral Alaska. Herring fisheries have existed in these areas for nearly a century and it is beyond the scope of this contract to enter into an exhaustive literature review of this species.

There is no standing work on sand lance in the northeastern Pacific, outside of listing occurrence and length frequencies (Blackburn 1978; Harris and Hartt 1977). Various researchers have written on other populations of Ammodytes from around the world, and the best summary of life history information was given by Reay (1970). Trumble (1973) described the extensive commercial fisheries for sand lance in Europe and Japan, and mentioned that large, commercially exploitable quantities probably exist in the northeastern Pacific, particularly the Gulf of Alaska.

Much has been written in the last decade on the impact of oil on herring and other marine fishes. Struhsaker (1977) exposed female herring to low levels of benzene, a soluble component of crude oils, and found that significant reduction occurred in survival of the ova, eggs, embryos and larvae. Exposure to benzene induced premature spawning, aberrant swimming behavior and disequilibrium in both sexes. Kuhnhold (1970) exposed cod, plaice and Atlantic herring to crude oils from different areas of the world and concluded that the effects on the eggs of these fish varied widely depending on the type of crude spilled. He observed that larvae of these species which remained in oil contaminated water had little chance of survival.

Mironov (1970) mentioned the highly toxic effects of oil pollution on marine fishes of the Black Sea, reiterating especially oil's adverse effects on eggs and larvae. Blumber (1969) stated that oil products are absorbed and incorporated into the lipids of fishes and cannot be readily eliminated as long as the animal lives.

The presence of forage fish species within the study area has been well documented during OCSEAP nearshore fish studies, (Blackburn 1978, Harris and Hartt 1977) and their importance as a food base for vertebrate predators has been established (Sanger, et. al. 1978; Baird and Hatch 1979; Krasnow et. al. 1979; Trumble 1973).

A short summary of life histories of forage fish occurring in the Kodiak Archipelago is presented in Table 1.

METHODS

Outline

There were several components to the study:

1) Aerial surveys to determine distribution and abundance of forage fish schools were flown by the project leader.

2) Ground surveys were conducted by two person teams which a) searched on extreme low tides for spawn deposited in areas of suitable intertidal habitat; b) captured forage fish in a number of ways and took length measurements and weights, collected otoliths and scales for ageing, and determined state of maturity by gonad examination.

3) Forage fish data were obtained from several sources other than fishing effort by ground crews: a) samples of herring were taken from commercial purse seine catches by the ground crews when the opportunity arose; b) fish samples were obtained from commercial shrimp trawl catches being unloaded at canneries; c) requests were placed in two newspapers and on two radio stations in the town of Kodiak from May 15 - May 31, asking that the public notify us of any forage fish spawning areas or activity known about or observed in the Kodiak vicinity.

Aerial Surveys

All aerial surveys began and ended in Kodiak City, which is in the northern third of the study area. The east side of the study area was divided into six aerial census areas, lettered A through F (Figure 1). The entire study area was never flown in a single survey due to observer fatigue and fuel limitations. Four to five hours of continuous observation was the maximum survey time. Survey routes were selected opportunistically depending upon weather conditions and logistic needs at the ground sites.

A Cessna 206 float plane was employed for all aerial surveys. Observations were made while flying along the shoreline at an altitude of 330 meters and a speed of 115 knots. Bays and points were rounded so that the actual distance flown was always greater than the straight line distance from the beginning to the end of each survey area. All schools were counted on the first "pass" of the day, a time lasting only a few minutes; this total count was the figure used for that day's survey. Length of survey area and fuel limitations were two elements which ruled out repeated "flybacks", except in those cases where direct counts and/or identification problems (e.g. is it a fish school, or a rock?) required more time than just the initial "pass" afforded the observer. The width of swath observed extended from the shore to approximately one kilometer offshore. The unit of analysis for aerial survey results is schools seen per kilometer flown, as in previous OCSEAP forage fish aerial surveys (Warner and Shafford 1979),

School sizes were broken into subjective categories: "small", "medium", and "large". Small schools are considered to be less than 5 metric tons in size, medium schools from 5 to 15 metric tons, and large schools greater than 15 metric tons. Observations were made through polarized sunglasses, and dictated into a cassette tape recorder. The data were later transcribed onto File Type 057 OCSEAP computer forms. A single flight was considered to be all aerial observations made during a calendar day.

Ground Surveys

Fish sampling and spawn surveys were conducted in five key areas within the study area: Izhut Bay, Chiniak/southern Marmot Bays, Sitkalidak Strait, Alitak Bay, and Sitkinak Lagoon. These key areas were chosen because of their accessability and they adequately represent the northern, central and southern portions of the study area. There were two ground crews, each consisting of a biologist and a technician. One crew remained at Izhut Bay from May 5 to June 20, 1979. That crew returned to Kodiak town in late June and collected forage fish, primarily capelin, from shrimp trawl catches from Alitak Bay being unloaded at canneries. The other crew worked from Sitkalidak Island and vicinity from May 4 - June 3, in lower Alitak Bay and vicinity from June 4 - June 22, and at Sitkinak Island from June 23 - July 13, 1979. The project leader, Warner, worked intermittently in areas near the town of Kodiak accessible by road system, including Monashka, Chiniak and Ugak Bays, from May 1 - June 4 and June 12 - July 1, 1979.

Specimens were collected with the following gear: 1) monofilament, variable-mesh gill net (VMG), 13.5 m long, 3 m deep, in five panels of equal size having 13, 19, 25, 31 and 38 mm bar mesh size, respectively; 2) multifilament, variable-mesh gill net varying from 30 - 40 m in length, from 3 - 5 m deep, in five panels of bar mesh size 13 - 38 mm; 3) tapered beach seines 47 m long, ranging from 0.9 - 4 m deep, with panels of 13 and 38 mm mesh (stretch measure) on each wing, and a cod panel of 6 mm (Figure 2). In addition, dip nets were used for collecting spawning capelin and shovels for digging sand lance and spawn on beaches. All gear was deployed opportunistically at the discretion of crew leaders. Forage fish were measured to the nearest millimeter and weighed to the nearest gram. Herring were measured in standard length and all other fish in fork length (Eddy 1969). Gonad development was judged using the Hjort scale of maturity (Hjort 1914). The index relies mainly on the size of the gonad in reference to the body cavity of the specimen (Table 2).

Table 1.--General information on forage fish in the Kodiak Archipelago.

Species	Peak Spawning Time	Spawning Habitat	Common Nearshore School Size	Longevity (yr) Average	Longevity (yr) Maximum	Adult Size (in)	Commercial Use Alaska	Commercial Use World
Herring	April-May	On marine vegetation in sheltered bays	10 - 15 tons	6	14	8 - 10	Roe Bait Food	Roe Bait Food Meal Oil
Sand lance	October	Gravel beaches with mild surf	1 - 3 tons	3	5	4 - 7	None	Bait Food Meal Oil
Capelin	May-June	Gravel beaches with mild to moderate surf	25 - 500 tons	2	4	5	None	Bait Food Meal Oil
Surf smelt	May-March	Protected sand and gravel beaches[1/]	Less than a ton	2 - 3	?	5 - 9	None	Food
Eulachon	May-June	Up rivers of small to major size	?	3	5	5 - 9	None	Food

[1/] in Puget Sound, Schaefer (1936)

Table 2. Gonad maturity index.

Stage	Key Characteristics
I	Virgin herring. Gonads very small, threadlike, 2-3 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 spents. 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.)

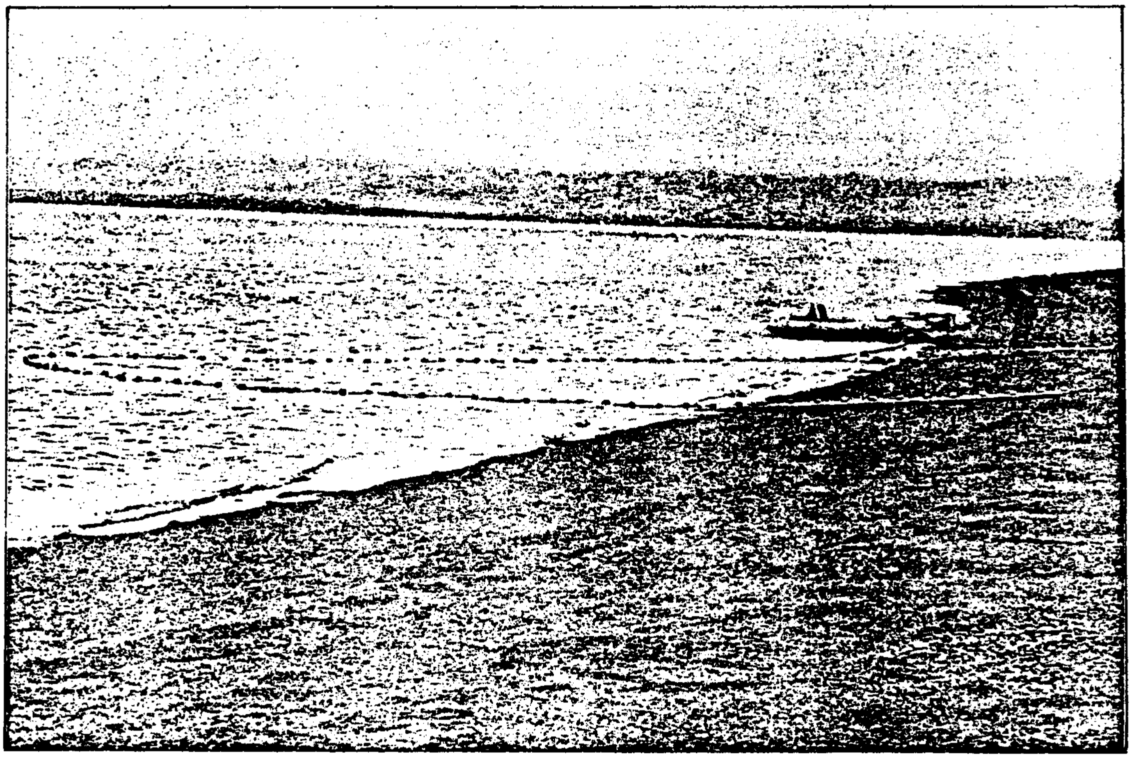

Figure 2 : Sampling for forage fish with Beach Seine, Trinity Islands, 1979.

In order to facilitate the processing (i.e. measuring, weighing, gonad indexing, etc.) of potentially large samples of forage fish obtained by ground crews, each of the five key areas listed at the beginning of this section was considered a "district" for sampling purposes. The fishing season was broken into 10 sampling weeks, beginning on May 1 and ending on July 14. A sampling program was conducted separately for each week a ground crew was present in each of the five districts.

Every week, the initial one hundred specimens of each species taken in a district were all processed; after this, one out of 10 were processed. Every week, a minimum of 75 herring scales and 15 otoliths of each other forage fish species were collected in each district, and more if time permitted. VMG subsamples for processing were taken so as to correctly represent the proportion of fish caught by each panel in a particular set. Total counts or estimates of catches were recorded at all times.

Herring samples from commercial purse seine catches consisted of a bucket or two of fish dipped from the hold of a fishing vessel in a manner so as to equally represent the upper, middle and lower levels of fish in a hold. Care was taken to sample catches from only a single locality or single bay. Commercial samples were taken opportunistically, and were considered separate from the sampling program conducted each week in each district.

Spawn surveys were conducted on foot, or from a small boat during low tides. Searches for herring spawn were conducted on beaches as well as in eelgrass and kelp beds. Samples of substrate were dug and examined for capelin and other forage fish spawn. Presence, extent and density of spawn deposition were noted, and also substrate type utilized. Roe densities were judged using a subjective scale of indices. Data were recorded in the field notebooks and transferred to spawn survey computer forms in camp.

Laboratory Procedures

Herring were aged by the use of scales, the collection and preparation of which has been described previously (Warner and Shafford 1979; Barton, Warner and Shafford 1977). Otoliths dried in envelopes in the field were placed on black plastic otolith cards in 100% glycerin and read under a stereoscopic microscope. Sand lance otoliths were read immediately after glycerin immersion using reflected light. Smelt otoliths required 1 - 3 hours in glycerin before clearing sufficiently to be read using reflected light, and transmitted light was used for verification in some cases. Each otolith was aged by two researchers, and only when the ages agreed were data used. All scales and otoliths were read employing the annulus method (Chuganova 1963; Scott 1973). The outside perimeter of the scale or otolith was counted as the last annulus, and "plus" growth noted when observed.

Data Formating

Data collected on ground surveys, i.e., specimen measurements and collected scales and otoliths, are on record and stored at the office of the ADF&G, Division of Commercial Fisheries, Kodiak, Alaska. As per contract agreement, all OCSEAP aerial survey data have been recorded on magnetic tape according to file type 057 format.

RESULTS

Aerial Surveys

The six census areas were surveyed for a total "in flight" time of 41 hours during 12 different flights. Ninety-two schools of forage fish were seen, 72 of which were not identified to species. Total coastline distance surveyed was 8,811 kilometers. Peak counts of schools seen per kilometer flown occurred in the Chiniak/Marmot Bay complex (census area B), which encompassed the City of Kodiak. Forty-eight percent of all schools counted were observed in this census area. The next highest was in Rolling Bay/Old Harbor (census area D) (Table 3).

Seventy-two percent of all schools fell in the "small" category, which is less than five tons. Biomass figures for forage fish schools are highly subjective and little emphasis is given them due to the imprecision involved.

A summary of aerial survey effort and results by time period are given in Table 4. Only two schools that were sighted were actually spawning, and the period of peak school counts (June 16 through June 30) occurred outside of the optimum spawning period documented by ground activities and catch data. No aerial surveys were flown during census period five (June 5 - June 15) due to inclement weather and aircraft logistic problems. Locations of school concentrations are given in Figure 3.

Eight schools of unusual size were observed on June 26, 1979 about 6 kilometers south of Old Harbor, Sitkalidak Straits (census area C). Field observations concerning this sighting were included in a memorandum to Jack Lechner, Regional Supervisor, ADF&G, Kodiak, Alaska. The following excerpts are taken from that memorandum:

> "On the evening of June 26, 1979 while involved in an aerial survey on my ongoing OCS forage fish project I observed eight extraordinarily large schools of forage fish in Sitkalidak Straits. I was then (aloft in a Cessna 206) at an altitude of 3,500 feet (1,250 meters).....(I) circled the schools numerous times, watching them move and "split" off from one another, often returning to their original shape while the pilot and I watched....The depth of the water (in the area where schools were seen) was 65 fathoms, hence calculating the volume of a cone*.....this would make each school a volume of 2,720,025 cubic yards of sea water. Large concentrations of capelin have been found within a few kilometers during shrimp surveys, and it is my opinion that the biomass of forage fish I observed would be a minimum of 8,500 tons and a maximum of 15,000 tons, though I feel these estimates to be conservative....The Sitkalidak schools I observed on June 26, 1979 were the largest aggregation of forage fish I've observed during the past 3-1/2 years. (Warner, interdepartmental memo, 1979).

During subsequent surveys in this area, no schools were again sighted. Despite observer confidence in the species identification of their sight schools, there are no empirical data from ground crews to make the identification definite.

*It has been observed during acoustic surveys that herring and capelin form cone or "plume" shaped schools, the narrow portion of the "cone" being closest to the surface.

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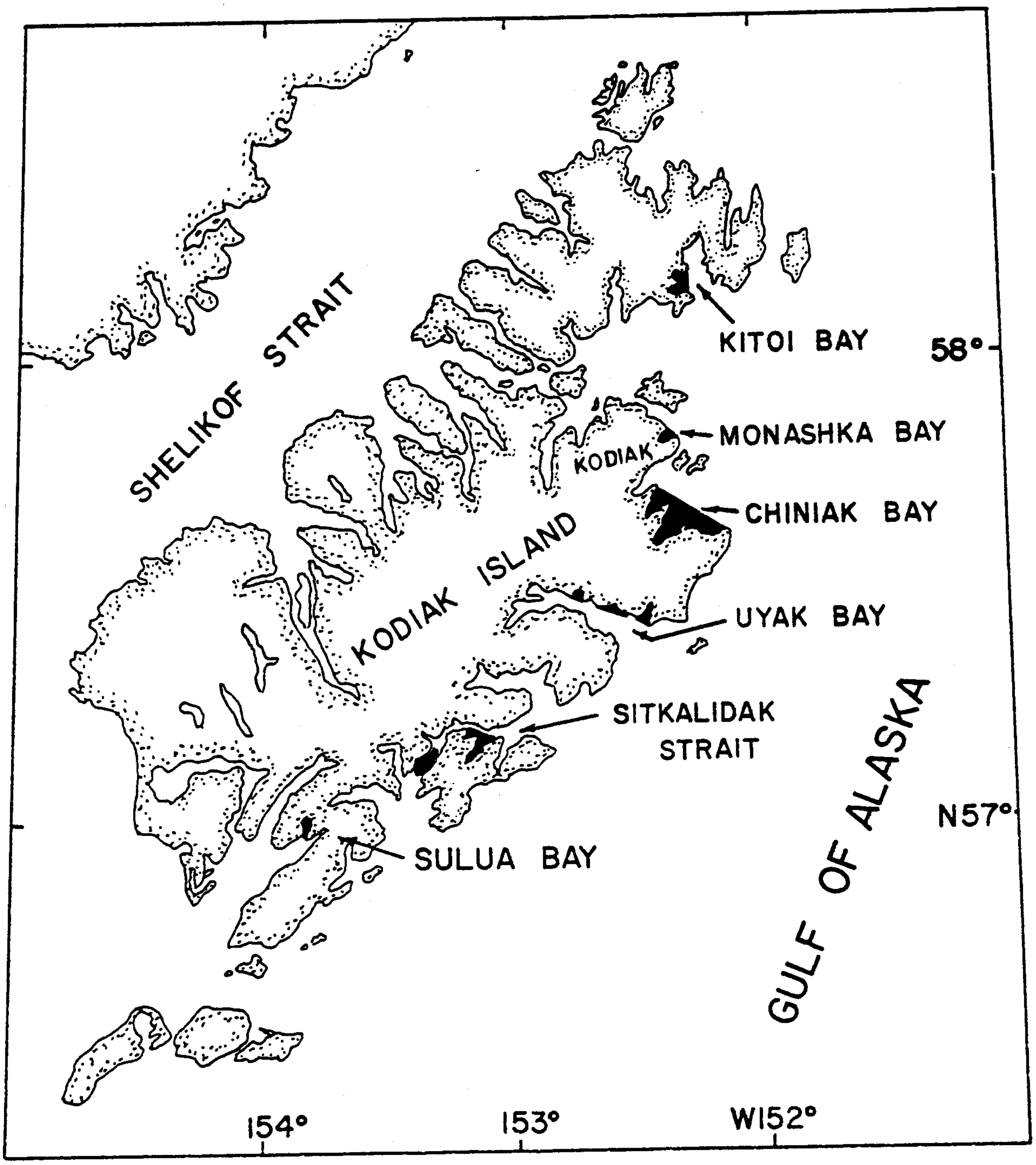


Figure 3. Areas of forage fish school concentrations (black shading) sighted during 1979 aerial surveys.

Spawn Surveys

A total of 125 spawn surveys was conducted at 38 locations (Figures 4 and Table 5). Capelin spawn was located at Monashka Bay, Pillar Creek Beach, and Kalsin Bay (census area B) during the last six days of May. No capelin spawn was found outside these areas. Herring spawn was found at Woman's Bay on June 28 and Pasagshak Bay on May 30 (census area B); Amee Bay on May 20, Barling Bay on May 10, and Three Saints Bay on May 20 (census area D). Spawning herring were observed from the air in Woman's Bay and Sulua Bay. The former observation was made on June 28 and included actually observing milt. The latter observation was made on May 23. Eulachon spawned in Kalsin River during the last week of May. Specimens of eulachon collected by sports fishermen were given to project biologists and subsequent examination disclosed the fish to be flowing, i.e. male and female sex products running freely from the vents.

Capelin spawning substrate results are discussed in the capelin section. Herring spawn was always found on eelgrass with one exception, and that was at Pasagshak Bay where it was found on Desmarestia (hair kelp) washed up along a 200 meter long area in the high tide zone. In a survey conducted 48 hours after the collection of spawning eulachon from Kalsin River, the substrate size was found to be 5 mm to 15 mm and composed of rough stream gravel. During the 48 hour period between the catching of the eulachon and the survey, extreme high water made it impossible to locate spawn or spawned-out eulachon.

Habitat types of sites examined for herring and capelin spawn in the Sitkalidak Island area are shown in Figures 5 and 6. The Sitkalidak area was considered to be representative of the rest of the study area, and more effort in mapping habitat type was expended there than in other areas during post season data analysis. Half the sites where herring spawn or spawning was observed occurred in the Sitkalidak Strait area. Although no capelin spawn was found in the Sitkalidak area, suitable beaches were common.

Pacific Herring

A total of 3,328 herring from five census areas (A, B, C, D, F) on the east side of Kodiak and Afognak Islands were measured, and of these 1,368 were aged. Spawn ready or ripe herring were found in all five areas. Spawn on substrate was found in three of the areas (B, C, D).

Herring caught with VMG in the widely separate areas of Izhut Bay and Sitkalidak Island showed similar mean length at age (Table 6), though different age compositions. At Sitkalidak Island three year old invidivuals dominated while at Izhut Bay five year olds were most numerous (Figures 7 and 8). Herring caught with power purse seine at these two sites were also dissimilar in age composition but showed similar mean lengths at age (Figure 9).

Overall, purse seine results yielded specimens from five census areas: Izhut Bay, Sitkalidak Island, Woman's Bay, Kiliuda Bay, and Sulua Bay (Table 7). VMG results yielded specimens from three census areas, though in area F (Izhut Bay, Sitkalidak Island and Alitak Bay) so few were captured (less than 12) as to make tabularization meaningless. Most herring processed for this study were from three and six years old; 72 percent of all VMG captured herring fell in this bracket, while 95 percent of purse seine herring fell within these four age groups. The youngest herring captured by VMG was 1 year old, while the oldest was 11. Samples of herring captured by purse seine showed the youngest was 2 years old, and the oldest 10.

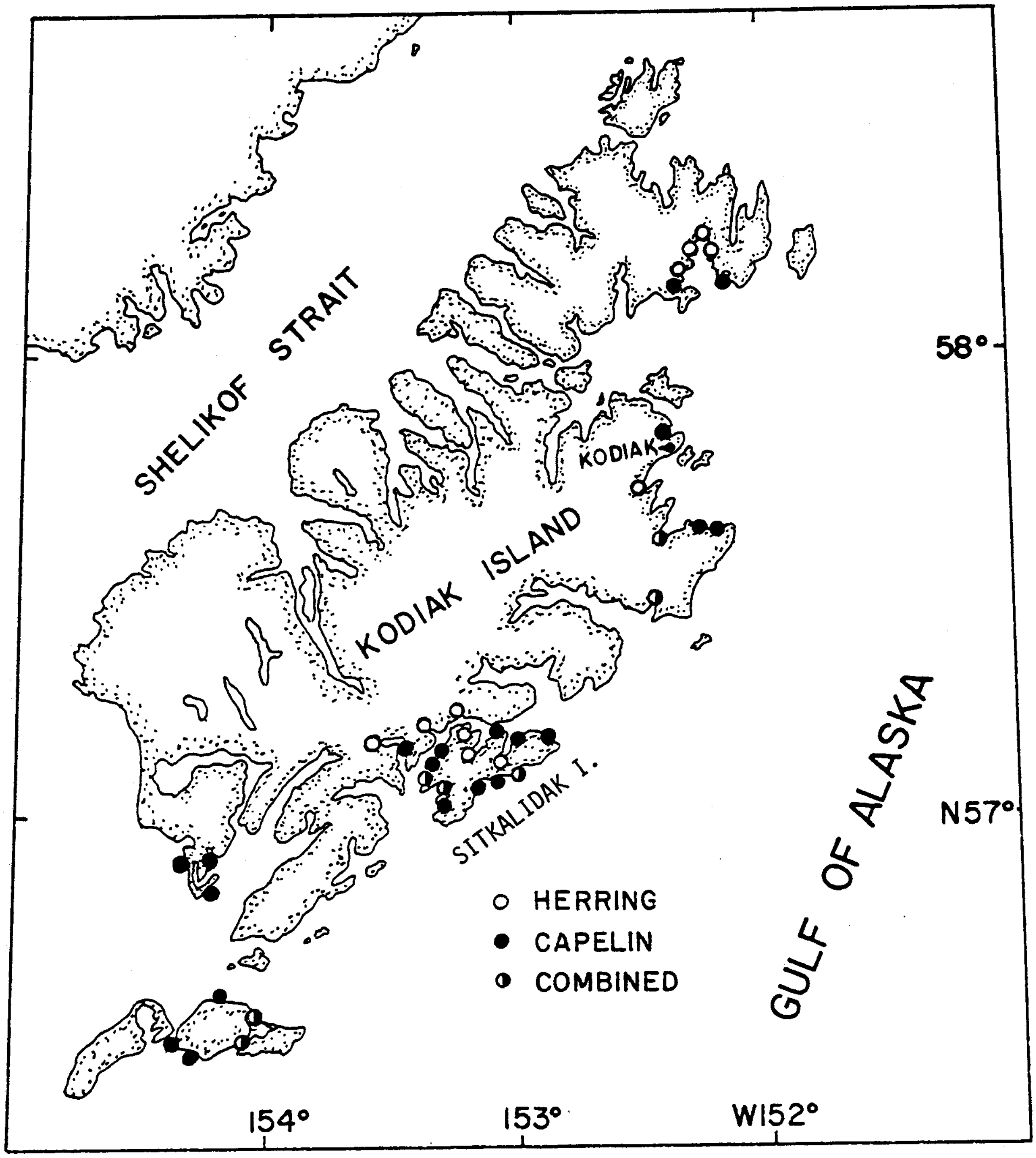


Figure 4. Forage fish spawn survey sites, 1979.

Table 5. Total number of ground surveys for spawning herring and capelin by area, and survey period.

	May					June			July	
Area & Sp.	1-7	8-14	15-21	22-28	29 - 4	5-11	12-18	19-25	26 - 4	5-13	Total
A											
Herring	4	7	2	9	2	1	0	0	0	0	25
Capelin	0	4	0	4	1	10	8				27
B											
Herring	0	0	0	0	0	0	0	0	0	0	0
Capelin	0	0	0	1	1	3					5
C											
Herring	2	7	11	1	0	0	0	0	0	0	21
Capelin	0	0	1	9	3	1					14
D											
Herring	0	1	0	0	1	0	1	0	0	0	3
Capelin	0	0			3	3	5				11
E											
Herring	0	0	0	0	0	0	0	0	0	0	0
Capelin	0	0									0
F											
Herring	0	0	0	0	0	0	0	0	0	4	4
Capelin	0	0						2	13	0	15
Totals	6	19	14	24	11	18	14	2	13	4	125

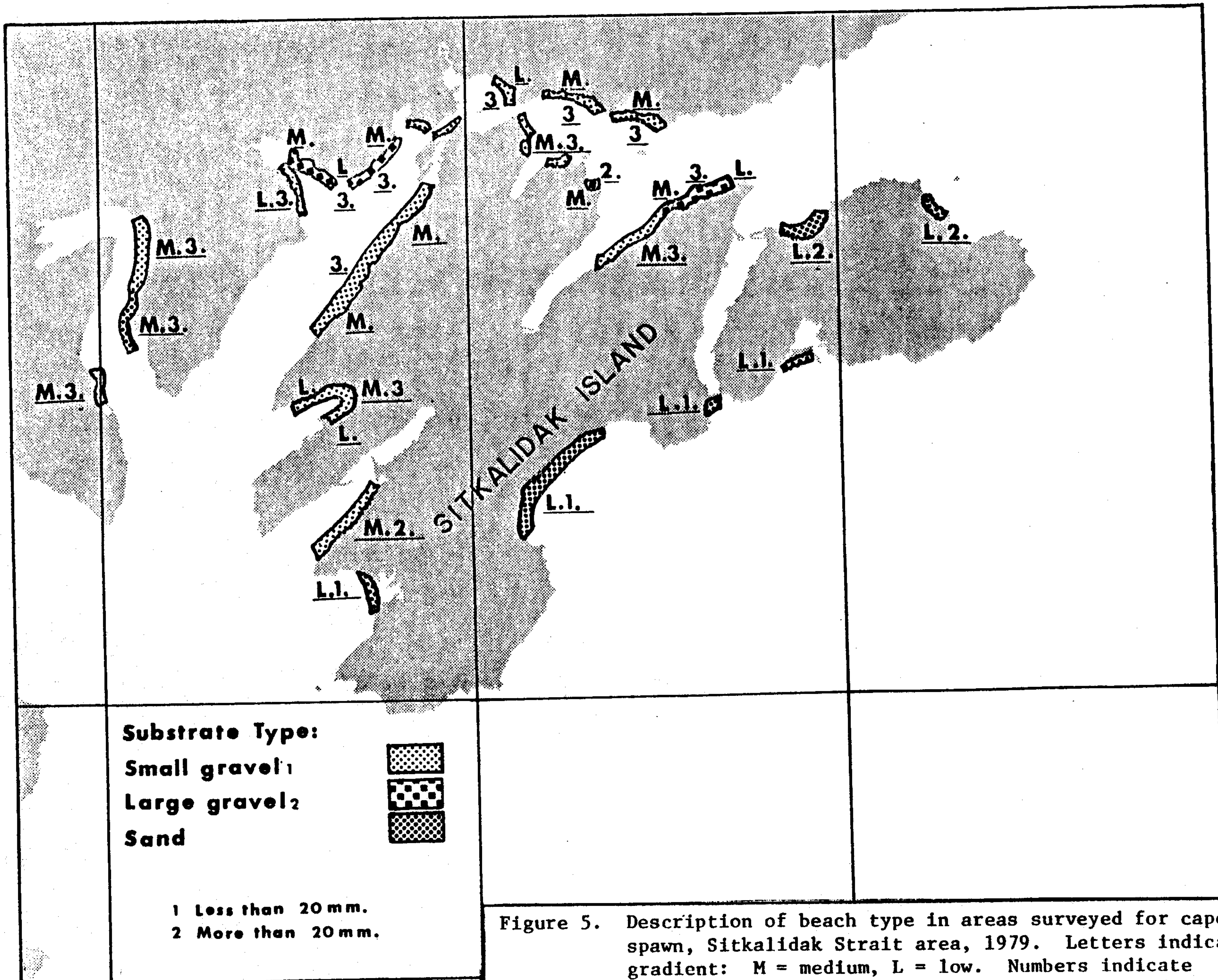


Figure 5. Description of beach type in areas surveyed for capelin spawn, Sitkalidak Strait area, 1979. Letters indicate gradient: M = medium, L = low. Numbers indicate predominant surf condition: 1 = heavy, 2 = medium, 3 = light.

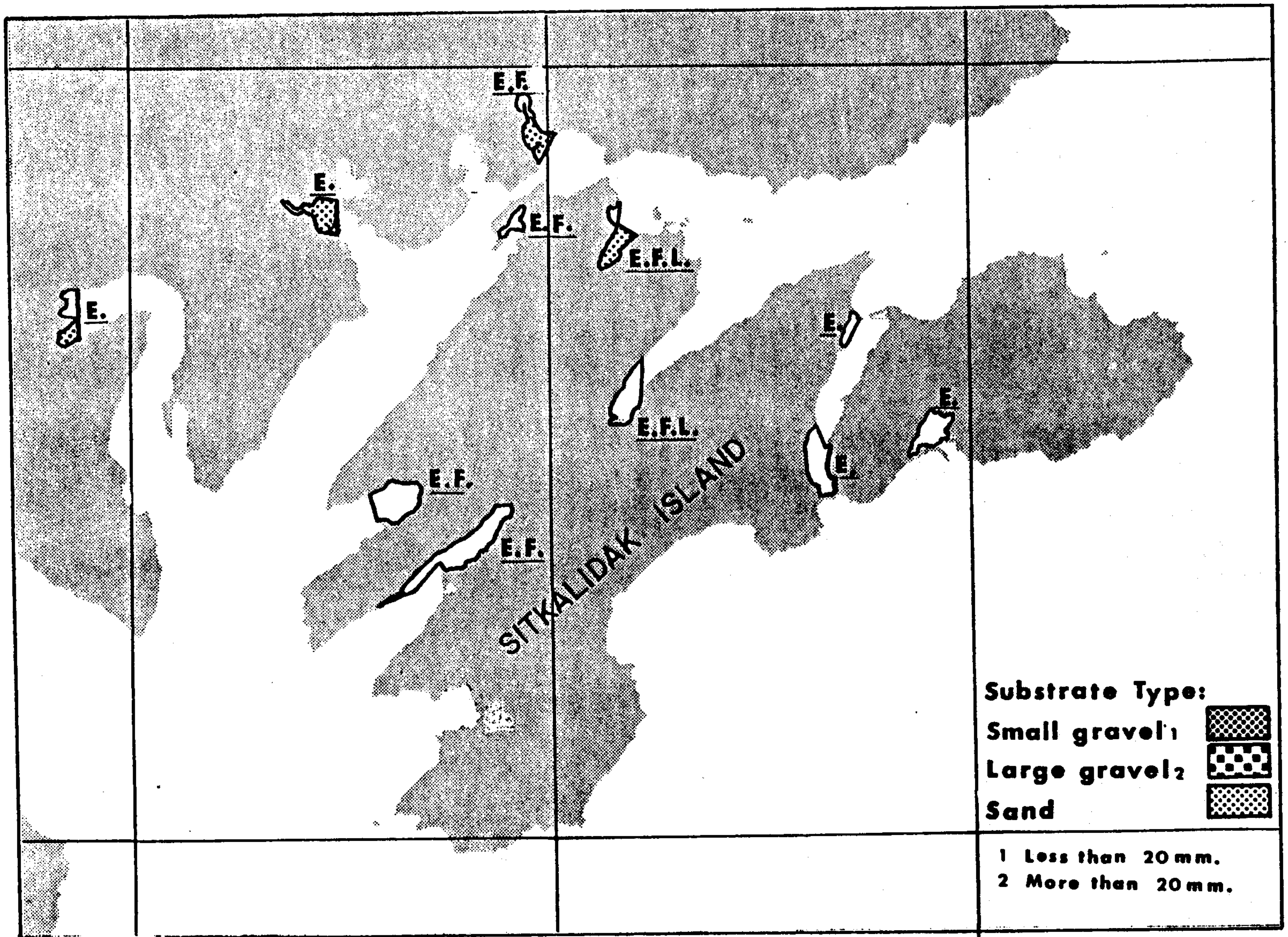


Figure 6. Intertidal areas surveyed for herring spawn, Sitkalidak Island area, 1979. Letters indicate dominant plant species: E = eelgrass (Zostera), F = Fucus, L = Laminaria. Stippling indicates where light herring spawn deposition was observed.

Table 6. Mean lengths and ranges (mm) of herring at age: captured by variable mesh gill net at 2 sites east side of Kodiak Archipelago; May - June, 1979, (number of fish in parenthesis).

Area	Age in Years					
	1	2	3	4	5	6
Izhut Bay[1]						
Mean		173 (88)	200 (32)	222 (22)	230 (80)	239 (29)
Range		148-187	170-219	193-257	178-273	214-281
Sitkalidak Island[2]						
Mean	116 (5)	178 (33)	208 (111)	217 (41)	234 (67)	239 (29)
Range	110-119	164-200	168-246	187-251	202-259	210-258
	7	8	9	10	11	12
Izhut Bay						
Mean	245 (6)	265 (8)	270 (3)	267 (2)	264 (1)	--
Range	236-271	255-279	260-285	265-270	264	--
Sitkalidak Island						
Mean	260 (2)	--	265 (8)	262 (2)	--	--
Range	256-264	--	243-275	258-266	--	--

[1]Overall sample size at Izhut Bay = 271.

[2]Overall sample size at Sitkalidak Island = 298.

Table 7. Mean lengths and ranges in mm of herring at age: captured by commercial purse seine at various sites, east side of Kodiak Archipelago May - June 1979 (number of fish in parentheses).

Area	Age in Years										Sample Size
	1	2	3	4	5	6	7	8	9	10	
Izhut Bay											
Mean	--	--	198(3)	220(12)	227(43)	234(4)	240(1)	255(2)	--		(65)
Range	--	--	187-209	209-230	204-247	222-244	240	244-267	--		
Sitkalidak Is.											
Mean	--	177(7)	198(88)	198(12)	218(7)	--	--	--	--	259(1)	(115)
Range	--	160-215	162-215	174-211	199-246	--	--	--	--	259	
Woman's Bay											
Mean	--	165(13)	192(174)	193(23)	208(6)	213(1)	--	--	--		(217)
Range	--	153-195	146-216	176-216	189-220	213	--	--	--		
Kiliuda Bay											
Mean	--	178(7)	204(121)	212(22)	223(26)	234(6)	223(1)	--	247(1)		(184)
Range	--	169-189	170-236	190-239	201-240	204-260	223	--	247		
Sulua Bay											
Mean	--	--	183(24)	199(27)	211(49)	220(17)	218(1)	--	--		(118)
Range	--	--	171-215	175-229	187-241	194-245	218	--	--		

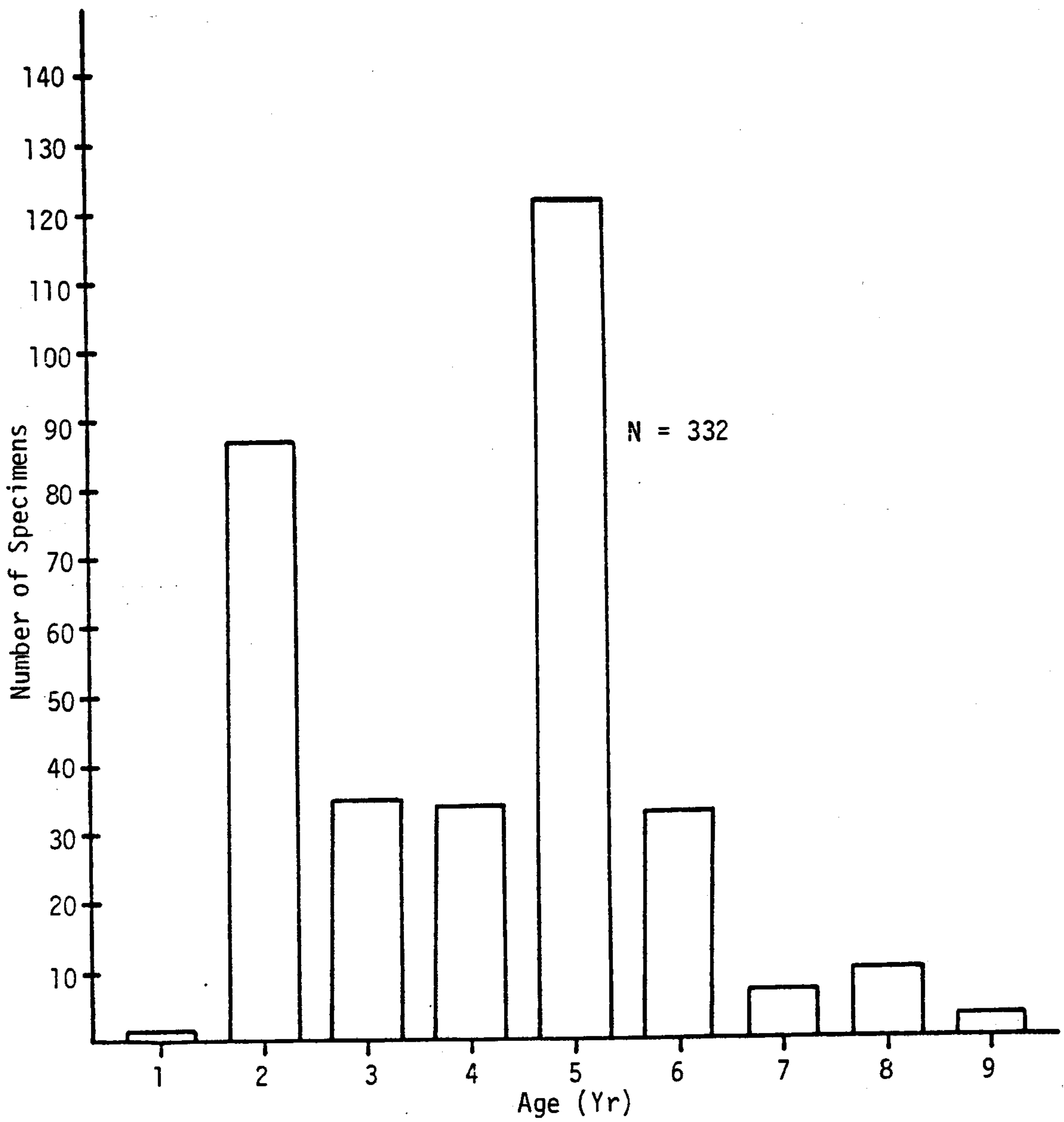


Figure 7. Age frequency distribution of herring (*Clupea harengus pallasi*) captured by variable mesh gill net, Izhut Bay, May-June, 1979.

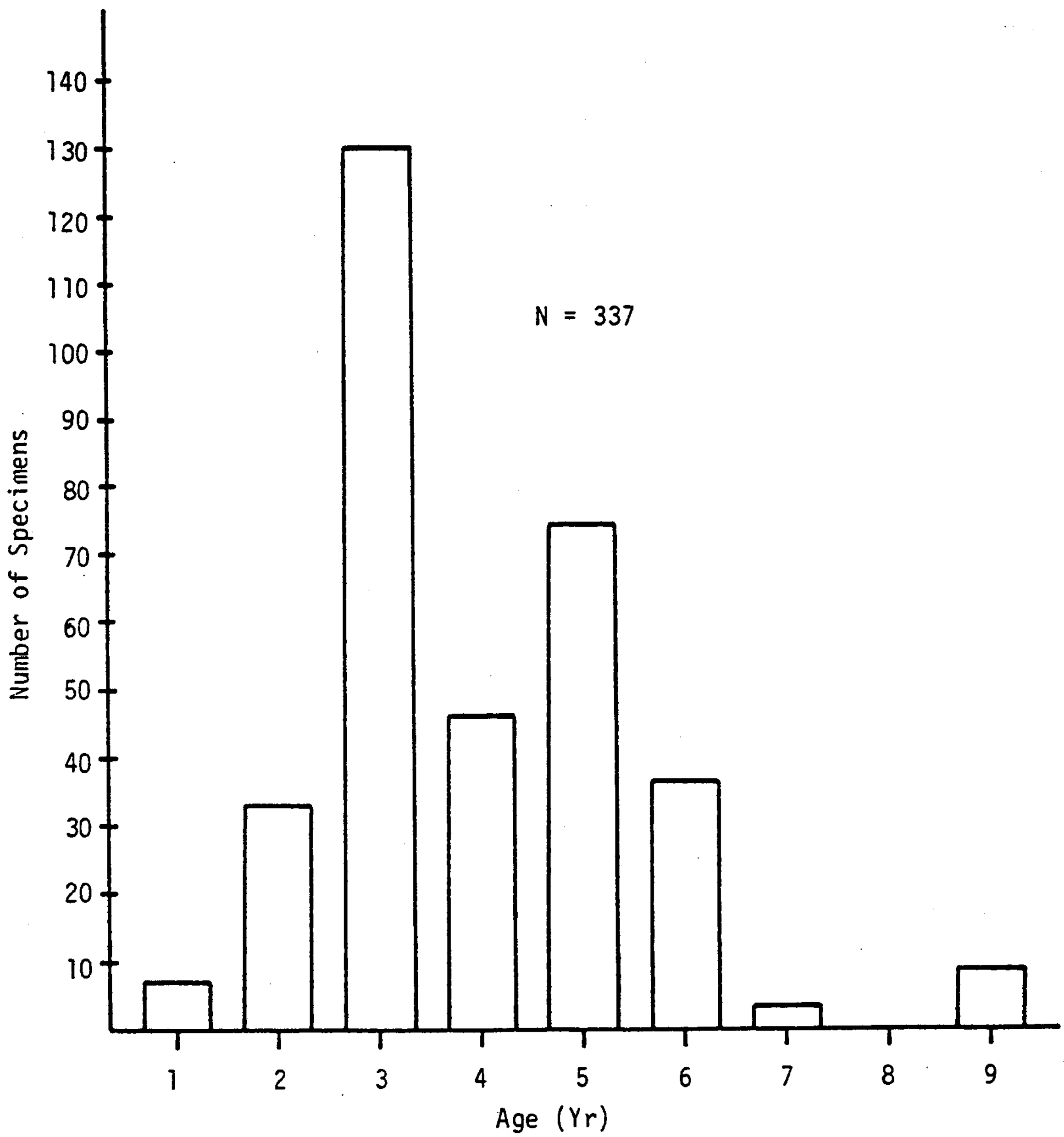


Figure 8. Age-frequency distribution of herring (*Clupea harengus pallasi*) caught by variable mesh gill net, Sitkalidak Island, May-June, 1979.

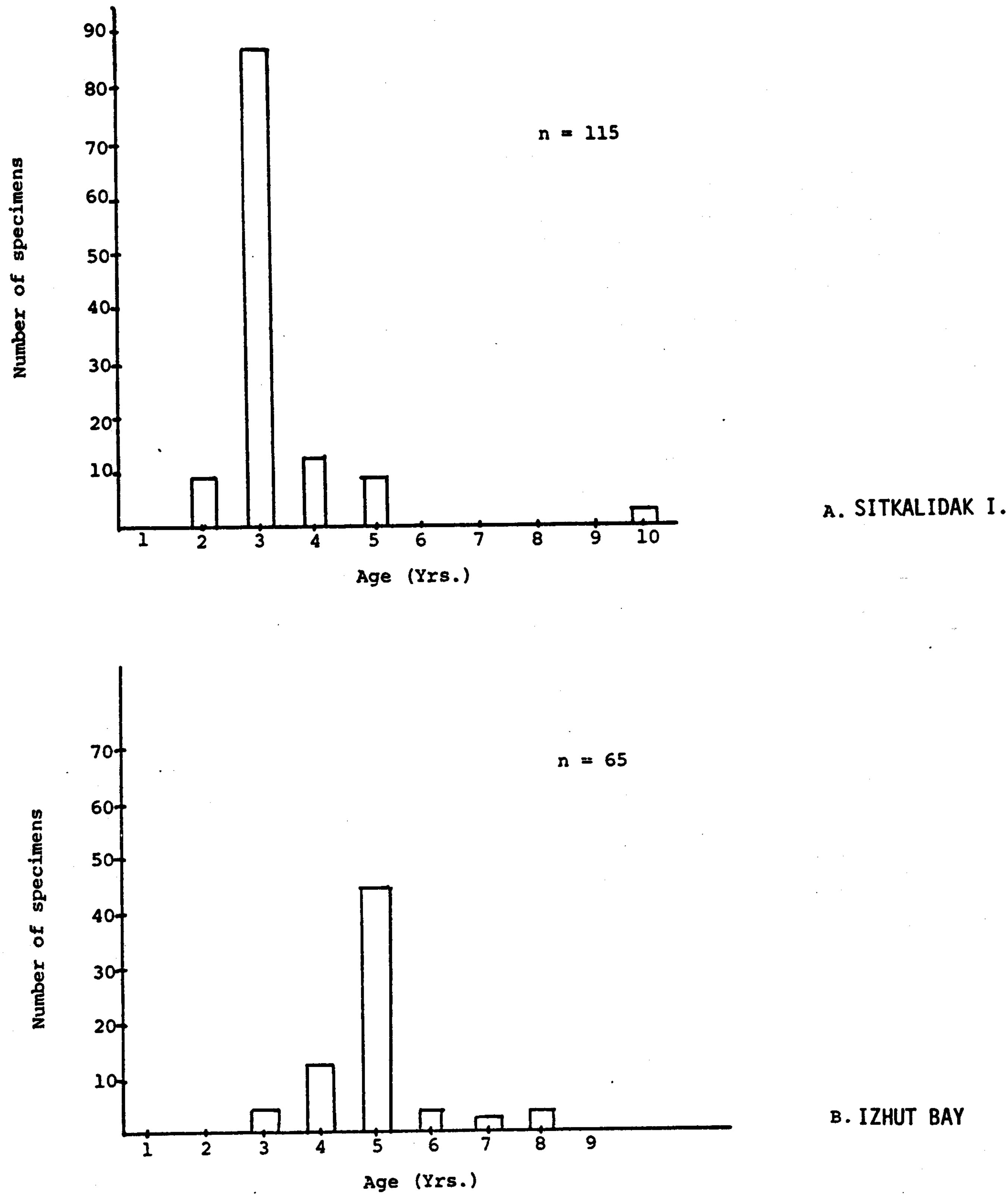


Figure 9. Age-frequency distribution of herring (Clupea harengus pallasi) captured by power purse seine at Sitkalidak (A) and Izhut Bay (B), 1979.

Inspection of herring gonads showed that most specimens mature at age two or three though sexual maturity is essentially complete in Kodiak/Afognak area herring by age four. Ninety percent of 2 year old herring from Izhut Bay reached gonad index 4 or greater, contrasted to Sitkalidak Island where only half of the two year olds were mature. A summary of gonad index values at age is given in Table 8.

Sand Lance

Table 14 shows the sexual maturity of each age class in summer, based on degree of gonad development. Most lance (74%) were of gonad index I. Few of the fish exceeded index III, and none attained index V. There were no indications of summer spawning.

In the fall of 1980, well after the first draft of this report had been prepared, the authors received from Mr. Duane French an account of extensive intertidal spawning by sand lance on the south shores of Ban Island and Paramanof Bay, on the west side of Afognak Island (Figure 1). He collected two specimens, one of each sex, on October 9. Both were in spawning condition, as were most other sand lance he examined on the beaches. There was roe in the gravel on Ban Island, and a cloud of milt which filled a cove 0.4 km wide on the shore of Paramanof Bay. During the three days (October 8 - 10, 1980) which Mr. French spent in Paramanof Bay, sand lance remained adjacent to gravel beaches of the same type utilized in summer. They schooled at high tide (the largest schools estimated at 2 - 3 tons) swimming back and forth at the mouths of small freshwater streams. At low tide, the fish were scattered across the surface of the gravel, heavily preyed upon by crows and gulls. There were many thousands of sand lance exposed to the air, especially in small, relatively moist rivulet-depressions. At the touch, the sand lance became quite active and even exuded sex products. Apparently actual spawning took place at high tide. A few juvenile herring were among the sand lance, indicating their presence in the schools, as reported similarly by Kühlmann and Karst (1967) for *A. tonianus* and *A. lanceolatus*. Schools of sand lance were observed in a brackish lake on the southeast shore of Ban Island. The lake, fed by a freshwater stream and probably receiving saltwater only on extreme high tides, drained across the gravel beach during ebb tide. Sand lance spawned in this drainage despite the strong freshwater influence.

Mr. Jerry McCrary of the Alaska Department of Fish and Game dug sand lance at extreme low tide on October 25, 1980 from beaches at Pillar Creek and Shahafka Cove, all near the town of Kodiak. From a sample of 40 ranging in length from 67 - 150 mm and in age from class 1 - 3, seven fish were in spawning condition. These ranged from 128 - 130 mm in length; two were of age class 3 and five from age class 2. Of the remaining, 21 of age class I and five of age class 2 were of gonad index III or less. Thus, Kodiak sand lance mature at age class 2, though some may mature at age class 3.

Sand lance occurred in forty-five percent of 38 beach seine sets from three widely separate areas: Izhut Bay, Sitkalidak Strait and Sitkinak Lagoon. It was the numerically dominant species in the overall beach seine catch (Tables 9, 10, and 11). Frequency of occurrence and CPUE was greatest in Sitkalidak Strait (54% and 986.4 fish/set) and at least in southwestern Alitak Bay (11% of 18 sets and 0.1 fish/set). Catch results from Sitkinak Island (44% and 43.2 fish/set) and Izhut Bay (38% and 75.9 fish/set) were similar.

Table 8. Hjort relative gonad index at age for herring (*Clupea harengus pallasi*) captured by variable mesh gill net at 2 sites, east side of Kodiak Archipelago, May - June, 1979.

Sitkalidak Island

Index	Age in Years											Total
	1	2	3	4	5	6	7	8	9	10	11	
1	4	1	0	0	0	0	0	0	0	0	0	5
2	1	9	1	0	3	0	0	0	0	0	0	14
3	0	1	9	0	0	0	0	0	3	0	0	13
4	0	15	67	19	24	20	1	0	1	0	0	147
5	0	4	48	25	43	10	3	0	2	0	0	135
6	0	0	1	0	1	1	0	0	0	0	0	3
7	0	0	3	1	3	4	0	0	2	0	0	13
8	0	0	0	0	0	0	0	0	0	0	0	0
Totals	5	30	129	45	74	35	4	0	8	0	0	330

Izhut Bay

Index	Age in Years											Total
	1	2	3	4	5	6	7	8	9	10	11	
1	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0
3	0	1	0	0	1	0	0	0	0	0	0	2
4	0	7	5	16	33	4	0	3	1	0	0	69
5	0	44	29	15	66	21	6	3	1	1	0	186
6	0	0	4	2	16	7	1	2	1	0	0	33
7	0	15	1	1	7	1	0	2	0	1	1	29
8	0	23	1	0	0	0	0	0	0	0	0	24
Totals	0	90	40	34	123	33	7	10	3	2	1	343

Table 9. Summary of beach seine catch, Izhut Bay, May 7 - June 19, 1979. Figures represent 16 sets. X = presence indicated.

Species	Frequency of Occurrence in Sets	% Frequency of Occurrence	Total Number Caught	CPUE (Fish/Set)
Chum salmon fry	1	6	15	0.9
Pink salmon fry	11	69	556+	34.8+
Dolly Varden	2	13	6	0.4
Sand Lance	6	38	1,214	75.9
Sculpins	5	31	11	0.7
Sculpin fry	1	6	X	--
Flounders	2	13	12	0.8

Table 10. Summary of beach seine catch, Sitkalidak Strait, May 7 - June 20, 1979. Figures represent 13 sets.

Species	Frequency of Occurrence in Sets	% Frequency of Occurrence	Total Number Caught	CPUE (Fish/Set)
Herring	1	8	3	0.2
Chum salmon fry	1	8	25	1.9
Pink salmon fry	7	54	240+	18.5+
Unid. salmon fry	1	8	1	0.1
Dolly Varden	4	31	19+	1.5+
Unidentified fry	2	8	7	0.5
All Pricklebacks	2	8	1	0.2
Sand Lance	7	54	12,823	986.4
Greenlings[1]	8	62	88+	6.8+
Sculpins[2]	9	69	121	9.3
Silverspotted sculpin	1	8	77	5.9
adult	1	8	2	0.2
fry	1	8	75	5.8
Tubenose poacher	1	8	1	0.1
Flounders	1	8	11	0.8

[1] Includes at least 35 whitespotted greenling; also, unidentified greenling fry were present in two sets.

[2] Includes 25 unidentified sculpin fry in one set and the silverspotted sculpins listed subsequently.

Table 11.--Summary of beach seine catch, Sitkinak Lagoon, June 25 - July 2, 1979. Figures represent 9 sets.

Species	Frequency of Occurrence in Sets	Percent Frequency of Occurrence	Total Number Caught	CPUE (Fish/Set)
King salmon smolt	3	33	6	0.7
Pink salmon fry	2	22	69	7.7
Chum salmon fry	1	11	4	0.4
Dolly Varden	3	33	12	1.3
Whitespotted greenling	1	22	1	0.1
Greenling fry	4	44	5,006	556.2
Sand lance	4	44	389	43.2
Great sculpin group	5	55	15	1.7
Staghorn sculpin	2	22	2	0.2
Starry flounder	1	11	1	0.1
Rock sole	1	11	2	0.2

At Sitkalidak Strait, sand lance were seined exclusively over beaches of coarse sand 1 - 4 mm in diameter, or fine gravel 5 - 10 mm in diameter, or combinations of the two, with larger pebbles or finer sand commonly present. Sand lance substrate was invariably well drained and well washed, bearing little or no mud. Throughout the study area, beaches of this type were generally dark gray, being derived predominantly from slate. Generally, beaches in bights or coves seemed preferred to beaches on small islands or exposed beaches in straits. Also, moderately long beaches with mild slopes seemed preferred to tiny beaches. In Izhut Bay, the Chiniak-Marmot Bay area and Alitak Bay, sand lance were seined over or found buried in beaches similar to those in the Sitkalidak area.

At Sitkinak Lagoon, sand lance were dug by hand during extreme low tides from gravel bars near the north entrance to the lagoon. The substrate was a loose mixture of fine and coarse slate sand with fine slate gravel to 15 mm in diameter. The flat bars drained via broad, shallow channels ranging from 2 - 15 mm deep and up to 1 m wide. The sand lance were concentrated in and adjacent to these channels.

In no part of the study area were sand lance found buried in beaches of fine, light colored sand, or in sand-mud mixture, several of which were examined by digging at extreme low tides on Sitkalidak Island (Seal Cove, Partition Cove, Ocean Beach, Rolling Bay) and Sitkinak Island (north and south spits). At Sitkinak Island, sand lance were seined above a beach of hard, light colored sand overlaid with varying amounts of fine gravel on the lagoon side shore of the main northern spit which forms the entrance to Sitkinak Lagoon. They were also seined along the steep hard beach of fine sand on the lagoon side of the southern spit, from a tidal current of 3 - 4 knots. Sand lance were never caught or observed along the seaward shores of the spits.

Length measurements were taken on 1,308 sand lance from three census areas: Izhut Bay, Sitkalidak Strait and Sitkinak Lagoon. Length frequencies are presented in Figure 10, and mean lengths at age in Table 12. A growth curve for sand lance at Sitkinak Lagoon is shown in Figure 11. The length frequency histograms from Izhut Bay and Sitkalidak Strait are almost identical and unimodal, but that from Sitkinak Lagoon is bimodal. The mean lengths at age of the Izhut Bay and Sitkalidak Strait samples are not significantly different, as the means are close and the ranges overlap. Using standard error of the difference between two means (Arkin and Colton 1956) we found the mean lengths at age of the Sitkinak and Sitkalidak Strait samples to be significantly different at the 99.7 confidence level (Table 13).

Three hundred eighty-eight sand lance were aged. Six age classes (0 - 5) were found. Very few class 0 fish were caught between May 7 and July 12. A single set made in Narrow Strait a few kilometers from the city of Kodiak on July 22 yielded only age class 0 fish. The mean length of a sample of 40 was 53.8 mm.

The age frequency distributions resulting from the beach seine samples were similar in all areas, with age class 1 predominant, age class 2 much less frequent, and age classes 4 and 5 infrequent (Figure 12). In no area did age class 3 occur in the beach seine samples. The age frequency of the beach seined sample at Sitkinak Lagoon was much different from that of the sample dug from the gravel (Figure 12C). Age class 3 was strong in the gravel sample, and age class 2 was much stronger than in the seine sample. The mean lengths at age from the two samples were not significantly different at the 99.7 confidence interval, though only classes 1 and 2 could be compared.

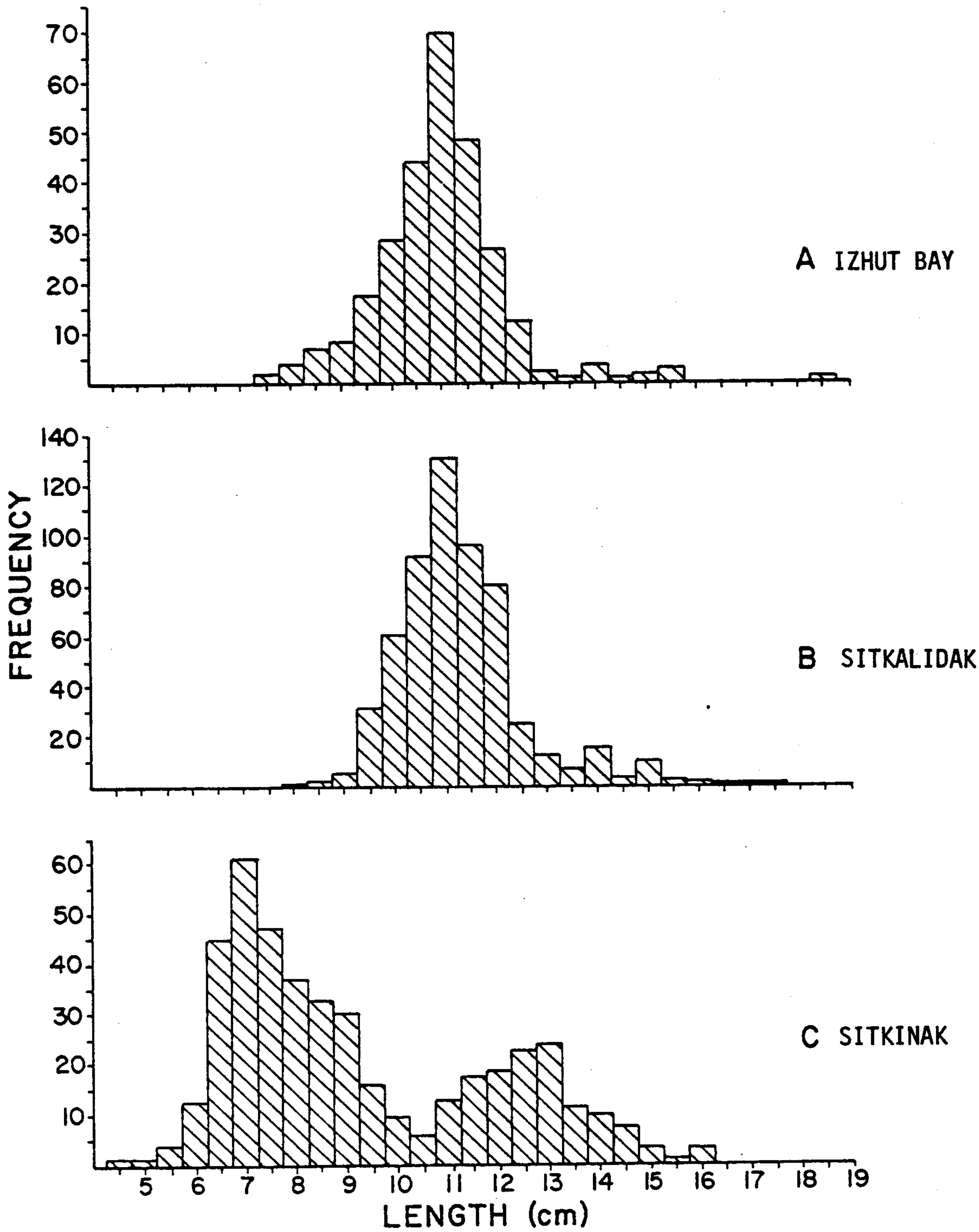


Figure 10. Length-frequency distributions of sand lance (Ammodytes hexapterus) sampled A.) by beach seine at Izhut Bay, May-June, 1979. n = 278. B.) by beach seine at Sitkalidak Strait, May-June, 1979. n = 579. C.) by beach seine and digging at Sitkinak Lagoon, June-July, 1979. n = 451.

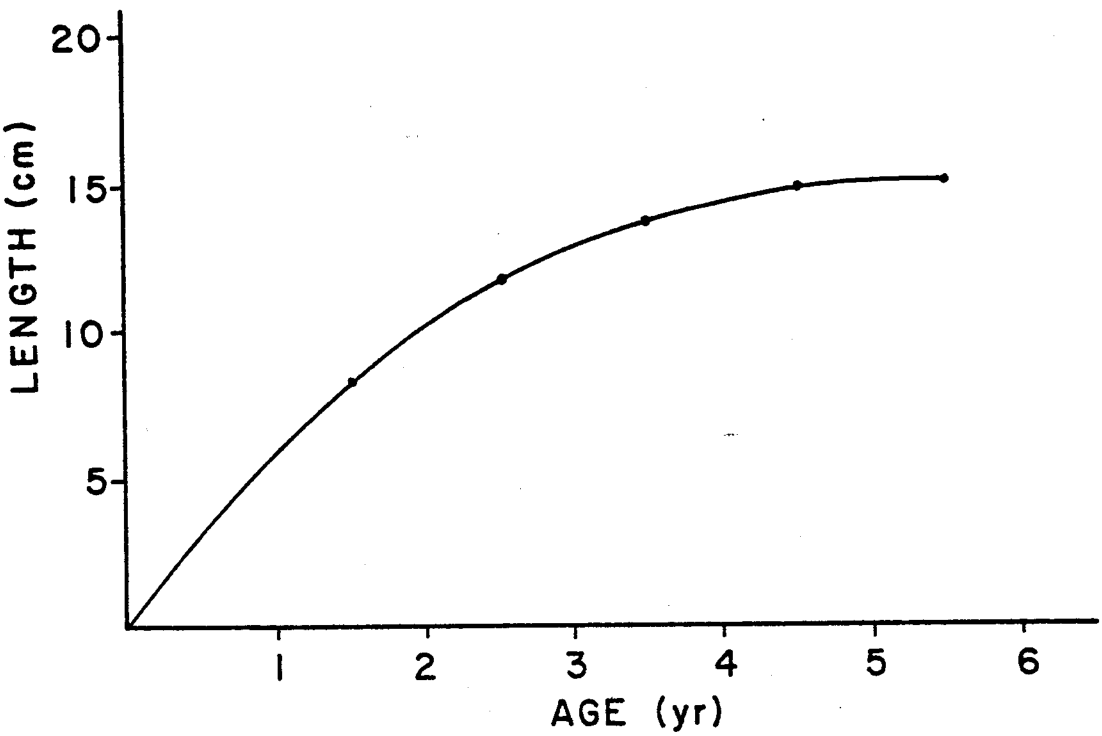


Figure 11. Growth curve of sand lance (Ammodytes hexapterus) at Sitkinak Lagoon. Points represent mean length at age class of fish taken in late June-early July, 1979.

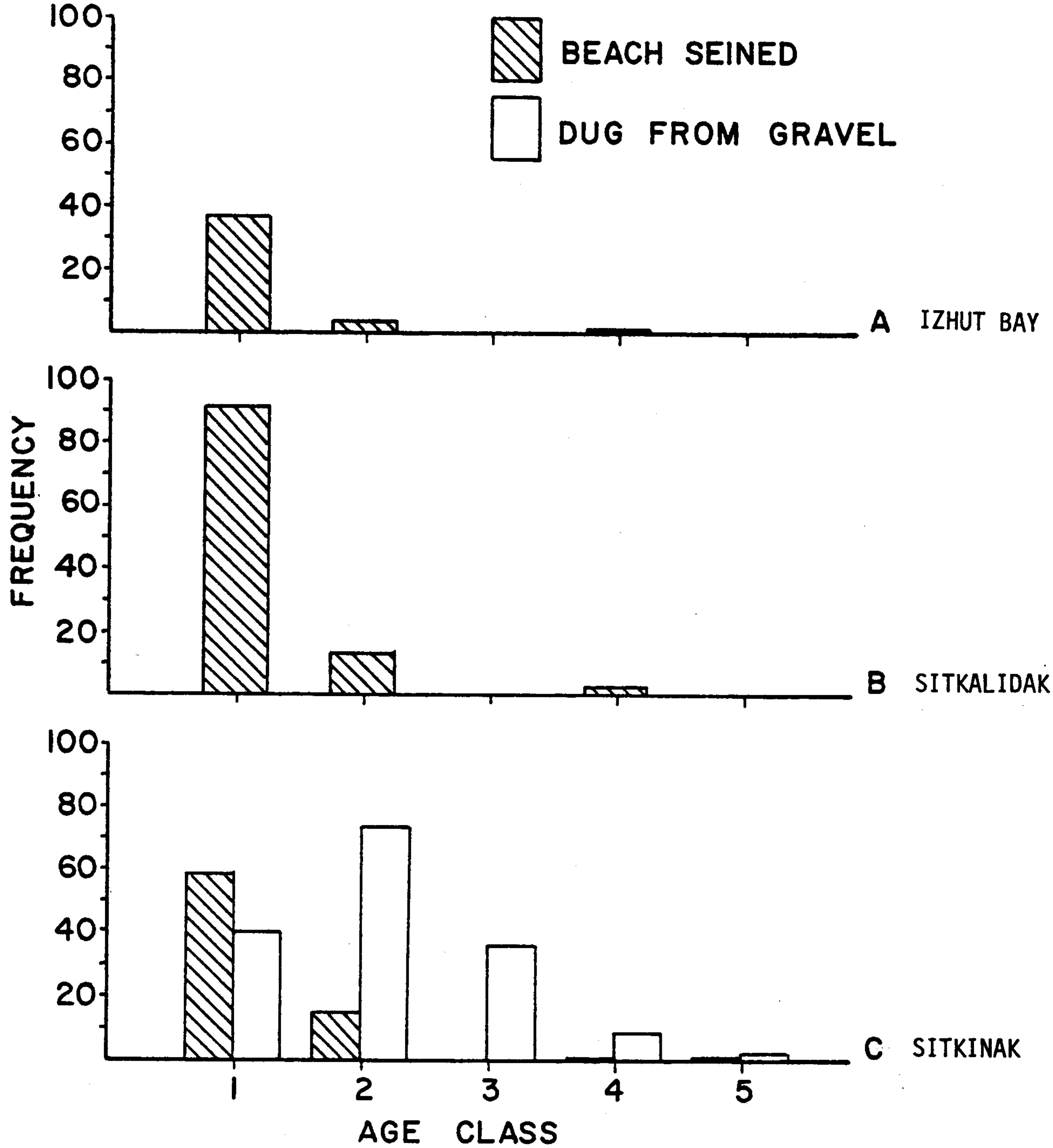


Figure 12. Age-frequency distributions of sand lance (<u>Ammodytes hexapterus</u>) sampled A.) by beach seine at Izhut Bay, May-June, 1979. n = 42. B.) by beach seine at Sitkalidak Strait, May-June, 1979. n = 109. C.) by beach seine (n = 76) and digging (n = 161) at Sitkinak Lagoon, June-July, 1979.

Table 12.--Means, followed by ranges, of body length (mm) at age class of sand lance from the east side of the Kodiak Archipelago, May-June, 1979. Mean lengths at age class of Barents Sea sand lance (*A. hexapterus marinus*) given by Andriyashev (1954) are presented for comparison. Numbers of individuals in the Kodiak samples are given in parenthesis.

Area	Age Classes					
	0	1	2	3	4	5
Izhut Bay n = 42		114.8 104-130 (37)	139.0 128-135 (4)		189.0 189 (1)	
Narrow Strait n = 40	53.8 49-60					
Sitkalidak Island n = 109		113.2 90-136 (02)	135.9 103-158 (14)		171.7 169-175 (3)	
Sitkinak Island n = 237		82.1 61-118 (98)	117.1 65-140 (90)	133.9 111-164 (36)	146.5 133-160 (10)	150.3 133-161 (3)
Offcoast of Murman	95	116	135	159	(166)	---
Offcoast of Novaya Zemlya	64	75	81	94	104	---

Table 13. Significance of the difference between mean lengths (mm) at age between Sitkinak and Sitkalidak sand lance, and between sand lance captured by two capture methods at Sitkinak Island.

Year Class	Samples Compared	Difference In Means	3(D)[1]
I	Sitkalidak/Sitkinak	31.1	4.5
II	Sitkalidak/Sitkinak	18.8	13.6
IV	Sitkalidak/Sitkinak	25.2	10.2
I	Sitkinak (Seined/Dug)	3.1	6.8
II	Sitkinak (Seined/Dug)	13.6	16.9

[1] Standard error of the difference between two means.

Casual field observations during this study showed predation by Dolly Varden, coho salmon and other species to be common (Table 15). The only information collected on sand lance food habits came from the examination of 115 fish dug at Sitkinak Island. Eighty-seven percent contained amphipods only; 13% were empty.

Capelin

Capelin spawn was detected only at two sites, both within Monashka Bay (census area B). Actual spawning was witnessed at one of those locations (Monashka Beach) by a project biologist. Spawn ready, or spawned out capelin were captured in four census areas: Izhut Bay, Monashka Bay, Sitkalidak Island and Alitak Bay. Through public interviews conducted after media announcements, capelin spawnings were found to have been annual at Roslyn Beach in Chiniak Bay (census area B) for a minimum of 25 years.

Spawning capelin were observed at a small beach at Monashka Bay at 11:45 p.m. on May 28, 1979 at high tide. During the spawning period an offshore wind blew at a 45 degree angle to the shore at less than 3 knots, and the surf was less than half a meter in height. The characteristic "cucumber" odor of smelt was noted when the observer was yet 200 meters from the spawning beach. Tens of thousands of capelin could be seen riding on the crest of each incoming wave, then retreating as the wave receded. The fish appeared unafraid of activities on the beach; however, they did avoid the lights used by fishermen and observers. There were few females in the large samples of fish taken by project personnel; this paucity of spawning females was previously noted by Warner and Shafford (1979). Sports fishermen present were interviewed and reported that on May 29, 1979 capelin spawned on the same beach for four hours, continuing past high tide and until dawn. A similar description of capelin spawning behavior was recorded at Pillar Beach (census area B) in 1977 (Ibid. 1979).

Inspection of the Monashka Beach site on the low tide following spawning revealed large quantities of roe 1 - 3 meters below (i.e. seaward from) where spawning activities had been observed the previous night (Figure 20). The gravel substrate in the spawning area was 2 - 20 mm in diameter and spawn had been washed into the substrate to a depth of 0.5 to 240 mm. Roe was white and about .75 mm in diameter. The density of deposition varied considerably, though levels usually exceeded 60 ova per .25 square meter of beach surface. Highest estimated densities were one hundred times that level. Predation on the deposited roe by amphipods was intense but unquantified. No spawning mortality was noted.

On the morning of May 29, 1979 the beach at Pillar Creek, which is approximately 5 kilometers from Monashka Beach (census area B), was also inspected for spawn deposition. Apparent spawning mortality of approximately a thousand individual male capelin was noted along the high tide line. Capelin spawn was also located by project personnel at this beach, and deposition features were identical to those on Monashka Beach.

A total of 620 capelin was taken from four census areas: Izhut Bay, Monashka Bay, Sitkalidak Island, and Alitak Bay. A total of 352 of these specimens was aged. Age 1 fish predominated in samples from the northern range of the study area (census areas A and B), whereas in the southern range (census areas C and F) age class 2 capelin dominated (Figures 17 and 18). A relationship between age and

Table 14. Sand lance gonad index (Hjort Scale) by age class, all areas, 1979. Table shows number of individuals, (n = 351).

Gonad Index	Age Class I	II	III	IV	V
I	215	40	4	-	-
II	3	32	14	7	2
III	-	17	10	3	1
IV	-	-	1	2	-

Table 15. Summary of miscellaneous observations of sand lance taken as prey along the east side of the Kodiak Archipelago in summer, 1979.

Date	Locality	Data
5/30/79	Sitkalidak Strait	A large Dolly Varden contained 15 sand lance.
6/20/79	Alitak Lagoon	Twelve large Dolly Varden sampled. One contained three sand lance and neried polychaetes; four contained neried polychaetes; seven were empty.
6/16/79	Moser Bay	Several captured Dolly Varden contained a few sand lance each.
6/21/79	Akhiok Bay	Sand lance in two of three *Myoxocephalus* sampled.
6/25/79	Sitkinak Lagoon	One Dolly Varden contained 40 sand lance.
6/27/79	Sitkinak Lagoon	Six sand lance in a *Mvoxocephalus*, one of seven of that genus and the genus *Leptocottus* which were sampled.
6/28/79	Sitkinak Lagoon	Of three Dolly Varden sampled, there were two sand lance in one and four in another.
7/11/79	Sitkinak Lagoon	In a night beach seine set using a lantern as an attractant, one of three Dolly Varden caught contained two sand lance.
8/20/79	Buskin River Vicinity	The stomachs of three coho salmon were filled with sand lance.

size was not apparent (Figure 19). Body lengths ranged between 93 and 149 mm (Figures 13 through 16), and the single year class dominance is apparent from these length frequencies. Few capelin taken were smaller than 100 mm and all were mature. All capelin examined showed strong sexual dimorphism, which is characteristic of the species.

Eulachon

Spawn ready eulachon were collected from three census areas: A, B and F (Izhut Bay, Kalsin Bay and Alitak Bay respectively). Maturity indices of the Kalsin Bay eulachon are shown in Table 16. Forty seven of these fish were spawning or had spawned, while 54 were in a pre-spawning condition. All these specimens were collected in fresh water. Eulachon samples from Alitak Bay were obtained from commercial shrimp vessels. Spawn ready eulachon were found along with pre-spawning specimens; however, gonad samples and body measurements were unuseable due to compaction in the vessel holds. Seven spawn ready eulachon were captured in Izhut Bay within a few kilometers of each other between May 24 and May 28. One eulachon was captured at Sitkalidak Island on May 30, and it was in a pre-spawning condition.

One hundred eight eulachon were collected and measured, and of this number 70 were aged. Eulachon from Izhut Bay were all 3 years old. Eulachon from Kalsin River were mostly 2 years old (Figure 22). Otoliths from eulachon taken at Alitak Bay were lost during processing and the age of the eulachon specimen from Sitkalidak was unknown.

Lengths of Kalsin River eulachon ranged from 175 mm to 220 mm (Figure 21), and were bimodal (Figure 21). Lengths of Izhut Bay eulachon ranged from 195 mm to 219 mm. The ratio of males to females in the Kalsin River eulachon was six to one. Insufficient data exist in other areas to project a meaningful sex ratio.

Surf Smelt

No spawning surf smelt, nor deposited spawn of surf smelt were found during this study. Six specimens of this species were caught, and three of these were in spawn ready condition.

The six surf smelt caught in this study were taken at Sitkalidak Strait (2), and Izhut Bay (4). Five of these fish were aged at 2 years and one at 3 years. Mean body size of these specimens was 192 mm in length and 89 grams in weight.

Miscellaneous Species and Catch per Unit of Effort (CPUE)

A total of twenty-two taxa of non-forage fish was collected (Table 17). Frequency of occurrence and CPUE of Dolly Varden was consistent (38 - 45% and .05 - .08 fish per hour respectively in gill net) in all areas (Tables 18, 19, 20, 21 for gill net catches, and Tables 9, 10, 11 and 22 for beach seine catches). The catch figures for other species caught by VMG were similar at Izhut Bay and Sitkalidak Strait. The frequency of greenling was 35% and 34% at these two localities respectively; cod 12% and 19%; flounders 8% and 15%. At Sitkinak Island, there was a much greater frequency of sculpins (80%) and flounders (50%) and a much greater CPUE for these groups.

Table 16.--Frequency distribution of gonad index for eulachon taken in the Kalsin River on May 27, 1979. N = 85

Gonad Index	Frequency of Occurrence	Percent Frequency of Occurrence
3	7	8
4	39	46
5	9	11
6	9	11
7	21	25

Table 17.--List of all miscellaneous species caught during forage fish investigations, Kodiak/Afognak Islands, 1979 OCSEAP research

Species Common Name	Scientific Name	Abundance
Pink salmon (fry)	Oncorhynchus gorbuscha	High
Chum salmon (fry)	Oncorhynchus keta	Moderate
King salmon (smolt)	Oncorhynchus tshawytscha	Low
Dolly Varden	Salvelinus malma	Moderate
Pacific cod	Gadus macrocephalus	Low
Threespine stickleback	Gasterosteus aculeatus	Low
Greenling (fry)	Hexagrammos	High
Rock greenling	Hexagrammos logocephalus	Low
Whitespotted greenling	Hexagrammos stelleni	Low
Masked greenling	Hexagrammos octogrammus	Low
Silverspotted sculpin	Blepsias cirrhosus	Low
Pacific staghorn sculpin	Leptocottus armatus	Low
Great sculpin (fry)	Myoxocephalus polyacanthocephalus	Moderate
Sturgeon poacher	Agonus acipenserinus	Low
Tubenose poacher	Pallasina barbata	Low
Pricklebacks	Stichaeidae	Low
Snake prickleback	Lumpenus sagitta	Low
Crescent gunnel	Pholis laeta	Low
Sole & Flounders	Pleuronectidae	Moderate
Rock sole	Lepidopsetta bilineata	Low
English sole	Parophrys vetulus	Low
Starry flounder	Platichthys stellatus	Low

Table 18. Summary of variable mesh gill net catch, Sitkinak Island, June 25 - July 5, 1979. (Eight sets in estuary on Tugidak Passage; all other sets on Sitkinak Lagoon.) Figures represent 20 sets, 363 net hours.

Species	Frequency of Occurrence in Sets	% Frequency of Occurrence	Total Number Caught	Average Number Per Set	CPUE (Fish/net hr.)
King salmon (smolt)	2	10	2	0.1	0.01
Dolly Varden	9	45	18	0.9	0.05
Threespine stickleback	1	5	1	0.1	0.01
Whitespotted greenling	5	25	13	0.7	0.04
Great sculpin group	3	15	14	0.7	0.04
Pacific staghorn sculpin	16	80	165	8.3	0.50
Starry flounder	10	50	29	1.5	0.08
Rock sole	2	10	7	0.4	0.02
All Sculpins	16	80	179	9.0	0.50
All Flounders	10	50	36	1.8	0.10

Table 19. Summary of variable mesh gill net catch, Sitkalidak Strait, May 4 - July 3, 1979. Figures represent 53 sets, 716 net hours.

Species	Frequency of Occurrence in Sets	% Frequency of Occurrence	Total Number Caught	Average Number Per Set	CPUE (Fish/net hr.)
Herring	33	62	2,023	38.2	2.83
Chum salmon (smolt)	1	2	1	0.1	0.01
Dolly Varden	24	45	56	1.1	0.08
Surf smelt	3	6	4	0.1	0.01
Capelin	9	17	81	1.5	0.11
Eulachon	1	2	2	0.1	0.01
Cod[1]	10	19	53	1.0	0.07
Greenling[2]	18	34	90	1.7	0.12
Sculpins	13	25	51	1.0	0.07
Flounders[3]	8	15	21	0.4	0.03

[1] Includes at least 27 Pacific cod.

[2] At least Rock greenling, Masked greenling and Whitespotted greenling were identified.

[3] Includes at least Rock sole, English sole and Starry flounder.

Table 20. **Variable mesh gill net catch at Rodman Beach in Alitak Bay,** Kodiak, June 18 - 20, 1979.

SPECIES	SET NUMBER 87	93	94	96	TOTAL
Staghorn sculpin				2	2
Great sculpin			3	5	8
Sturgeon poacher		3	1	5	9
Snake prickleback				2	2
Silverspotted sculpin		2			2
Pacific cod		2		1	3
Whitespotted greenling		1	2		3
Dolly varden	1		5	23	29
Herring		1	3	2	6
Hours of soak time	10	12	9	14	45
Total fish per set	1	9	14	40	64

Table 21. Summary of variable mesh gill net catch, Izhut Bay, May 7 - June 20, 1979. Figures represent 52 sets, 1,131 net hours.

Species	Frequency of Occurrence in Sets	% Frequency of Occurrence	Total Number Caught	Average Number Per Set	CPUE (Fish/net hr.)
Herring	35	67	1,432	27.5	1.27
Dolly Varden	20	38	80	1.5	0.07
Surf smelt	2	4	2	0.1	0.01
Capelin	10	19	81	1.6	0.07
Eulachon	6	12	11	0.2	0.01
Cod	6	12	6	0.1	0.01
Pricklebacks	1	2	2	0.1	0.01
Rockfish	1	2	1	0.1	0.01
Greenling	18	35	69	1.3	0.06
Sand lance	1	2	1	0.1	0.01
Sculpins	5	10	8	0.2	0.01
Flounders	4	8	7	0.1	0.01

Sets of over 30 hours soak time were omitted from this summary.

Table 22. Beach seine catch, west shore Alitak Lagoon (sets 88-92) and Rodman Reach (95).

SPECIES	SET NUMBER 88	89	90	91	92	95	TOTAL
Pink salmon	17		10	50	30	1	108
Chum salmon	2						2
King salmon		2	1	2			5
Dolly varden	2				10		12
Crescent gunnel						4	4
Great sculpin			1	5	2	3	30
Whitespotted greenling						3	3
Greenling species						1	1
Greenling fry	1	2		3			6
Staghorn sculpin						1	1
Sand lance			1				1
Unid. Sculpin fry	1						1
Total fish per set	23	23	13	60	42	13	174

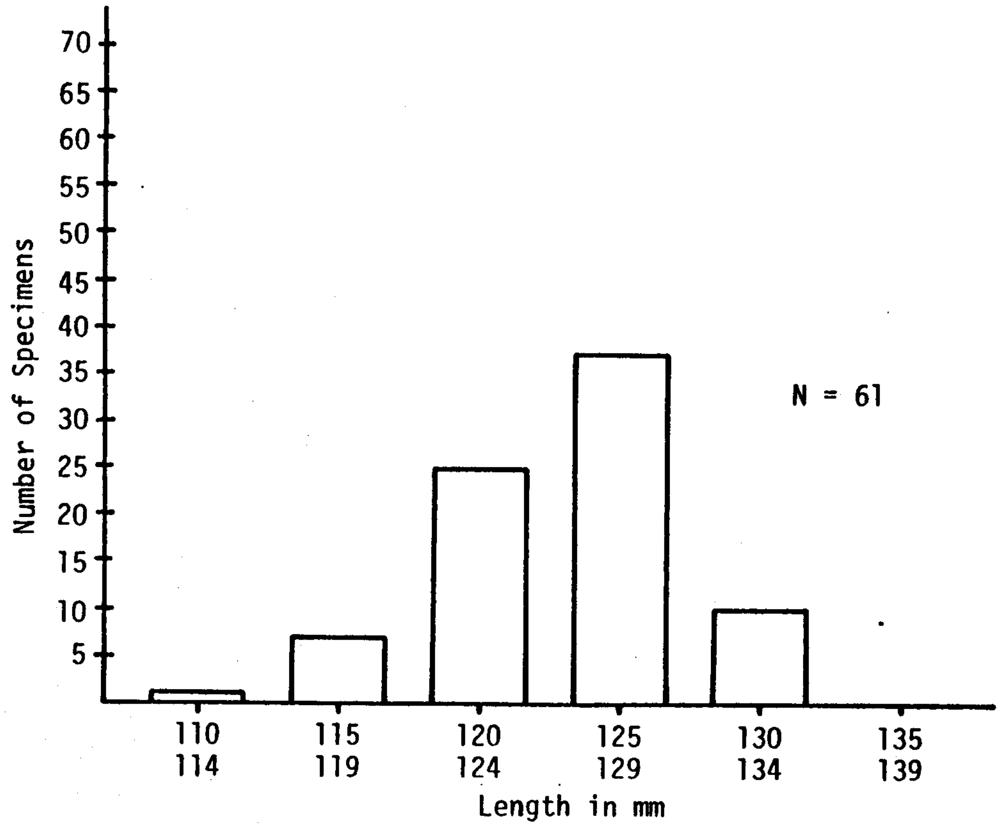


Figure 13. Length-frequency distribution of capelin (*Mallotus villosus*) captured by variable mesh gill net, Izhut Bay, 1979.

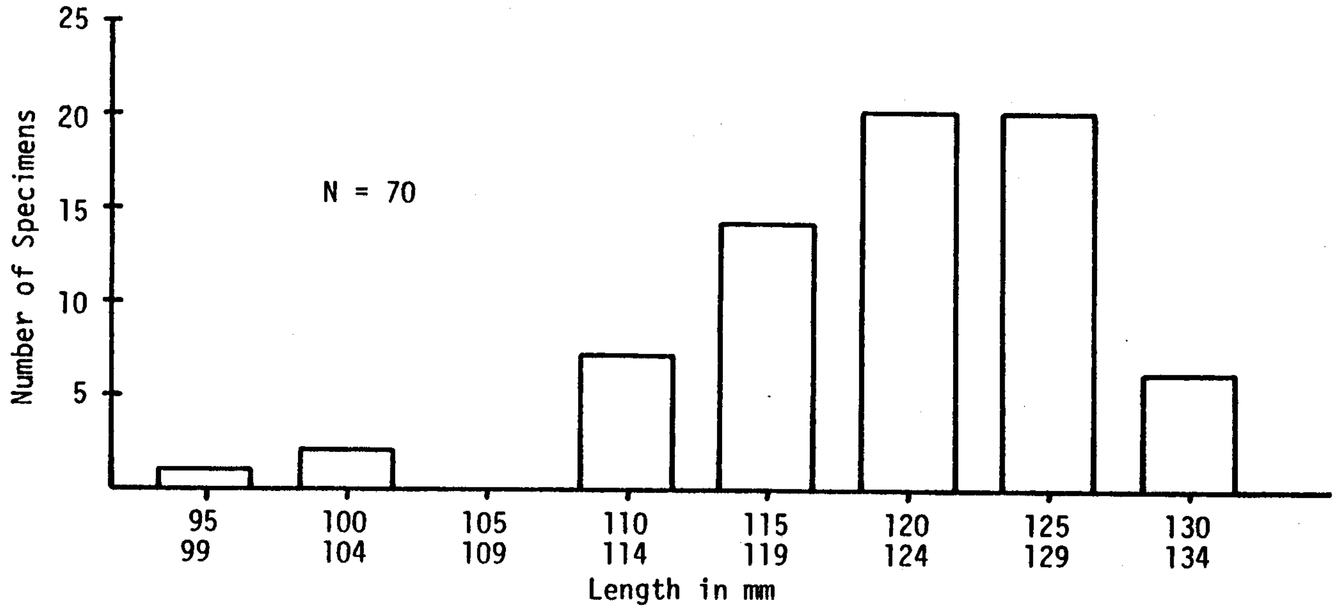


Figure 14. Length-frequency distribution of spawning capelin (*Mallotus villosus*) recovered from beach, Monashka Bay, 1979.

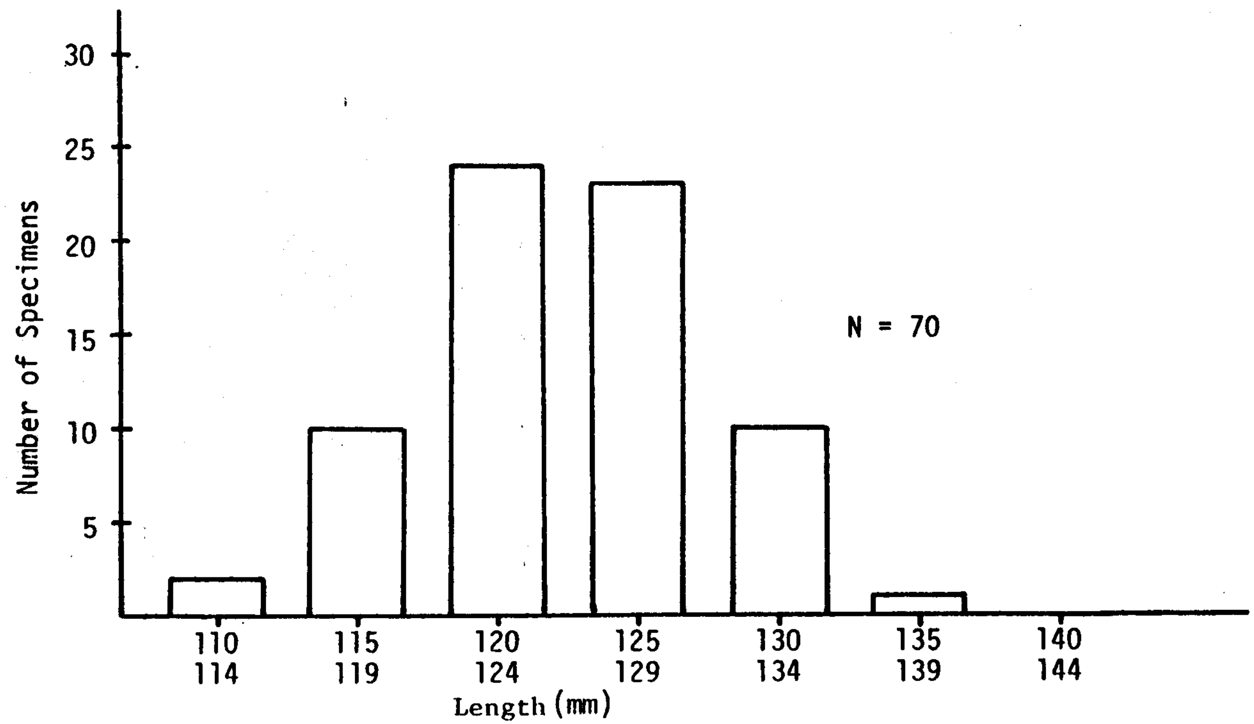


Figure 15. Length-frequency distribution of capelin (*Mallotus villosus*) captured by variable mesh gill net, Sitkalidak Island, May-July 1979.

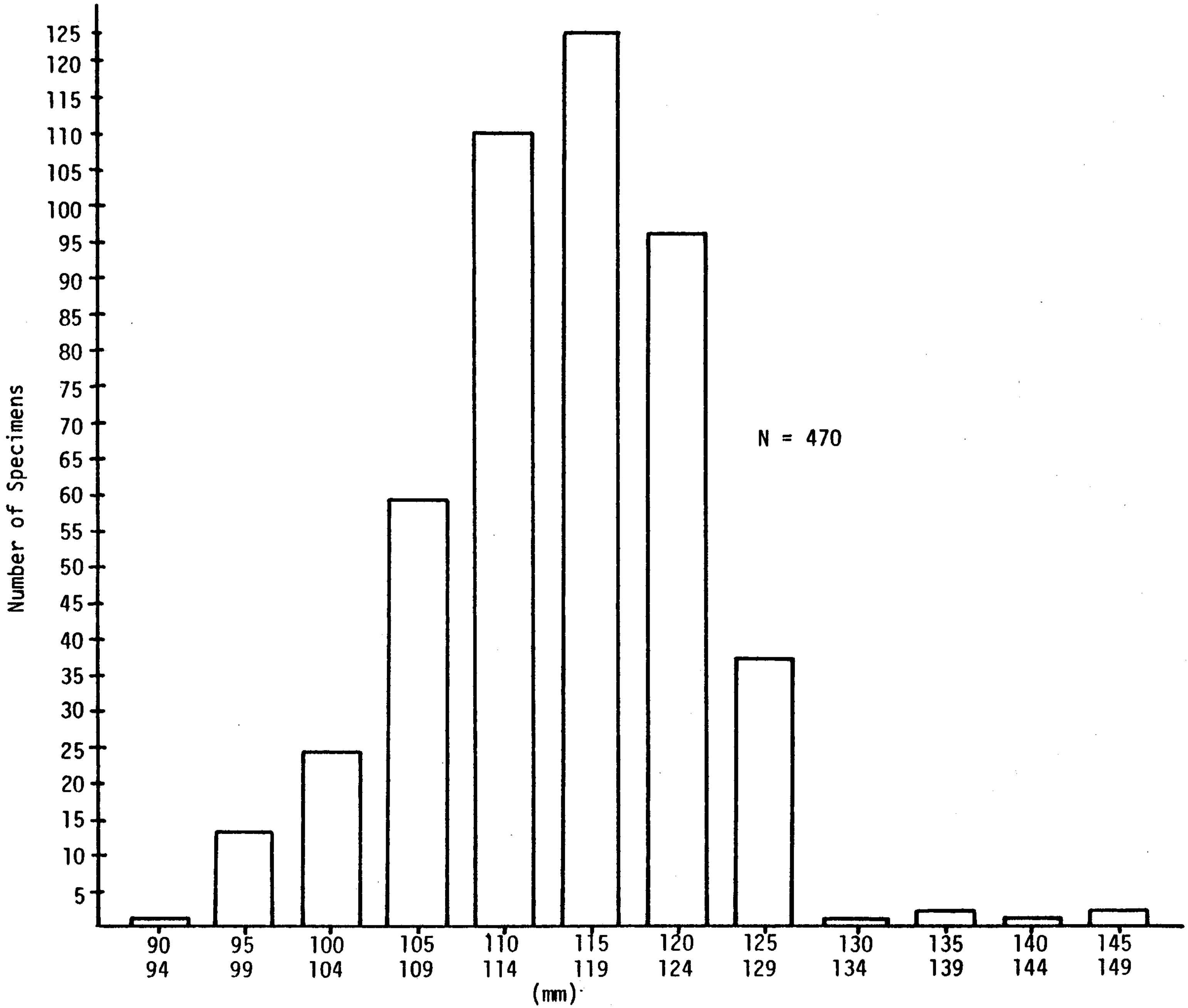


Figure 16 . Length-frequency distribution of capelin (*Mallotus villosus*) caught by commercial otter trawl, June 1979, Alitak Bay.

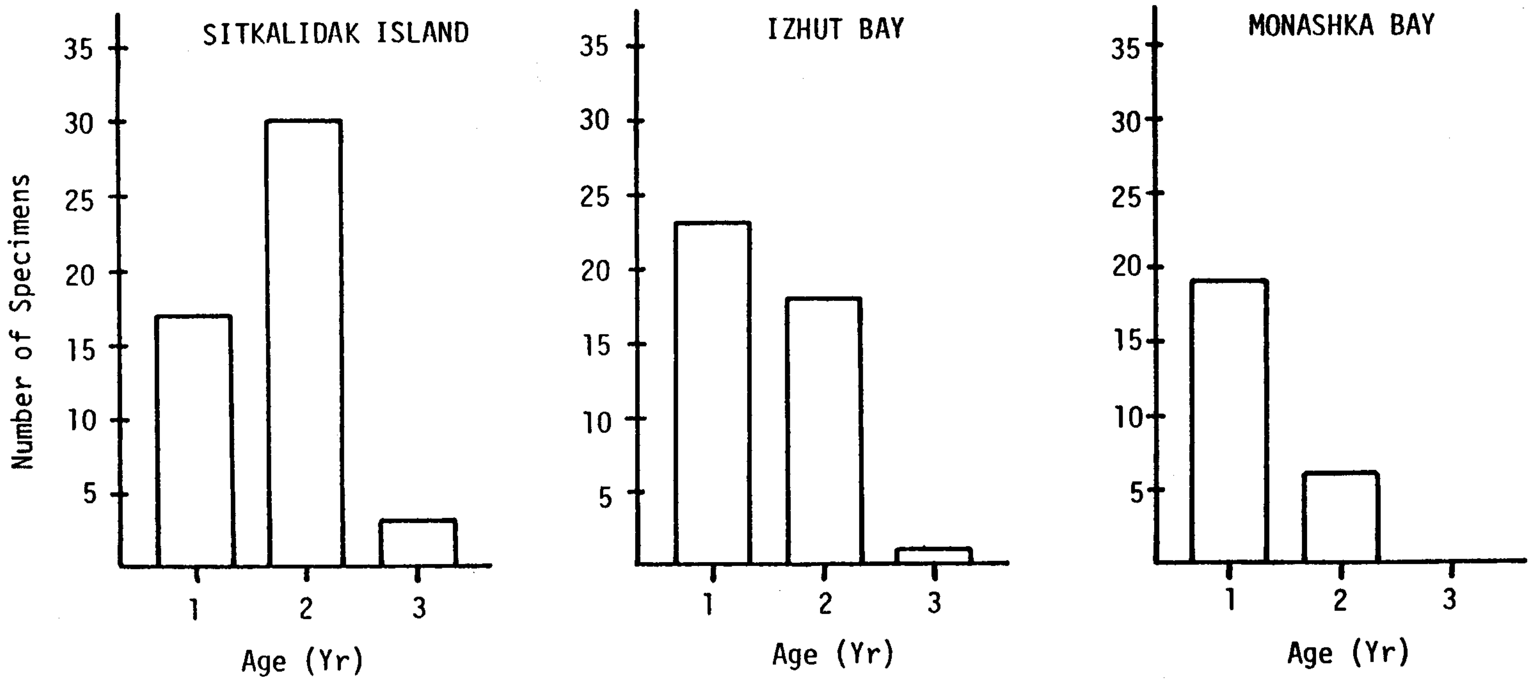


Figure 17. Age-frequency distribution of capelin (*Mallotus villosus*) captured at various sites along the east side of the Kodiak Archipelago, May-July, 1979. Capelin from Sitkalidak Island and Izhut Bay were caught by variable mesh gill net, capelin from Monashka Bay were recovered by hand from the beach.

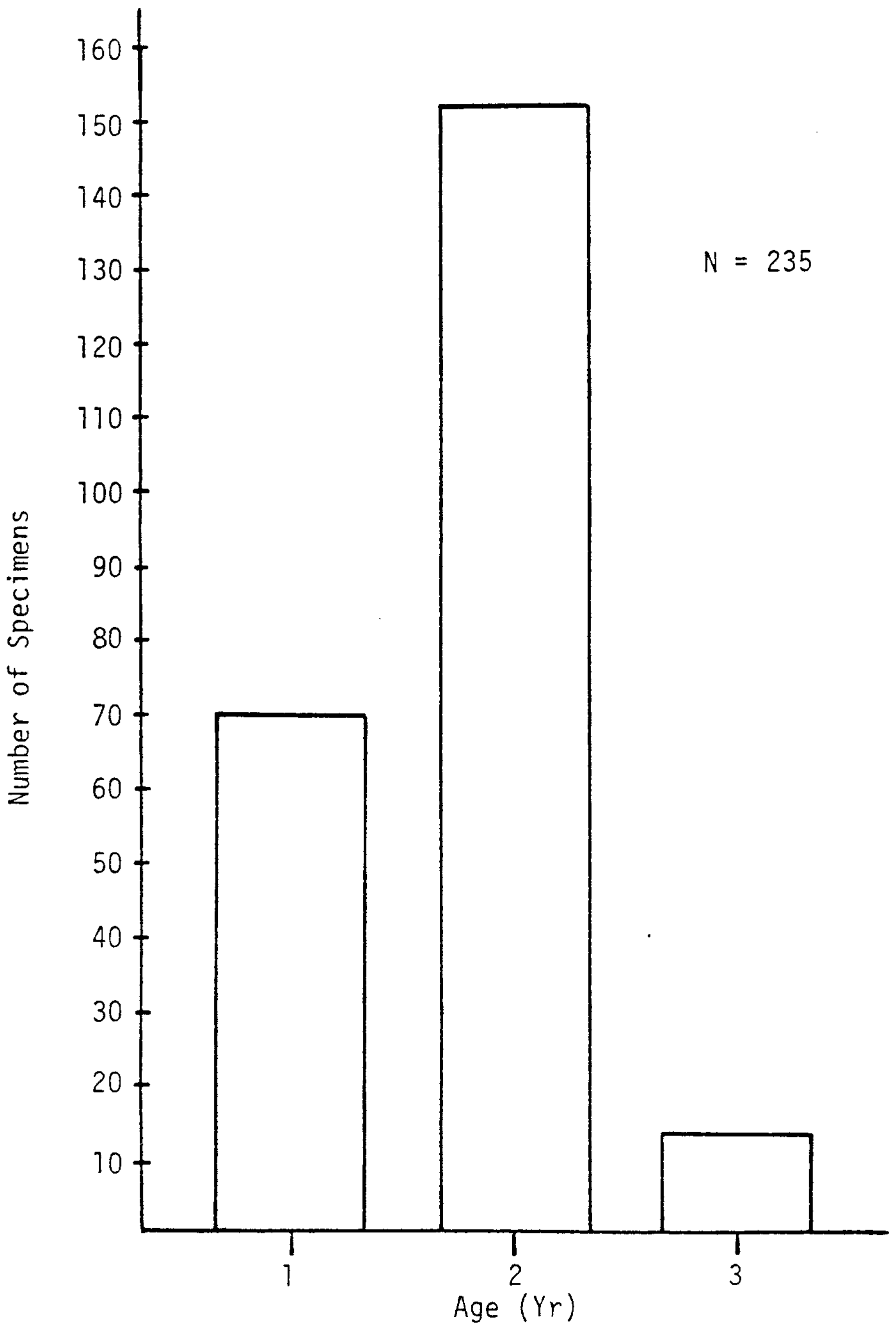


Figure 18. Age-frequency distribution of capelin (*Mallotus villosus*) captured by commercial otter trawl in Alitak Bay, June, 1979.

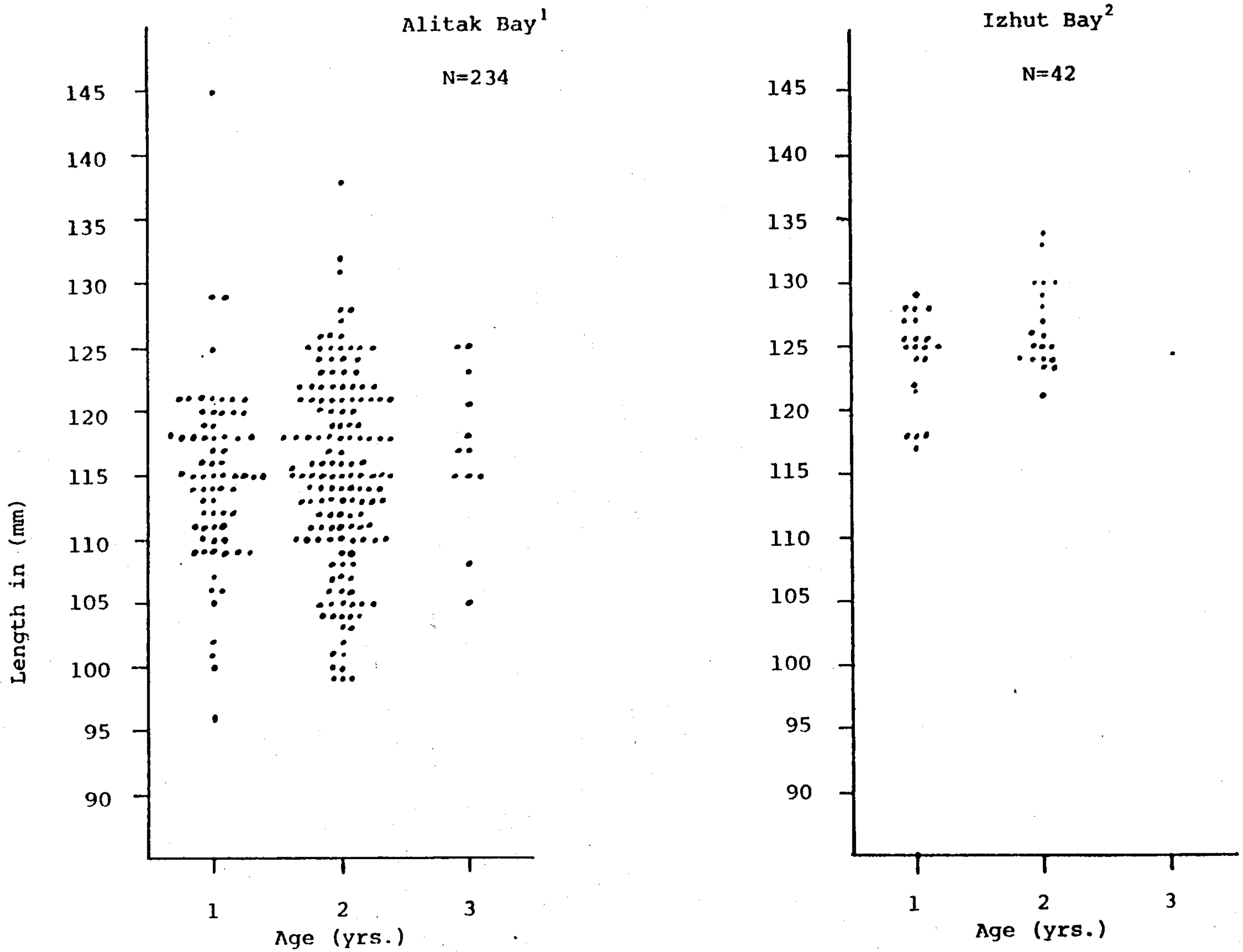
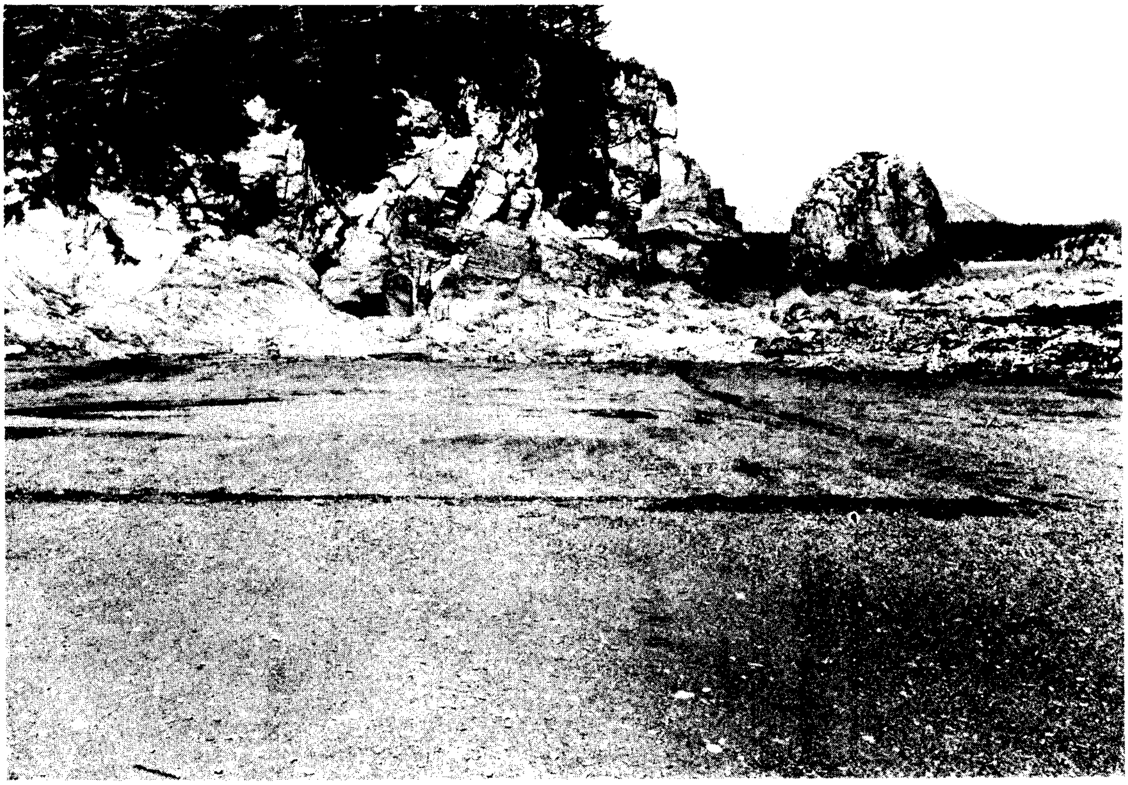
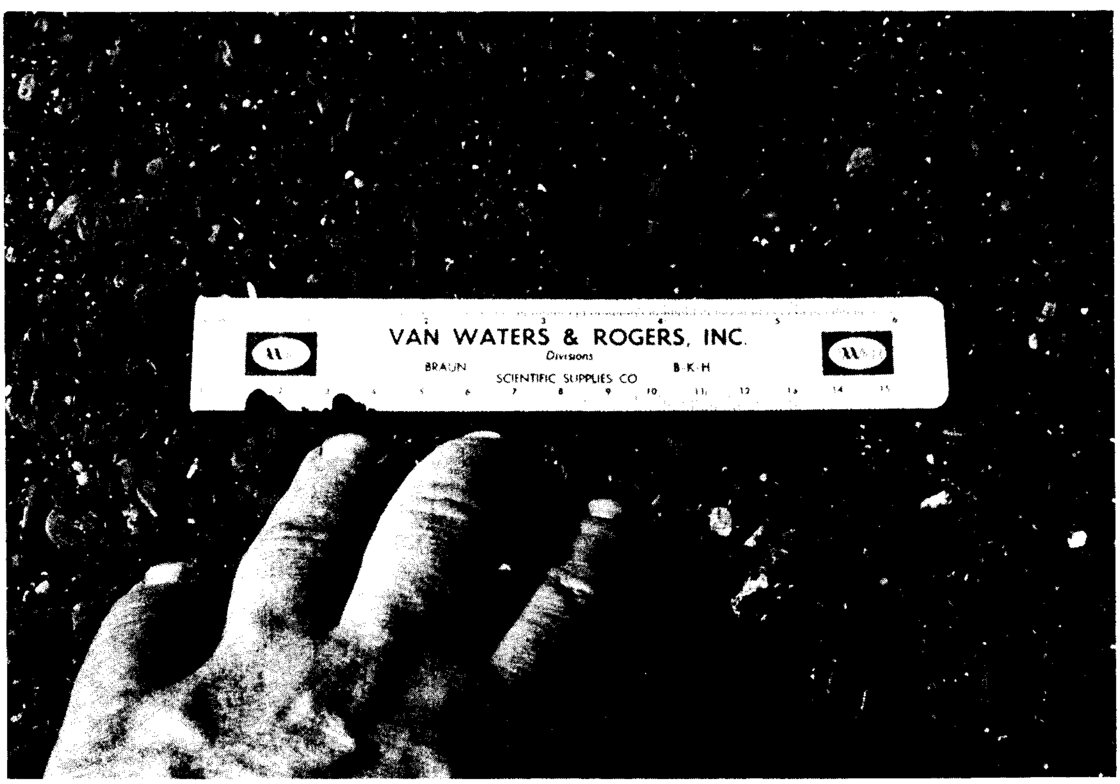


Figure 19. Length-frequency distribution, by age group, of capelin (<u>Mallotus villosus</u>) captured by commercial otter trawl[1] and variable mesh gill net[2] at two sites on the east side of the Kodiak Archipelago, May-June, 1979. Dots represent individuals.

Figure 20.



a. Beach area where capelin spawning was observed, May 1979.



b. Typical capelin spawning substrate, Monashka Bay, Kodiak Island, 1979.

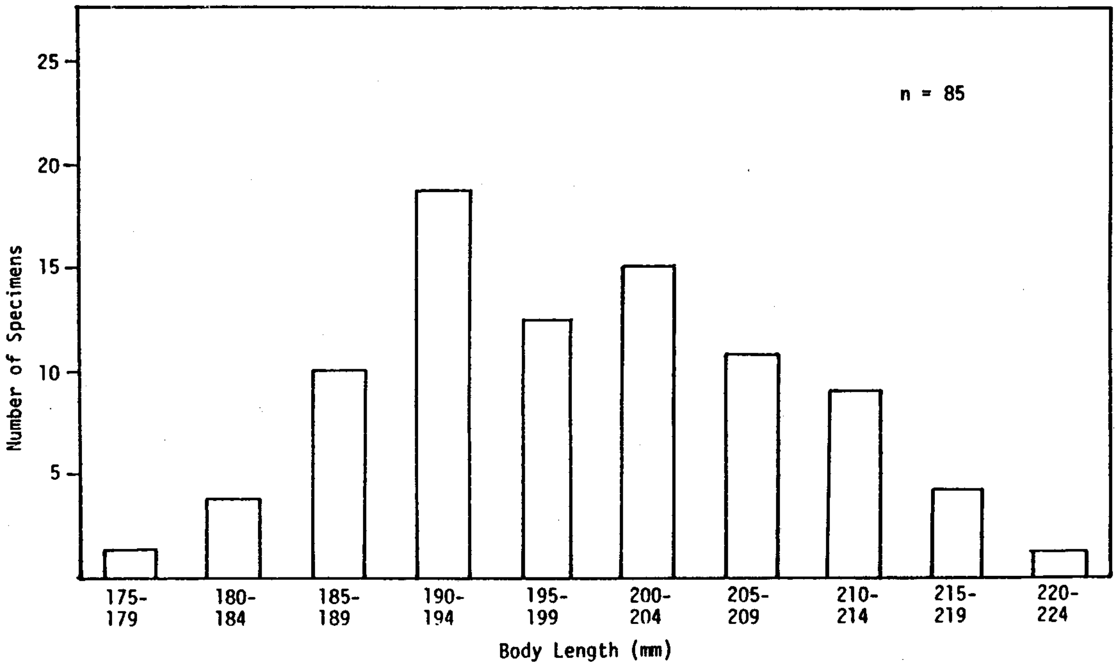


Figure 21. Length-frequency distribution of eulachon (Thaleichthys pacificus) caught by dip net at Kalsin River, Kodiak Island, May 1979.

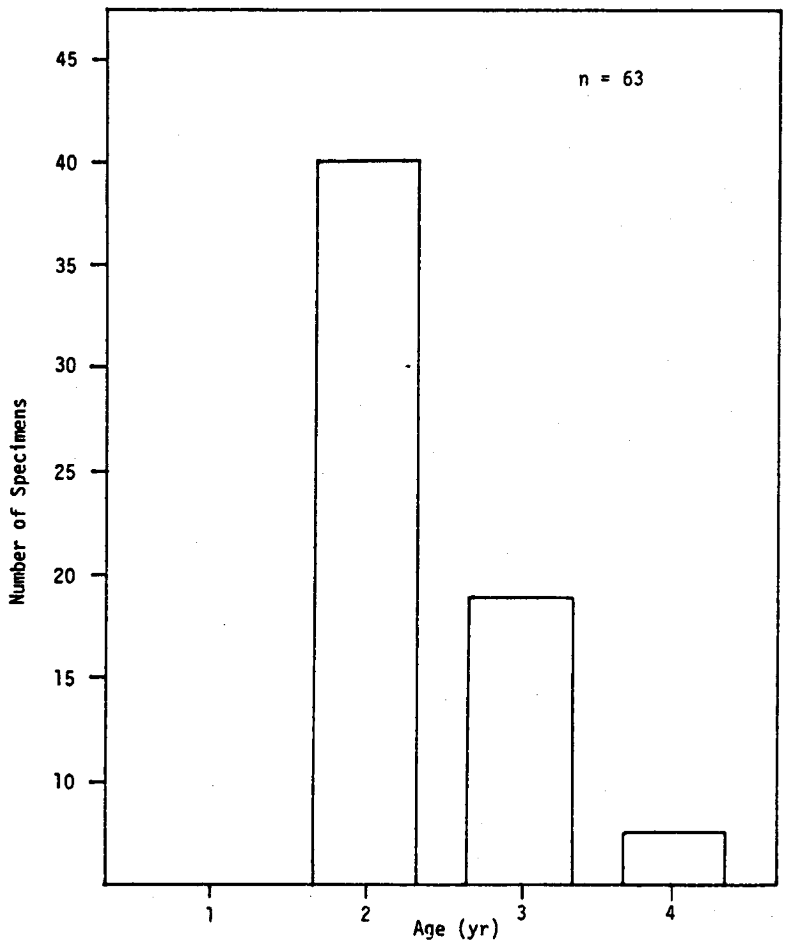


Figure 22. Age-frequency distribution of spawning eulachon (Thaleichthys pacificus) dip netted from the Kalsin River, Kodiak Island, May 1979.

The average catch of non-forage fish species in VMG at Sitkinak (12.6 fish/set) was much less than at Izhut (32.9 fish/set). Catches of pink salmon fry in beach seines were consistently high in all areas. The frequency of occurrence of sculpins was high in all areas.

DISCUSSION

Aerial Surveys

All observations made during aerial surveys are subjective except for the counts of schools sighted. School size, either from a standpoint of biomass or area is highly subjective and a function of observer experience. It is the opinion of the senior author that school size, as judged from the air is an extremely fluid parameter, i.e. that frequently an observed school's size will vary within minutes by, often times, a factor of 2. Species composition of a school and distinguishing a fish school from non-fish subsurface objects is often difficult because of turbulence, turbidity, light conditions, fatigue or a combination of all these factors. Statements derived solely from aerial surveys must, therefore, be severely limited in scope if no other form of data (i.e. ground surveys, fishing results, etc.) exist for a given study zone.

Aerial observations of forage fish schools in the Kodiak area were more difficult than OCSEAP aerial surveys conducted in the Bering Sea by the same observer. The highly convoluted shoreline of Kodiak and Afognak Islands made air turbulence a decisive factor on every survey, i.e. meaning that some portions of a census area simply couldn't be surveyed safely and were passed over until weather conditions improved. Also, many more subsurface objects, which appear similar to fish schools were sighted, hence, prudence had to be employed. In the final analysis, few schools were counted unless movement was observed directly or indirectly.

Too few hours were dedicated to aerial surveys, considering the study area size, but in spite of this, aerial survey indications of high forage fish density correlated well with ground results. Few schools were seen in the Trinity Islands; these results, we feel, accurately describe a situation there; e.g. that the forage fish species studied during this project do not rely on this area for nearshore spawning during the summer months. Aerial surveys indicate that forage fish are active in areas only where shelter is afforded from violent open ocean conditions.

The importance of aerial surveys in a spawning study is limited; sighted schools cannot be determined as to spawning state and activity except in instances where milt is observed in the water, or digging in substrate is observed. Finally, actual ground activities must be conducted to confirm any aerial observations concerning spawning. There is no substitute for actually finding fertilized ova *in situ*.

Pacific Herring

Herring are a significant component of the spawning forage fish community along the east coast of the Kodiak Island Archipelago in the spring and summer of the year. Generally, they require secluded bays within larger bays with eelgrass and kelp substrate on which to spawn. Herring begin spawning in early spring of the year, often as early as mid to late April. During their spawning cycle they are subject to commercial fishing pressure.

Herring are the longest lived of the forage fishes included in this study, and individual specimens of over 10 years of age have been identified. Assuming a sexual maturity at 2 or 3 years of age, a 10 year old herring could have completed seven to eight spawning cycles. This longevity has direct petroleum impact relevance. The more spawning cycles an individual year class can complete, the less likelihood that an entire population could be obliterated by an oil spill during a single year, as that population of fish is not dependent on a single year-class for sustaining itself. How quickly and ably a herring school would avoid a spill area is not known. The toxic effects of crude oil and refined oil products on egg and young of this genus have been demonstrated in other studies. Adult physiological reaction to crude oil has been shown to vary in impoundment studies.

Nearshore spills, depending on drift direction would have a high probability of having adverse effect on eelgrass and algae substrate on which herring depend for proper spawning. Because of the toxicity of these substances to the eggs, a bay or inlet subjected to a petroleum spill would, in the opinion of these researchers, be rendered useless for herring spawning. Petroleum spills during the spring of the year probably would subject herring to the highest degree of risk. It is possible that an entire year-class of eggs or larvae could be annihilated by an oil spill.

Sand Lance

Sand lance were abundant at each of three widely separate localities on the east side of the Kodiak Archipelago in summer, though seine catches varied greatly with time and location. Harris and Hartt (1977) similarly found sand lance to be the numerically dominant fish species in the nearshore zone in summer in Alitak, Kaiugnak and Ugak Bays, all on the east side of the archipelago. They also noted a variability in catches, which indicates a highly clustered distribution. Frequency of occurrence and catch per unit effort were highest in Sitkalidak Strait and lowest in southwestern Alitak Bay. Harris and Hartt (1977) found fewer lance in the southwestern portion than in the rest of Alitak Bay. They obtained sand lance at all tide stages, though we found seining much more productive at mid to high tide than at low tide. The factors determining local distribution are poorly understood (Reay 1970), though they include diurnal behavior and tide stage in some populations of Ammodytes.

The presence of Kodiak sand lance in the brackish lake on Ban Island indicates a tolerance to low salinity, as has been observed in some other species within the genus (Ibid.) We commonly found sand lance in the gravel at stream mouths, and Mr. French specifically mentioned schooling near stream mouths and small freshwater outlets during spawning. Freshwater influence, therefore, seems to a greater or lesser extent related to local distribution.

The habitat in which sand lance bury themselves in summer and spawn in fall is very similar or identical to that utilized by capelin, i.e., beaches of coarse sand and fine gravel.

The adequacy of the beach seine as a sampling tool for sand lance is in doubt as evidenced by the differences in age frequencies of beach seined samples and those dug from gravel at Sitkinak Island (Figure 12). Kühlmann and Karst (1967) reported the segregation of A. tobianus into schools of fish of a similar size. While such behavior might account for differences in age-frequency between the samples, it does not explain why schools of older, larger fish were never caught by beach seine.

Kodiak Archipelago sand lance show a number of similarities to the subspecies A.h. marinus in the Barents Sea, discussed by Andriyashev (1954). Mean lengths at age of Barents Sea/Murman and Sitkalidak Strait samples are nearly identical (Table 12). Mean lengths of the Novaya Zemlya and Sitkinak Lagoon samples are among the smallest in the genus, judging from the summary of mean lengths at age for various species given by Reay (1970). Kodiak sand lance attain age class 5; Barents Sea sand lance age class 4. Kodiak sand lance mature at age classes 2 and 3; Barents Sea sand lance at age class 3. Kodiak sand lance spawn intertidally in October, then disappear from the nearshore zone. They possibly bury themselves in the substrate in deeper water, as is the case with some other species in winter (Ibid.). They may continue to spawn for a month or two in deeper water, though this is purely speculation. Barents Sea sand lance move offshore in October and spawn in depths of 25 - 100 m from November - February.

Kodiak sand lance age class determination was based upon the assumption of January or February hatching dates. Blackburn (1978) back-calculated these dates for sand lance in Cook Inlet, the mouth of which lies 50 km north of the Kodiak Archipelago. Given October spawning in the archipelago, eggs possibly hatch by the end of December. The effective hatching date might still be January or February, as some autumn spawning Ammodytes are known to overwinter as larvae, spending 3 - 5 months in that stage (Reay 1970 after Kändler 1941).

The observations and specimens contributed by Mr. Duane French constitute, as far as we know, the first spawning record for Ammodytes in the northeastern Pacific Ocean. The spawning took place at the beginning of the first spring tide series in October. Specimens in spawning condition were also obtained at the peak of the second spring tide series in October. Whether or not spawning took place during the rest of that month is unknown.

Sand lance are most susceptible to oil impact from May - October, as an undetermined proportion of the population is present in the nearshore zone at that time. In summer both larvae and adults occur in the pelagic and mesopelagic zones of bays as well as in nearshore zones (Harris and Hartt 1977). October is probably a particularly sensitive time, as sand lance appear on beaches in greater densities than at any other time of the year to spawn. Barents Sea sand lance migrate to deeper water in autumn (Andriyashev 1954), and it is assumed that Kodiak sand lance also take part in this type of migration. They are absent from the intertidal from November to mid April. It would be speculative to make any statements about the long-term effects of an oil spill. It can be said, however, that if sand lance were eliminated from, or drastically reduced along, the east side of the archipelago, the consequences on various vertebrate predators would be marked, either by a decrease in their productivity or greatly increased usage of other prey species such as capelin.

This study has made original contributions concerning the basic biology of sand lance in the eastern Pacific, especially the information on longevity, growth, age structure and reproduction. It has been demonstrated that beach seining alone is inadequate for reliably sampling sand lance populations. Future research should pay careful attention to sampling techniques.

Capelin

Because of the large concentrations of capelin found in the area of Sitkalidak Straits (census area C) during shrimp surveys by ADF&G biologists, this area was expected to produce extensive observations of spawning capelin and spawn deposition.

The negative results in Sitkalidak Straits were a surprise to project personnel. Interviews concerning spawning capelin at the village of Old Harbor (located on the dividing point of census areas C and D) failed to reveal any native residents who could recall capelin runs.

Ancillary data from projects occurring after the contractual end of this project indicate that capelin biomass in the Sitkalidak area is high. Winter shrimp cruises completed by the ADF&G in January of 1980 again revealed dense concentrations of capelin. Prior to this, trawl catches of six to nine tons (per one mile tow) throughout an area of approximately 10 square miles (McCrary, pers. comm., 1979) have been common.

Spawn surveys conducted at locations where capelin had been observed spawning only six hours before often revealed that locating spawn was difficult. Capelin spawn was difficult to find because of two basic reasons: 1) The area where the fish spawn is <u>not</u> where the ova subsequently become deposited in the substrate. The fertilized ova become buried considerably seaward of the spawning location, depending on the slope of the beach. 2) Once the area of spawn deposition was located, a slow cautious examination was required before individual ova became evident to the naked eye. Once the observer began sighting individual ova, the subsequent sightings of other ova became easier. Because of these experiences in looking for capelin spawn, the job of giving adequate coverage to dozens of beaches in an area the size of Sitkalidak Island became more formidable than anticipated. A two man crew (which was the field complement in census area C and D), looking for capelin spawn on beaches where they hadn't seen spawning capelin, became a hit and miss proposition.

This study, and others in the Bering Sea, show that capelin rarely live longer than four years, and more commonly two or three years. Research in these areas indicate capelin spawn mainly once, sometimes twice, and rarely three times during their lifetime. Atlantic capelin also have this characteristic (Templeman 1948). It would follow that the biomass of capelin in different areas would have the distinct potential of being cyclic, i.e. reaching high numbers in some years, yet almost absent during others, as is true with this species in the Barents Sea.

Investigators world-wide regard the capelin as a spring spawner with spawning confined to certain high tide cycles in mid-to late spring. However, there is evidence that in Alaska the capelin spawning period is longer than previously estimated (Warner and Shafford 1979). Capelin spawning has been observed in August in Prince William Sound by marine mammal biologists (Hall, pers. comm. 1979). Larvae less than 20 mm in length have been captured in Cook Inlet during August, and two distinct body length modes of larvae 20 mm apart were found there (Blackburn 1978). Blackburn hypothesized that spawning occurred over an extended time period. If this were the case, it would explain the variable mean length at age results for capelin in 1979.

If the duration of capelin spawning exceeded the time period previously accepted, the time of hatch and subsequent metamorphosis of larvae into the adult stage at 12 to 16 months, would take place over a long period of time. Ageing capelin, therefore, would be difficult because of the varying amounts of summer growth prior to the formation of the first visible annulus.

Like herring, capelin would be the most vulnerable to petroleum spills during the nearshore spawning portion of their life cycle. Adverse impact to capelin stocks along the study area would likely carry over quickly to vertebrate populations which depend on these fish for food. It is established that capelin are the most important prey species for marine birds inhabiting this area. Capelin predominate in the summer diet of sooty and short-tailed shearwaters, black-legged kittiwakes, tufted puffins and common murres. These five species comprise most of the numbers and biomass of the marine bird community in the Kodiak area in spring and summer (Sanger et. al. 1978). Similar results were obtained for marine birds in the Izhut Bay area on Afognak Island (Krasnow et. al. 1979).

Eulachon

The importance of eulachon as a forage fish in the study area is uncertain. During other OCSEAP research along the east coast of Kodiak Island, eulachon were listed as an occasional member of the nearshore finfish community (Blackburn 1978). Our study showed them to be of minor significance compared to herring, capelin and sand lance, although catches during 1980 shrimp research cruises resulted in consistent numbers of this species in deep, (i.e. more than 50 meters) nearshore waters along the study area.

Eulachon have a life history in the Kodiak area similar to that of more southern populations. They are an anadromous smelt, ascending rivers to spawn in the spring. In Chiniak Bay they utilize Kalsin River, and in Marmot Bay, Pillar Creek. Both of these rivers have runs dating back at least seven years (Blondin, pers. comm.). These two systems were examined soon after the eulachon had spawned in 1979, but no carcasses were found. It is not known if adults all die after spawning, although it is assumed in the literature that some survive (Smith and Saalfield 1955). Our surveys of the two spawning streams indicate that post-spawning adults live at least long enough to swim back into the sea. Although four year old fish from Kalsin River were examined, it could not be determined if these were repeat spawners. Eulachon in Kalsin River were spawn ready; a few fish accompanying ripe spawners were not close to spawning condition.

Eulachon in Alaska may attain high population densities some years (Warner and Shafford 1979). Runs have been described of such magnitude that they clog a river system and pollute the mouth of the river with organic waste resulting from the decomposition of dead fish (Ibid.). Such anecdotal information of strong runs is lacking in the study area.

Eulachon, once up a spawning river, would be unaffected by a petroleum spill, though their access into or from the river might be impeded, and larvae returning to the sea could be affected.

Surf Smelt

Although few surf smelt were caught during this study, we feel that this only superficially indicates a low population density. Though there is no secondary evidence to indicate a high density of surf smelt (i.e. stomach contents from bird/mammal research), historical observations show that this species can reach high population levels in the Chiniak/Marmot Bay area.

During commercial fishing activities in the winter of 1966-67 more than 10 metric tons of surf smelt were landed in Kodiak in a period of six weeks (Warner ADF&G field notes). These were subsequently marketed as "silver smelt" in local markets, which were unable to handle the glut of fish. At that time, surf smelt congregated by the hundreds of tons in Kodiak's small boat harbor.

From the scanty information obtained in this study and from what is known of other populations, the following statements can be made: The surf smelt does not presently seem to be of high population density in summer along the east side of the Kodiak Archipelago. Undetermined numbers of these fish apparently spawn during summer months, and possibly during other seasons. Detailed spawning habitat demands are unknown.

Miscellaneous Species

Adult Dolly Varden and pink and chum salmon fry are ubiquitous and fairly abundant in the nearshore zones in summer along the east side of the Kodiak/Afognak Island area. The catch of miscellaneous species at Izhut Bay and Sitkalidak Strait reinforces the conclusion that the fish community structure in these two areas is similar. That these areas differ from Sitkinak Lagoon is evidenced by: 1) morphometric differences in the sand lance populations; 2) occurrence of all forage fish species in the former localities, but not in Sitkinak Lagoon; 3) similarities in frequency of occurrence of non-forage fish species at the former localities but not at the latter.

CONCLUSIONS

The following conclusions have been derived from the results of this study:

1. Capelin spawn commonly in the nearshore areas of Chiniak, Monashka and Pasagshak Bays.

2. Capelin spawn was found to be moved and buried by surf some distance seaward from where spawning occurred.

3. Capelin utilize pebble/gravel beaches of mild to moderate slope for spawning during spring high tides.

4. Chiniak Bay yielded the highest density of schools of forage fish along the east side of the Kodiak Archipelago, with Sitkalidak Straits being a close second.

5. Sand lance are an abundant part of spring/summer nearshore catches.

6. Sand lance spawn in the autumn of the year in the nearshore zone.

7. Herring utilize eelgrass for spawning substrate.

8. Eulachon spawn in a river system which empties into Chiniak Bay.

9. Eulachon can live as long as 4 years in the study area.

10. Sand lance can live to an age of five years.

11. The mean length at age data of Sitkinak Island sand lance was different from that at Sitkalidak Island and Izhut Bay, suggesting that these two areas harbor different stocks of sand lance.

12. Beach seining caught different sizes and ages of sand lance than did digging, hence, each method alone is inadequate to fully sample sand lance stocks in the study area.

13. Surf smelt were a minor forage fish species in the study area in 1979.

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ADDENDUM

This study was supported by the Bureau of Land Management through inter-agency agreement with the National Oceanic and Atmospheric Administration, 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 reference to Blumber (1969) on page 4 is out of date. More recent work indicates fish exposed to petroleum in water, sediment, and food supply readily take up hydrocarbons (Varansi and Malins, 1977) and these hydrocarbons accumulate in tissues such as those of the liver, brain, and muscle (Collier et al., 1980; Dixit and Anderson, 1977). However, metabolism and excretion progressively reduce the body burden so that hydrocarbons are not always detected (Malins and Hodgins, 1981). How quickly fish can detect petroleum hydrocarbons depends on the species, the tissue where hydrocarbons are concentrated, and other factors such as temperature and salinity. For example, severely contaminated longnose killifish (Fundulus similus) appear to be completely free of petroleum hydrocarbons after 200 hours in clean water (Neff and Anderson, 1976).

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SEASONAL COMPOSITION AND ABUNDANCE OF JUVENILE AND ADULT MARINE FINFISH AND CRAB SPECIES IN THE NEARSHORE ZONE OF KODIAK ISLAND'S EASTSIDE DURING APRIL 1978 THROUGH MARCH 1979

by

James E. Blackburn and Peter B. Jackson

Alaska Department of Fish and Game

Final Report
Outer Continental Shelf Environmental Assessment Program
Research Unit 552

April 1982

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SUMMARY OF OBJECTIVES AND RESULTS WITH RESPECT TO OCS OIL AND GAS DEVELOPMENT

This study was one portion of a multiple-part study of the marine ecosystem on the east side of the Kodiak Archipelago, which was conducted in preparation for exploratory drilling for oil and gas on the continental shelf. This study was to determine the seasonal composition, relative abundance, movements and habitat use of principal finfish (and commercial crabs) in the nearshore zone. Associated studies used fish and crabs captured in this study for food habits studies.

Oil exploration in the Kodiak lease area constitutes a potential for environmental degradation and it is a legal requirement of the Bureau of Land Management (BLM) to consider this potential as a part of the cost of leasing.

Important commercial fisheries on the east side of Kodiak include king crab, Tanner crab, Dungeness crab, shrimp, scallops, salmon, herring, halibut and bottomfish. The history, size and distribution of these fisheries are reviewed.

Samples were collected using beach seine, gill net, trammel net, try net, surface tow net and otter trawl. Numerically predominant taxa in the beach seine were Pacific sand lance, juvenile pink salmon, juvenile chum salmon and Myoxocephalus spp. sculpins. Numerically predominant species in the gill net were Pacific herring, adult pink salmon and Dolly Varden. Numerically predominant species in the trammel net were masked greenling, rock greenling, whitespotted greenling and rock sole. Pacific sand lance greatly predominated the catches of the surface tow net which also captured many larvae during summer. The predominant (by weight) species in the try net were king crab, rock sole and yellowfin sole, while the predominant taxa (by weight) in the otter trawl were rock sole, yellow Irish Lord, yellowfin sole, Myoxocephalus spp. sculpins and flathead sole.

Seasonality consisted primarily of movement of juveniles and adults of benthic species to shallower areas for summer and summer occurrence of larval and juvenile life history stages. During winter most fish resided deeper but king crabs moved to shallower waters. Differences in catch were found to be related to tidal stage.

Differences between bays were not pronounced and were probably associated with specific features such as depth, exposure of the bay, type and amount of each habitat present and hydrography. The only notable differences between areas were a relatively large number of species captured at the mouth of Kiliuda Bay; and in Saposa Bay, which is in inner Izhut, summer try net catches contained few live fish and a few dead and decaying fish, suggestive of an anoxic environment.

Specific features of distribution, abundance, migration, growth and reproduction were presented for important taxa.

INTRODUCTION

General Nature and Scope of Study

This study is a survey of the nearshore finfish and commercial crab resources of the eastside of Kodiak Island. The study was to establish a baseline for prediction of oil development conflicts with natural resources. The study was executed in four bays on the eastside of Kodiak selected as representative of the area and was conducted in all four seasons. This study was part of a large study of the Kodiak area with other projects addressing plankton, birds, food habits of fishes and crabs, fish pathology, marine mammals, transport and other aspects. The food habit samples were taken from catches of this project.

Specific Objectives

A. Determine the seasonal composition and relative abundance of principal finfish species (adult and juvenile) on the Kodiak shelf with emphasis on nearshore areas.

B. Describe the temporal dynamics and habitat use by principal finfish species, including their juvenile stages.

Relevance to Problems of Petroleum Development

Oil exploration in the Kodiak lease area constitutes a potential for environmental degradation and it is a legal requirement of the Bureau of Land Management (BLM) to consider this potential as a part of the cost of leasing.

Since the livelihood of the vast majority of the people of this area is based upon the harvest of renewable resources, the study of the living marine resources of Kodiak is an important portion of the prelease studies.

Acknowledgements

A large number of people contributed to this study, especially the skipper of the M/V YANKEE CLIPPER, Doug Lohse; the R/V COMMANDO skipper Tom Oswald and engineer Olaf Rockness; and the field crew members, Leslie Watson, Mark Buckley, Tom Bledsoe and Kelly Meeusen. Bill Johnson created the computer routines to analyze the data, Larry Holyoke did most of the report preparation and Joan Peterson typed the manuscript. Personnel from associated projects cooperated in the conduct of activities and thus substantially contributed to this study.

This study was supported by the Bureau of Land Management through interagency agreement with the National Oceanic and Atmospheric Administration, 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.

CURRENT STATE OF KNOWLEDGE

Knowledge of the marine fishes of Alaska is incomplete. Several undescribed species are known to exist. The distribution of many species is not well known. Keys for identification are not complete. And this situation exists at a time when most of the effort in biology is turning toward ecological problems, with the assumption that taxonomic problems have all been solved. As an example two important genera of sculpins, Myoxocephalus and Gymnocanthus, could not be reliably identified to species at the outset of this study. In addition, a recent summary of pelagic fishes (Macy et al.,1978) includes distributional features of rainbow smelt (Osmerus mordax) in the North Pacific. As far as we have been able to determine, records of rainbow smelt apparently are misidentifications of eulachon and may all be incorrect.

Wilimovsky (1958) published the first key to fishes of Alaska, in which he stated "Although there have been a number of separate lists and descriptive summaries, such as Everman and Goldsborough's Fishes of Alaska, none of these publications contains keys to, or sufficient descriptive data with which to identify, the fish fauna." Wilimovsky continued his work on Alaskan fishes, publishing information on the inshore fish fauna of the Aleutian Archipelago (Wilimovsky, 1963).

Other individuals have continued to add to ichthyological information; McPhail (1965) described a new ronquil from the Aleutians; Hubbard and Reeder (1965) presented new locality records for Alaskan fishes; Quast (1968) published new records for 14 species; and Peden (1970) described a new cottid (this is not a complete list). The knowledge of Alaskan fishes is growing and Wilimovsky's key is becoming out of date. Quast and Hall (1972) updated the distribution information with a list of Alaska fishes.

Forage fish species have received no directed study. Trumble (1973) and Macy et al. (1978) reviewed the available information on underutilized and pelagic species. These reviews cover general aspects, but features of distribution and abundance in the Kodiak area are not known.

Trawl surveys of bottomfish in the Kodiak area have been conducted. Alverson et al. (1964) reported a survey of the Northeastern Pacific Ocean. Ronholt et al. (1978) reviewed all the trawl surveys that have been conducted in the Gulf of Alaska. These surveys were designed to yield information on abundance of commercial species, which they do; however, knowledge of distribution and its seasonal changes is not complete, even for the major commercial species.

Previous OCSEAP (Outer Continental Shelf Environmental Assessment Project) surveys have been completed in the Kodiak area. Two coordinated surveys were simultaneously conducted in Ugak, Alitak and Kaiugnak Bays in 1976-77; one study addressed the nearshore and pelagic fishes (Harris and Hartt, 1977) and the other addressed the demersal fishes (with an otter trawl) (Blackburn, 1979).

A summary of pertinent information on commercially exploited species in the Kodiak area follows.

King Crab

King crab have been taken in virtually all of the lease area east of Kodiak. The area of greatest king crab catches was the southeast district with a mean annual catch of 5.3 million pounds (Figure 1).

King crab was first harvested in the Kodiak management area in 1951. From 1951 to 1965 catches of king crab increased to their historically highest value in 1965 of 95 million pounds, but have since declined. The fishery now depends primarily upon recruit crab and thus catch in any season depends heavily upon the reproductive success of a single year-class. Catches were very low in 1972, 1977 and 1978. The king crab fishery operated during every month of the year through the 1960's. Now, 1981, it opens September 15 and remains open until December 15 in the Kodiak area or until the guideline harvest is taken. Once closed it reopens for larger seven and a half inch crab in the Kodiak area and remains open through January 15.

King crab move into relatively shallow water in winter where their eggs hatch from February through April. This is followed by moulting and mating so that the female carries eggs for about 11 months of the year. During this time the adults are quite concentrated; nearly all of the bays on Kodiak are known or suspected to harbor spawning concentrations and virtually all shallow water is used by crabs during spawning.

Tanner Crab

Tanner crab have been harvested in virtually all of the lease area east of the Kodiak Archipelago. Mean annual Tanner crab catches have been 4.4 million pounds in the northeast district, 4.1 million pounds in the eastern district and 3.4 million pounds in the southeast district(Figure 2).

The Tanner crab fishery has been in existence since 1967. The catches increased in the first few years of the fishery and by the 1971-72 fishing season, the harvest was less than 10 million pounds in the Kodiak Management Area. As king crab abundance declined in the late 1960's and early 70's, markets opened up, prices increased, and more vessels participated in the fishery. By the end of the 1972-73 season, Tanner crab had become the predominant winter and spring shellfishery with 30.5 million pounds harvested in the Kodiak area. Since then, the annual landings in Kodiak have varied between about 13.6 and 33.3 million pounds,largely as a result of disputes over price and competition with other fisheries. There are indications at this time that future catches of Tanner crab will be a little below historic levels.

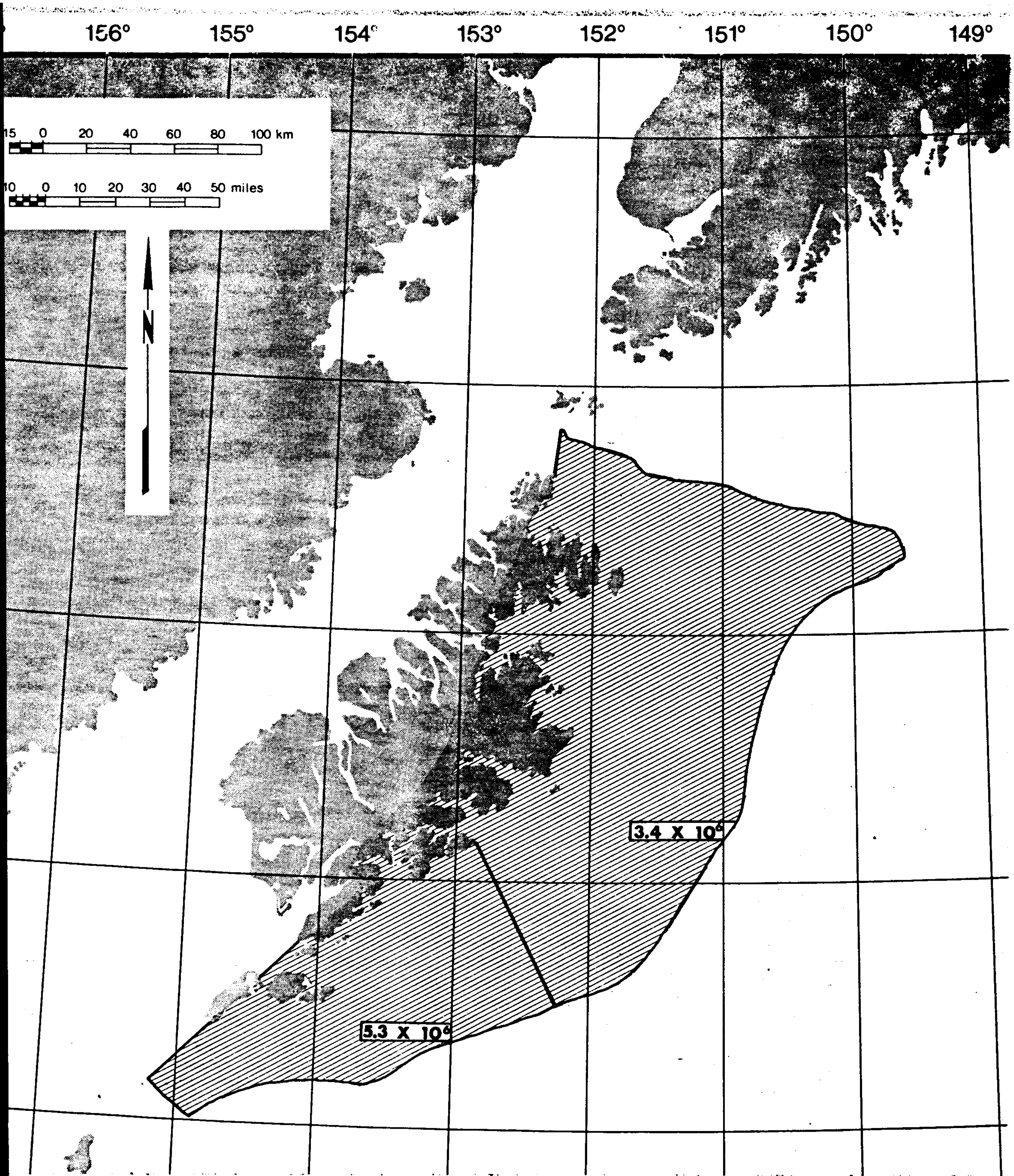

Figure 1. Mean annual catch of king crab in pounds during 1971-72 through 1978-79 fishing seasons by districts on the east side of Kodiak.

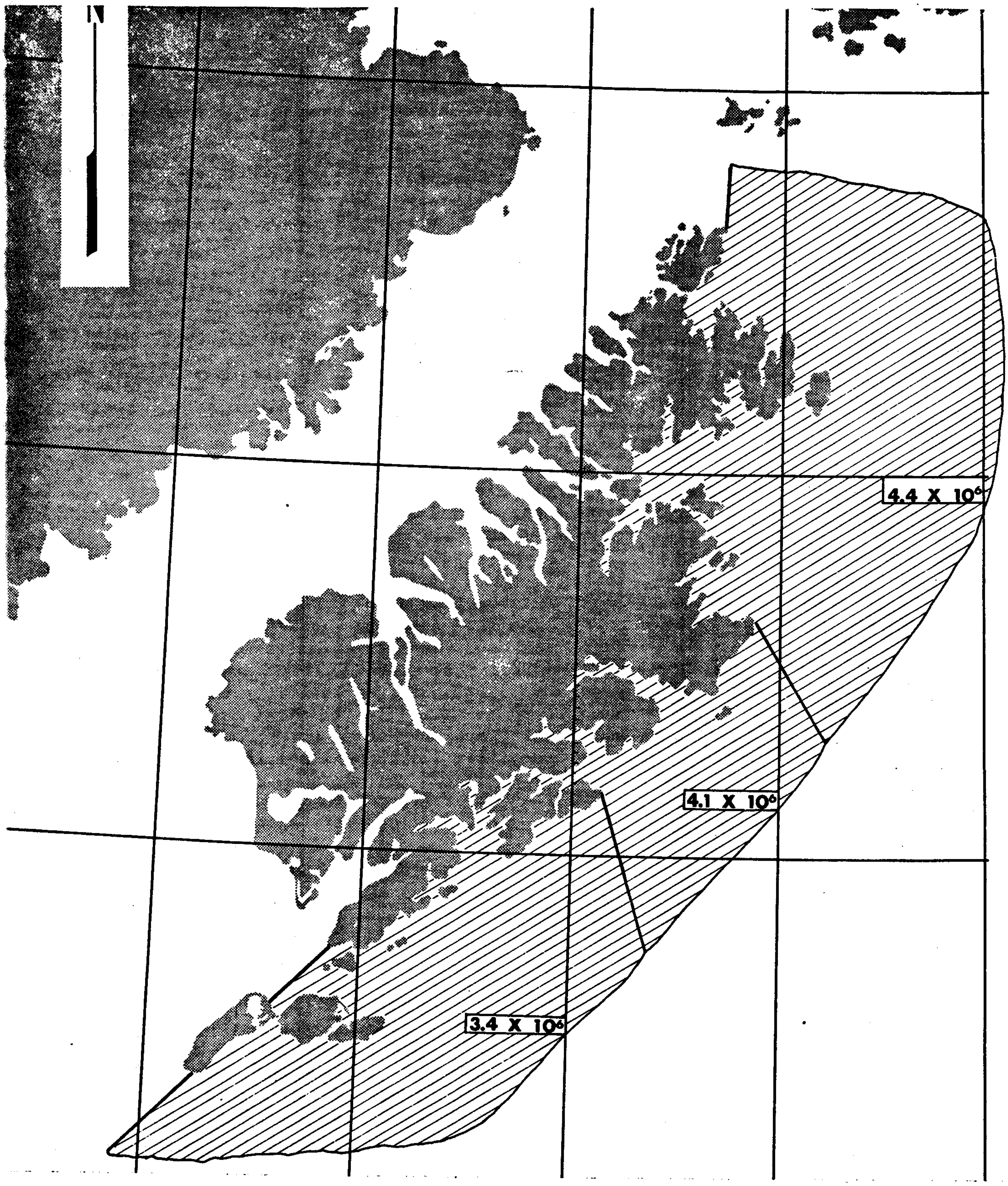

Figure 2. Mean annual catch of Tanner crab in pounds during 1971-72 through 1978-79 fishing seasons by districts on the east side of Kodiak.

The Tanner crab fishing season has included landings in every month of the year. Crab must be delivered alive, and during summer in the early years of the fishery there was a high mortality before delivery. Apparently, Tanner crab could not survive summer surface water temperatures, so the fishery has been restricted to the winter-spring period. In the Kodiak Management Area the season is from February 10 through April 30, with areas being closed earlier if catches reach the guideline harvest level. Seasons may be changed by the Alaska Board of Fisheries.

Little is known about the spawning areas and life history of the Tanner crab. Most bays on the east side of Kodiak are suspected to be spawning areas.

Dungeness Crab

Commercial catches of Dungeness crab have been widespread throughout the lease area. The area of greatest Dungeness crab catches has been the eastern district with a mean annual catch of 366 thousand pounds, followed by the southeastern district with 288 thousand pounds and the northeastern district with 84 thousand pounds (Figure 3).

The Kodiak area Dungeness crab fishery began in 1962 with a harvest of 1.9 million pounds. As a result of favorable market conditions and large virgin stocks in the Kodiak area, commercial harvests increased and peaked in the four year period from 1967-70 with an average annual harvest of 6.3 million pounds. During the early 1970's the fishery in the Kodiak area declined as a result of biological and environmental factors accompanied by adverse marketing conditions. In the mid 1970's low prices and other more lucrative fisheries have kept the Dungeness production at a low level. The outlook for the Dungeness crab fishery is no different from its history. Stock abundance is satisfactory but market conditions will probably continue to fluctuate from year to year.

Dungeness crab spawning areas encompass the entire lease area off the east coast of the Kodiak Archipelago.

Shrimp

Shrimp are commercially harvested in virtually all the lease area on the east side of the Kodiak Archipelago. Mean annual catches have been greater than 8 million pounds in the Outer Marmot and Two Headed districts. The estimated mean annual catches are 4 to 8 million pounds in Alitak and Kiliuda Bays, 1 to 4 million pounds in Inner Marmot Bay, and less than 1 million pounds in Ugak Bay.

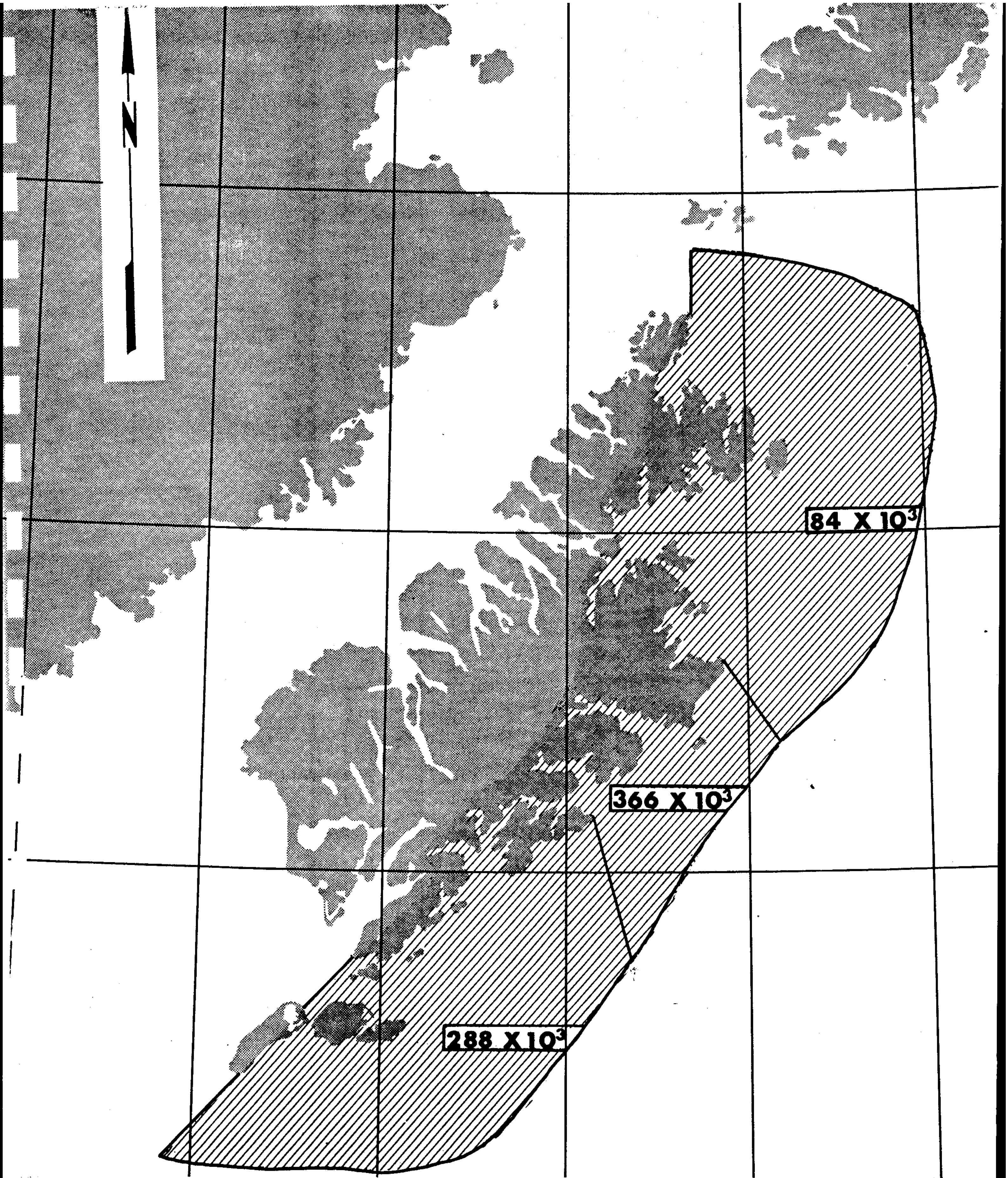

Figure 3. Mean annual catch of Dungeness crab in pounds during 1972 through 1978 fishing seasons by districts on the east side of Kodiak.

The stocks of shrimp have been seriously reduced in areas of historically high production. Stocks in Marmot Bay, the Two Headed area and Kiliuda Bay are especially reduced. Shrimp stocks in Ugak Bay were seriously reduced in the early 70's and the bay was closed for a number of years. The Ugak stocks have slowly grown and in 1979 a short opening there yielded less than a million pounds. The outlook for shrimp harvests on the east side of Kodiak in the immediate future is far below the historic levels. There is, however, some initial activity toward developing a pot fishery for prawns.

Scallops

The fishery for weathervane scallops (*Patinopectin caurinus*) has been conducted primarily on the continental shelf on the east side of Kodiak. The scallop fishery began in 1967 and expanded in the Kodiak area to 1.4 million pounds in 1970 and decreased thereafter, with no fishery in 1977 and 1978 and modest landings since (Table 1). A considerable amount of exploration was conducted by the fishermen and it is considered likely that all productive areas have been identified. Distribution of catches is presented by Ronholt et al. (1978). The historic catches are in Table 1.

Table 1. Historic commercial catch in pounds of weathervane scallops in the Kodiak area.

Year	Catch	Year	Catch	Year	Catch
1967	7,788	1972	1,038,793	1977	0
1968	872,803	1973	935,705	1978	0
1969	1,012,860	1974	147,945	1979	24,826
1970	1,417,612	1975	294,142	1980	371,018[1]
1971	841,211	1976	75,245	1981	396,000[2]

[1]353,443 pounds shucked and 17,575 pounds unshucked.
[2]Approximate.

Salmon

All five species of salmon are harvested in the Kodiak area. The 1948-78 average catch was 6.2 million pinks, 709,000 chums, 512,000 red, 42,000 coho and 1,300 chinook or king salmon.

Pink salmon spawn in virtually every stream on Kodiak and there are 23 streams on the east side that have mean 1969-78 escapements of 10,000 or more (Figure 4; Appendix Table 1). These important spawning

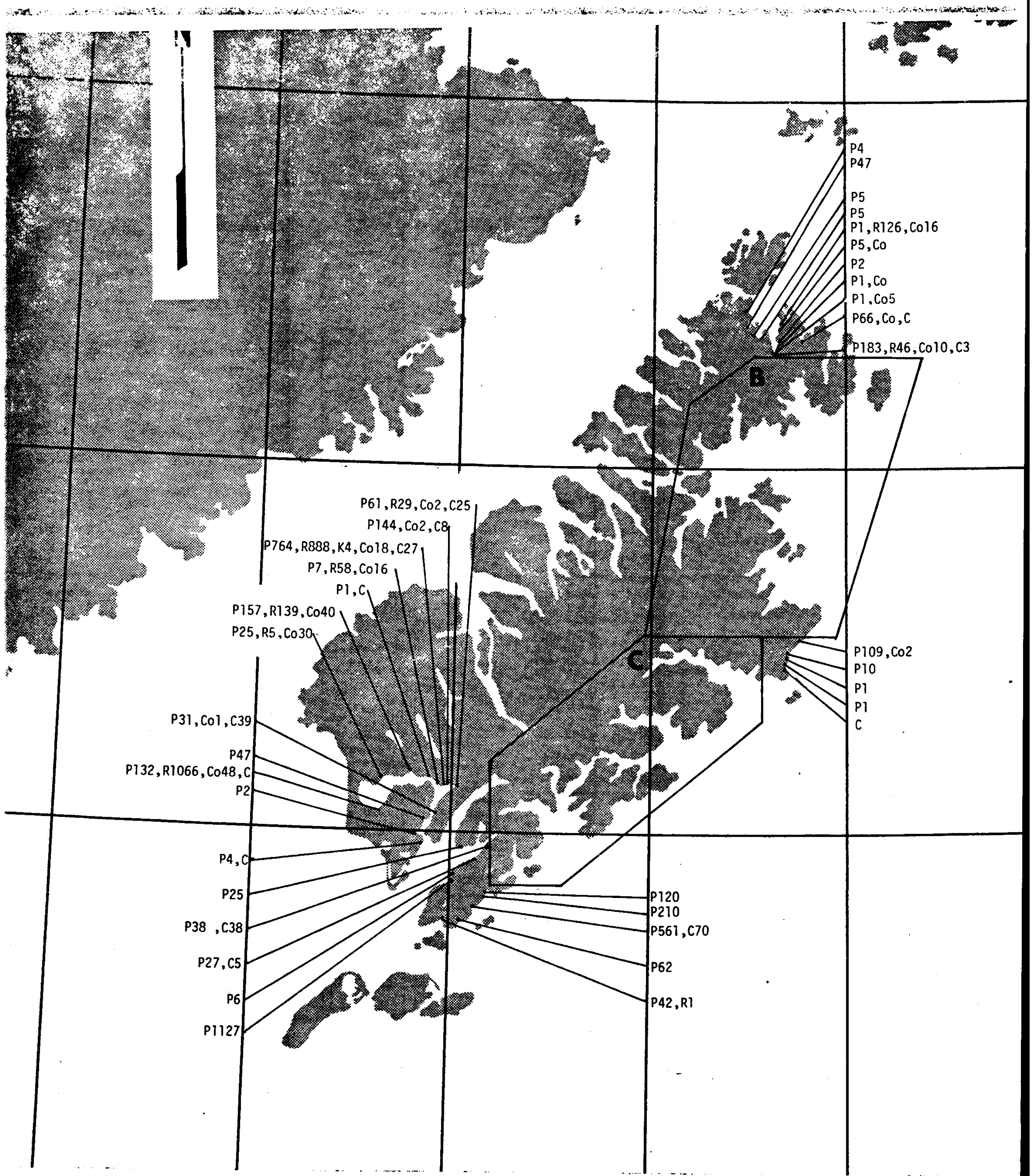

Figure 4A. Salmon spawning streams on the east side of Kodiak Archipelago. The species and run size, shown in hundreds of fish, is based on aerial counts and weir counts from data files maintained by ADF&G as "Peak Counts" for the years 1975 through 1978. The symbols indicate: P - pink salmon, R - red salmon, Co - coho salmon, K - king salmon, C - chum salmon.

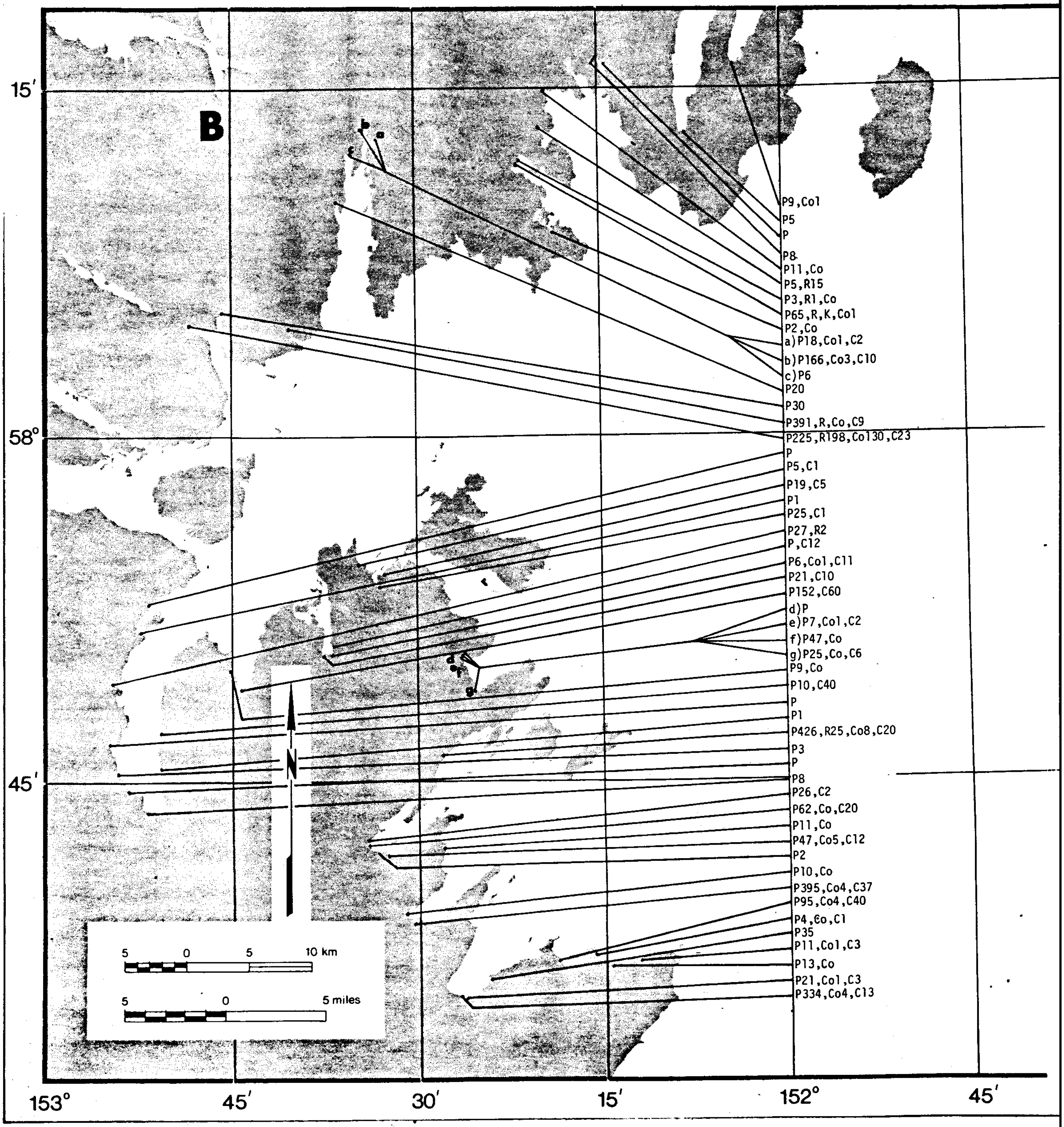

Figure 4B. Salmon spawning streams ... (cont.).

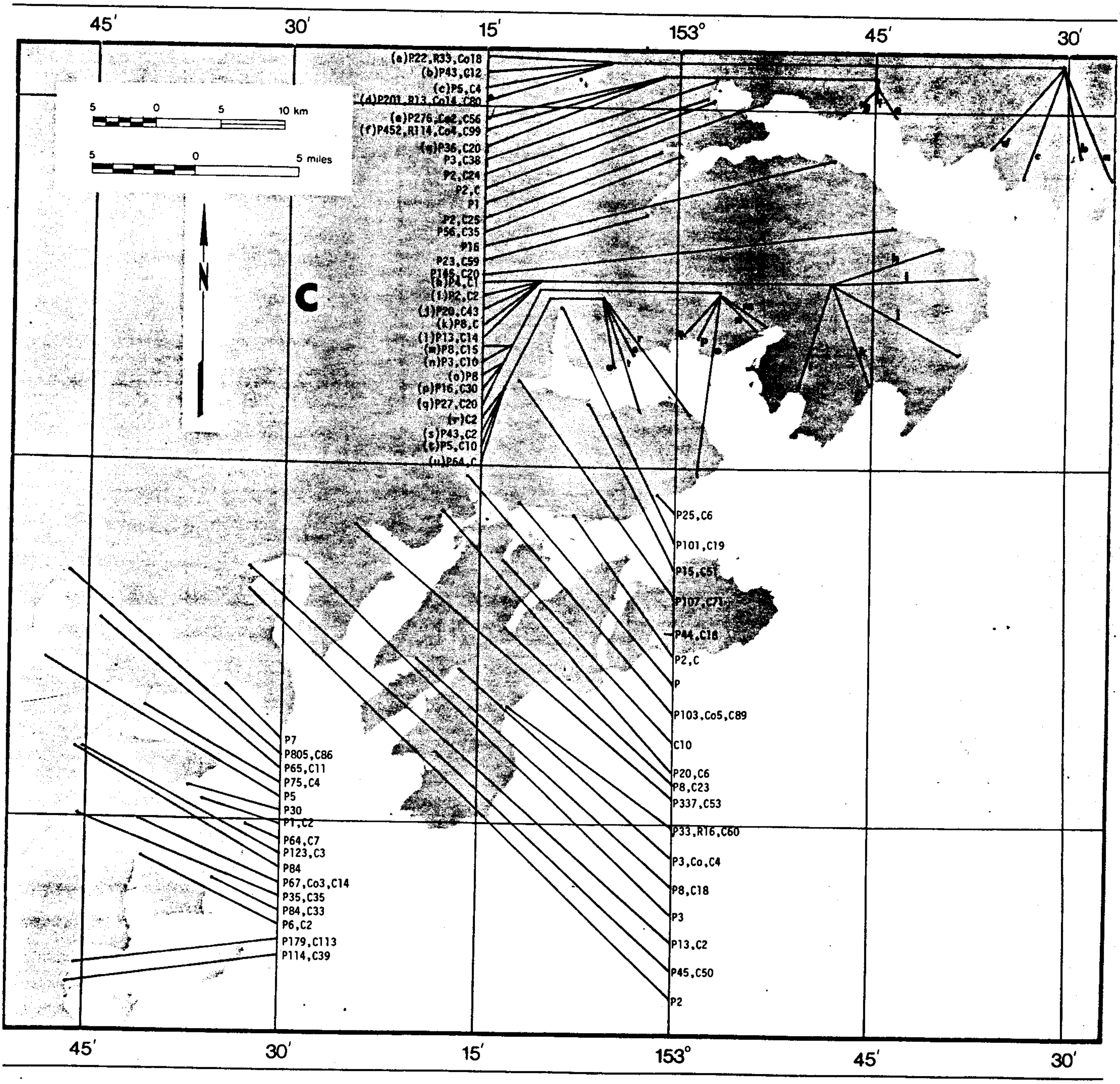

Figure 4C. Salmon spawning streams ... (cont.).

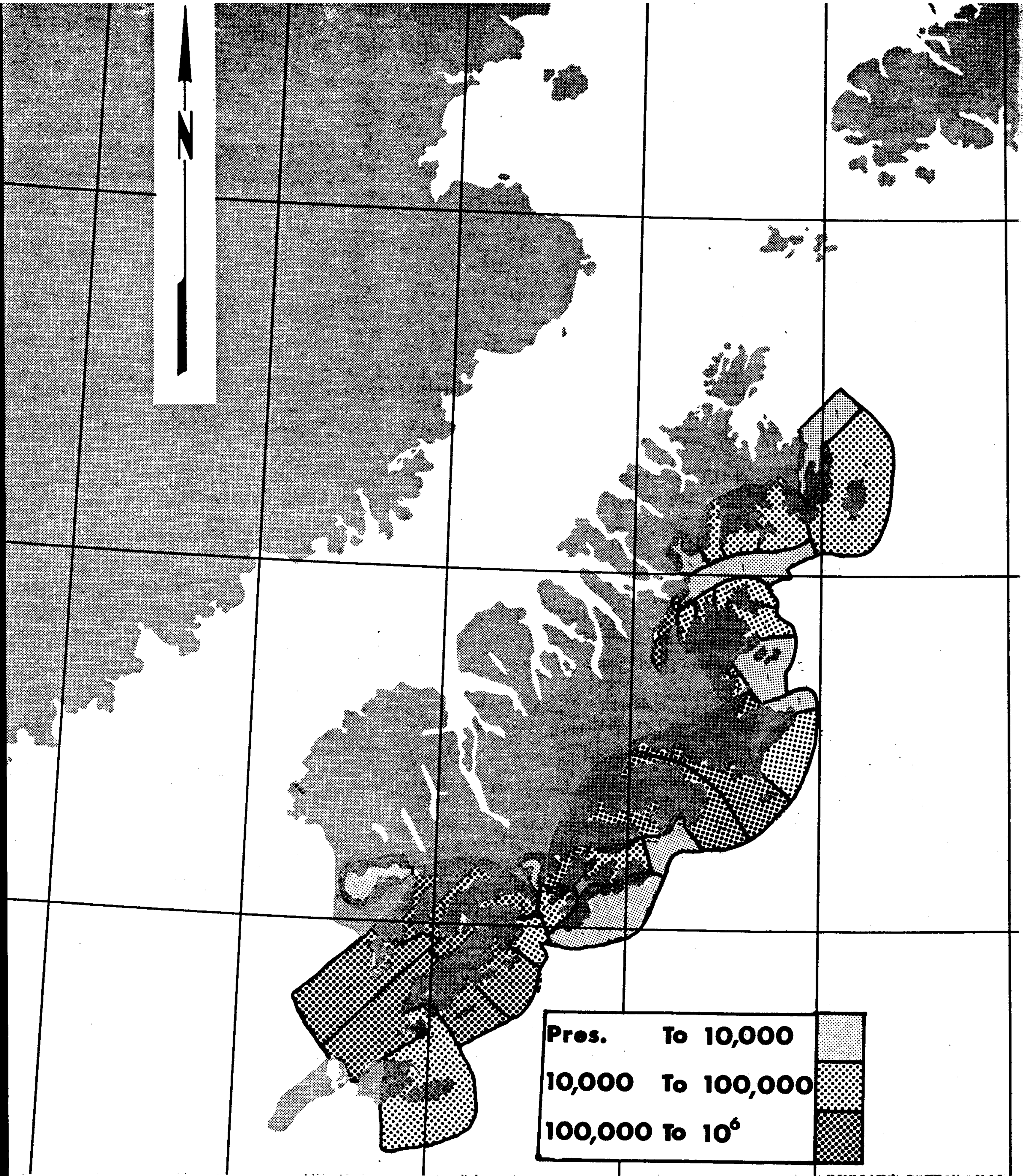

Figure 5. Mean annual pink salmon catch in numbers of fish by statistical area on the east side of Kodiak for the years 1969-1978.

streams are dispersed over the Archipelago, with a concentration of several large runs on the southwest side of Kodiak (Streams on the west side of the Kodiak Archipelago are not included in this report).

Statistical areas on the east side of the Archipelago in which the harvest of pink salmon has averaged more than 100,000 fish per year during 1969-78 are those statistical areas encompassing Kizhuyak Bay, Kalsin Bay, both statistical areas in Ugak Bay, Kiliuda Bay, Sitkalidak Strait at Old Harbor, Kaiugnak Bay, Kaguyak Bay, Geese Islands and all five statistical areas in Alitak Bay (Fig. 5).

The fishery for pink salmon occurs almost entirely during July and August with more than 80% of the catch between mid-July and mid-August (Figure 6).

Chum salmon use about 105 streams on the east side of the Archipelago of which half have more than 1,000 spawners, 14 have more than 5,000 and one has more than 10,000 (Figure 4). Of the 14 streams with over 5,000 spawners, four flow into Ugak Bay, two flow into Kiliuda Bay and five are between Kiliuda and Kiavak bays (Figure 4).

The catches of chum salmon have averaged between 10,000 and 100,000 fish annually in three statistical areas near Kizhuyak Bay, in Kalsin Bay, in two statistical areas in Ugak Bay, in Kiliuda Bay, in Sitkalidak Straits at Old Harbor and in three of the statistical areas in Alitak Bay (Figure 7).

The harvest of chums has occurred primarily during the last half of July and August (Figure 6).

Red salmon spawn in 20 streams on the east side of the Kodiak Archipelago. Of these streams, 14 have averaged more than 1,000 spawners, six have averaged more than 10,000 and one, Upper Station, has averaged over 100,000 (Figure 4; Appendix Table 1). The average annual catches of red salmon on the east side of the islands have been over 10,000 fish in two adjacent statistical areas of Alitak Bay (Figure 8). Red salmon catches peak in June, thus they are the target species of the early season salmon fishery (Figure 6). Some catch continues through September as different populations return at different times (Figure 6).

The data on coho escapements are incomplete. Since coho return later than the other salmon (Figure 6), the commercial fishery does not fully utilize this species and stream survey information on escapement is incomplete. According to the available data coho salmon spawn in about 50 streams on the east side of the Kodiak Archipelago; eleven of these have runs averaging over 1,000 fish (Figure 4; Appendix Table 1). Only two statistical areas have yielded catches averaging over 1,000 cohos, one of which is on Duck Bay on Afognak Island and the other is Moser Bay off Alitak Bay (Figure 9).

King salmon are not common on the east side of the islands. They spawn in one stream flowing into Olga Bay where the largest run was 205 fish (Figure 4). The only statistical area with a historical catch of more than 100 Kings is in Alitak Bay (Figure 10). Most of the catches of king salmon occur during June and July (Figure 6).

Concerning the offshore migration of juvenile salmon, Stern (1977) stated: " Information available on juvenile salmonids after they enter the marine waters of the total Kodiak region is scarce. The most definitive data are for the Kodiak Island district, and applies mainly to pink salmon. Since 1962, the Fisheries Research Institute (FRI) of the University of Washington has sampled juvenile salmonids in the bays of Kodiak Island by means of tow nets in order to forecast the following year's return of pink salmon (Tyler 1976 MS). The results of this research are also useful in understanding the timing and movements of juvenile salmonids after they enter the marine environment and are the basis for the following discussion".

"Juvenile pink salmon that leave streams entering bays, fjords, and channels remain in these protected waters for several months. It is suspected that young salmonids that leave streams along unprotected shorelines move directly offshore. Those pinks that do enter protected areas, such as bays, move directly from river mouths to intermediate areas along the the shorelines. Here the juvenile pinks remain in the surface waters and form large schools in the preferred areas. After approximately forty-five days the pinks gradually move to the open water areas in the bays where they remain for approximately another forty-five days. These movements are pictured in Figure 35 (from Tyler 1976 MS), which shows that in the spring and early summer, juvenile pinks are concentrated at the heads of bays. By mid-summer, it can be seen from the figures, that juvenile pinks are distributed throughout the bays and that in August and September they are concentrated near the mouths of the bays. FRI research has also found that young pinks tend to leave from shorter bays earlier (e.g., Kaiugnak and Malina Bays) than from longer bays, especially those that have a network of arms (like Alitak Bay). Departure from these waters is gradual, beginning in late June, peaking in August, and lasting through September. After leaving the open waters of the protected areas, the juvenile pinks move offshore and begin their high seas period of life. There is some evidence to indicate that some pinks, after departing a particular bay, may move back into the open waters of adjacent bays. Small numbers of chum are also included in the catches made by tow-netting in the various bays. Walker (1968 MS) reported that juvenile chum salmon appeared to stay nearshore longer than the pinks, although a small percentage of chums were found in the open water catches of pinks. Chums were seen to remain in or near river mouths for up to several weeks".

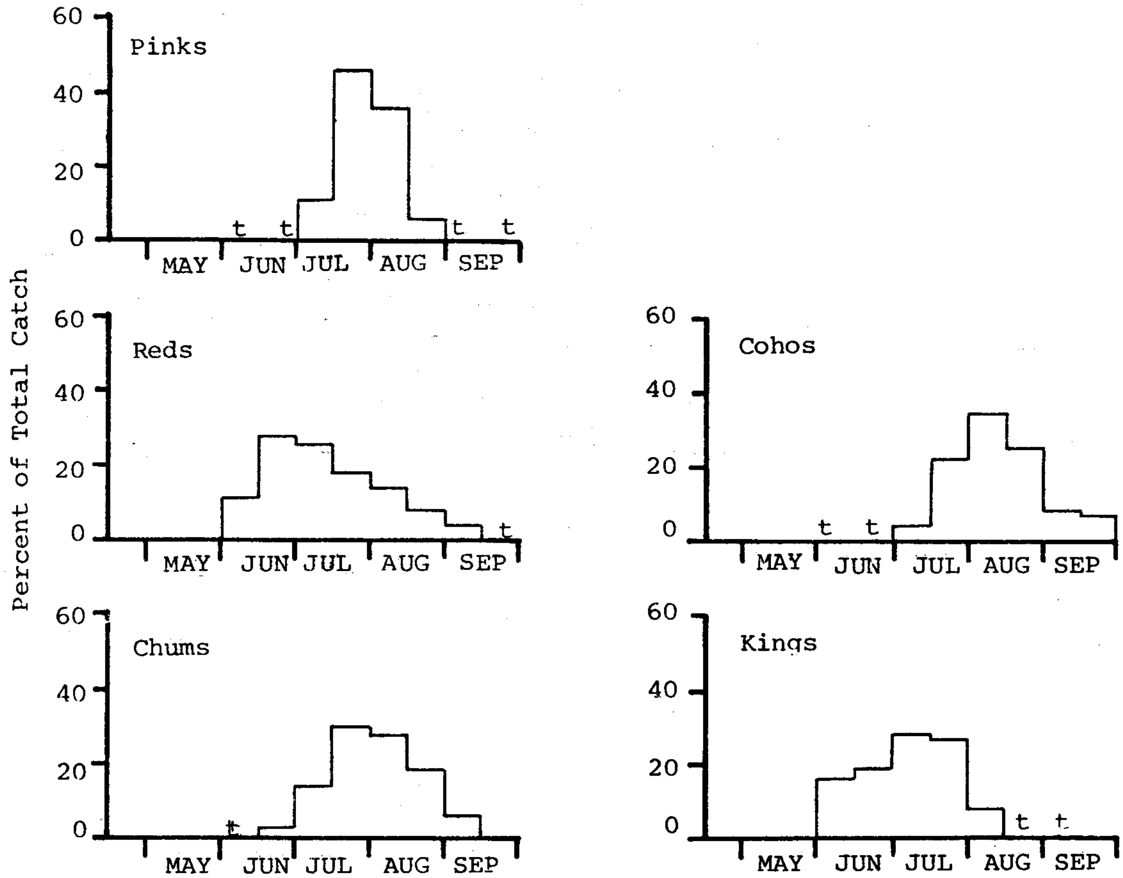

Figure 6. Commercial catch of salmon by species and time in the Kodiak Management Area. Data taken from International North Pacific Fisheries Commission, Statistical Yearbooks for the years 1960-63 and 1970-73.

Fisheries Research Institute has also conducted juvenile studies (using tow-neting) in Chignik Lagoon. The studies, which were conducted from 1961-68, were intended to show various aspects of the distribution and abundance of the post-smolt sockeye salmon in the lagoon (Dahlberg 1968, Phinney 1968). These studies showed that juvenile sockeyes behaved similarly to Kodiak pink salmon juveniles. The young sockeye were seen to delay their offshore migration and remain for a short period of time in the lagoon. Phinney (1968) reported that sockeye post-smolts initially inhabited the littoral areas of the lagoon gradually moving into deeper waters of the lagoon. He also noted that sockeye juveniles remained in the lagoon from four to six weeks before departing for offshore waters.

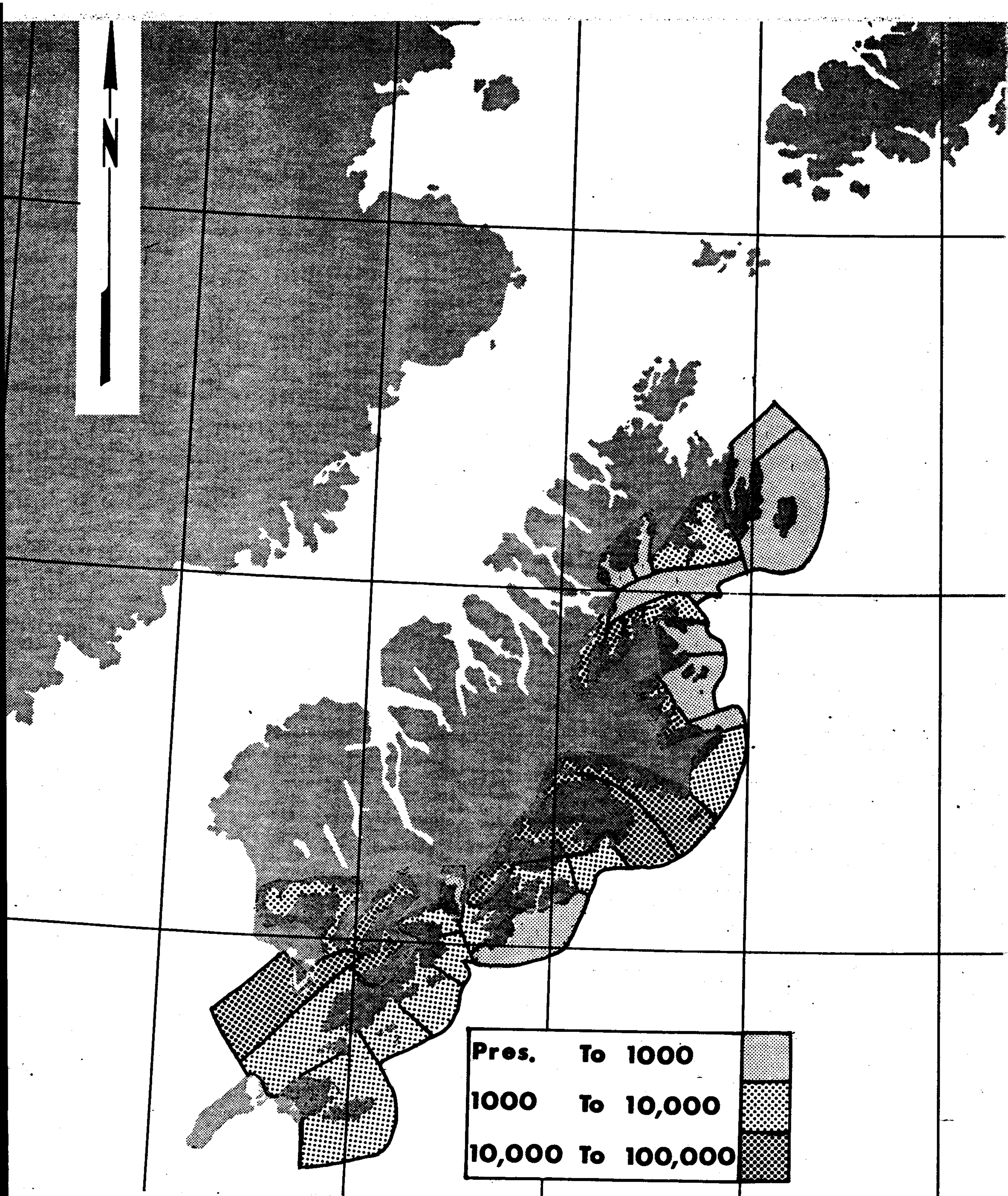

Figure 7. Mean annual chum salmon catch in number of fish by statistical area on the east side of Kodiak for the years 1969-1978.

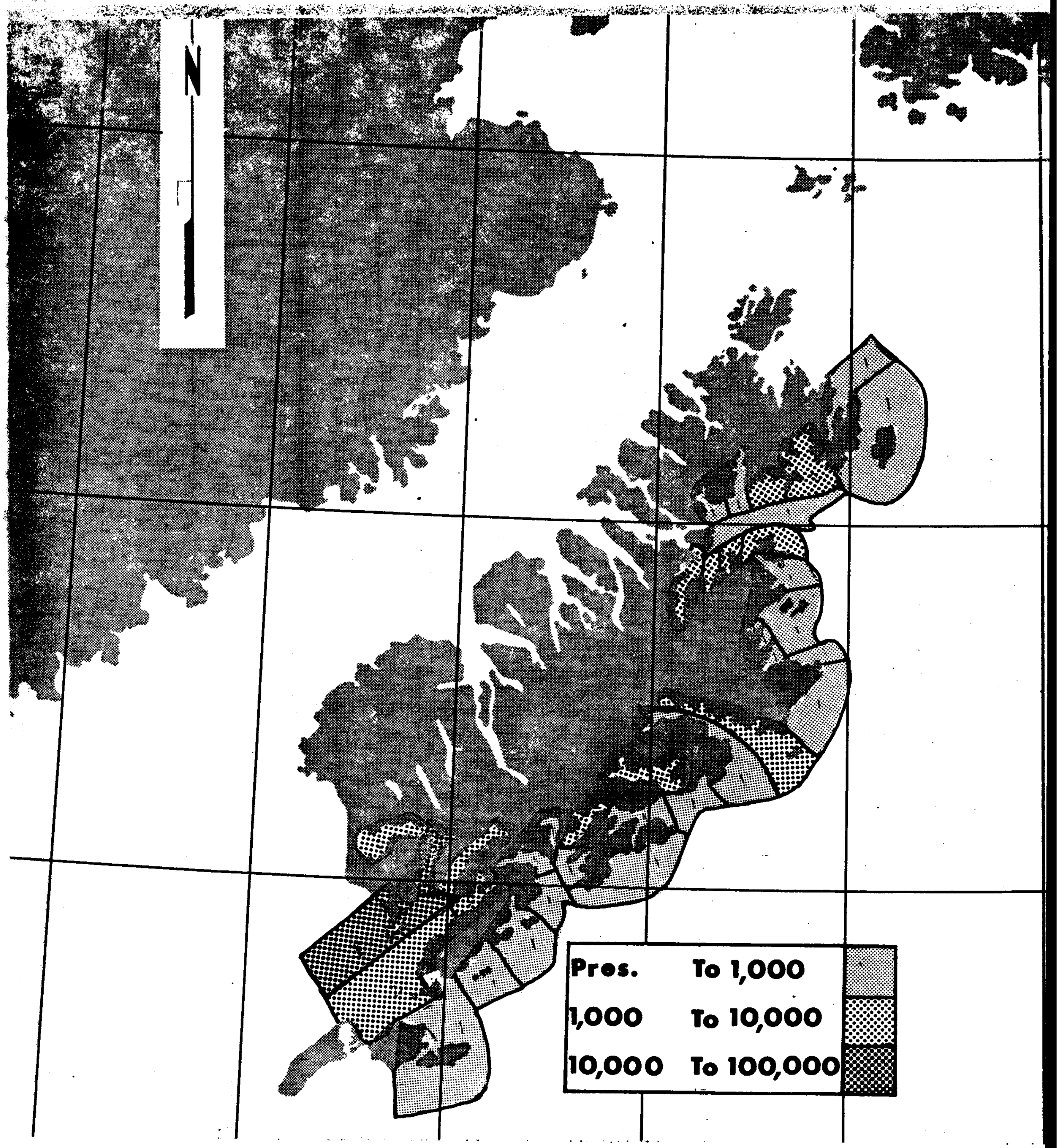

Figure 8. Mean annual red salmon catch in numbers of fish by statistical area on the east side of Kodiak for the years 1969-1978.

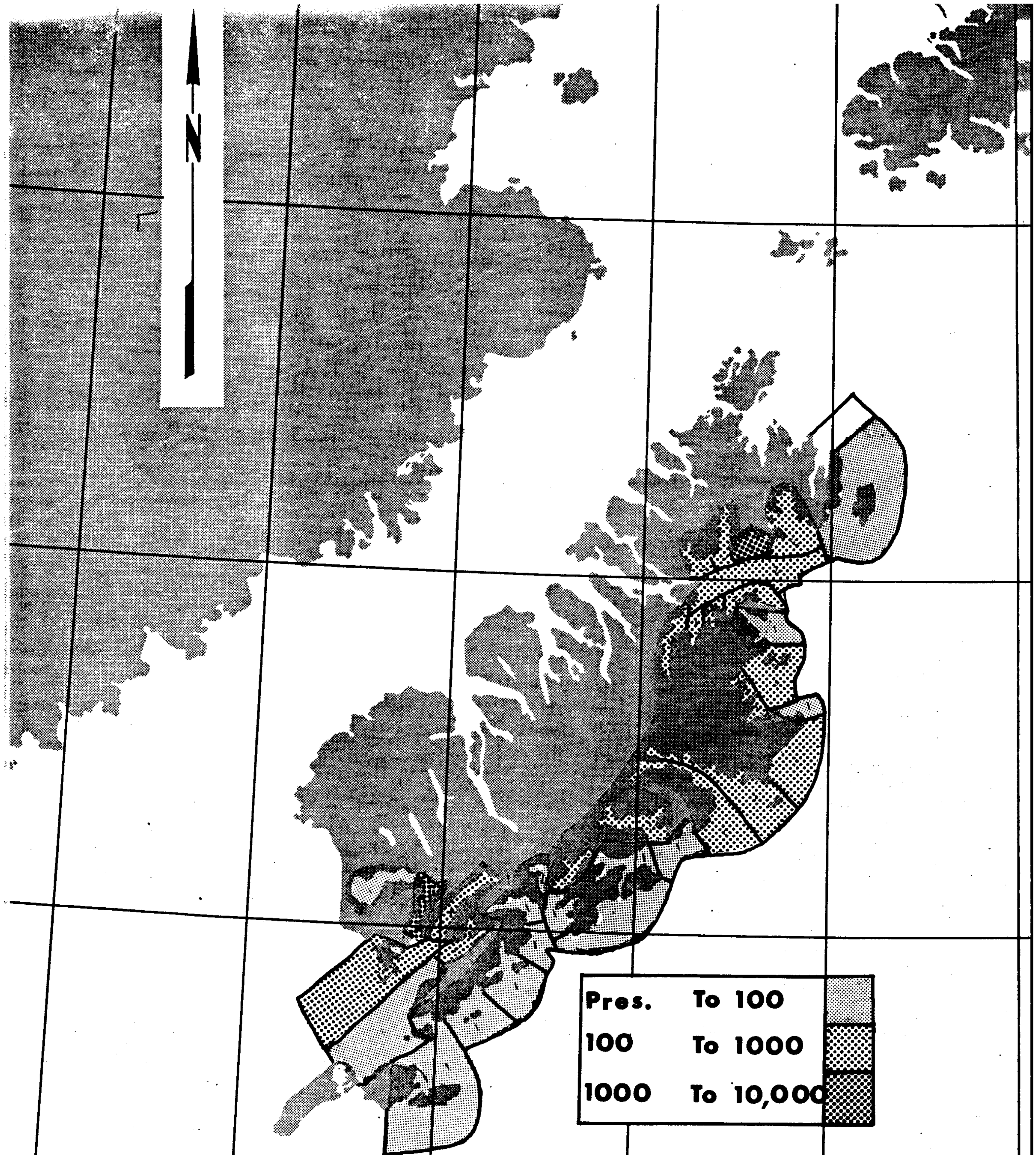

Figure 9. Mean annual coho salmon catch in numbers of fish by statistical area on the east side of Kodiak for the years 1969-1978.

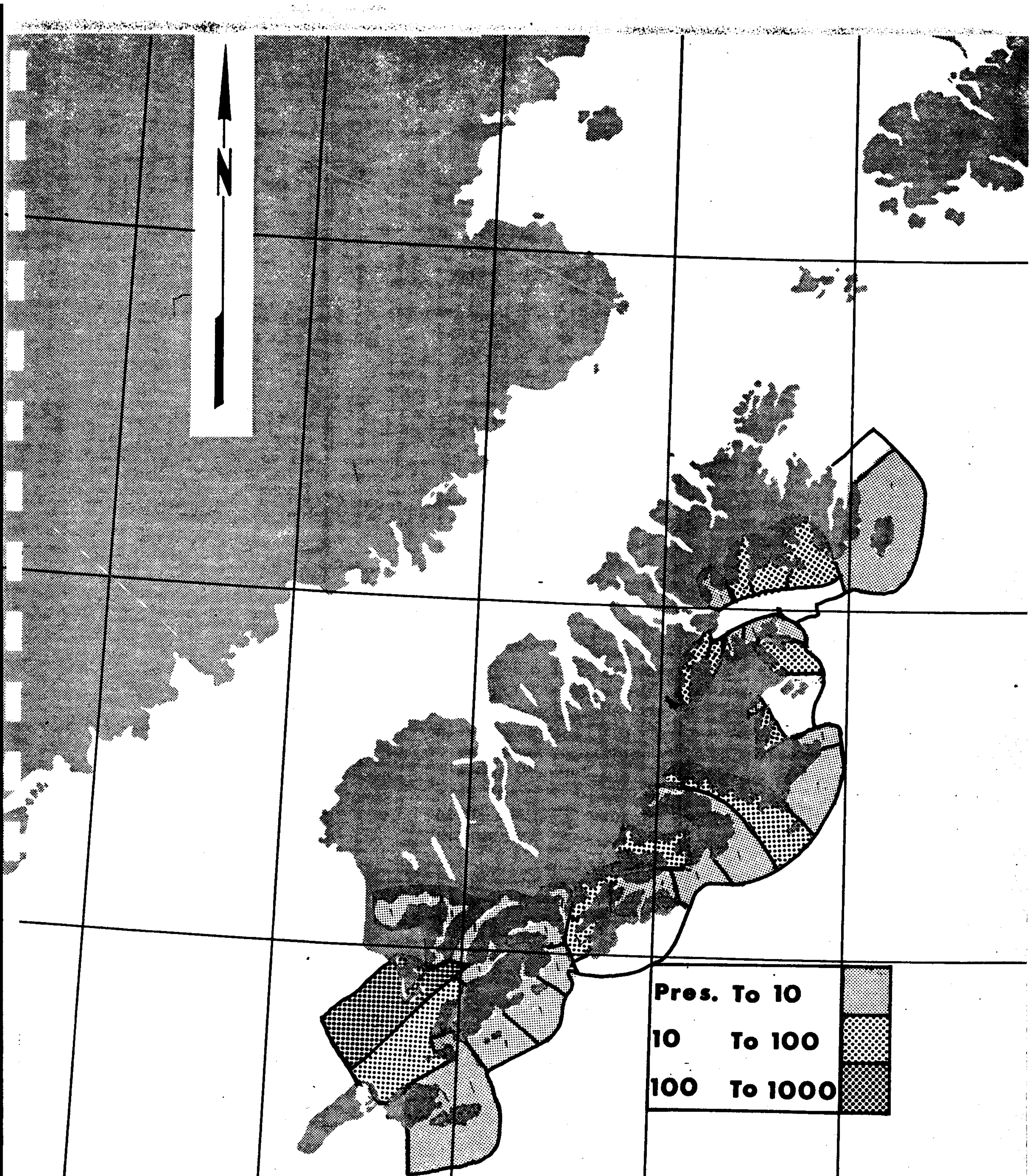

Figure 10. Mean annual king salmon catch in numbers of fish by statistical area on the east side of Kodiak for the years of 1969-1978.

Herring

The Kodiak area herring fishery has existed since 1912 with a sustained harvest reported between 1916 and 1954. Between 1934 and 1950 an average of 40,000 short tons were harvested annually. During the peak year of 1934, 120,797 short tons were processed. This fishery occurred primarily on summer and fall herring by large seiners, but gillnets and herring pounds were also used.

Previous to the development of large processing plants for herring reduction operations, several small operators put up salted and bait herring. During the height of the fishery, herring were utilized for meal, oil, pickling, dry salting and halibut bait. Market conditions for meal and oil became unprofitable, and no herring were processed between 1960 and 1963. The Japanese market for roe herring has sparked new interest and a limited roe herring fishery has developed since 1963. Herring is also being utilized for halibut and crab bait.

During the years of high herring harvest, fishing effort encompassed the entire island. Total catches on the east side of the island between 1936-1959 exceeded 10,000 tons only in one area, south Sitkalidak Strait,and were between 1,000 - 10,000 tons in two areas, Chiniak Bay and Kiliuda Bay to north Sitkalidak (Reid, 1971).

More recently the harvest of herring has been for roe. It has been concentrated primarily on the west side of the Archipelago with herring purse seiners taking most of the catch while gillnet gear takes a small portion of the catch. Bait herring caught by trawl in winter were delivered for the first time in 1978.

There currently is a 2,400 ton area-wide quota on herring during the roe season of March 1 to June 30. Due to the erratic spawning behavior the past few years, it has not been possible to take this amount of herring in the desirable mature condition, and consequently the average harvest for the last five years has only been 424.7 tons.

Herring are found all around the North Pacific rim. In North America they have been found north as far as the Beaufort Sea and south to San Diego, California. The maximum length is 38 cm, but a 23-25 cm individual is about average and will weigh about 150 g. Few survive to the age of 9 or 10 years, but a rare individual will live for 15 years. Herring will spawn when 3-4 years old (more commonly 4 in Alaska). A female will lay 10,000 - 59,000 eggs each year depending upon age. Herring feed primarily on planktonic crustaceans (copepods and euphausiids) and are in turn fed upon by gulls, seals, sea lions, ling cod and king and silver salmon.

The time of herring spawning around the Kodiak Archipelago varies from late April until mid-July. Herring spawn in comparatively shallow water along the shore in protected bays around Kodiak and Afognak islands. Spawning probably occurs in every bay but the most important spawning bays are Perenosa, Tonki, Izhut/Kitoi, Duck, Kazakof, Afognak, Monashka, Womens, Ugak (the extreme inner portion), Shearwater, Sitkalidka Straits (both north and south), Sulua, and Moser/ Olga Bays. The females lay their eggs in rows most commonly on kelp. The males swim about among the spawning females releasing milt. The eggs are fertilized by a "hit and miss" arrangement and the waters around a spawning population will turn whitish as a result of the milt. Although Pacific herring prefer to spawn on kelp, they will spawn on just about anything when their numbers are dense. Kodiak herring commonly use eelgrass (Zostera), hair kelp (Desmarestia) and rockweed (Fucus). Macrocystis, which is responsible for much of the roe kelp fishery in S. E. Alaska, grows only rarely in Kodiak. The eggs take from 12 to 20 days to hatch depending upon temperature and exposure, with longer exposure resulting in shorter incubation time. The most robust (heaviest) larval herring come from eggs that are exposed by the tides from 4-6 hours per day (Jones, 1972). Egg mortality may vary from 50% to 99% as a result of predation by fishes, snails, crabs and birds; and eggs in dense spawning areas may be suffocated if the mass is too thick; and exceptionally warm or cold weather or dry conditions increase mortality, and waves may cause kelp to be torn up and cast upon the beach, causing severe mortality.

The larval herring bear little resemblance to the adult. They are about 6 mm in length and are nearly transparent. Their swimming ability is feeble; therefore, this period is one of the more critical stages for the larvae. They rely upon the little remaining egg yolk for the first few days before they begin to feed on minute planktonic organisms. They are at the mercy of water currents, local food supplies and predators, such as comb jellies, arrow worms, jelly fish and others. Larval mortality may exceed 99% during this time. Optimum temperature and salinity for larval survival is 8.5° C and 17% salinity (Alderdice and Velsen, 1971).

By early September at a size of 30 mm the larval herring begins to look like a small adult. The juveniles then move in large schools and frequent kelp beds. By late fall they move into deep or offshore waters (ADF&G, 1978).

Halibut

The halibut catch has been widely distributed throughout the lease area and a large share of the shelf on the east side of Kodiak Island is considered to be a major fishing ground (IPHC, 1978a, Figure 2). There has been a seasonal trend in the location of the fishing activity. As halibut migrate from deeper water in winter to shallow water in summer, the fishery follows. In the early season, about May, the fishery is most active in deeper areas and in midsummer some of the activity is as shallow as 10 fm. Some of the fishermen have reported that halibut seem to follow the salmon into the bays and halibut have been found with salmon in their stomachs (R. Myhre, personal communication).

The halibut fishery has a long history of consistent production, but it declined in the last decade. The total annual catch reached 69 million pounds in 1915 and fell to 44 million pounds in 1931. Thereafter, the annual catch generally increased and exceeded 70 million pounds in 1962 but fell below 25 million pounds in 1974 (IPHC, 1978a). Incidental catch of juvenile halibut by foreign trawlers was identified as part of the cause of the recent decline. The halibut commission has conducted surveys of the abundance of juvenile halibut in the Bering Sea and Gulf of Alaska. In the Bering Sea the abundance of juveniles declined from about 45 per hour of trawling in 1963 to less than 5 in 1972, and it has since increased to nearly 20 in 1977. In the Gulf of Alaska a similar catch rate in 1963 declined to about 20 per hour in 1975-76 and increased somewhat in 1977 (IPHC, 1978b). Since there is wide migration, the abundance of juveniles in the Bering Sea directly affects abundance of adult halibut in the Kodiak area several years later. The outlook is, therefore, for increased catches in the 1980's but not as great as historic levels (IPHC, 1978b).

Mature halibut concentrate on spawning grounds along the edge of the continental shelf at depths from 182 m to 455 m during November to March. Major spawning sites in the vicinity of Kodiak include Portlock Banks and Chirikof Island. In addition to these major spawning grounds, there is reason to believe that spawning is widespread and occurs in many areas, although not in concentrations as dense as those mentioned above. Evidence to support this conclusion is based on the widespread distribution of mature halibut during the winter months as indicated by research and commercial fishing (IPHC, 1978a).

Spawning of halibut on the Cape St. James spawning ground occurs from December through March with a peak in mid-January (Van Cleve and Seymour, 1953).

Bottomfish

The bottomfish fishery has been dominated by foreign fleets, primarily Japan and U.S.S.R. These fisheries have been generally most active along the Continental Shelf edge. Ronholt et al. (1978) presented a detailed discussion of this fishery. The Japanese catches during 1969-74 were Pacific Ocean Perch (45%), sablefish (27%), pollock (15%) and arrowtooth flounder (3%) (Ronholt et al., 1978).

The domestic bottomfish fishery has been expanding in recent years, and it has targeted upon pollock and Pacific cod. This fishery has occurred primarily in the south Sitkalidak Straits - Two Headed Island area, outer Barnabas trough and in Shelikof Strait.

STUDY AREA

The Kodiak Archipelago lies just off the northwestern perimeter of the Gulf of Alaska and is an extension of the Kenai Peninsula. Most of the islands are mountainous terrain, surrounded by numerous estuarine bays and rugged coast.

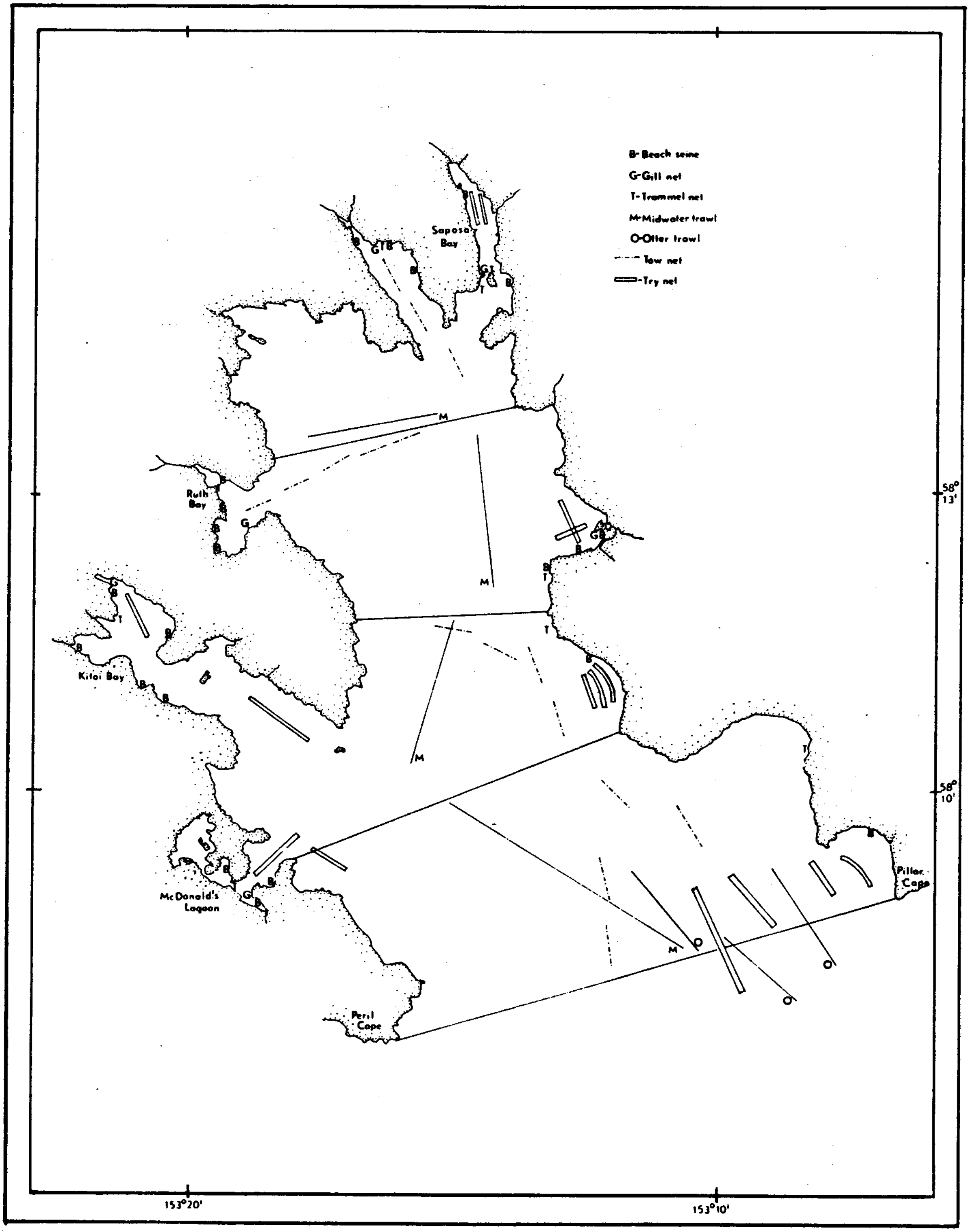

Figure 11A. Izhut Bay sampling region with sampling strata and station locations by gear type, 1978-79.

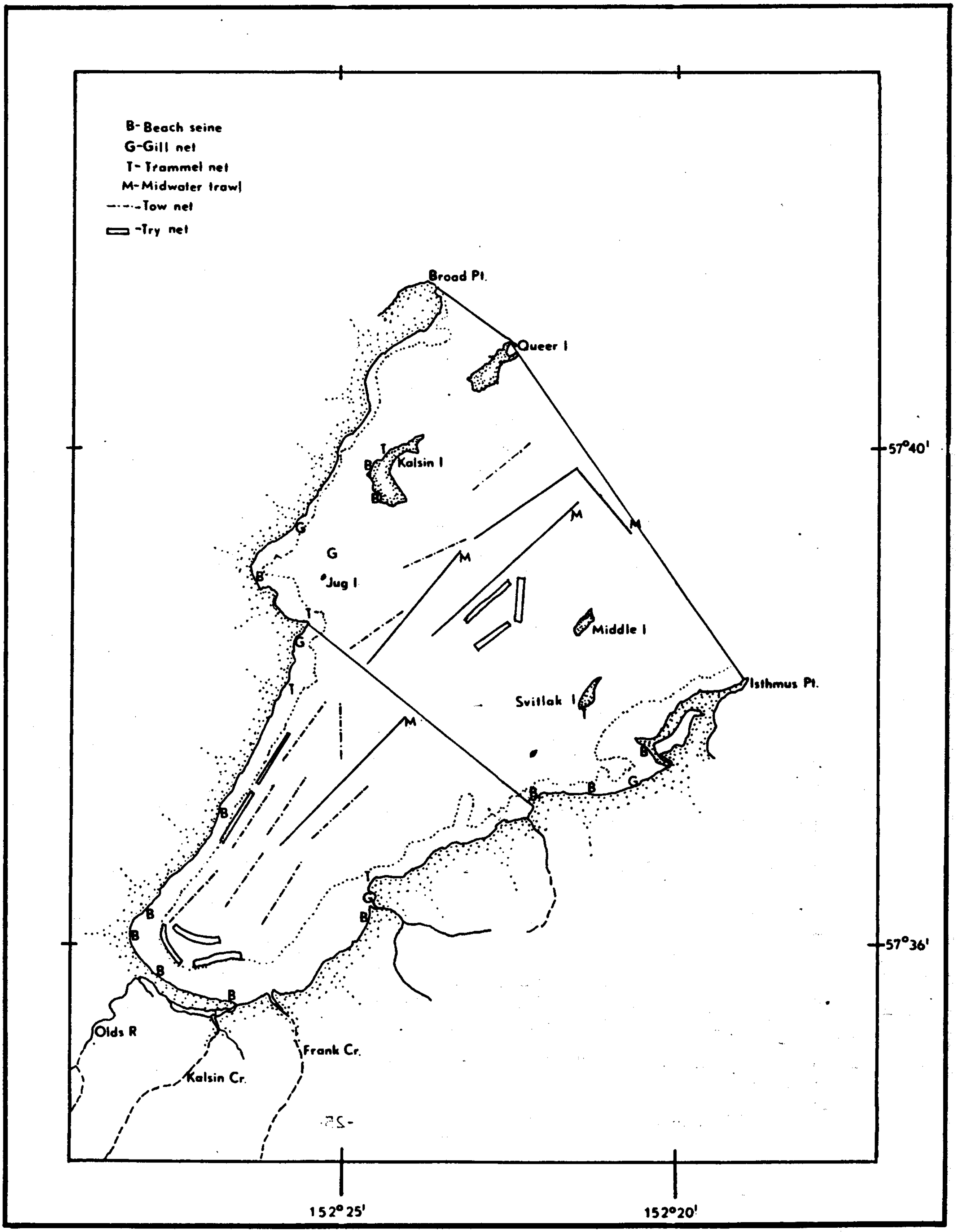

Figure 11B. Kalsin Bay sampling region with sampling strata and station locations by gear type, 1978-79.

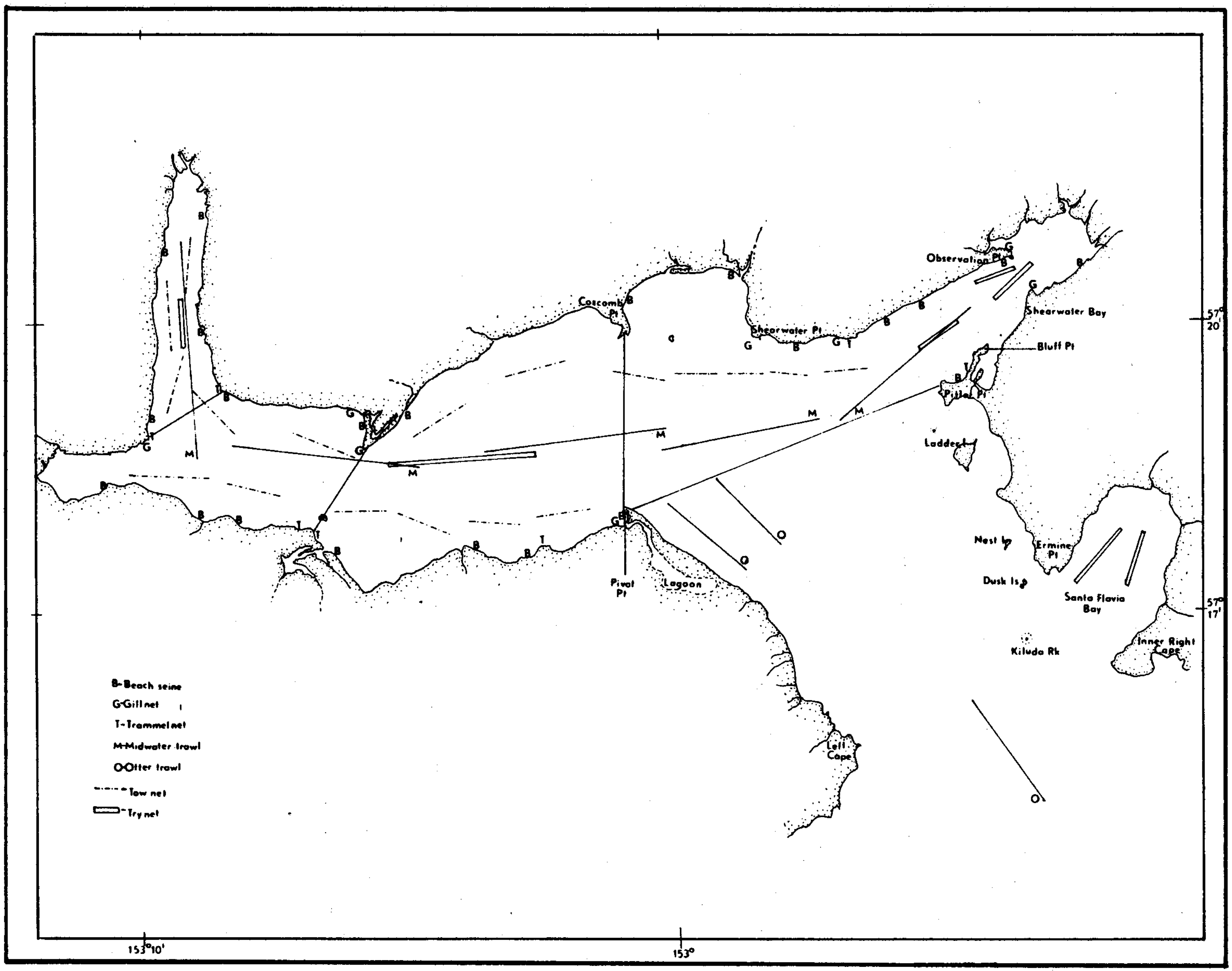

Figure 11C. Kiliuda Bay sampling region with sampling strata and station locations by gear type, 1978-79.

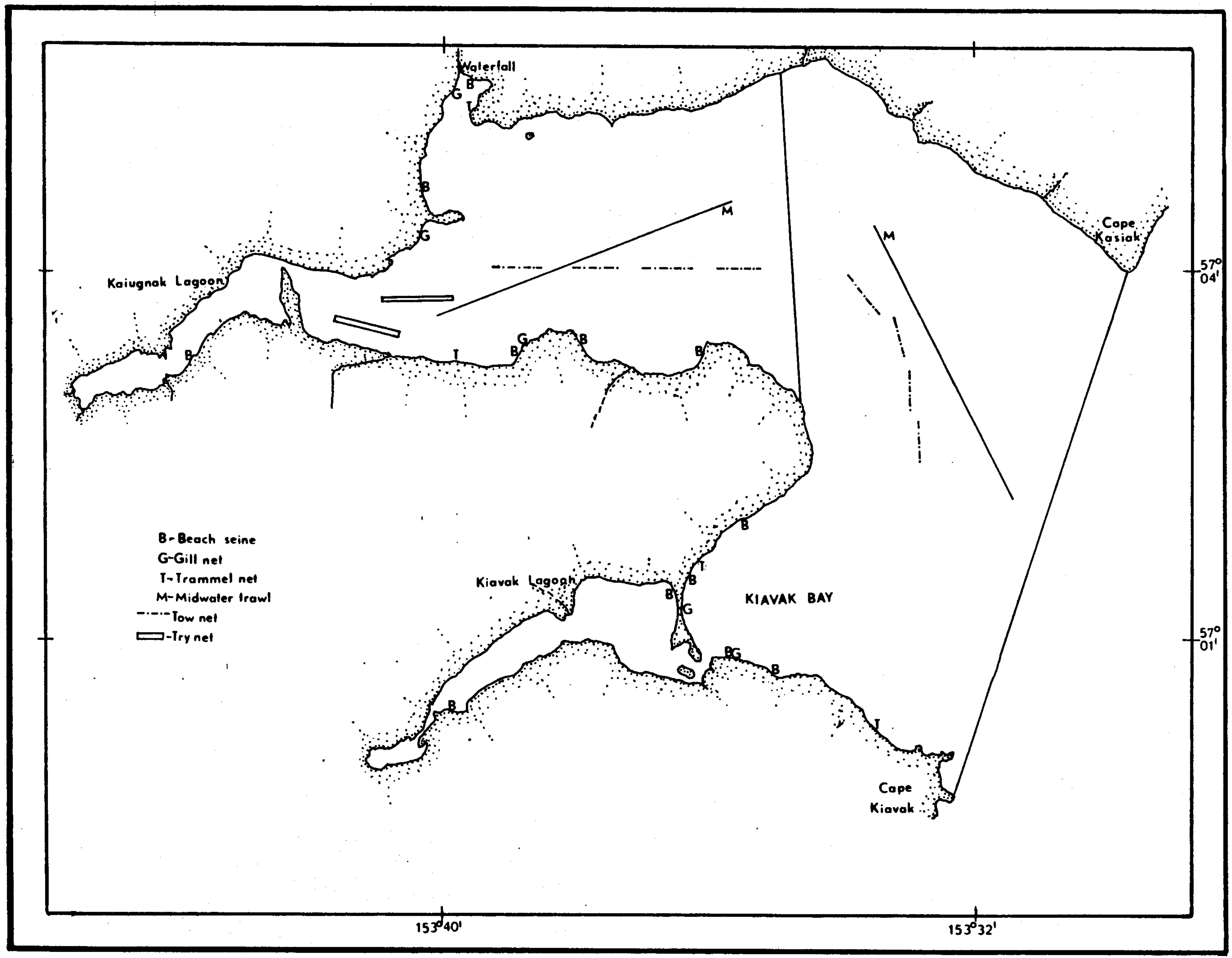

Figure 11D. Kaiugnak Bay sampling region with sampling strata and station locations by gear type, 1978-79.

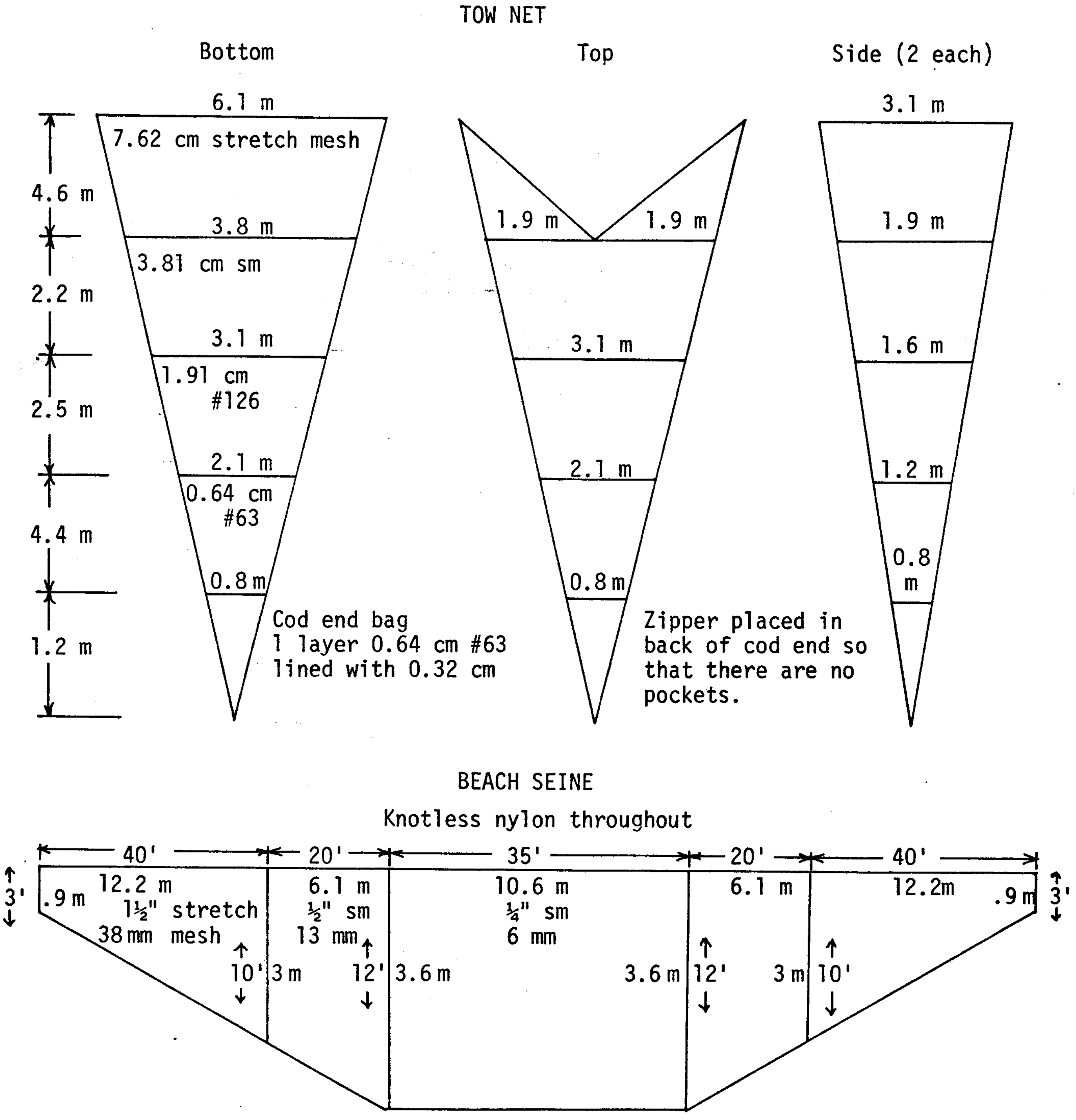

Figure 12. Specifications of the tow net and beach seine, diagrammatically shown.

The broad shelf on the east side of the island is 50 to 100 fathoms deep in most areas. Even along the shore very little area is less than 50 fathoms deep. Weak and variable currents are found over the Continental Shelf, while the much stronger Alaskan Current is concentrated along the shelf edge (SAI, 1979). Areas of fresh water influence occur mainly in the local coastal waters.

This study was conducted in four bays on the east side of the Kodiak Archipelago. The bays, Izhut, Kalsin, Kiliuda, and Kaiugnak, were deemed representative of the area and were considered logistically suitable.

Izhut Bay has steep rocky shores and cobble beaches exposed to surf with extensive kelp beds and little intertidal area. The bay is predominantly 50-115 fathoms deep with a trough extending to just past Ruth Bay where the bottom shoals sharply to a small area around the shoreline less than 10 fm deep. Five small, shallow enclosed inlets can be found around Izhut Bay, one of which, Saposa Bay, is about 10 fm deep with a 3 to 4 fm sill at its mouth. No other sills occur in Izhut Bay.

Kalsin Bay exhibits a large sandy shoreline with intermittent rocky outcrops. Two major creeks flow into the head of the bay. The mouth of the bay has numerous islands and submarine reefs that extend almost into the middle of the bay and at low tide considerable intertidal areas are exposed. About half of the bay is sandy bottomed and shallow (11-44 fm), the remainder is 10 fm or less.

Kiliuda Bay is relatively shallow (12-48 fm) with a 16 fm deep sill in the outer-mid region which isolates a 58 fm mud bottom hole in the middle of the bay from the 57 fm deep outer bay. Most of the shoreline is protected sandy beach with small islands, reefs and rocky outcroppings occurring at the mouth. There are numerous small lagoons and one small estuary. Kiliuda receives a considerable quantity of melt water runoff.

Kaiugnak Bay is similar to Izhut in its exposed rocky shoreline, but has small sand bights and two large lagoons with dense eelgrass beds located at the head of Kaiugnak and Kiavak Bays. Several reefs occur near both the northern shore and the head of the bay. Moderate portions of the bay are 10 fm or less in depth, while most of the bottom is precipitous, resulting in depths ranging from 13-62 fathoms.

SOURCES, METHODS AND RATIONALE OF DATA COLLECTION

Kalsin and Kaiugnak Bays were each divided into two regions and Izhut and Kiliuda into four regions. The intention was to sample each approximately equal sized region with about the same number of hauls of each gear. Izhut and Kiliuda Bays are much larger than Kalsin and Kaiugnak Bays. The otter trawl was used only in outer Izhut and outer Kiliuda Bays to sample depths and areas that were intermediate between the nearshore zone sampled with the other gear and the offshore zone sampled by previous surveys. The otter trawl was added as an afterthought by the contractor on the advice of program reviewers. Local conditions dictated minor variations from this scheme; for example, there was very little bottom in Kaiugnak Bay on which try netting was possible. The sampling locations are illustrated in Figure 11.

The sampling gears employed were beach seine, gill net, trammel net, tow net, try net and otter trawl. These are described in detail below. A midwater trawl was unsuccessfully used and results are not presented. Surface temperature and salinity were measured with a Yellow Springs Instrument Co., Model 33 Temperature/Salinity Meter.

Sampling was conducted during April, May, June, July, August and November of 1978 and March of 1979. During the first five cruises, Kalsin Bay was sampled from the 1st to 7th, Izhut from the 8th to 15th, Kiliuda from the 16th to 23rd, and Kaiugnak from the 24th through the end of the month. During November and March, the sequence did not change, but the time of month varied. The basic sampling crew consisted of four people, two from the University of Washington (U of W) representing Research Unit 553, and two from the Alaska Department of Fish and Game (ADF&G). These four people worked together to accomplish the objectives of the two different projects. The U of W was responsible for determining food habits of the fishes captured. A representative from the University of Alaska, Institute of Marine Science (IMS) representing Research Unit 5, was present during sampling in Izhut and Kiliuda Bays to take stomachs of crabs for food habits studies. When the sampling designed for this study provided insufficient crabs for R. U. 5, additional effort was devoted to collecting crabs. The fish catch of these samples was not enumerated; however, stomachs were occasionally taken for food habits analysis. A representative of National Marine Fisheries Service (NMFS), representing Research Unit 332, was present during several of the summer cruises to study pathology of fish, crab and shrimp.

During the months of April through August, the sampling crew lived aboard and worked from the chartered vessel M/V YANKEE CLIPPER, which was 65 ft. (19.8 m) long and had a relatively large unobstructed aft deck. A 19 ft. (5.7 m) Boston Whaler with a 70 hp outboard was stored on deck when traveling and was used to pull one side of the tow net and conduct other sampling. A 14 ft (4.3 m) aluminum skiff was sometimes used for beach seining. The R/V COMMANDO was made available one or two days per month in both Izhut and Kiliuda Bays for otter trawling. During November and March the crew lived aboard and worked from the R/V COMMANDO, which was also used for plankton sampling.

Beach Seine

The beach seine was constructed as shown in Figure 12. Approximately 50 ft. (15 m) lines of rope with anchors were attached to each end. The net was set in an arc such that each end of the net was usually within 10 ft. (3 m) of the beach and the net was immediately retrieved. Each set covered approximately 370 m^2. Sampling stations were informally selected on suitable beaches so as to evenly cover the study area. Once stations were selected, they were visited on each successive cruise.

Sampling was conducted during the day. Depth sampled did not exceed the depth of the net, 3.7m (12 ft.)

Gill Net

Gill nets were 6 ft. (1.8 m) deep and 100 ft. (30.4 m) long and each consisted of 25 ft. (7.6 m) long panels of 1",1½", 2" and 2½" (25 mm, 38 mm, 51 mm, and 64 mm) stretch mesh knotted nylon. The nets were hung to float, were anchored at selected locations and retrieved after a 2.5 hour soak. They were placed near shore much as were the trammel nets and were fished only during the day. Depths fished were estimated and ranged from 2 m to 20 m with 62% of the sets at less than 7 m and 83% of the sets at less than 10 m.

Trammel Net

The trammel nets were constructed of three adjacent panels (two outer and one inner) each 150 ft. (45.7 m) by 6 ft. (1.8 m). The two outer panels were made with 20" (0.5 m) stretch mesh of #9 twine 8 mesh deep by 68 mesh long. The single inner panel was 2" (51 mm) stretch mesh of #139 twine, 68 mesh deep by 2016 mesh long. All panels were white knotted nylon. The lead line was 75 lb. lead core rope and the floatline was 1/2" (13 mm) polyfoam core line.

The trammel nets were hung to sink and were fished on the bottom. Two nets were fastened together; one end was fastened on the beach and the other end was anchored offshore, with the set perpendicular to the beach. Sets were generally 2.5 hours long and during the day. Depths fished were estimated and ranged from 2 m to 20 m with 14% of the sets at 2 to 3 m, 60% of the sets at less than 7 m and 80% of the sets at less than 10 m.

Tow Net

The tow net was constructed as illustrated in Figure 12. It was held open vertically by spreader bars of 2" (51 mm) galvanized steel pipe and was held open horizontally by a towing vessel on each side. It opened approximately 10 ft. (3 m) vertically and 20 ft. (6.1 m) horizontally when fishing. It was towed at the surface between a skiff and the charter vessel on approximately 100 ft. (30.4 m) of line for 10 minutes at approximately 3.5 kph so that about 0.6 km were covered in one tow or 0.0036 km. Vessel speed and distance covered were estimated by eye. Depths at locations fished ranged from 14 m to 183 m with 1% of the hauls in water less than 20 m deep, 35% of the hauls in water less than 40 m deep, 62% of the hauls in water less than 60 m deep, 78% of the hauls in water less than 80 m deep and 93% of the hauls in water less than 100 m deep. All sampling was conducted during daylight.

Try Net

The try net was a standard 20 ft. (6.1 m) try net purchased from McNeir Net and Supply Co. It had a 22 ft. (7 m) footrope, a 20 ft.

(6.1 m) headrope, and was made with 1-1/2" (38 mm) #9 webbing throughout with a 1-1/2" (38 mm) #18 bag and was dipped in green gard. Otter boards were 15" x 30" (38 cm x 76 cm). It was equipped with a tickler of 3/8" (9.5 mm) chain which was slightly shorter than the footrope so that it preceeded the footrope when the net was in operation. It was pulled at about 3.5 kph so that about 0.6 km were covered in one tow. The net was considered to open about 5.3 m horizontally and 0.7 m vertically so that one tow covered about 3200 m of bottom. Sampling stations were selected in the field. Vessel speed and distance covered were estimated by eye. Depths fished ranged from 8 m to 81 m with 32% of the hauls at less than 20 m, 69% of the hauls at less than 30 m, 86% of the hauls at less than 40 m, and 96% of the hauls at less than 50 m.

Otter Trawl

Sampling was conducted with a 400 mesh eastern otter trawl with a 30 m footrope and 27 m headrope. It was 26 m in total length, with a 4 m long cod end. The net was constructed with 4 inch mesh at the mouth and 3-1/2 inch mesh in the body and cod end and had a 1-1/4 inch mesh cod end liner. There were 15 floats 20 cm in diameter on the headrope, and no tickler or rollers. The bridles were 9 m long and the doors were 2.7 m (9 ft.) by 1.8 m (7 ft.) Astoria V design. This net is considered to open 1.5 m high by 12.2 m wide. The net was pulled with a 3 to 1 scope for 1 nautical mile (1.85 km), and 0.02261 km were covered in each haul. The data are reported in catch per km however. Stations were chosen at depths of approximately 30 fm, 40 fm and 50 fm in Izhut and Kiliuda bays. Distance covered was measured by Loran C. Depths trawled ranged from 43 to 110 m with 53% of the hauls between 70 and 89 m and 85% of the hauls between 60 m and 99 m.

Sample Handling

Immediately after capture, catches were sorted to species when possible, counted, weighed and recorded. Life history stage was recorded when it was possible to determine;and for some species the catches were sorted by life history state, i.e. adult, juvenile and larval. Length frequencies were taken. Samples were taken for food habits analysis by R.U. 553. The stomachs were removed from large fish after they were weighed, measured and the data recorded. Small fish were preserved whole for food habit analysis and in some cases lengths of these fishes were not taken in the field. Lengths were recorded from the majority of fish that were not used for food habit analysis. Catches of the otter trawl were subsampled before sorting was initiated,and some specimens were taken for food habit analysis from the unsorted portion of the catch.

Sorting of beach seine, trammel net and gill net catches was occassionally delayed for several hours after capture. When this occurred, specimens were injected with 10% formaldehyde solution to arrest digestion if they were to be kept for food habit analysis.

Stages of Maturity

Sexual maturity was determined according to the following National Oceanographic Data Center (NODC) Sex Maturity Codes:

Immature - Gonads small (barely determine sex), apparently has not spawned for the first time.

Maturing - Ovaries small to large, eggs all opaque or mixture of opaque and transparent eggs or mostly transparent eggs, testes swelling.

Spawning - Eggs and milt running.

Spent - Ovaries and testes flacid.

Sexually inactive - Adults with gonads firm and shaped.

These descriptions were inadequate. Small gonads may be found in immature, maturing and sexually inactive fish. These stages appear differently in different species of fish and without descriptions of the sexual cycle, staging of fish with these criteria was subjective, with the exception of the spawning category. Fish with freely flowing eggs or milt are distinctive. Fish with fully developed ovaries or testes which are not yet running are also distinctive, but the criteria above do not distinguish them from early maturing fish.

The personnel that made the sexual maturity determinations were inexperienced at the outset of the project, but one person was involved with the entire collection of data so there was some continuity of classification.

The results should be considered with the above qualifications in mind.

Sample Analysis

All species identified are listed, with their scientific names, in Table 2. The tables presenting catch per unit of effort for each gear contain every taxomonic group captured while those tables presenting relative abundance for each gear contain only those taxa comprising more than a trace (more than 0.05% of total) of the seven month mean.

The number of individuals captured is presented from beach seine, gill net, trammel net and surface tow net. Weight of individuals caught is presented for the try net and otter trawl. Weight has been used to report the results of trawl effort by other investigators (Hughes and Alton 1974, Ronholt et.al., 1978), thus its use here serves to make results comparable. Many of the fish caught by the beach seine and surface tow net were too small to be appropriately represented in terms of weight, given the accuracy attainable in the field.

All lengths measured were fork lengths. All age references are based on length frequency interpretations.

Area Comparisons

Dendrograms of percent similarity of the 12 subareas were constructed for each gear. The first step was converting the mean catch in numbers for all cruises to percent composition by subareas. Then, the percent composition figures were compared, each area with all other areas, one at a time in the following manner. For a given gear, two areas were compared by summing the smaller percent composition for each species.

This procedure resulted in 66 numbers, each representing percent similarity between two subareas. From these, the largest number was found and the two areas which had yielded that number were combined. This formed the first junction of two areas in the dendrogram. A percent similarity was then generated for this new group of areas with each other area by calculating weighted means of the uncombined values. The weighting was based on the number of areas which were in each group so that recalculated percent similarities were always simple means of the original percent similarities.

Once the new table of percent similarities was completed, the largest number was again chosen and the above process was repeated until all areas had been combined.

Diversity

All diversities were calculated using Shannon diversity and were divided by total catch to standardize the resulting diversities. Such an approach yields values commonly termed diversity per individual (Clifford and Stephenson, 1975). The basic formula for this measure is:

$$\text{Diversity} = \frac{1}{N} (N \text{ Log } N - \Sigma \, n \log n)$$

Diversity was partitioned to within-area and between-area components, within species and between species components, total diversity and interaction (Clifford and Stephenson, 1975). For a given gear, the diversity within areas is the species diversity of each subarea (12 separate values) while the diversity between areas is calculated using total catch in each of the 12 subareas (this is the diversity of the 12 subareas ignoring species). For a given gear the within-species diversity was calculated for each species using its catch in each of the 12 subareas,while the between-species diversity was calculated using species totals for all 12 subareas. For a given gear the total diversity was calculated using every number in the table (every species in every area but no totals). The interaction was calculated by summing the diversity between species and the diversity between areas and subtracting total diversity.

The basic tables upon which this diversity partitioning was per formed were summaries of mean catch in numbers of individuals per set or haul by subarea and taxon for all cruises combined for each gear and are presented in their entirety as Appendix Tables.

Pielou (1972 and 1977) proposed a method of calculating niche width and niche overlap from diversities partitioned as these were. In the terms presented above, niche width was calculated by subtracting between-species diversity from total diversity and dividing the result by between-area diversity. This is essentially a weighted mean of the within-species diversities. The niche overlap was calculated by subtracting between-area diversity from total diversity and dividing the result by the between species diversity.

Species Associations

The same tables that were used for diversity calculations were used for species association analyses. The measure of association that was used was the correlation coefficient from linear regression. This measure has several advantages. It is commonly used for other purposes and thus is easily understood by many, it is directly relatable to a probability of significance, the resulting value is the same regardless of the choice of which species is x and which is y, and it ranges from -1 to +1 indicating both positive and negative association. Dendrograms were constructed in the same manner as described for percent similarities.

Note that species distinctions made in the field were maintained in this analysis. Several species of *Myoxocephalus* as well as terpug (Hexagrammidae) occur in the analysis but nowhere else in this report.

Data Limitations[1]

The community of fishes observed during faunal surveys and the relative importance of species or species groups within the community is largely a function of the sampling tools employed. Try nets, otter trawls, beach seines, tow nets and especially trammel nets and gill nets are selective. Sizes and even species of fish captured are influenced by such features as mesh size used, gear configuration, towing speed and method of employment (beach seine may be set far from the beach and pulled to shore or set with the ends nearly ashore, as it was in this study). Passive gear such as the trammel net and gill net depends upon the activity of the fish to become entangled, and catches are affected by the sensitivity of the fish to the presence of the net, body size and shape, presence of spines, behavior and other features. Even species within the size range which theoretically would be retained if engulfed by a towed net may differ in their ability to avoid the mouth of the net. The selective feature of all gears thus alters the species composition and sizes and quantities of species captured from that which occur in its path. The degree to which "apparent" distribution and relative abundance differs from the actual is unknown. Thus, it is important to note that subsequent discussions of distribution and relative abundance of species reflect the results obtained with the sampling gear employed.

The beach seine and tow net each yielded large numbers of age 0 fish, including larval, post larval and early juvenile stages. The early stages were difficult to identify and too numerous for field crews to include in the data. However, samples were routinely taken, identifications made and estimates of abundance (1, 10, 100 or 1,000) entered in the data.

[1]This section is adapted from a similar discussion for trawls by Alverson et al. (1964).

RESULTS

Identified in this study on the east side of Kodiak were 22 families and 89 species of fish (Table 2). Three of the records constitute range extensions. One longfin gunnel was collected and the identity confirmed by Norman Wilimovsky. This constitutes an extension of the known range from British Columbia and is the first Alaskan record of this species. A modest number of warthead sculpins were captured, and these have not been reported south of the Bering Sea in Alaska. One longnose skate was reported; its identity was not confirmed with a specimen, however. This record constitutes an extension of the range from Southeast Alaska.

There were two species captured that were previously undescribed and remain undescribed, one Myoxocephalus and one Bathymaster. There were four species captured that are recorded in Kodiak only by Harris and Hartt (1977). These were the tube-snout, the plain sculpin, manacled sculpin and Bering poacher. Four species that were captured have a range limit at Kodiak. The slim sculpin, buffalo sculpin and penpoint gunnel are known to occur from Kodiak to the east, and the scissortail sculpin is recorded from Kodiak to the west.

At the beginning of this study considerable confusion existed in the taxonomy of Myoxocephalus and Gymnocanthus, which was partially clarified during the study. Myoxocephalus were found to consist of four types. The great sculpin, which was abundant in the extreme nearshore zone (at beach seine depth); the plain sculpin, which was common just off the beaches beyond beach seine depth; the warthead sculpin, which was less common and also occurred at try net depth and beyond; and an undescribed species of which 2 or 3 specimens were captured. Further changes seem likely as more collections are examined. The Gymnocanthus were identified as armorhead and threaded sculpin on the basis of total fin ray counts of both dorsal, anal, and both pectorals; the threaded sculpin had less than 82 and the armorhead sculpin more than 82 rays. Once the fish are separated thus, consistent differences in body shape, coloration and distribution are apparent. Unfortunately, separation within Myoxocephalus and Gymnocanthus was not consistent through this study.

Some problems were also encountered with the sea poacher genus Occella. Between lower Cook Inlet (Blackburn et al., 1979) and Kodiak (this study) two types of Occella were encountered that could not be separated by existing fish identification guides. Based on drawings only, the Cook Inlet specimens were identified as warty poacher and the Kodiak specimens as Bering poacher. It is possible that both types occurred in Kodiak but were not noticed since they are very similar. The existing distribution information indicates the warty poacher occurs as far north as Shelikof Bay in Southeast Alaska (Gruchy, 1970) and Hart (1973) contains an incorrect citation indicating this species has been reported in Bristol Bay. The Bering poacher has been reported south of the Bering Sea by Phinney (1972) in Chignik Bay and by Harris and Hartt (1977) who found it near Kodiak.

Table 2. Fish species captured on the east side of Kodiak during sampling in April through August and November, 1978 and in March, 1979 and gear in which they were captured. B = Beach Seine, G = Gill Net, T = Trammel Net, TN = Tow Net, TY = Try Net and OT = Otter Trawl.

Squalidae		
Spiny dogfish	*Squalus acanthias*	OT
Rajidae		
Big skate	*Raja binoculata*	OT
Longnose skate	*Raja rhina*	OT
Clupeidae		
Pacific herring	*Clupea harengus pallasii*	B,G,T,TY,OT
Salmonidae		
Pink salmon	*Oncorhynchus gorbuscha*	B,G,T,TN
Chum salmon	*Oncorhynchus keta*	B,G,TN
Coho salmon	*Oncorhynchus kisutch*	B,G
Sockeye salmon	*Oncorhynchus nerka*	G
Dolly Varden	*Salvelinus malma*	B,G,T
Osmeridae		
Surf smelt	*Hypomesus pretiosus*	B,G
Capelin	*Mallotus villosus*	B,G,TN,TY,OT
Eulachon	*Thaleichthys pacificus*	OT
Gadidae		
Pacific cod	*Gadus macrocephalus*	B,G,T,TN,TY,OT
Pacific tomcod	*Microgadus proximus*	B,G,T,TY,OT
Walleye pollock	*Theragra chalcogramma*	B,G,T,TY,OT
Zoarcidae		
Shortfin eelpout	*Lycodes brevipes*	TY,OT
Wattled eelpout	*Lycodes palearis*	OT
Gasterosteidae		
Threespine stickleback	*Gasterosteus aculeatus*	B,TN
Tube-snout	*Aulorhynchus flavidus*	B
Scorpaenidae		
Dusky rockfish	*Sebastes ciliatus*	G,T,TY
Darkblotched rockfish	*Sebastes crameri*	OT
Black rockfish	*Sebastes melanops*	G,T

Table 2. (continued)

Hexagrammidae		
Kelp greenling	*Hexagrammos decagrammus*	B,T,TN,TY,OT
Rock greenling	*Hexagrammos lagocephalus*	B,G,T,TY,OT
Masked greenling	*Hexagrammos octogrammus*	B,G,T,TY,OT
Whitespotted greenling	*Hexagrammos stelleri*	B,G,T,TN,TY,OT
Lingcod	*Ophiodon elongatus*	B,TN,TY,OT
Anoplopomatidae		
Sablefish	*Anoplopoma fimbria*	TY,OT
Cottidae		
Padded sculpin	*Artedius fenestralis*	B,TY
Crested sculpin	*Blepsias bilobus*	T,TY
Silverspotted sculpin	*Blepsias cirrhosus*	B,T,TN,TY
Sharpnose sculpin	*Clinocottus acuticeps*	B
Spinyhead sculpin	*Dasycottus setiger*	TY,OT
Buffalo sculpin	*Enophrys bison*	B,T,TY
Antlered sculpin	*Enophrys diceraus*	
Armorhead sculpin	*Gymnocanthus galeatus*	T,TY,OT
Threaded sculpin	*Gymnocanthus pistilliger*	T,TY,OT
Red Irish Lord	*Hemilepidotus hemilepidotus*	B,T,TY,OT
Yellow Irish Lord	*Hemilepidotus jordani*	B,T,TY,OT
Bigmouth sculpin	*Hemitripterus bolini*	TY,OT
Northern sculpin	*Icelinus borealis*	TY,OT
Pacific staghorn sculpin	*Leptocottus armatus*	B,G,T,TY,OT
Plain sculpin	*Myoxocephalus jaok.*	B,T,TY,OT
Warthead sculpin	*M. niger*	1
Great sculpin	*M. polyacanthocephalus*	B,G,T,TY,OT
Sailfin sculpin	*Nautichthys oculofasciatus*	T,TY
Tidepool sculpin	*Oligocottus maculosus*	B
Slim sculpin	*Radulinus asprellus*	TY
Manacled sculpin	*Synchirus gilli*	B
Scissortail sculpin	*Triglops forficata*	TY
Roughspine sculpin	*Triglops macellus*	TY
Ribbed sculpin	*Triglops pingelii*	TY,OT
Tadpole sculpin	*Psychrolutes paradoxus*	TN
Agonidae		
Smooth alligatorfish	*Anoplagonus inermis*	TY,OT
Sturgeon poacher	*Agonus acipenserinus*	T,TY,OT
Bering poacher	*Occella dodecaedron*	TY
Tubenose poacher	*Pallasina barbata*	B,TN,TY
Cyclopteridae		
Spotted snailfish	*Liparis callyodon*	B
Marbled snailfish	*Liparis dennyi*	TY

Table 2. (continued)

Trichodontidae		
Pacific sandfish	*Trichodon trichodon*	B,TY,OT
Bathymasteridae		
Alaskan ronquil	*Bathymaster caeruleofasciatus*	T
Searcher	*Bathymaster signatus*	B,T,TY,OT
Northern ronquil	*Ronquilus jordani*	OT
Anarhichadidae		
Wolf eel	*Anarrhichthys ocellatus*	T
Stichaeidae		
High cockscomb	*Anoplarchus purpurescens*	B,TY
Snake prickleback	*Lumpenus sagitta*	B,G,TY,OT
Daubed shanny	*Lumpenus maculatus*	TY,OT
Stout eelblenny	*Lumpenus medius*	TY,OT
Whitebarred blenny	*Poroclinus rothrocki*	B,OT
Arctic shanny	*Stichaeus punctatus*	B,TY
Cryptacanthodidae		
Giant wrymouth	*Delolepis gigantea*	2
Dwarf wrymouth	*Lyconectes aleutensis*	2
Pholididae		
Penpoint gunnel	*Apodichthys flavidus*	B
Longfin gunnel	*Pholis clemensi*	TY
Crescent gunnel	*Pholis laeta*	B,TY
Zaproridae		
Prowfish	*Zaprora silenus*	B,TN
Ammodytidae		
Pacific sand lance	*Ammodytes hexapterus*	B,TN
Pleuronectidae		
Arrowtooth flounder	*Atheresthes stomias*	TY,OT
Rex sole	*Glyptocephalus zachirus*	TY,OT
Flathead sole	*Hippoglossoides elassodon*	T,TY,OT
Butter sole	*Isopsetta isolepis*	B,TY,OT
Rock sole	*Lepidopsetta bilineata*	B,T,TY,OT
Yellowfin sole	*Limanda aspera*	B,T,TY,OT
Dover sole	*Microstomus pacificus*	TY,OT
English sole	*Parophrys vetulus*	B,TY,OT
Starry flounder	*Platichthys stellatus*	B,G,T,TY,OT
Alaska plaice	*Pleuronectes quadrituberculatus*	B,TY
Sand sole	*Psettichthys melanostictus*	B,TY,OT
Pacific halibut	*Hippoglossus stenolepis*	B,T,TY,OT

[1]Specimen identified, gear not recorded.
[2]Larvae captured in tow net.

Some confusion also exists in the genus Hexagrammos. We report four species. Rock greenling and terpug were separated in the field, based on the length of a pair of cirri on the head, at the urging of field personnel from the University of Washington. At the end of the study none of the field crew believed that the separation was valid, and further work has shown that male and female rock greenling are very different which appears to account for the separation. Data on terpug have been combined with that on rock greenling.

Relative Abundance

The numerically predominant taxa in the beach seine catches in order of greatest abundance were Pacific sand lance, juvenile pink salmon, juvenile Myoxocephalus sculpins, juvenile chum salmon, juvenile Pacific cod, masked greenling and whitespotted greenling (Table 3). A considerable share of the beach seine catches were larvae, primarily Myoxocephalus sp. larvae in March, April, May and June, capelin larvae in November and Pacific sandfish larvae in March 1979.

When ranked by biomass the beach seine catches appear quite different. The beach seine catches by weight were 74% pink salmon, 15% sandlance, 3.3% Dolly Varden, 1.9% Myoxocephalus spp. and 1.0% masked greenling.

The numerically predominant taxa in the gill net catches in order of greatest abundance were Pacific herring, adult pink salmon, Dolly Varden, masked greenling, rock greenling, whitespotted greenling, one-year-old Pacific cod and surf smelt. (Table 4).

The numerically predominant taxa in the trammel net catches in order of greatest abundance were masked greenling, rock greenling, whitespotted greenling, rock sole, Myoxocephalus sculpins, Pacific herring, and Pacific cod, which were nearly all one year old (Table 5).

The numerically predominant taxa in the tow net catches, excluding larvae, were overwhelmingly Pacific sand lance followed by juvenile chum salmon and juvenile pink salmon (Table 6). A large share of the tow net catch were larvae, including capelin, pricklebacks, Myoxocephalus spp., cod spp., sculpin spp., flounder spp., ronquil spp., snailfish spp. and yellow Irish Lord (Table 7).

The predominant taxa in the try net by weight in order of greatest abundance were king crab, rock sole, yellowfin sole, Myoxocephalus spp., Tanner crab, Gymnocanthus spp., yellow Irish Lord, flathead sole, butter sole, starry flounder and Dungeness crab (Table 8).

The predominant taxa in the otter trawl by weight in order of greatest abundance were rock sole, yellow Irish Lord, yellowfin sole, Myoxocephalus spp., flathead sole, Pacific cod, Pacific halibut, sablefish walleye pollock and Pacific tomcod (Table 9).

Table 3. Relative abundance in percent of total catch in numbers by month for beach seine on the east side of Kodiak Island, April 1978 through March 1979.

Taxon	APRIL	MAY	JUNE	JULY	AUGUST	NOVEMBER	MARCH	RANK	MEAN
Pacific sand lance	1.6	13.9	27.3	87.4	97.1	24.0	32.1	1	84.2
Pink salmon	67.0	62.9	41.3	2.7	0.9	0	1.2	2	9.0
Chum salmon	19.3	20.1	16.3	1.3	T	0.2	1.2	3	2.9
Myoxocephalus spp.	1.2	0.7	4.7	1.2	0.3	24.7	26.2	4	0.8
Pacific cod	0.1	T	T	1.8	0.5	3.1	0	5	0.6
Masked greenling	4.7	0.5	1.4	1.0	0.3	19.2	14.3	6	0.6
Whitespotted greenling	0	0.1	0.8	1.5	0.4	2.0	1.2	7	0.5
Silverspotted sculpin	1.4	0.4	1.7	0.6	0.1	1.5	2.4	8	0.2
Tubenose poacher	0.1	0.2	1.2	0.3	0.1	3.5	2.4	9	0.2
Dolly Varden	1.3	0.1	0.4	0.4	T	3.3	0	10	0.1
Pacific tomcod	0	0	1.8	0	0	0	1.2	11	0.1
Crescent gunnel	0.6	0.1	0.2	0.1	0.1	0.2	1.2	12	0.1
Rock sole	0.4	0.1	0.4	0.2	T	6.2	3.6	13	0.1
Coho salmon	0	0	1.6	T	0	0	0	14	0.1
Rock greenling	0.5	0.1	0.2	0.1	T	3.1	2.4	15	0.1
Gymnocanthus spp.	0	T	0.1	0.1	0.1	0.2	0	16	0.1
Snake prickleback	0	0.3	T	0.2	T	0	0	17	0.1
Threespine stickleback	0.1	0.1	0.4	0.1	T	0	0	18	0.1
Total Catch	1,481	15,150	9,083	22,537	129,098	547	84		177,980

T = Trace

Table 4. Relative abundance in percent of total catch in numbers by month for gill net on the east side of Kodiak, April 1978 through March 1979.

Taxon	APRIL	MAY	JUNE	JULY	AUGUST	NOVEMBER	MARCH	RANK	MEAN
Pacific herring	100.0	81.6	93.2	40.5	2.1	0	0	1	70.0
Pink salmon	0	0	0	14.7	27.1	0	0	2	6.1
Dolly Varden	0	2.8	1.7	20.7	6.3	0	0	3	5.6
Masked greenling	0	1.4	0.3	2.6	18.8	0	0	4	3.4
Rock greenling	0	2.1	0.3	9.4	5.2	0	0	5	2.8
Whitespotted greenling	0	0	0	0.9	16.7	0	0	6	2.4
Pacific cod	0	3.6	0.3	3.5	3.1	0	0	7	1.8
Surf smelt	0	2.1	1.4	0.9	0	0	0	8	1.3
Myoxocephalus spp.	0	2.8	0	0.9	3.1	0	0	9	1.1
Pacific staghorn sculpin	0	0	0.3	1.7	4.2	0	0	10	1.0
Chum salmon	0	0	0.3	0.9	4.2	0	0	11	0.8
Dusky rockfish	0	0	1.1	1.7	0	0	0	12	0.8
Sockeye salmon	0	0	0.3	1.7	2.1	0	0	13	0.7
Snake prickleback	0	0	0.6	0	2.1	0	0	14	0.6
Capelin	0	1.4	0.3	0	0	0	0	15	0.4
Coho salmon	0	0	0	0	2.1	0	0	16	0.3
Walleye pollock	0	0	0	0	2.1	0	0	17	0.3
Black rockfish	0	1.4	0	0	0	0	0	18	0.3
Pacific tomcod	0	0.7	0	0	0	0	0	19	0.1
Starry flounder	0	0	0	0	1.0	0	0	20	0.1
Total Catch	2	141	354	116	96				709

Table 5. Relative abundance in percent of total catch in numbers by month for trammel net on the east side of Kodiak, April 1978 through March 1979.

Taxon	APRIL	MAY	JUNE	JULY	AUGUST	NOVEMBER	MARCH	RANK	MEAN
Masked greenling	21.3	20.7	34.5	58.9	61.2	28.9	4.3	1	50.0
Rock greenling	44.5	46.1	42.1	25.1	20.1	35.3	55.3	2	28.9
Whitespotted greenling	2.1	3.7	6.4	5.0	8.0	9.8	0	3	6.1
Rock sole	12.8	11.3	7.7	4.4	2.2	10.2	27.7	4	5.4
<u>Myoxocephalus</u> spp.	8.5	3.5	1.5	1.1	1.1	7.7	4.3	5	1.8
Pacific herring	0	10.3	2.6	0	0.3	0	0	6	1.6
Pacific cod	0	0	1.2	1.9	0.8	3.0	0	7	1.2
Yellowfin sole	0	1.1	1.7	.9	0.5	0	0	8	0.9
Kelp greenling	5.3	1.1	0.7	0.3	0.7	2.6	0	9	0.8
Dolly Varden	0	0.2	0	0.8	0.9	0.9	0	10	0.6
Black rockfish	2.1	1.1	0	0	1.6	0	0	11	0.6
Red Irish Lord	0	0	0.4	0.3	0.4	0.4	0	12	0.3
Pacific staghorn sculpin	1.1	0.3	0.6	0.3	0.1	0.4	0	13	0.3
Pacific tomcod	0	0	0	0	0.6	0	6.4	14	0.2
Dusky rockfish	0	0	0.1	0.5	0	0	0	15	0.2
<u>Gymnocanthus</u> spp.	0	0	0.1	0.1	0.3	0	2.1	16	0.2
Starry flounder	2.1	0.3	0.1	T	0.2	0	0	17	0.2
Pink salmon	0	0	0	T	0.3	0	0	18	0.1
Sturgeon poacher	0	0	0	T	0.3	0	0	19	0.1
Walleye pollock	0	0	0	T	0.2	0	0	20	0.1
Silverspotted sculpin	0	0.2	0	T	0.1	0	0	21	0.1
Yellow Irish Lord	0	0	0	0.1	0	0	0	22	0.1
Pacific halibut	0	0	0.1	T	0.1	0	0	23	0.1
Total Catch	94	653	817	2,233	1,922	235	47		6,001

T = Trace

Table 6. Relative abundance in percent of total catch in numbers, excluding larvae, by month for tow net on the east side of Kodiak, April 1978 through March 1979.

Taxon	APRIL	MAY	JUNE	JULY	AUGUST	NOVEMBER	MARCH[1]	RANK	MEAN
Pacific sand lance	45.4	0.5	0	99.3	98.1	10.0	0	1	96.5
Chum salmon	9.1	25.8	84.9	0.1	0	0	0	2	1.8
Pink salmon	18.2	63.8	4.0	0.6	1.1	0	0	3	1.1
Capelin	9.1	0	10.7	T	0	90.0	0	4	0.3
Threespine stickleback	18.2	6.6	0.2	0	0.2	0	20.0	5	0.1
Lingcod	0	0	0	0	0.5	0	0	6	0.1
Total Catch	11	213	674	29,243	5,261	30	5		35,437

[1]Kelp greenling - 60%, greenling sp. 20%.

Table 7. Relative abundance in percent of total catch in numbers, including larvae, by month for tow net on the east side of Kodiak, April 1978 through March 1979.

Taxon	APRIL	MAY	JUNE	JULY	AUGUST	NOVEMBER	MARCH	RANK	MEAN
Pacific sand lance	37.7	96.1	18.1	99.3	93.2	1.4	0	1	75.5
Capelin	42.4	2.3	0.4	T	5.0	90.6	93.5	2	3.4
Pricklebacks	10.9	T	12.5	0	0	0	5.3	3	3.3
<u>Myoxocephalus</u> spp.	8.5	0.5	11.1	0	0	0	0	4	3.0
Cod family	0	T	11.4	0	0	0	0	5	2.8
Sculpin family	T	0	10.8	0	T	0	0.1	6	2.6
Flounder family	0	0	10.8	0	0	0	0	7	2.6
Ronquil family	0	0	10.8	0	0	0	0	8	2.6
Snailfish spp.	0	0	5.4	0	0	0	0	9	1.3
Yellow Irish Lord	0	0	5.4	0	0	0	0	10	1.3
Chum salmon	0.1	.3	3.1	0.1	0	0	0	11	0.9
Pink salmon	0.2	.7	.2	0.6	1.1	0	0	12	0.5
Threespine stickleback	0.2	.1	T	0	0.2	0	0.1	13	T
Greenling sp.	0	T	0	0	0	8.0	0.1	14	T
Total Catch	1,211	20,122	18,521	29,272	5,549	211	1,150		76,036

T = Trace

Table 8. Relative abundance in percent of total catch in weight by month for try net on the east side of Kodiak, April 1978 through March 1979.

Taxon	APRIL	MAY	JUNE	JULY	AUGUST	NOVEMBER	MARCH	RANK	MEAN
King crab	0[1]	34.9	31.7	29.8	9.3	53.5	83.0	1	33.6
Rock sole	86.1	29.1	23.0	25.4	21.1	17.5	4.2	2	22.7
Yellowfin sole	1.2	17.4	27.2	21.5	36.6	9.2	1.0	3	21.6
Myoxocephalus spp.	3.4	2.4	4.3	6.0	9.9	4.2	2.4	4	5.5
Tanner crab	0[1]	5.6	3.2	4.3	2.3	7.2	4.8	5	4.1
Gymnocanthus spp.	4.5	3.8	2.1	2.1	2.2	1.9	1.6	6	2.3
Yellow Irish Lord	0.1	0.5	1.5	1.9	4.9	T	T	7	1.9
Flathead sole	0.1	0.3	1.0	2.6	3.7	0.8	0.4	8	1.8
Butter sole	0	1.4	1.9	1.7	1.4	1.3	0	9	1.4
Starry flounder	0.5	2.3	1.0	0.4	2.1	0.4	0.5	10	1.1
Dungeness crab	0	0.3	0	1.7	1.4	2.1	1.3	11	1.1
Whitespotted greenling	0.4	0.6	1.0	0.7	1.1	0.3	0.2	12	0.8
Pacific halibut	0.1	0.3	0.2	0.5	1.2	0.5	0	13	0.5
Sand sole	0	0.6	0.5	0.5	0.5	0.1	0	14	0.4
Arrowtooth flounder	0	0.2	0.3	0.2	0.5	0.1	0	15	0.2
Pacific staghorn sculpin	0.2	0.1	0.2	0.1	0.5	T	0.1	16	0.2
Alaska plaice	0.1	0	0.1	0	0.3	0.3	0	17	0.1
Ribbed sculpin	0	T	T	0	0.4	0.1	0.1	18	0.1
Pacific cod	1.3	0.1	0.1	0.2	0.1	T	T	19	0.1
Searcher	0	0.1	T	0.2	0.2	T	0	20	0.1
Pacific tomcod	0	0	0.2	0.2	T	0	0	21	0.1
Walleye pollock	0.2	0.1	0.2	T	T	T	0	22	0.1
Masked greenling	0.8	0	T	0	0.1	0	0	23	0.1
Sablefish	0	0	0	0.1	0	0	0	24	T
Total Catch, kg	51.7	240.29	489.25	472.61	518.14	318.69	208.4		2299.08

[1]King and Tanner crab were not recorded during the first cruise.
T<0.05

Table 9. Relative abundance in percent of total catch in weight by month for otter trawl on the east side of Kodiak, April 1978 through March 1979.

Taxon	APRIL	MAY	JUNE	JULY	AUGUST	NOVEMBER	MARCH	RANK	MEAN
Rock sole	32.5	33.4	25.0	9.6	6.0	15.6	21.8	1	20.0
Yellow Irish Lord	0.4	20.2	15.0	40.1	17.3	14.4	1.9	2	18.5
Yellowfin sole	19.8	7.3	11.1	8.4	12.5	19.7	19.0	3	12.3
Myoxocephalus spp.	6.3	14.6	6.4	9.3	7.0	5.6	19.4	4	8.8
Flathead sole	1.9	3.4	12.1	11.1	17.4	2.1	2.7	5	8.7
Pacific cod	5.6	3.9	2.8	1.5	7.3	4.4	0.4	6	4.1
Pacific halibut	1.6	1.8	3.2	2.3	9.1	2.6	8.6	7	3.9
Sablefish	T	1.1	12.9	0.8	0.7	0.8	0	8	3.3
Walleye pollock	1.6	0.5	0.4	2.4	8.7	4.2	5.5	9	3.1
Pacific tomcod	3.4	0.2	0.2	4.5	0.5	13.0	2.9	10	3.0
Gymnocanthus spp.	1.3	5.1	2.8	3.0	2.8	0.2	1.8	11	2.8
Tanner crab	8.4	2.2	1.2	1.4	3.5	0.7	5.8	12	2.5
Arrowtooth flounder	1.2	2.3	1.3	1.2	2.0	3.4	2.5	13	1.9
King crab	2.9	1.5	2.5	1.6	1.5	1.5	1.1	14	1.8
Big skate	3.4	0.2	0.5	0.6	1.5	0	0	15	0.8
Starry flounder	1.2	0.6	1.2	0.3	0.4	1.0	1.7	16	0.8
Butter sole	1.5	0.9	0.2	0.4	0.5	1.5	0.1	17	0.7
Pacific staghorn sculpin	0.7	0.2	0.1	0	0	3.4	0.4	18	0.6
Sculpin spp.	2.7	0	0	0	0	2.7	0	19	0.6
Dungeness crab	0.5	0.2	0.1	0.9	0.5	1.0	0.7	20	0.5
Sand sole	T	0	0.1	0	0	0.5	2.5	21	0.2
English sole	0.2	T	0.3	0	0	0.4	T	22	0.1
Searcher	0.2	0.1	0.1	0.1	0.1	0.2	T	23	0.1
Whitespotted greenling	0.1	0	0.1	0.1	0.1	T	0.3	24	0.1
Sturgeon poacher	0.1	0.2	T	0	0.1	T	T	25	0.1
Eulachon	T	0.2	0	0	0	0.1	T	26	0.1
Spinyhead sculpin	0.1	T	T	T	0.1	T	0.2	27	0.1
Re : sole	T	T	T	T	0.1	0.1	T	28	0.1
Total Catch, kg	2274.06	5633.02	5878.86	4059.87	5449.10	3871.82	992.42		28,159.15

T<0.05

Seasonality by Habitat

Nearshore Habitat

The nearshore is probably the most complex habitat encountered in this study and it yielded more species than the pelagic habitat. The nearshore habitat was sampled primarily by the beach seine, gill net and trammel net (Tables 10, 11 and 12). This zone provided an important nursery for many of the fish fauna.

In spring, juvenile pink and chum salmon were the most abundant taxa while larva of several species, especially *Myoxocephalus* and greenling were common. Dolly Varden are an important predator of this zone. The first Dollies were captured in April and they increased in abundance until July. Dollies are generally restricted to the immediate nearshore zone, but they enter streams during the summer for intermittent periods. Dollies occurred in abundance in all three types of nearshore gear. Sand lance were the numerically predominant species in the beach seine catches. They are primarily a pelagic species that also occurs nearshore. During March and April they tended to occur singly, but in May they first occurred in abundance. Pacific herring used the nearshore zone from mid-April through early June for spawning, with greatest catches in the gill net in May and June.

During June through August the nearshore zone was utilized more than at any other time period. This is associated with movement to shallower water during summer by virtually every fish species (Blackburn, 1978 and 1979) and with the metamorphosis of larvae into juveniles and shallow water residence of juveniles which is a summer occurrence for most fish. Sand lance occurred in modest numbers through most of this time, being more abundant in early June and much more abundant in August as the pelagic juveniles moved into bays. As in the spring, juvenile chum and pink salmon continued to be abundant in the nearshore zone through the summer. Chum were present in abundance a little later than the pinks and during July and August adults were present. Dolly Varden continued to be common in the summer and juvenile Pacific cod about 6 to 8 cm were commonly found in July and August. This species was found in greatest numbers in eelgrass and lagoon areas in Kiliuda and Kaiugnak Bays.

Juvenile *Gymnocanthus*' 2-3 cm in length appeared in June and grew to sizes of 4-5 cm in August, and juvenile *Myoxocephalus* were abundant, growing from 2 cm in May 30 3-5 cm in August. Staghorn sculpin were less abundant than they have been in other areas such as Cook Inlet and Chignik (Blackburn et al., 1979; Phinney, 1972). This is probably associated with their preference for muddy-bottomed estuarine areas. Starry flounder, a common summer nearshore resident, also prefer muddy bottomed estuarine areas and were more abundant in Cook Inlet. Rock sole were common in the nearshore all summer but were more abundant in the demersal zone.

Rockfish were not frequently captured with any of the sampling gear, but they are a well known nearshore rocky or kelp habitat resident, especially black rockfish. The greenlings are very important summer residents of the nearshore zone and were captured in abundance, especially in the trammel nets. They spawn in the nearshore zone during summer and fall, larvae are

Table 10. Beach seine catch in numbers of individuals[1] per haul and standard error, by taxon and cruise on the east side of Kodiak, 1978 and 1979.

Taxon	APRIL	MAY	JUNE	JULY	AUGUST	NOVEMBER	MARCH	MEAN
King crab		0.1±0.1						T±T[2]
Dungeness crab		0.2±0.2		0.4±0.3	0.3±0.2			0.1±0.1
Pacific herring					0.1±0.1			T±T
Pink salmon	19.5±9.4	156.1±48.4	60.5±17.5	10.0±3.9	17.4±9.1		T±T	38.4±8.1
Chum salmon	5.6±2.5	50.0±17.1	23.8±8.4	4.6±1.5	0.2±0.1	T±T	T±T	12.3±2.9
Coho salmon			2.3±2.3	T±T				0.4±0.3
Dolly Varden	0.4±0.3	0.2±0.1	0.6±0.3	1.5±1.1	0.3±0.2	0.3±0.2		0.5±0.2
Surf smelt				T±T	T±T	T±T		T±T
Capelin			T±T		T±T	T±T		T±T
Pacific cod	T±T	0.1±0.1	T±T	6.6±2.7	9.5±4.1	0.3±0.2		2.5±0.8
Pacific tomcod			2.6±1.7				T±T	0.4±0.3
Walleye pollock			T±T			T±T		T±T
Threespine stickleback	T±T	0.3±0.1	0.6±0.3	0.3±0.1	0.2±0.1			0.2±0.1
Tube-snout							T±T	T±T
Hexagrammos sp.	T±T	T±T	T±T	0.1±0.1				T±T
Kelp greenling			T±T					T±T
Rock greenling	0.2±0.1	0.3±0.1	0.3±0.2	0.3±0.1	0.7±0.2	0.3±0.1	T±T	0.3±0.1
Masked greenling	1.4±0.5	1.2±0.4	2.1±0.8	3.6±1.2	6.3±1.9	1.7±0.9	0.2±0.1	2.4±0.4
Whitespotted greenling		0.3±0.1	1.2±0.4	5.5±1.2	7.4±1.4	0.2±0.1	T±T	2.2±0.3
Lingcod				T±T	0.6±0.3			0.1±0.1
Sculpin spp.	0.1±0.1	T±T		1.2±0.7	T±T	T±T		0.2±0.1
Padded sculpin		0.1±T	T±T	T±T	T±T	T±T		T±T
Silverspotted sculpin	0.4±0.2	1.1±0.6	2.5±1.8	2.1±1.3	1.0±0.4	0.1±0.1	T±T	1.1±0.4
Sharpnose sculpin				0.1±0.1		T±T	T±T	T±T
Buffalo sculpin	0.1±0.1	0.2±0.1	0.1±T	0.1±T	0.2±0.1	T±T	T±T	0.1±T
Gymnocanthus spp.		T±T	0.1±0.1	0.4±0.3	1.2±0.6	T±T		0.3±0.1
Hemilepidotus spp.	0.1±0.1							T±T
Red Irish Lord					T±T			T±T
Yellow Irish Lord	T±T		T±T	T±T	0.2±0.1	T±T	T±T	0.1±T
Pacific staghorn sculpin			0.1±0.1	0.2±0.1	0.2±0.1	T±T	T±T	0.1±T

(continued)

[1]Juvenile and adult fish combined
[2]T<0.05

Table 10. (continued)

Taxon	APRIL	MAY	JUNE	JULY	AUGUST	NOVEMBER	MARCH	MEAN
Myoxocephalus spp.	0.4±0.1	0.5±0.1	6.9±1.9	4.6±1.4	6.8±1.7	2.1±0.4	0.4±0.2	3.2±0.5
Tidepool sculpin						T±T		T±T
Manacled sculpin		T±T		T±T	0.1±0.1	0.1±T		T±T
Tubenose poacher	T±T	0.5±0.3	1.7±1.3	1.2±0.4	2.4±1.6	0.3±0.1	T±T	0.9±0.3
Snailfish spp.		T±T					T±T	T±T
Liparis spp.						0.2±0.2		T±T
Spotted snailfish					0.2±0.1			T±T
Pacific sandfish					T±T			T±T
Searcher					T±T			T±T
High cockscomb					T±T			T±T
Snake prickleback		0.7±0.7	0.1±0.1	0.8±0.8	0.1±0.1			0.2±0.2
Whitebarred prickleback		T±T						T±T
Arctic shanny	T±T	T±T	T±T		T±T	T±T	T±T	T±T
Penpoint gunnel		T±T			T±T	T±T		T±T
Crescent gunnel	0.2±0.1	0.3±0.1	0.3±0.1	0.2±0.2	1.6±0.6	T±T	T±T	0.4±0.1
Prowfish					T±T			T±T
Pacific sand lance	0.5±0.2	34.4±18.3	40.0±32.4	317.8±221.9	1959.4±706.7	2.1±1.1	0.5±0.3	359.4±117.7
Flounder spp.	0.1±T							T±T
Butter sole		T±T						T±T
Rock sole	0.1±0.1	0.3±0.1	0.5±0.2	0.7±0.3	0.4±0.1	0.5±0.2	0.1±T	0.4±0.1
Yellowfin sole		0.1±0.1		T±T				T±T
English sole				0.3±0.3	0.1±T			0.1±T
Starry flounder	0.1±T	0.1±T	0.1±0.1	0.3±0.2	0.1±0.1	0.1±0.1	T±T	0.1±T
Alaska plaice			T±T	T±T				T±T
Sand sole		T±T	T±T	0.3±0.2				0.1±T
Pacific halibut					0.1±0.1			T±T
Number of hauls	51	61	62	62	64	63	54	417

Table 11. Gill net catch in numbers of individuals per set and standard error, by taxon and cruise on the east side of Kodiak, 1978 and 1979.

Taxon	APRIL	MAY	JUNE	JULY	AUGUST	NOVEMBER	MARCH	MEAN
Pacific herring[1]	0.3±0.3	4.6±2.6	14.3±12.6	2.0±0.9	0.1±0.1			4.9±2.9
Pink salmon[1]				0.7±0.6	1.1±0.4			0.4±0.2
Chum salmon[1]			T±T[2]	T±T	0.2±0.1			0.1±T
Coho salmon[1]					0.1±0.1			T±T
Sockeye salmon[1]			T±T	0.1±0.1	0.1±0.1			T±T
Dolly Varden		0.2±0.1	0.3±0.1	1.0±0.4	0.2±0.2			0.4±0.1
Surf smelt		0.1±0.1	0.2±0.2	T±T				0.1±0.1
Capelin		0.1±0.1	T±T	0.2±0.1				T±T
Pacific cod		0.2±0.2	T±T	0.2±0.1	0.1±0.1			0.2±0.1
Pacific tomcod		T±T						T±T
Walleye pollock					0.1±0.1			T±T
Dusky rockfish			0.2±0.2	0.1±0.1				0.1±T
Black rockfish		0.1±0.1						T±T
Rock greenling[1]		0.1±0.1	T±T	0.5±0.4	0.2±0.2			0.3±0.1
Masked greenling[1]		0.1±0.1	T±T	0.1±0.1	0.7±0.4			1.7±1.5
Whitespotted greenling[1]				T±T	0.7±0.6			0.2±0.2
Pacific staghorn sculpin			T±T	0.1±0.1	0.2±0.2			0.1±T
Myoxocephalus spp.		0.2±0.1		0.1±0.1	0.1±0.1			0.1±T
Snake prickleback			0.1±0.1		0.1±0.1			T±T
Starry flounder					T±T			T±T
Number of sets	7	25	23	23	24	0	0	102

[1]Adults
[2]T<0.05

Table 12. Trammel net catch in numbers of individuals per set and standard error, by taxon and cruise on the east side of Kodiak, 1978 and 1979.

Taxon	APRIL	MAY	JUNE	JULY	AUGUST	NOVEMBER	MARCH	MEAN
Pacific herring		3.3±2.7	1.1±1.0		0.2±0.1			0.7±0.4
Pink salmon				0.1± 0.1	0.3±0.2			0.1±T
Dolly Varden		0.1±0.1		0.9± 0.4	0.9±0.6	0.1±0.1		0.3±0.1
Pacific cod			0.5±0.3	2.0± 0.7	0.7±0.3	0.3±0.3		0.6±0.1
Pacific tomcod					0.6±0.5		0.2±0.1	0.1±0.1
Walleye pollock				0.1± 0.1	0.2±0.2			T±T
Dusky rockfish			0.1±0.1	0.6± 0.6				0.1±0.1
Black rockfish	0.1±0.1	0.3±0.4			1.4±1.0			0.3±0.2
<u>Hexagrammos</u> sp.				0.1± 0.1				T±T
Kelp greenling	0.3±0.2	0.3±0.2	0.3±0.2	0.3± 0.2	0.7±0.4	0.3±0.1		0.3±0.1
Rock greenling	2.8±0.9	15.1±3.8	18.1±4.2	26.7± 6.8	18.4±4.3	4.2±1.0	1.7±0.7	13.4±1.7
Masked greenling	1.3±0.6	6.8±2.3	14.8±3.3	62.6±14.4	56.0±8.3	3.4±1.1	0.1±0.1	22.9±3.5
Whitespotted greenling	0.1±0.1	1.2±0.3	2.7±0.6	5.3± 1.6	7.3±1.6	1.1±0.6		2.8±0.4
Sculpin spp.						0.1±0.1		T±T
Crested sculpin				0.1± 0.1				T±T
Silverspotted sculpin		0.1±0.1		0.1± 0.1	0.1±0.1			T±T
Buffalo sculpin						0.1±0.1		T±T
<u>Gymnocanthus</u> spp			0.1±0.1	0.2± 0.2	0.2±0.2		0.1±0.1	0.1±0.1
Red Irish Lord			0.2±0.1	0.3± 0.2	0.3±0.2	0.1±0.1		0.1±T
Yellow Irish Lord				0.2± 0.1				T±T
Pacific staghorn sculpin	0.1±0.1	0.1±0.1	0.3±0.2	0.3± 0.3	0.1±0.1			0.1±0.1
<u>Myoxocephalus</u> spp.	0.5±0.2	1.2±0.3	0.6±0.2	1.1± 0.4	1.1±0.3	0.9±0.3	0.1±0.1	0.8±0.1
Sailfin sculpin		0.1±0.1						T±T
Sturgeon poacher				0.1± 0.1	0.2±0.2			T±T
Alaska ronquil			0.1±0.1					T±T
Searcher		0.1±0.1						T±T
Wolf eel					0.1±0.1			T±T
Rock sole	0.8±0.2	3.7±1.0	3.3±1.1	4.7± 1.9	2.0±0.9	1.2±0.3	0.9±0.3	2.5±0.3
Yellowfin sole		0.3±0.2	0.7±0.7	1.0± 0.9	0.5±0.3			0.4±0.2
Starry flounder	0.1±0.1	0.1±0.1	0.1±0.1	0.1± 0.1	0.1±0.1			0.1±T
Pacific halibut			0.1±0.1	0.1± 0.1	0.1±0.1			T±T
Number of sets	15	20	19	20	21	20	15	130

T<0.05

present, primarily in the pelagic zone, in late fall, winter and spring; and juveniles take up demersal residence in the nearshore zone in mid-summer, as can be seen by the increased catch rates of greenling in the beach seine in July and August. A number of other species are common in the nearshore zone in summer such as tubenose poacher and silverspotted sculpin, which were occasionally captured in considerable abundance.

During August Pacific sand lance and Pacific cod were in far greater numbers than earlier. Most of the juvenile salmonid species had already migrated out of the nearshore zone in August while Dolly Varden were still abundant.

During winter the most important feature of the nearshore zone is the reduced abundance of all species and reduced number of species present. Both total catch and number of species in November were considerably less than in summer and in March were at the lowest point of the study. During this period the beach seine catches were predominated by sand lance, Myoxocephalus, masked greenling, rock sole, tubenose poacher and rock greenling, in order of abundance. Dolly Varden were present in November but not in March. Trammel net catches were predominantly rock greenling, rock sole, masked greenling and Myoxocephalus in winter. Whitespotted greenling ranked 4th in November but were absent in March, and Pacific tomcod were absent in November and ranked 3rd in March. Tomcod may have been coming inshore to spawn. Sand lance were at much lower abundance than during summer, which may be due to their habit of taking refuge by burying in sand. The Myoxocephalus were almost exclusively young of the year great sculpins and were the predominant species along with sand lance, although their abundance was as low as one seventeenth of the summer abundance. The greenlings were at a much lower abundance than in summer but remained important.

An important feature of the nearshore habitat is its relationship to tides. The beach seine catches were summarized for the entire study by the tidal stage at which they were made: high tide plus or minus one hour, low tide plus or minus one hour, flood tide and ebb tide. Catches were considerably lower on ebb tide (172 fish per set), intermediate on low tide (510 fish per set) and flood tide (601 fish per set) and greatest on high tide (784 fish per set).

For the different species there are a number of apparent trends, some of which may be spurious, but the same trends were observed in identical samples in Cook Inlet (Blackburn et al., 1979). Pink salmon (mostly juvenile) catches were much greater on flood tide (50.7 per haul), least on high (10.5 per haul) and low (13.9 per haul) and intermediate on ebb (37.3 per haul). Chum salmon juveniles basically showed the same trend, except the lowest was the low tide (4.6 per haul) and intermediate was the high and ebb tide. Dolly Varden were more abundant on flood tide (0.8 per haul) than on the other tides (0.1 to 0.4 per haul). Myoxocephalus spp. catches were 44.1 per haul on ebb tide, 15.1 on flood tide, 7.7 per haul on low tide and 7.2 per haul on high tide. Pacific sand lance catches were 739.2 per haul on high tide, 501.8 on flood, 454.1 on low and 65.9 on ebb tide. The greatest beach seine catch of flounders occurred during low tide, and the next highest catch was during ebb tide. Rock sole was the only flounder encountered in all four tidal stages.

Pelagic Habitat

The pelagic habitat, sampled by the surface tow net and gill net (Tables 11 and 13), is simpler than either the nearshore or the demersal habitat and contains primarily three groups of fish taxa. These are the forage species, salmonid species and the larval/juvenile stages of many demersal and nearshore fish. The forage species consist mainly of sand lance, herring and capelin. Although surf smelt may be abundant locally, they were not captured in abundance in this study.

Pacific sand lance spawn in mid-winter and their larvae are generally found all across the shelf during spring and early summer. Age 1 and older sand lance distribution is not clear during spring-early summer, but they appear to be dispersed when captured in nets and to be common in sand where they take refuge. Capelin of age 1 are about 50 to 70 mm during April and begin metamorphosis to their juvenile stage when about 65 mm in length. Older capelin, mostly age 2, aggregate prior to their late May spawning, as they appear in the otter trawl catches at this time in greater abundance than at any other time. Their spawning seems to be continous from late May through June and into July. During April-May adult herring enter the surface waters in mass just prior to their spawning and juvenile pink and chum salmon begin to enter shallow fringes of the pelagic zone. By late April a large number of larval taxa enter the pelagic environment and subsequently grow to juveniles and then most settle to the demersal or nearshore zone by early June.

During June through August juvenile pink and chum salmon moved from the nearshore zone into the pelagic and dispersed from the bays. Adult capelin were captured in greatest numbers in the surface waters during June as their beach or demersal spawning apparently continued. In late summer sand lance moved inshore, becoming very abundant within the bays where they probably take refuge during the winter. The pelagic juvenile stages of greenlings persist through part of the summer; the whitespotted greenling, the most common species found, apparently settled to the bottom during July and August. Juvenile lingcod, another member of the greenling family, appeared only in July and August, apparently as they were metamorphosing into juvenile fish and were preparing to settle to the bottom.

During November only capelin were captured in the tow net. The surface waters were sparsely populated until March when greenlings began to hatch. Threespine stickleback were captured in the pelagic zone throughout the year, except during November. Their movements are not known well enough to interpret.

Demersal Habitat

The demersal habitat was sampled primarily by the try net and otter trawl (Tables 14 and 15). During March and April large catches of rock and yellowfin sole were encountered in the try net and otter trawl. Large catches of Pacific cod, tomcod, walleye pollock, *Myoxocephalus* spp. and flathead sole were observed in the otter trawl. Rock sole and yellowfin sole were the predominant fish found during spring. A larger number of sculpin species were observed than in either the pelagic or nearshore habitat.

Table 13. Tow net catch in numbers of individuals per km and standard error by taxon and cruise on the east side of Kodiak, 1978 and 1979.

Taxon	APRIL	MAY	JUNE	JULY	AUGUST	NOVEMBER	MARCH	MEAN
Pink salmon	0.2±0.2	10.6±5.6	2.3±2.0	7.7±6.9	2.5±2.1			2.9±1.4
Chum salmon	0.1±0.1	4.3±2.9	47.7±39.6	0.9±0.9				3.8±2.8
Capelin	0.1±0.1		6.0±4.4	0.2±0.2		1.0±1.0		0.7±0.4
Pacific cod				0.5±0.4	T±T			0.1±0.1
Threespine stickleback	0.3±0.2	1.1±0.8	0.1±0.1		0.3±0.2		0.1±0.1	0.2±0.1
Hexagrammos sp.		0.3±0.3					0.1±0.1	T±T
Kelp greenling							0.3±0.2	T±T
Whitespotted greenling		0.2±0.2	0.2±0.1		0.2±0.1			0.1±T
Lingcod				T±T	1.0±0.7			0.2±0.2
Silverspotted sculpin					T±T			T±T
Tadpole sculpin				T±T				T±T
Tubenose poacher					T±T			T±T
Prowfish				0.2±0.1	T±T			T±T
Pacific sand lance	0.7±0.6	0.1±0.1		1395±1004	215±164	0.1±0.1		289.5±178.9
Number of tows	18	16	15	37	48	53	27	214

T< 0.05

Table 14. Try net catch in kilograms per 10 minute tow and standard error by taxon and cruise on the east side of Kodiak, 1978 and 1979.

Taxon	APRIL	MAY	JUNE	JULY	AUGUST	NOVEMBER	MARCH	MEAN
King crab	[1]	2.9±0.8	5.7±1.9	5.0±1.5	1.7±0.6	6.8±5.4	7.9±3.2	4.2±0.9
Tanner crab		0.5±0.2	0.6±0.2	0.7±0.2	0.4±0.2	0.9±0.5	0.5±0.2	0.5±0.1
Dungeness crab		T±T		0.3±0.1	0.2±0.1	0.2±0.2	0.1±0.1	0.1±T
Capelin			T±T				T±T	T±T
Pacific cod	T±T	T±T	T±T	T±T	T±T	T±T	T±T	T±T
Pacific tomcod			T±T	T±T	T±T	T±T		T±T
Walleye pollock	T±T	T±T	T±T	T±T	T±T	T±T		T±T
Shortfin eelpout					T±T			T±T
Dusky rockfish					T±T			T±T
Darkblotched rockfish		T±T						T±T
Kelp greenling					T±T			T±T
Rock greenling					T±T	T±T		T±T
Masked greenling	T±T		T±T		T±T	T±T		T±T
Whitespotted greenling	T±T	T±T	0.2±0.1	0.1±T	0.2±0.1	0.1±T	T±T	0.1±T
Lingcod					T±T	T±T		T±T
Sablefish				T±T	T±T			T±T
Sculpin sp.		T±T	T±T					T±T
Crested sculpin			T±T			T±T		T±T
Silverspotted sculpin	T±T					T±T	T±T	T±T
Spinyhead sculpin	T±T	T±T	T±T	T±T	T±T			T±T
Buffalo sculpin	T±T							T±T
Gymnocanthus spp.	0.1±T	0.2±0.1	0.5±0.3	0.3±0.2	0.5±0.3	0.2±0.1	0.1±0.1	0.3±0.1
Red Irish Lord	T±T					T±T		T±T
Yellow Irish Lord	T±T	T±T	0.3±0.2	0.3±0.1	0.9±0.5	T±T	T±T	0.2±0.1
Bigmouth sculpin	T±T							T±T
Northern sculpin		T±T						T±T
Pacific staghorn sculpin	T±T	T±T	T±T	T±T	0.1±0.1	T±T	T±T	T±T
Myoxocephalus sp.	0.1±0.1	0.2±0.1	0.8±0.3	1.0±0.3	1.8±0.5	0.5±0.3	0.2±0.2	0.7±0.1
Sailfin sculpin				T±T				T±T

T<0.05

[1] King crab caught, but not recorded.

Table 14. continued

Taxon	APRIL	MAY	JUNE	JULY	AUGUST	NOVEMBER	MARCH	MEAN
Slim sculpin			T±T					T±T
Triglops sp.				T±T				T±T
Scissortail sculpin	T±T		T±T					T±T
Roughspine sculpin				T±T		T±T		T±T
Ribbed sculpin		T±T	T±T		0.1±0.1	T±T	T±T	T±T
Smooth alligatorfish		T±T						T±T
Sturgeon poacher	T±T	T±T	T±T	T±T	T±T	T±T	T±T	T±T
Bering poacher					T±T			T±T
Tubenose poacher	T±T		T±T					T±T
Snailfish sp.	T±T					T±T	T±T	T±T
Liparis sp.	T±T		T±T					T±T
Marbled snailfish	T±T							T±T
Pacific sandfish			T±T	T±T			T±T	T±T
Searcher		T±T	T±T	T±T	T±T	T±T		T±T
High cockscomb	T±T							T±T
Snake prickleback		T±T	T±T	T±T	T±T			T±T
Daubed shanny		T±T		T±T	T±T		T±T	T±T
Stout eelblenny			T±T	T±T	T±T			T±T
Arctic shanny		T±T			T±T			T±T
Crescent gunnel	T±T	T±T					T±T	T±T
Arrowtooth flounder		T±T	0.1±T	T±T	0.1±0.1	T±T		T±T
Rex sole					T±T			T±T
Flathead sole		T±T	0.2±0.1	0.4±0.2	0.7±0.2	0.1±T	T±T	0.2±T
Butter sole		0.1±0.1	0.4±0.2	0.3±0.1	0.3±0.1	0.2±0.1		0.2±T
Rock sole	1.8±0.6	2.1±0.5	4.2±1.5	4.3±1.3	3.9±1.1	2.2±0.5	0.4±0.1	2.8±0.4
Yellowfin sole	T±T	1.4±0.3	4.9±1.4	3.7±0.8	6.7±1.7	1.2±0.4	0.1±0.1	2.7±0.4
Dover sole			T±T	T±T	T±T			T±T
English sole			T±T		T±T	T±T		T±T
Starry flounder	T±T	0.2±0.1	0.2±0.1	0.1±0.1	0.4±0.3	0.1±0.1	T±T	0.1±0.1
Alaska plaice	T±T		T±T		T±T	T±T		T±T
Sand sole		T±T	0.1±T	0.1±0.1	0.1±0.1	T±T		T±T
Pacific halibut	T±T	T±T	T±T	0.1±T	0.2±0.1	0.1±T	T±T	0.1±T
Number of tows	25	31	27	28	28	25	22	186

Table 15. Otter trawl catch in kilograms per km trawled and standard error, by taxon and cruise on the east side of Kodiak, 1978 and 1979.

Taxon	APRIL	MAY	JUNE	JULY	AUGUST	NOVEMBER	MARCH	MEAN
Scallop	0.2±0.2							T±T
Hermit crab	0.2±0.2							T±T
King crab	5.2±2.0	8.7±4.4	13.6±9.9	7.0±4.2	7.3±5.4	9.4±9.4	0.8±0.8	7.3±2.1
Hyas crab	T±T							T±T
Tanner crab	14.3±2.1	13.2±5.0	6.5±5.0	5.6±2.4	17.3±10.9	4.1±2.5	5.9±2.4	9.7±2.0
Dungeness crab	0.9±0.8	1.0±0.9	0.7±0.5	3.6±1.4	2.5±1.4	4.5±2.5	0.7±0.3	1.9±0.5
Spiny dogfish				0.2±0.2				T±T
Big skate	6.1±6.1	1.3±0.8	2.7±2.2	2.6±2.6	7.4±6.0			3.1±1.4
Longnose skate					0.6±0.6			0.1±0.1
Pacific herring	T±T	T±T	0.1±0.1	0.1±0.1	0.1±0.1	0.3±0.2	T±T	0.1±T
Capelin	0.1±0.1	0.1±0.1	T±T	T±T	T±T		0.3±0.3	0.1±0.1
Eulachon	T±T	1.3±1.2				0.5±0.4	T±T	0.2±0.2
Pacific cod	9.6±8.1	23.2±6.7	15.1±8.2	6.5±4.5	36.0±31.3	27.3±23.5	0.4±0.2	16.3±5.7
Pacific tomcod	5.5±3.4	1.2±0.9	0.8±0.7	16.8±12.4	2.7±1.1	55.7±50.9	3.2±2.8	11.3±6.5
Walleye pollock	2.7±1.2	2.7±1.4	2.3±1.5	9.3±3.6	43.2±37.3	24.1±11.2	6.2±6.1	12.7±5.8
Shortfin eelpout			0.4±0.3	0.1±0.1	0.1±0.1			0.1±0.1
Wattled eelpout				T±T	0.3±0.2			T±T
Sebastes sp.	T±T	T±T			T±T			T±T
Darkblotched rockfish						0.1±0.1		T±T
Hexagrammos sp.	0.1±0.1							T±T
Kelp greenling	0.1±0.1							T±T
Rock greenling	0.1±0.1							T±T
Masked greenling	0.4±0.4							0.1±0.1
Whitespotted greenling	0.1±0.1		0.7±0.6	0.5±0.4	0.5±0.5	0.3±0.3	0.3±0.2	0.3±0.1
Lingcod	T±T	0.1±0.1						T±T
Sablefish	0.1±0.1	6.6±4.4	69.8±58.9	3.2±2.0	3.3±1.6	5.0±4.9		12.6±8.8
Sculpin sp.	4.8±2.7					12.1±10.1		2.3±1.5
Spinyhead sculpin	0.1±0.1	0.1±0.1	0.1±0.1	0.1±0.1	0.6±0.6	0.2±0.2	0.2±0.2	0.2±0.1
Gymnocanthus spp.	2.2±1.6	30.1±24.5	15.0±3.7	12.0±3.8	14.1±7.9	1.4±1.4	1.5±0.7	10.5±4.7
Red Irish Lord						0.9±0.6		0.1±0.1
Yellow Irish Lord	0.7±0.5	119.6±100.4	81.5±45.3	169.8±111.3	85.5±65.9	90.2±77.2	2.1±2.0	75.3±25.0
Bigmouth sculpin					0.1±0.1			T±T

T<0.05

(continued)

Table 15. continued

Taxon	April	May	June	July	August	November	March	Mean
Northern sculpin	T±T							T±T
Pacific staghorn sculpin	1.1±0.7	1.0±1.0	0.3±0.2			22.1±16.2	0.4±0.3	3.1±2.1
<u>Myoxocephalus</u> sp.	10.2±5.9	89.9±67.9	34.4±13.4	39.0±21.4	34.4±28.0	31.4±13.17	19.6±7.8	36.2±13.2
<u>Triglops</u> sp.		0.1±0.6			T±T			T±T
Ribbed sculpin	T±T	T±T		T±T	T±T			T±T
Smooth alligatorfish	T±T							T±T
Sturgeon poacher	0.1±T	1.3±1.3	0.2±0.2		0.3±0.3	0.2±0.2		0.3±0.3
Snailfish sp.		0.1±0.1						T±T
Pacific sandfish	T±T	0.2±0.2		0.3±0.1	0.1±0.2	0.1±0.1	0.1±0.1	0.1±T
Searcher	0.4±0.3	0.6±0.4	0.6±0.5	0.5±0.4	0.6±0.5	0.8±0.6	T±T	0.5±0.2
Northern ronquil	0.3±0.3							0.0±0.1
Pricklebacks	T±T							T±T
Snake prickleback	T±T	0.1±0.1	0.1±0.1	0.1±0.1	T±T		T±T	0.1±T
Daubed shanny				0.1±T	T±T			T±T
Stout eelblenny					T±T			T±T
Whitebarred blenny	T±T							T±T
Arrowtooth flounder	1.9±1.1	13.9±10.8	7.1±4.3	4.4±2.1	9.9±3.2	17.9±4.2	2.9±1.6	7.8±1.7
Rex sole	T±T	0.1±0.1	0.2±0.2	0.1±0.1	0.4±0.4	0.6±0.6	T±T	0.2±0.1
Flathead sole	3.2±1.3	19.9±7.9	65.9±39.5	46.0±24.5	86.0±36.6	11.4±6.1	3.0±1.9	33.8±9.4
Butter sole	2.6±2.1	5.2±3.3	1.3±1.0	1.5±0.7	2.4±1.3	9.3±4.3	0.1±0.1	3.0±0.8
Rock sole	55.0±32.2	198.1±170.6	129.8±17.0	36.8±19.8	29.8±14.5	66.9±56.4	22.2±12.8	73.7±24.7
Yellowfin sole	33.2±8.4	44.0±9.0	60.4±24.3	33.0±11.6	61.7±18.6	109.7±35.6	20.2±9.0	50.0±7.6
Dover sole			0.2±0.2	T±T	0.1±0.1	0.3±0.1		0.1±T
English sole	0.3±0.3	0.2±0.2	1.5±1.5			1.7±1.4	T±T	0.5±0.3
Starry flounder	2.1±0.6	3.7±1.7	6.6±3.4	1.2±0.7	2.1±0.6	4.9±2.1	1.4±0.9	3.1±0.7
Sand sole	T±T		0.3±0.3			2.8±1.9	2.4±1.0	0.7±0.3
Pacific halibut	2.8±1.8	10.5±3.7	17.5±8.9	9.3±4.2	45.1±14.3	13.5±4.4	9.6±8.6	15.3±3.3
Number of trawls	7	5	6	6	6	5	6	41

Area Comparisons

The percent similarity comparison of the different subareas serves to illustrate the degree of similarity in the catches between areas (Figure 13). One of the advantages of the percent similarity is that it shows directly how much of the catch (in terms of percent composition) is identical between areas. However, the percent similarity is also affected most by the predominant species. Thus, with the very high predominance of sandlance in the beach seine and tow net catches, it was necessary to exclude sandlance when calculating this index. As presented, the percent similarity index is affected most by three or four predominant species.

In the beach seine there were two main groupings of areas which combined at 45 percent similarity (Figure 13). One group of areas (inner Kalsin, outer Kiliuda, outer middle Kiliuda, and inner Kiliuda) had catches that were predominantly chum salmon (mostly juveniles) or nearly so,with pink salmon (mostly juveniles) of an equal or lesser proportion of the catch. The other group of areas (inner Izhut, outer middle Izhut, inner middle Izhut, outer Kaiugnak, inner Kaiugnak, outer Kalsin and inner middle Kiliuda) had predominantly pinks with chums absent or in low proportions (Table 16).

In the gill net the last areas combined at 29 percent similarity, eight areas combined at 36 percent similarity and seven areas combined at 53 per cent similarity (Figure 13). The gill net had very small catches that were greatly predominated by herring overall and in different proportions in different areas (Table 17). The distribution of herring was important in the area similarity of gill net catches.

In the trammel net all areas combined at 40 percent similarity while 10 areas combined at 58% similarity (Figure 13).

The various species of greenling greatly predominated the trammel net catches and occurred in varying proportions in different areas, dictating area similarities (Table 18).

The tow net catches were very dissimilar between areas (Figure 13). Three areas, outer middle Izhut, outer Izhut and inner middle Kiliuda, yielded capelin almost exclusively and no other area had more than four percent capelin (Table 19; note that sandlance were excluded from this analysis). Capelin never occurred more than once in any subarea in the tow net, which indicates their distribution is probably not accurately reflected by the data presented here. Four areas, inner Izhut, outer middle Kiliuda, outer Kiliuda and inner Kalsin,combined at 75 percent similarity, which is due to a predominance of juvenile pink salmon in these areas (Table 19).

In the try net catches, all areas combined at 28 percent similarity and nine areas combined at 50 percent similarity (Figure 13). The outer middle Izhut and outer Izhut areas had a great predominance of rock sole causing their dissimilarity with the other areas (Table 20).

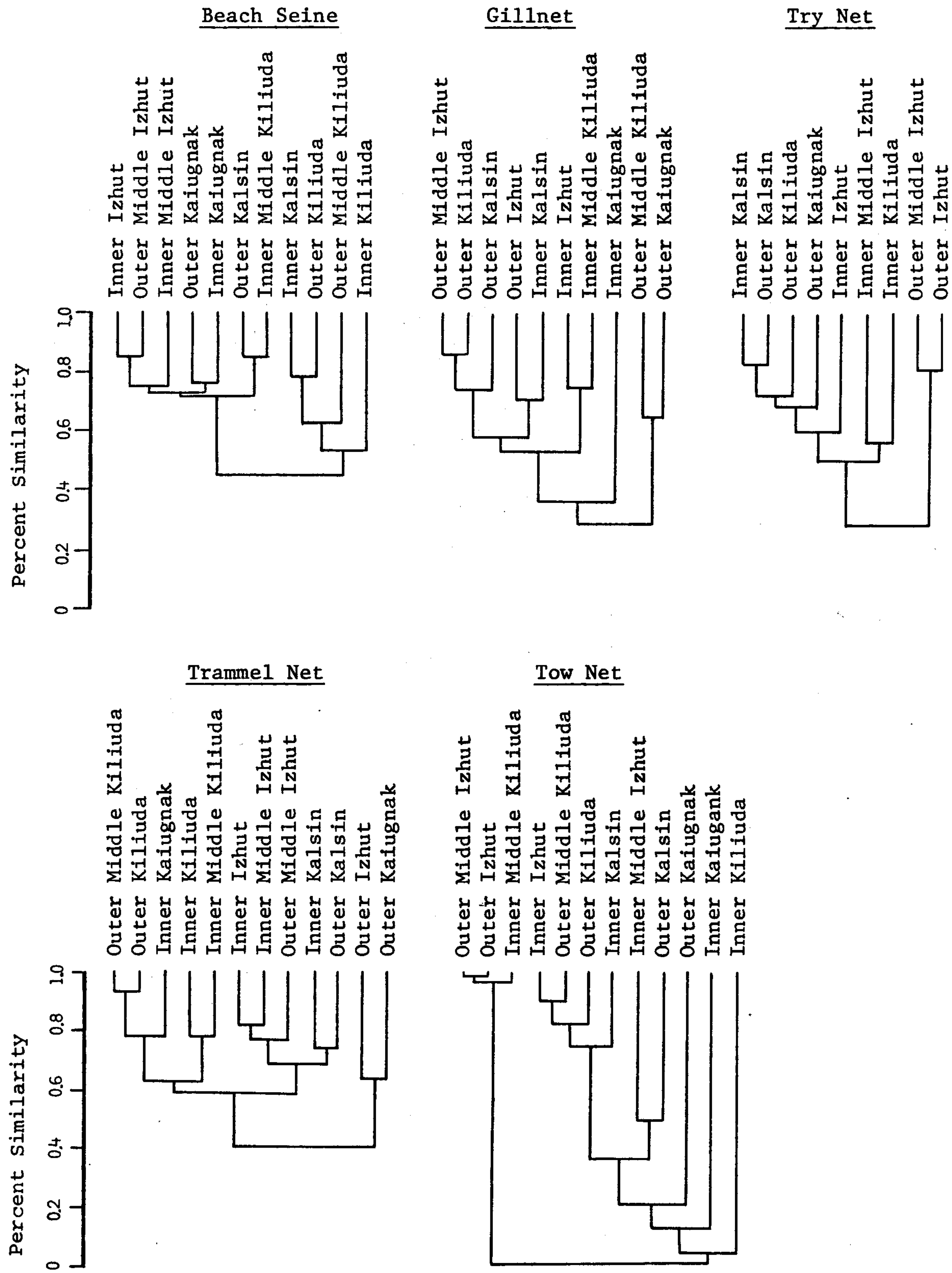

Figure 13. Dendrograms of percent similarity of the catches in the areas sampled by each gear type.

Table 16. Mean beach seine catch in numbers of fish per set by subarea and taxon for all cruises combined.

	IZHUT				KALSIN		KILIUDA				KAIUGNAK	
	Inner	Inner Middle	Outer Middle	Outer	Inner	Outer	Inner	Inner Middle	Outer Middle	Outer	Inner	Outer
King crab										.1		
Dungeness crab	.2				.4					.8		T
Pacific herring		.1	.2			.1						
Pink salmon	22.3	15.1	20.7		17.6	28.8	3.9	23.1	3.6	22.8	165.9	126.5
Chum salmon					12.3	8.9	52.1	8.1	9.3	24.6	18.6	2.0
Coho salmon			2.9		T					T		.1
Dolly Varden	T	.2	.6		.1	.5	.1	.1	.6	.2	.5	2.6
Surf smelt			T							.1		
Capelin					T				T	T		
Pacific cod juv.	T	1.8	.1		.4		5.7	.5	3.2	1.9	.3	16.7
Pacific tomcod					T						.6	4.5
Walleye pollock	T				T							
Threespine stickleback			.1		T	.1	.3	.2	.8	.1	.3	.7
Tube-snout			T			T						
<u>Hexagrammos</u> spp.		T	T		T	.1	T	T		.1		
Kelp greenling			T									
Rock greenling	.2	.4	.1		T	T	T	.3	.6	.1	.7	.9
Masked greenling	3.0	2.6	1.5		.6	1.7	1.5	3.7	1.0	3.6	3.7	4.2
Whitespotted greenling	3.5	1.4	3.0		3.4	3.5	1.3	1.2	1.0	.7	1.4	4.3
Lingcod	.2	.1	T		T		.6	.1		T	.1	T
Sculpin spp.		.1			.9		T		.2	.1	.9	
Padded sculpin	T	T	T		.1	.1				T		
Silverspotted sculpin	.1	.1	.1		.1	.3	4.2	1.2	.2	.3	.7	5.8
Sharpnose sculpin		.1	T					.1				
Buffalo sculpin	.1	.1	.1		T	.1	.1	.1	.1	.3	.1	T
<u>Gymnocanthus</u> spp.						T	.3	.1	.9	T	1.7	
<u>Hemilepidotus</u> spp.		.1										
Red Irish Lord												T
Yellow Irish Lord	T	.1			.1		.2	.1		T	.2	T
Pacific staghorn sculpin	T		.1		.2	T		.2		.2	.2	
<u>Myoxocephalus</u> spp.	1.0	2.2	.1		2.9	1.6	4.1	2.1	2.6	1.2	5.8	4.1
Plain sculpin						T						
Great sculpin	1.6	.6	.2		.5	1.2	.4	2.5	1.1	.4	3.2	.3

Table 16. (continued)

	IZHUT				KALSIN		KILIUDA				KAIUGNAK	
	Inner	Inner Middle	Outer Middle	Outer	Inner	Outer	Inner	Inner Middle	Outer Middle	Outer	Inner	Outer
Tidepool sculpin		T										
Manacled sculpin	.1	.3										
Tubenose poacher	T	.1			.1	.2	.7	.2	.1	.9	.8	8.5
Snailfish spp.					T	T			.4			
Spotted snailfish						.1					.2	
Pacific sandfish	.1											
Searcher		T										
High cockscomb	.1											
Snake prickleback								.1		T		3.2
Whitebarred blenny		T										
Arctic shanny		.2	T		.1						T	
Penpoint gunnel		T	T			T						
Cresent gunnel	.6	.2	.3		.2	1.1	.8	.2	.1	.1	.1	.6
Prowfish	T	T										
Pacific sand lance	862.1	381.3	109.7		895.2	117.8	1.8	63.1	36.6	27.0	974.9	735.0
Flounder spp.		T						T		T		
Butter sole										T		
Rock sole	.1	.7	.1		.6	.3		.2	.5	1.3	.1	
Yellowfin sole	.1				T							
English sole	T					T				.4	.1	
Starry flounder					.3	.1		.1	.1	.4	.3	
Alaska plaice						T				T		
Sand sole					.1					.4	.1	
Pacific halibut										.1		

T = Trace

Table 17. Mean gill net catch in numbers of fish per set by subarea and taxon for all cruises combined.

	IZHUT				KALSIN		KILIUDA				KAIUGNAK	
	Inner	Inner Middle	Outer Middle	Outer	Inner	Outer	Inner	Inner Middle	Outer Middle	Outer	Inner	Outer
Pacific herring	.2		9.7	3.0	1.2	5.2		.9	.2	20.2	1.0	.2
Pink salmon adult	.1					.2		.6	.7	.4	.7	1.2
Chum salmon adult			.1		.2					.2		
Coho salmon adult						.1						.1
Sockeye salmon adult						.3		.1			.1	
Dolly Varden			.2	1.0	.6	.6		.1	.2	.8	.2	1.2
Surf smelt				2.0	.1	.7					.1	
Capelin			.2									
Pacific cod juv.			.4						.2	.3	.2	
Pacific tomcod			.1									
Walleye pollock										.1		
Dusky rockfish											.5	
Black rockfish											.2	
Rock greenling										.5	1.0	
Masked greenling	.1		.2		.2	.1				.1	.2	
Whitespotted greenling						.1				1.1		
Pacific staghorn sculpin								.1		.3		.1
Great sculpin					.1	.2				.3		
Snake prickleback										.3		
Starry flounder										.1		

Table 18. Mean trammel net catch in numbers of individuals per set by subarea and taxon for all cruises combined.

	IZHUT				KASLIN		KILIUDA				KAIUGNAK	
	Inner	Inner Middle	Outer Middle	Outer	Inner	Outer	Inner	Inner Middle	Outer Middle	Outer	Inner	Outer
Pacific herring	.2		.1		2.6	4.3						.1
Pink salmon adult									.1			.5
Dolly Varden					.7	1.2			.5	.2	.4	
Pacific cod juvenile	.2		1.1		.1	.7	.7	.6	1.4	.9	.2	.1
Pacific tomcod	.8		.1				.1	.1	.1			
Walleye pollock	.1						.1		.2			
Dusky rockfish			.1	3.7								
Black rockfish		1.6	.6	5.7								
Hexagrammos spp.		.1										
Kelp greenling	.3	1.4	.7	.7			.2	.1	.1	.1		1.1
Rock greenling	13.0	10.8	10.8	15.7	10.1	12.1	1.7	1.7	7.1	11.6	25.6	37.8
Masked greenling	12.6	9.5	6.1	4.3	15.2	20.8	9.8	28.6	48.6	50.2	44.5	6.9
Whitespotted greenling	1.7	1.9	3.1	.3	3.4	1.0	5.8	7.9	3.2	2.4	2.4	0.6
Sculpin spp.		.2										
Crested sculpin	.1											
Silverspotted sculpin	.1			.7							.1	
Buffalo sculpin										.1		
Gymnocanthus spp.							.1	.1				
Armorhead sculpin								.1				
Threaded sculpin			.1				.5					
Red Irish Lord	.2		.1			.1			.1	.2	.1	.8
Yellow Irish Lord									.1		.1	
Pacific staghorn sculpin			.1		.9	.1				.1		
Myoxocephalus spp.	.2		.1		.8	1.6	.2	.1	.1	.2	.6	.1
Plain sculpin												.1
Great sculpin	.1		.2	.3	.9	.5	1.0	.6	.8	.5	.2	.2
Sailfin sculpin			.1									
Sturgeon poacher					.1	.4						
Alaska ronquil						.1						
Searcher		.1										
Wolf eel									.1			

Table 18. (continued)

	IZHUT				KALSIN		KILIUDA				KAIUGNAK	
	Inner	Inner Middle	Outer Middle	Outer	Inner	Outer	Inner	Inner Middle	Outer Middle	Outer	Inner	Outer
Flathead sole			.1									
Rock sole	1.8	3.0	4.3	1.0	6.9	2.6	2.6	5.7	.6	.2	.7	
Yellowfin sole			.2		2.4		.9	.7	.1			
Starry flounder					.4	.1			.1		.1	
Pacific halibut	.1			.3	.1							

Table 19. Mean tow net catch in numbers of individuals per km towed by subarea and taxon for all cruises combined.

	IZHUT				KALSIN		KILIUDA				KAIUGNAK	
	Inner	Inner Middle	Outer Middle	Outer	Inner	Outer	Inner	Inner Middle	Outer Middle	Outer	Inner	Outer
Pink salmon juv.	2.5	.2			8.8	1.2	1.0		14.7	1.1		.4
Chum salmon juv.					2.3	.3	64.1	.1				
Capelin			3.1	7.0				3.3	.4	.1		
Pacific cod juv.		.1							.7	.1		.1
Threespine stickleback		.2			.1	1.4	.1		.1		.1	.9
Hexagrammos spp.	.1				.2							
Kelp greenling		.2										
Whitespotted greenling		.1		.1	.2							.5
Lingcod	.2				.2	.1			.1			2.5
Silverspotted sculpin											.1	
Tadpole sculpin									.1			
Tubenose poacher					.1							
Prowfish									.1	.1		.3
Pacific sand lance	102.9	.5			.2	.1	26.6	1195.7	1697.3	1.1	488.0	

Table 20. Mean try net catch in numbers of fish per 10 minutes towed by subarea and taxon for all cruises combined.

	IZHUT				KALSIN		KILIUDA				KAIUGNAK	
	Inner	Inner Middle	Outer Middle	Outer	Inner	Outer	Inner	Inner Middle	Outer Middle	Outer	Inner	Outer
King crab					86.7	24.1				26.8	2.3	
Tanner crab	7.3	25.5	20.8	3.0	35.8	67.1	112.0			161.3	.5	
Dungeness crab		.6	1.6	.6	.2		7.0			5.6		
Pacific herring					.2							
Capelin					1.4	.9						
Pacific cod		.6			1.0	.6				6.0	1.8	
Pacific tomcod				.2						7.8		
Walleye pollock	1.3	2.3			5.4	3.6				1.8	.5	
Shortfin eelpout	.7											
Dusky rockfish										.2		
Kelp greenling										.2		
Rock greenling										.2	1.4	
Masked greenling										.7	4.2	
Whitespotted greenling	1.3	2.8	2.0	.4	5.4	3.6	3.0			9.0	11.1	
Lingcod		.6	.2		.2	.9				.5	.5	
Sablefish										.2		
Sculpin spp.		.6			1.0					.2		
Padded sculpin					.2					.4		
Crested sculpin										.4		
Silverspotted sculpin										1.1	.9	
Spinyhead sculpin		5.7	.9			.3				1.2	.5	
Buffalo sculpin						.6						
Gymnocanthus spp.		1.1	1.8	2.3	24.2	27.3	8.0			7.6	1.8	
Armorhead sculpin		3.4	12.2	14.7	2.1	2.7	5.0			9.4	.5	
Threaded sculpin			1.1	.4	44.5	32.7	190.0			17.1	15.7	
Red Irish Lord										.2	.9	
Yellow Irish Lord	.7	7.4		2.3	1.5	2.1	3.0			35.6	13.8	
Bigmouth sculpin			.2									
Northern sculpin				.4								
Pacific staghorn sculpin			.4		.4	.3	1.0			2.8		
Myoxocephalus spp.		6.2	1.4	.2	.2	3.0	4.0			1.9	4.6	
Plain sculpin					7.5	1.8				11.1	1.4	
Great sculpin	.7	1.7	.4	.6	.6	.9				5.3	3.2	

Table 20. (continued)

	IZHUT				KALSIN		KILIUDA				KAIUGNAK	
	Inner	Inner Middle	Outer Middle	Outer	Inner	Outer	Inner	Inner Middle	Outer Middle	Outer	Inner	Outer
Shorthorn sculpin	.7				.2					.4		
Sailfin sculpin		.6										
Slim sculpin							2.0					
<u>Triglops</u> spp.											3.7	
Scissortail sculpin										.2	.5	
Roughspine sculpin				.2						.2		
Ribbed sculpin			.4	1.5		.9	13.0			3.7	7.4	
Smooth alligatorfish				.2								
Sturgeon poacher		1.1	.7	2.6	4.1	.6				3.5		
Bering poacher										.2		
Tubenose poacher					.2					.2	.5	
Snailfish spp.					1.5						.5	
<u>Liparis</u> spp.										.9		
Marbled snailfish			.4									
Pacific sandfish				.4						.2		
Searcher		22.6	.5	.4	.4	1.2	1.0			3.7		
Prickleback spp.										.2	.5	
High cockscomb		.6			.2							
<u>Lumpenus</u> spp.							1.0					
Snake prickleback	4.0	.6	.2	.2	1.7		2.0			1.8	.9	
Daubed shanny		2.8					1.0			1.8		
Stout eelblenny	1.3	2.3					2.0			6.0		
Arctic shanny										.4	1.4	
Longfin gunnel										.2		
Crescent gunnel										.7	1.8	
Arrowtooth flounder		27.2	3.7	5.6	.8	39.5				4.6		
Rex sole					.4							
Flathead sole	4.7	103.6	20.4	6.4	93.1	93.9	126.0			60.7	7.8	
Butter sole		3.4	6.2	9.4	1.4	5.6				17.8		
Rock sole	10.0	8.5	254.2	426.6	169.4	220.1	11.0			157.9	60.0	
Yellowfin sole	9.3	76.4	23.1	6.6	282.0	451.0	220.0			269.5	167.5	
Dover sole		.6			.2	5.6				.5		
English sole		1.1	.2	.2						1.8		
Starry flounder	.7			1.5	2.1	.3	2.0			.2		
Alaska plaice					1.0	.6				.2		
Sand sole			1.6	1.1	.6					.7		
Pacific halibut			1.6	4.5	3.7	2.7				4.6	1.8	

The otter trawl was used only in two areas so this analysis was not performed. The otter trawl catch by area is presented in Table 21.

Izhut Bay was physically unique; it is the deepest bay and has the most rocky shoreline of any of the bays, as discussed under Study Area. There were no juvenile chum salmon captured in Izhut Bay (Table 16 and 19). Izhut is the only bay among the four sampled in which there are no streams in which chum salmon spawn (Figure 4). The total try net catch in inner Izhut Bay (Table 20) was much lower than in any other area. In July and August try net catches in this area contained very few live fish and a few dead and decaying fish. This situation is suggestive of an anoxic environment and this bay has the elements necessary for such an environment to develop. The bay has a maximum depth of 13 fm with a narrow mouth of 2 to 4 fm depth and is protected. Typically, in such conditions deeper waters have no opportunity to exchange with oxygenated waters due to summer stratification. Surface waters can exchange, bringing in plankton which will settle to the deeper waters and decay, consuming oxygen. Due to the relatively small volume of the deeper portion of this bay it can contain little oxygen.

The inner portion of Kiliuda Bay also had evidence of reduced fish catch in summer, with evidence that anoxia may have occurred. Inner Kiliuda does not have a sill preventing deep water exchange.

Kalsin Bay displayed only one outstanding characteristic in terms of catch. The try net yielded greater catches of king crab and yellowfin sole than in any other area (Table 20).

Kiliuda Bay was unique in several respects; the outer area yielded the greatest number of species captured by the beach seine, gill net and also by the try net (Figure 14). Juvenile chum salmon catches in both the beach seine and tow net were far higher in inner Kiliuda than in any other area. In three of the areas of Kiliuda Bay, chum salmon were more abundant than pink salmon in the beach seine collection (Table 16), a feature that occurred in no other area. The catches of sandlance in the beach seine were lower in every area of Kiliuda Bay than in any other area (Table 16) while tow net catches of sandlance were highest within the inner middle and outer middle Kiliuda Bay area (Table 19). The trammel net yielded higher proportions of masked greenling from all areas of Kiliuda than in any other area;and in the inner Kiliuda and inner middle Kiliuda areas catches of rock greenling were lower than in any other area while catches of whitespotted greenling were higher than in any other area (Table 18). The try net yielded higher catches of Tanner crab and Dungeness crab in two Kiliuda Bay areas sampled than any other areas (Table 20).

Kaiugnak Bay yielded far higher catch rates of pink salmon from both its areas than occurred in any other area (Table 16). The outer Kaiugnak Bay area consisted primarily of a large shallow lagoon.

Table 21. Otter trawl catch in kilograms per kilometer trawled and number of trawls, by taxon and area. T represents trace, less than 0.05 kg/km.

Taxon	Outer Izhut	Outer Kiliuda
Scallops	0.1	
Hermit crab		0.1
King crab	0.3	13.7
Hyas crab		T
Tanner crab	8.3	11.3
Dungeness crab	3.8	0.3
Spiny dogfish		0.1
Big skate	T	6.2
Longnose skate		0.2
Pacific herring	0.1	T
Capelin	T	0.2
Eulachon	T	0.4
Pacific cod	8.9	22.7
Pacific tomcod	23.4	0.3
Walleye pollock	6.7	17.2
Shortfin eelpout	0.1	T
Wattled eelpout	0.1	T
Sebastes sp.	T	T
Darkblotched rockfish	T	
Hexagrammos sp.	T	
Kelp greenling	T	T
Rock greenling		T
Masked greenling		0.1
Whitespotted greenling	0.1	0.6
Lingcod		T
Sablefish	21.5	4.5
Sculpin sp.	3.1	1.7
Spinyhead sculpin	0.4	0.1
Gymnocanthus spp.	15.9	6.0
Red Irish Lord	0.2	
Yellow Irish Lord	4.2	138.1
Bigmouth sculpin	T	
Northern sculpin	T	
Pacific staghorn sculpin	0.9	3.8
Myoxocephalus spp.	17.4	50.8
Triglops sp.	T	T
Ribbed sculpin	T	T
Smooth alligatorfish		T
Sturgeon poacher	T	0.6
Snailfish sp.		T
Pacific sandfish	0.2	0.1
Searcher	0.8	0.3
Northern ronquil	0.1	
Pricklebacks	T	
Snake prickleback	0.1	T
Daubed shanny	T	T

Table 21. Continued

Taxon	Outer Izhut	Outer Kiliuda
Stout eelblenny		T
Whitebarred blenny		T
Arrowtooth flounder	11.6	3.7
Rex sole	0.3	0.1
Flathead sole	26.3	41.6
Butter sole	2.3	3.3
Rock sole	148.9	9.4
Yellowfin sole	48.6	47.6
Dover sole	0.2	
English sole	1.1	T
Starry flounder	2.5	3.7
Sand sole	0.6	0.6
Pacific halibut	8.9	21.0
Number of trawls	20	21

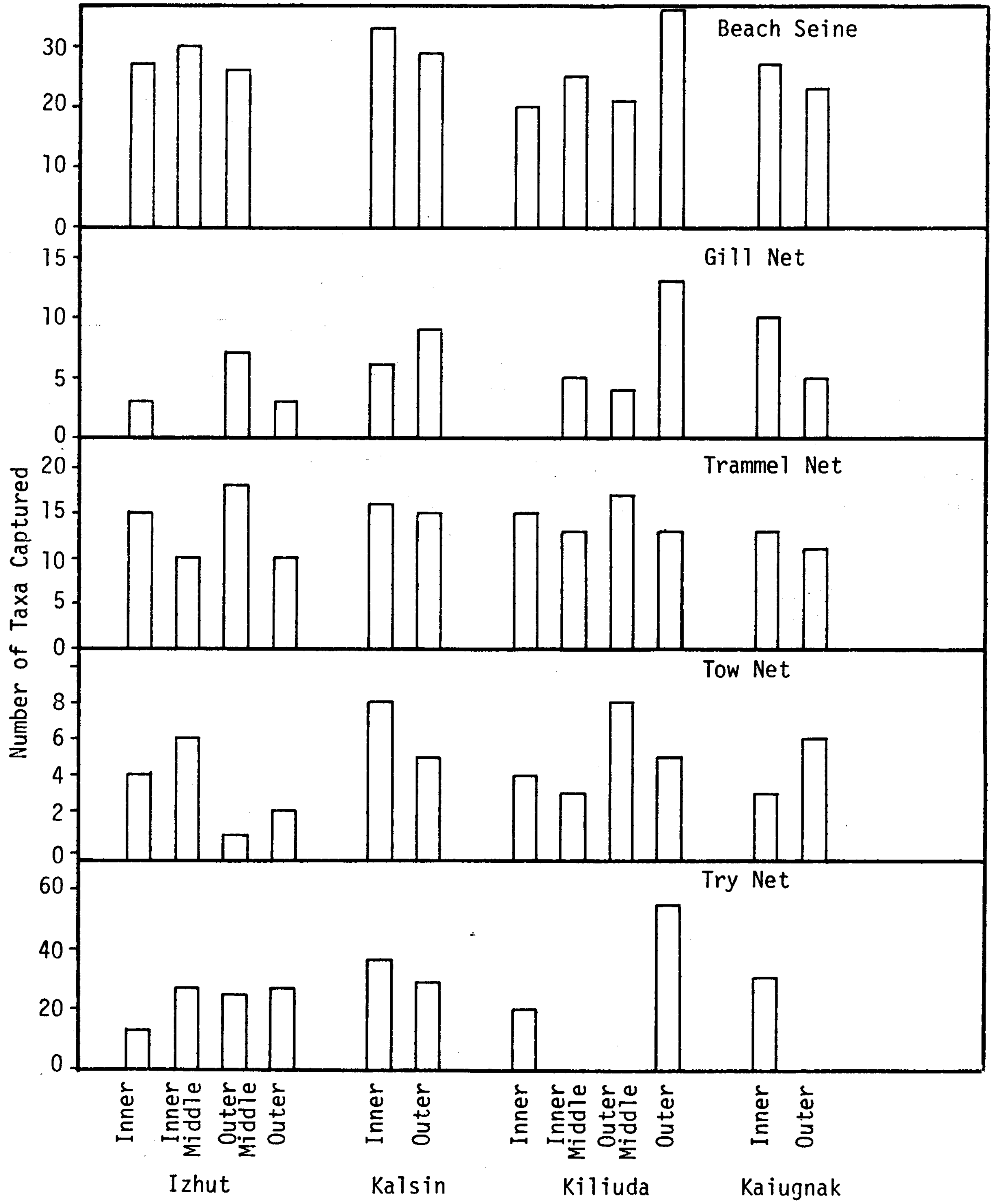

Figure 14. Number of taxa captured in each sampling gear and subarea on the east side of the Kodiak Archipelago, 1978-1979. The otter trawl was not included because it was used in only two subareas.

The beach seine yielded much higher catch rates in this outer Kaiugnak area than in any other area sampled for Dolly Varden, juvenile Pacific cod, Pacific tomcod, tubenose poacher and snake prickleback. Silver-spotted sculpin catches in the beach seine were also very high in outer Kaiugnak, and the catch of this species was also very high in inner Kiliuda (Table 16). The trammel net yielded the highest catch rates of rock greenling and some of the lowest catch rates of whitespotted greenling in Kaiugnak Bay.

Species Associations

The results of the species association analyses both depend upon and reveal the relative abilities of the different sampling gear to catch a variety of fish species. As will be shown, the try net, beach seine, and trammel net caught a considerably greater variety of species than the gill net or tow net. The gill net catch was greatly predominated by three species while the tow net catch was so highly variable that the distribution features are probably due to chance.

There were 18 species in the beach seine catches that were judged to be sufficiently frequent and abundant that their correlation with other species would have meaning. A number of highly significant correlations occurred. After grouping the larger correlations there were five groups remaining at a correlation coefficient of .35 (Figure 15). One of these consisted mainly of the predominant species, sand lance, pink salmon, masked greenling, great sculpin and *Myoxocephalus* spp. Weakly associated with this was another group composed of Pacific cod, tubenose poacher, Dolly Varden, silverspotted sculpin, threespine stickleback, and rock greenling. The other three groups were not associated with any other group and two were negatively associated with all others. (Note that negative association did not appear at as large a value as positive association partly because species were grouped before negative values were encountered.)

The group composed of lingcod juveniles and chum salmon had large catches in inner Kiliuda in common; and when this area is eliminated the relationship between them vanishes. This grouping is probably spurious.

There were only six species in the gill net catches that were sufficiently frequent that their correlation with other species would have meaning. Among these species there was only one significant correlation, between Pacific cod and Pacific herring (Figure 15).

In the trammel net catches there were 17 species sufficiently frequent to include in interspecies correlations. There were a number of significant correlations; and after grouping the larger correlations there were six groups remaining at a correlation coefficient of .35 (Figure 15). In one group were staghorn sculpin, starry flounder, yellowfin sole, rock-sole and terpug. Associated with this group was a group composed of white-spotted greenling and great sculpin. These two were related to a third group composed of Dolly Varden, herring, *Myoxocephalus* spp., and shorthorn sculpin (note that shorthorn sculpin is not necessarily a valid identification but for the purposes of this analysis distinctions made in the field

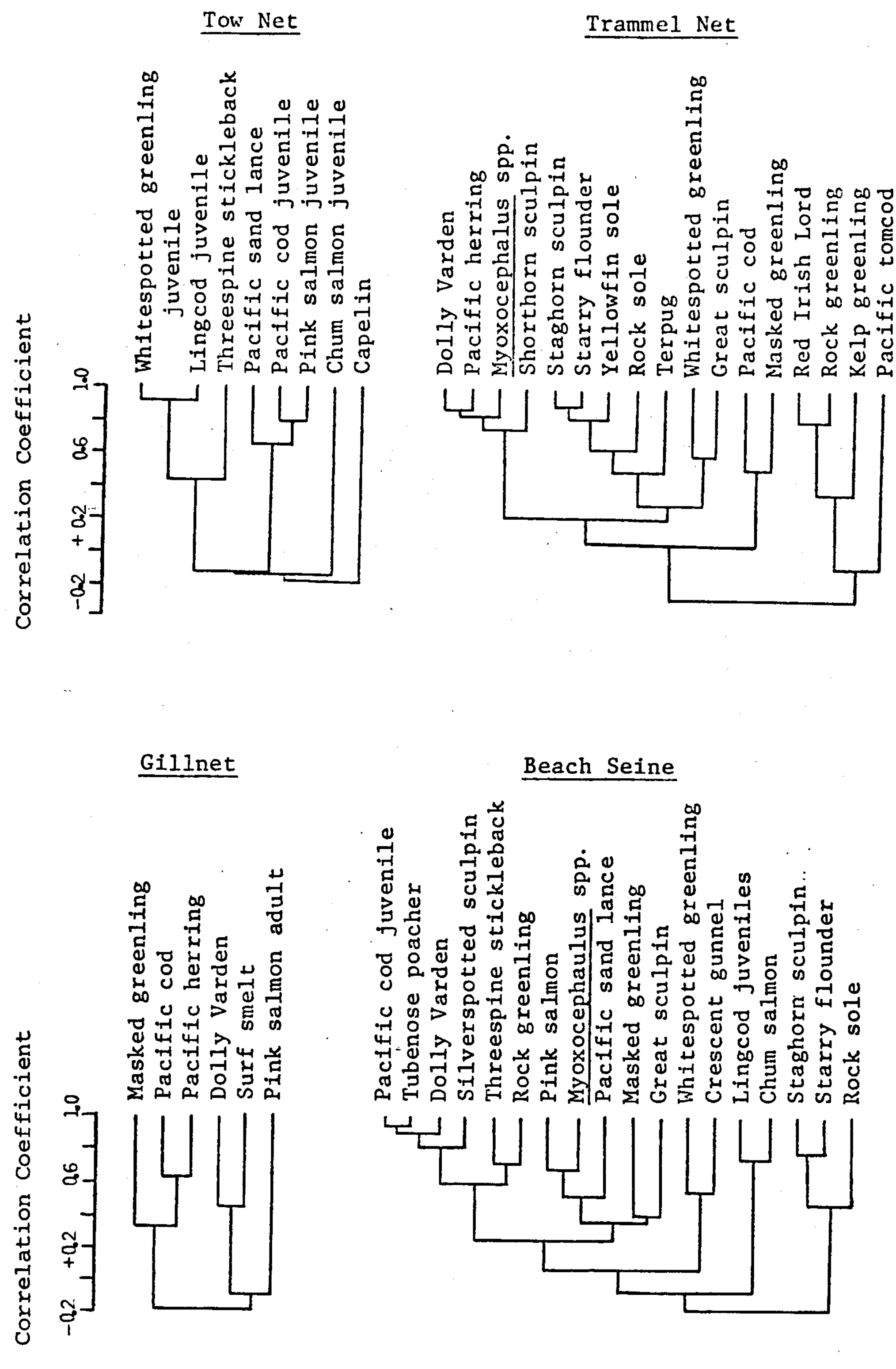

Figure 15. Dendrograms of the correlation coefficients among species from mean catches by area, for four gear types.

were maintained). The remaining three groups were not associated or were negatively associated with all other groups. Red Irish lord, rock greenling and kelp greenling comprised one group; Pacific tomcod comprised a group, while Pacific cod and masked greenling comprised the remaining group (Figure 15).

There were eight species in the tow net catches that were sufficiently frequent to include in interspecific correlations. After larger correlation coefficients were combined there were four groups remaining at a correlation coefficient of .35 (Figure 15). Each of these groups was negatively associated with all others. The groups were, 1. whitespotted greenling juveniles, lingcod juveniles and threespine stickleback juveniles; 2. sand lance, Pacific cod juveniles, and pink salmon juveniles; 3. chum salmon juveniles and 4. capelin (Figure 15).

In the try net catches there were 31 species sufficiently frequent to include in interspecific correlations. A number of significant correlation coefficients occurred, and after grouping species with high correlations there were six groups remaining at a correlation coefficient of .35 (Figure 16). Of these groups, one contained 13 species, one contained eight species, three groups contained three species and one contained a single species (Figure 16).

Diversity

The diversity measure employed (Shannon index divided by total catch, in which form it is termed diversity per individual; Clifford and Stephenson, 1975) is largest when all the numbers greater than zero are most similiar. It also increases as the total number of separate numbers increases.

The diversity between species was highest for the try net and lowest for the tow net (Table 22). Since this index uses the total catch of each species (Table 16,17,18,19 and 20) this result indicates that the differences among the tow net species totals were greater than for any other gear and the differences among the try net species totals were less than for any other gear.

Table 22. Shannon diversity per individual (times 100 to remove decimals) between species, area, total and interaction for each sampling gear.

	Between Species	Between Subareas	Total	Interaction
Beach Seine	71	91	149	14
Gill Net	61	79	122	18
Trammel Net	69	105	160	14
Tow Net	54	70	83	41
Try Net	93	88	164	16

Try Net

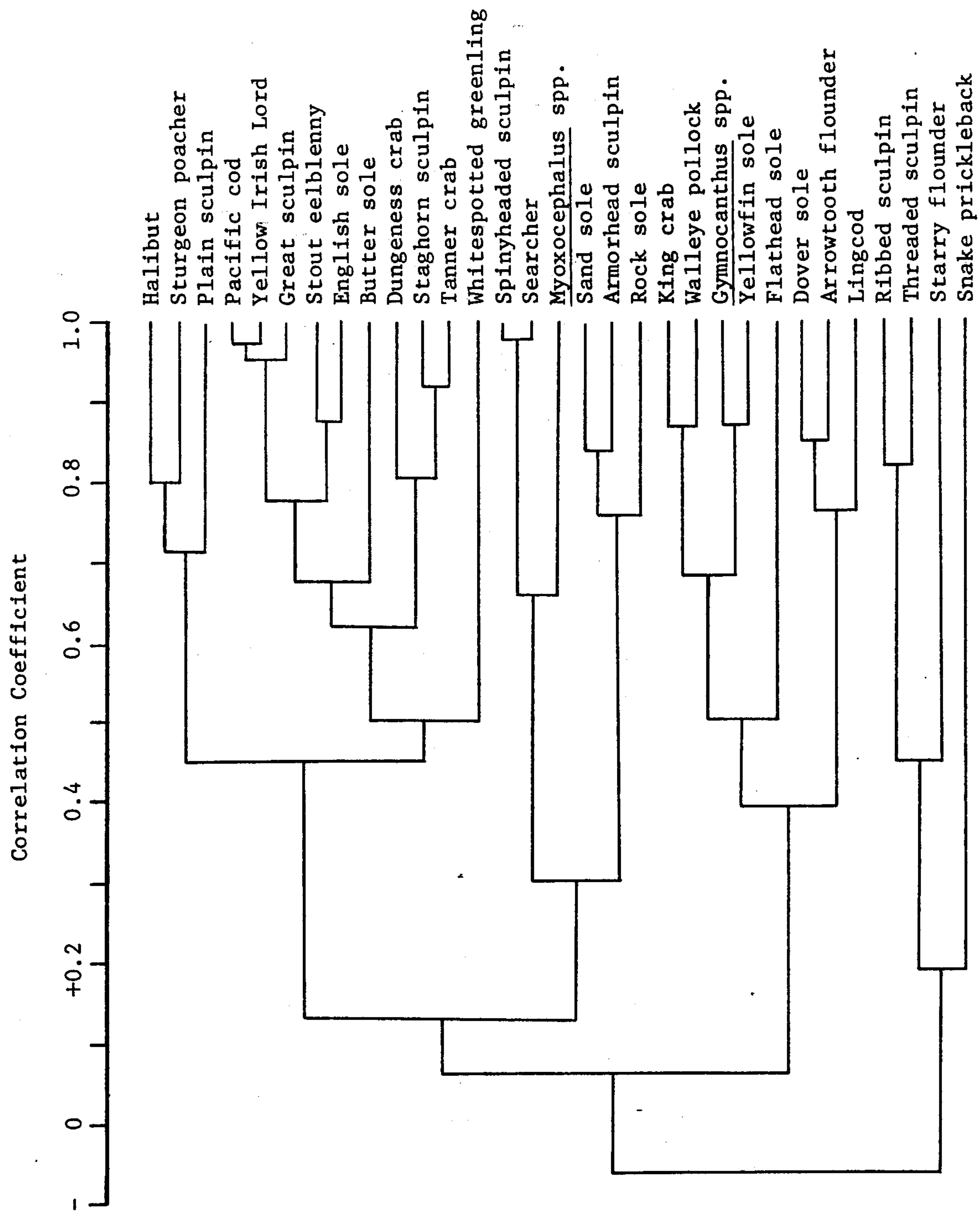

Figure 16. Dendrogram of the correlation coefficients among species from mean catches by area in the try net.

The diversity between areas was highest for the trammel net and lowest for the tow net (Table 22). Since this index uses the total catch in each subarea (Table 16, 17, 18, 19, and 20), this result indicates that the differences among areas was least for the trammel net and greatest for the tow net catches.

The total diversity was highest for the try net, trammel net and beach seine and least for the gill net and tow net (Table 22). Since this index uses all numbers in each table of species by area (Tables 16, 17, 18, 19 and 20) the result indicates that the variation among these numbers is least in the try net, trammel net and beach seine and greatest for the gill net and tow net.

The interactive diversity was about 9 to 14 percent of the total diversity for all sampling gear except the tow net, for which it was nearly 50 percent of the total diversity (Table 22). This index reflects the fidelity of species to areas. Thus, the high interactive diversity for the tow net indicates greater fidelity between species and areas in this gear. However, this is probably due in part to inadequate sampling.

The diversity of species catches within each subarea (Table 23) is a reflection of the equitability of species numbers, greater diversity indicating greater equitability. From the beach seine catches the greatest diversity was found in outer middle Kiliuda (Table 23). Greatest diversity was found in inner Kaiugnak with the gill net, inner Kalsin with the trammel net, inner middle Izhut with the tow net and outer Kiliuda with the try net (Table 23).

The diversity of each species between subareas (Table 24) for each gear type is an indication of the equitability of the catch, higher diversity indicating greater equitability. Only two species, Pacific cod and whitespotted greenling had significant differences between area diversities from all five gear types (Table 24). A total of six species had significant difference between area diversities from four gear types: Pacific herring, pink salmon, rock greenling, masked greenling, staghorn sculpin and great sculpin.

The species with greatest diversity in the beach seine catches were masked greenling, whitespotted greenling, Myoxocephalus spp., buffalo sculpin, crescent gunnel and great sculpin (Table 24). The species with greatest diversity in the gill net catches were Dolly Varden, adult pink salmon and masked greenling (Table 24). The species with greatest diversity in the trammel net catches were whitespotted greenling, rock greenling, masked greenling, great sculpin and rock sole (Table 24). The species with greatest diversity in the tow net catches were juvenile pink salmon, threespine stickleback and capelin (Table 24). The species with greatest diversity in the try net catches were whitespotted greenling, flathead sole, yellowfin sole, rock sole, Myoxocephalus spp., snake prickleback, and Pacific halibut (Table 24).

Table 23. Shannon diversity per individual (times 100 to remove decimals) within each subarea by sampling gear.

	Izhut				Kalsin		Kiliuda				Kaiugnak	
	Inner	Inner Middle	Outer Middle	Outer	Inner	Outer	Inner	Inner Middle	Outer Middle	Outer	Inner	Outer
Beach seine	54	74	53		73	63	57	73	95	72	39	58
Gill Net	45		23	44	60	51		52	52	38	87	50
Trammel Net	61	68	78	68	85	71	76	53	40	38	42	35
Tow Net	18	68	0	3	36	46	4	6	19	33	30	60
Try Net	91	91	53	32	84	76	75			98	79	

The number of taxa captured is an indication of diversity (Figure 14). The amount of effort affects the number of taxa captured (Table 25) but there is no way to completely remove the effect of varying effort. If it is assumed that the subareas were sampled approximately equally, the number of taxa in each subarea in each sampling gear provides a direct indication of species richness. The most taxa were caught in the try net and the greatest number of species in the try net were captured in outer Kiliuda (Figure 14). The beach seine yielded generally the second greatest number of taxa and the greatest number of taxa were taken in outer Kiliuda also (Figure 14).

The trammel net yielded the third greatest number of taxa and the greatest number of taxa were taken with this gear in outer middle Izhut (Figure 14). The greatest number of taxa in the gill net were taken in outer Kiliuda (Figure 14). The greatest number of taxa in the tow net were taken in inner Kalsin and outer middle Kiliuda (Figure 14).

The diversity by sampling date does not show clear trends in all gear types (Figure 17). The diversity of beach seine and tow net samples was depressed considerably in July and August by the high abundance of sand lance. All gear showed highest species counts during August, with the exception of the otter trawl (Figure 17).

Table 24. Shannon diversity per individual (times 100 to remove decimals) among subareas for each species and each sampling gear. A few species were omitted when all entries were zero (one occurrence in any one gear). Otter trawl was omitted because it was used in only two areas while the other sampling gears were used in nine or more of the areas.

	Beach Seine	Gill Net	Trammel Net	Tow Net	Try Net
King crab	0				43
Tanner crab					71
Dungeness crab	43				55
Pacific herring	45	65	39		0
Pink salmon	79	76	20	60	
Chum salmon	76	46		8	
Coho salmon	8	30			
Sockeye salmon		41			
Dolly Varden	76	85	63		
Surf smelt	13	36	-		
Capelin	48	0		50	29
Pacific cod	61	58	88	41	51
Pacific tomcod	16	0	48		5
Walleye pollock	30	0	45		69
Threespine stickleback	78			59	
Tube-snout	30				
Dusky rockfish		0	5		0
Black rockfish			33		
<u>Hexagrammos</u> spp.	60		0	28	
Kelp greenling	0		79	0	0
Rock greenling	82	28	96		16
Masked greenling	99	75	96		18

Table 24. Continued...

	Beach Seine	Gill Net	Trammel Net	Tow Net	Try Net
Whitespotted greenling	98	12	97	45	82
Terpug			58		
Ling cod	63			33	72
Sculpin spp.	54		0		41
Padded sculpin	55				28
Crested sculpin			0		0
Silverspotted sculpin	65		30	0	30
Sharpnose sculpin	37				
Spinyhead sculpin					46
Buffalo sculpin	94		0		0
Gymnocanthus spp.	46		30		68
Armorhead sculpin			0		77
Threaded sculpin			20		50
Red Irish Lord	0		68		21
Yellow Irish Lord	79		30		61
Staghorn sculpin	72	41	36		53
Myoxocephalus spp.	95		76		76
Plain sculpin	0		0		47
Great sculpin	90	44	96		73
Shorthorn sculpin	60		59		43
Slim sculpin					0
Manacled sculpin	24				
Scissortail sculpin					26
Roughspine sculpin					30
Ribbed sculpin					57
Sturgeon poacher			22		68
Tubenose poacher	46			0	43
Snailfish spp.	10				24
Spotted Snailfish	28				
Sandfish	0				28
Searcher	0		0		39
Prickleback spp.					26
High cockscomb	0				24
Snake prickleback	7	0			76
Daubed shanny					44
Stout eelblenny					53
Arctic shanny	38				23
Penpoint gunnel	48				
Crescent gunnel	91				26
Prowfish	30			41	
Pacific sand lance	80			49	
Arrowtooth flounder					54
Rex sole					0
Flathead sole			0		79
Butter sole	0				67
Rock sole	81		91		76
Yellowfin sole	13		51		77
Dover sole					29
English sole	29				45
Starry Flounder	71	0	50		67
Alaska plaice	30				41
Sand sole	38				57
Pacific halibut	0		41		75

Table 25. Number of hauls or sets of each gear type in each subarea for all cruises combined.

	Izhut				Kalsin		Kiliuda				Kaiugnak	
	Inner	Inner Middle	Outer Middle	Outer	Inner	Outer	Inner	Inner Middle	Outer Middle	Outer	Inner	Outer
Beach Seine	36	37	48	0	37	37	35	36	38	47	35	31
Gill Net	8	6	11	1	8	9	0	20	4	15	12	8
Trammel Net	13	8	15	3	14	12	10	7	14	11	12	11
Tow Net	18	26	12	14	30	13	16	15	23	15	16	16
Try Net	9	11	34	27	31	21	6	0	0	34	13	0
Otter Trawl[1]	0	0	0	20	0	0	0	0	0	21	0	0

[1]The otter trawl was not used in all areas because this study was designed as a nearshore survey and some otter trawling was added as an afterthought to provide some link with existing information on otter trawl catches.

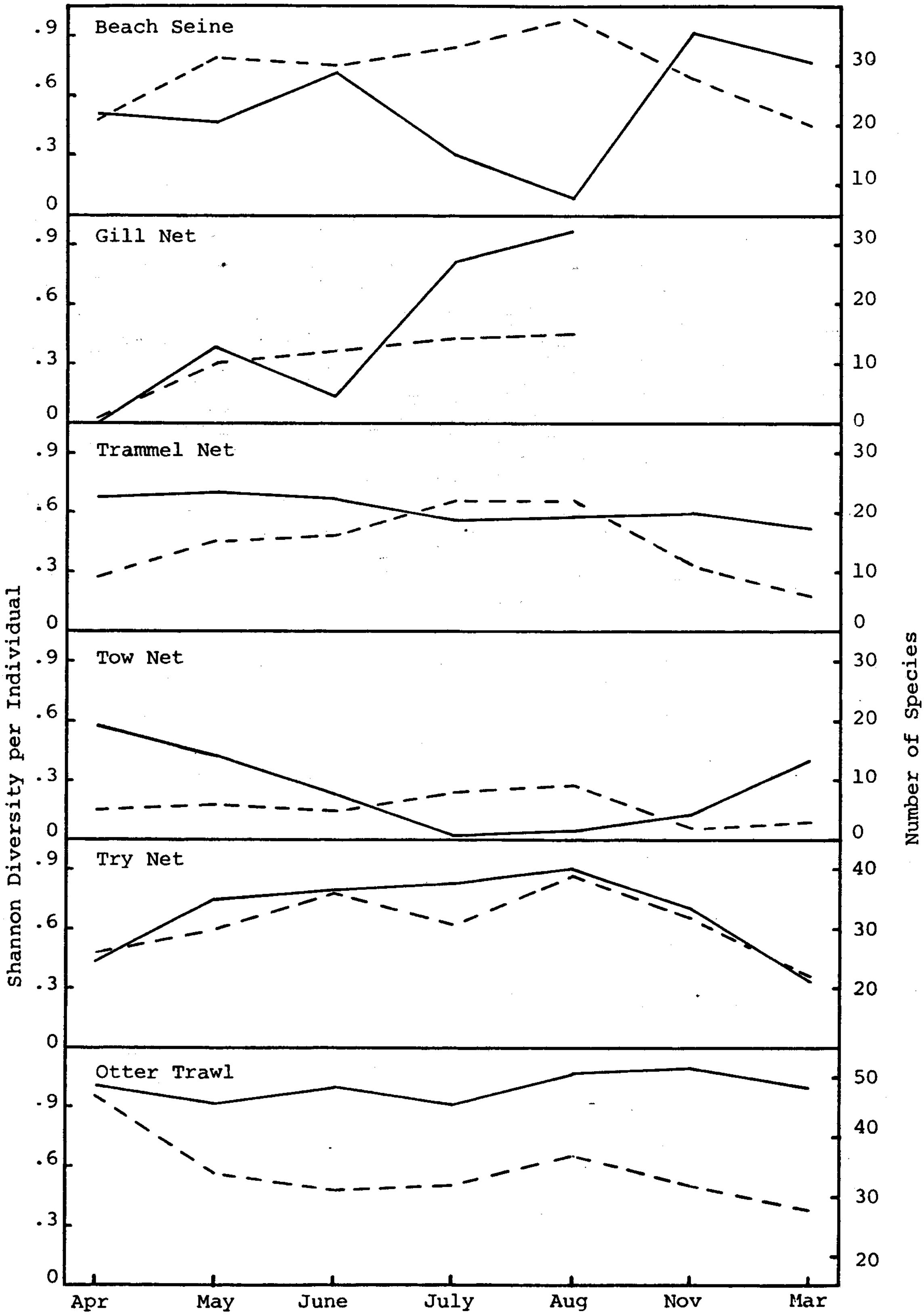

Figure 17. Shannon diversity per individual (solid line) and number of species (dashed line) by gear and month.

Features of Distribution, Abundance, Migration, Growth and Reproduction of Prominent Taxa

King Crab

Although they occurred in every cruise, known seasonal migration features, described earlier, were not clearly displayed (Tables 10,14, 15).

King crab were captured in outer Izhut in the trawl (Table 21), inner and outer Kalsin in the try net (Table 20), outer Kiliuda in the beach seine, try net and otter trawl (Tables 16, 20 and 21) and inner Kaiugnak in the try net (Table 20).

Tanner Crab

Seasonal features of Tanner crab catches are not consistent in the try net and otter trawl but the two types of gear captured Tanner crab of considerably different sizes. The otter trawl, which sampled 30 to 50 fathoms deep, captured larger crab, with mean weights ranging from 0.36 to 0.67 kg/crab by cruise. The try net sampled 10 fathoms and shallower and captured crab 0.02 kg to 0.37 kg/crab by cruise. The mean catch of crab in the otter trawl in June was strongly biased downward due to failure to record weights or counts, partly due to the soft shell of the recently molted crab.

Tanner crab are known to occur in shallower waters in April and May and this is reflected in the higher otter trawl catches at this time. Lower otter trawl catches during the other portions of the year are due to movement into deeper waters. Tanner crab were captured in all areas in the try net (Table 20).

Pacific Herring

Seasonality was apparent, with greatest gill and trammel net catches in May and June. Catch variability was quite high for herring,and differences between bays cannot be stated with any degree of confidence; however, the highest catches in the gill net were obtained in outer Kiliuda, outer Kalsin and the two outer areas of Izhut (Table 17). Herring in spawning condition were captured in April, May and June (Table 26).

Age 0 herring were 3 to 4 cm in August and a few captured in November were 6 to 7 cm. Older age classes cannot be identified from the existing length frequencies (Figure 18).

Pink Salmon

Pink salmon occurred from March to August, with greatest abundance in June and July. Pinks were present in all areas sampled, and the greatest juvenile pink salmon catches were in the beach seine in

Table 26. Stage of maturity by date for each species examined. Data were collected on the eastside of the Kodiak Archipelago during April through November of 1978 and March of 1979. The criteria used to classify gonads did not clearly separate spent, inactive, and maturing; thus these results should be used with caution. The values are numbers of fish.

	APRIL		MAY		JUNE		JULY		AUGUST		NOVEMBER		MARCH	
	1-15	16-30	1-15	16-31	1-15	16-30	1-15	16-31	1-15	16-31	1-8	12-18	3-10	15-18
Pacific Herring														
Maturing		2	3		3									
Spawning		1	95	1	5									
Spent			3		8	1	8							
Pink Salmon														
Maturing								7	13	2				
Chum Salmon														
Maturing										2				
Coho Salmon														
Maturing										1				
Sockeye Salmon														
Maturing					1			1						
Dolly Varden														
Maturing		9	2	1		3	2	6	2	1		2		
Spawning					1						1			
Spent					8						13			
Inactive			4	1	1									
Surf Smelt														
Maturing			1		3						2			
Spawning			2											

Table 26. Stage of maturity by date for each species examined. (CONTINUED)

	APRIL		MAY		JUNE		JULY		AUGUST		NOVEMBER		MARCH	
	1-15	16-30	1-15	16-31	1-15	16-30	1-15	16-31	1-15	16-31	1-8	12-18	3-10	15-18
Capelin														
Maturing		1			3	3								20
Spawning			1		4	1							3	
Spent					4									
Inactive					2									
Eulachon														
Maturing												13		
Spawning		2												
Pacific Cod														
Maturing	5				14	14		6				9	5	
Spawning		1												
Inactive				1	6	2		10		13		5	2	
Pacific Tomcod														
Maturing	4								1		1		15	
Spawning													3	2
Inactive									5		5			
Walleye Pollock														
Maturing							3	6	9	8	2	1		13
Spawning	3													
Spent										1				
Inactive										5	1	8		
Threespine Stickleback														
Maturing				1		3		1						

Table 26. Stage of maturity by date for each species examined. (CONTINUED)

	APRIL		MAY		JUNE		JULY		AUGUST		NOVEMBER		MARCH	
	1-15	16-30	1-15	16-31	1-15	16-30	1-15	16-31	1-15	16-31	1-8	12-18	3-10	15-18
Black Rockfish														
Maturing	2								4					
Kelp Greenling														
Maturing	2		2				2				4			
Spawning							1				2			
Spent									1					
Inactive	3					2			5					
Rock Greenling														
Maturing	1	27	76	44	95	67	48	28	15	1			5	4
Spawning					1	38	31	26	36	14				
Spent						18	15	6	19	29				4
Inactive	2			4	1	3	2		4	3	36	34	10	3
Masked Greenling														
Maturing	1	29	18	80	47	146	70	58	65	38	4			3
Spawning						7	40	41	27	46				
Spent						1	2	4	5	8				
Inactive	2		1	2		1	1	1		1	34	38		1
Whitespotted Greenling														
Maturing		2	5	25	32	46	33	63	38	28	1	1	3	5
Spawning					1	5	1	5	16	54				
Spent										1				
Inactive				10	3	8	3	2	3		19	14	3	
Terpug														
Maturing			2	2	9									

Table 26. Stage of maturity by date for each species examined. (CONTINUED)

	APRIL		MAY		JUNE		JULY		AUGUST		NOVEMBER		MARCH	
	1-15	16-30	1-15	16-31	1-15	16-30	1-15	16-31	1-15	16-31	1-8	12-18	3-10	15-18
Silverspotted Sculpin														
Maturing					1									
Threaded Sculpin														
Maturing														1
Spawning													2	1
Red Irish Lord														
Maturing						2	3	3	1	3	1			
Inactive						1						1		
Yellow Irish Lord														
Maturing			28	19	12	45	19	26	12	5			11	1
Spawning						7			5	4				
Spent										1				
Inactive				19	1			16	2	29	22	19	9	
Staghorn Sculpin														
Maturing	1				2	2	6	2	2			2		
Inactive						4								
Plain Sculpin														
Maturing						1	1				2			
Great Sculpin														
Maturing	1	1	12	19	2	23	8	15	8	17	4			
Spent				2		1		3	4					
Inactive	1		1	28	4	3		14	1	9	3			

Table 26. Stage of maturity by date for each species examined. (CONTINUED)

	APRIL		MAY		JUNE		JULY		AUGUST		NOVEMBER		MARCH	
	1-15	16-30	1-15	16-31	1-15	16-30	1-15	16-31	1-15	16-31	1-8	12-18	3-10	15-18
<u>Manacled Sculpin</u>														
Maturing	4		1											
Spawning							1							
<u>Ribbed Sculpin</u>														
Maturing											1			
Spawning											1			
<u>Tubenose Poacher</u>														
Maturing											3	4		
Spawning				1										
<u>Pacific Sandfish</u>														
Maturing	1		1	1			21	9	18			2	1	
Spawning													5	
Spent				4	1				1					
Inactive				4				3						
<u>Alaska Ronquil</u>														
Spawning					1									
<u>Searcher</u>														
Maturing	2													
<u>Snake Prickleback</u>														
Maturing			1		14	1	13	10	1	2				2
Inactive								6	2	2				

Table 26. Stage of maturity by date for each species examined. (CONTINUED)

	APRIL		MAY		JUNE		JULY		AUGUST		NOVEMBER		MARCH	
	1-15	16-30	1-15	16-31	1-15	16-30	1-15	16-31	1-15	16-31	1-8	12-18	3-10	15-18
Arctic Shanny														
Maturing				1										
Crescent Gunnel														
Maturing					1	1	7	5	6	4				
Spent														1
Inactive	1			3					5	1				
Pacific Sandlance														
Maturing								1	1	18		1		
Spawning										1	10	48		
Spent										2		2		
Inactive								6	3					
Arrowtooth Flounder														
Maturing			1											
Flathead Sole														
Maturing			3	17	21	34	18	14	22	16	23	6	7	1
Spawning				1		2	7		2	1	2			
Spent						1		3						
Inactive				1	27				1	3	1	1		
Buttersole														
Maturing			9	5	1						10			
Spawning			1											
Rocksole														
Maturing	78	14	146	71	157	53	99	43	54	19	130	17	42	5
Spawning			2		10	1	2		1			1		
Spent	1					2	6	10	8		3		4	
Inactive			4	1	57	1		10	52	21	21	2	22	24

Table 26. Stage of maturity by date for each species examined. (CONTINUED)

	APRIL		MAY		JUNE		JULY		AUGUST		NOVEMBER		MARCH	
	1-15	16-30	1-15	16-31	1-15	16-30	1-15	16-31	1-15	16-31	1-8	12-18	3-10	15-18
<u>Yellowfin Sole</u>														
Maturing		3	105	41	122	47	31	44	47	15	74	40	51	36
Spawning			1		76	69	61	17	24	54	4			
Spent							3	12	5	7	5			
Inactive					1			2	4	2	1			1
<u>Starry Flounder</u>														
Maturing		1	5		3					1				
Inactive											5			
<u>Alaska Plaice</u>														
Maturing											2			
<u>Sandsole</u>														
Maturing			2			1								
<u>Pacific Halibut</u>														
Maturing							6							

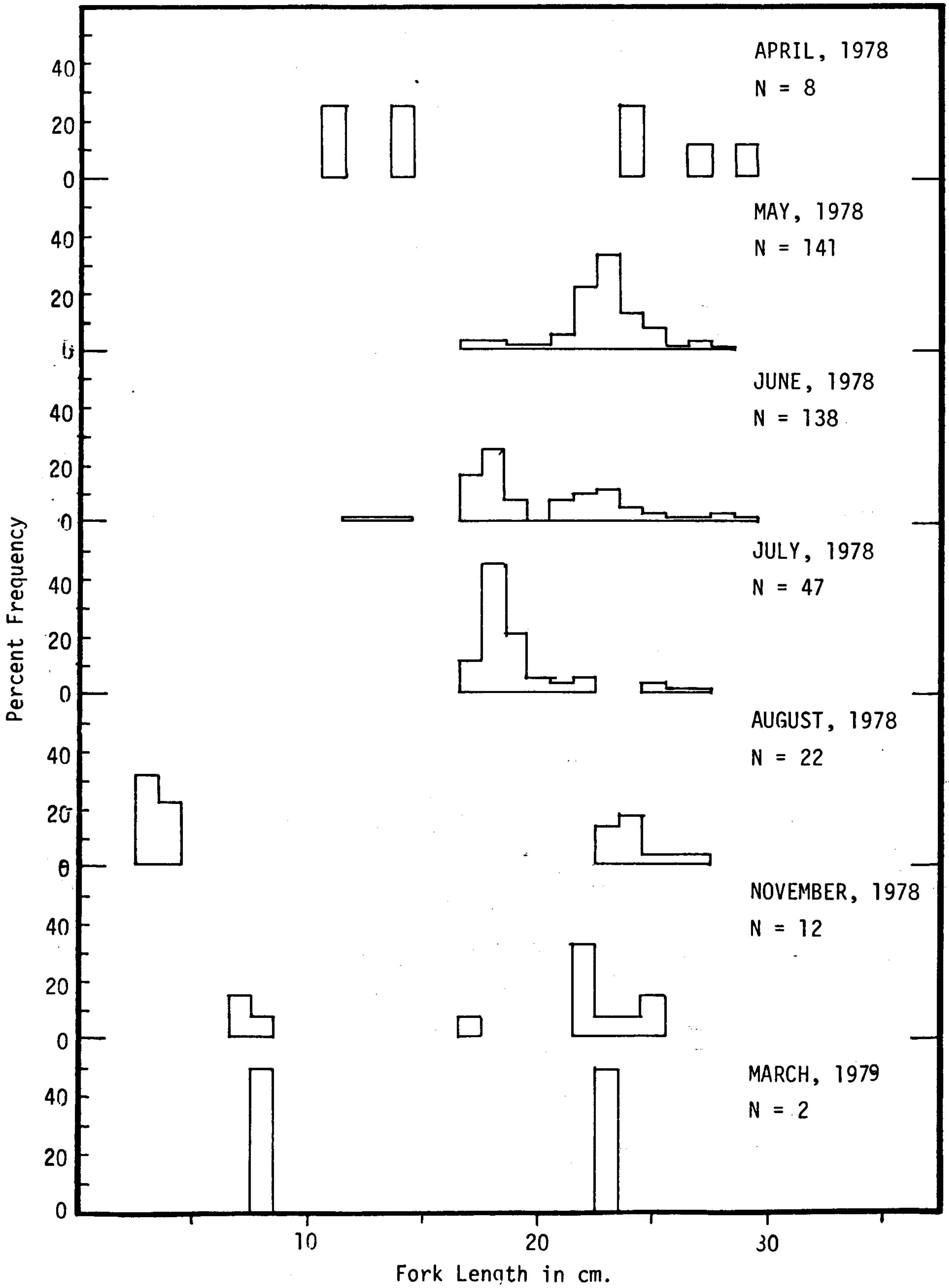

Figure 18. Relative length frequency of Pacific herring by month of capture. The catch by all types of gear and all bays combined, April 1978 through March 1979 on the east side of Kodiak.

Kaiugnak Bay (Table 16). Tow net catches were larger in Kalsin and Kiliuda Bays (Table 19). Adult pink salmon occurred in trace amounts in July and greater numbers in August in the beach seine, trammel net and gill net. Adult pink salmon were captured from late July through late August (Table 26).

The degree of exposure of each bay, or size of the bay, probably affected catches, as young pinks tend to leave shorter bays earlier than longer bays, especially those with a series of arms (Stern, 1977). In addition, catches of juveniles in any bay would be affected by the number of fish spawning in streams near the bay in question, as there is evidence that some pinks, after departing a particular bay, may move back into the open water of adjacent bays (Stern, 1977).

The age 0 pink salmon followed a definite pattern of growth. The first catch of a 3 cm juvenile occurred in March,and the mean length of fish caught in August was 10 cm (Figure 19). Pinks 3 cm in length occurred from March into June: This is the size at which they descend from freshwater.

Chum Salmon

Juvenile chum salmon occurred throughout the year with greatest abundance in May and June. Adults were captured from June to August, with the greatest catch in August (Table 11). Largest beach seine catches of juvenile chum salmon were in inner and outer Kiliuda, inner Kaiugnak and inner Kalsin Bays (Table 16).

No chums were caught in Izhut. There are no chum salmon streams in Izhut and there are much larger total runs to Kiliuda than Kalsin or Kaiugnak, which compares favorably with catches. Only two adult chum salmon were captured, in late August (Table 26).

Growth of juvenile chum salmon was not clear. Immigration and emigration probably had a strong effect on the length frequency (Figure 20).

Coho Salmon

Distribution or seasonal features of coho salmon distribution are not apparent although one large catch of juveniles occurred in Izhut Bay in June (Tables 10 and 16).

The juvenile coho salmon caught during June to August ranged in size from 8 cm to 17 cm, with a mean length of 14 cm (Figure 21). One adult coho was captured in late August (Table 26).

Dolly Varden

Dolly Varden were present from April through November and catches were greatest in July. Beach seine catches were greatest in outer

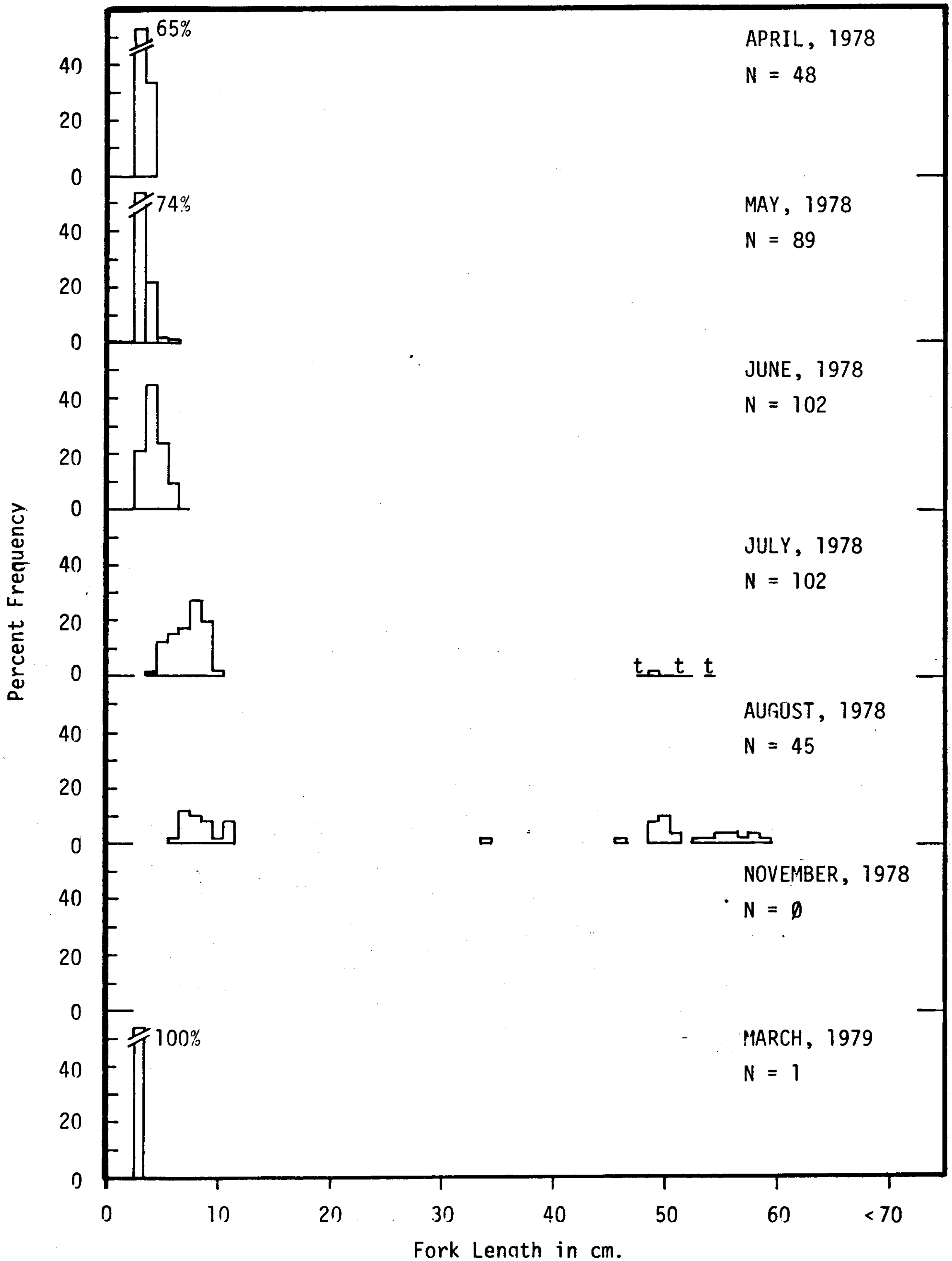

Figure 19. Relative length-frequency of pink salmon by month of capture. The catch by all types of gear and all bays combined, April 1978 through March 1979 on the east side of Kodiak. t refers to trace amounts.

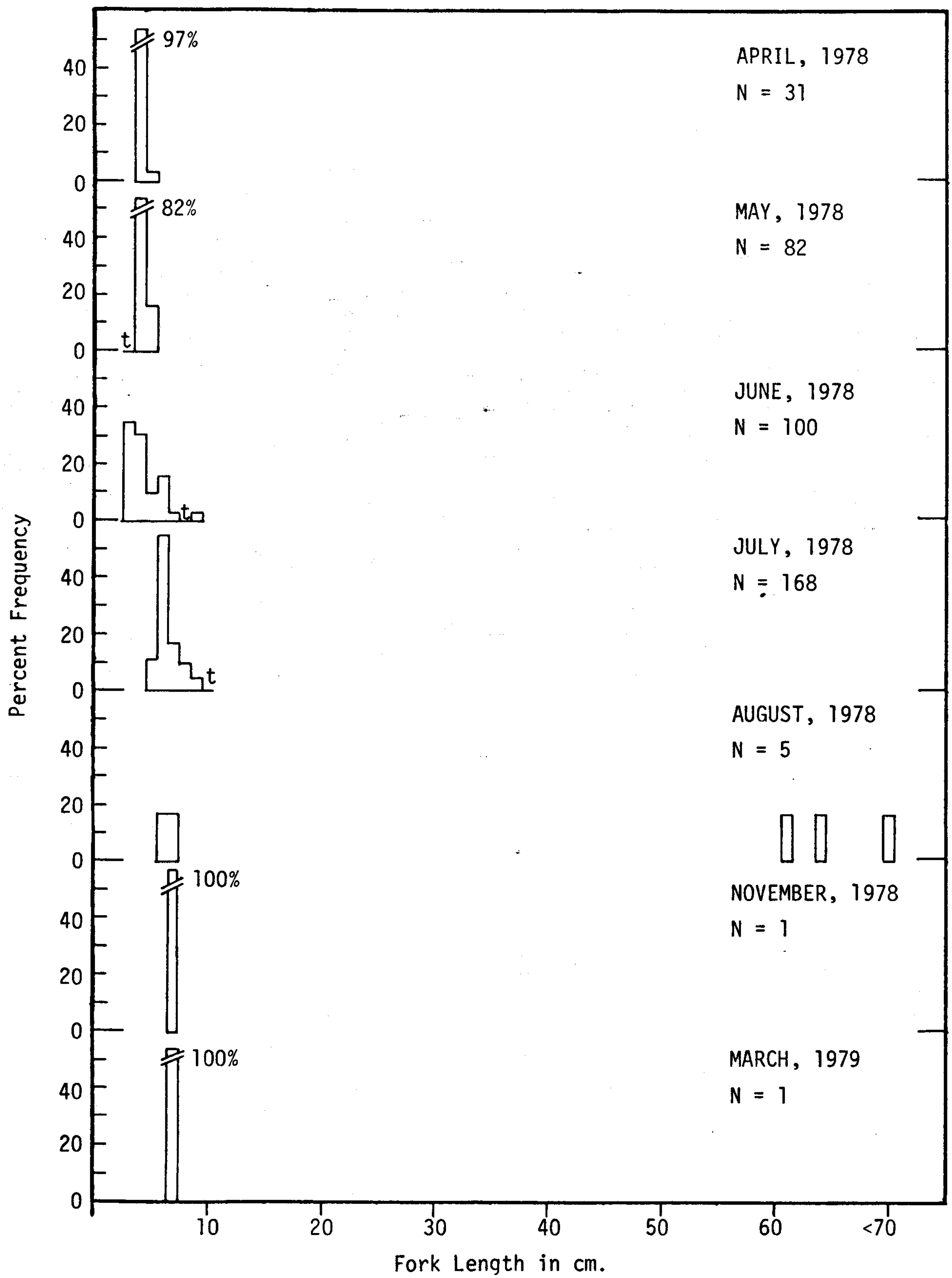

Figure 20. Relative length-frequency of chum salmon by month of capture. The catch by all types of gear and all bays combined, April 1978 through March 1979 on the east side of Kodiak. t refers to trace amounts.

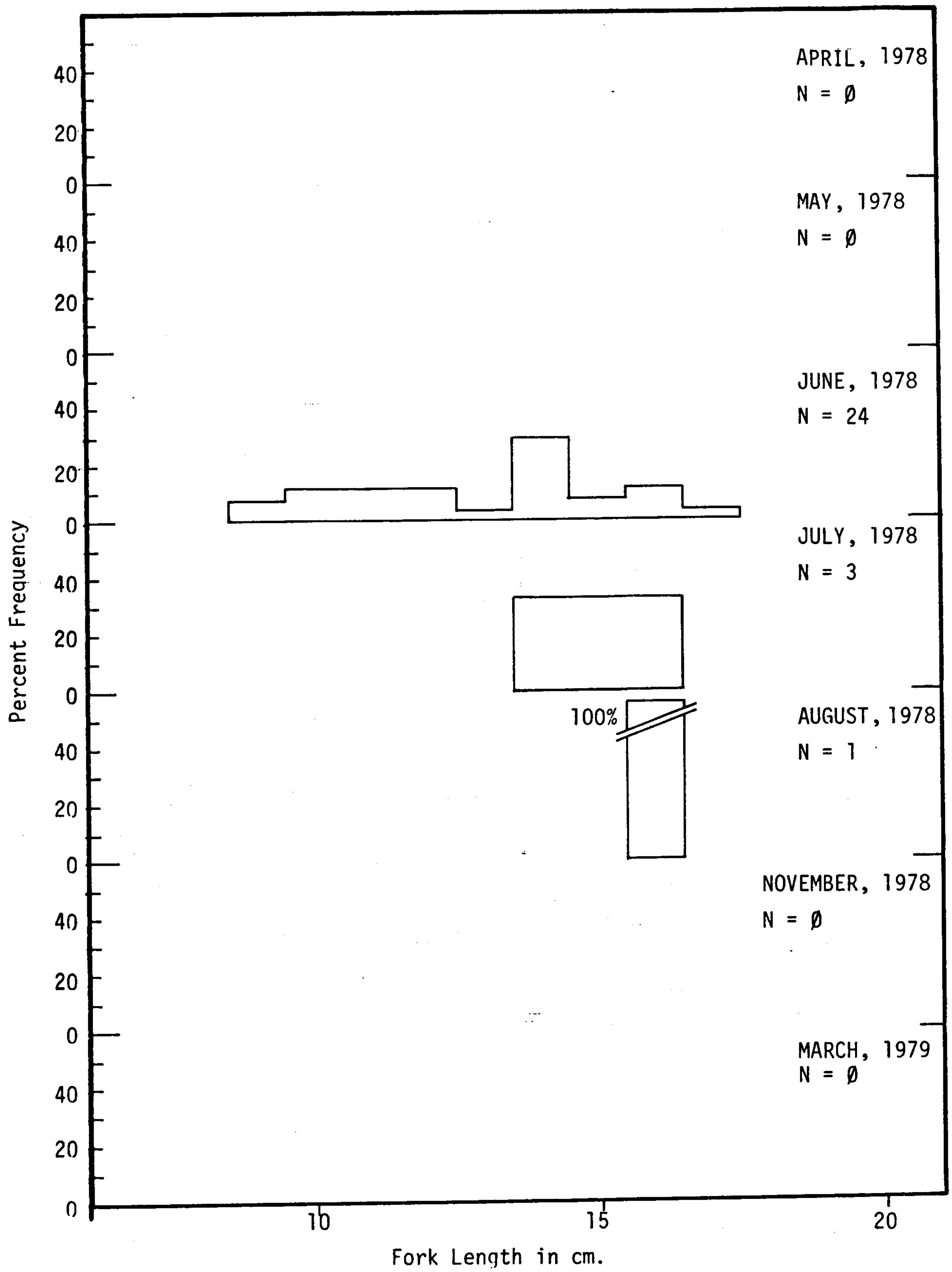

Figure 21. Relative length-frequency of coho salmon by month of capture. The catch by all types of gear and all bays combined, April 1978 through March 1979 on the east side of Kodiak.

Kaiugnak Bay; however, much of this is due to two large catches: 13 Dollies were taken in one of 4 sets in April and 65 Dollies were taken in one set in June (Table 16). Dolly Varden were present in the beach seine in all other areas at a fairly uniform abundance (Table 16). Dolly Varden also were caught by the gill net and trammel net in most areas (Table 17 and 18).

The length frequency data provided no insight to the growth of Dolly Varden (Figure 22). Most Dollies were 26 to 38 cm in length. Dolly Varden were judged to be in spawning condition in early June and in early November (Table 26).

Capelin

Capelin catches were highly variable and juveniles and adults were captured only in Izhut and Kiliuda Bays in the tow net (Table 19) and in Kalsin in the beach seine (Table 16). Larvae were captured in all bays but it was not possible to quantify their catch.

Three age classes can be distinguished in the length frequency data. Age 0 capelin were 3 cm in August and 4 cm in November. Age 1 capelin appeared abundantly in March at 5 cm and grew to 10 cm by November. Age 2 capelin were 11 cm in March and 11 to 12 cm by June. No age 2 capelin were caught after June (Figure 23). Adult capelin were judged to be in spawning condition in early May, early and late June and in early March (Table 26).

Pacific Cod

The beach seine catches of Pacific cod were almost exclusively age 0 fish with lengths of 5 to 9 cm in July and August while about six age 1 fish, 13 to 20 cm were captured in April-June. The gill net and trammel net catches were all age 1 cod, mostly 21 to 25 cm, taken primarily in June through August. The otter trawl captured all age classes, including age 0 in November. The try net captured a few small age 1 cod in summer and very few age 0 cod. Apparently cod are present their first two summers in the shallows (about 10 fm or less), the second year somewhat deeper than the first, but it cannot be said that they are absent deeper based on our data. At age 2 and greater, they reside deeper than about 10 fathoms (18 m). Commercial concentrations usually occur between 80 and 260 m (Pereyra et al., 1976). They demonstrate seasonal migration to shallower water in summer (Table 10, 11, 12 and 15).

Beach seine catches (age 0) tended to be greater in Kiliuda Bay and Kaiugnak Bay (Table 16) and tow net catch (also age 0) was greatest in outer middle Kiliuda. Gill and trammel net catches did not reveal a difference between bays, but the otter trawl yielded more Pacific cod in Kiliuda than in Izhut Bay.

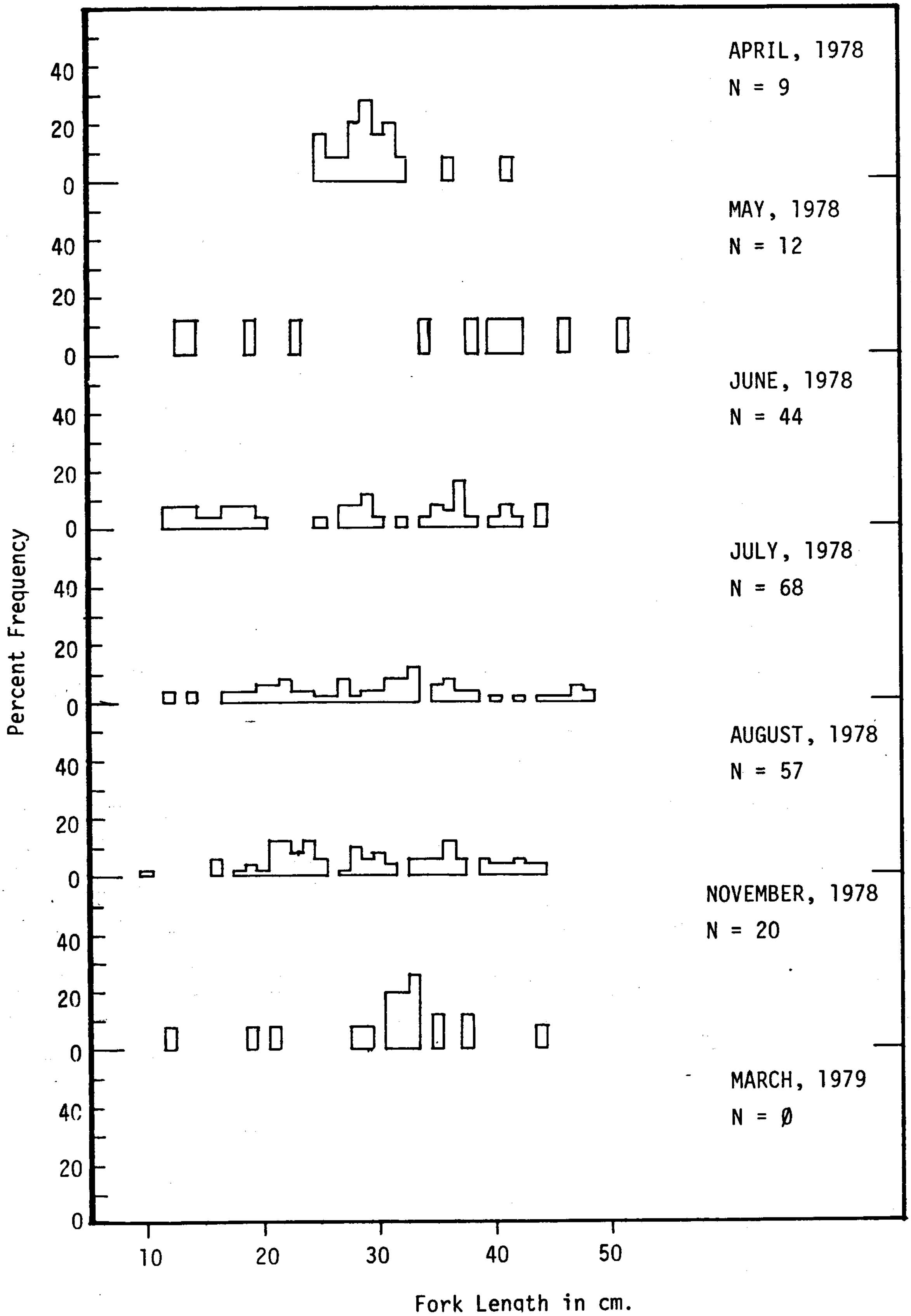

Figure 22. Relative length-frequency of Dolly Varden by month of capture. The catch by all types of gear and all bays combined, April 1978 through March 1979 on the east side of Kodiak.

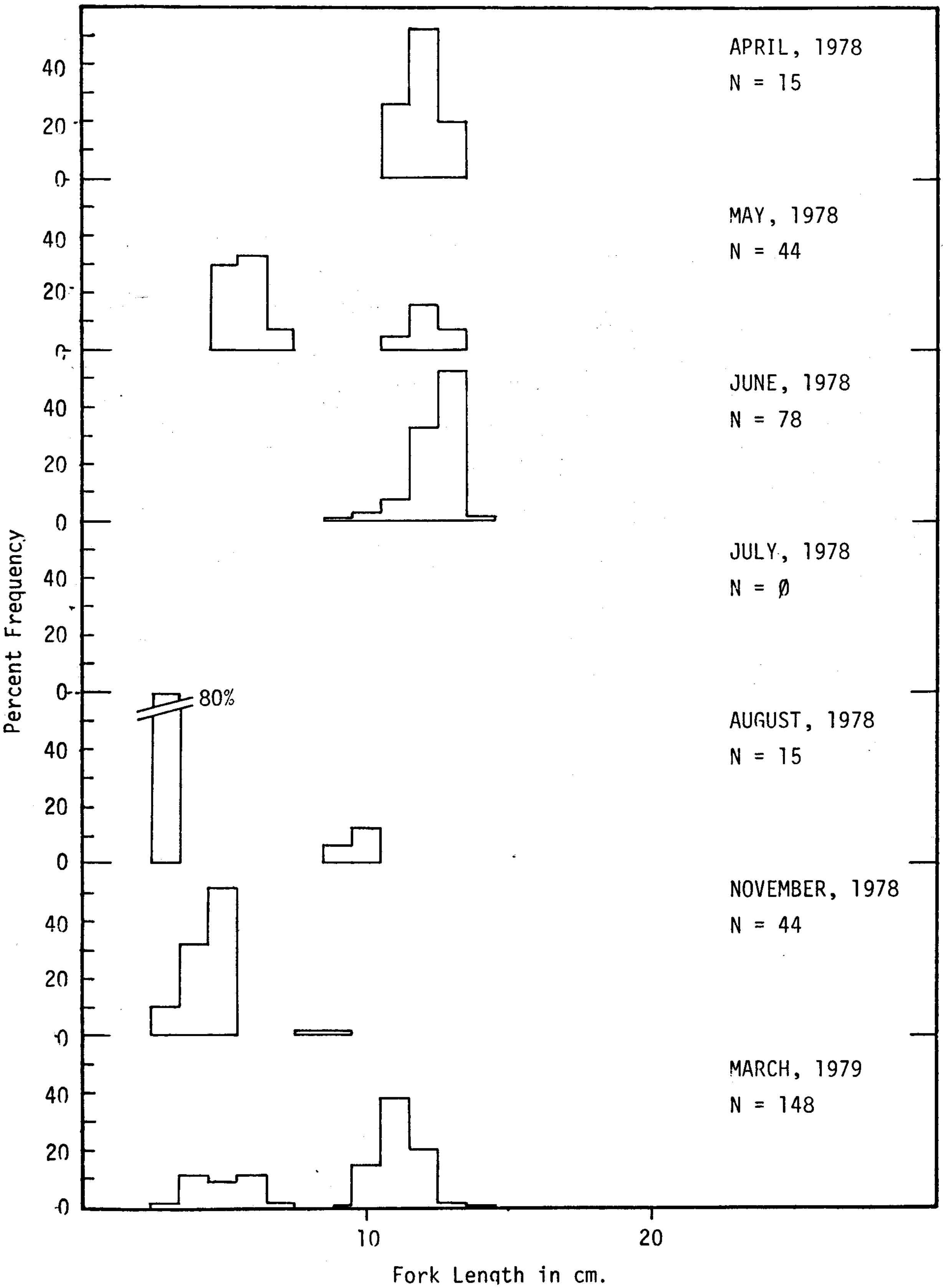

Figure 23. Relative length-frequency of capelin by month of capture. The catch by all types of gear combined, April 1978 through March 1979 on the east side of Kodiak.

Age 0 Pacific cod grew from 6 cm in July to about 12 cm in November. Age 1 fish were 15 cm in March and grew to about 32 cm in November (Figure 24). Greater ages cannot be assigned based on length frequency. One Pacific cod captured in late April was in spawning condition (Table 26).

Pacific Tomcod

The Pacific tomcod occurred in all four bays throughout the year, but the greatest catch was made by the otter trawl, in which catches were greater in Izhut than Kiliuda Bays (Table 10, 15, 16, 17,18, 20, and 21). No bay had more tomcod than any other as each gear showed different relative catches between bays.

Age 0 Pacific tomcod grew from about 3 to 5 cm in June to 11 to 12 cm in November. Age 1 fish were about 15 cm in June and 17 to 18 cm in July and what appears to be age 3 tomcod grew from about 24 cm in May to about 25 to 28 cm in November (Figure 25). This apparent size at age is essentially identical to that similarly interpreted from figures published from Puget Sound by Stober and Solo (1973). Pacific tomcod in spawning condition were captured in March (Table 26).

Walleye Pollock

Walleye pollock were relatively abundant in otter trawl catches in both Izhut and Kiliuda Bays (Table 21). Walleye pollock were caught throughout the year by the otter trawl and the catch was greatest in July, August and November. Pollock were caught by other gear types, but the catches were much less than in the otter trawl (Tables 10, 11, 12, 14 and 15).

Age 0 pollock first appeared in November at 12 cm and grew from 12 cm in March to 24 cm in November. The first two age groups made up the majority of the total catch (Figure 26). Pollock in spawning condition were captured only in early April (Table 26).

Rockfish

Rockfish composed a relatively minor portion of the catches, which is a little surprising since they are very common and in certain areas undoubtedly a major taxon. It is possible that the nearshore species of rockfish are not very susceptible to the sampling gear used.

Rockfish were 3.5% of the weight and 0.85% of the number caught in the trammel net, and 0.7% of the weight and 1.1% of the numbers caught in the gill net. The gill net catches were predominatly dusky rockfish with a few black rockfish while trammel net catches were predominatly black rockfish with a few dusky. The try net yielded only dusky rockfish while the otter trawl yielded darkblotched rockfish.

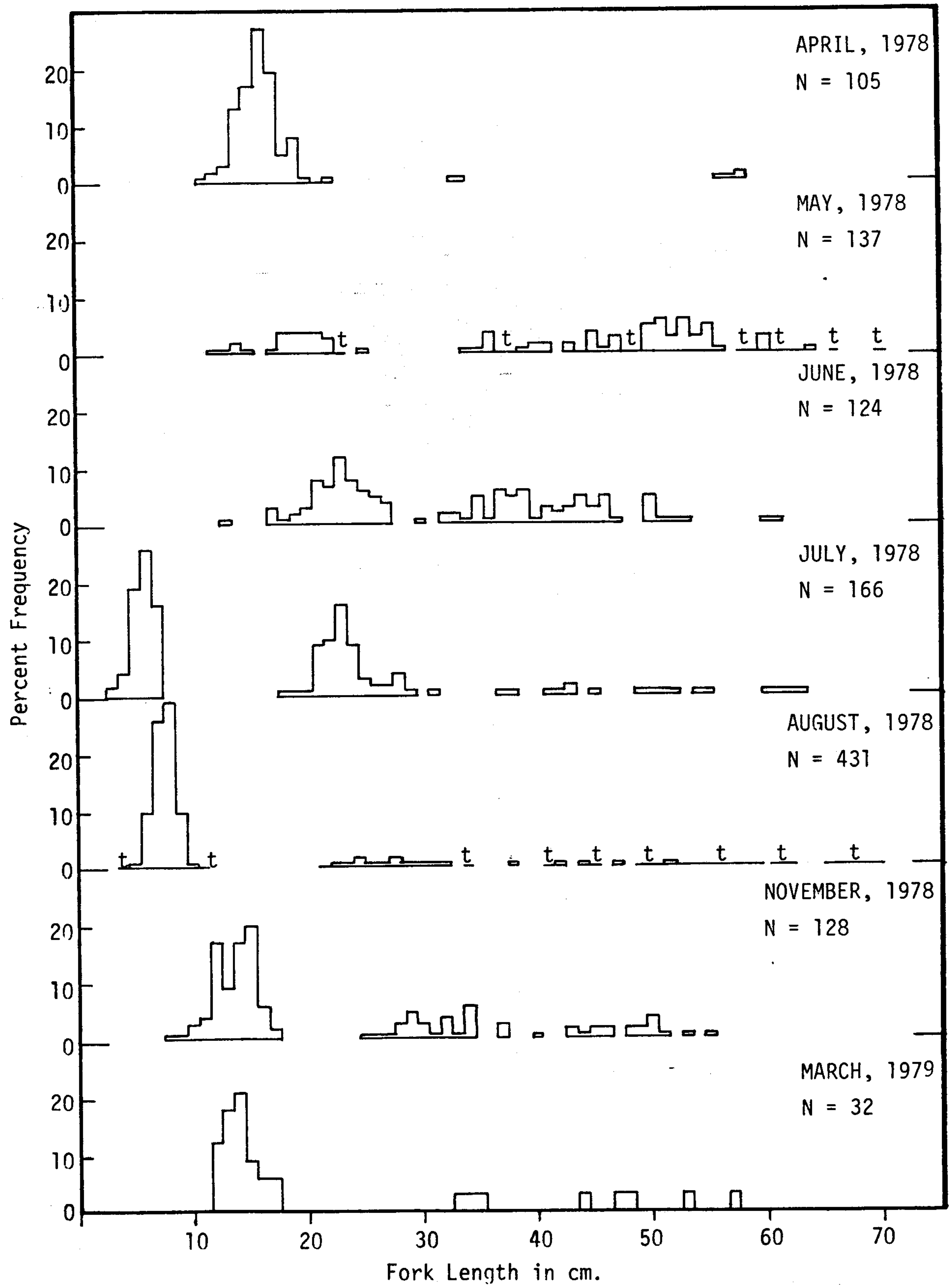

Figure 24. Relative length-frequency of Pacific cod by month of capture. The catch by all types of gear and all bays combined, April 1978 through March 1979 on the east side of Kodiak. t refers to trace amounts.

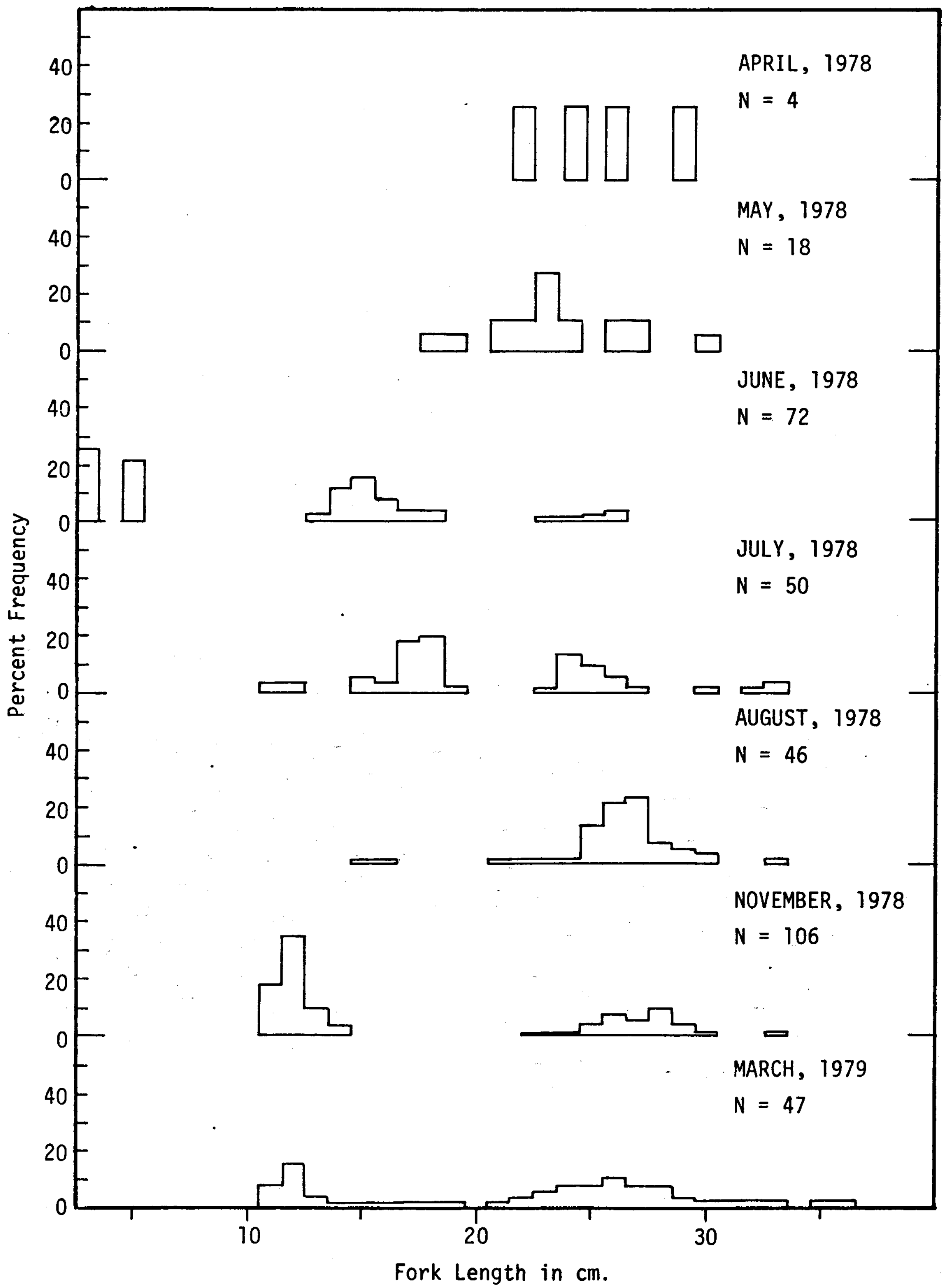

Figure 25. Relative length-frequency of Pacific tomcod by month of capture. The catch by all types of gear and all bays combined, April 1978 through March 1979 on the east side of Kodiak.

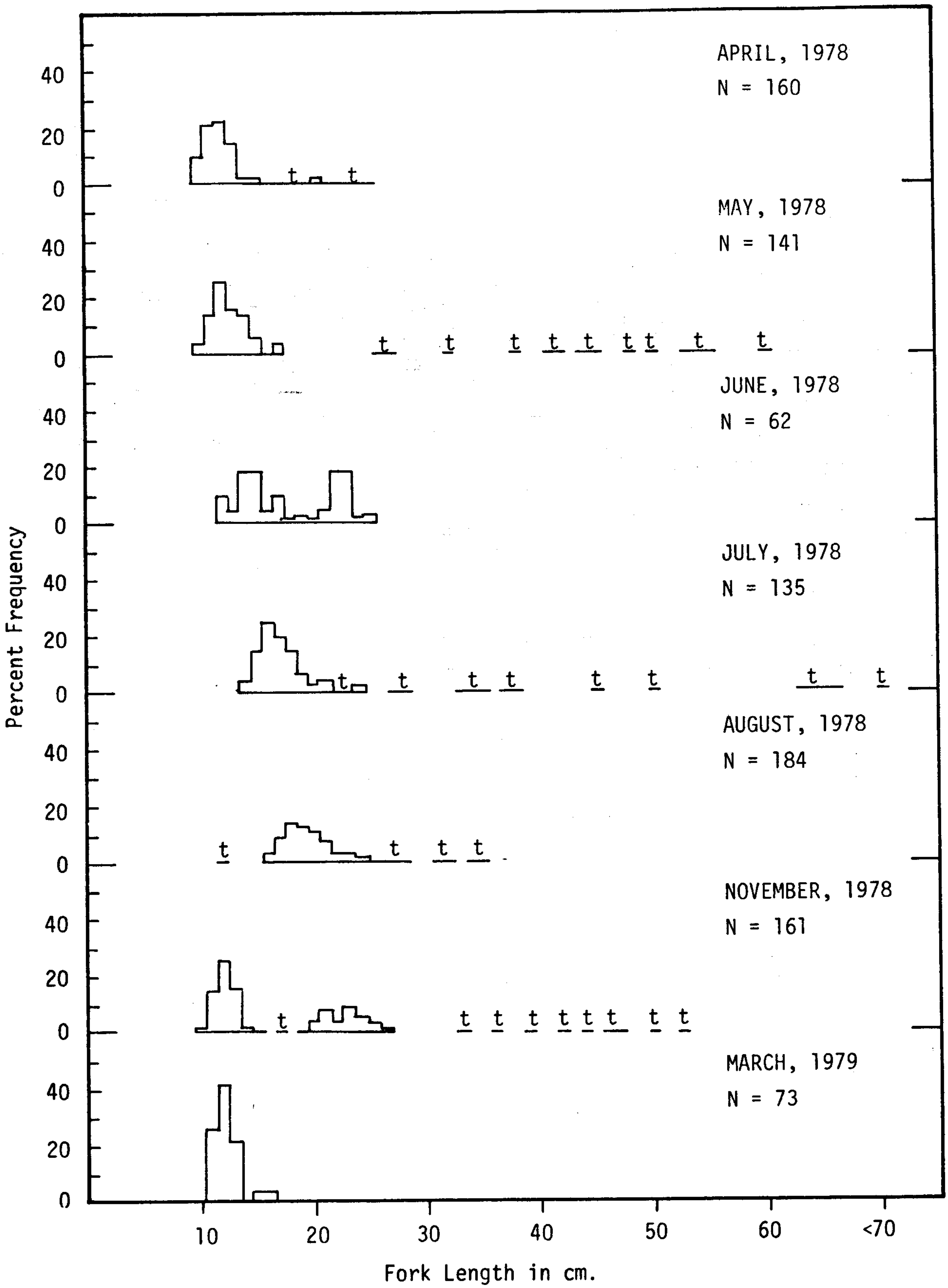

Figure 26. Relative length-frequency of walleye pollock by month of capture. The catch by all types of gear and all bays combined; April 1978 through March 1979 on the east side of Kodiak. t refers to trace amounts.

Rock Greenling

Rock greenling occurred in all cruises with greatest trammel net catches during May through August (Tables 3 and 5). They occurred in all bays with the greatest trammel net catches in Kaiugnak Bay and lowest in Kiliuda (Table 18).

Rock greenling with freely flowing sex products were observed during June, July and August. The greatest spawning activity apparently occurred from mid-June through mid-August (Table 26). They attained substantial spawning activity earlier than either the whitespotted or masked greenling.

Growth of rock greenling was similar to that of other greenling. Age 0 fish attained about 8-9 cm by July and 12 cm by November. Size of age 1 fish is not clear but a mode at about 19-20 cm in August could represent them (Figure 27).

Masked Greenling

Masked greenling distribution was more restricted than that of whitespotted greenling since only a trace was captured in the try net and otter trawl (Tables 14 and 15). Pelagic juveniles were not captured in the tow net, but they were captured in the beach seine. Masked greenling were captured in all four bays in large quantities on all cruises by beach seine and trammel net (Tables 16 and 18), and catches of it were greatest in July and August, while the lowest was in March (Tables 10 and 12).

Adults with flowing sex products were captured during June, July and August with greatest frequency in July and August (Table 26). The first such individuals were captured on June 19 and there was no detectable change in the frequency of ripe adults between early July and the end of August when summer sampling ended. The smallest mature fish was 17 cm. Fish smaller than about 15-17 cm were usually preserved whole by F.R.I. personnel for later food habit analysis rather than opened for removal of stomach and maturity determination.

The ovaries of both masked and rock greenling in early summer contained ova of several size classes throughout. Later the largest ova, about 2 to 2.5 mm diameter,were loose within the posterior portion of the ovary. The anterior portion of the ovary contained smaller ova of two size classes which varied in size between fish but were generally about 0.6 to 1.0 mm and 1.2 to 1.5 mm in diameter. Kovtun (1979) described several size modes among the ova of the greenling Pleurogrammus azonus and described three successive spawnings at 10 to 13 day intervals.

Growth of masked greenling was similar to that of whitespotted greenling, but masked were smaller at each age. Age 0 masked greenling

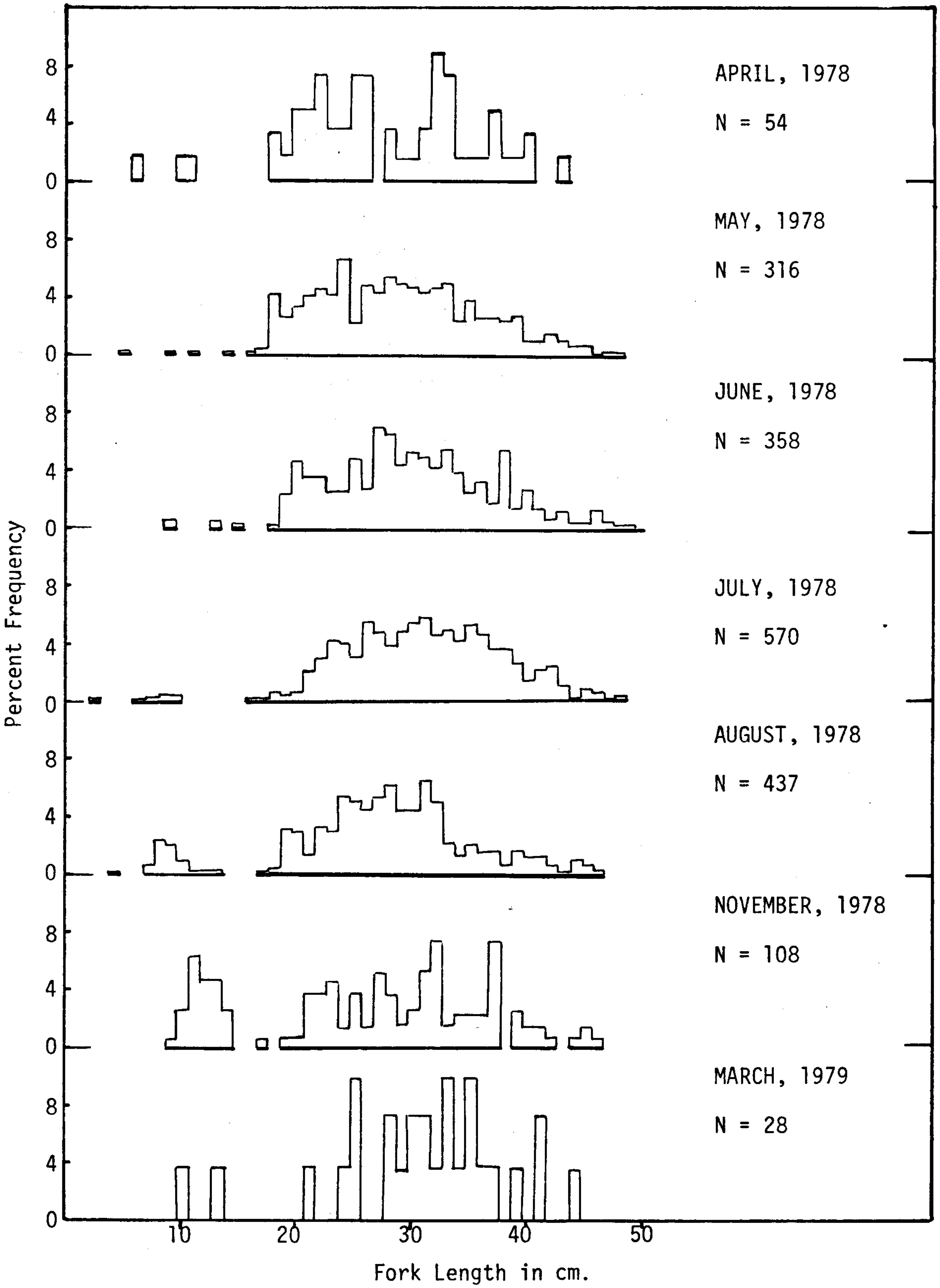

Figure 27. Relative length-frequency of rock greenling by month of capture. The catch by all types of gear and all bays combined, April 1978 through March 1979 on the east side of Kodiak.

were about 5 cm or so in June. The mode of age 1 fish is not separate from larger fish after June but could be interpreted as being 17-18 cm in August (Figure 28).

Whitespotted Greenling

Whitespotted greenling were common in all gear types (Table 3, 4 and 5). Whitespotted greenling catches were lowest in November, March and April and highest in July and August (Tables 10, 11 and 12). Trawling conducted in 1976 and 1977 at depths of 30 to 100 m indicated a high relative abundance of whitespotted greenling in winter (Blackburn, 1979). This information and the data collected in this survey suggest that these greenling undergo a winter migration to deeper water.

Whitespotted greenling of both sexes were observed in spawing condition, with freely flowing sex products, during June, July and August, but they were much more common in August, especially the last half of August. The first individual in spawning condition was captured June 12 and five more were taken June 22 (Table 26).

The smallest individual in spawning condition was 17.3 cm in length but most were over 20 cm. Comparison of length frequencies of running ripe fish with the population length frequency indicates they apparently mature at age 2.

Juvenile whitespotted greenling, less than one year of age, are pelagic in the spring, until about July. They have coloration which is unlike either the larval or juvenile stage. About July, when they are about 6 to 8 cm, they metamorphose to a juvenile form, take up bottom residence and their diet changes (Blackburn et al., 1979).

Age 0 whitespotted greenling grew from about 5 cm in May to 10 to 15 cm in November (Figure 29). Growth of age 1 fish is not as apparent, but it appears that most are about 20 cm by August.

Sablefish

Sablefish occurred from April through November in the otter trawl and try net, with greatest catch in June (Tables 14 and 15). The majority of the sablefish were caught in the mouth of Izhut and Kiliuda Bays by the otter trawl. The try net yielded one in Kiliuda Bay.

Growth of sablefish is quite clear from the length data but difficult to reconcile with published information. From the first catch in April to the last catch in November the predominant age class grew from 26.6 cm to 37.1 cm and averaged 1.49 cm per month (Figure 30). A length frequency of this same age class was obtained in March 1979 from the commercial fishery by a domestic groundfish observer project funded by the North Pacific Fishery Management Council. These fish

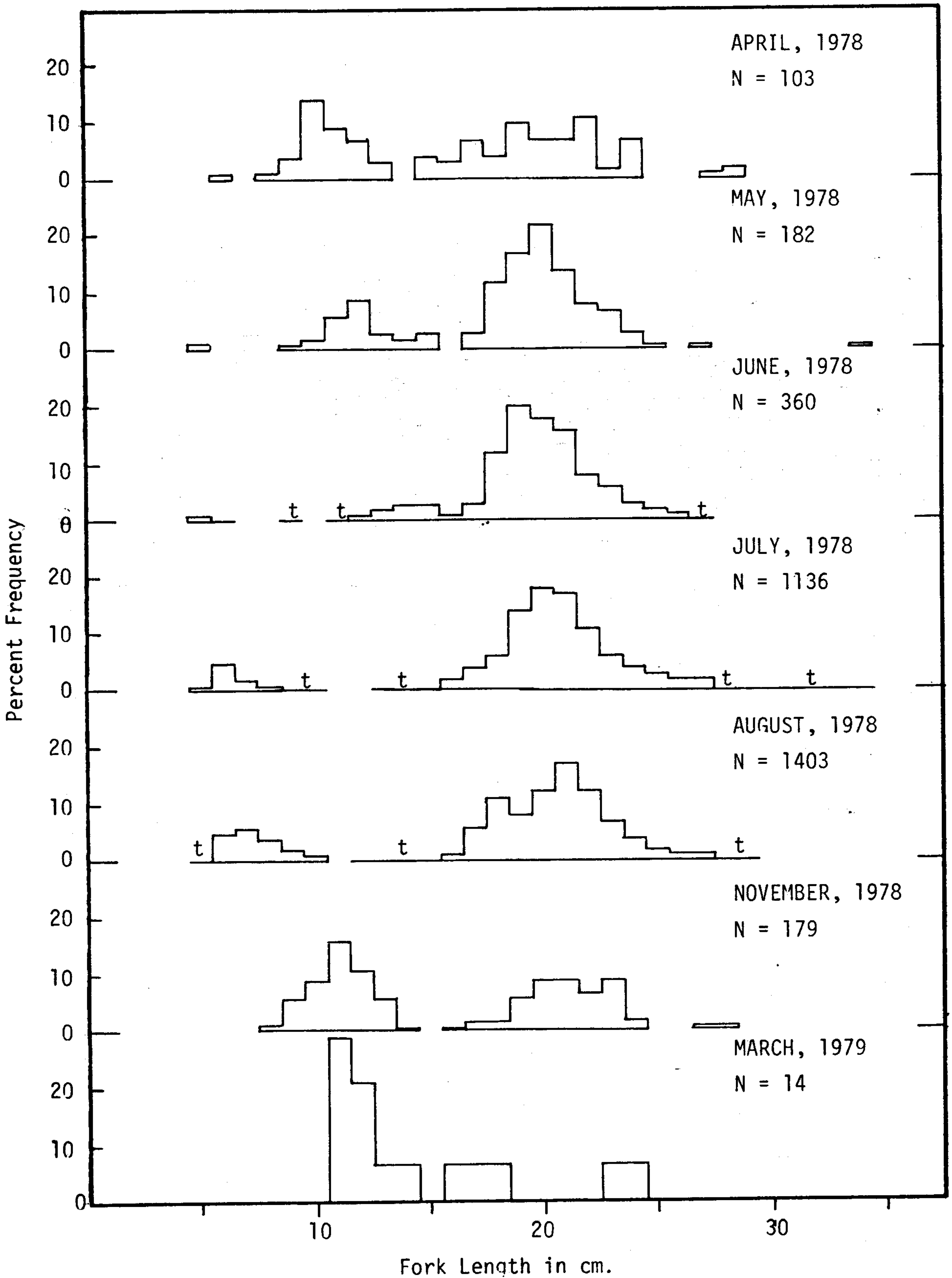

Figure 28. Relative length-frequency of masked greenling by month of capture. The catch by all types of gear and all bays combined, April 1978 through March 1979 on the east side of Kodiak.

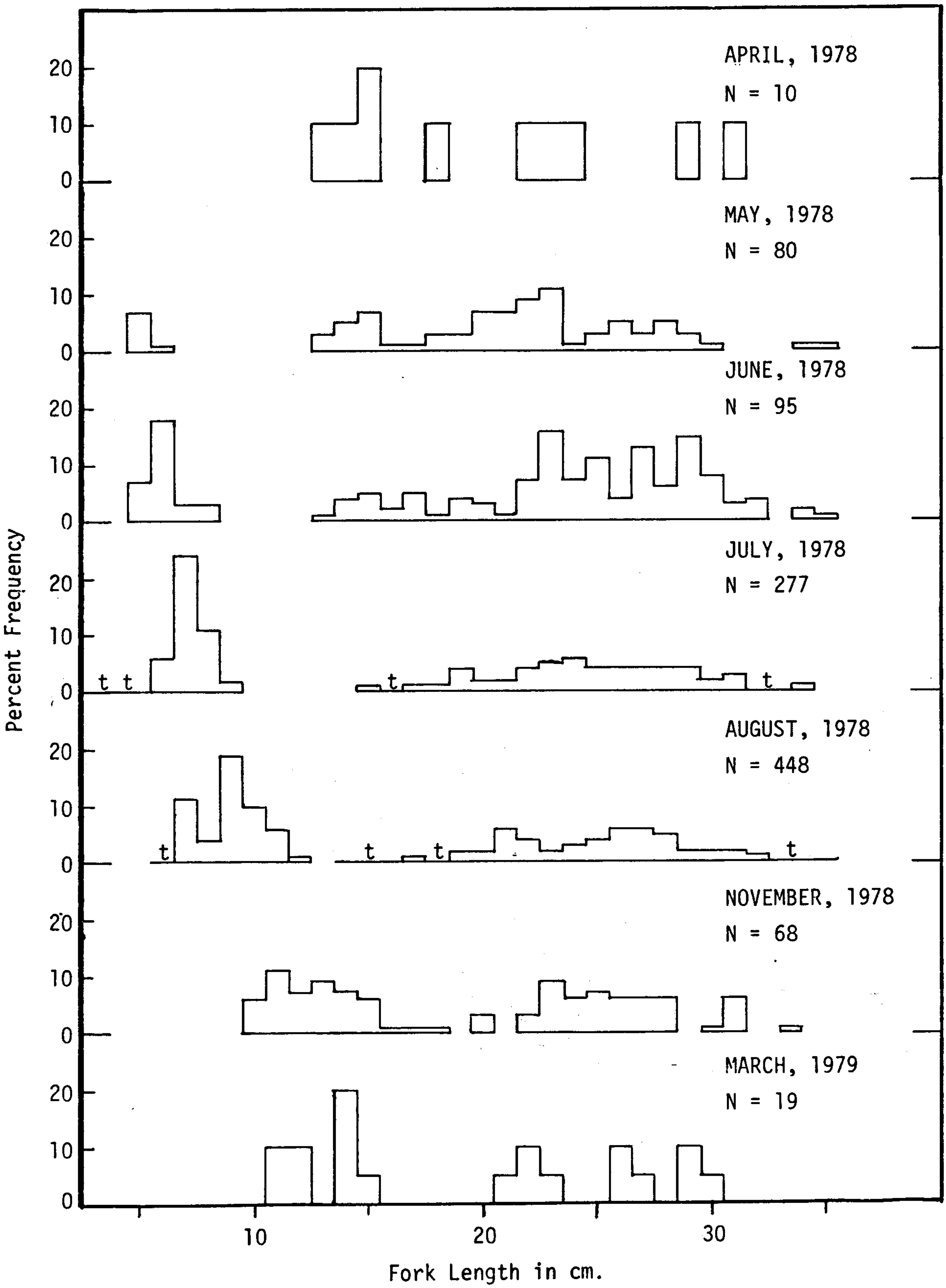

Figure 29. Relative length-frequency of whitespotted greenling by month of capture. The catch by all types of gear and all bays combined, April 1978 through March 1979 on the east side of Kodiak. t refers to trace amounts.

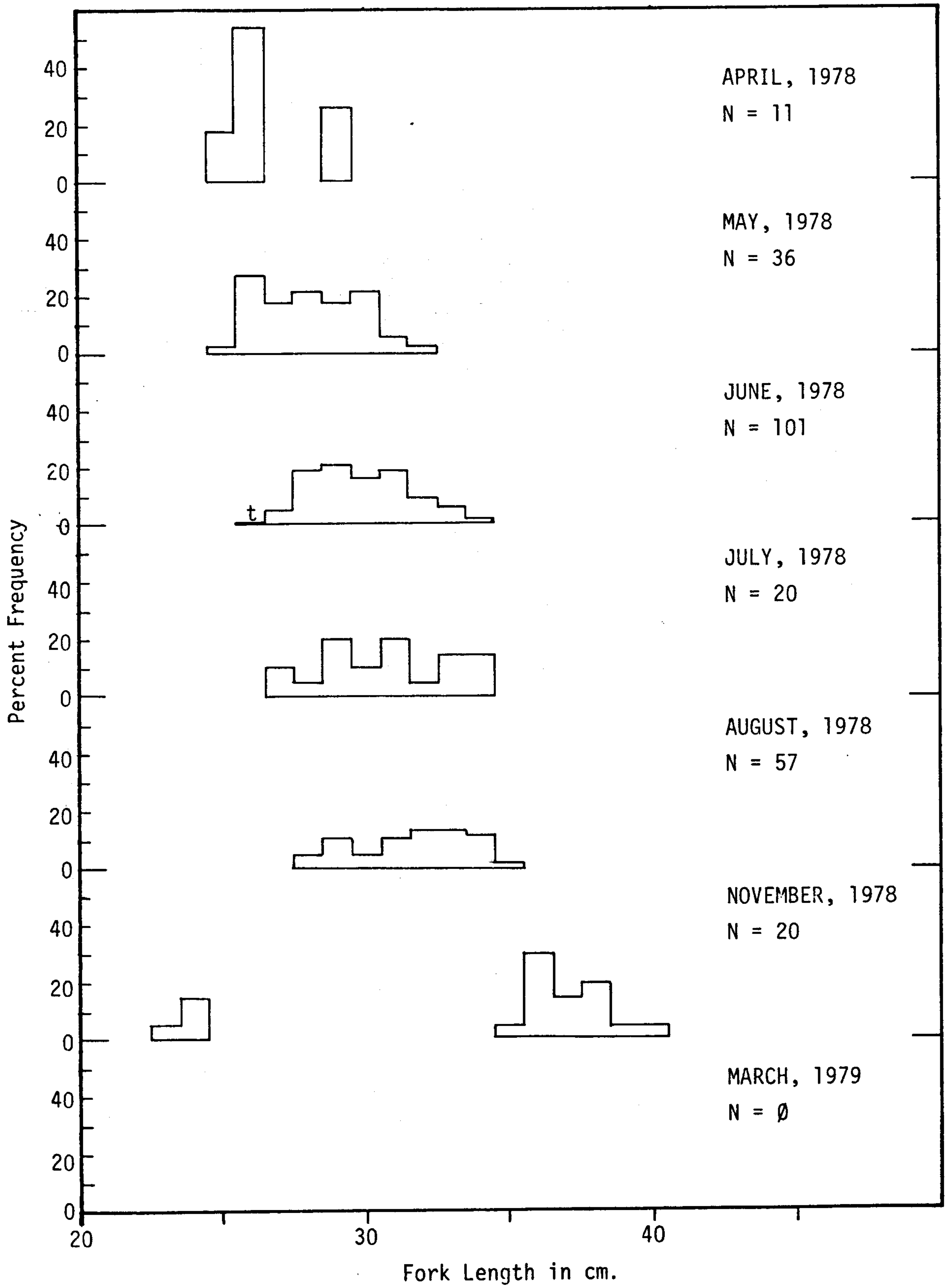

Figure 30. Relative length-frequency of sablefish by month of capture. The catch by all types of gear and all bays combined, April 1978 through March 1979 on the east side of Kodiak. t refers to trace amounts.

were 43.7 cm (93 fish) for a growth rate of 1.65 cm/month from November. The growth is remarkably consistent, about 1.55 cm/month, even through the winter, a time when many fish species grow more slowly or stop growing competely. Four individuals of a younger age class appeared in November at 23.8 cm, which is about 3.3 cm larger than the main age class would have been in November, assuming constant growth.

Placing an age on these sablefish is difficult from published information. Low and Marasco (1979) provide size at age information for Gulf of Alaska blackcod, which indicates age 1 fish are 34 cm, age 2 are 42 cm and age 3 are 49 cm. By assuming a constant growth rate of 1.55 cm per month from hatching until they are 26.6 cm in April 1978, the birthdate is about December 1976. The growth rate is probably more rapid during the first year and mid-winter is known to be the spawning time. Thus the main age class captured was probably age 1.

Gymnocanthus

Sculpins of the genus Gymnocanthus were common in all gear that sampled demersal species.

When the two taxa were separated the threaded sculpin was about 3 to 7 times more abundant than the armorhead sculpin in the try net samples,and the otter trawl samples contained exclusively armorhead sculpin, except in March,when threaded sculpin were deeper and yielded a CPUE OF 0.4 kg per km.

Three male threaded sculpin of 16 to 20 cm fork length were found to have freely flowing sex products in March, which constitutes the only indication of spawning time (Table 26). Larvae of Gymnocanthus were abundant during about late April through early June following which time considerable numbers of juveniles were captured. Juveniles were 2 to 3 cm in June, and 3 to 6 cm, with a mode of 4 to 5 cm in August. Another size mode, obviously one year olds, was 7 to 9 cm in June and 9-11 cm in August. Some of the one year olds were identified and armorhead sculpin apparently reached a larger size. The bulk of the adult armorhead sculpins were greater than 23 cm in fork length and the bulk of the adult threaded sculpins were less than 21 cm.

Yellow Irish Lord

The otter trawl and try net catches of Yellow Irish Lords were considerably greater in Kiliuda and Kaiugnak Bays (Tables 20 and 21).

Male yellow Irish Lords of 29 to 34 cm fork length with freely flowing sex products were recorded in June and August (Table 26). Gorbunova (1964) reports that Hemilepidotine sculpins spawn at the end of summer, August and September, throughout their range, although spring and early summer spawning has been reported. Larvae appear in November and December (Gorbunova, 1964) and, as noted above,larvae or early juveniles appeared in June at about 3 cm and grew to 6 to 8 cm by November. A mode of yearlings at about 8 to 9 cm in April grew to about 11 to 13 cm by August.

The greatest catches in shallow water occurred during June through August with the beach seine and try net catches greatest in August. This suggests that they spawn in shallow water at this time,and Gorbunova (1964) reports that the group generally spawns in 10 to 20 m of water.

Otter trawl catches of this species were much greater in summer (Table 15) suggesting that seasonal migration to deeper water in winter took them out of the depths sampled.

Myoxocephalus spp.

Several taxa of Myoxocephalus spp. sculpins were identified and, at times, separately enumerated;but the identifications appear inconsistent,so all identifications have been reduced to the generic level. The prominent species of this taxon are the great sculpin, plain sculpin and to a lesser extent the warthead sculpin. Only a couple individuals of a fourth, unidentified taxon occurred.

Distribution trends are not pronounced but Izhut tended to have the lowest apparent abundance (Tables 15, 18, 20 and 21).

Seasonally low abundance occurred during March and April in all gear types (Tables 10, 12,14 and 15). High abundance occurred during May through August. The period of high abundance was shortest in the shallowest gear; beach seine catches were greatest during June through August. The period of higher abundance in the trammel net, try net and otter trawl included May and November, with the greatest catch in the otter trawl in May (Table 15).

The stage of maturity data does not clearly indicate spawning season (Table 26) but larvae occurred in April, May and June (Appendix Table 1) and transformed to age 0 juveniles in early summer. The beach seine captured age 0 Myoxocephalus that grew from 2 cm in May to 3 to 5 cm in August, and about 5 to 7 cm in March. The other gear captured larger fish (Figure 31).

Pacific Sand Lance

Pacific sand lance are a pelagic species which aggregate highly so that catch variability is extremely large. The larvae were too small to be quantitatively retained by the net in the early summer; they were 2 to 5 cm in May. They grew rapidly; most were 7 to 10 cm in August and were recruited to the samples during the summer. Age 1 sand lance appeared to grow from 9 to 10 cm in April to about 13 cm in November (Figure 32).

The beach seine catch was greatest in July and August, especially August, while the tow net catch was greatest in July (Tables 10 and 13).

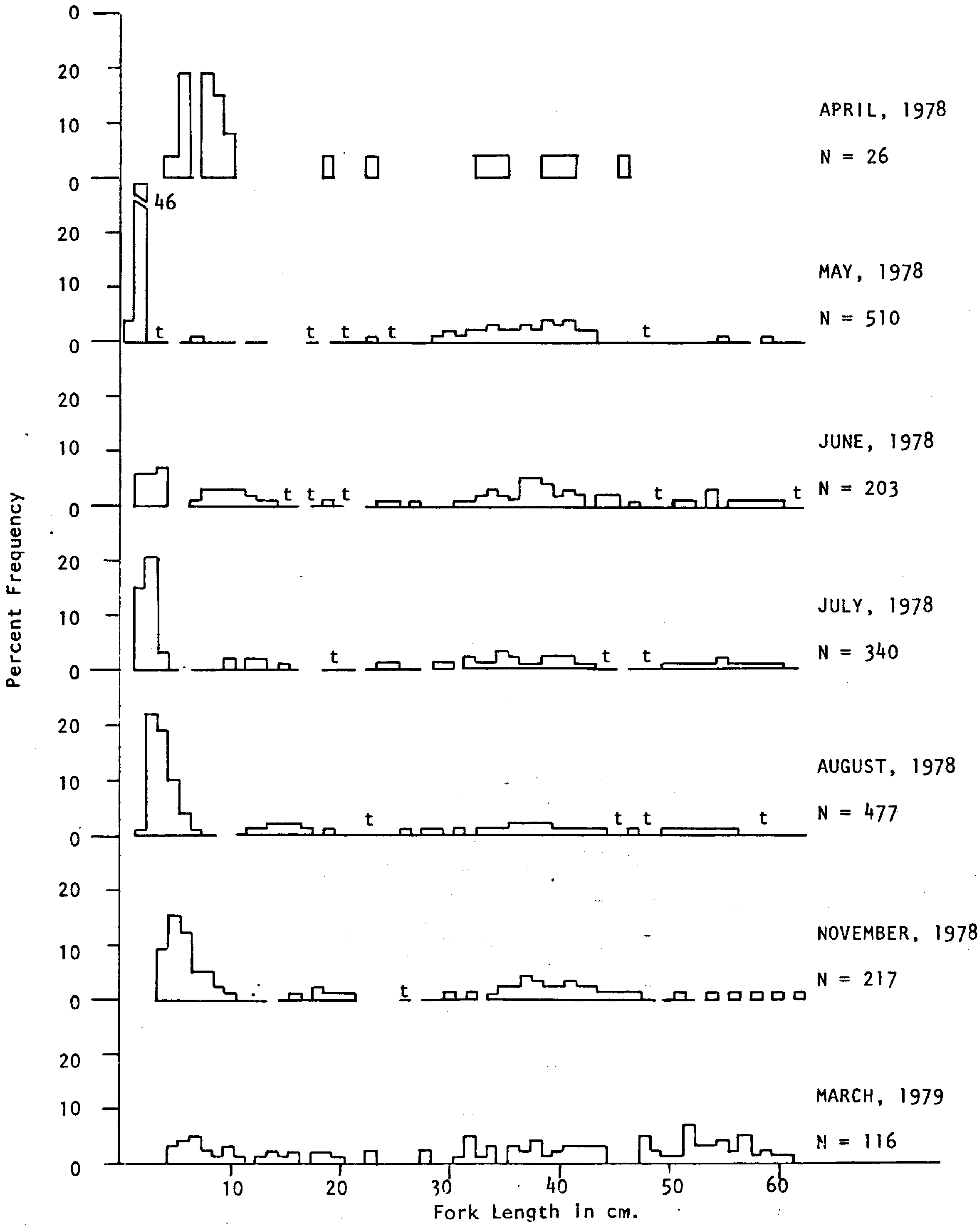

Figure 31. Relative length-frequency of Myoxocephalus spp. by month of capture. The catch by all types of gear and all bays combined, April 1978 through March 1979 on the east side of Kodiak. t refers to trace amounts.

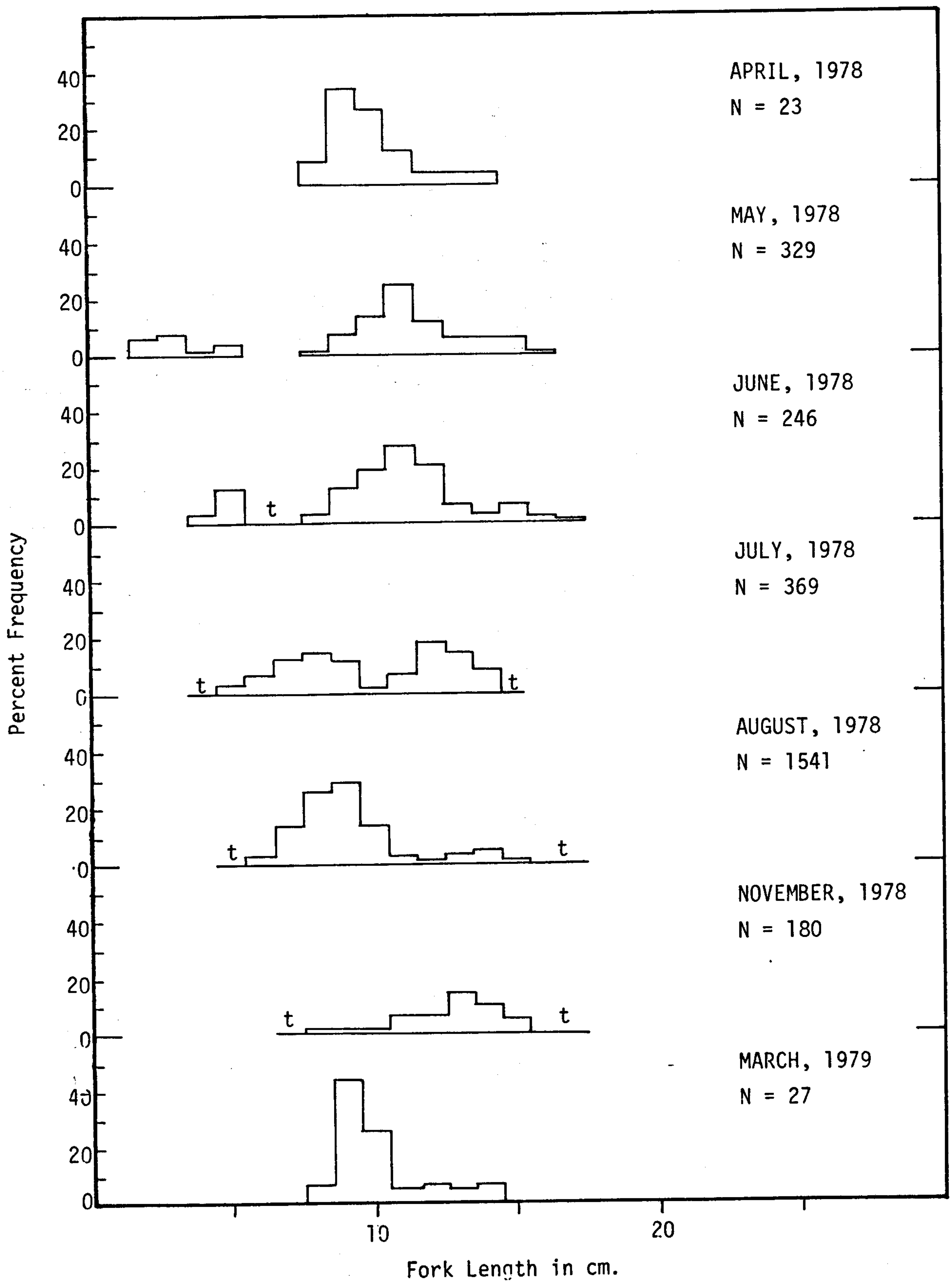

Figure 32. Relative length-frequency of Pacific sand lance by month of capture. The catch by all types of gear and all bays combined, April 1978 through March 1979 on the east side of Kodiak. t refers to trace amounts.

Table 27. Beach seine catch of sand lance in numbers of fish per haul by cm size class and month and by age class. Data from east side of Kodiak, 1978-79.

LENGTH CM	APRIL	MAY	JUNE	JULY	AUGUST	NOVEMBER	MARCH
4			1.6	0.1			
5			1.7	0.4	0.2		
6			0.2	2.4	62		
7			0.1	3.1	339	T[1]	
8	T	0.1	0.1	6.0	513	T	T
9	0.2	0.5	1.8	17.8	577	0.1	0.2
10	0.2	4.3	9.1	6.0	344	0.1	0.1
11	0.1	13.5	10.9	20.6	60	0.2	
12		8.6	9.9	102	8.4	0.2	T
13		3.0	2.5	95	29.5	0.7	T
14	T	3.6	1.0	60	30.1	0.6	T
15		2.8	3.3	0.2	2.2	0.2	
16		0.7	0.9		T	T	
17			0.1		T	T	
Age 0	T	0	3.7	29.2	1896	0.3	0
Age 1[2]	0.4	28.5	34.8	283	70	1.8	0.4
Age 2+	T	8.1	4.8	0.1	0.1	T	0.1

[1] T = less than 0.05 per haul
[2] Birthday is considered to be January 1

Month to month differences in abundance were extremely high and appear to be best explained by mid-summer recruitment of age 0 fish to the samples, movement to inshore areas during late summer and probable winter residence in refuge (buried in sand as protection from predation).

Recruitment of sand lance to the catches is a natural result of growth and is assumed to be complete by a size of 5 cm. The influx of age 0 sand lance in the beach seine catches was fairly uniform over the range of 5 to 11 cm and was greatest in August (Table 27). If the late summer increase in sand lance was exclusively due to recruitment, the influx would tend to be in all months over a small range of sizes. An inshore migration of age 0 sand lance began in July and was more apparent in August.

An increase in the abundance of age 1 sand lance from April to May and June is quite apparent in Table 27 and a considerably greater abundance occurred in July. This may also represent an inshore migration, but is considerably earlier than that of the age 0 sand lance.

The catch distribution suggests extreme inshore occurrence in August as the inner most regions of the bays yielded the greatest catches in both the tow net and beach seine (Tables 16 and 19; Appendix Tables)

Adult sand lance with freely flowing sex products were observed in August and November (Table 26). Larval sand lance were captured in April and May (Appendix Table 2).

Winter distribution patterns are not clear, but it is the authors belief they spend much of the winter buried in sand. The growth rate during winter is minimal and sand lance are commonly found in intertidal sand during winter. During spring the catches were frequently single fish which is unusual for a schooling species.

Arrowtooth Flounder

Arrowtooth flounder were slightly more prevalent in the northern bays. Izhut and Kalsin Bays had the greatest catches, Kiliuda had a smaller catch whereas none was captured in Kaiugnak (Tables 20 and 21). Seasonal trends in catch rates include highest try net catches in summer and highest otter trawl catches in May and November (Tables 14 and 15). The try net catches were almost exclusively age 0 and 1 fish. The large May catch in the otter trawl included a lot of age 2 fish while the August and November catches included large numbers of age 1 fish. Apparently, the low otter trawl catch rates in June and July were due to the depth stratification,with older fish deeper;and during this time the depth trawled fell between the depths occupied by age 1 and age 2 fish which may have moved deeper as they grew.

The length-frequency histograms (Figure 33) clearly illustrate the first two years of the arrowtooth flounder. Age 0 fish grew from 6 cm in August to about 9 cm in November. Age 1 arrowtooth flounder were 12 cm in March and grew to 19 cm in November. Age 2 were 19 cm in March and grew to 25 cm in August, and greater ages cannot be assigned based on length frequency.

Flathead Sole

Relative abundance of flathead sole was greatest during June through August and least in March and April, a reflection of the seasonal migration to shallower water in summer (Tables 14 and 15). There appears to be no demonstrable differences in catch rates between bays or regions of bays.

The length-frequency histograms (figure 34) indicate that most of the flathead sole were juveniles of less than 20 cm. Growth is not clear from length-frequency data (Figure 34). Weak length modes at 7 to 8 cm and 11 cm in April appear to be successive age classes, with the 11-cm-mode progressing to about 14 to 15 cm in August and November. Flathead sole in spawning condition were captured in May, June, July, August and November (Table 26).

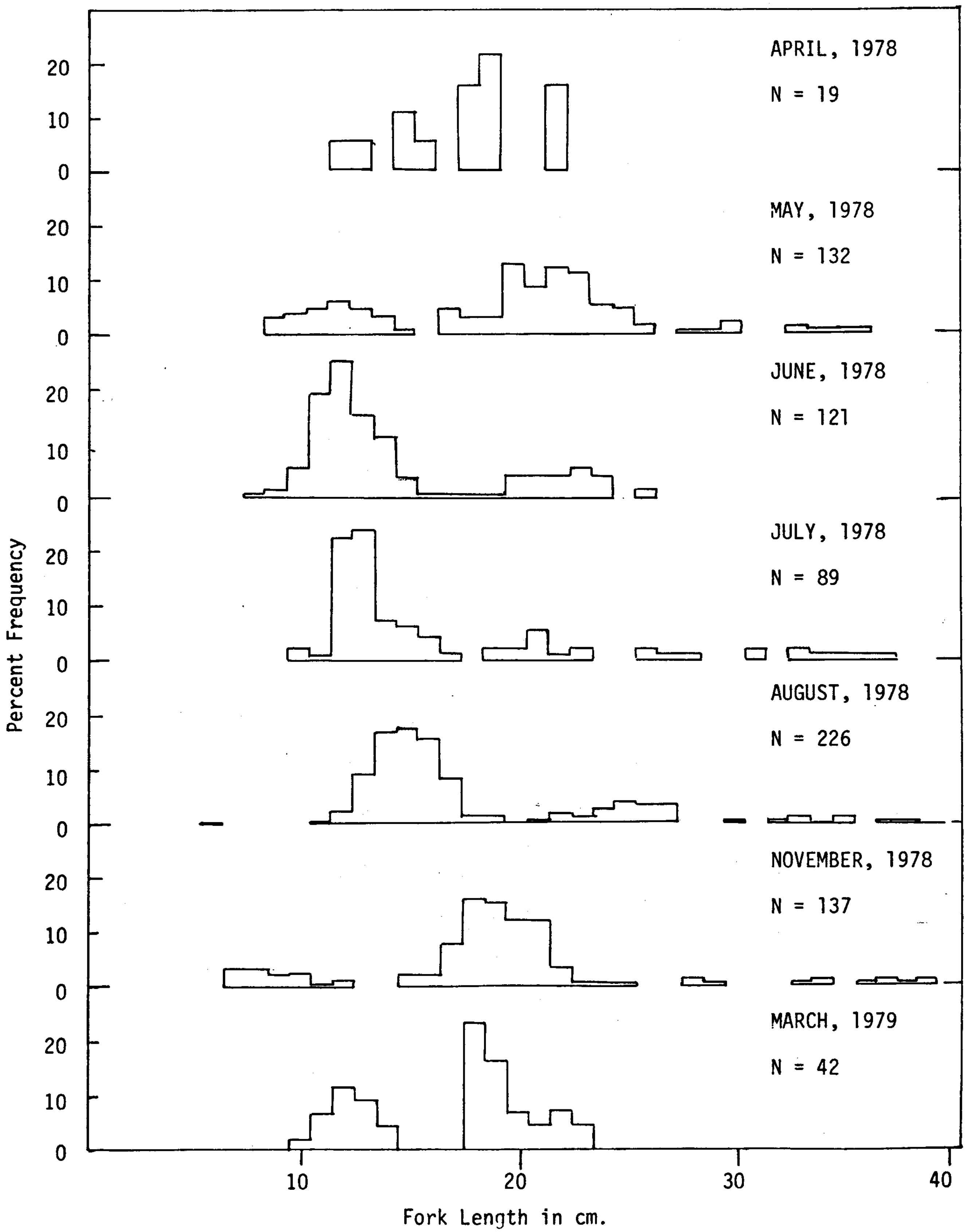

Figure 33. Relative length-frequency of arrowtooth flounder by month of capture. The catch by all types of gear and all bays combined, April 1978 through March 1979 on the east side of Kodiak.

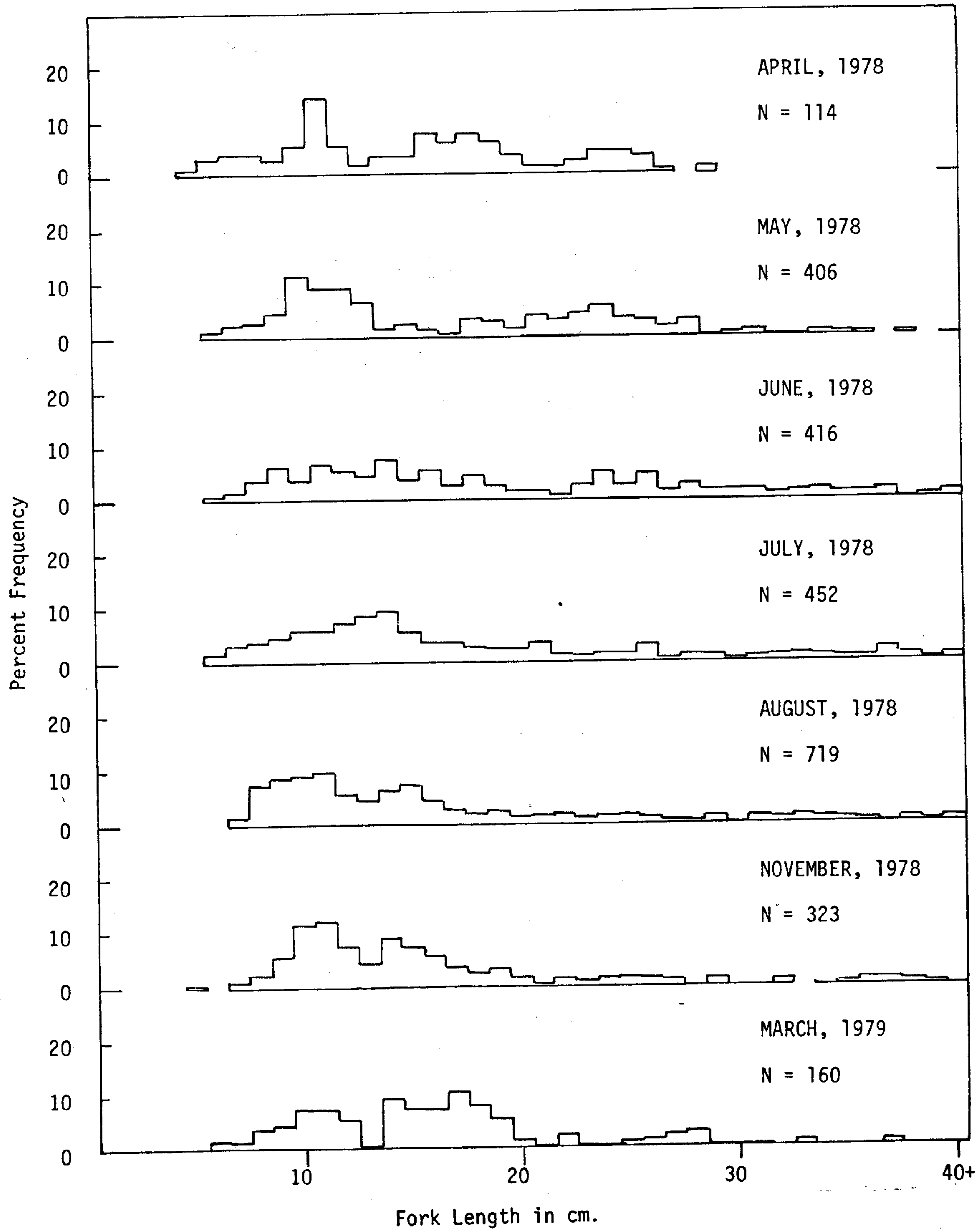

Figure 34. Relative length-frequency of flathead sole by month of capture. The catch by all types of gear and all bays combined, April 1978 through March 1979 on the east side of Kodiak.

Butter Sole

The try net catches displayed a distinct seasonal peak abundance during June through August, decreasing in November (Table 14). The otter trawl catches fluctuated widely with greatest catches during May and November (Table 15), as fish were moving into and out of the shallower try net depths. This species apparently resides in shallow water in summer and at depths greater than those sampled by the otter trawl during winter.

The catches of butter sole did not display strong differences between bays but were slightly greater in Kiliuda Bay in both try net and otter trawl than in any other bay (Tables 20 and 21). Try net catches of butter sole displayed strong distributional features within bays, with largest catches at the mouth of each bay, and catches decreased within the bay to smallest in the innermost subareas (Appendix Tables). No butter sole were captured in Kaiugnak Bay but try netting was only conducted in the inner region.

All sizes of butter sole from 7 to 39 cm were captured. Although the length data do not distinctly show growth by a progression of modes through time, there are 3 strong modes in July suggestive of age 1 fish at 13 cm, age 2 at 20-21 cm and age 3 at about 25 cm (Figure 35). One butter sole was captured in spawning condition in early May (Table 26).

Rock Sole

Rock sole were widely distributed in all bays, but the greatest catch was in Izhut Bay by the try net and otter trawls (Tables 20 and 21). Higher catches were obtained in the summer and lower catches in the winter with all types of gear, indicative of summer migration inshore (Tables 14 and 15).

The length frequency data provided some insight into the growth of young rock sole. Age 1 rock sole were about 6 cm in March and by November they grew to about 10 cm. Greater ages cannot be assigned based on length frequency (Figure 36). Rock sole judged to be in spawning condition were captured in May, June, July, August and November (Table 26).

Yellowfin Sole

Seasonality of yellowfin sole was evident in greater shallow water catches (try net and trammel net) in the summer, but the otter trawl catches, though somewhat seasonally variable, cannot be interpreted (Tables 12, 14 and 15). Yellowfin sole were observed in all bays, but maximum catches by the trammel and try nets were in Kalsin Bay and second highest catches were in Kiliuda Bay (Tables 18 and 20).

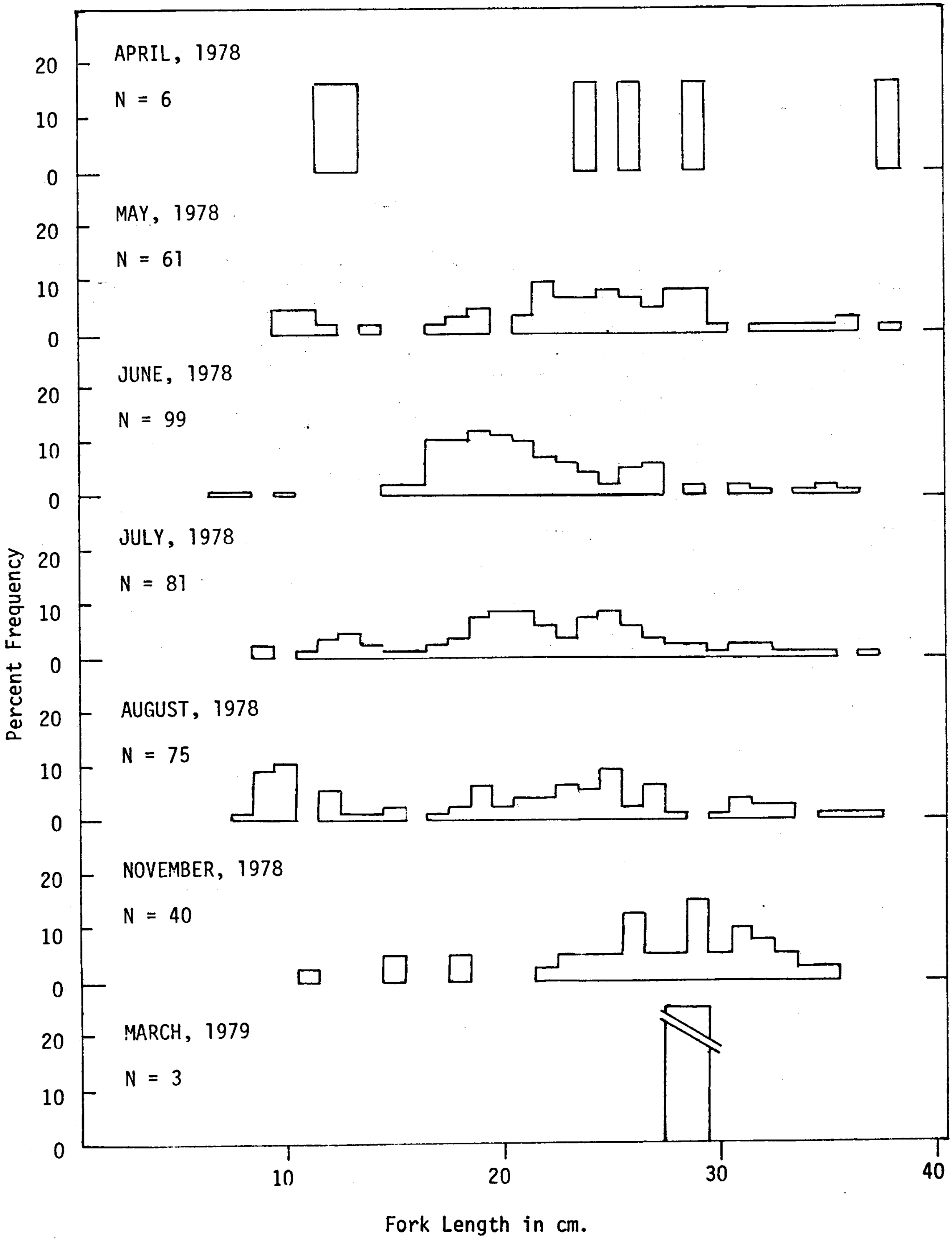

Figure 35. Relative length-frequency of butter sole by month of capture. The catch by all types of gear and all bays combined, April 1978 through March 1979 on the east side of Kodiak.

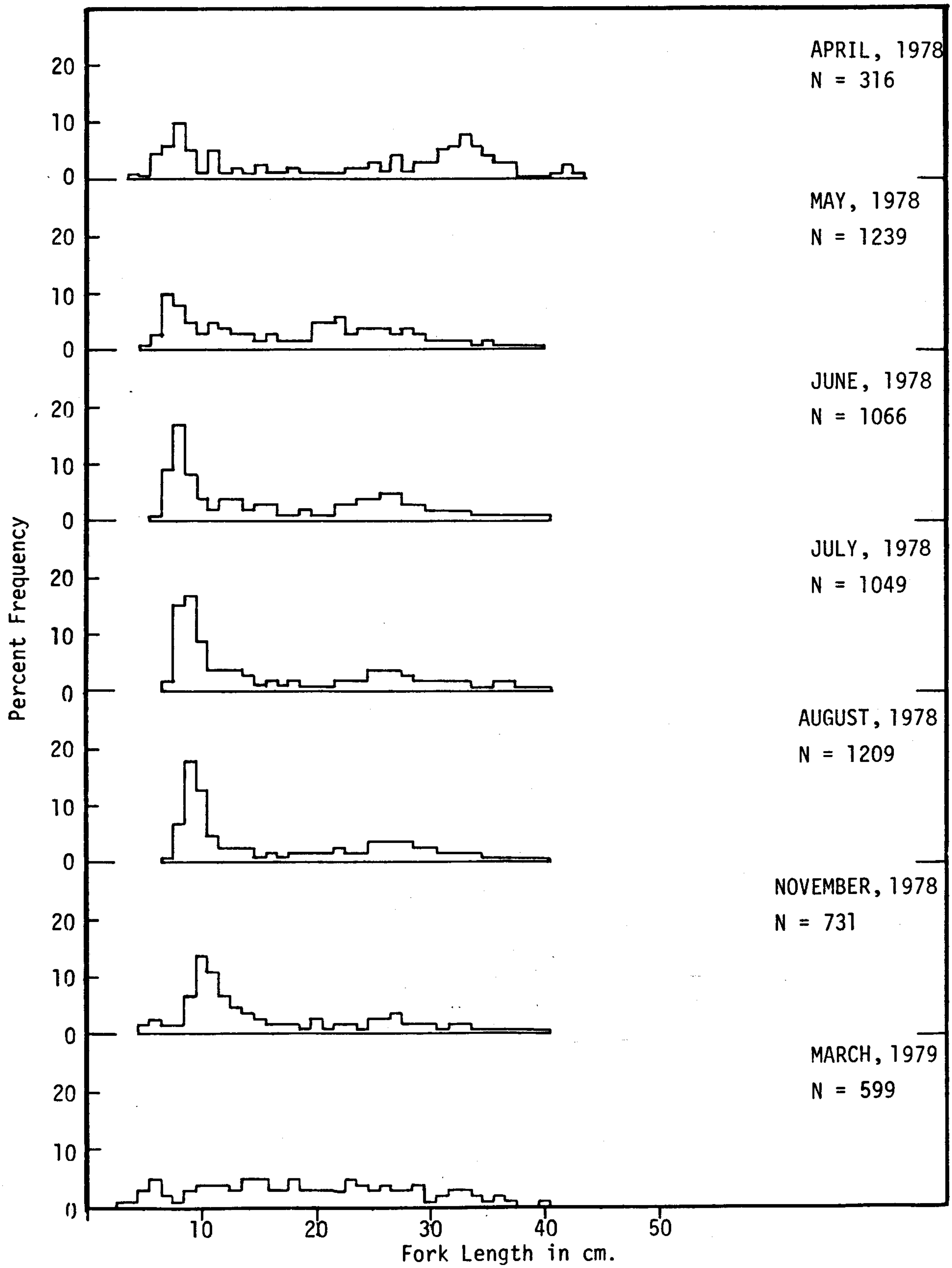

Figure 36. Relative length-frequency of rock sole by month of capture. The catch by all types of gear and all bays combined, April 1978 through March 1979 on the east side of Kodiak.

Growth of young yellowfin sole was evident from the length frequency data. The smallest fish, which are assumed to be age 1, were 4 to 5 cm in April and grew to about 8 to 9 cm by November. The age 2 fish grew to about 12 to 13 cm by August. The size at greater age cannot be interpreted from larger fish (Figure 37). Yellowfin sole judged to be in spawning condition were captured in May, June, July August and November (Table 26).

Starry Flounder

Starry flounder were encountered in all months and bays, although differences in catch between bays were small and not consistent in different gear (Tables 14, 15, 20 and 21). There were consistently higher beach seine catches in some locations near river mouths. A weak trend towards seasonality was apparent, with greatest beach seine and gill net catches during mid-summer, while greatest try net and otter trawl catches were in early summer and fall (Tables 10,11, 13 and 14).

Sizes captured ranged from 6 to 60 cm and were evenly spread within those extremes so that growth information is very weak. The length frequency data (not presented because no size modes are present) could be interpreted to indicate growth of about 6 to 7 cm per year in the first 3 years so that November sizes are 6 - 7 cm at age 0, 13 cm at age 1 and 20 cm at age 2. Starry flounder in spawning condition were not captured (Table 26).

Pacific Halibut

The otter trawl and try net captured halibut throughout the year and in all four bays. The Pacific halibut displayed a very weak tendency towards a seasonal migration with greater abundance in the summer (Tables 10, 12, 14 and 15), the season when they are considered to be farthest inshore.

The length-frequency data show a vague picture of the first three years of the halibut. The mean length for age 1 fish in August was 7 cm and in November 10 cm. In March the age 2 fish averaged 12 cm and by November increased to 20 cm. The third age class was difficult to separate from older age classes, but apparently grew from 23 cm in March to 32 cm in November (Figure 38)). This growth rate corresponds to the published growth information (Southward, 1967).

Water Surface Temperature

The water surface temperature ranged from 1.4 C in early March to 16.7 C in early August (Figure 39). Considerable variation occurred over relatively short time periods due to the wide range of areas sampled, from open water to shallow protected areas to near river mouths.

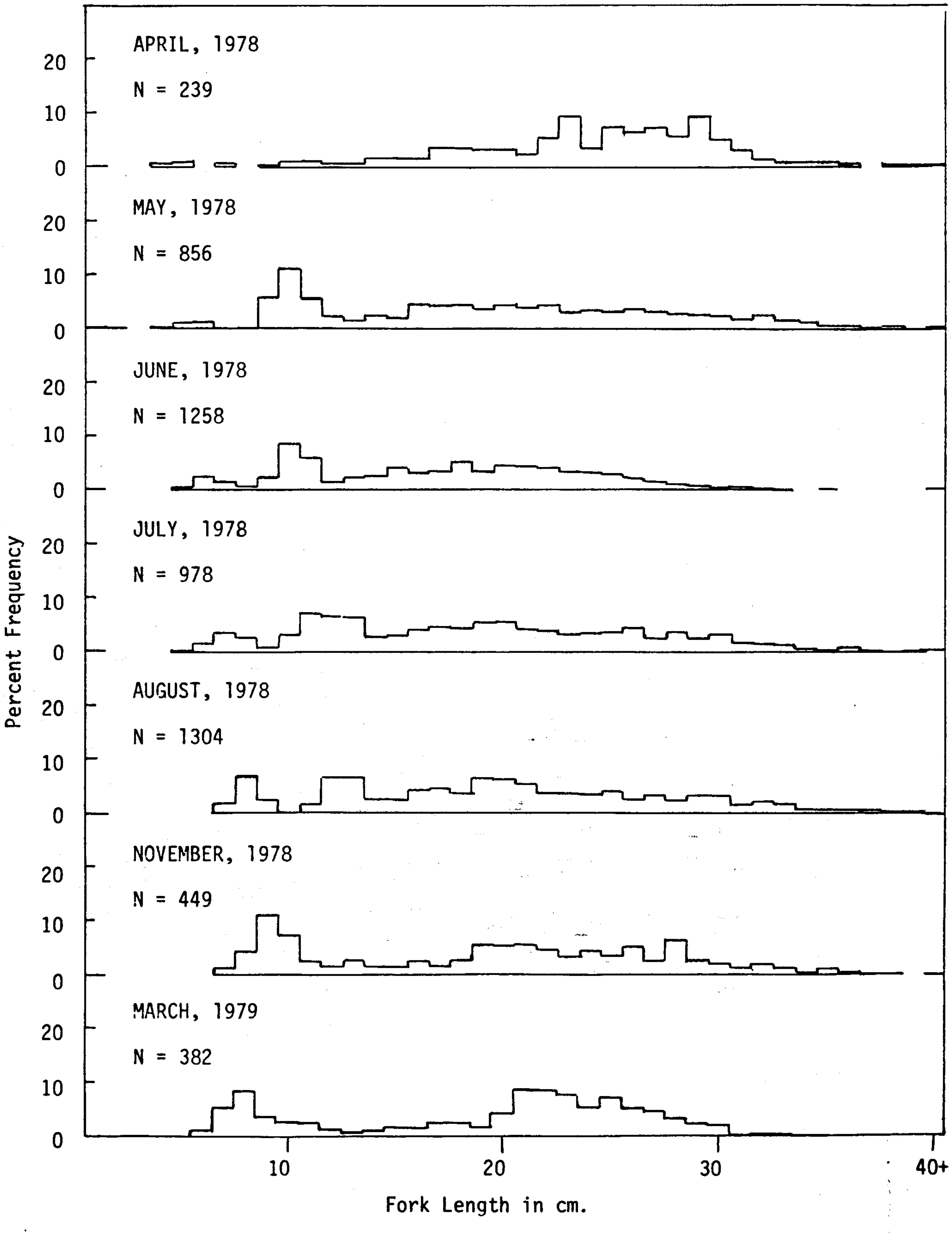

Figure 37. Relative length-frequency of yellowfin sole by month of capture. The catch by all types of gear and all bays combined, April 1978 through March 1979 on the east side of Kodiak.

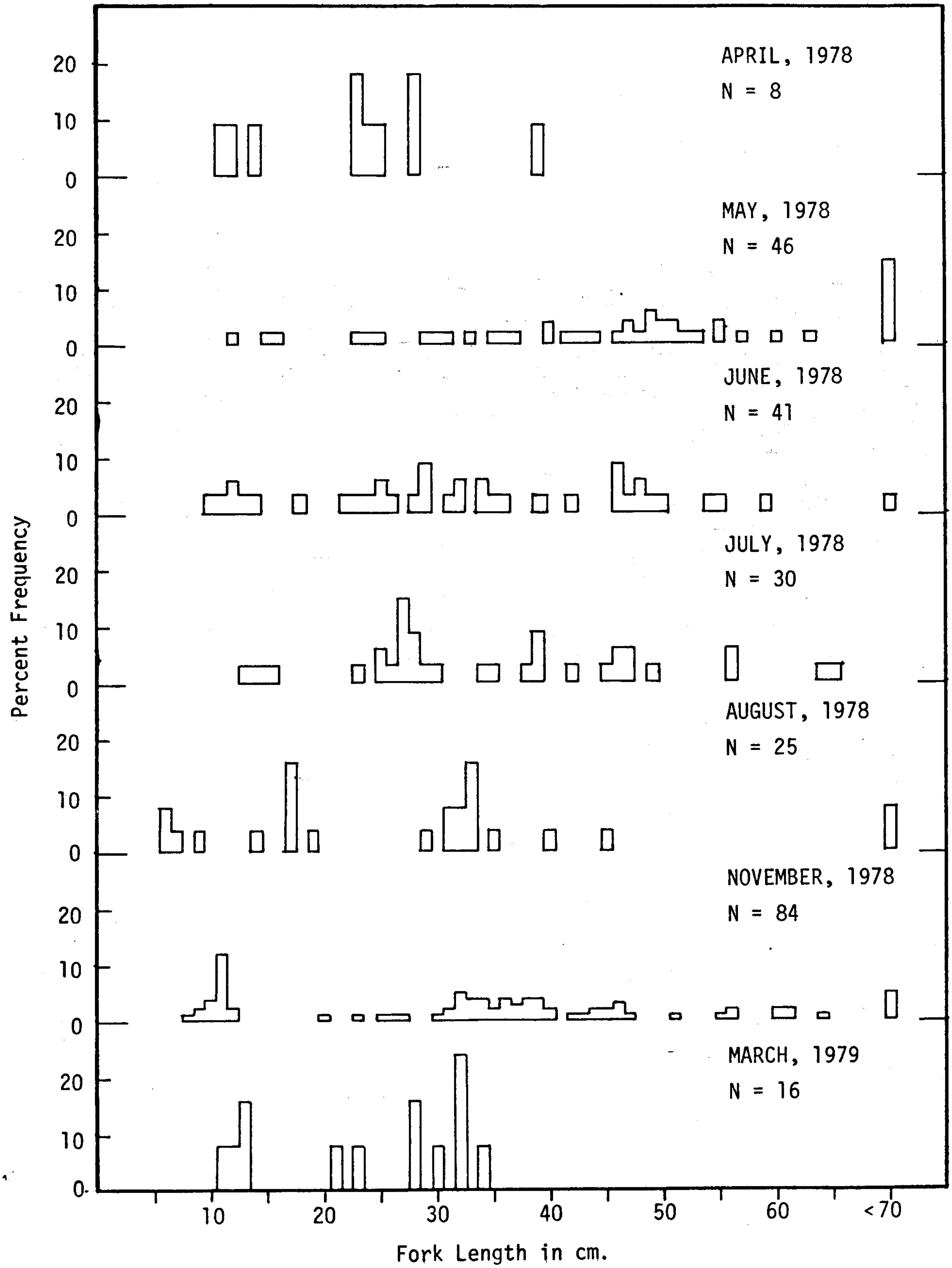

Figure 38. Relative length-frequency of Pacific halibut by month of capture. The catch by all types of gear and all bays combined, April 1978 through March 1979 on the east side of Kodiak.

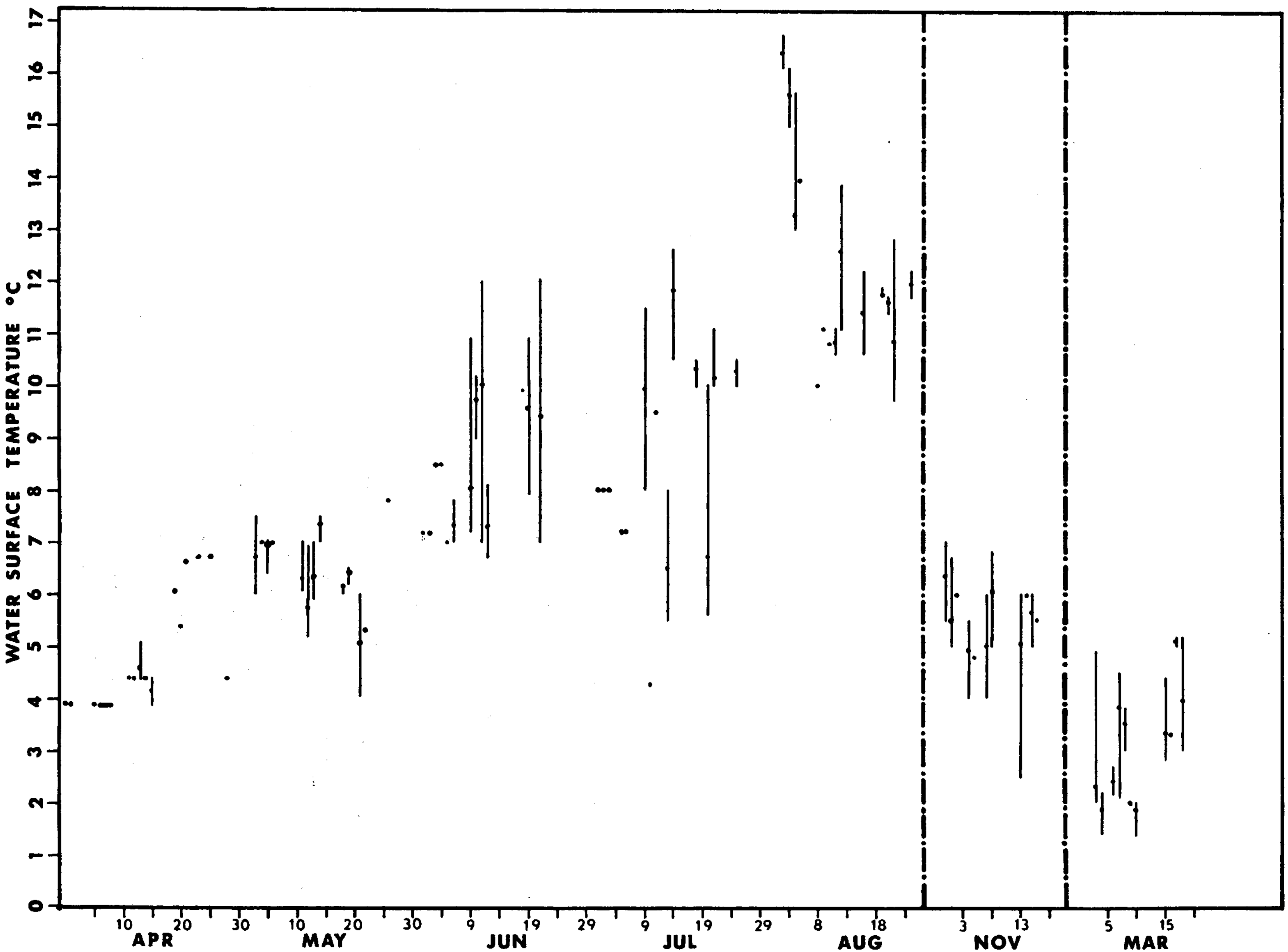

Figure 39. Water surface temperature daily mean and range by date during April through August 1978, November 1978 and March 1979.

Salinity

Salinity was recorded with 186 hauls. There were two records of 5 ppt., two records of 15 ppt, six records (3.2%) were 21 ppt or less and all others were between 26.0 ppt and 36.0 ppt. There were 35 records (18.8%) less than 30 ppt., 94 records (50.5%) less than 31 ppt., 135 records (72.6%) less than 32 ppt., 154 records (82.8%) records less than 33 ppt., and 179 records (96.2%) less than 35 ppt.

The information present in the salinity records does not justify further presentation or analysis. Seasonal or regional differences are not sufficiently documented.

Salinity was recorded with too small a proportion of the samples to justify comparison of catches at different salinities.

With surface salinities of 26 ppt or more on nearly 98% of the records and 30 ppt or more on 80% of the records, it is clear that the area sampled was primarily oceanic.

DISCUSSION

A description of the fish assemblages of the Kodiak area is not complete until certain dependable features of distribution are addressed as well as cyclic features. Most species display increasing size at increasing depth. Little attention was placed on establishing this feature in this report since it has been previously established (Alverson et al., 1964, for flounders; Hughes and Alton, 1974, for pollock; Blackburn, 1978 and 1979, in studies similar to this one). Butter sole seem to be an exception to this rule since the evidence from this study and from Blackburn (1978 and 1979) clearly indicate mixture of all sizes at depths occupied by the species.

An important corollary of this generality is that the smallest individuals of most species are in the shallowest water. Oil spill impact is generally considered greatest in surface waters and along shorelines and egg, larval and juvenile stages are considered most vulnerable to oil pollution. Both the impact and most vulnerable stages of fish are in shallow water.

Another important feature is that different species tend to occupy different depths and different ranges of depths. For example, in summer starry flounder seem to be mostly in the extreme shallows and in rivers; butter sole are mostly in 5 to 30 fathoms or so while arrowtooth flounder and flathead sole juveniles are within the 5 to 30 fathom depth range, but adults are most abundant at well over 100 fathoms.

There was little difference in catches attributable to location within bays in this study. There were generally fewer species farther within bays;and in Saposa Bay, the innermost area in Izhut Bay, there was evidence of reduced catches in late summer apparently due to oxygen depletion in the bottom water. Blackburn (1979) demonstrated some differences in otter trawl catch associated with distance into Ugak Bay.

The otter trawl yielded significantly more rock sole in the Izhut area than in the Kiliuda area and this appears to be a real feature when trawling results from a wider area are compared. From surveys summarized by Ronholt et al. (1978) the Marmot Bay-Albatross Bank area seems to have more rock sole than other areas on the east side of Kodiak.

The only short term cyclic feature investigated was the effect of tide on catches. Considerable differences in beach seine catch were found on different tide stages. The meaning of this relationship to the functioning of the nearshore zone is not clear.

Seasonal features are extremely important, especially in the nearshore zone. Movement to deep water for winter leaves few fish in this area while inshore movement for summer results in considerably higher catches of several fish. The largest component of the seasonal variability is associated with the reproductive cycles of many marine and anadromous species. Juvenile salmon migrate through the nearshore zone mostly during April through July and adults pass through it during May through September. But many marine fish invade the pelagic and nearshore zone first as larvae or eggs and as these fish and invertebrates grow they occupy different habitats; size and vulnerability to sampling gear change so that during the summer period the composition of the nearshore fauna seems to change constantly.

Long term changes and differences between years are known to occur. The year this study was conducted was the third successive relatively warm winter in the Kodiak area. Salmon runs were large due to favorable environment while unusually harsh winters in the early 1970's were considered the cause of low salmon runs which resulted from spawn in those years. As discussed earlier in this report, the herring fishery during the 1930's and 1940's averaged 40,000 short tons catch per year in the Kodiak area while the current harvest is about 2,000 metric tons. The difference is thought to be due to changes in abundance.

During a survey conducted during 1976-77 on the east side of Kodiak, which was very similar to this one, very large catches of age 0 Pacific sandfish were obtained (Harris and Hartt, 1977; Blackburn, 1979). Similar catches of this species were not taken during this study.

The 1977 year class of sablefish, which constituted nearly all of the sablefish caught in this study, has become recognized as the largest year class of this species seen in a long time.

The numerical taxonomic approaches yielded some interesting results; however, they have a couple weaknesses. There is no way of calculating variance estimates for diversities or area similarities and there is no way of constructing dendrograms that illustrate alternative groupings.

(That is, when two groups were combined there occasionally was a third group that was quite similar to one of the combined groups but not to the other. This situation never occurred at high levels of association.) In short, it is difficult to separate meaningful from spurious results. To do so requires comparison of results between gear types, comparison with previous papers, and careful interpretation of data.

The ability of the various sampling gear to obtain a representative (repeatable) sample affects all the results, so a discussion of the relative merits of the catches of each gear is in order.

The greatest number of species were taken with the try net, the beach seine and the trammel net, in that order. The otter trawl is excluded in all numerical taxonomy results because it was not used in all areas. The total diversity was greatest in the try net, trammel net and beach seine, in that order. Since numerical properties dictate that diversity increases as sample size increases and diversity increases with decreasing variability, diversity seems to be a very good indicator of reliability of results. Total diversity indicates that tow net results are least reliable and gill net results are more reliable, but not nearly comparable to try net, trammel net or beach seine results.

The tow net sampled pelagic fish which were usually highly aggregated (schooled as well as concentrated in good feeding areas), and it is necessary to conduct extensive sampling to get highly reliable results. The gill net also sampled pelagic fish (herring, adult salmon, smelt) and a few demersal fish although it was deployed in the littoral zone. Since this gear caught and killed adult salmon its use was restricted by the field crew, which may be partially responsible for low reliability of catches. The trammel net and try net caught almost exclusively demersal species, which are in general much more uniformly distributed than pelagic species and very much less mobile. Thus catches by the try net and trammel net are commonly very repeatable. The beach seine caught both pelagic fish and demersal fish in the nearshore zone; more sets were made than with any other gear and fish were almost always caught. The large amount of effort with the beach seine and the abundance of fish in the nearshore zone combine to provide reliable results.

The area similarity dendrograms illustrate the similarity of the various areas but they are affected by the relative ability of the different gear to obtain representative samples of the predominant species in an area. One would expect geographic affinities (areas of one bay to be most similar with each other) to exist partly because of similarity of habitat within a bay and partly due to dispersion of species from specific habitats. Geographic affinities definitely are predominant in the two very nearshore, reliable gear types, beach seine and trammel net (Figure 13), while some geographic affinity is present in the try net catches (Figure 13). The two less reliable gear types, gill net and tow net, show little geographic affinity (Figure 13).

The geographic affinities that are most prominent are based on the distribution of juvenile pink and chum salmon (beach seine) which is related to the proximity of producing streams, and on the distribution of greenling species (trammel net) which is probably related to specific elements of the kelp habitat or kelp abundance. There does not appear to be a cline of species abundance (gradual change of species with distance) along the archipelago. The differences between areas are due primarily to shifts in relative abundance of predominant species, not to changes of species composition. There is a marked similarity of catches throughout the study area.

Pielou (1972 and 1977) has used components of diversity, partitioned as in this study, as measures of niche width and niche overlap. To do so, however, requires that sampling be conducted by habitat. Since the samples presented here were collected by geographic area, not habitat, it is perhaps inappropriate to use the terms niche width and niche overlap; however, they are used for simplicity.

Pielou (1972 and 1977) presented a method of scaling niche width and niche overlap between 0 and 1 for minimum to maximum. The indices of niche width and niche overlap thus calculated (Table 28) were markedly lower for the tow net and slightly lower for the gill net than for the other three types of gear. In addition, niche width was greater than niche overlap for all gear except the try net, for which they were about equal.

Table 28. Niche width and niche overlap by gear type. Calculations were by the method of Pielou (1972), using the 12 subareas as sampling sites.

	Niche Width	Niche Overlap
Beach Seine	.86	.82
Gill Net	.77	.70
Trammel Net	.87	.80
Tow Net	.41	.24
Try Net	.81	.82

Low figures for niche width indicate that each species tends to be restricted to a subset of the areas while high values indicate that they tend to occur indifferently in the different areas. Low figures for niche overlap indicate that each area contains a relatively small subset, of low diversity, of the community species complement while high overlap indicates that the species diversity within each area approaches that of the community treated as an undivided whole (Pielou, 1977).

The niche width and niche overlap figures are both relatively high but niche width is higher for all but one gear (Table 28). Since diversity is higher when all the numbers comprising it are more even (have lower variability) the higher value for niche width indicates that the catch rates between areas and within species are more even than the catch rates within areas and between species. If the areas sampled had been much more widely separated the within species catch rates would be less even and the niche width would be lower.

The numerator of the niche width figure is essentially a weighted mean of all of the site diversities of the various species, from Table 24. The individual site diversities of the various species are also worthy of some attention. They provide an indication of the relative ubiquity of each species, with higher values for those species which are most evenly distributed among areas. For example, the buffalo sculpin had a very high site diversity from the beach seine collections (Table 24) while its mean density was uniformly very low (Table 16). It is the belief of the authors that these values are characteristic of the individual species, but that they are strongly influenced by the collection methods. If a particular species of fish is not expected to occur throughout the range of use of a particular gear then the site diversity of that species will be lowered. For example, the site diversities of all the flounders except starry flounder and rock sole, are greater for the try net than for any other gear. The try net is the gear that most directly samples the habitat of flounders. Rock sole and starry flounder occur at shallower depths than the other flounders, with starry flounder more abundant in the very shallow depths sampled by the beach seine and trammel net than at the slightly greater depths sampled by the try net.

In addition, certain species are more susceptible to capture by certain gear types than by others. Herring are more common and more predominant in the gill net collections although nearly the same zone was sampled with the trammel net and beach seine. Greenling were nearly all most susceptible to capture by the trammel net. The gear to which a species was most susceptible seems to have yielded higher site diversities for that species.

Species Associations

The species dendrograms for each gear are very interesting but very difficult to discuss for several reasons: as presented they are inflexible, without any method of assessing variability and consequently there is no method of assessing validity; there are a number of measures of similarity between taxa that could have been employed; there are a number of ways data may have been handled (lumped by area and time, separated by time, haul by haul, etc.); and there are a number of ways the groups may have been constructed from a matrix of similarity values. All these choices affect the details of the species similarity dendrograms. Thus, it is very difficult to make clear statements of results from the dendrograms and especially difficult to separate the valid details present in the dendrograms from the invalid or spurious details.

Another important characteristic of species association analyses is that they are functions of the survey design. To understand this feature, consider the following example. Within a given area, Area A, species 1 and species 2 are independently distributed while in an adjacent area, Area B, neither species occurrs. Samples taken within Area A would not reflect any relationship between these two species while samples taken in both Area A and Area B considered together would result in a degree of association between the two species. In fact the species are related by both occurring within one area (although they are independent within that area), but the level of association must be considered. If Area A is Hawaii and Area B is Kodiak the species association is based on geographic features,but if Area A is kelp beds on Kodiak Island and Area B is sand bottom then the association could be said to be based on habitat.

One more example of the effect of survey design on association is pertinent. Consider species A and species,B both of which occur at increasing abundance with increasing depth from 0 m, but abundance of species A reaches a maximum at 25 m and decreases deeper while abundance of species B increases to at least 50 m. Samples taken between 0 and 25 m will reveal a positive association while a separate study at 25 m to 50 m would reveal a negative association. Since marine fish abundance is strongly associated with depth, any species association is a function of the depths sampled.

With these considerations in mind the dendrograms may be examined for meaningful associations. From the beach seine dendrogram, staghorn sculpin, starry flounder and rock sole were combined while the same three were combined, along with yellowfin sole, from the trammel net. Staghorn sculpin and starry flounder were found to be strongly associated in beach seine catches in Cook Inlet in 1976, so this association is probably valid. The inclusion of rock sole in this group seems valid due to consistency, and the inclusion of yellowfin sole in this group in the trammel net catches is probably meaningful. However, in the try net catches there was no association among any of these four species, undoubtedly due to the different depth and sampling characteristics of the try net.

A very different type of relationship may be seen for Pacific cod. Pacific cod was one of the members of the highest or second highest correlation in four of the five gear types. In the beach seine it combined with three other species (correlation greater than 0.8) before any other two species combined, and in the try net it combined with two other species at correlation of 0.95 and with four other species at a correlation of 0.78. Pacific cod seems to be always associated strongly with some other species. Also, Pacific cod seems to be a member of the group with the largest number of species. Examination of try net catch data for August revealed that Pacific cod were caught on few hauls but they occurred when the number of species captured were greatest.

It is possible that Pacific cod require high levels of food abundance which is indicated in the samples by positive correlation with high species counts.

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Appendix Table 1. Names and general locations of salmon spawning streams that averaged 10,000 or more spawners of any species as listed in Figure 4. Streams are listed in the sequence they appear on the shoreline from north to south.

	Name	Location
Figure 4A	Perenosa	Drains Portage Lake to Perenosa Bay
	Pauls Lake	Eastside of Perenos Bay
	Sacramento Creek	Between C. Chiniak and Narrow Cape
	Tundra Lakes Creek	Aliulik Peninsula south of Kaguyak
	Sow Creek	Aliulik Peninsula south of Kaguyak
	7 Rivers	Aliulik Peninsula south of Kaguyak
	Humpy River	Aliulik Peninsula opposite Kaguyak
	Talifson's Creek	Northeast Olga Bay
	Dog Salmon River	Drains Frazer Lake to Olga Bay
	Akalura	Drains Akalura Lake to Olga Bay
	Upper Station	Drains Upper Station Lakes to Olga Bay
Figure 4B	Danger River	Danger Bay, north end
	Marka Creek	Between Danger Bay and Afognak Bay
	Afognak River	Drains Afognak Lake to Afognak Bay
	Sheratin River	On Sheratin Bay
	Buskin River	3 miles S.W. of City of Kodiak
	American River	On Middle Bay
	Sid Olds Creek	On Kalsin Bay
Figure 4C	Miam River	On Portage Bay
	Hurst Creek	On Saltery Cove
	Saltery Creek	On Saltery Cove
	Eagle Harbor	On Eagle Harbor
	North Kiliuda	Inner Kiliuda, north arm
	West Kiliuda	Inner Kiliuda, west arm
	Midway Bay	On Midway Bay, north of Old Harbor
	Barling Bay	Barling Bay, south of Old Harbor
	Kaiugnak Lagoon	Inner Kaiugnak Bay
	North Kaguyak	Kaguyak Bay
	West Kaguyak	Kaguyak Bay -
	Deadman River	Head of Deadman Bay

Appendix Table 2. Presence of each life history stage of each taxon by month of collection on the east side of the Kodiak Archipelago during April through November of 1978 and March of 1979. The sampling gear caught large larvae (greater than 10-15 mm) better than small larvae. The larval tomcod and larval pollock probably were very small juveniles. The distinction between juvenile and adult is subjective for many species, however, when stomachs were removed gonads were examined to assist in the distinction. Most flatfish were called juvenile at less than 20 cm. Life history stages are L-larvae, J-juvenile and A-adult.

	Stage	Mar	Apr	May	Jun	Jul	Aug	Nov
King Crab	J	J		J	J	J	J	
	A	A	A	A	A	A	A	A
Tanner Crab	J	J	J	J	J	J	J	J
	A	A	A	A	A	A	A	A
Dungeness Crab	J	J	J	J	J	J	J	J
	A	A	A	A	A	A	A	A
Dogfish	J							
	A					A		
Big Skate	J			J				
	A		A	A	A	A	A	
Longnose Skate	J							
	A						A	
Pacific herring	L						L	
	J	J	J		J	J	J	J
	A	A	A	A	A	A	A	A
Pink Salmon	J	J	J	J	J	J	J	
	A					A	A	
Chum Salmon	J	J	J	J	J	J	J	J
	A						A	
Coho Salmon	J				J	J	J	
	A						A	
Sockeye Salmon	J							
	A				A	A	A	
Dolly Varden	J			J	J	J	J	J
	A		A	A	A	A	A	A
Surf Smelt	L							
	J					J	J	
	A			A	A	A		A
Capelin	L	L	L	L	L	L	L	L
	J		J	J			J	J
	A	A	A	A	A	A	A	

Appendix Table 2. Continued...

	Stage	Mar	Apr	May	Jun	Jul	Aug	Nov
Eulachon	L							
	J							
	A	A	A	A				A
Gadidae spp.	L			L	L			L
	J							
	A							
Pacific Cod	L					L		
	J	J	J	J	J	J	J	J
	A	A	A	A	A	A	A	A
Pacific tomcod	L				L			
	J	J	J	J	J	J	J	J
	A	A	A			A	A	A
Walleye pollock	L					L		
	J	J	J	J	J	J	J	J
	A	A	A	A		A	A	A
Shortfin eelpout	J			J		J		
	A				A	A	A	
Wattled eelpout	J						J	
	A					A	A	
Threespine stickleback	J	J	J		J	J	J	
	A		A	A	A	A	A	
Tubesnout	J							
	A	A						
Rockfish spp.	J		J	J			J	
	A							
Dusky Rockfish	J				J	J	J	
	A				A	A		
Darkblotched Rockfish	J			J				J
	A							
Black Rockfish	J			J				
	A		A	A			A	
Greenling spp.	L	L	L					L
	J	J	J	J	J	J		
	A		A			A		

Appendix Table 2 Continued . . .

	Stage	Mar	Apr	May	Jun	Jul	Aug	Nov
Kelp greenling	L							
	J	J			J		J	
	A		A	A	A	A	A	A
Rock greenling	L							
	J	J	J	J	J	J	J	J
	A	A	A	A	A	A	A	A
Masked greenling	L							
	J	J	J	J	J	J	J	J
	A	A	A	A	A	A	A	A
Whitespotted Greenling	L							
	J	J	J	J	J	J	J	J
	A	A	A	A	A	A	A	A
Lingcod	L			L	L			
	J	J	J	J		J	J	J
	A							
Sablefish	L							
	J		J	J	J	J	J	J
	A							
Sculpin spp.	L	L	L	L	L	L	L	
	J		J	J	J	J	J	J
	A		A	A				A
Padded sculpin	L							
	J	J		J			J	J
	A			A	A	A		
Crested sculpin	L							
	J							
	A				A	A		A
Silverspotted Sculpin	L			L				
	J	J	J	J	J	J	J	J
	A		A	A	A	A	A	A
Sharpnose sculpin	L				L	L	L	
	J	J				J		J
	A							
Spinyhead sculpin	L							
	J	J	J	J	J	J	J	J
	A	A	A	A		A	A	A

Appendix Table 2 Continued . . .

	Stage	Mar	Apr	May	Jun	Jul	Aug	Nov
Buffalo sculpin	L							
	J	J	J	J	J	J	J	J
	A		A	A	A	A		A
Gymnocanthus spp.	L				L			
	J		J	J	J	J	J	J
	A		A	A	A	A	A	
Armorhead	L							
sculpin	J	J	J	J	J	J	J	J
	A	A		A	A	A	A	A
Threaded sculpin	L							
	J	J			J	J	J	J
	A	A		A	A	A	A	A
Red Irish Lord	L							
	J		J				J	J
	A				A	A	A	A
Yellow Irish Lord	L				L			
	J	J	J	J	J	J	J	J
	A	A	A	A	A	A	A	A
Bigmouth sculpin	L							
	J		J				J	
	A							
Northern sculpin	L							
	J		J	J				
	A							
Pacific staghorn	L							
sculpin	J	J				J	J	J
	A	A	A	A	A	A	A	A
Myoxocephalus	L		L	L	L			
spp.	J	J	J	J	J	J	J	J
	A	A	A	A	A	A	A	A
Plain Sculpin	L							
	J			J	J	J	J	
	A			A	A	A	A	A
Great Sculpin	L							
	J		J	J	J	J	J	J
	A		A	A	A	A	A	A

Appendix Table 2 Continued . . .

	Stage	Mar	Apr	May	Jun	Jul	Aug	Nov
Sailfin sculpin	L							
	J					J		
	A			A				
Tidepool sculpin	L							
	J							J
	A							
Slim sculpin	L							
	J				J			
	A							
Manacled sculpin	L							
	J						J	J
	A		A	A		A		A
Scissortail sculpin	L							
	J							
	A		A		A			
Roughspine sculpin	L							
	J					J		J
	A							
Ribbed sculpin	L							
	J	J	J		J		J	J
	A	A	A	A	A	A	A	A
Tadpole sculpin	L							
	J							
	A					A		
Poacher spp.	L	L		L				
	J							
	A							
Smooth alligator-fish	L							
	J							
	A		A	A				
Sturgeon poacher	L							
	J	J	J	J	J	J	J	J
	A	A	A	A	A	A	A	A
Bering poacher	L							
	J							
	A						A	
Tubenose poacher	L			L	L			
	J			J	J	J	J	J
	A	A	A	A	A	A	A	A

Appendix Table 2 Continued . . .

	Stage	Mar	Apr	May	Jun	Jul	Aug	Nov
Snailfish spp.	L			L	L	L	L	
	J	J	J	J	J			J
	A	A	A	A				A
Spotted snailfish	L			L		L		
	J						J	
	A						A	
Marbled snailfish	L							
	J		J					
	A		A					
Pacific sandfish	L	L	L	L				
	J		J	J			J	
	A	A	A	A	A	A	A	A
Bathymasteridae	L		L		L			
	J							
	A							
Searcher	L							
	J		J	J	J	J	J	J
	A	A	A	A	A	A	A	A
Northern Ronquil	L							
	J		J					
	A		A					
Wolf eel	L							
	J						J	
	A							
Pricklebacks	L	L	L	L	L	L		
	J		J				J	
	A		A					
High cockscomb	L							
	J	J	J				J	
	A						A	
Snake prickle-back	L			L				
	J	J		J	J	J	J	
	A	A	A	A	A	A	A	
Daubed shanny	L							
	J	J			J	J	J	
	A		A	A		A	A	

Appendix Table 2 Continued . . .

	Stage	Mar	Apr	May	Jun	Jul	Aug	Nov
Stout eelblenny	L							
	J			J	J	J		
	A			A	A	A	A	
Whitebarred blenny	L							
	J			J				
	A		A	A				
Arctic shanny	L							
	J	J			J		J	J
	A		A	A			A	
Giant wrymouth	L		L	L	L			
	J							
	A							
Dwarf wrymouth	L			L	L			
	J							
	A							
Pholidae spp.	L			L	L			
	J							
	A							
Penpoint gunnel	L							
	J						J	
	A			A			A	A
Longfin gunnel	L							
	J							
	A				A			
Crescent gunnel	L					L		
	J	J	J	J	J	J	J	J
	A	A	A	A	A	A	A	
Prowfish	L							
	J					J	J	
	A							
Sandlance	L		L	L				
	J	J	J	J	J	J	J	J
	A	A	A	A	A	A	A	A
Flounder spp.	L			L	L	L		L
	J		J					
	A							

Appendix Table 2 Continued...

	Stage	Mar	Apr	May	Jun	Jul	Aug	Nov
Arrowtooth	L							
	J	J	J	J	J	J	J	J
	A		A	A	A	A	A	A
Rex sole	L							
	J	J	J		J	J	J	J
	A			A		A	A	
Flathead sole	L							
	J	J	J	J	J	J	J	J
	A	A	A	A	A	A	A	A
Butter sole	L							
	J		J	J	J	J	J	J
	A	A	A	A	A	A	A	A
Rock sole	L							
	J	J	J	J	J	J	J	J
	A	A	A	A	A	A	A	A
Yellowfin sole	L							
	J	J	J	J	J	J	J	J
	A	A	A	A	A	A	A	A
Dover sole	L							
	J				J	J	J	J
	A				A	A	A	
English sole	L							
	J	J		J		J	J	J
	A		A		A			A
Starry flounder	L							
	J	J	J	J	J	J	J	J
	A	A	A	A	A	A	A	A
Alaska plaice	L							
	J		J	J	J	J		
	A				A		A	A
Sand sole	L							
	J	J		J	J	J		J
	A	A	A	A	A	A	A	A
Pacific halibut	L					L		
	J	J	J	J	J	J	J	J
	A	A	A	A	A	A	A	A

Appendix Table 3. Beach seine catch in numbers of fish per haul and numbers of hauls by taxon and month in inner Izhut Bay. T represents trace, less than 0.05 fish/set.

	Apr	May	Jun	Jul	Aug	Nov	Mar	Mean
Dungeness crab					1.5			0.2
Pink salmon	1.2	1.8	146.4	9.3				22.3
Dolly Varden					0.2			T
Pacific cod	0.2							T
Walleye pollock			0.2					T
Rock greenling	0.5	0.8			0.2	0.2		0.2
Masked greenling	1.8	5.0		3.3	8.3	1.0		3.0
Whitespotted greenling		0.8	0.4	6.0	14.2			3.5
Lingcod					1.3			0.2
Padded sculpin		0.2						T
Silverspotted sculpin		0.4			0.2	0.2		0.1
Buffalo sculpin		0.2	0.2			0.2		0.1
Yellow Irish Lord						0.2		T
Pacific staghorn sculpin					0.2			T
Myoxocephalus spp.		0.8		4.3	9.0	1.6	0.8	2.6
Manacled sculpin				0.2		0.4		0.1
Tubenose poacher						0.2		T
Pacific sandfish					0.3			0.1
High cockscomb					0.5			0.1
Crescent gunnel		0.8			3.0			0.6
Prowfish					0.2			T
Pacific sand lance			9.6	197.3	4967.2	0.2		862.1
Rock sole				0.2		0.8		0.1
Yellowfin sole		0.6						0.1
English sole					0.2			T
Numbers of hauls	4	5	5	6	6	5	5	36

Appendix Table 4. Beach seine catch in numbers of fish per haul and numbers of hauls by taxon and month in inner middle Izhut Bay. T represents trace, less than 0.05 fish/set.

	Apr	May	Jun	Jul	Aug	Nov	Mar	Mean
Pacific herring					0.3			0.1
Pink salmon	1.0	3.0	134.8					15.1
Dolly varden				0.2		0.9		0.2
Pacific cod				0.2	9.4			1.8
Hexagrammos sp.			0.2					T
Rock greenling	0.6	0.8	0.7		0.7	0.1		0.4
Masked greenling	2.0	0.6	4.5	5.4	4.3	1.0		2.6
Whitespotted greenling			0.7	2.0	5.3	0.3		1.4
Lingcod					0.4			0.1
Sculpin spp.	0.4							0.1
Padded sculpin					0.1			T
Silverspotted sculpin	0.2		0.2	0.2				0.1
Sharpnose sculpin				0.2		0.1		0.1
Buffalo sculpin			0.2	0.2			0.2	0.1
Hemilepidotus spp.	0.8							0.1
Yellow Irish Lord			0.5					0.1
Myoxocephalus spp.	0.2	16.2	1.5	0.8	1.1	0.4	0.2	2.8
Tidepool sculpin						0.1		T
Manacled sculpin		0.2			1.1	0.3		0.3
Tubenose poacher	0.2	0.2			0.1	0.3		0.1
Searcher					0.1			T
Whitebarred prickleback		0.2						T
Arctic shanny			0.7			0.4	0.2	0.2
Penpoint gunnel						0.1		T
Crescent gunnel	0.2		0.7	0.2		0.1		0.2
Prowfish					0.1			T
Pacific sand lance	2.0	1.6	4.8	2595.8	156.7			381.3
Founder spp.	0.2							T
Rock sole		0.6	0.2		1.3	1.6	0.2	0.7
Number of hauls	5	5	4	5	7	7	4	37

Appendix Table 5. Beach seine catch in numbers of fish per haul and numbers of hauls by taxon and month in outer middle Izhut Bay. T represents trace, less than 0.05 fish/set.

	Apr	May	Jun	Jul	Aug	Nov	Mar	Mean
Pacific herring			0.4		0.6			0.2
Pink salmon	62.6	81.8	3.5	10.9	11.6			20.7
Coho salmon			17.5					2.9
Dolly Varden			1.6	0.9		1.0		0.6
Surf smelt						0.2		T
Pacific cod		0.2	0.1	0.1	0.1			0.1
Threespine stickleback	0.2		0.1		0.2			0.1
Tube-snout							0.2	T
Hexagrammos sp.		0.3						T
Kelp greenling			0.2					T
Rock greenling	0.2		0.2	0.2	0.2			0.1
Masked greenling	3.6	0.5	2.5	2.1	1.8		0.2	1.5
Whitespotted greenling		0.3	0.4	12.6	4.8		0.2	3.0
Lingcod					0.2			T
Padded sculpin			0.1		0.1			T
Silverspotted sculpin	1.2							0.1
Sharpnose sculpin						0.1		T
Buffalo sculpin	0.6	0.2		0.1				0.1
Pacific staghorn sculpin			0.2		0.1			0.1
Myoxocephalus spp.	0.4		0.1	0.5	0.1	0.7		0.3
Arctic shanny					0.1			T
Penpoint gunnel		0.2			0.1			T
Crescent gunnel	0.6	0.2	1.1	0.1	0.2			0.3
Pacific sand lance		3.7	0.1	668.0	0.1	1.0		109.7
Rock sole		0.2	0.2	0.1		0.2		0.1
Numbers of hauls	5	6	8	8	8	8	5	48

Appendix Table 6. Beach seine catch in numbers of fish per haul and numbers of hauls by taxon and month in inner Kalsin Bay. T represents trace, less than 0.05 fish/set.

	Apr	May	Jun	Jul	Aug	Nov	Mar	Mean
Dungeness crab				3.7				0.4
Pink salmon	0.6	22.7	34.8	72.8	2.4			17.6
Chum salmon	0.9	36.2	37.3	1.8				12.3
Coho salmon				0.2				T
Dolly Varden					1.0			0.1
Capelin			0.2					T
Pacific cod					2.6			0.4
Pacific tomcod							0.2	T
Walleye pollock						0.2		T
Threespine stickleback				0.2				T
Hexagrammos sp.				0.2				T
Rock greenling	0.1							T
Masked greenling	0.6	0.2		0.7	2.6			0.6
Whitespotted greenling				17.8	11.0			3.4
Ling cod				0.2				T
Sculpin spp.				8.0				0.9
Padded sculpin				0.7				0.1
Silverspotted sculpin	0.6							0.1
Buffalo sculpin						0.2		T
Yellow Irish Lord	0.1			0.2				0.1
Pacific staghorn sculpin				1.5	0.6			0.2
Myoxocephalus spp.	1.0	0.5	0.5	18.5	4.4	3.4	0.5	3.4
Tubenose poacher					0.4	0.2		0.1
Snailfish spp.		0.2						T
Arctic Shanny	0.1				0.2			0.1
Crescent gunnel	0.3	0.8						0.2
Pacific sand lance				25.0	6603.8	0.8		895.2
Rock sole	0.6	0.3	0.8	1.8	0.4	0.2		0.6
Yellowfin sole				0.2				T
Starry flounder	0.1	0.5	0.7		0.2	0.2		0.3
Sand sole				0.5				0.1
Number of hauls	7	6	6	4	5	5	4	32

Appendix Table 7. Beach seine catch in numbers of fish per haul and numbers of hauls by taxon and month in outer Kalsin Bay. T represents trace, less than 0.05 fish/set.

	Apr	May	Jun	Jul	Aug	Nov	Mar	Mean
Pacific herring						0.5		0.1
Pink salmon	0.5	118.5	50.3	7.7	0.8			28.8
Chum salmon		48.2	6.5	0.2				8.9
Dolly Varden		0.2	1.5	0.7	0.7			0.5
Threespine stickleback				0.2	0.5			0.1
Tube-snout							0.2	T
Hexagrammos sp.				0.3				0.1
Rock greenling					0.2			T
Masked greenling		0.3	0.3	1.3	8.5			1.7
Whitespotted greenling			0.5	6.8	14.2			3.5
Padded sculpin		0.2				0.6		0.1
Silverspotted sculpin					1.8		0.2	0.3
Buffalo sculpin		0.2			0.2			0.1
Gymnocanthus spp.					0.2			T
Pacific staghorn sculpin					0.2			T
Myoxocephalus spp.	2.5	0.7	6.7	2.0	1.8	5.5	0.2	2.8
Tubenose poacher			0.3	0.2	0.7	0.2		0.2
Snailfish spp.							0.2	T
Spotted snailfish					0.7			0.1
Penpoint gunnel					0.2			T
Crescent gunnel			0.2		6.8			1.1
Pacific sand lance	0.5	0.5		0.2	725.2	0.2		117.8
Rock sole		0.3	0.3	0.5	0.5	0.2	0.2	0.3
English sole					0.2			T
Starry flounder					0.5		0.2	0.1
Alaska plaice				0.2				T
Number of hauls	2	6	6	6	6	6	5	37

Appendix Table 8. Beach seine catch in numbers of fish per haul and numbers of hauls by taxon and month in inner Kiliuda Bay. T represents trace, less than 0.05 fish/set.

	Apr	May	Jun	Jul	Aug	Nov	Mar	Mean
Pink salmon	2.2	21.8	1.2	0.8	1.4		0.2	3.9
Chum salmon	7.6	188.8	165.0	2.8	0.4			52.1
Dolly Varden		0.2				0.2		0.1
Pacific cod				28.0	11.6			5.7
Threespine stickleback		1.0	0.8					0.3
Hexagrammos sp.				0.2				T
Rock greenling		0.2						T
Masked greenling		0.4	1.2	7.4	1.6		0.2	1.5
Whitespotted greenling		1.0	2.2	5.0	1.0			1.3
Ling cod					4.0			0.6
Sculpin spp.	0.2							T
Silverspotted sculpin		2.8	4.2	22.2	0.2			4.2
Buffalo sculpin		0.2			0.2			0.1
Gymnocanthus spp.				0.8	1.0			0.3
Yellow Irish Lord					1.2			0.2
Myoxocephalus spp	0.2	0.4	14.0	2.4	13.6	0.6		4.5
Tubenose poacher		0.4	0.4	3.8		0.2	0.2	0.7
Crescent gunnel		1.2		1.8	2.6			0.8
Pacific sand lance		8.0	1.6	1.4	1.2	0.2		1.8
Number of hauls	5	5	5	5	5	5	5	35

Appendix Table 9. Beach seine catch in numbers of fish per haul and numbers of hauls by taxon and month in inner middle Kiliuda Bay. T represents trace, less than 0.05 fish/set.

	Apr	May	Jun	Jul	Aug	Nov	Mar	Mean
Pink salmon	14.5	11.4	1.0	8.6	128.0			23.1
Chum salmon	1.8	12.2	30.8	12.0	1.0		0.2	8.1
Dolly Varden		0.4		0.2		0.2		0.1
Pacific cod				0.6	2.6	0.6		0.5
Threespine stickleback			0.4	0.8	0.2			0.2
<u>Hexagrammos</u> sp.	0.2							T
Rock greenling						1.8	0.4	0.3
Masked greenling	3.8	4.4	1.2	1.4	2.8	10.8	1.6	3.7
Whitespotted greenling			1.2	4.0	2.0	1.4		1.2
Ling cod					0.4			0.1
Silverspotted sculpin	0.7	2.4	1.8	0.2	1.8	1.2	0.2	1.2
Sharpnose sculpin				0.8			0.2	0.1
Buffalo sculpin				0.2	0.2	0.2		0.1
<u>Gymnocanthus</u> spp.				0.4	0.4			0.1
Yellow Irish Lord					0.2	0.2	0.2	0.1
Pacific staghorn sculpin			1.0	0.2	0.4		0.4	0.2
<u>Myoxocephalus</u> spp.		1.2	10.0	4.4	15.6	0.6	0.6	4.6
Tubenose poacher	0.2			0.2	0.2	0.8		0.2
Snake prickleback			0.4					0.1
Crescent gunnel	0.3				0.6		0.2	0.2
Pacific sand lance	1.3	3.6	3.8	10.0	416.2	15.8	3.2	63.1
Flounder spp.	0.2							T
Rock sole			0.6		0.2	0.2	0.2	0.2
Starry flounder	0.2			0.4	0.2			0.1
Number of Hauls	6	5	5	5	5	5	5	36

Appendix Table 10. Beach seine catch in numbers of fish per haul and numbers of hauls by taxon and month in outer middle Kiliuda Bay. T represents trace, less than 0.05 fish/set.

	Apr	May	Jun	Jul	Aug	Nov	Mar	Mean
Pink salmon	1.3	4.8	6.8	11.2	2.0			3.6
Chum salmon	17.3	10.4	10.6	22.8	0.4	0.2		9.3
Dolly Varden	0.9	0.6	0.2	0.4	2.0			0.6
Capelin						0.2		T
Pacific cod				11.0	12.4			3.2
Threespine stickleback		0.8	4.2	0.2	0.8			0.8
Rock greenling	0.1	0.6		1.2	2.4			0.6
Masked greenling	0.9	0.2		2.4	3.4		0.4	1.0
Whitespotted greenling				1.4	5.8			1.0
Sculpin spp.				1.8				0.2
Silverspotted sculpin	0.6				0.6			0.2
Buffalo sculpin	0.1	0.2						0.1
Gymnocanthus spp.					6.6	0.2		0.9
Myoxocephalus spp.	0.3	0.6	5.6	5.2	11.6	3.4	0.4	3.7
Tubenose poacher					0.2	0.2	0.2	0.1
Snailfish spp.						2.8		0.4
Crescent gunnel	0.1		0.4					0.1
Pacific sand lance		75.6		6.4	187.2		2.0	36.6
Rock sole		0.2	0.4	0.6	0.2	2.4		0.5
Starry flounder						0.4		0.1
Number of hauls	7	5	5	5	5	5	6	38

Appendix Table 11. Beach seine catch in numbers of fish per haul and numbers of hauls by taxon and month in outer Kiliuda Bay. T represents trace, less than 0.05 fish/set.

	Apr	May	Jun	Jul	Aug	Nov	Mar	Mean
King crab		0.8						0.1
Dungeness crab		2.5		1.6	1.8			0.8
Pink salmon	22.0	20.8	110.6	2.0	1.0			22.8
Chum salmon	13.1	144.3	20.1	8.1				24.6
Coho salmon				0.3				T
Dolly Varden		0.3	0.1	1.0		0.1		0.2
Surf smelt				0.3	0.2	0.1		0.1
Capelin					0.2			T
Pacific cod		0.5		0.9	11.0	2.0		1.9
Threespine stickleback			0.3		0.2			0.1
Hexagrammos sp.				0.7				0.1
Rock greenling				0.1	0.3	0.1		0.1
Masked greenling	0.1	0.7	2.6	2.4	21.8			3.6
Whitespotted greenling			1.4	2.3	0.8			0.7
Ling cod					0.3			T
Sculpin spp.				0.7	0.2	0.1		0.1
Padded sculpin		0.3						T
Silverspotted sculpin	0.1			0.7	1.7			0.3
Buffalo sculpin	0.4	0.5	0.3	0.1	1.0			0.3
Gymnocanthus spp.				0.3				T
Yellow Irish Lord					0.3			T
Pacific staghorn sculpin			0.1	0.6	0.2	0.3		0.2
Myoxocephalus spp.		1.2	1.7	2.0	0.8	0.7		0.9
Snake prickleback				0.3				T
Crescent gunnel					0.8			0.1
Pacific sand lance	0.6	0.8	16.1	0.4	188.2	1.9		27.0
Flounder spp	0.1							T
Butter sole		0.2						T
Rock sole	0.3	1.0	2.1	4.3	1.0	0.3		1.3
English sole				2.6	0.3			0.4
Starry flounder	0.1	0.2		1.9	0.7			0.4
Alaska plaice			0.1					T
Sand sole			0.3	2.1				0.4
Pacific halibut					0.7			0.1
Tubenose poacher		1.2	1.7	2.0	0.8	0.7		0.9
Number of hauls	7	6	7	7	6	7	7	47

Appendix Table 12. Beach seine catch in numbers of fish per haul and numbers of hauls by taxon and month in inner Kaiugnak Bay. T represents trace, less than 0.05 fish/set.

	Apr	May	Jun	Jul	Aug	Nov	Mar	Mean
Pink salmon	134.3	722.7		1.2	56.5			165.9
Chum salmon	6.0	83.6	5.0	4.0				18.6
Dolly Varden	4.3	0.1	0.4	0.3		0.2		0.5
Pacific cod				1.3	0.7			0.3
Pacific tomcod			4.2					0.6[1]
Threespine stickleback	0.3	0.6	0.2	0.5				0.3
Rock greenling		0.6	0.2	0.3	2.0	0.7		0.7
Masked greenling		0.7	2.8	11.8	0.3	6.5		3.7
Whitespotted greenling		0.4	0.6	1.8	5.3			1.4
Ling cod					0.5			0.1
Sculpin spp.	1.0	0.3		4.5				0.9
Silverspotted sculpin		0.1	2.2	2.2		0.2		0.7
Buffalo sculpin		0.3		0.2	0.2			0.1
Gymnocanthus spp.		0.1	1.0	3.2	5.5			1.7
Yellow Irish Lord					1.0			0.2
Pacific staghorn sculpin				0.5	0.5			0.2
Myoxocephalus spp.		0.6	17.0	15.2	18.0	4.5		9.0
Tubenose poacher		0.4	0.6	2.5	0.8	0.3		0.8
Arctic shanny		0.1						T
Crescent gunnel		0.1	0.2	0.2	0.3			0.1
Pacific sand lance		230.1	453.0	0.8	5036.3	3.8		974.9
Rock sole		0.1	0.4		0.3			0.1
English sole				0.5				0.1
Starry flounder		0.1	0.2	0.5		0.7		0.3
Sand sole		0.4						0.1
Spotted snailfish					1.0			0.2
Number of hauls	3	7	5	6	6	6	2	35

[1]Appears to be a misidentification of juvenile Pacific cod.

Appendix Table 13. Beach seine catch in numbers of fish per haul and numbers of hauls by taxon and month in outer Kaiugnak Bay. T represents trace, less than 0.05 fish/set.

	Apr	May	Jun	Jul	Aug	Nov	Mar	Mean
Dungeness crab					0.2			T
Pink salmon		557.8	186.5	2.6				126.5
Chum salmon		6.6	2.7	2.2	0.2			2.0
Coho salmon			0.7					0.1
Dolly Varden			2.0	13.4	0.2			2.6
Pacific cod				38.8	64.6			16.7
Pacific tomcod			23.0					4.5[1]
Threespine stickleback		1.0	1.0	1.8	0.6			0.7
Rock greenling		0.4	1.8	1.4	1.4	0.2		0.9
Masked greenling		0.8	7.7	1.0	14.8			4.2
Whitespotted greenling		0.7	5.5	0.8	18.2	0.5		4.3
Ling cod					0.2			T
Silverspotted sculpin		7.8	18.7	0.2	5.4			5.8
Buffalo sculpin					0.2			T
Red Irish Lord					0.2			T
Yellow Irish Lord				0.2				T
Myoxocephalus spp.		0.4	17.0	0.6	4.2	1.0	1.2	4.4
Tubenose poacher		3.6	14.5	5.0	26.4	0.2		8.5
Snake prickleback		8.0	0.3	9.8	1.4			3.2
Crescent gunnel			0.3		3.6			0.6
Pacific sand lance		3.0	0.7	0.6	4552.2	0.2	0.2	735.0
Number of hauls	0	5	6	5	5	4	6	31

[1]appears to be a misidentification of juvenile Pacific cod.

Appendix Table 14. Gill net catch in numbers of fish per set and number of sets, by taxon and month in inner Izhut Bay.

	Apr	May	Jun	Jul	Aug	Nov	Mar	Mean
Pacific herring		1.0						0.2
Pink salmon					0.5			0.1
Masked greenling					0.5			0.1
Number of sets	0	2	2	2	2	0	0	8

Appendix Table 15. Gill net catch in numbers of fish per set and numbers of sets, by taxon and month in inner middle Izhut Bay.

	Apr	May	Jun	Jul	Aug	Nov	Mar	Mean
			No Catch					
Number of sets	0	1	1	2	2	0	0	6

Appendix Table 16. Gill net catch in numbers of fish per set and numbers of sets, by taxon and month in outer middle Izhut Bay.

	Apr	May	Jun	Jul	Aug	Nov	Mar	Mean
Pacific herring		23.5		0.5	1.0			9.7
Chum salmon				0.5				0.1
Dolly Varden		0.2		0.5				0.2
Capelin		0.5						0.2
Pacific cod		1.0						0.4
Pacific tomcod		0.2						0.1
Masked greenling		0.5						0.2
Number of sets	0	4	2	3	2	0	0	11

Appendix Table 17. Gill net catch in numbers of fish per set and number of sets, by taxon and month in outer Izhut Bay

	Apr	May	Jun	Jul	Aug	Nov	Mar	Mean
Pacific herring			3.0					3.0
Dolly Varden			1.0					1.0
Surf smelt			2.0					2.0
Number of sets	0		0	1	0	0	0	1

Appendix Table 18. Gill net catch in numbers of fish per set and number of sets, by taxon and month in inner Kalsin Bay.

	Apr	May	Jun	Jul	Aug	Nov	Mar	Mean
Pacific herring			4.5	0.5				1.2
Chum salmon			0.5		0.5			0.2
Dolly Varden				1.0	1.5			0.6
Surf smelt				0.5				0.1
Masked greenling					1.0			0.2
Great sculpin		0.5						0.1
Number of sets	0	2	2	2	2	0	0	8

Appendix Table 19. Gill net catch in numbers of fish per set and numbers of sets, by taxon and month in outer Kalsin Bay

	Apr	May	Jun	Jul	Aug	Nov	Mar	Mean
Pacific herring		6.0	7.0	7.5				5.2
Pink salmon					1.0			0.2
Coho salmon					0.5			1.0
Sockeye salmon			0.5		1.0			0.3
Dolly Varden			0.3		0.4	1.5		0.6
Surf smelt		1.0	1.5					0.7
Masked greenling				0.5				0.1
Great sculpin		0.7						0.2
Whitespotted greenling				0.5				0.1
Number of sets	0	3	2	2	2	0	0	9

Appendix Table 20. Gill net catch in numbers of fish per set and number of sets, by taxon and month in inner middle Kiliuda.

	Apr	May	Jun	Jul	Aug	Nov	Mar	Mean
Pacific herring	0.7			4.3				0.9
Pink salmon				3.3				0.6
Sockeye salmon				0.2				0.1
Dolly Varden			0.2	0.2				0.1
Pacific staghorn sculpin				0.2				0.1
Number of sets	3	4	5	4	4	0	0	20

Appendix Table 21. Gill net catch in numbers of fish per set and number of sets, by taxon and month in outer middle Kiliuda.

	Apr	May	Jun	Jul	Aug	Nov	Mar	Mean
Pacific herring				1.0				0.2
Pink salmon					3.0			0.7
Dolly Varden		1.0						0.2
Pacific cod					1.0			0.2
Number of sets	1	1	0	1	1	0	0	4

Appendix Table 22. Gill net catch in numbers of fish per set and number of sets, by taxon and month in outer Kiliuda.

	Apr	May	Jun	Jul	Aug	Nov	Mar	Mean
Pacific herring		0.3	99.0	1.7				20.2
Pink salmon					1.5			0.4
Chum salmon					0.7			0.2
Dolly Varden		0.3	1.0	2.7				0.8
Pacific cod				1.0	0.5			0.3
Walleye pollock					0.5			0.1
Rock greenling				2.3	0.2			0.5
Masked greenling				0.3	3.5			1.0
Whitespotted greenling					4.0			1.1
Pacific staghorn sculpin			0.3		1.0			0.3
Great sculpin		0.3		0.3	0.7			0.3
Snake prickleback			0.7		0.5			0.3
Starry flounder					0.2			0.1
Number of sets	2	3	3	3	4	0	0	15

Appendix Table 23. Gill net catch in numbers of fish per set and number of sets, by taxon and month in inner Kaiugnak Bay.

	Apr	May	Jun	Jul	Aug	Nov	Mar	Mean
Pacific herring			1.7	3.5				1.0
Pink salmon					2.7			0.7
Sockeye salmon				0.5				0.1
Dolly Varden			0.3	0.5				0.2
Capelin			0.3					0.1
Pacific cod		0.3	0.3	0.5				0.2
Dusky rockfish			1.3	1.0				0.5
Black rockfish		0.7						0.2
Rock greenling		1.0	0.3	2.0	1.3			1.0
Masked greenling			0.3	1.0				0.2
Number of sets	1	3	3	2	3	0	0	12

Appendix Table 24. Gill net catch in numbers of fish per set and number of sets, by taxon and month in outer Kaiugnak Bay.

	Apr	May	Jun	Jul	Aug	Nov	Mar	Mean
Pacific herring			1.0					0.2
Pink salmon				2.0	3.0			1.2
Coho salmon					0.5			0.1
Dolly Varden				5.0				1.2
Pacific staghorn sculpin				0.5				0.1
Number of sets	0	2	2	2	2	0	0	8

Appendix Table 25. Trammel net catch in numbers of fish per set and number of sets by taxon and month in inner Izhut Bay.

	Apr	May	Jun	Jul	Aug	Nov	Mar	Mean
Pacific herring					1.0			0.2
Pacific cod					1.0	0.5		0.2
Pacific tomcod					5.5			0.8
Walleye pollock					0.5			0.1
Kelp greenling			1.0			1.0		0.3
Rock greenling	1.0	15.0	16.5	13.5	28.0	4.0	7.0	13.0
Masked greenling	1.0	1.0	10.0	14.5	55.0	1.0		12.6
Whitespotted greenling			1.5	4.5	4.5	0.5		1.7
Crested sculpin				0.5				0.1
Silverspotted sculpin				0.5				0.1
Red Irish Lord				1.0				0.2
Myoxocephalus spp.					0.5	1.0		0.3
Rock sole	2.0	1.0	1.0	1.5	1.5	3.5	2.0	1.8
Pacific halibut				0.5				0.1
Number of sets	1	2	2	2	2	2	2	13

Appendix Table 26. Trammel net catch in numbers of fish per set and numbers of sets by taxon and month in inner middle Izhut Bay.

	Apr	May	Jun	Jul	Aug	Nov	Mar	Mean
Black rockfish					6.5			1.6
Hexagrammos spp.				1.0				0.1
Kelp greenling		2.0		1.0	4.0			1.4
Rock greenling	1.0	5.0	16.0	15.0	23.5	2.0	1.0	10.8
Masked greenling	1.0	1.0	4.0	32.0	18.5	1.0		9.5
Whitespotted greenling			1.0	1.0	6.5			1.9
Sculpin spp.						2.0		0.2
Searcher		1.0						0.1
Rock sole		10.0	3.0		3.0	4.0	1.0	3.0
Number of sets	1	1	1	1	2	1	1	8

Appendix Table 27. Trammel net catch in numbers of fish per set and number of sets by taxon and month in outer middle Izhut Bay.

	Apr	May	Jun	Jul	Aug	Nov	Mar	Mean
Pacific herring					0.5			0.1
Pacific cod			0.5	2.0	1.5	3.0		1.1
Pacific tomcod							0.5	0.1
Dusky rockfish			0.5					0.1
Black rockfish	1.0	3.5						0.6
Kelp greenling	1.5		0.5	1.7	0.5			0.7
Rock greenling	1.0	11.0	13.5	24.3	14.0	5.0		10.8
Masked greenling		4.0	3.5	8.0	25.0	1.0		6.1
Whitespotted greenling		1.0	1.5	2.0	13.0	5.0		3.1
Threaded sculpin							0.5	0.1
Red Irish Lord				0.3				0.1
Pacific staghorn sculpin				0.3				0.1
Myoxocephalus spp.		1.5	1.0					0.3
Sailfin sculpin		0.5						0.1
Flathead sole					0.5			0.1
Rock sole		5.0	10.1	7.7	2.0	1.5	2.0	4.3
Yellowfin sole		1.0		0.3				0.2
Number of sets	2	2	2	3	2	2	2	15

Appendix Table 28. Trammel net catch in numbers of fish per set and number of sets by taxon and month in outer Izhut Bay.

	Apr	May	Jun	Jul	Aug	Nov	Mar	Mean
Dusky rockfish				11.0				3.7
Black rockfish					17.0			5.7
Kelp greenling	1.0			1.0				0.7
Rock greenling	7.0			22.0	18.0			15.7
Masked greenling				4.0	9.0			4.3
Whitespotted greenling				1.0				0.3
Silverspotted sculpin					2.0			0.7
Myoxocephalus spp.	1.0							0.3
Rock sole				3.0				1.0
Pacific halibut					1.0			0.3
Number of sets	1	0	0	1	1	0	0	3

Appendix Table 29. Trammel net catch in numbers of fish per set and number of sets by taxon and month in inner Kalsin Bay.

	Apr	May	Jun	Jul	Aug	Nov	Mar	Mean
Pacific herring		7.5	10.5		0.5			2.6
Dolly Varden				0.5	4.5			0.7
Pacific cod				0.5				0.1
Rock greenling	0.5	3.5	13.5	14.0	33.5	6.0		10.1
Masked greenling			6.0	23.5	67.5	9.5		15.2
Whitespotted greenling		0.5	3.5	6.5	9.5	3.5		3.4
Pacific staghorn sculpin	0.5	0.5	2.0	2.5	1.0			0.9
Myoxocephalus spp.		1.0	2.5	4.5	1.0	2.0	0.5	1.7
Sturgeon poacher					0.5			0.1
Rock sole	1.5	5.0	8.0	20.0	9.5	2.5	1.5	6.0
Yellowfin sole		1.5	7.0	8.5				2.4
Starry flounder		0.5	0.5	0.5	1.5			0.4
Pacific halibut		0.5						0.1
Number of sets	2	2	2	2	2	2	2	14

Appendix Table 30. Trammel net catch in numbers of fish per set and number of sets by taxon and month in outer Kalsin Bay.

	Apr	May	Jun	Jul	Aug	Nov	Mar	Mean
Pacific herring		26.0						4.3
Dolly Varden		0.5		4.0	1.5	0.7		1.2
Pacific cod				4.5				0.7
Rock greenling	2.0	6.5	16.5	30.0	17.0	1.0		12.1
Masked greenling		3.0	5.5	36.0	79.5	0.7		20.8
Whitespotted greenling			2.0	1.0	3.0			1.0
Red Irish Lord					0.5			0.1
Pacific staghorn sculpin		0.5						0.1
Myoxocephalus spp.	2.0	1.5	1.0	3.5	3.0	1.6		2.1
Sturgeon poacher				0.5	2.0			0.4
Alaska ronquil			0.5					0.1
Rock sole		3.0	5.5	3.0	2.0	1.3		2.6
Starry flounder		0.5						0.1
Number of sets	1	2	2	2	2	3	0	12

Appendix Table 31. Trammel net catch in numbers of fish per set and number of sets by taxon and month in inner Kiliuda Bay.

	Apr	May	Jun	Jul	Aug	Nov	Mar	Mean
Pacific cod				4.0	3.0			0.7
Pacific tomcod							0.5	0.1
Walleye pollock					1.0			0.1
Kelp greenling					2.0			0.2
Rock greenling	2.0	1.5	4.0	1.0		3.5		1.7
Masked greenling		5.0	11.0	48.0	22.0	3.5		9.8
Whitespotted greenling		3.0	6.0	27.0	17.0	1.0		5.8
Gymnocanthus spp.				1.0				0.1
Threaded sculpin					5.0			0.5
Myoxocephalus spp.	2.0	2.0		2.0	3.0	0.5		1.2
Rock sole	1.0	10.5		1.0	2.0	0.5		2.6
Yellowfin sole		1.0		1.0	6.0			0.9
Number of sets	1	2	1	1	1	2	2	10

Appendix Table 32. Trammel net catch in numbers of fish per set and number of sets by taxon and month in inner middle Kiliuda Bay.

	Apr	May	Jun	Jul	Aug	Nov	Mar	Mean
Pacific cod				3.0	1.0			0.6
Pacific tomcod							1.0	0.1
Kelp greenling	1.0							0.1
Rock greenling		3.0		1.0	6.0	1.0	1.0	1.7
Masked greenling		5.0	16.0	79.0	100.0			28.6
Whitespotted greenling		3.0	9.0	19.0	24.0			7.9
Gymnocanthus spp.			1.0					0.1
Armorhead sculpin					1.0			0.1
Myoxocephalus spp.		2.0		1.0	1.0	1.0		0.7
Rock sole	1.0	8.0	6.0	21.0	4.0			5.7
Yellowfin sole				2.0	3.0			0.7
Number of sets	1	1	1	1	1	1	1	7

Appendix Table 33. Trammel net catch in numbers of fish per set and number of sets by taxon and month in outer middle Kiliuda Bay.

	Apr	May	Jun	Jul	Aug	Nov	Mar	Mean
Pink salmon				0.5	0.5			0.1
Dolly Varden				2.0	1.5			0.5
Pacific cod			3.5	6.0	0.5			1.4
Pacific tomcod					0.5			0.1
Walleye pollock					1.5			0.2
Kelp greenling		0.5				0.5		0.1
Rock greenling	3.5	8.0	11.0	18.0	5.0	2.5	2.0	7.1
Masked greenling	2.5	2.0	21.5	191.0	112.5	10.5	0.5	48.6
Whitespotted greenling			2.0	8.5	10.5	1.5		3.2
Red Irish Lord					0.5			0.1
Yellow Irish Lord				1.0				0.1
Myoxocephalus spp.		2.0		1.0	2.5	0.5		0.9
Wolf eel					0.5			0.1
Rock sole	0.5	1.5	1.0	0.5			0.5	0.6
Yellowfin sole					0.5			0.1
Starry flounder	0.5							0.1
Number of sets	2	2	2	2	2	2	2	14

Appendix Table 34. Trammel net catch in numbers of fish per set and number of sets by taxon and month in outer Kiliuda Bay.

	Apr	May	Jun	Jul	Aug	Nov	Mar	Mean
Dolly Varden				0.5	1.0			0.2
Pacific cod				3.5	2.0			0.9
Kelp greenling						0.5		0.1
Rock greenling	3.0	16.0	15.0	16.0	10.5	9.5	2.0	11.6
Masked greenling	2.0	19.0	35.0	143.0	98.0	5.0		50.2
Whitespotted greenling	1.0	2.0	4.0	5.5	2.5			2.4
Buffalo sculpin						0.5		0.1
Red Irish Lord				1.0				0.2
Pacific staghorn sculpin			0.5					0.1
Myoxocephalus spp.	1.0	1.5		1.0	1.0			0.7
Rock sole		1.0						0.2
Number of sets	1	2	2	1	2	2	1	11

Appendix Table 35. Trammel net catch in numbers of fish per set and number of sets by taxon and month in inner Kaiugnak Bay.

	Apr	May	Jun	Jul	Aug	Nov	Mar	Mean
Dolly Varden				2.0	0.5			0.4
Pacific cod			1.0					0.2
Rock greenling	8.0	47.0	21.0	66.0	10.0	1.5		25.6
Masked greenling	5.5	27.0	41.5	139.0	53.0	1.0		44.5
Whitespotted greenling	0.5	3.5	1.5	3.0	6.0			2.4
Silverspotted sculpin		0.5						0.1
Red Irish Lord				0.5				0.1
Yellow Irish Lord				0.5				0.1
Myoxocephalus spp.	1.0	0.5	1.0		1.0	2.0		0.8
Rock sole	2.0	1.0	1.5					0.7
Starry flounder	0.5							0.1
Number of sets	2	2	2	2	2	2	0	12

Appendix Table 36. Trammel net catch in numbers of fish per set and number of sets by taxon and month in outer Kaiugnak Bay.

	Apr	May	Jun	Jul	Aug	Nov	Mar	Mean
Pacific herring					0.5			0.1
Pink salmon					2.5			0.5
Pacific cod					0.5			0.1
Kelp greenling		2.0	1.5		1.5	2.0		1.1
Rock greenling		38.0	55.0	66.5	40.0	13.0	2.0	37.8
Masked greenling		3.5	2.5	17.0	13.5	2.0	0.5	6.9
Whitespotted greenling		0.5	2.0		1.0			0.6
Red Irish Lord			1.5		2.5	1.0		0.8
Myoxocephalus spp.		0.5	0.5	0.5			0.5	0.4
Number of sets	0	2	2	2	2	1	2	11

Appendix Table 37. Surface tow net catch in numbers of fish per kilometer towed and number of tows, by taxon and month in inner Izhut Bay.

	Apr	May	Jun	Jul	Aug	Nov	Mar	Mean
Pink salmon	0.5		10.4					2.5
Hexagrammos spp.							0.8	0.1
Ling cod					1.3			0.2
Pacific sand lance					700.0			102.9
Number of tows	3	0	3	3	3	3	3	18

Appendix Table 38. Surface tow net catch in numbers of fish per kilometer towed and number of tows, by taxon and month in inner middle Izhut Bay

	Apr	May	Jun	Jul	Aug	Nov	Mar	Mean
Pink salmon			0.6					0.2
Pacific cod					0.4			0.1
Threespine stickleback	0.5						0.5	0.2
Kelp greenling							1.5	0.2
Whitespotted greenling			0.3					0.1
Pacific sand lance					2.8			0.5
Number of tows	5	0	4	2	5	5	5	26

Appendix Table 39. Surface tow net catch in numbers of fish per kilometer towed and number of tows, by taxon and month in outer middle Izhut Bay.

	Apr	May	Jun	Jul	Aug	Nov	Mar	Mean
Capelin			23.8					3.1
Number of tows	0	0	1	3	4	4	0	12

Appendix Table 40. Surface tow net catch in numbers of fish per kilometer towed and number of tows, by taxon and month in outer Izhut Bay.

	Apr	May	Jun	Jul	Aug	Nov	Mar	Mean
Capelin			33.1					7.0
Whitespotted greenling			0.6					0.1
Numbers of tows	0	0	2	4	4	4	0	14

Appendix Table 41. Surface tow net catch in numbers of fish per kilometer towed and number of tows, by taxon and month in inner Kalsin Bay.

	Apr	May	Jun	Jul	Aug	Nov	Mar	Mean
Pink salmon		18.4			18.5			8.8
Chum salmon		6.9						2.3
Threespine stickleback		0.2						0.1
Hexagrammos spp.		0.6						0.2
Whitespotted greenling		0.5						0.2
Ling cod					1.1			0.2
Tubenose poacher					0.4			0.1
Pacific sand lance		0.2				0.6		0.2
Numbers of tows	0	8	1	0	5	8	8	30

Appendix Table 42. Surface tow net catch in numbers of fish per kilometer towed and number of tows, by taxon and month in outer Kalsin Bay.

	Apr	May	Jun	Jul	Aug	Nov	Mar	Mean
Pink salmon		6.2			0.6			1.2
Chum salmon		1.9						0.3
Threespine stickleback		8.1						1.4
Ling cod					0.6			0.1
Pacific sand lance					0.6			0.1
Number of tows	0	2	2	0	3	3	3	13

Appendix Table 43. Surface tow net catch in numbers of fish per kilometer towed and number of tows, by taxon and month in inner Kiliuda Bay.

	Apr	May	Jun	Jul	Aug	Nov	Mar	Mean
Pink salmon		3.3			0.7			1.0
Chum salmon		3.3	357.5	10.7				64.1
Threespine stickleback			0.6					0.1
Pacific sand lance					164.7			26.6
Number of tows	2	3	2	3	3	3	0	16

Appendix Table 44. Surface tow net catch in numbers of fish per kilometer towed and number of tows, by taxon and month in inner middle Kiliuda Bay.

	Apr	May	Jun	Jul	Aug	Nov	Mar	Mean
Chum salmon	0.8							0.1
Capelin						13.5		3.3
Pacific sand lance				9685.0				1195.7
Number of tows	3	3	0	2	3	4	0	15

Appendix Table 45. Surface tow net catch in numbers of fish per kilometer towed and number of tows, by taxon and month in outer middle Kiliuda Bay.

	Apr	May	Jun	Jul	Aug	Nov	Mar	Mean
Pink salmon	0.6			43.9				14.7
Capelin				1.3				0.4
Pacific cod				2.1				0.7
Threespine stickleback	0.6							0.1
Lingcod				0.3				0.1
Tadpole sculpin				0.3				0.1
Prowfish					0.3			0.1
Pacific sand lance	0.6			5091.6				1697.3
Number of tows	4	0	0	7	6	6	0	23

Appendix Table 46. Surface tow net catch in numbers of fish per kilometer towed and number of tows, by taxon and month in outer Kiliuda Bay.

	Apr	May	Jun	Jul	Aug	Nov	Mar	Mean
Pink salmon				1.2	2.5			1.1
Capelin	2.5							0.1
Pacific cod				0.4				0.1
Prowfish				0.4				0.1
Pacific sand lance	10.0			1.6				1.1
Number of sets	1	0	0	5	4	5	0	15

Appendix Table 47. Surface tow net catch in numbers of fish per kilometer towed and number of tows, by taxon and month in inner Kaiugnak Bay.

	Apr	May	Jun	Jul	Aug	Nov	Mar	Mean
Threespine stickleback					0.5			0.1
Silverspotted sculpin					0.5			0.1
Pacific sand lance					1927.5			488.0
Number of sets	0	0	0	4	4	4	4	16

Appendix Table 48. Surface tow net catch in numbers of fish per kilometer towed and number of tows, by taxon and month in outer Kaiugnak Bay.

	Apr	May	Jun	Jul	Aug	Nov	Mar	Mean
Pink salmon					1.4			0.4
Pacific cod				0.5				0.1
Threespine stickleback					3.3			0.9
Whitespotted greenling					1.9			0.5
Ling cod					9.0			2.5
Prowfish				1.0				0.3
Number of sets	0	0	0	4	4	4	4	16

Appendix Table 49. Try net catch in kilograms per hour of trawling and number of tows, by taxon and month in inner Izhut Bay. T represents trace, less than 0.05 kg/hr.

	Apr	May	Jun	Jul	Aug	Nov	Mar	Mean
Tanner crab		1.7						0.4
Walleye pollock					T			T
Shortfin eelpout		T						T
Whitespotted greenling		0.1						T
Yellow Irish Lord		T						T
Myoxocephalus spp.	0.1	3.7						0.8
Snake prickleback		0.2		0.2	T			0.1
Stout eelblenny			T					T
Flathead sole		0.1						T
Rock sole	4.4	2.0		1.8				1.3
Yellowfin sole		5.8	0.1		1.3			1.6
Starry flounder		1.1						0.3
Numbers of tows	1	2	2	2	2	0	0	9

Appendix Table 50. Try net catch in kilograms per hour of trawling and number of tows, by taxon and month in inner middle Izhut Bay. T represents trace, less than 0.05 kg/hr.

	Apr	May	Jun	Jul	Aug	Nov	Mar	Mean
Tanner crab		0.2		2.8	0.1	0.3		0.6
Dungeness crab				1.5				0.3
Pacific cod				0.3				0.1
Walleye pollock		T			0.1	0.1		T
Whitespotted greenling		1.0				2.4		0.6
Ling cod						0.2		T
Sculpin spp		T						T
Spinyhead sculpin		0.1	0.2	0.1	T			0.1
Gymnocanthus spp.		0.4						0.1
Armorhead sculpin			3.0	3.0				0.8
Yellow Irish Lord		0.5		5.2		0.2		1.2
Myoxocephalus spp.	0.1	4.8		14.7	9.6			6.4
Sailfin sculpin				T				T
Sturgeon poacher		T						T
Searcher		0.1	0.6	2.4	1.1			0.8
High cockscomb	0.1							T
Snake prickleback				0.1				T
Daubed shanny				0.1	T			T
Stout eelblenny				0.1				T
Arrowtooth flounder		T	0.2	0.8	1.9	0.9		0.6
Flathead sole		0.3	0.3	14.3	2.5	1.8		3.5
Butter sole				2.8	0.5	0.1		0.6
Rock sole	T	0.5	1.9	0.5		1.2		0.5
Yellowfin sole		7.6	1.4	20.0	22.6	3.0		11.3
Dover sole				T				T
English sole						0.1		T
Number of tows	1	4	1	2	2	1	0	11

Appendix Table 51. Try net catch in kilograms per hour of trawling and number of tows, by taxon and month in outer middle Izhut Bay. T represents trace, less than 0.05 kg/hr.

	Apr	May	Jun	Jul	Aug	Nov	Mar	Mean
Tanner crab			2.5	0.9		T	5.2	1.3
Dungeness crab				1.6			0.2	0.3
Whitespotted greenling			0.7	0.2	0.4	0.1	T	0.2
Ling cod						T		T
Spinyhead sculpin	0.1		T				T	T
Gymnocanthus spp.	0.1		0.1		T			T
Armorhead sculpin	T		2.2	0.1	0.1	0.3	0.1	0.4
Threaded sculpin				T	0.1	T	0.1	T
Bigmouth sculpin	T							T
Pacific staghorn sculpin			0.2		0.4			0.1
Myoxocephalus spp.			4.6	5.9	2.5		5.4	2.8
Ribbed sculpin			T					T
Sturgeon poacher	0.1		T	T	T			T
Marbled snailfish	0.1							T
Searcher					0.2			T
Snake prickleback			T					T
Arrowtooth flounder		T	T	T	0.3	T		0.1
Flathead sole	T		0.6	0.1	1.4	0.9	0.3	0.5
Butter sole		0.8		1.1	4.5	0.7		1.0
Rock sole	8.6	39.1	24.9	30.4	32.9	19.0	4.1	23.0
Yellowfin sole	T	2.3	3.4	0.4	8.3	2.8	0.1	2.6
English sole					T			T
Sand sole			1.1	0.6	1.5	0.1		0.5
Pacific halibut		0.5	0.2			T		0.1
Number of tows	4	5	5	5	5	5	5	34

Appendix Table 52. Try net catch in kilograms per hour of trawling and number of tows, by taxon and month in outer Izhut Bay. T represents trace, less than 0.05 kg/hr.

	Apr	May	Jun	Jul	Aug	Nov	Mar	Mean
Tanner crab		0.1	T	T		T		T
Dungeness crab				0.5			T	0.1
Pacific tomcod			0.1					T
Whitespotted greenling						T	T	T
Gymnocanthus spp.	T	6.0			0.1			1.1
Armorhead sculpin			1.1	0.1	0.5	0.9	0.1	0.4
Threaded sculpin				0.1				T
Yellow Irish Lord		0.7		0.1				0.1
Northern sculpin		T						T
Myoxocephalus spp.			0.1	1.7				0.2
Roughspine sculpin				T				T
Ribbed sculpin		T			0.1			T
Smooth alligatorfish		T						T
Sturgeon poacher		T		0.1	T			T
Pacific sandfish			T				0.2	T
Searcher		T						T
Snake prickleback					0.1			T
Arrowtooth flounder		0.6		0.1	0.1	0.1		0.2
Flathead sole		0.1		0.8				0.1
Butter sole		0.1		4.1	0.3	0.2		0.7
Rock sole	53.7	15.8	105.3	109.0	92.4	30.4	3.9	57.3
Yellowfin sole		0.8	1.6	1.6				0.6
English sole						T		T
Starry flounder			2.5	16.1				2.6
Sand sole		2.1				0.2		0.3
Pacific halibut		0.9	1.1	0.8	0.2			0.4
Number of tows	4	3	4	4	4	4	4	27

Appendix Table 53. Try net catch in kilograms per hour of trawling and number of tows, by taxon and month in inner Kalsin Bay. T represents trace, less than 0.05 kg/hr.

	Apr	May	Jun	Jul	Aug	Nov	Mar	Mean
King crab		49.4	151.3	111.8	51.8	193.9	102.4	94.8
Tanner crab		10.5	6.9	11.2	6.1	27.4	2.1	9.2
Dungeness crab					1.6			0.2
Pacific herring							T	T
Capelin			0.1				T	T
Pacific cod			0.1				0.1	T
Walleye pollock		T	0.5		0.2			0.1
Whitespotted greenling		0.2	2.1	0.1	1.6		0.1	0.5
Ling cod						T		T
Sculpin spp.			0.1					T
Padded sculpin							T	T
Gymnocanthus spp.	0.3	0.8	2.7	0.5				0.6
Armorhead sculpin							0.2	T
Threaded sculpin				3.0	4.8	0.2	0.2	1.1
Yellow Irish Lord			0.4		T			0.1
Pacific staghorn sculpin			0.3				0.2	0.1
Myoxocephalus spp.		T	5.8	0.5	35.0			5.3
Sturgeon poarcher		T	T			T	0.3	0.1
Tubenose poacher			T					T
Snailfish spp.	T					T	0.3	0.1
Searcher					T			T
High cockscomb							T	T
Snake prickleback			0.1		T			T
Arrowtooth flounder			0.1					T
Rex sole					0.1			T
Flathead sole		0.1	0.9	0.1	11.8	T		1.7
Butter sole			0.3	0.1	0.3	1.5		0.3
Rock sole	3.6	9.8	18.5	7.1	10.6	10.4	2.8	8.6
Yellowfin sole		17.9	97.9	69.4	134.6	7.0	T	42.4
Dover sole			T					T
Starry flounder	0.3	7.6	3.9			1.7		1.8
Alaska plaice	0.1	T	0.1			1.2		0.2
Sand sole		2.0				T		0.3
Pacific halibut				0.1	0.8	0.8	T	0.2
Number of tows	5	4	4	4	4	5	5	31

Appendix Table 54. Try net catch in kilograms per hour of trawling and number of tows, by taxon and month in outer Kalsin Bay. T represents trace, less than 0.05 kg/hr.

	Apr	May	Jun	Jul	Aug	Nov	Mar	Mean
King crab		13.0	63.4	62.6	15.5	19.2		26.1
Tanner crab		6.7	17.6	11.9	5.8		7.8	7.0
Capelin			0.1					T
Pacific cod				0.3				T
Walleye pollock	T	0.2	0.1					0.1
Whitespotted greenling		0.2	0.7		1.3	0.9		0.5
Lingcod						0.2		T
Spinyhead sculpin				T				T
Buffalo sculpin	T							T
Gymnocanthus spp.	1.4	2.0	2.6		3.2			1.5
Armorhead sculpin				2.9				0.4
Threaded sculpin			2.8	1.8	0.2	3.3	0.6	1.2
Yellow Irish Lord			0.2	1.2				0.2
Pacific staghorn sculpin				1.3				0.2
Myoxocephalus spp.			4.8		13.4	11.9	0.9	4.6
Ribbed sculpin					T	0.1		T
Sturgeon poacher		T	T					T
Searcher			0.1	0.1				T
Arrowtooth flounder		T	2.5	1.0	0.8	0.1		0.7
Flathead sole		0.2	4.4	6.7	4.8	T		2.3
Butter sole			2.5	1.1	0.3	4.5		1.2
Rock sole	5.2	8.3	7.2	6.5	4.9	10.8	0.1	6.9
Yellowfin sole	0.1	19.3	86.9	42.5	86.7	22.0		39.2
Dover sole			0.1	0.1	0.3			0.1
Starry flounder			1.0					0.1
Alaska plaice			1.0		1.2			0.3
Pacific halibut	0.1		0.1		1.6	1.5		0.5
Number of tows	3	5	3	3	3	3	1	21

Appendix Table 55. Try net catch in kilograms per hour of trawling and number of tows, by taxon and month in inner Kiliuda Bay. T represents trace, less than 0.05 kg/hr.

	Apr	May	Jun	Jul	Aug	Nov	Mar	Mean
Tanner crab		0.6			1.1	T	8.0	1.6
Dungeness crab					6.6	1.0	10.8	3.1
Whitespotted greenling							1.8	0.3
Gymnocanthus spp.		1.6	0.5					0.3
Armorhead sculpin				0.8				0.1
Threaded sculpin			1.0		0.6	6.9	15.0	3.8
Yellow Irish Lord							0.1	T
Pacific staghorn sculpin							0.1	T
Myoxocephalus spp.						0.1	0.1	T
Slim sculpin			0.2					T
Ribbed sculpin					0.2		1.5	0.3
Searcher						0.2		T
Lumpenus spp.					0.5			0.1
Daubed shanny							0.5	0.1
Stout eelblenny					T			T
Flathead sole		0.5	0.4	1.1	10.2	4.8	3.0	3.3
Rock sole						1.8	0.9	0.5
Yellowfin sole		6.1	12.8	4.1	9.6	9.6	7.8	8.3
Starry flounder			6.9				6.0	2.2
Number of tows	0	1	1	1	1	1	1	6

Appendix Table 56. Try net catch in kilograms per hour of trawling and number of tows, by taxon and month in outer Kiliuda Bay. T represents trace, less than 0.05 kg/hr.

	Apr	May	Jun	Jul	Aug	Nov	Mar	Mean
King crab		45.8	25.7	44.5	7.1		105.2	33.6
Tanner crab		0.9	0.3	6.5	5.8	T	1.5	2.2
Dungeness crab		0.8		7.1	5.8	9.8	0.8	3.3
Pacific cod	0.8	0.2	0.4	0.8	0.4	0.1		0.4
Pacific tomcod			1.3	0.8	0.1	T		0.3
Walleye pollock			0.4	0.1		T		0.1
Dusky rockfish					T			T
Kelp greenling					0.1			T
Rock greenling						T		T
Masked greenling			0.2		0.3			0.1
Whitespotted greenling	0.2	0.3	2.5	2.5	3.6	0.5	0.1	1.4
Ling cod					T	0.1		T
Sablefish				0.3				T
Sculpin spp.		T						T
Padded sculpin					T			T
Crested sculpin			0.3			0.2		0.1
Silverspotted sculpin	T					T	T	T
Spinyhead sculpin	T		T	T	T			T
Gymnocanthus spp.	1.3	1.5	1.3					0.6
Armorhead sculpin		T	1.5	0.7	4.7	2.0		1.2
Threaded sculpin		0.4		2.2	2.0	1.1	0.1	0.8
Red Irish Lord						0.1		T
Yellow Irish Lord	T	0.3	8.5	5.0	28.9	T	T	6.3
Pacific staghorn sculpin	0.1	0.2	0.7		2.6	0.1		0.6
Myoxocephalus spp.	2.1	1.6	11.7	16.8	18.0	3.4	0.5	7.9
Scissortail sculpin			T					T
Roughspine sculpin						0.1		T
Ribbed sculpin			T		2.4	T		0.4
Sturgeon poacher			T	0.1	0.3	T		0.1
Bering poacher					T			T
Tubenose poacher							T	T
Snailfish spp.	0.1		T					T
Pacific sandfish				T				T
Searcher			T	0.1	0.5			0.1
Prickleback spp.					T			T
Snake prickleback		T			0.1		T	T
Daubed shanny		T			0.2			T
Stout eelblenny			0.1	T	T			T
Arctic shanny					T			T
Longfin gunnel			T					T
Crescent gunnel	T						T	T
Arrowtooth flounder				0.1	1.1	T		0.2

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Appendix Table 56. Try net catch in kilograms per hour of trawling and number of tows, by taxon and month in outer Kiliuda Bay. T represents trace, less than 0.05 kg/hr. (Continued)

	Apr	May	Jun	Jul	Aug	Nov	Mar	Mean
Flathead sole		T	1.7	4.2	5.9	0.9	T	1.8
Butter sole		3.3	9.6	3.4	3.6			2.9
Rock sole	3.8	13.7	6.0	14.6	11.2	6.8	0.1	8.1
Yellowfin sole	0.4	6.0	18.4	23.0	42.2	12.1	0.9	14.8
Dover sole			T	T	T			T
English sole			0.1		0.1	0.5		0.1
Starry flounder			1.0					0.2
Alaska plaice					1.0			0.1
Sand sole				2.1	1.6			0.5
Pacific halibut		0.3	0.3	1.4	4.9	T		1.0
Number of tows	5	5	5	5	5	4	5	34

Appendix Table 57. Try net catch in kilograms per hour of trawling and number of tows, by taxon and month in inner Kaiugnak Bay. T represents trace, less than 0.05 kg/hr.

	Apr	May	Jun	Jul	Aug	Nov	Mar	Mean
King crab		9.3	3.3	T				1.9
Tanner crab				T				T
Pacific cod		0.1		T		T		T
Walleye pollock	0.1							T
Rock greenling					T	0.1		T
Masked greenling	1.3				1.1	T		0.4
Whitespotted greenling		0.2	0.7	2.2	2.7	0.7		1.0
Lingcod						T		T
Silverspotted sculpin	0.1							T
Spinyhead sculpin			T					T
<u>Gymnocanthus</u> spp.	0.7	0.2	0.2					0.2
Armorhead sculpin					0.2			T
Threaded sculpin			0.7	5.1	0.9	T		1.0
Red Irish Lord	0.2					T		T
Yellow Irish Lord	0.1	0.1		7.3	3.2	0.1		1.7
<u>Myoxocephalus</u> spp.			2.9	8.9	2.4	15.6		4.6
<u>Triglops</u> spp				0.2				T
Scissortail sculpin	T							T
Ribbed sculpin			0.3		T	0.3		0.1
Tubenose poacher	T							T
Snailfish spp.							0.1	T
Prickleback spp.	T							T

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Appendix Table 57. Try net catch in kilograms per hour of trawling and number of tows, by taxon and month in inner Kaiugnak Bay. T represents trace, less than 0.05 kg/hr. (continued)

	Apr	May	Jun	Jul	Aug	Nov	Mar	Mean
Snake prickleback				0.1				T
Arctic shanny		0.1						T
Crescent gunnel	T	0.1						T
Flathead sole	T		0.9	0.1				0.2
Rock sole	4.7	1.1	0.5	4.7	3.6	3.0		2.7
Yellowfin sole	0.5	0.7	7.2	22.8	12.4	0.7		6.8
Pacific halibut		0.1		0.4		T		0.1
Numbers of tows	2	2	2	2	2	2	1	13

Appendix Table 58. Otter trawl catch in kilograms per kilometer trawled and number of trawls, by taxon and month in outer Izhut Bay. T represents trace, less than 0.05 kg/km.

	Apr	May	Jun	Jul	Aug	Nov	Mar	Mean
Scallop	0.5							0.1
King crab	1.0		0.8					0.3
Tanner crab	15.9	9.3	2.6	2.0	18.6	0.5	9.3	8.3
Dungeness crab	2.1	2.4	1.5	6.6	4.5	7.6	0.7	3.8
Big skate		T						T
Pacific herring		T	0.2	0.2	0.3	0.1	0.1	0.1
Capelin		0.2	0.1		0.1			T
Eulachon	T						T	T
Pacific cod	20.8	26.7	11.8	0.3	1.2	2.0	0.7	8.9
Pacific tomcod	13.2	2.9	1.6	33.7	4.9	91.1	6.5	23.4
Walleye pollock	4.7	0.8	1.0	11.0	7.6	9.9	12.4	6.7
Shortfin eelpout			0.7		0.2			0.1
Wattled eelpout					0.4			0.1
Sebastes sp.	0.1							T
Darkblotched rockfish						0.2		T
Hexagrammos sp.	0.1							T
Kelp greenling	0.1							T
Whitespotted greenling	0.1		0.2	0.3	T		0.1	0.1
Sablefish		2.0	125.2	5.6	3.1			21.5
Sculpin sp.	T					20.2		3.1
Spinyhead sculpin	0.3	0.1		0.2	1.3	0.3	0.5	0.4
Gymnocanthus spp[1]	4.7	64.2	16.6	14.7	20.8		1.0	15.9
Red Irish Lord						1.5		0.2

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Appendix Table 58. Otter trawl catch in kilograms per kilometer trawled and number of trawls, by taxon and month in outer Izhut Bay. T represents trace, less than 0.05 kg/km. (continued)

	Apr	May	Jun	Jul	Aug	Nov	Mar	Mean
Yellow Irish Lord	1.5	7.1	3.3	1.3	6.6	6.6	4.2	4.2
Bigmouth sculpin					0.2			T
Northern sculpin	T							T
Pacific staghorn sculpin	2.6					2.7	0.7	0.9
Myoxocephalus sp.	21.0	32.2	13.8	5.0	14.6	13.8	29.7	17.4
Triglops sp.					0.1			T
Ribbed sculpin	T			T	T			T
Sturgeon poacher	0.1		T					T
Pacific sandfish	0.1	T		0.4	0.5		0.2	0.2
Searcher	0.5	0.9	1.1	0.2	1.0	1.5	0.1	0.8
Northern ronquil	0.7							0.1
Pricklebacks	T							T
Snake prickleback		T	0.2	0.3	0.1			0.1
Daubed shanny				0.1				T
Arrowtooth flounder	4.4	29.0	11.6	7.7	14.5	11.9	5.8	11.6
Rex sole	T	0.2	0.4	0.2	0.9		T	0.3
Flathead sole	5.4	14.6	8.9	18.1	116.6	7.3	5.5	26.3
Butter sole	5.3	2.6		1.6	3.1	2.6		2.3
Rock sole	119.9	459.9	256.8	63.3	52.5	108.5	34.4	148.9
Yellowfin sole	55.2	39.6	40.8	40.1	67.8	54.4	34.9	48.6
Dover sole			0.4	0.1	0.1	0.4		0.2
English sole	0.6	0.4	3.1			2.9	T	1.1
Starry flounder	1.9	1.1	6.5	0.4	1.0	4.9	0.8	2.5
Sand sole	0.1		0.6			1.5	2.8	0.6
Pacific halibut	2.3	9.2	0.5	6.6	19.7	9.4	19.0	8.9
Number of trawls	3	2	3	3	3	3	3	20

[1]Gymnocanthus were not identified in April or May. During the remainder of the survey all individuals taken were armorhead sculpin.

Appendix Table 59. Otter trawl catch in kilograms per kilometer trawled and number of trawls, by taxon and month in outer Kiliuda Bay. T represents trace, less than 0.05 kg/km.

	Apr	May	Jun	Jul	Aug	Nov	Mar	Mean
Hermit crab	0.4							0.1
King crab	8.4	14.6	26.4	14.0	14.6	23.6	1.6	13.7
Hyas crab	T							T
Tanner crab	13.2	16.0	10.3	9.2	16.1	9.7	2.5	11.3
Dungeness crab		0.1		0.5	0.6		0.7	0.3
Spiny dogfish				0.5				0.1
Big skate	10.8	2.1	5.5	5.2	14.9			6.2
Longnose skate					1.2			0.2
Pacific herring	0.1					0.4		T
Capelin	0.2	T	T	T			0.7	0.2
Eulachon	T	2.2				1.3		0.4
Pacific cod	0.8	21.2	18.0	12.7	70.8	65.2	0.1	22.7
Pacific tomcod					0.5	2.6	T	0.3
Walleye pollock	1.3	4.1	3.6	7.7	78.7	45.4	0.1	17.2
Shortfin eelpout			T	0.2				T
Wattled eelpout				0.1	0.2			T
Sebastes sp.		T			T			T
Kelp greenling							T	T
Rock greenling	0.1							T
Masked greenling	0.7							0.1
Whitespotted greenling	T		1.3	0.8	1.0	0.6	0.4	0.6
Lingcod	T	0.2					T	T
Sablefish	0.1	9.9	10.3	0.8	3.5	12.6		4.5
Sculpin sp.	8.3							1.7
Spinyhead sculpin	T	0.1	0.3	T	T		T	0.1
Gymnocanthus spp.[1]	0.3	7.5	13.4	9.2	7.4	3.5	2.1	6.0
Yellow Irish Lord		197.9	159.6	338.3	164.5	215.5	T	138.1
Pacific staghorn sculpin		1.6	0.6			51.2	0.2	3.8
Myoxocephalus sp.	1.5	124.5	54.7	73.1	54.3	57.8	9.6	50.8
Triglops sp.		0.1						T
Ribbed sculpin	T	0.1					T	T
Smooth alligatorfish	T							T
Sturgeon poacher	0.1	2.2	0.4		0.6	0.6	T	0.6
Snailfish		0.1						T
Pacific sandfish	T	0.4		0.2		0.2		0.1
Searcher	0.3	0.3	0.3	0.8	0.1			0.3
Snake prickleback	0.1	0.1			T		T	T
Daubed shanny	T		T	T	T			T
Stout eelblenny					T			T
Whitebarred blenny	T							T
Arrowtooth flounder	T	3.8	2.4	1.1	5.4	26.9	T	3.7
Rex sole		T				1.5		0.1
Flathead sole	1.7	23.8	122.6	73.8	55.4	17.6	0.5	41.6

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Appendix Table 59. Otter trawl catch in kilograms per kilometer trawled and number of trawls, by taxon and month in outer Kiliuda Bay. T represents trace, less than 0.05 kg/km. (continued)

	Apr	May	Jun	Jul	Aug	Nov	Mar	Mean
Butter sole	0.5	7.0	2.6	1.3	1.8	19.2	0.2	3.3
Rock sole	3.6	23.4	5.6	10.4	7.2	4.1	10.1	9.4
Yellowfin sole	16.9	46.8	78.5	25.9	55.6	192.6	5.5	47.6
English sole							T	T
Starry flounder	2.3	5.4	6.8	2.0	3.3	4.8	2.0	3.7
Sand sole						4.7	1.9	0.6
Pacific halibut	3.1	11.5	34.5	12.0	70.5	19.8	0.3	21.0
Numbers of trawls	4	3	3	3	3	2	3	21

[1]*Gymnocanthus* were not identified in April or May. During the remainder of the survey all were armorhead sculpin except four threaded sculpins in March.

ECOLOGY AND BEHAVIOR OF SOUTHERN HEMISPHERE SHEARWATERS (Genus *Puffinus*) WHEN OVER THE OUTER CONTINENTAL SHELF OF THE GULF OF ALASKA AND BERING SEA DURING THE NORTHERN SUMMER (1975-1976)

by

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Final Report
Outer Continental Shelf Environmental Assessment Program
Research Unit 239

October 1982

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I. SUMMARY OF OBJECTIVES, CONCLUSIONS AND IMPLICATIONS WITH RESPECT TO OCS OIL AND GAS DEVELOPMENT

Several millions of Sooty Shearwaters (*Puffinus griseus*) and Short-tailed Shearwaters (*P. tenuirostris*) visit Alaskan coastal waters (OCS) during the northern summer months. They breed in Australia, New Zealand and Chile during the Northern Hemisphere's winter.

In accordance with Work Statement R.U. No. 239, attached to Contract No. 03-5-022-78, between the U.S. National Oceanic and Atmospheric Administration and the University of Calgary, data collected on the distribution, ecology and behavior of shearwaters during their non-breeding season, during the field work for this environmental assessment, have been used by Juan Guzman in partial fulfillment of the requirements for a Ph.D. degree at the University of Calgary (Guzman, 1981).

A. OBJECTIVES

The objectives were to learn something about the activities of these Southern Hemisphere seabirds and to delineate:

i) their distributions

ii) their regional movements and responses to environmental influences,

iii) the ecological requirements of these shearwaters, and

iv) whether shearwaters would be at serious risk from oil drilling and production.

B. CONCLUSIONS AND IMPLICATIONS

1. The Southern Hemisphere shearwaters are the predominant seabird species (over 90%), in terms of the total numbers of birds counted at sea from May to September each year, in Alaskan waters.
2. They mainly occupy the Continental Shelf of Alaska, rather than zones close inshore, and do not appear to overlap in their feeding areas or habits with local breeding species of seabirds to any significant extent.
3. Their distribution patterns are patchy, but what determines their movements remains undetermined.
4. The visiting shearwaters molt while in Alaskan waters.
5. Serious oil leaks that become widespread around the source, or continuing pollution down-current, could in certain localities or times alter the food chains upon which shearwaters are dependent. This might drastically reduce their numbers, or their ability to survive through the summer season and remain well-fed and healthy enough to successfully make the return migration to their breeding grounds in the Southern Hemisphere.
6. Because they breed in Australia, New Zealand and

Chile, interest in the fate of these birds assumes an international aspect that cannot be ignored.

II. INTRODUCTION

A. GENERAL NATURE AND SCOPE OF THE STUDY

The reproductive biology and the migrations of those shearwaters (Order Procellariiformes, Genus *Puffinus*) that breed at high latitudes in the Southern Hemisphere, but avoid the hazards of the southern winter season by making trans-equatorial migrations to visit rich feeding grounds in the North Pacific Ocean during the northern summer season, have been described by various authors in Palmer (1962) and by Richdale (1963), Phillips (1963), Ashmole (1971), Serventy et al. (1971), Shuntov (1974) and Guzman et al. (in prep.). Nevertheless, the ecology and behavior of these shearwaters during the non-breeding season in the North Pacific Ocean has not been studied in any depth until recently, even though many millions of these seabirds visit and evidently depend, as an integral part of their life cycle, upon the marine resources of the Bering Sea and Gulf of Alaska for several months each year. This project was devoted to their ecology and behavior during this period (May - September) when Short-tailed Shearwaters and Sooty Shearwaters occur over the Alaskan Outer Continental Shelf.

It is necessary to refer to both species together in most of this report, sometimes as 'unidentified shearwaters', because most were usually seen only at distances at which separation of the species was not possible. The differences are noted by:

i) Croxall (1971) who refers to "heavy build, white flash on linings of long narrow wings" in Sooty Shearwaters, and the body of Short-tailed Shearwaters as "very short behind long narrow wings";

ii) Serventy et al. (1971, in captions to Figures 71 and 72 on pages 127-128), who state that in Sooty Shearwaters "the white areas in centre of the [under] wing can be seen from a considerable distance" and distinguish them from the grey underwing coverts of the Short-tailed Shearwater, and who state that the bill of the Sooty Shearwater is also "longer and more slender";

iii) Falla et al. (1970), who state that the Sooty Shearwater has a "conspicuous silvery flash of the underwing coverts", while the Short-tailed Shearwater is "usually lacking the pale areas under the wings...The bill is proportionately shorter...and the general smaller size is also a useful field character"; and

iv) Fullagar (1970) who refers to the Short-tailed Shearwater as "slightly smaller" and to the Sooty Shearwater as having "pale wing linings" and a "longer bill".

The above descriptions were all obtained from Southern Hemisphere authors. In the Northern Hemisphere, when these shearwaters are molting, observers generally describe distinguishing the two species as from difficult to extremely difficult (e.g. Isleib and Kessel, 1973; Wahl, 1975; Stallcup, 1976). British Columbian Patrick W. Martin (personal communication) notes that during molting "many of the characteristics of colour break down...I have found underwing colour to be wholly unreliable as a diagnostic character, probably owing to the fact that these are wintering birds and continually molting when in the North-eastern Pacific". However, J.R.G. found that, under good conditions and within 50 meters, up to 60 per cent could be distinguished. The large size and long bill were used to identify the Sooty Shearwater, and the shorter bill and abrupt forehead were used to distinguish the Short-tailed Shearwater.

Because of the devotion of this Research Unit to shearwaters, and because shearwaters formed over 90% of the several million seabirds recorded by J.R.G. during cruises on R/V DISCOVERER and R/V SURVEYOR, the text of this Final Report does not deal with other seabirds. Nevertheless, all other seabirds encountered were counted, and these counts have been submitted as raw data in a magnetic data tape and separate tabulations, submitted previously.

The latest information on the likely impact of petroleum on shearwaters is considered, insofar as this is yet predictable, in relation to their known distribution in Alaskan waters.

B. SPECIFIC OBJECTIVES

The revised objectives of this project, based on field experience and what proved to be practicable in 1975, became to obtain data on:

1. The latitudinal-longitudinal distribution of the Short-tailed Shearwater and the Sooty Shearwater in four regions, the Northeastern Gulf of Alaska (NEGOA), the Kodiak Island Shelf, the Northwestern Gulf of Alaska (NWGOA) and the Southeastern Bering Sea and, in particular, the relationships between the distribution of these shearwaters and a) the distance from the coast of Alaska, and b) whether the birds were most abundant over the Continental Shelf or beyond it.
2. The sizes of the flocks in which shearwaters are observed, and the behavioral dynamics of aggregated shearwaters when these were encountered.
3. The plumage and molt condition of these Southern Hemisphere visitors during the months May - August.

C. RELEVANCE TO THE PROBLEMS OF PETROLEUM DEVELOPMENT

Extensive direct ('acute') kills of seabirds have been recorded as a result of oil spills in various sites around the world. Few if any have, so far, threatened the extinction of a species. This should not lead to complacency, however, because extinction of a species is a possibility in Alaska. This is because the Bering Sea - Aleutian Islands region is 'home' to several endemic species of seabirds not found elsewhere.

Perhaps more significant, but far less easy to evaluate, are the longer term ('chronic') effects of oil pollution of the sea upon the food resources, proper reproductive functioning and traditional livable habitat requirements of seabirds. Some aspects of these questions are reviewed in the next section.

From this field study in 1975 and 1976 it is only possible to say that, before it is possible to determine whether offshore oil development in Alaska would or would not have a serious impact on the survival of populations of visiting (non-breeding) shearwaters, more prolonged study of the movements and distribution of shearwaters over the OCS area is required. The dispersal of oil over the surface of the water depends upon several environmental factors (e.g. winds and currents), some of which are also involved in bringing about the actual distribution and movements of certain elements in the food chain that lead up to those that are the food of shearwaters. Data from other data sources that might make such an assessment feasible have not yet been obtained.

Analytical techniques for petroleum fractions in animal tissues, and trace metals in feathers or bones derived from identifiable or 'signatured' oils from particular oil fields, are still in their relative infancy (but see references provided later). Yet, these are essential as baseline data against which pollutant levels in future years can then be compared. It is necessary, for example, to establish now what such pollutant levels in shearwaters are that can be 'labelled' as having been derived from Middle Eastern tanker-borne oils, so that the degree of pollutant uptake of Alaskan oils may be correctly assessed during the 1980's. To what extent, for instance, do such pollutants currently disappear from the visiting shearwaters' bodies during their sojourn in Alaskan waters, and how will this be altered now that North Slope oil has begun to move by tanker down the west coast of Canada from Valdez?

III. CURRENT STATE OF KNOWLEDGE

A. AN INTERNATIONAL RESOURCE

Although the Short-tailed Shearwater and the Sooty Shearwater are the most numerous species of seabirds over the Outer Continental Shelf of the Gulf of Alaska and the Bering Sea away from the immediate coastline in the summer months, neither species breeds in Alaska. They visit subarctic North Pacific waters during their non-breeding season, occurring in Alaskan waters during the period of winter in the Southern Hemisphere, from April to September.

Green (1916) described a migration of shearwaters in April 1915 as "a three days' constant stream...in an almost unbroken line past Langara Island [British Columbia], all heading from Dixon Entrance and disappearing to the north-west towards the Aleutian Islands....migrating hosts, returning to spend their winter in our summer seas after breeding". Gabrielson and Lincoln (1959) in The Birds of Alaska describe "the endless swarms...[of Sooty Shearwaters]...one of those great spectacles...never to be forgotten...one of the most spectacular panoramas of life which this continent has to offer." The Sooty Shearwater is described by Johnson (1965) in The Birds of Chile as "probably the sea-bird which in sheer numbers surpasses all others".

Isleib and Kessel (1973) describe the Sooty Shearwater as "the most numerous" in the North Gulf Coast area east of Kodiak Island. They reported "tremendous concentrations totalling millions" of Sooty Shearwaters on 1 July 1965 in inner Kennedy Entrance between the Chugach and Barren Islands (over 2,600,000), and in June 1965 "square miles of sitting birds" in Hinchinbrook Entrance.

Estimates of the numbers of both species of shearwaters "wintering" in the Bering Sea have been attempted (Shuntov 1974, Sanger and Baird 1977) and are around 10 million birds, making them the most abundant species there during the northern summer (Hunt et al. 1981b).

The Short-tailed Shearwater is the Tasmanian "mutton bird" of Australian commerce, and Serventy et al. (1971) state, in The Handbook of Australian Sea-Birds, that 54,000 Short-tailed Shearwaters had been banded by Australian Government agencies up to 1965, in the course of studies upon this economically-important species of seabird. Estimates of the total world population of Short-tailed Shearwaters are hard to obtain but Dr. Naarding of Tasmania has recently calculated that there are 16 million (Kuroda, 1982). In economic terms, in one year alone (1968), 466,000 were harvested for food, fat, pharmaceutical oils and down at $12-16 per 100 birds, a total value of about $A 70,000 (Serventy et al. 1971).

The Short-tailed Shearwater was previously reported to be the more common of the two species in the Bering Sea and among the Aleutian Islands (Murie, 1959). The Sooty Shearwater, which migrates both north and south along the western seaboards of South and North America, was said to be the more common of the two species in the eastern sectors of the Gulf of Alaska. But the true status of the two species in the northwestern part of the Gulf of Alaska and the Aleutian Islands is less clear.

Shearwaters have been the subject of study by Japanese scientists for many years e.g. Kuroda (1955, 1957, 1960), and have been studied in the northwest Pacific Ocean in recent years by Wahl (1978), Tanaka and Kajihara (1979), Ogi et al. (1980) and Ogi (1981).

Shearwaters do not return to the colony until they are at least three years old and do not breed until older than this; some subadult birds may remain in the Northern Hemisphere until mature (Serventy 1956b, Serventy et al. 1971).

The OCS Draft Study Plan (page 20) referred to the seabird population of the Gulf of Alaska as an "International Resource", and this the shearwaters from southern Chile, New Zealand and Australia certainly are. Sowl and Bartonek (1974) discussed the value of seabirds, and described them as Alaska's "most neglected resource".

Finally, the carrying of influenza viruses by water birds (Webster and Laver, 1975; Webster et al. 1976, 1977), apparently includes shearwaters (Kaplan and Webster 1977), making the migrations of shearwaters a topic of concern in the field of epidemiology and international aspects of disease control.

B. SHEARWATER ECOLOGY AT SEA IN THE COASTAL DOMAIN AND THE IMPORTANCE OF THE ALASKA CONTINENTAL SHELF TO SHEARWATERS

The writings of Murie (1959), Gabrielson and Lincoln (1959), Swartz (1967), Martin and Myres (1969), Bartonek (1971, "102 statement-description of bird resources along proposed tanker route from Port of Valdez to southern terminals"), Bartonek and Gibson (1972), Isleib and Kessel (1973), Shuntov (1964, 1974) and Gill et al. (1979) on the North Pacific region, provide the background accounts of the ecology of shearwaters during the period of the year when they occur close to shore in the Bering Sea and the Gulf of Alaska.

The subject has been most recently reviewed by Strauch (1980) for the Northeastern Gulf of Alaska and Strauch et al. (1980) for the Kodiak Island region of the Northwestern Gulf of Alaska. Hunt et al. (1981b, 1982) have reported on the pelagic distribution of marine birds in the Southeastern Bering Sea. Besides our own previous reports for 1975 and 1976 (Myres and Guzman, 1976-1977), shipboard surveys in Alaskan waters during the OCSEAP program have been reported as follows: for 1975, Lensink and Bartonek (1976); for 1976, Gould et al. (1977); and for 1977, Lensink et al. (1978). Aerial surveys were reported by Harrison et al. (1977) and Harrison (1982).

The number of shearwaters observed in the center of the Gulf of Alaska, however, has not been spectacular at all (M.T. Myres, unpublished data from 1958 to 1981, for Ocean Weather Station "Papa" at 50 degrees N, 145 degrees W), so it was evident that more information was needed on the width of the coastal zone along which the shearwaters feed and migrate.

Sanger (1972, page 601) estimated that the group to which the shearwaters belong comprised 84% of the standing stocks and 89% of the biomass in the Coastal Domain of the North Pacific Ocean during the summer. Interference with the food chain on the Alaskan Outer Continental Shelf might cause a substantial reduction in the world population of these most abundant birds, since a high proportion of the total population appears to depend on the resources of the region for a large period of the year.

The role of shearwaters in rapidly recycling nutrients in the surface marine ecosystem, in redistributing them during their movements, and in thus fertilizing the waters of the Subarctic North Pacific Ocean, is clear from their preponderant numbers and position at the top of the food chain, feeding as they do on euphausiids, squids and fish and converting these to readily reabsorbed feces. Sanger (1972) warned that since the Sooty and Short-tailed Shearwaters "have populations numbering at least in the tens of millions....a large reduction in their numbers could influence their ecosystems adversely".

Wiens et al. (1980) simulated the energetics of seabird populations and their sensitivity to perturbations in their food supply.

There is no evidence that shearwaters form an important food for any predator upon them, although when they die their bodies are contributed to the scavengers and decomposers in the region in which this occurs. The rapid migrations of Short-tailed and Sooty Shearwaters across the equatorial zone suggest that they export little in the way of nutrients from Alaskan waters to that zone; rather, because many shearwaters newly raised each year in Australasian and Chilean colonies must die during their stay in Alaskan waters there may be a net importation of biomass as a result of their coming there. About the importance of shearwaters to the Australasian countries there can, in any case, be little doubt.

The interactions of shearwaters with other species of seabirds are complicated by (1) the fact that the shearwaters are not tied to breeding colonies in the Northern Hemisphere, (2) their enormous numbers, (3) their mobility, and (4) their usual avoidance of nearshore waters (bays and inlets). Hoffman et al. (1981) consider shearwaters to be both catalysts (attracting other species to feeding areas) and suppressors (preventing feeding by other species). They found that shearwaters and kittiwakes initiated most mixed-species feeding flocks in Alaska.

C. MOVEMENTS OF SHEARWATERS WITHIN THE COASTAL ZONE DURING THE SUMMER MONTHS IN RELATION TO FOOD AND WEATHER-RELATED STRESSES

Sanger (1972, page 607) wrote that "very little is known about distribution, abundance, and movements of seabirds in the region and their relationships with the pelagic environment". For a long time, the Short-tailed Shearwater has been known to sailors in Alaskan waters as the "whale bird" (Gabrielson and Lincoln, 1959), and Murie (1959) states that "it may be significant that the center of abundance of shearwaters in the Aleutians today coincides fairly well with localities where whales were once particularly abundant in the Fox Island group". A relationship exists between the distribution of baleen whales and a high marine productivity where there are water mass boundaries (Uda, 1954), and in both the Gulf of Alaska and the Bering Sea whales apparently move along the margin of the Alaskan Stream (Nemoto, 1959; Fig.16.12 in Nasu, 1974). Harrison (1979) discusses the association of shearwaters with whales in the northern Bering Sea, and it is significant that whales were seen on August 17, 1975, at the same time as several million shearwaters (Table 1).

One of the unexplained facts frequently noticed is that shearwaters "vary in numbers from day to day in any given locality" (Martin and Myres, 1969). While this is apparently most often due to feeding conditions changing with the tides or winds and currents, Manikowski (1971) obtained some evidence that some seabirds leave an oceanic region that is in the path of an advancing storm or advancing fronts associated with cyclonic conditions. Shearwaters may make cyclone-related "weather movements" from one locality to another within their overall region for the particular season, but we were not able to determine whether the directions in which flocks were observed moving during the summer months, when they are not actually migrating, were weather-related or wind-related.

The ability of shearwaters to smell (Grubb, 1972) suggested the probability that the wind could either inform them of feeding conditions upwind (Hutchison and Wenzel 1980) e.g. at upwelling areas, or of weather conditions at a distance, and produce a local movement in response.

The extent to which shearwaters feed or make organized local movements at night outside the breeding season is unknown. That shearwaters can feed on fish in darkness was established for Wedge-tailed Shearwaters (Puffinus pacificus) by Gould (1967). So, it may not be surprising if flocks seen one day are not to be found in the same place on the next day but, because the vessels from which observations in this study were made were usually travelling at night, little information on this phenomenon was obtained during this study and it remains a major gap in our knowledge.

Because euphausiids come nearer to the surface at night (Alton and Blackburn 1972), it would be expected that shearwaters might feed at night at the lower latitudes in southern Alaska in summer, although few observers have been very specific about this. On the other hand, swarming of euphausiids takes place in the daytime (Komaki 1967). Komaki also points out that Euphausia pacifica swarms off Japan at temperatures between 7 - 16 degrees C from February - May.

Bad weather sometimes causes mortality to seabirds on a large scale at sea (e.g. Bailey and Davenport, 1972).

TABLE 1 : AGGREGATIONS OF SHEARWATERS OF MORE THAN 10,000 BIRDS SEEN IN 1975

MONTH DAY TIME	REGION AREA LOCATION DS=distance from shore(est.) D=depth estimate (fathoms)	PHYSICAL CONDITIONS SST=sea surface temp. AT=air temp. B=barometric pressure W=wind; direction(degrees) strength(knots) S=wave height(feet)+ swell height(feet)/ direction(degrees)	CENSUS DATA No. of birds, Transect type(N,E or S), and duration CA=census area (km^2) MD=max. density (birds/km^2)	DESCRIPTIVE REMARKS F=No. of flocks FSR=flock size range MFS=mean flock size
June 8 2000-2115	BERING SEA North Bristol Bay 58°10'N., 159°44'W. DS 28 nm. D 15	SST 3.6°C AT 6.0°C B 29.74 W 135°/6k S 1 + 2/100°	15,350 E - 75 min. CA 28.7 km^2 MD 535	Short-tailed Shearwaters F 21 FSR 150-1000+ MFS 731 Molt.
June 10 1045-1100	BERING SEA South of Cape Newenham 58°02'N., 161°52'W. DS 32 nm. D 23	SST 1.6°C AT 5.0°C B 29.98,rising W 265°/5k S 0+0/-	15,000 E - 15 min. CA 35.7 km^2 MD 421	Short-tailed Shearwaters F 13, on the water MFS 1,154 Molt From 1115-1130 there were another 8000 birds in 8 flocks and from 1345-1442, 6000 birds in 5 flocks. The distance between these flocks was ca. 500m.
June 10 2210-2245	BERING SEA Southwest of Cape Newenham 58°22'N., 163°03'W. DS 34 nm. D 17	SST 1.8°C AT 3.6°C B 29.95 W 265°/5k S 0+0/-	110,000 E - 35 min. CA 121 km^2 MD 909	Short-tailed Shearwaters F 47, on the water (70,000 birds) at 2210 F 32, on the water (40,000 birds) at 2240 FSR 200 - 2000 birds MFS 1,392 Some birds were flying among the flocks, others formed small groups of 10-50 birds. No more than 1 % were flying simultaneously. Food regurgitated under harassment from jaegers was semidigested euphausiids

Table 1 (continued):

June 12 0430-0500	BERING SEA Outer Kusko-kwim Bay 58°47'N., 164°15'W. DS 60nm. D 17	SST 1.8°C AT 2.1°C B 29.82,falling W 035°/16k S 1+2/020°	17,500 S - 30 min. CA 38.5 km^2 MD --	Short-tailed Shearwaters F 1 (17,500 birds) MFS 17,500 A big flock that crossed the bow for 30 minutes. It was only 100 metres wide but more than 10 km long (an area of ca. 1.0 km^2). The distance between individual birds was only 2-25 metres.
July 24 1325-1440	ALEUTIANS Urilia Bay, North Unimak Island 54°57'N., 164°21'W. DS 2.5 nm. D 9	SST 6.7°C AT 15.6°C B 29.64 W 320°/2k S 0+?	42,000 (est.) E - 75 min. CA 1.13 km^2 MD 37,168 (Urilia Bay)	Short-tailed Shearwaters The birds were moving from east to west (towards 270°) for 75 minutes. They were travelling in long files ca. 50 metres wide. The birds settled on the water ca. 2 miles to the west in flocks of ca. 1000 birds each.
July 24 2135-2220	ALEUTIANS North Unimak Pass, Shelf Edge. 54°33'N., 165°37'W. DS 15 nm.(exact) D 173 (exact)	SST 6.7°C AT 9.4°C B 29.64 W 290°/8k S 0+1/220°	50,714 E - 45 min. CA 9.72 km^2 MD 5,218	Short-tailed Shearwaters
July 27 1155-1200	ALEUTIANS North Akutan Pass,Shelf Edge 54°09'N., 166°14'W. DS 5 nm. D 28	SST 7.8°C AT 8.9°C B 30.13 W 112°/9k S - + -	57,000 E - 5 min. CA 1.54 km^2 MD 37,013 (N.Akutan Pass)	Short-tailed Shearwaters (plus some Sooty Shearwaters) Fog, so birds were estimated only out to 500m. from the ship during this 5 minute observation period.

Table 1 (continued):

August 5 0915-1420	KODIAK SHELF NE Kodiak, NE of Woody & Long Islands 57°50'N., 152°17'W. DS 2 nm. D less than 30	SST 8.6°C AT 12.3°C B ? W ?/? S 2+1/?	50,000 E - 305 min. (Launch trip) CA 45 km² MD 1,701	Sooty Shearwaters (90% of total, and Short-tailed 10% of total). A mixed flock with 20,000 Black-legged Kittiwakes. Feeding on small fish.
August 6 0920-1430	KODIAK SHELF NE Kodiak, NE of Woody & Long Islands 57°50'N., 152°17'W. DS 2nm. D less than 30	SST 8.9°C AT 19.4°C B 29.83 W -/- S -/-	40,000 E - 310 min. (Launch trip) CA 45 km² MD 1,460	Short-tailed Shearwaters (70% of total) A mixed flock with 20,000 Black-legged Kittiwakes. Feeding on small fish.
August 11 1715-1730	NWGOA Shumagin Islands 55°08'N., 160°27'W. DS 1.2 nm. (exact) D 29 (exact)	SST 10.0°C AT 11.5°C B 29.58, falling W 015°/12k S 1+2/110°	16,000 N - 15 min. CA 1.95 km² MD 8,210	Sooty Shearwaters
August 17 1435-2000	BERING SEA South Nunivak Island 59°03'N., 167°58'W. ⟶ 58°39'N., 167°42'W. (a transit distance of 25-30 miles). DS min. 63 nm. max. 82 nm. D 22-29	SST 8.9°C ⟶ 8.3°C AT 10.0°C ⟶ 9.4°C B 29.69 ⟶ 29.64 W 060°/11k ⟶ 060°/14k S 1+4/340° ⟶ 2+3/320° (2) The Shearwaters were both settled on the water and flying, often in big circles. Some appeared to be feeding. Individual flocks varied greatly in size, in the distance between each flock and the next one, and in the distance from one bird to another. FSR 100-6,000. Many flocks took off and flew only 100-200m before settling again.	6 - 10,000,000 (in 5 1/2 hrs) E - 325 min. CA(est.) 1152 km² MD(est.) 5,210 - 8,680 (max. in 10 minutes: CA 12.96 km² MD 15,432).	Both Short-tailed and Sooty Shearwaters were present, but accurate relative proportions of each were not established for the entire "super-aggregation". Short-tailed Shearwaters predominated, but some individual flocks were mainly (80%) composed of Sooty Shearwaters. (1) "Flocks all over the ocean to the horizon - flocks with thousands of birds." Numbers of shearwaters between the ship and the horizon were calculated at various times during the day as follows: 1510-1530: 40,000 (to horizon) + 100,000 (near horizon) = 140,000 1535 : 200,000 1615-1625: 250,000 (At least five whales were seen during this period.)

Table 1 (continued):

August 18 1615-1635	BERING SEA East of Pribilof Islands 57°22'N., 167°35'W. DS 77 nm. D 40	SST 10.0°C AT 11.1°C B 29.52 W 040°/17k S 3+4/070°	68,000 E - 20 min. 1615-1620 CA 4.2 km^2 MD 12,619 1620-1635 CA 0.7 km^2 MD 21,733	Species unidentified, but both Short-tailed and Sooty Shearwaters believed present. From 1615-1620 a flock estimated at about 50,000 was in flight about 3 nm. from the ship. "The birds fly in circles." Closer to the ship there was another 3,000 birds about half of which were settled on the water. In this flock the birds "fly in circles too".
		Fog made observation difficult from 1620-1635, but two flocks (of 10,000 and 5,000 birds respectively) were recorded. In the smaller flock, about 75% were sitting on the water. Feeding birds dove from a height of 2-3 metres.		

Storms at sea often result in pelagic seabirds being seen in unusual numbers along the coasts of the Pacific Northwestern States, perhaps aggregated and blocked by the land mass in the course of making normal 'escape flights' away from approaching bad weather. In response to bad weather conditions and poor feeding conditions, the relative distribution of pollutant residues (e.g. DDT derivatives, dieldrin and PCB's) as between one tissue and another may change in shearwaters over quite short periods of a few days (or a week or two), and such mobilization of pollutants and exposure of more sensitive tissues and organ systems to them should induce stress and, on occasions, mass mortality. Seabird specimens taken under different conditions could exhibit different values.

D. THE THREAT OF OIL TO SEABIRDS

Because shearwaters travel along both the North American coast and the coast of Japan during their migrations across the equatorial, tropical and temperate latitudes, they are exposed to pollutants. Among these near industrial areas are polychlorinated biphenyls, which have been found in seabirds.

The fate of oil in the ocean has been reviewed by ZoBell (1964), Berridge (1968), Pilpel (1968), Anderson et al. (1974) and the Ocean Affairs Board (1975).

One of the busiest oil tanker routes in the world is that from the Persian Gulf to Japan, and Short-tailed Shearwaters migrate along part of this route in the Western Pacific Ocean. The oil threat to seabirds on the Canadian West Coast has been reviewed by Bartonek and Sowl (1972), Vermeer and Vermeer (1975), Canada (1978), and Thompson (1978), and on the Yukon coast by Vermeer and Anweiler (1975).

Of the damage that can be caused by oil, among the most important is the oiling of birds (Clark and Kennedy, 1968; Vermeer and Vermeer, 1974 and 1975; Smith, 1975). The feathers of birds once oiled lose their waterproofing and insulating quality, and consequently the birds lose their buoyancy and the capacity to control the temperature of the body (Vermeer and Vermeer, 1975). Overall effects of oil pollution of the sea on seabirds have been documented by Clark and Kennedy (1968), Clark (1969), Bourne (1970, 1972, 1976) and Ohlendorf et al. (1978).

In 1970, at least one tanker/day was arriving in Cook Inlet to load oil from the Kenai-Cook Inlet oilfields, and it has been estimated that 0.3% of all oil handled in Cook Inlet is spilled (Kinney et al., 1969); further, tides and winds flush much of this oil out of Cook Inlet rapidly. The toxicity of the water-soluble fraction of Cook Inlet crude oil has been studied by Nunes and Benville (1978) and Whipple et al. (1979). With the movement of Prudhoe Bay crude from Valdez by tankers that started in June 1977, the problem cannot but escalate.

The history of incidents involving oil and seabirds is a long one with an extensive literature. The number of birds killed during a spill of oil depends mainly on the characteristics of the 'incident', physical conditions of the environment (currents, weather, distance offshore), season of the year, proximity to colonies and species of birds present in the area. It has been estimated that 150,000 - 400,000 seabirds are killed annually in the North Atlantic Ocean (Tanis and Morzer Bruyns, 1969).

During the winter 1969/70 the U.S. Dept. of the Interior (1970) estimated that from 10,000 - 100,000 seabirds were killed by oil (probably routine ballast discharges) in the Gulf of Alaska. Jim King ("Bird kills from oil contamination in the Gulf of Alaska, February - March 1970"; unpublished report to Regional Director, Bureau of Sport Fish and Wildlife, Portland, Oregon, March 1970) considered that they were found ashore mainly because of an unusual 6-week period of southeast winds in February-March 1970, <u>not</u> because the mortality level was itself abnormal; the abundance of globs of oil "formed around feathers" suggested that the birds from which they came had died and decomposed at sea some considerable time earlier and that this might be quite a common event offshore. It was stressed that it is impossible to calculate the number of seabirds that are not drifted ashore, but are instead 'trapped' in the offshore Alaskan Gyre of the Gulf of Alaska.

Differences in the effects of oil on different taxa are not well known, although species behave in varying ways in the presence of oil on the surface of the water: murres and penguins dive, and Manx shearwaters, gulls and kittiwakes fly away (Bourne, 1968; Vermeer and Vermeer, 1975). Oil Vulnerability Indices were prepared for 176 species of marine birds by King and Sanger (1979). For the Northeast Pacific Ocean, Sooty and Short-tailed Shearwaters had total scores of 51 and 53 respectively, which is in the middle range (maximum vulnerability is 100). Ford et al. (1982) attempted to estimate the long-term consequences to seabird populations of both one-time and chronic oil spills.

Unfortunately most species react only after contact with an oil slick. Under calm wind conditions and smooth-surfaced areas of down-welling, shearwaters tend to aggregate and settle; unfortunately, oil slicks tend to simulate these natural conditions under still-air conditions or very light winds and smooth the water surface. In such circumstances shearwaters could become oiled in large numbers, although we know of no recorded incidents of this, perhaps because major oil spills and large aggregations of shearwaters may not so far have coincided in the oceans of the world prior to this possibility having arisen in Alaskan waters.

Another cause of seabird mortality, indirectly due to petroleum, is likely to be caused by loss of the food species upon which seabirds depend on. Few confirmed and documented examples have been studied in detail, however.

Judging by reports of Bourne (1968), Monaghan et al. (1973), Wellman (1973), Wong et al. (1974, 1976a), Butler (1975) and Brown and Huffman (1976), southern hemisphere shearwaters have plenty of opportunity for ingesting petroleum products. Boersma (1981) has demonstrated that storm-petrels breeding in the Barren Islands, north of Kodiak Island, do ingest fuel hydrocarbons and that these can be detected in stomach samples.

E. THE DETECTION OF OIL-DERIVED HYDROCARBONS AND THEIR EFFECTS

The degree to which oil and oil-derived hydrocarbons are harmful to water birds, and in what manner, is not well established, apart from i) acute toxicity through ingestion and ii) the loss of thermoregulatory capacity caused by oiling of the plumage (Hartung and Hunt, 1965; Hartung, 1967).

Methods for determining the presence of petroleum-derived residues in plant and animal tissues, including zooplankton and fish had only recently begun to be developed when this study of shearwaters was first proposed. Effects of petroleum uptake on marine organisms and its transfer through the food chain have been described in: ZoBell (1964), Synder et al. (1971), Lee et al. (1972), Lee (1975, 1977), Holmes and Cronshaw (1977), Malins (1977), Stegeman (1977), Wolfe (1977, 1978), Malins (1979), Whipple et al. (1979) and Neff and Anderson (1981).

The detection and fate of oil-derived hydrocarbons in seawater have been studied by Boylan and Tripp (1971), Payne (1976), Wong et al. (1976a, 1976b) and Cretney et al. (1977). Bourne and Bibby (1975) showed how the temperature of the water varies the threat of oil to seabirds.

Slow, chronic, harmful effects on seabirds from petroleum breakdown products and fractions were almost unknown when this study began. Clark and Kennedy (1968 pages 11-16) and Clark (1969) had reviewed what was known. Hartung and Hunt (1966) found that industrial oil caused lipid pneumonia, gut irritation, fatty livers and adrenocortical hyperplasia when fed to ducks. Crocker et al. (1975) studied the effects of oil fractions on intestinal functions in ducklings. Peaker (1971) suggested that oiling of birds could affect the activity of the salt glands. The influence of petroleum products on avian reproduction (egg formation, and embryo and chick development) has been studied by Hartung (1965), Grau et al. (1977), Albers and Szaro (1978), Miller et al. (1978), Butler and Lukasiewicz (1979), Peakall et al. (1980), and Ainley et al. (1981). McEwan and Whitehead (1978) suggested that mature gulls may be able to metabolize low levels of petroleum hydrocarbons.

F. OCEANOGRAPHY OF THE STUDY AREA (FIVE REGIONS)

The oceanography of the subarctic North Pacific Ocean has been studied extensively during the last 30 years by, among others, Fleming (1955), Dodimead et al. (1963), Uda (1963), Tully (1964), Dodimead and Pickard (1967), Royer (1975), Ingraham et al. (1976), Favorite et al. (1976), Sobey (1980a, 1980b) and Muench and Schumacher (1981).

The oceanography of the Bering Sea has been reviewed in, among others, Zenkevitch (1963), Kitano (1970), and various authors in Hood and Kelley (1974) and Hood and Calder (1981), including Gershanovitch et al. (1974), Girs (1974) and Hughes et al. (1974).

The study area is composed of five regions or geographical units, as described in this section: Central Gulf of Alaska, NEGOA, Kodiak Island Shelf, NWGOA, and Bering Sea.

The nomenclature of the oceanographic Domains and Current Systems discussed in this section follows that of Favorite et al. (1976).

They distinguished the following surface (upper 125 metres) Domains and Current Systems in the Subarctic region, as shown in Figure 1.

(1) Domains (white in Figure 1)
- E= Ridge Domain and Alaskan Gyre
- F= Transition Domain
- G= Dilute Domain
- I= Upwelling Domain
- J= Coastal Domain

(2) Current Systems (black in Figure 1).
- A= Bering Current System
- C= Subarctic Current System
- D= Alaska Current System (Alaska Stream)
- H= California Current System
- L= Okhotsk - Kuril Current System

(3) Gyres (anticlockwise) (thin arrows).
- B= Bering Sea Gyre
- E= Alaskan Gyre
- M= Okhotsk Sea Gyre
- N= Western Subarctic Gyre

(4) K= Subarctic Boundary

1. The Central Gulf of Alaska

The Northeastern Pacific Ocean above 50 degrees N (the Central Gulf) includes the northern boundary of the Upwelling Domain, the Coastal Domain, the Dilute Domain, the Subarctic Current, the Ridge Domain and Alaska Stream (Fig.1). When J.R.G. sailed between Seattle and Kodiak Island, on three occasions, all of these domains and currents were crossed at some point. For most of the year, shearwaters are not common over the open ocean of the

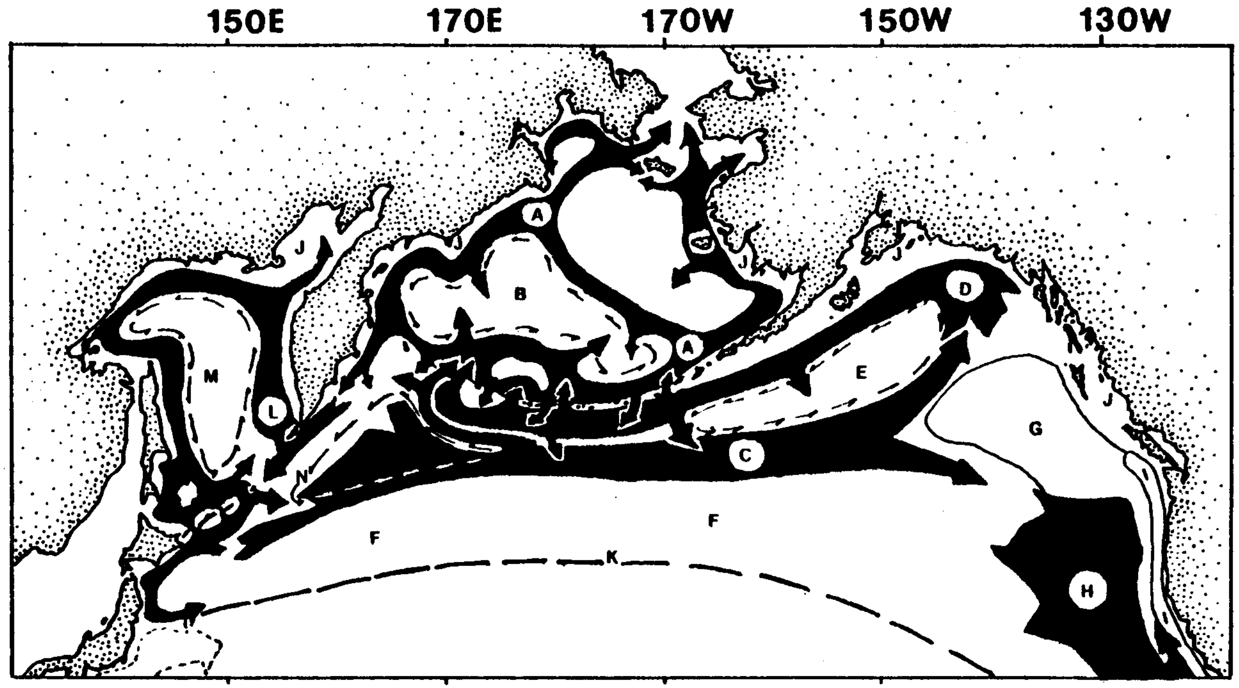


Figure 1. Subarctic Domains and Current Systems, according to Favorite et al. (1976). For interpretation of the letters (A-N) see text section III F (page 18).

Central Gulf.

Some seamounts of the Kodiak-Bowie Seamount Chain were passed on the trans-Gulf crossing. The ones considered most important, because of the number of shearwaters encountered, were the Giacomini, Surveyor and Welker Seamounts. These seamounts are located in the Ridge Domain and Dilute Domain and in the Subarctic Current System in between them. Upstream seamounts produce small scale subsurface fluctuations in dynamic topography that are manifested as baroclinic eddies at the sea surface (Royer, 1978).

Shearwaters concentrate in the Coastal Domain and the Upwelling Domain (Fig.1) and are found only in low numbers in all other domains and currents.

2. Northeastern Gulf of Alaska (NEGOA)

The Northeastern Gulf of Alaska (NEGOA) covers the area from Yakutat Bay to 147 degrees W. The study area lies mainly within the Coastal Domain and the Alaska Current System (Fig.1).

The influx of fresh water is a major driving force over the NEGOA shelf (Roden, 1967; Royer, 1979; Sobey, 1980b). Precipitation and runoff are the most important sources of low density waters nearshore. This occurs mainly during spring and early summer, from huge glaciers that almost extend down to tidewater.

Bathymetry is another factor affecting circulation. Troughs in the shelf region seem to direct flow towards the shore. Islands such as Middleton Island and Kayak Island, seem to have an important role in directing water flow shorewards or seawards.

3. The Kodiak Island Shelf

The Continental Shelf in the Gulf of Alaska is at its widest between Prince William Sound and Kodiak Island. The Kodiak Shelf is characterized by the presence of a series of troughs, which run across the shelf to the Shelf Break or act as channels for current flow between the continental slope and the inner shelf near Kodiak Island. From N-S these are Amatuli, Stevenson, Chiniak and Kiliuda Troughs. Kennedy Entrance lies between the Barren Islands and the Kenai Peninsula, and Stevenson Entrance between the Barren Islands and Afognak Island. Shallow banks are located between these troughs. From N-S these are Portlock Bank and North, Middle and South Albatross Banks (Sobey 1980a in the Kodiak Interim Synthesis Report, Science Applications, Inc.).

The Kodiak Shelf is located in the Coastal Domain. Along the Shelf Break, flow is dominated by the Alaska Current System (Alaska Stream) (Fig.1). The shelf is influenced by low salinity waters near the coast and denser waters along the Shelf Break. Upwellings are weak during the summer.

4. The Northwestern Gulf of Alaska (NWGOA) and Unimak Pass

The Continental Shelf becomes quite narrow west of the Shumagin Islands.

The Alaskan Stream, as it flows westward along the south side of the Aleutian Islands, penetrates into the Bering Sea through the passes along this chain and has a warming effect (Favorite, 1967; Kitano, 1970). Marked temperature and salinity fronts at the boundaries of the warm, dilute, low-salinity Alaskan Stream have been shown to exist in the spring and summer between 155-165 degrees W and south of Adak Island (Favorite et al. 1976).

There are altogether approximately 40 passes along the Aleutians, with the depth increasing towards the west. From east to west, these passes are grouped in six areas of major exchange: (i) Unimak , (ii) Amukta , (iii) Amchitka , (iv) Buldir, (v) Near and (vi) Kamchatka (Favorite et al. 1976). Flow through the passes may be either northward or southward (Reed, 1971). It is highly variable, and may be "greatly influenced by how far south of the passes the main axis of the Alaskan Stream occurs and at what longitude [westward] the main recirculation of coastal water [back] into the Gulf of Alaska takes place" (Favorite, 1974). Reed (1968) showed that at 165 degrees W the Alaskan Stream is only just over half as wide in September as in January, and concluded that the volume of flow is "correlated with the seasonal pressure systems", as had been postulated by Uda (1963).

Unimak Pass is the most important for this study. It is a shallow opening, only 60 metres deep, and is the first large communication between the Gulf of Alaska and the Bering Sea. Unimak Pass is characterized during spring and summer by the presence of thousands of shearwaters, no doubt because of the high concentration of nutrients, and hence of prey items, possibly due to a considerable degree of mixing that brings the nutrients to the euphotic zone.

5. The Bering Sea

Favorite et al. (1976) suggested a circulation pattern for the Bering Sea, which they called the Bering Current System. Water flows from the Alaska Stream north through several passes west of Unimak Island, and then is incorporated either into the Bering Current System flowing northwest along the Bering Sea Shelf Break, or into a coastal current flowing northeast along the north side of the Alaska Peninsula. There is a northward flow over the continental shelf in Bristol Bay and along the Alaskan coast towards the Bering Strait. The situation over the southeastern shelf is complicated by the effects of tidal and wind currents and fresh water runoff. Gershanovich et al.(1974) stated that tidal currents are very important on the shelf near the Pribilof Islands and on the continental slope. In the Southeastern Bering Sea, the area of interest for shearwaters is the eastern Continental Shelf and the Shelf Break Front.

Sancetta (1981) distinguished four zones, separated by three fronts: (i) the Shelf Break Front at the edge of the Bering Sea Basin at the 200 metres isobath (100 fathoms), (ii) a Middle Shelf Front at the 100 metres isobath (50 fathoms), and (iii) an Inner Shelf Front at the 50 metres isobath (25 fathoms) (Figure 2).

The Shelf Break appears to be permanent, and to separate more saline, warmer, waters of the Alaskan Stream and the Bering Basin from cooler, lower salinity, waters from the shelf. The Middle and Inner Shelf Fronts appear to be seasonal, and the thermocline is affected by wind and tidal vertical mixing. Thus, the waters between 50 - 100 metres are stirred by tidal and wind vertical mixing, which increases the concentration of nutrients available to the primary producers, resulting in a spring bloom of phytoplankton.

G. THE MARINE ENVIRONMENT

Seabird distributions must be understood in relation to the marine environments they use, such as the complex arrangements of Domains, Current Systems and Fronts that occur in the Subarctic North Pacific Ocean (Fig. 1). They maintain "a paradoxical consistency in their habitat preferences throughout the year" (Brown, 1980).

The analysis of the distribution of shearwaters in this report has mainly been based on an habitat classification derived from Kessel (1979) and Sancetta (1981). For this purpose the distance and the depth offshore at which shearwaters were found have been considered the basic environmental parameters in the analysis.

1. Marine Habitats

Kessel (1979) has classified the bird habitats of Alaska. Based on studies carried out by PROBES (Processes and Resources of the Bering Sea), there are 4-5 major marine habitats (Waters or Zones) separated by structural fronts (Kessel) which are defined in terms of vertical mixing of the water by winds and tides (Sancetta, 1981), as follows (Fig. 2):

A= Nearshore Zone
B= Inshore Zone (<50 m = 25 fathoms)
C= Middle Shelf Zone (25 - 50 fathoms)
D= Outer Shelf Zone (50 - 100 fathoms)
E= Oceanic Zone (>100 fathoms)

The Middle Shelf Zone and Outer Shelf Zone together make up the Offshore Waters.

(1). Nearshore Waters

The Nearshore Zone includes waters that are protected by the configuration of the coast and/or by islands, and that are also generally shallow, e.g. bays and inlets.

(2). Inshore Waters

The Inshore Zone consists of exposed coastal waters

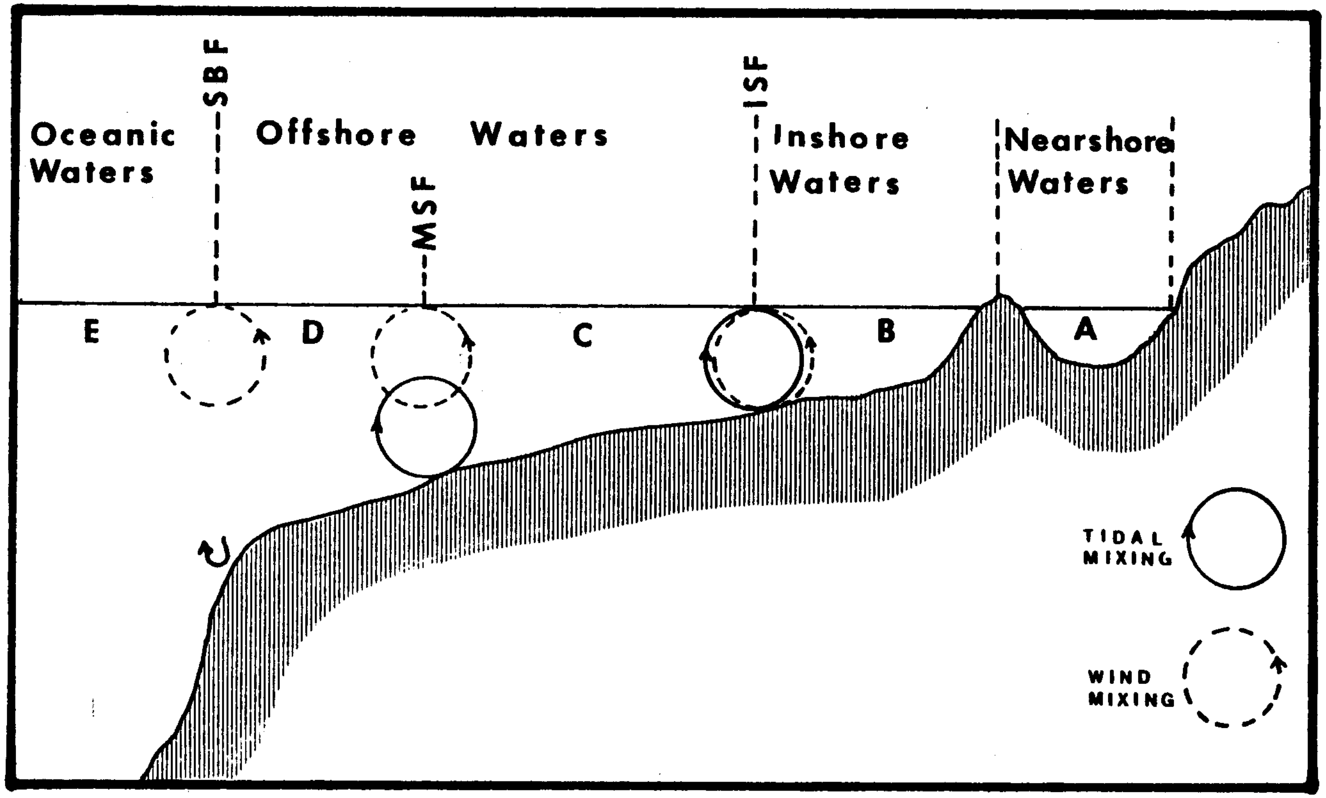


Figure 2. Schematic Cross-section Representation of the Continental Shelf to show Marine Habitats for Alaskan Waters, after Kessel (1979) and Sancetta (1981). For interpretation see text section III G (page 21).

that extend out to the Inner Shelf Front. The depth does not usually exceed 50 meters (25 fathoms) and they do not generally extend more than 6 km offshore. Both wind and tidal mixing occur at the sea surface at the Inner Shelf Front (Fig.2).

(3). Offshore Waters

Offshore waters extend seawards from the Inner Shelf Front and can be subdivided into:
(i) the Middle Shelf Zone (C in Fig.2), which extends from the Inner Front to the Middle Shelf Front, i.e. from the 25 - 50 fathoms isobaths, and (ii) the Outer Shelf Zone (D in Fig.2), which extends from the Middle Shelf Front to the Shelf Break Front , i.e. from the 50 - 100 fathoms isobaths.

(4). Oceanic Waters

Beyond the Shelf Break Front is the Oceanic Zone, with depths greater than 100 fathoms. Kessel considered everything beyond the Inner Shelf Front as being Offshore Waters, but use of that term will here mean only the region between the Inner Shelf Front and the Shelf Break Front, as in Sancetta (1981). Kessel's Oceanic Zone will be called Oceanic Waters.

2. Circulation of Nutrients

The circulation of nutrients in a vertical direction can be achieved by several different processes (Sverdrup et al. 1942; King, 1975; Davis, 1977; Boje & Tomczac, 1978; Sobey, 1980 a and b).

(1). Influence of Winds

When Ekman transport pushes near-surface waters offshore away from a coastline, a divergence zone arises and water from deeper layers moves to the surface to replace the water masses moving away horizontally. This is upwelling (King, 1975; Boje & Tomczac, 1978; Sobey, 1980a). Downwelling occurs when waters of the surface layer are pushed inshore.

Upwellings are the most important factor in the supply of nutrients. An Upwelling Index (Bakun 1973, 1975) can be defined as being "numerically equal to the offshore component of the Ekman transport per 100 meters of coastline". Positive values of the Upwelling Index indicate upwelling, and negative values refer to downwelling.

For the Northeastern Gulf of Alaska, the Upwelling Indices, averaged over 1975-1977, have been calculated by Royer (in Sobey, 1980 a and b). He found a very short upwelling season in the NEGOA, from about May to August, with only a very small positive index value. During the rest of the year strong downwelling prevails along the coastal area of NEGOA and the Kodiak shelf.

On the Kodiak Island shelf, Ingraham et al. (1976) also reported Upwelling Indices with weak positive values from June to September, and strong negative values during the winter when there is considerable downwelling in this area.

Sobey maintains that the upwelling season "is probably too short to be biologically significant". In the Gulf of Alaska upwellings are probably not an important oceanographical factor responsible for high productivity, hence concentration of nutrients must be due to other oceanographic features.

Another mechanism by which wind can affect nutrient circulation is direct forcing. Direct forcing of the surface waters may occur when depth is small (35-50 m) compared to Ekman depth, or when wind fluctuates over short periods of time (shorter than the inertial period of about 14 hours in GOA).

(2). Turbulence and Local Currents

Along coasts there is an important supply of nutrients from runoff from the land, which are then transported along the coast by offshore currents and tidal currents. The stirring of nutrients from the bottom by wave action, and downslope transport along continental slopes and submarine canyons, are also important mechanisms increasing the amounts of nutrients available.

(3). Density Currents

Due to changes in water temperature, seasonal vertical mixing by changes in water density are particularly important in mid-latitudes, where it helps in transporting nutrients to the euphotic zone. Along the coast of NEGOA and the Kodiak Shelf there is a very strong stratification in the summer season, but during the winter there is a mixing (Sobey, 1980 a and b).

(4). Geostrophic Circulation

Favorite et al. (1976) calculated the wind driven transport of the sea surface currents "by computing geostrophic winds from the sea-level atmospheric pressure distribution". They found an area of current divergence in the Aleutian area between 50 - 55 degrees N, from December to February and in June and September. It shifted northward to 55 - 60 degrees N from March to May, and it was absent in July and August. They suggested that, as "this feature exists for most of the year", the vertical transport "should be considered as an important mechanism in this area". It is probably partly responsible for high productivity,and hence for concentration of food items for secondary and tertiary consumers in the Aleutian Island passes.

3. Productivity, and the Foods taken by Shearwaters

Biological productivity and plankton have been described for the coastal areas of the Gulf of Alaska by Larrence et al. (1977), Dunn et al. (1979b) and Fucik (1980), for the Bering Sea by Motoda and Minoda (1974), and for the southeastern Bering Sea by Iverson et al. (1979) in relation to the Shelf Break Front. The distribution of euphausiids in the North Pacific has been described by Brinton (1962), Nemoto (1962), Ponomavera (1963) and Komaki (1967).

The foods taken by shearwaters in the Northern Hemisphere have been reported by Lensink et al. (1976), Sanger and Baird (1977), Sanger et al. (1978), Krasnow et al. (1979), Ogi et al. (1980), Brown et al. (1981) and Ogi (1981).

The diving behavior of shearwaters for food has been described by Brown et al. (1981), and Dunn (1973) and Birkhead (1976) described how the fishing ability of terns and guillemots is affected by windspeed and the condition of the sea surface - shearwaters may be similarly affected. Slater (1976) discovered a tidal rhythm in guillemots feeding on sandlance some distance offshore.

The trophic relationships of seabirds in the North Pacific Ocean and Bering Sea have been described by Lensink et al. (1976), Sanger and Baird (1977), Sanger et al. (1978) and Ainley and Sanger (1979).

Seabirds sometimes occur in interspecific feeding assemblages (Sealy, 1973, Hoffman et al. 1981). The community structure and interrelationships of marine birds, including shearwaters, in the North Pacific Ocean have been analyzed by Wiens et al. (1978).

IV. STUDY AREAS

The areas studied were at sea in the North Pacific Ocean and the Bering Sea, between 50 - 60 degrees North and 140 - 180 degrees West (10 degree x 10 degree Marsden Squares 195, 196, 197 and 198). This huge area includes parts of the following oceanographic regions: Coastal Domain, Alaskan Stream Domain, Transitional Domain, Central Subarctic Domain and Western Subarctic Domain (Figure 1) (Favorite et al. 1976) in the Gulf of Alaska and the Bering Sea.

Where to draw the boundary line between NEGOA and NWGOA has been a constant problem. In 1975 the NEGOA Contineta1 Shelf, east of 150 degrees W, was not visited and Kodiak Island was included in the NWGOA. Greater activity just northeast of Kodiak Island early in 1976 necessitated treating that area also as part of the NEGOA. In this Final Report, NWGOA is limited to the region west of Chirikof Island to Akutan Pass (ca. 156 - 167 degrees W), and an intermediate area, the Kodiak Island Shelf, has been distinguished as occupying the area from Chirikof Island east to Amatuli Trough (148 - 155 degrees W.).

The area covered, as well as the cruises and periods of observations, were mainly pre-determined by the schedules of vessels used for other research ('ships of convenience').

A. PERIODS OF OBSERVATION

All observations for R.U. 239 were made by J.R. Guzman. The first ones were made on June 3, 1975, north of Adak Island, and the last ones were made on August 19, 1976.

Observations were made during 1975-1976 for a total of

142 days (1975-58 days; 1976-84 days) spread over seven months (ranging from May through August).

During 1975, one cruise was made on board the NOAA R/V DISCOVERER and two cruises on board the NOAA R/V SURVEYOR. In 1976, three cruises were made on board the R/V DISCOVERER and two cruises on board the R/V SURVEYOR. This was a combined total of eight cruises aboard the NOAA vessels. Small boats (launchers) were lowered from the vessel, when weather and time allowed, for collection and direct observations of shearwaters.

SUMMARY OF SHIP TIME

MAIN LOCATION	DATES	No. OF DAYS	VESSEL	FILE I.D.
	1975			
Bering Sea	June 2-19	18	Discoverer	01UC75
Bering Sea	July 11- Aug. 1	21	Surveyor	02UC75
Kodiak I.	Aug. 3-6	4	Launch	03UC75
Bering Sea	Aug. 7-22	15	Surveyor	03UC75
Total		58		
	1976			
NEGOA	May 3-22	20	Discoverer	01UC76
NEGOA	May 24-30	7	Discoverer	02UC76
Bering Sea	June 5-25	21	Surveyor	03UC76
NEGOA	July 16-31	16	Discoverer	04UC76
Bering Sea	Aug. 1-20	20	Surveyor	05UC76
Total		84		

The above listing shows only the main location visited during each cruise. In more detail, the time was spent as follows: the Northeastern Gulf of Alaska (40 days), the Northwestern Gulf of Alaska, including Kodiak Island (13 days), the Bering Sea (77 days), and in transit across the Gulf between Seattle and Kodiak (12 days).

B. TRACKS OF NOAA VESSELS

For location of the places named here refer to the <u>Kodiak Interim Synthesis Report</u> (Science Applications, Inc., March 1980, pages 4-7) and the <u>Northeast Gulf of Alaska Interim Synthesis Report</u> (Science Applications, Inc., July 1980, pages 4-7).

The approximate tracks of the vessels appeared on maps in Myres and Guzman (1976 - 1977), and in Guzman (1981). The actual Transect and Station counts of all shearwaters recorded were also plotted on these maps. On those maps each plot represented one single observation, or a group of observations if these were so close together that it was impossible to represent them separately on the map. The maps showed daylight observation linked together in daily sequences. The lines linked the order in which the observations were taken rather than the actual tracklines of the vessels. Numbers against each plot referred to the day of the month, and were placed in front of the first observation of each day. The symbols represented absolute numbers of birds seen at each particular spot. They showed presence or absence of shearwaters, and the relative sizes of the aggregations.

1. 1975.

(1). June

The areas covered during this month were all west of 150 degrees West, and the observations were almost entirely confined within the Eastern Bering Sea. J.R.G. joined R/V DISCOVERER at Adak Island.

Observations were made during (i) a transit cruise from Adak Island in the central Aleutians to the Pribilof Islands near the edge of the Continental Shelf in the central Southeastern Bering Sea, and southeast of the Pribilof Islands, (ii) a cruise along the north side of the Alaska Peninsula as far east as inner Bristol Bay, (iii) a cruise in the northern part of outer Bristol Bay past Cape Newenham, (iv) a cruise close to Nunivak Island and as far west as the edge of the continental shelf west of the Pribilof Islands, (v) a cruise in the central Southeastern Bering Sea east of the Pribilof Islands, and (vi) during a transit voyage through Unimak Pass to Seward on the Kenai Peninsula of the Gulf of Alaska.

In the Bering Sea in June 1975 there was a lack of shearwaters to the northwest and towards the edge of the shelf in the west. Highest numbers were found off Kuskokwim Bay, Cape Newenham and inner Bristol Bay. On the one-way transit of the NWGOA to Kodiak at the end of the cruise only low numbers of shearwaters were recorded beyond the 1000 fathoms isobath.

(2). July

There were transit voyages (i) from Seattle to Kodiak across the Gulf of Alaska and (ii) from Kodiak to Unimak Pass. Formal observations were made (iii) in the Bering Sea along the north side of the inner Aleutian Islands and outermost Alaska Peninsula, and north as far as Cape Newenham. These were followed by (iv) a return transit voyage from Unimak Pass back to Kodiak.

Altogether, about 2,700 shearwaters were recorded when passing southwest of the Welker and Surveyor Seamounts in the Gulf of Alaska during the transit from Seattle to Kodiak on R/V SURVEYOR. The inside passage, along the south side of the Alaska Peninsula was very poor in shearwaters. Shearwaters were abundant around Unimak Pass and Amak Island. None was seen around Cape Newenham. On the return trip along the continental shelf break of the NWGOA they were seen only between Chirikof Island and Kodiak Island.

(3). August

As in June, the bulk of the information was obtained within the Bering Sea. Observations were first made in the Northwestern Gulf of Alaska (i) off Kodiak Harbor (Chiniak Bay), (ii) between Kodiak and the Barren Islands, (iii) in Shelikof Strait, and (iv) near the Trinity Islands and Chirikof Island. Finally, observations were made (v) in the Eastern Bering Sea.

Between 6 - 10 million shearwaters were seen, over a 30 nm distance, during 6 hours of observation, starting about 50 nm southwest of Nunivak Island on August 17, 1975 (see Figure 10). This was the largest aggregation of shearwaters seen.

2. 1976

(1). May

Observations were made in the NEGOA during (i) a transit voyage from Juneau to Kodiak along approx. 58 degrees N latitude across the deep waters of the northern Gulf of Alaska, (ii) a transit cruise from Kodiak to Cook Inlet and back,(iii) a transit cruise from Kodiak to Icy Bay, (iv) surveys in the Icy Bay - Kayak Island area, and (v) a return transit cruise to Kodiak. Finally, there was (vi) a second cruise into Cook Inlet and then on to Prince William Sound.

Shearwaters were well distributed, and very abundant over, and along the edge of, the continental shelf of the NEGOA between Icy Bay and Kayak Island, along the edges of Amatuli Trough, in Kennedy Entrance and over Stevenson Trough.

Shearwaters were found over Oceanic Waters along latitude 58 degrees N, in the Central Gulf of Alaska, on May 4, 1976, seen flying during all record periods towards the W (270 degrees) in sparse flocks (long files), which was the only time during five transit voyages across the Gulf of Alaska that a definite directional migratory movement was observed. The wind was from the ESE - SSE at 15 - 25 knots. The largest flock seen was of 300 birds, and most flocks were only 1 - 44 birds. Some small groups stopped to dive and then continued flying.

(2). June

Observations were made during (i) a transit voyage from Kodiak to Unimak Pass, (ii) a transit cruise from Unimak Pass to the Pribilof Islands, followed by nearly five days near the islands and a return transit to Dutch Harbor on Unalaska Island, (iii) along the north side of the inner Aleutian Islands and outermost Alaska Peninsula. Following this, there were transit voyages (iv) from Unimak Pass back to Kodiak, and (v) from Kodiak to Seattle across the Gulf of Alaska.

Unlike 1975, the inner continental shelf of the Bering Sea and Bristol Bay were, unfortunately, not visited.

Shearwaters were again absent from the Pribilof area, but were abundant between Unimak and Amak Islands, and in the NWGOA between Chirikof Island and the Trinity Islands, and over Kiliuda Trough off Sitkalidak Island.

Two relatively large flocks of 1,200 and 4,000 shearwaters were seen near Giacomini Seamount in the Gulf of Alaska on June 21, 1976, during the transit from Kodiak to Seattle.

(3). July

Observations were made during (i) a transit voyage across the Gulf of Alaska (from Seattle to Kodiak,) (ii) a transit cruise across the deep waters of the northern Gulf of Alaska and (from Kodiak to Icy Bay), and (iii) a cruise along the continental shelf back to Kodiak.

The numbers of shearwaters were quite low over the continental shelf of the NEGOA, except off Kodiak Island. About 3,100 shearwaters were seen near Surveyor Seamount on July 18, in five groupings averaging just over 600 birds each. Very small numbers of shearwaters were also seen over Oceanic Waters along latitude 58 degrees N, in the Central Gulf of Alaska beyond the shelf edge, on July 20 - 21.

(4). August

Observations were made during (i) a rapid transit voyage from Kodiak across the Northwestern Gulf of Alaska and Bering Sea to Nome on the south shore of the Seward Peninsula, (ii) surveys in Norton Sound , and (iii) a rapid return transit voyage from Nome across the Bering Sea and Northwestern Gulf of Alaska to Kodiak.

During both crossings of the Southeastern Bering Sea and between Unimak Pass and Kodiak along the 100 fathoms line, shearwaters were seen regularly, but flocks never exceeded medium size levels.

In conclusion, to determine the locations of particular shearwater observations, the reader should refer to the maps already published in Myres and Guzman (1976-1977), or in Guzman (1981). In the remainder of this final report, these observations are analysed by latilong blocks, by distance from shore and by water depth, as described in Section V.

V. SOURCES, METHODS AND RATIONALE OF DATA COLLECTION

A. COUNTING SHEARWATERS

The problems of counting birds at sea have been widely discussed. Dixon (1977) showed that the distances at which birds sitting on the sea are first seen varies with the species. Bailey and Bourne (1972) and Wahl (1978) presented guidelines. Heinemann (1981) developed a range finder for use when censusing pelagic birds at sea. King (1970, 1974) refined a number of observational methods developed earlier by Kuroda (1960). Recent modifications in methodology have been made by Nettleship and Tull (1970), and Brown et al. (1975). In Alaskan waters, Bartonek and Gibson (1972) prepared maps for each species recorded in Bristol Bay that showed the number of birds per 20 miles of transect. Sanger (1970) also used the indices of Kuroda (1960), and later Sanger (1972, pages 596-597) devised an equation for the standing stock of 'ecologically similar groups of species' by season and oceanographic domain. This was converted to biomass by inclusion of average weights of 'representative birds'.

In this study, observations were made with 7x binoculars. Hand counters were used to tally the birds. The numbers of birds seen, and comments on their behavior, were recorded on a tape recorder, and later transcribed onto the forms. The recording methods developed by the U.S. Fish and Wildlife Service in Anchorage, specifically for the Alaska OCSEAP (NOAA) surveys, were employed. The census method involved data forms (i) for ship transects (Form OBS-2-75 for Pelagic Bird Observations: Transect Records), and (ii) for station records (Form OBS-3-75 for Pelagic Bird Observations: Station Records).

Normal Transect Counts were made mainly from atop the pilot house (flying bridge), in a 90 degree quadrant out to a distance of 300 m forward from the ship on one side only, in three zones, each 100 m wide.

In 1975 counts were made during a standard 15 minutes of observation once in every hour, but in 1976 this was changed to a standard 10 minutes record period every 30 minutes. Thus, in 1976 more of the available time was utilized for recording compared with 1975 (30 minutes instead of 15 minutes in every hour sampled).

In addition, e.g. whenever visibility was limited by fog, so-called Experimental Transect Counts were made. They were recorded on the same forms as the Normal Transects, but an "E" was placed before the number to show that the information was collected using other censusing procedures than those for Normal Transect Counts. Whenever time permitted, all the shearwaters that it was possible to see from the ship were counted, and if these observations did not qualify as Normal Transect Counts they were recorded as "E" Transects.

The observations were generally carried out towards the side with least glare, i.e. away from the sun. But when shearwaters were encountered, the side considered was that where shearwaters were present or from which they were approaching the vessel.

All the transects carried out from May 3 - 20, 1976, were treated as Experimental Transects ("E") because both sides of the ship were surveyed, and the time periods varied from 10 - 30 minutes. This method (including birds on both sides of the ship during a transect) proved to be impractical, because it is very difficult to observe and count all species of seabirds over the entire area simultaneously.

Furthermore, because most birds normally cross the bow from one side to the other, there is a risk of counting birds twice and the disadvantage of assigning birds to an area twice as large as necessary. Counting off one side only usually results in almost as many being counted as off both sides.

After May 24, 1976, transects of 10 minutes duration were employed because this proved to be more practical and valuable than the one 15 minutes period each hour employed in 1975. Fewer counts were forfeited because of interruptions, and it allowed for a higher number of 'record periods' during a single hour. It was easier to work three transects of 10 minutes into 'block periods' of 30 minutes per hour. Any information besides counting was recorded under remarks.

At fixed Ship Stations all the birds up to 600 m all around the ship were counted.

Eventually all the data collected was transcribed onto coded forms developed by the USF&WS in Anchorage, for use by the U.S. National Oceanographic Data Center (NODC), for all OCSEAP projects in Alaskan waters.

B. SPECIMENS

Whenever possible, specimens were collected with a 20-gauge shotgun under USF&WS sub-permit (No. 7-SC-25) of the federal permit to Dr. C.Lensink, and USF&WS sub-permits of State of Alaska permit No. 76-148. Only 38 specimens were collected in 1975-1976. They were distributed as follows:

	Short-tailed Shearwater	Sooty Shearwater
1975.	12,June 10, off Cape Newenham (Bering Sea)	None
	12,August 19, off Kodiak	None
1976	13,June 15, off Amak Is. (Bering Sea)	1,August 20, Chiniak Bay (Kodiak)
Totals:	37	1

A technique for capturing shearwaters alive at sea has been described by Gill et al. (1970), and this could be used to band them or to attach radio transmitters in Alaskan waters. Unfortunately, sexing of shearwaters by cloacal examination is only possible during the breeding season (Serventy 1956a).

C. PLANKTON, SQUIDS AND FISH

As soon as birds were collected, they were weighed. Formaldehyde was forced into the esophagus to stop digestion. Stomachs were removed for analysis by

Mr. G.A. Sanger of the USF&WS, Anchorage, Alaska. The analyses of the foods taken by shearwaters in 1976 in the Gulf of Alaska and southern Bering Sea were published by Sanger and Baird (1977).

Unfortunately very little data on the occurrence and distribution of plankton, squids or fish were collected by other Research Units in the OCSEAP program on cruises of R/V DISCOVERER or R/V SURVEYOR during which J.R.G. collected simultaneous shearwater observations. Therefore, it was not possible to make direct correlations of the food taken by birds with what was available to them.

VI. RESULTS

A. METHODS OF PRESENTATION

For the year 1975, maps of the densities of shearwaters (birds/km2) were prepared for the Annual Report, but for the year 1976, actual numbers of birds seen at each observation point were plotted on maps for the Annual Report (Myres and Guzman, 1976-1977). Similar maps of actual numbers of birds counted in 1975 appeared in the Quarterly Report at the end of the 1975 season. Both methods of presentation (actual counts and densities) have drawbacks. Actual counts vary over a huge range of numbers and are not tempered by any averaging procedure, but they do identify precisely where local aggregations occurred. Density calculations obscure the strong gradient that exists from the vast area of ocean with no shearwaters at all, or very small numbers, to highly concentrated local aggregations.

Seabirds are highly mobile organisms and very patchy in distribution. It is difficult to submit count data obtained during infrequent, widely-spaced and non-parallel track-lines by ships-of-convenience to standard statistical analysis. Marine ornithologists now favor the standardization of counts into 10-minute units of equal effort.

1. "Latilong" Blocks

The study areas were each divided into regular latitude-longitude ('latilong') blocks. The latilong block sizes used were either 30'N X 30'W or 1 degree N X 1 degree W. Each 1 degree N x 1 degree W latilong has a surface area that is 60 nautical miles (111 km) tall from South-North and 30 - 35 nautical miles (56 - 64 km) wide from East-West, depending on the latitude, at 55 - 60 degrees N.

For each block visited we have plotted vertically: (i) at the top, the Effort (expressed as the number of 10-minute periods of observation), (ii) and (iii) the average number of birds of each species seen per unit-effort, and (iv) at the bottom, the average number of <u>all</u> shearwaters (including unidentified shearwaters) seen per unit effort. See the <u>Key to Symbols on Maps</u> at the start of the portfolio of figures.

2. Unit-effort (10-minute counts)

The shearwater counts have been presented as the number of birds seen per 10 minutes of observation. Because the USF&WS switched from a 15-minute standard for Normal Transects in 1975 to 10-minute Normal Transects in 1976, we had to switch as well. As the data were collected in a very opportunistic way, not all the observations were made during standard 10-minute periods; sometimes observations were carried out for much longer periods of time.

To convert non-standard counts into 10-minute unit-efforts, the number of birds seen per 10 minutes was calculated from the total time of the particular non-standard observation. The total number of minutes of original observation was divided by 10, to determine the number of unit-efforts (periods of 10 minutes); any surplus value bigger than 0.5 was counted as an extra unit-effort. All Normal Transects, E-Transects and Station counts, described earlier, have been converted into unit-efforts.

3. The Shearwater Distribution Maps

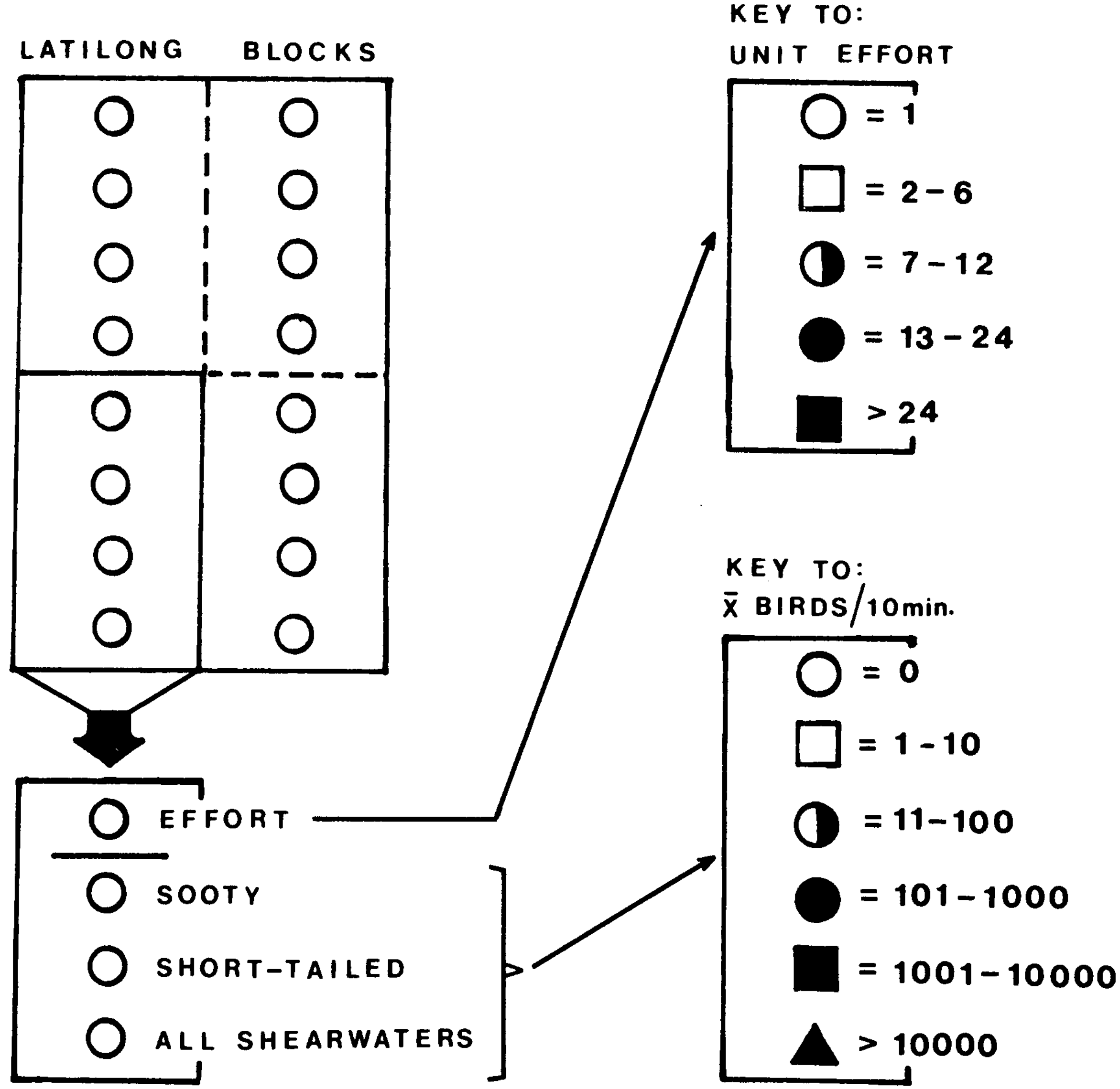
The total number of birds seen in each latilong block was divided by the number of unit-efforts in that block, so as to obtain the mean number of birds seen per unit-effort per block.

The mean number of birds per 10-minute unit-effort in each block visited, is presented for all cruises, month by month, in Figures 3-13. The topmost symbol in each 4-symbol group is the total number of unit efforts in that block upon which the analysis is based (see the Key to Symbols on Maps at the start of the portfolio of figures). The three lower symbols in each block represent (in sequence downwards), first the Sooty Shearwater, then the Short-tailed Shearwater and finally all shearwaters together (Sooty + Short-tailed + unidentified Shearwaters). Thus, to determine the mean total number of shearwaters in each latilong block, scan only the lowest symbol in each group. To determine the mean number of Sooty Shearwaters scan across the line containing the second symbol down, and for the Short-tailed Shearwaters scan across the line containing the third symbol down in each group.

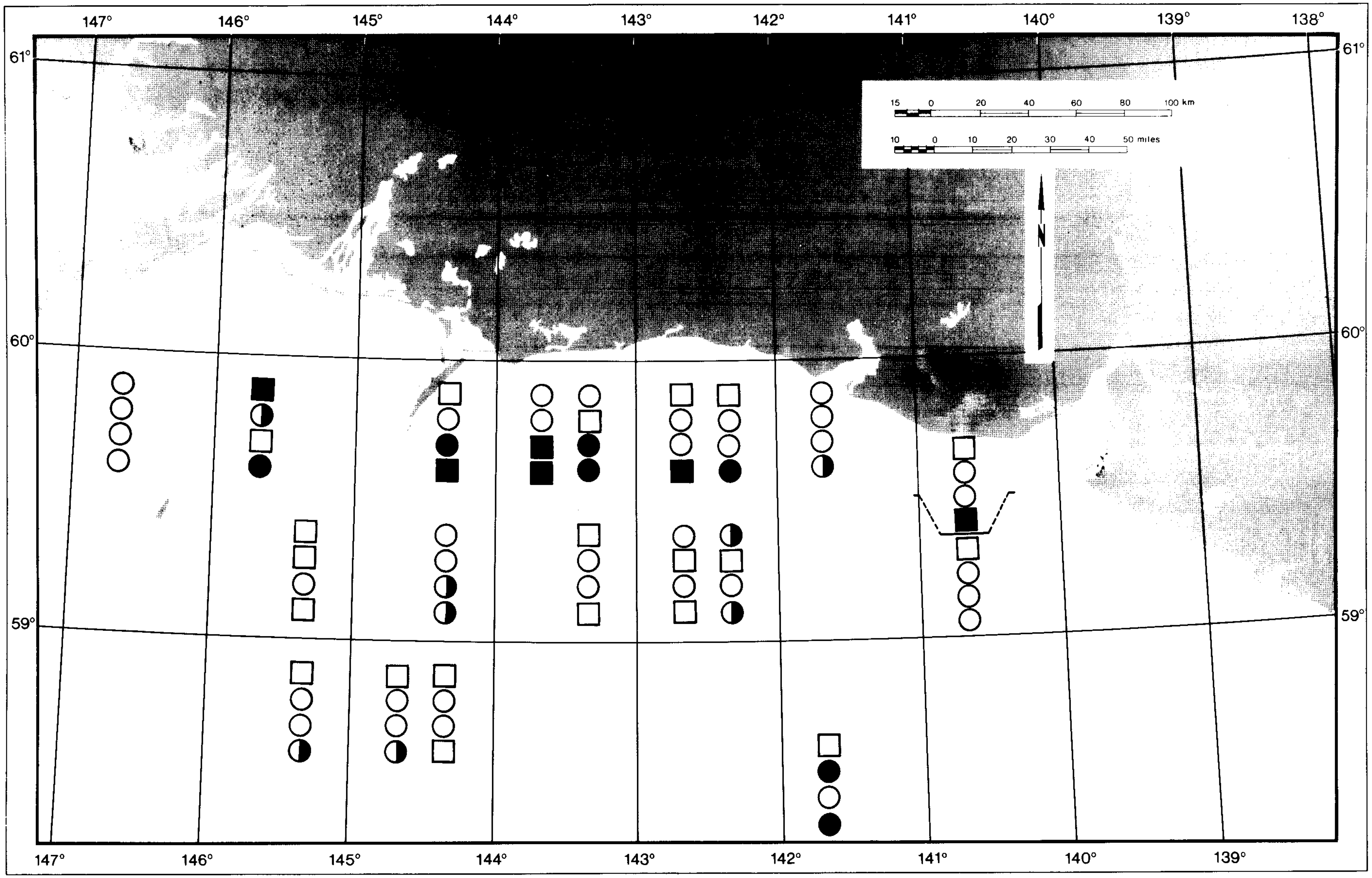
No attempt has been made to calculate density of birds per km square, as was done by the USF&WS, Anchorage, because the vessels could not be relied upon to maintain a uniform speed from which a fixed length of distance travelled in a standard time would allow the calculation of the area of observation. Furthermore, the distribution of shearwaters is so patchy that a figure for density of birds per square km calculated from sample counts in a small area misrepresents the average density in a large unit area, although calculations of this kind might be useful when dealing with assemblages of bird species.

4. Distance and Depth Analyses

The data have been analysed in two ways:

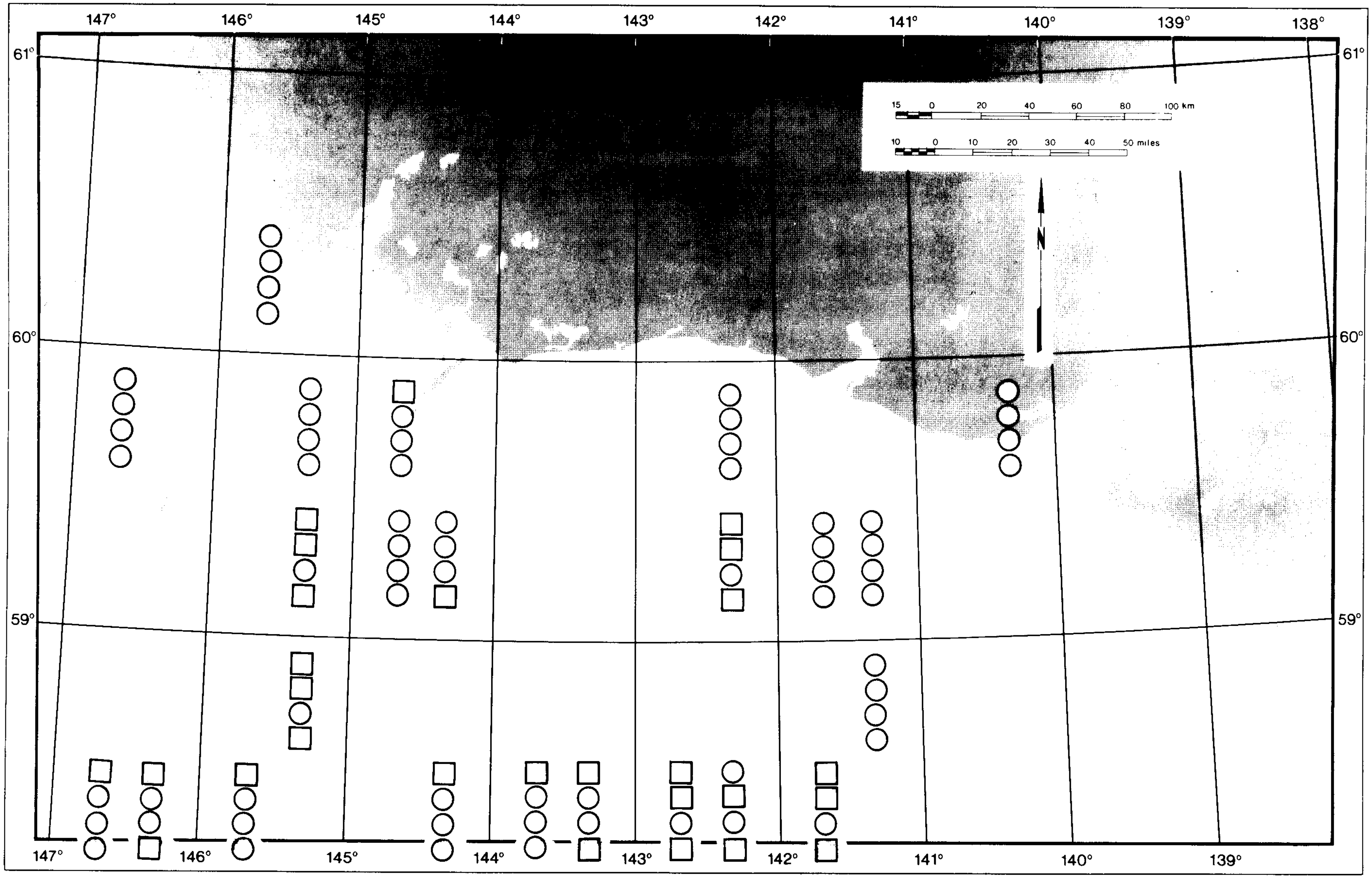


KEYS TO SYMBOLS ON MAPS



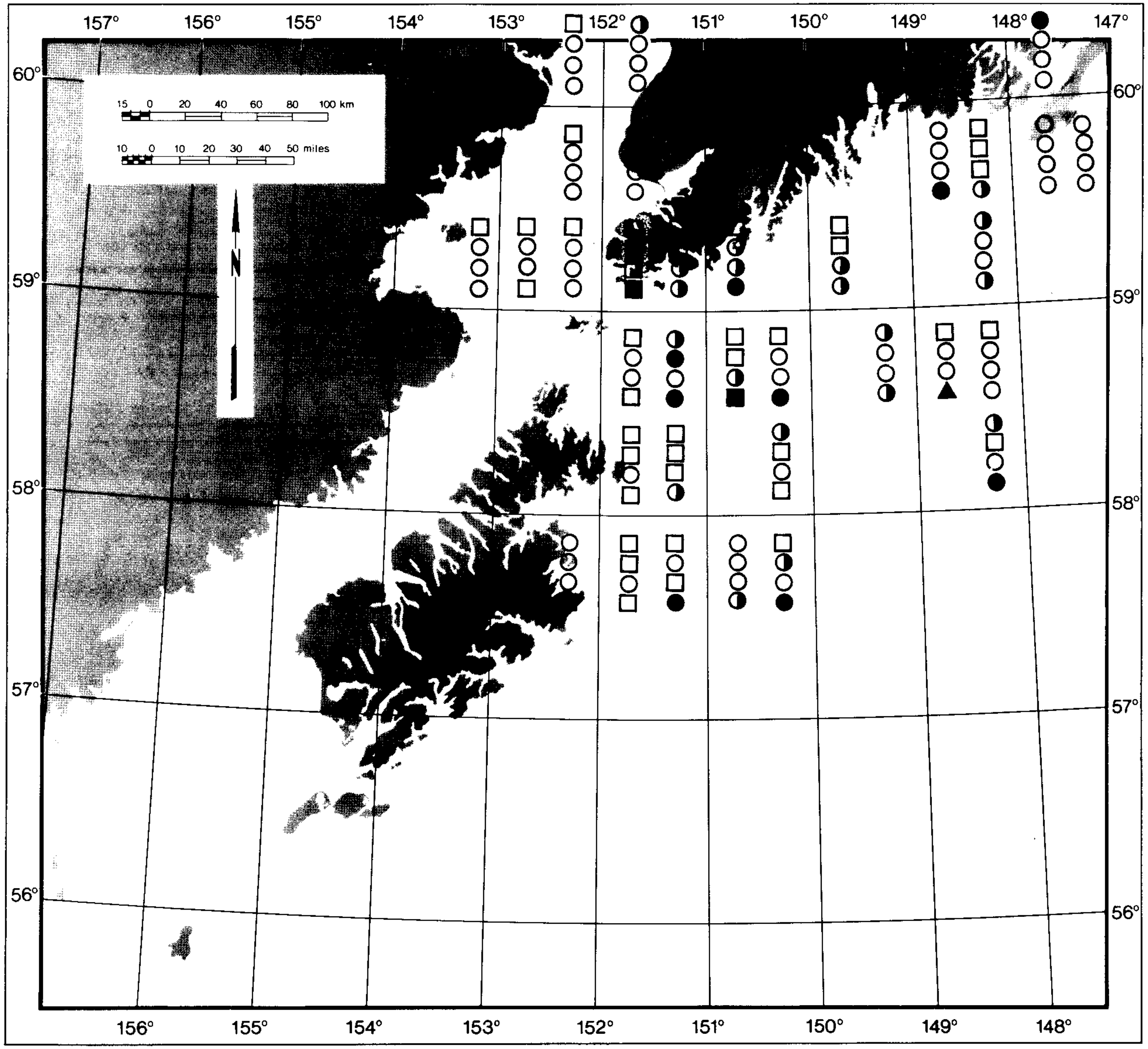
MAY 1976

Figure 3. Shearwater Distributions in NEGOA, May (1976).



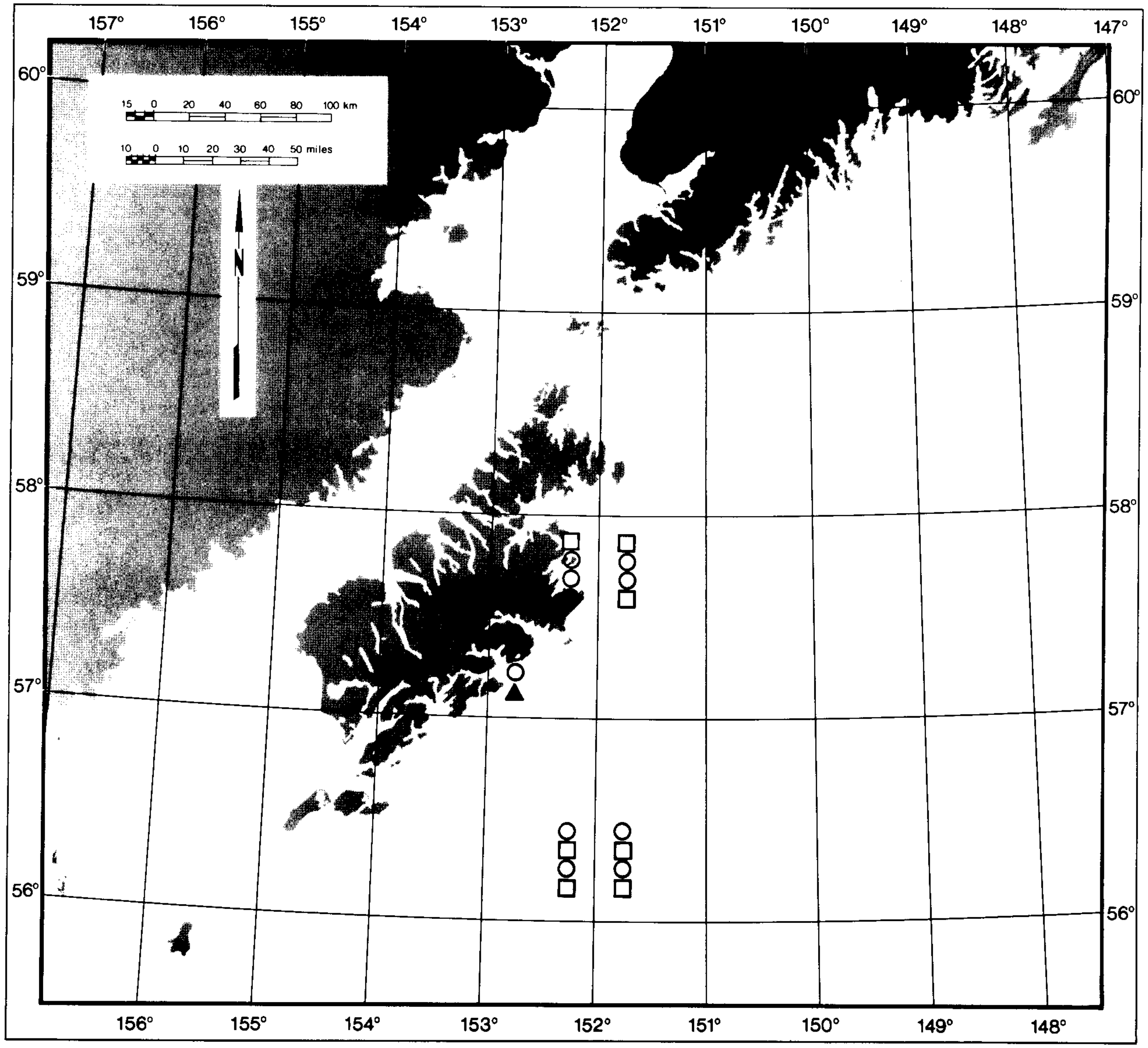
JULY 1976

Figure 4. Shearwater Distributions in NEGOA, July (1976).



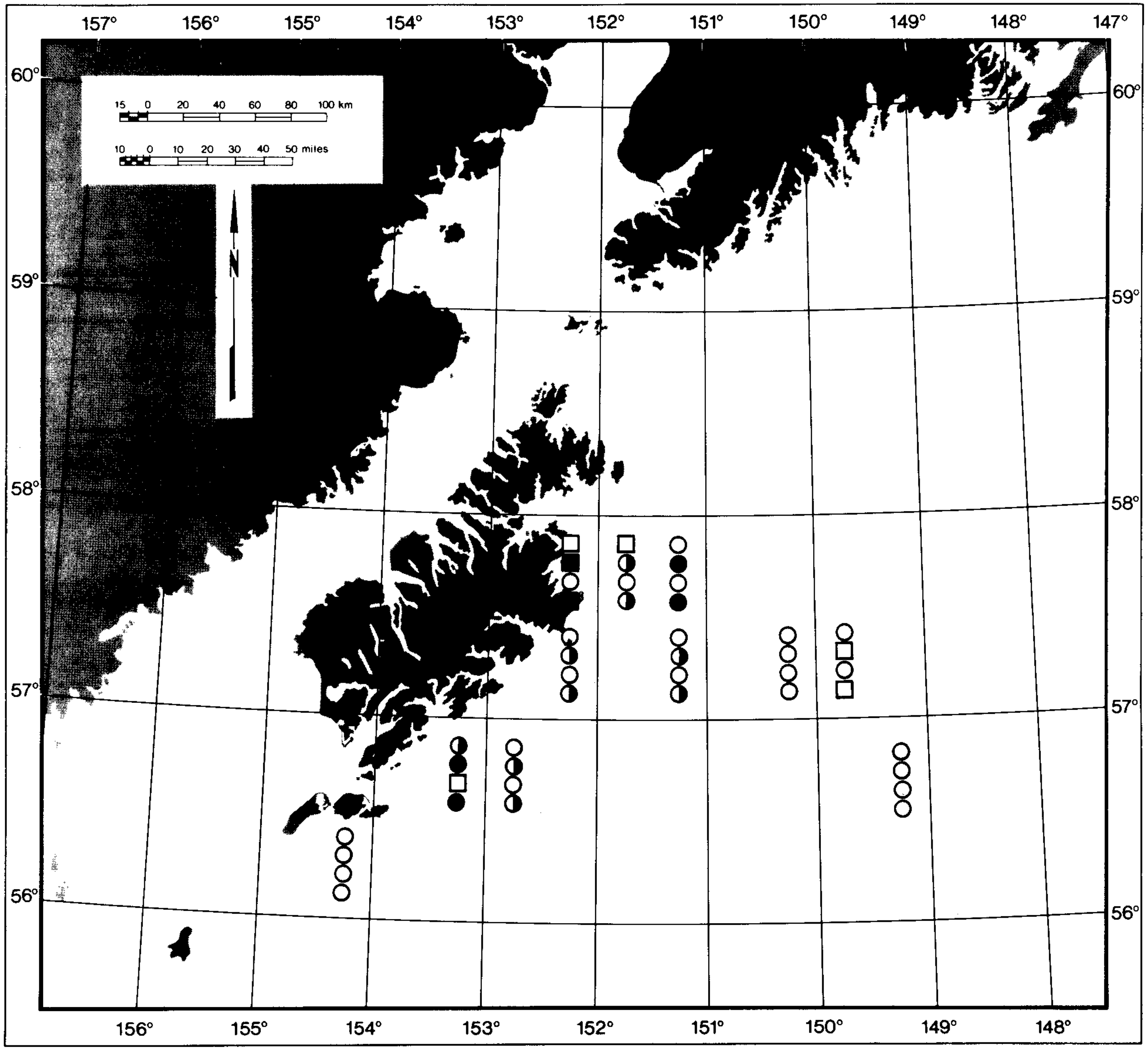
MAY 1976

Figure 5. Shearwater Distributions on Kodiak Island Shelf, May (1976).



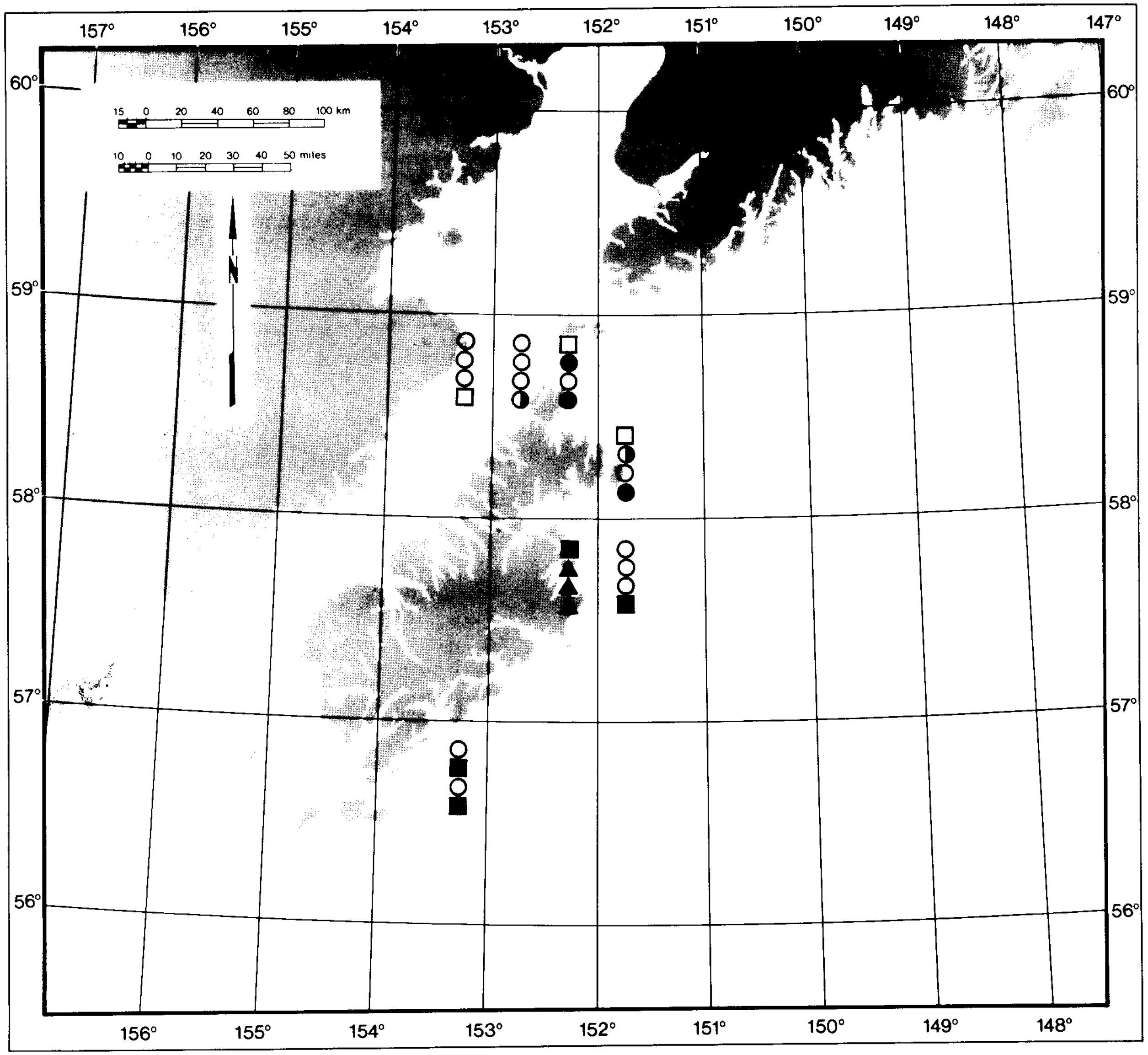
JUNE 1975-76

Figure 6. Shearwater Distributions on Kodiak Island Shelf, June (1975-1976).



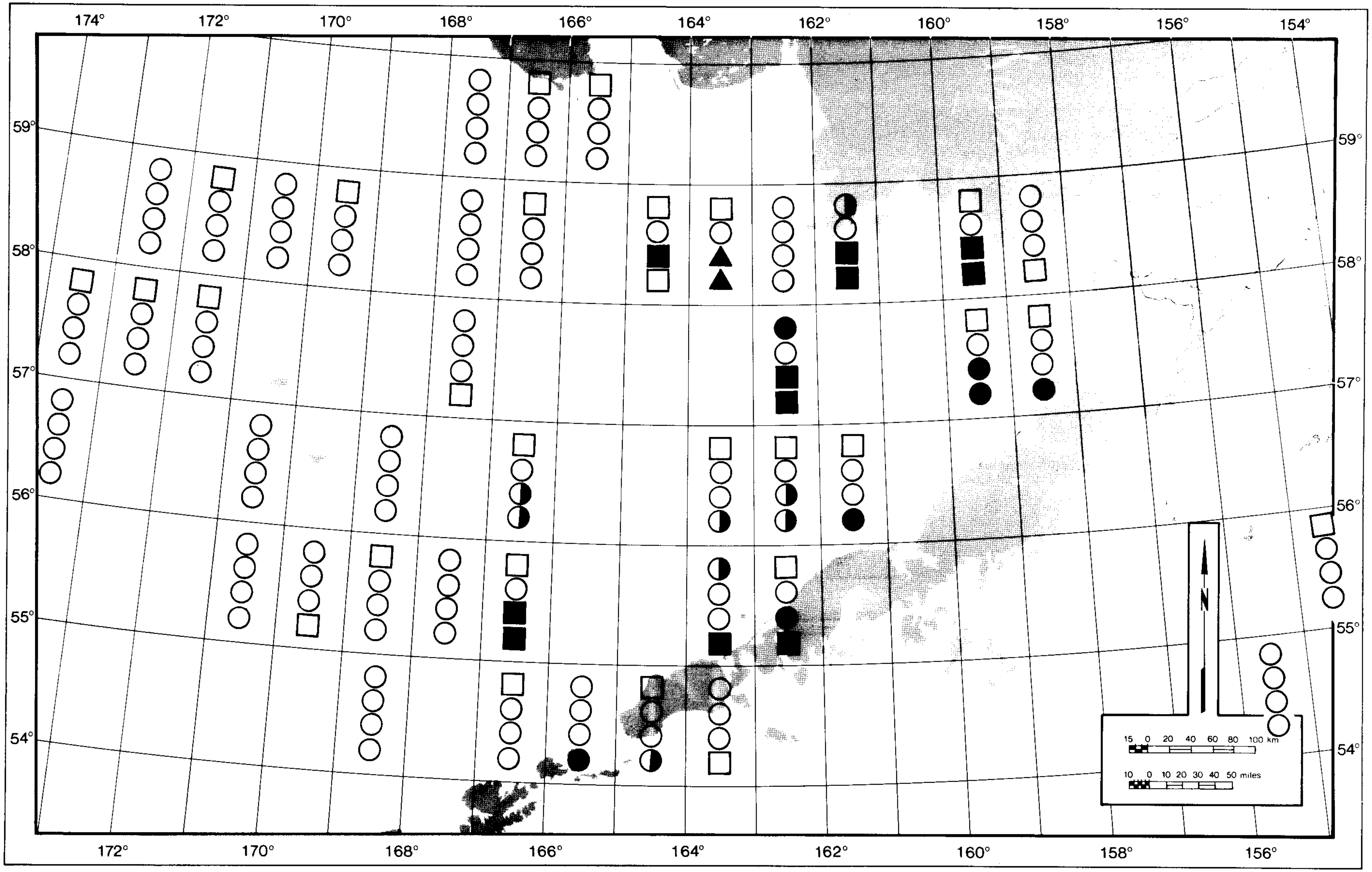
JULY 1975-76

Figure 7. Shearwater Distributions on Kodiak Island Shelf, July (1975-1976).



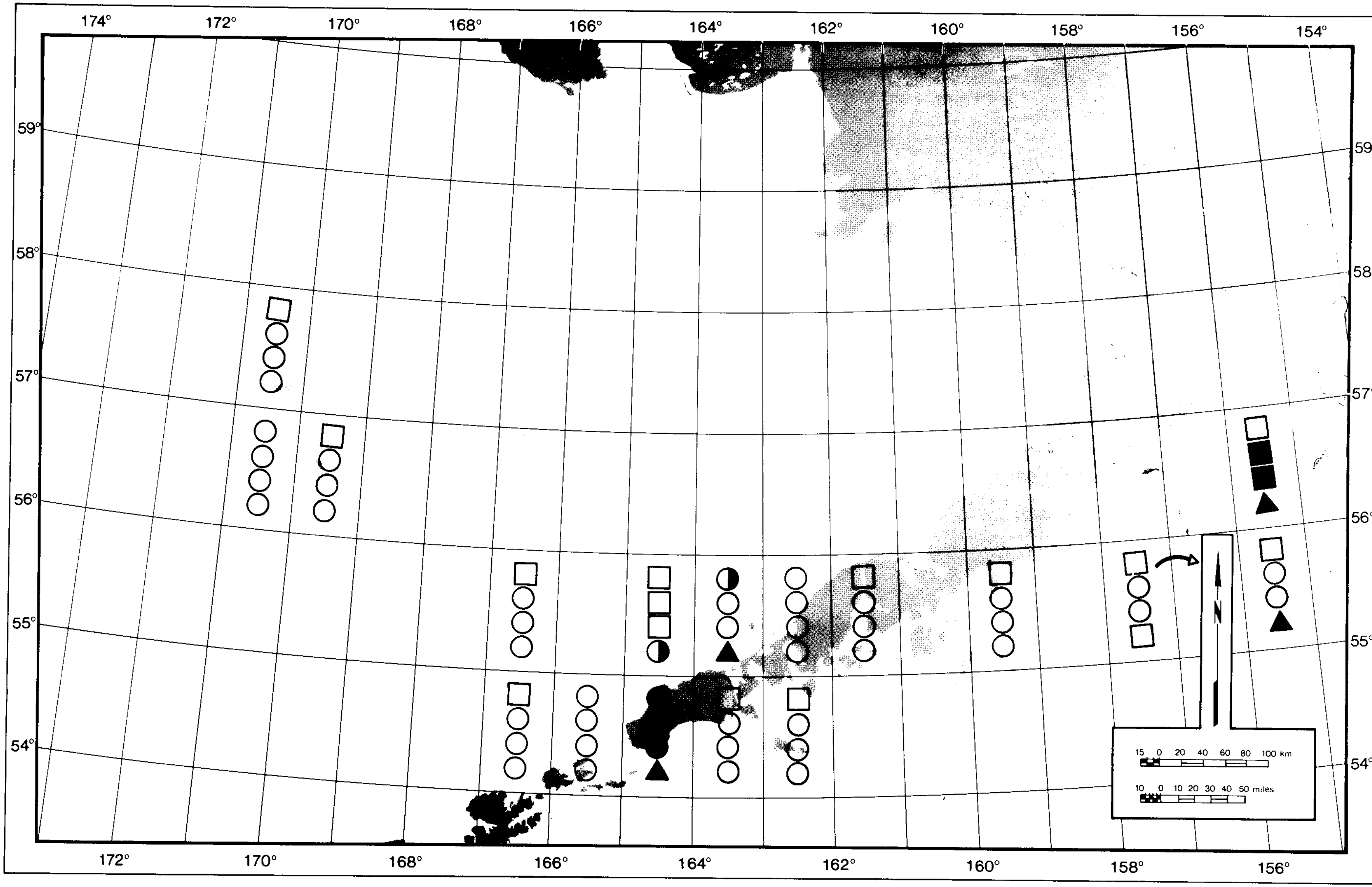
AUGUST 1975

Figure 8. Shearwater Distributions on Kodiak Island Shelf, August (1975).



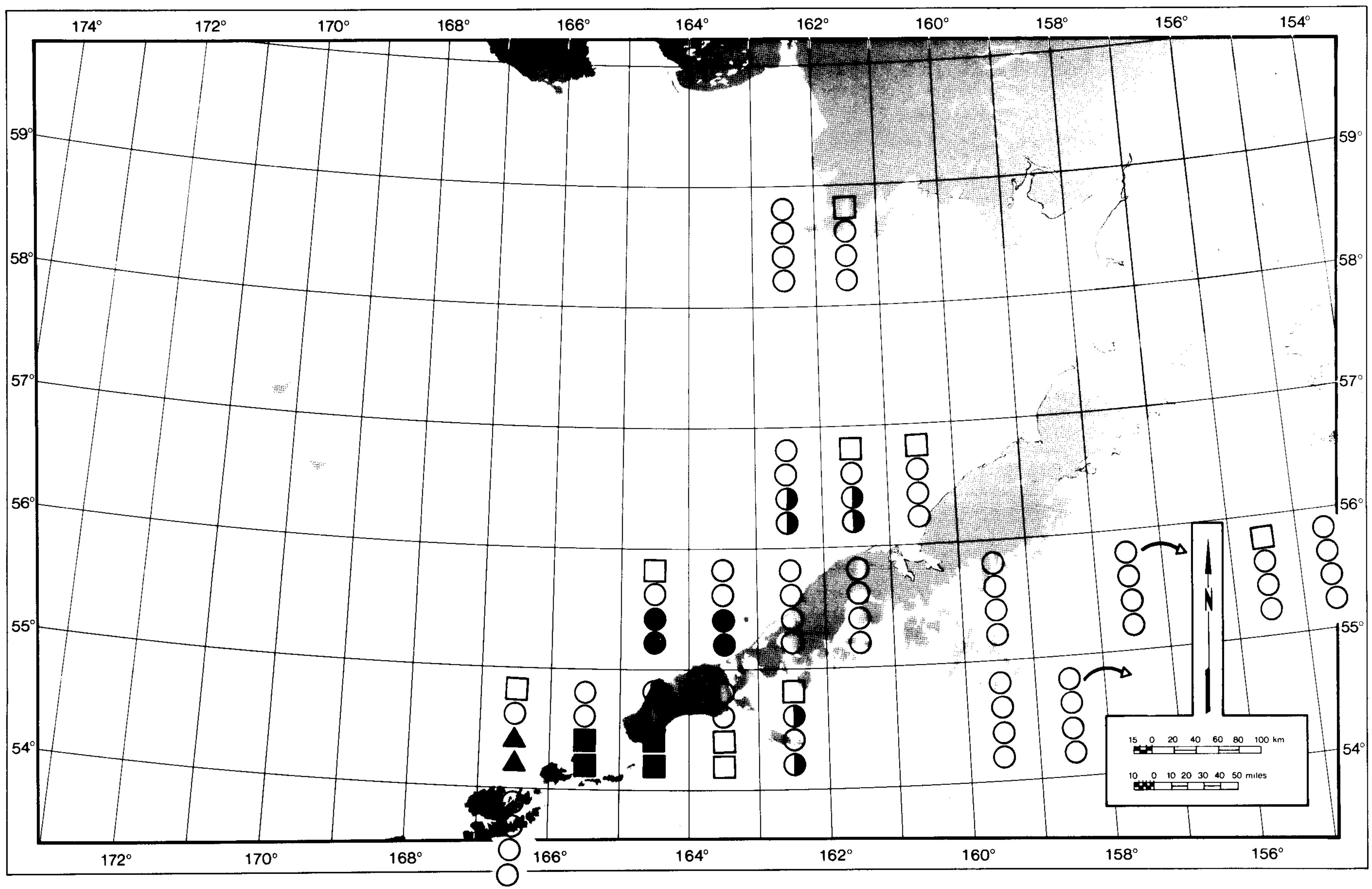
JUNE 1975

Figure 9. Shearwater Distributions in NWGOA and the Bering Sea, June (1975).



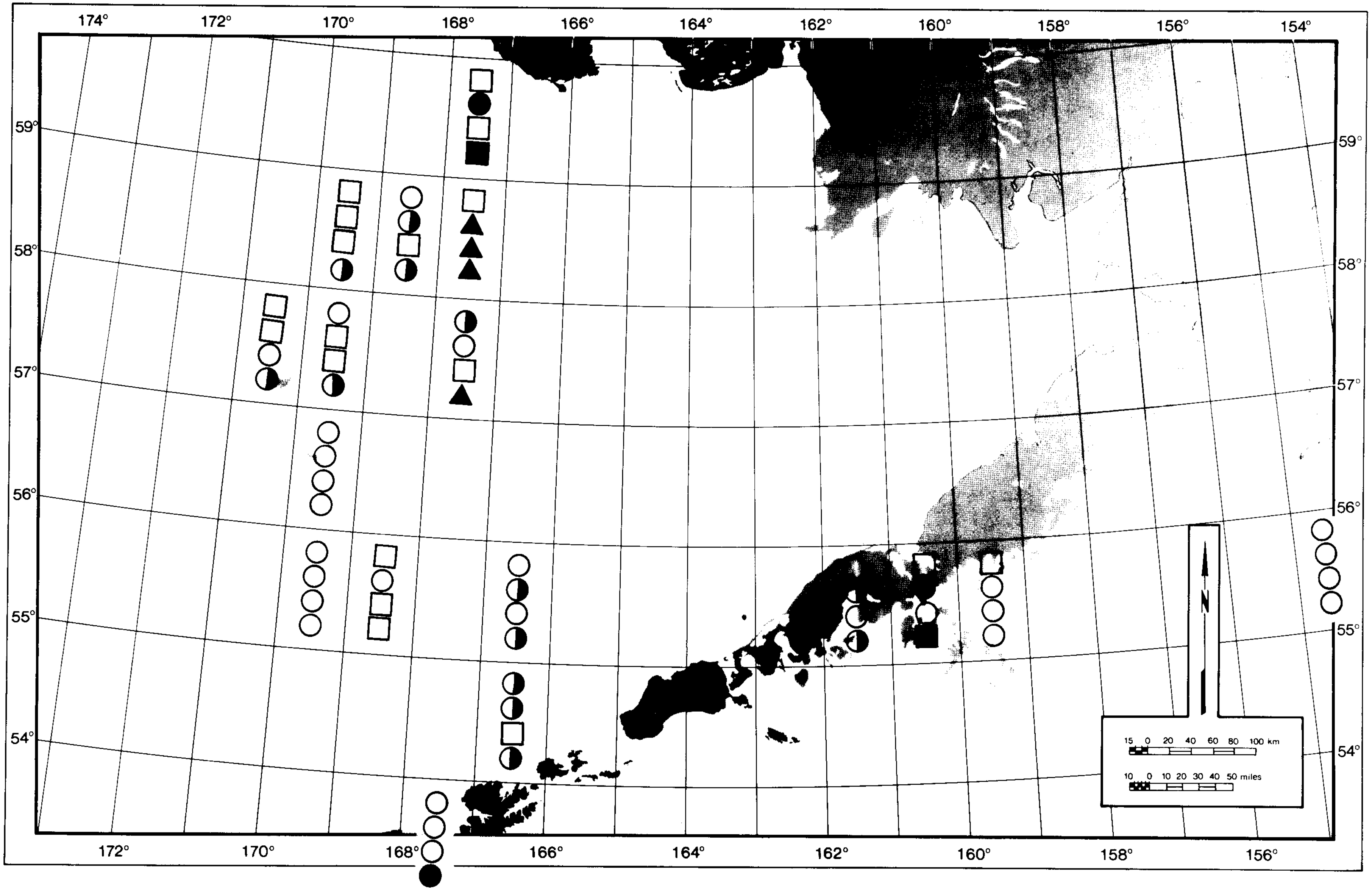
JUNE 1976

Figure 10. Shearwater Distributions in NWGOA and the Bering Sea, June (1976).



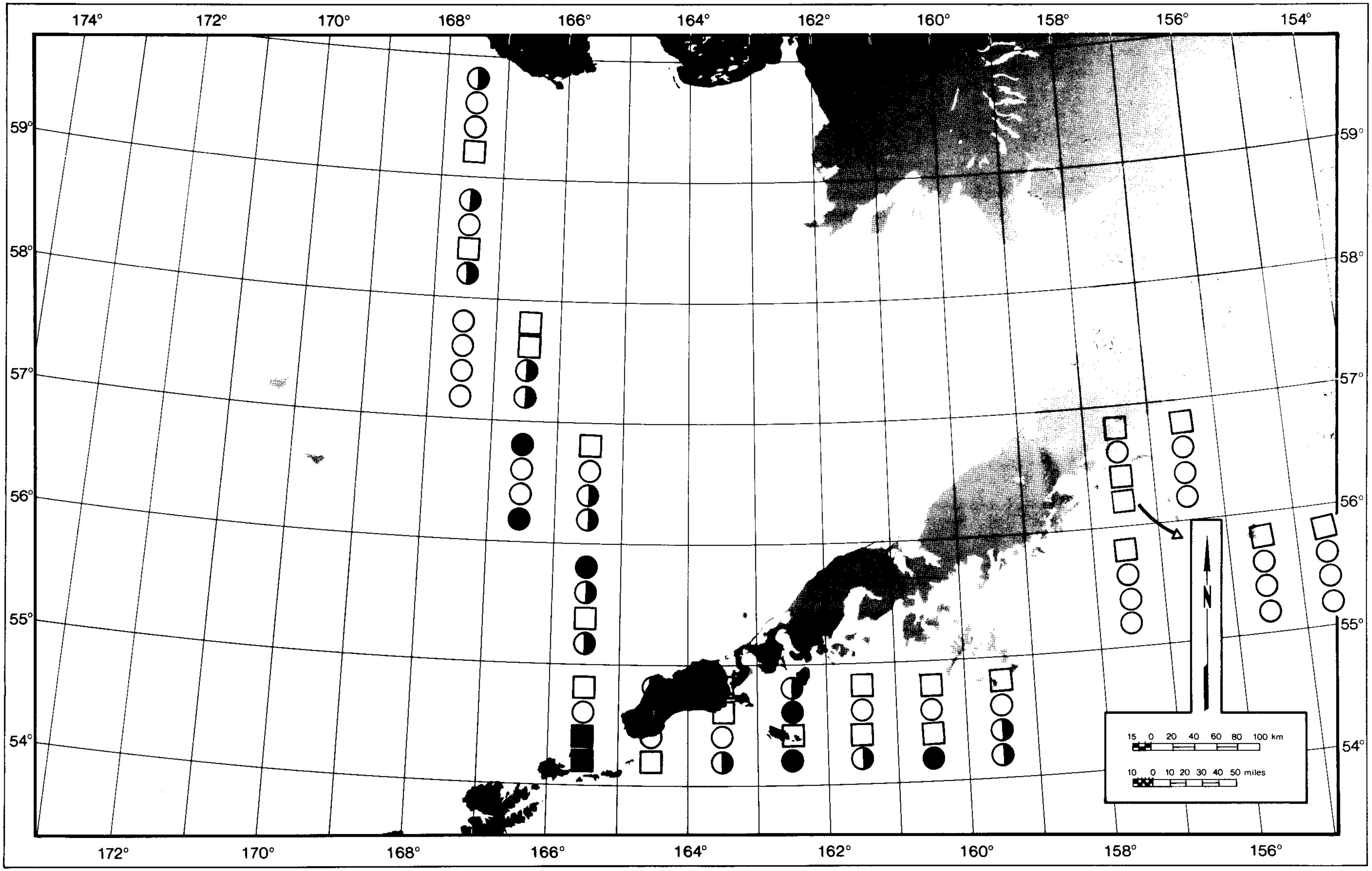
JULY 1975

Figure 11. Shearwater Distributions in NWGOA and the Bering Sea, July (1975).



AUGUST 1975

Figure 12. Shearwater Distributions in NWGOA and the Bering Sea, August (1975).



AUGUST 1976

Figure 13. Shearwater Distributions in NWGOA and the Bering Sea, August (1976).

(1). Distribution of birds in relation to the distance offshore (Figs 14-17). This does not discriminate the different habitats over the continental shelf, but does shed information on the response of shearwaters to coastlines, the Continental Shelf edge, seamounts, and possibly on their movements over the wintering grounds.
(2). Distribution of birds in relation to depth of the water, as a measure of habitat selection (Figs 18-20). One of the best indicators of the degree of tidal and wind mixing over the continental shelf is the depth of the water; so, habitats are basically defined in terms of the isobaths along the continental shelf.

Since the perimeter of the Gulf of Alaska is mountainous, most of the study area presents a very rugged shelf, characterized by the presence of troughs, canyons and sounds. Waters in these features can be quite deep and, indeed,the 100 m isobath (50 fathoms), comes in some places very close to the shore line. However, the 200 m (100 fathoms) isobath is not affected and is found about 60 nm offshore. The eastern shore of the Bering Sea, in contrast, is not as mountainous and the continental shelf offshore has less relief, is shallower and has the shelf edge much farther offshore.

5. Aggregations

Shearwaters were seen in groupings of varying sizes: (i) loose groups of 2-12 birds travelling together, (ii) small flocks of up to a few hundred birds, (iii) large flocks of a few thousand, and (iv) very large grouping of more than 10,000 birds, here referred to as aggregations. These are themselves composed of separated clusters of up to a few hundred birds each.

The large aggregations of shearwaters that were seen in 1975-1976 (10,000 birds or more) are presented in Tables 1-2. Highlights are discussed in the following sections.

6. Sea-Surface Temperatures

The sea surface temperatures associated with aggregations are presented in Table 3.

7. Disposition of Contract Data

The data were coded, keypunched and transfered to magnetic tape. This was sent to the Juneau Project Office in April 1977, although an amended tape was not submitted by the Juneau Project office to the National Oceanographic Data Center (NODC) in Washington, D.C. until 1978.

Also submitted in 1977 were 389 pages of computer-printed data that presented all of our observations on all the species of seabirds seen during the study, by 1 degree N X 1 degree W latilongs on a month-by-month basis.

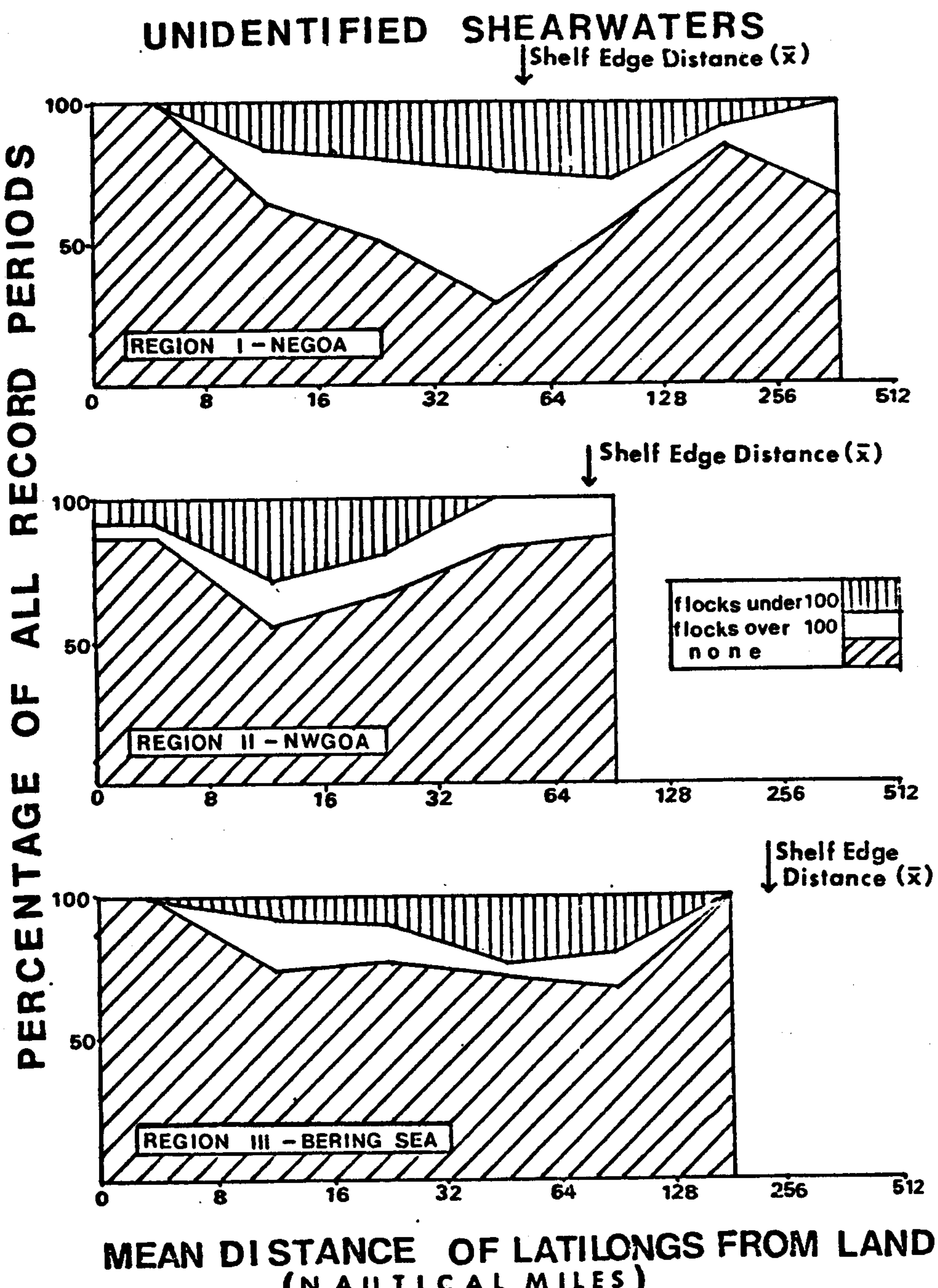


Figure 14. Proportions of 10-minute observation periods in which (a) no shearwaters, (b) flocks of under 100 birds, and (c) flocks of over 100 birds, were seen at different distances from land, 1975-1976.

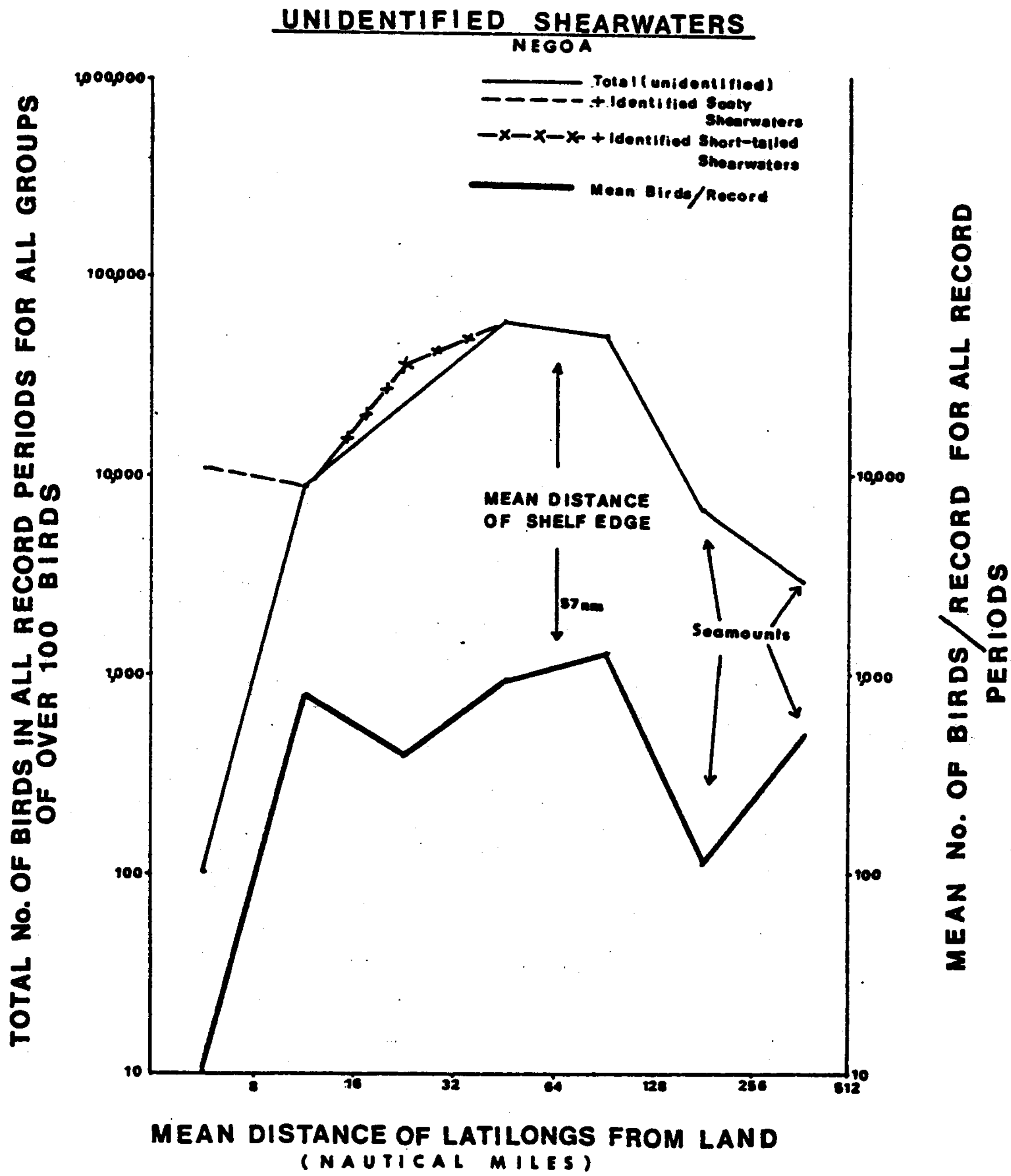


Figure 15. Distribution of shearwaters in the NEGOA in 1975-1976 by Distance Zones from the nearest land (section Vl C).

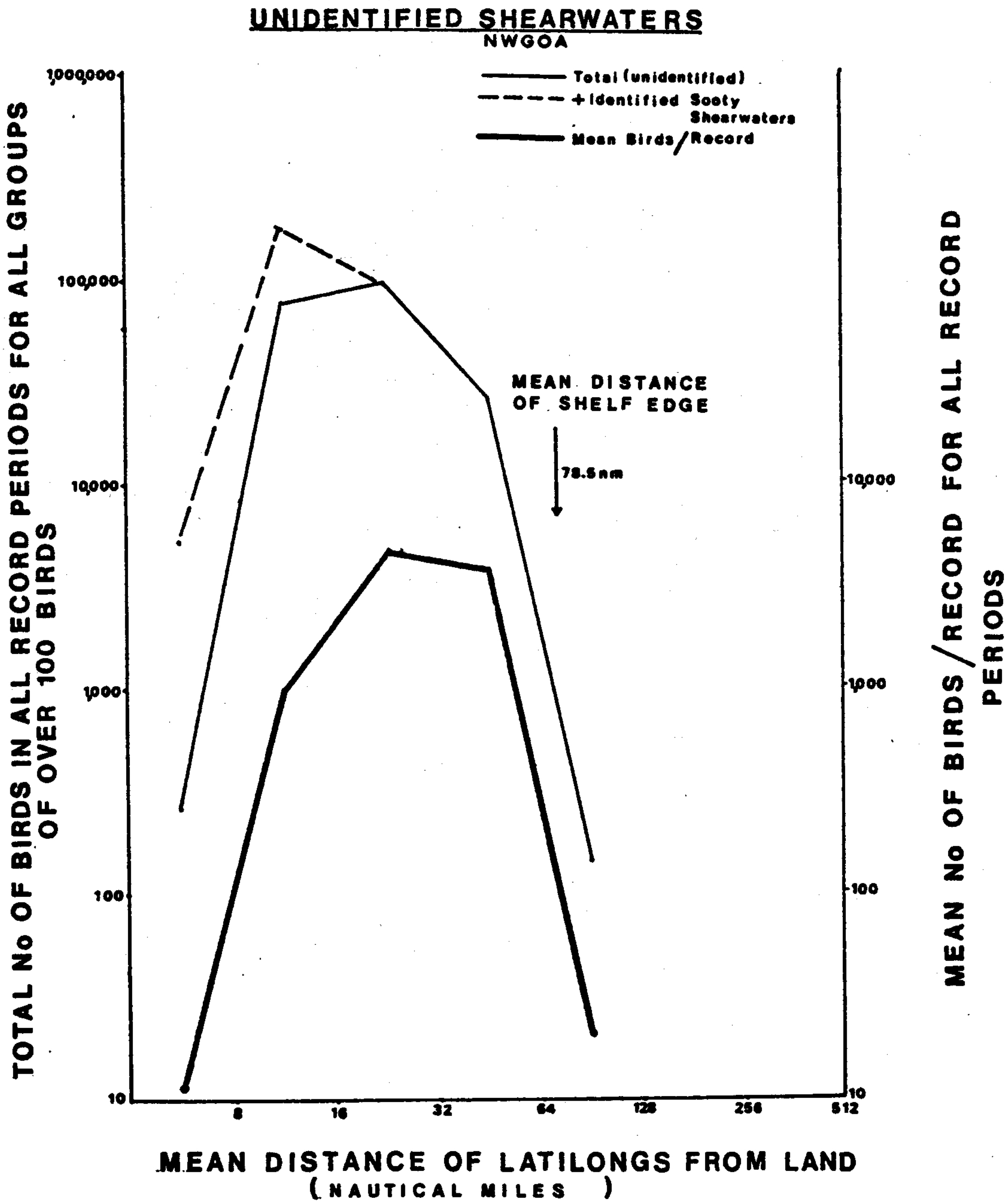


Figure 16. Distribution of shearwaters in the NWGOA in 1975-1976 by Distance Zones from the nearest land. In this presentation NWGOA includes Kodiak Island and adjacent waters.

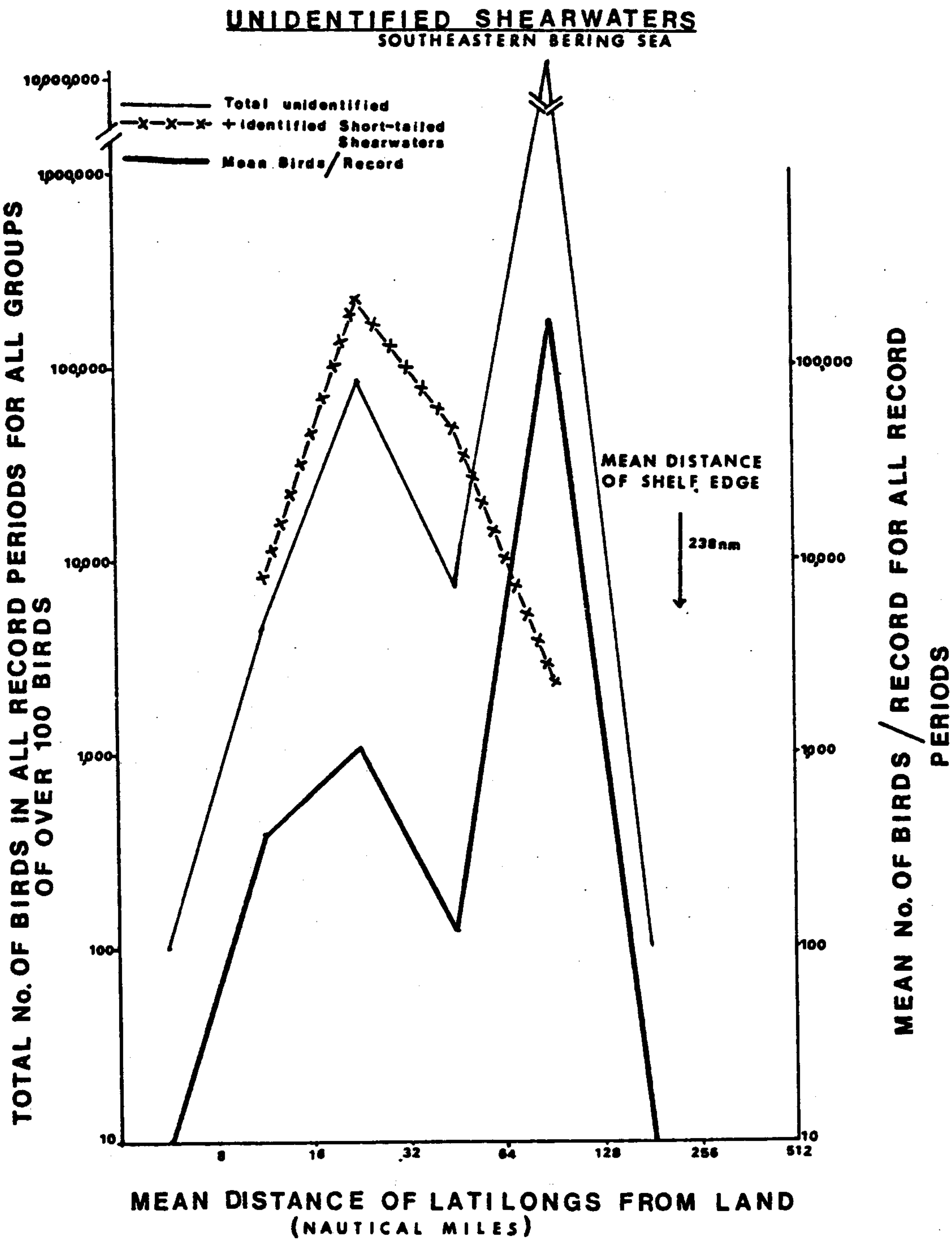


Figure 17. Distribution of shearwaters in the Bering Sea in 1975-1976 by Distance Zones from the nearest land.

TABLE 2 : AGGREGATIONS OF SHEARWATERS OF MORE THAN 10,000 BIRDS SEEN IN 1976

MONTH DAY TIME	REGION AREA LOCATION DS=distance from shore(est.) D=depth estimate (fathoms)	PHYSICAL CONDITIONS SST=sea surface temp. AT=air temp. B=barometric pressure W=wind; direction (degrees) strength (knots) S=wave height(feet)+ swell height(feet)/ direction(degrees)	CENSUS DATA No. of birds, Transect type(N,E or S), and duration CA=census area (km^2) MD=max. density(birds/km^2)	DESCRIPTIVE REMARKS F=No. of flocks FSR=flock size range MFS=mean flock size
May 8 1130-1200	KODIAK SHELF Amatuli Trough Shelf Edge 58°33'N., 149°00'W. DS 65 nm. D 59	SST 5.3°C AT 5.2°C B 29.82,falling W 080°/24k S 3+2/145°	17,500 E - 30 min. CA 10.5 km^2 MD 1,905	Species unidentified.
May 8 1925-2010	KODIAK SHELF Amatuli Trough Shelf Edge 58°35'N., 148°55'W. DS 65 nm. D 59	SST 5.4°C AT 4.0°C B 29.63, falling W 070°/33k S 4+3/140°	50,020 E - 45 min. CA 11.85 km^2 MD 2,532	Both Sooty and Short-tailed Shearwaters. From 1925-1930 20,000 birds were distributed as follows: F 20 MFS 1000 From 1940-2010 another 30,020 were estimated. Some flocks were composed mainly of one species and some flocks mainly of the other.
May 16 1300-1310	NEGOA Shelf Edge (Bering Glacier) 59°43'N., 142°52'W. DS 22 nm. D 100-120	SST 5.8°C AT 6.1°C B 29.91,falling W 295°/14k S 2+3/195°	15,000 E - 10 min. CA ? MD ?	Species unidentified. This flock of 15,000 birds was recorded during only a 10 minute period.

Table 2 (continued):

May 19 1045-1300	NEGOA Shelf (SE Hinchin- brook Island) 59°50'N., 145°41'W. DS 28 nm. D 42	SST 5.8°C AT 5.0°C B 29.72,falling W 100°/40k S 9+7/110°,then 12+6/150°	16,500 S - 70 min. + E - 60 min. CA 2.26 km^2 MD 5,974	Species unidentified. From 1045-1155 Shearwaters were passing at a rate of 150-200/minute, for a total of about 13,500. From 1200-1300 they were still passing at a rate of about 45 birds/minute for a total of about 3,000.
May 27 1350-1400	KODIAK SHELF Inner Kennedy Entrance. 59°02'N., 151°38'W. DS 4 nm. D 40-70 (?)	SST 5.0°C AT 4.8°C B 29.60,falling W 290°/38k S 7+?/275°	10,600 N - 10 min. CA ? MD ?	Sooty Shearwaters Feeding flocks of 5,000 + 5,300 + 300 were passed during only a 10 minute transect. F 3 FSR 300-5,300
May 30 1000-1010	KODIAK SHELF Inner Kennedy Entrance. 58°48'N., 150°48'W. DS 25 nm. D 70-100	SST 6.0°C AT 6.0°C B 29.73,rising W 285°/34k S 3+?/290°	20,000 N - 10 min. CA ? MD ?	Species unidentified. Some 20,000 shearwaters that were feeding at the surface were passed during only a 10 minute transect.
June 6 1030-1040	NWGOA Chirikof/ Trinity Islands 56°02'N., 155°04'W. DS 18 nm. D 20-40	SST 6.1°C AT 6.0°C B 30.22,rising W 240°/12k S 1+2/190°	30,000 E - 10 min. CA 2.6 km^2 MD 11,615	Mainly Sooty Shearwaters. F 20 FSR 1000-2000
June 8 0720-0730	ALEUTIANS South Unimak Pass 54°26'N., 164°52'W. DS 2 nm.(?) D 26+	SST 4.4°C AT 4.5°C B 30.25 W 290°/4k S 1+1/270°	46,000 E - 10 min. (Helicopter) CA ? MD ?	Species unidentified. The concentration was divided in to three aggregations of birds, separated from each other by ca. 1000m.,as follows: (i) 16,000 F 4 FSR 2,000-5,000 MFS 4,000 (ii) 10,000-15,000 (iii) 15,000-20,000 Reaction to the helicopter,flying at ca. 400m., was to fly in different directions and to dive.

Table 2 (continued):

June 15 0830-0900	ALEUTIANS NE Unimak Pass 54°54'N., 164°42'W. DS 5 nm. D 30 (?)	SST 5.6°C* AT 7.5°C B 29.76 W 350°/8k* S 0+1/040° * From 0830-0840, SST was 6.2°C, W was 052°/10k	18,550 N - 30 min. (3 x 10 min.) CA - MD -	Mainly Short-tailed Shearwaters but some flocks mostly Sooty Shearwaters. During the three 10 minute Normal Transects combined here, shearwaters were seen as follows: (i) 4,700 within 100m. + 2,500 at 800m. that were feeding by dive-plunging. (ii) F 7, FSR 250-3000, MFS 1180. (iii) F 3, FSR 100-2000, MFS 1033.
June 15 1230-1235	BERING SEA West Amak Island. 55°15'N., 163°38'W. DS 13 nm. D 25-30	SST 4.4°C AT 7.0°C B 29.74 W 050°/9k S 1+0/-	10,000 E - 5 min. CA 2.0 km^2 MD 5,000	Species unidentified. During this 5 minute period a flock of about 10,000 was passed sitting on the water, feeding and flying in circles.
June 16 1140-1420	BERING SEA Alaska Peninsula * 55°13'N., 163°01'W. DS 1 nm. (exact) D 10-15 (*Amak Island, then Cape Glazenap - opposite Amak Is.)	SST 4.4°C AT 5.8°C→5.5°C B 29.51, rising to 29.56 W 330°/15k S 1+0/-	50,000 (minimum) S - 55 min. (in 3 periods) CA 0.57 km^2 (1140-1145 only) MD 17,544 (max.)	Species not identified. (i) 1140-1145. A concentration of 10,000 only 3,000m from the shore of Amak Island (see CA and MD), at 55°23'N., 163°10'W. (ii) 1220-1230. A flock of 30-40,000 feeding in a very big circle. (iii) 1330-1410. A concentration of 10,000 grouped in three flocks. Feeding by plunging from ca. 50 cm above the water. When they start diving they concentrated in small areas in compact groups. After feeding and flying in circles for 5-6 minutes, two flocks settled on the water. Later they flew in circles, feeding, again. The third flock turned SE and disappeared. (iv) 1410-1420. Flocks totalling about 5,000 birds appeared from the horizon and joined the two circling, feeding flocks. Finally all the birds flew ESE.
June 17 2300-2310	ALEUTIANS NE Unimak Pass. 54°42'N., 164°56'W. DS 5 nm. D 30	SST 5.6°C AT 5.0°C B 29.92, rising W 225°/12k S 2+6/280°	55,000 E - 10 min. CA 7.8 km^2 MD 6,410	Species not identified. All birds sitting on the water. F 21 (counted) MFS ca. 1000 There was also a long file of about 25,000 birds that was 50m wide and 3,000m. long.

Table 2 (continued):

June 19 1035-1045	NWGOA Chirikof Island Shelf Edge 55°59'N., 155°34'W. DS 5 nm. D 14	SST 7.8°C AT 7.5°C B 29.93 W 305°/6k S 0+2/240°	ca. 30,000 S - 10 min. CA 56.6 km² MD 533	Species unidentified.
June 19 1215-1245	NWGOA Chirikof/ Trinity Islands 56°01'N., 155°00'W. DS 20 nm. D 20-40	SST 5.6°C AT 10.3°C→7.9°C B 29.94,rising W 310°/9k S 1+2/190°	50,000 E - 30 min. CA 2.68 km² MD 9,259 (max.)	Aggregations of several thousands of Short-tailed Shearwaters apparently predominated,although smaller groups may have been Sooty Shearwaters. (i) 1215-1230. 25,000 in three big flocks, and flocks of 100-500, were feeding by plunging. Wing molt was observed. (ii) 1230-1245. 20,000-30,000 FSR 100-1000. 2,000 flew NW.
June 19 2225-2235	KODIAK SHELF SE Kodiak Shelf 57°08'N., 152°38'W. DS 8 nm. D approx. 35(?)	SST 5.6°C AT 9.5°C B 29.96,rising W 090°/6k S 1+2/220°	50,000 E - 10 min. CA 6.3 km² MD 7,937	Many were Sooty Shearwaters. F 33 (sitting on water) FSR 1000-2000 Birds flew off ENE.
July 31 1037-1050	KODIAK SHELF Kodiak approx. 57°50'N., 152°00'W. DS 8 nm. D 20-30	SST 8.3°C AT 10.6°C B 30.26 W 190°/8k S 0+2/180°	17,000 E - 13 min. CA ? MD ?	Species unidentified. F 12 FSR 350-1,500 MFS 1,500

TABLE 3 : RANGES OF WATER TEMPERATURES AT SHEARWATER AGGREGATIONS

YEAR	DATE	SEA SURFACE TEMP. ($^{\circ}$C)	SPECIES	LOCATION
A. BERING SEA				
1975	June 8	3.6°	ST	North Bristol Bay
1975	June 10	1.6° - 1.8°	ST	S and SW of Cape Newenham
1975	June 12	1.8°	ST	Outer Kuskokwim Bay
1976	June 15	5.6°	ST/S	NE Unimak Pass
1976	June 15	4.4°	?	West Amak Island
1976	June 16	4.4°	?	Alaska Peninsula
1976	June 17	5.6°	?	NE Unimak Pass
1975	July 24	6.7°	ST	North Unimak Island
1975	July 24	6.7°	ST	North Unimak Pass
1975	July 27	7.8°	ST	North Akutan Pass
1975	August 17	8.9° - 8.3°	ST/S	S Nunivak Island
1975	August 18	10.0°	?ST/S	E Pribilof Islands
B. NWGOA				
1976	June 6	6.1°	S	Chirikof/Trinity Islands
1976	June 8	4.4°	?	South Unimak Pass
1976	June 19	7.8° - 5.6°	ST	Chirikof/Trinity Islands
1975	August 11	10.0°	ST/S	Shumagin Islands

Table 3 (continued):

C. KODIAK SHELF (and Inshore Waters)

1976	May 8	5.3° - 5.4°	ST/S	Amatuli Trough
1976	May 27	5.0°	S	Kennedy Entrance
1976	May 30	6.0°	?	Kennedy Entrance
1976	June 19	5.6°	ST/S	Kiliuda Trough
1976	July 31	8.3°	?	Kodiak
1975	August 5	8.6°	ST/S	NE Kodiak
1975	August 6	8.9°	ST/S	NE Kodiak

D. NEGOA

1976	May 16	5.8°	?	Bering Glacier
1976	May 19	5.8°	?	SE Hinchinbrook Island

ST = Short-tailed Shearwaters

S = Sooty Shearwaters

B. REGIONAL AND SEASONAL DISTRIBUTIONS OF SHEARWATERS

The literature available on the distribution of Sooty and Short-tailed Shearwaters in Alaskan waters has been summarized by Guzman (1981).

The previous records of Short-tailed Shearwaters show that they have been reported in really high numbers only in Unimak Pass (up to 1 million birds). In neither the Bering Sea nor the Gulf of Alaska have they been reported in really large numbers.

Sooty Shearwaters presented a different situation. They have been previously reported in the "millions" in the NEGOA, but only in very small numbers in the Aleutian Islands and the Bering Sea.

It seems that, due to the difficulties in telling these two species apart (which was explained in Section II.A.), (but incorrect) idea that Short-tailed Shearwaters move only into the Bering Sea (see the emphasis in Gabrielson and Lincoln, 1959) and Sooty Shearwaters into the Gulf of Alaska, observers have been inclined to 'decide' that the birds seen in the Bering Sea are Short-tailed and those seen in the Gulf of Alaska are Sooty Shearwaters. There probably is a great deal of misidentification; many Short-tailed Shearwaters visiting the Gulf of Alaska may have been identified as Sooty Shearwaters, and a reverse kind of misidentification of Sooty Shearwaters as Short-tailed may also have taken place in the Bering Sea.

We will deal with the distribution of shearwaters (i) region by region, and (ii) within each region month by month. The text will be mainly concerned with all records that are outstanding, either by being positive and significant or by being negative and displaying the areas not visited by shearwaters.

1. NORTHEASTERN GULF OF ALASKA (NEGOA) (Figures 3-4).

This region was visited only twice, first in May 1976 and a second time in July, 1976.

(1). May 1976.

In May 1976 the Northeastern Gulf of Alaska (NEGOA) (Fig. 3) was given extensive and fairly even observational coverage. Unit efforts were well distributed and provided good samplings of the distribution of shearwaters in the region during the early part of the residency of shearwaters in the North Pacific.

Shearwaters were well distributed, and very abundant over and along the edge of the Continental Shelf (Shelf Break) of the NEGOA between Icy Bay and 146 degrees W in May 1976. Most could not be identified to species. Shearwaters were also found over Oceanic Waters beyond the Shelf Break Front on May 4 (see Section IV.B). On May 12 also, when on transit from Kodiak to Icy Bay, shearwaters were seen in all record periods when over Oceanic Waters beyond the Shelf Break Front, although in low numbers below 100 birds per record period.

No shearwaters were seen inside Cook Inlet on May 6-7 and only two birds were seen there on May 25-26. No shearwaters at all were seen inside Prince William Sound on May 28-29.

Near the Barren Islands a flock of 6,500 shearwaters was seen on May 8. On May 27 an aggregation of 10,600 and on May 30 two aggregations of 5,000 and 20,000 birds were seen in Inner Kennedy Entrance, near the Chugach Islands between the Barren Islands and the Kenai Peninsula. Further out, at the edge of Portlock Bank and Amatuli Trough, three large aggregations were found on May 8: 17,500, 20,000 and 30,000 birds containing both Sooty and Short-tailed Shearwaters (Table 2). Each aggregation was distributed over 10-12 square Km so that the density was only about 2,000-2,500 birds/square Km.

West of Kayak Island and southeast of Hinchinbrook Island, over 16,500 shearwaters were counted on May 19 flying SSW over the Continental Shelf between 0930-1600 hours (peak 1045-1300). The wind was from the ESE at 35-40 knots. The number of birds passing the ship ranged from 2.5-400/minute, but at the peak passage it was 150-200/minute for a total of 13,500 in 70 minutes.

East of Kayak Island, 15,000 shearwaters were seen on May 16 at the Shelf Break Front off the Bering Glacier and south and southeast of Kayak Island groups of 7,500 and 2,500 were also seen at the Shelf Break Front on the same day. Off Icy Cape on May 15 another 8,000 birds were seen in fog and rough seas.

Short-tailed Shearwaters were quite abundant at the Shelf Break Front east of Kayak Island on May 16; the identification of Short-tailed Shearwaters SE of Kayak I. led to the conclusion that many of the unidentified shearwaters there then were probably Short-tailed Shearwaters. If this is correct it was an unanticipated finding. Many Short-tailed Shearwaters may move first of all into the NEGOA right after arrival in early May from the breeding grounds in Australia. They probably do this to exploit the spring peak of zooplankton.

Sooty Shearwaters seemed to be still moving into the NEGOA from lower latitudes along the American and Canadian coastlines during May.

(2). July 1976

The second time that the NEGOA area was visited was in July, 1976. Effort in the NEGOA in July 1976 was not high, but covered a wide area including Oceanic Waters and the Shelf Break. Observations over the continental shelf were actually in a minority.

Unlike May, the number of shearwaters seen in July was very low (Fig. 4). Most of the continental shelf in the eastern NEGOA was devoid of shearwaters, but small parties of Sooty Shearwaters were present at the Shelf Break. The maximum number recorded at any one time was only 350. They were also seen over Oceanic Waters (see Section IV.B) of the northern Gulf of Alaska (Fig. 4).

The Sooty Shearwater was the only species identified. Perhaps Sooty Shearwaters were already moving out of this sector of the continental shelf. The Short-tailed Shearwaters seen in May 1976 were not encountered again; they had, no doubt, moved into the Bering Sea.

2. KODIAK ISLAND SHELF (Figures 5-8)

Most of the cruises to NEGOA, NWGOA and the Bering Sea in 1975 and the 1976 started and/or finished at Kodiak, which resulted in many observations on shearwaters off Kodiak Island.

(1). May 1976

Cook Inlet was practically devoid of shearwaters, except for a few unidentified ones. Prince William Sound was not visited by shearwaters at all during this month. There was only one block with an average number of over 10,000 shearwaters per 10 minutes. This was over Amatuli Trough toward the edge of the Continental Shelf, and was due to over 60,000 birds which were seen on May 8 (Table 2). The Kodiak Shelf offshore from Chiniak Bay was well surveyed (Fig. 5), but the numbers of shearwaters seen were generally very low. However, large aggregations were encountered over Kennedy Entrance, Stevenson Trough and along the edges of Amatuli Trough.

Sooty Shearwaters were mainly restricted to Kennedy Entrance. Short-tailed Shearwaters were abundant not only at Kennedy Entrance but also at Amatuli Trough in smaller numbers.

Four aggregations of 10,000 or more birds each, were seen on May 8 (two), 27 and 30 (Table 2). In one of them (May 27) all the birds identified were Sooty Shearwaters. On May 8, at the edge of Amatuli Trough, an aggregation of 50,000 shearwaters was encountered and in this case both species of shearwaters were present. In the other two aggregations the shearwaters were not identified to the species level.

(2). June 1975-1976

In 1975, after a cruise in the Bering Sea, the vessel cruised from Unimak Pass to Seward over Oceanic Waters beyond the Chirikof Island - Kodiak Island Shelf Break Front on June 18. Very few shearwaters were seen (Fig.6), and none were seen during most record periods. The only identified birds were Sooty Shearwaters.

In 1976, about 30,000 mainly Sooty Shearwaters were seen east of Chirikof Island on June 6. On June 19, during the return journey, three aggregations (totalling 80,000 birds) were found north and northeast of Chirikof Island,

and these were predominantly Short-tailed Shearwaters (Table 2; latilongs between 155-156 degrees in Figure 10). Another 50,000 Short-tailed Shearwaters (in 33 flocks) were seen later on the same day over Kiliuda Trough on the Kodiak Shelf (Table 2; Fig. 6).

(3). July 1975-1976

During July 1975, the Kodiak Shelf was crossed while arriving from Seattle on July 15, and then when travelling between Unimak Pass and Kodiak on July 31 (Fig.7). A flock of about 2,600 Sooty Shearwaters was recorded over Kiliuda Trough and another of about 5,000 birds over Chiniak Trough on July 31. There were few Short-tailed Shearwaters.

In July 1976, the shelf off Chiniak Bay was crossed during a voyage from Seattle to Kodiak and when sailing towards and returning from NEGOA (Fig. 7). An aggregation of 17,000 shearwaters was found off Long Island on July 31 (Table 2) when J.R.G. was ending a cruise in the NEGOA; though mostly unidentified, some were Sooty Shearwaters.

(4). August 1975

When R/V SURVEYOR was docked in Kodiak Harbor on August 5 and 6, 1975, J.R.G. went by launch to the south part of Marmot Bay (just north of Long Island), and during both days large aggregations of 50,000 and 40,000 birds respectively were seen (Table 1; Fig. 8). On August 5 the 50,000 birds were mainly (90%) identified as Sooty Shearwaters and the following day the 40,000 birds were believed to be 70% Short-tailed Shearwaters. The difference between the two days could be due to problems of identification, since only a few birds were identified on each day and the percentages of each species were estimated on the basis of those identifications. The shearwaters on both days were in mixed feeding flocks with 20,000 Black-legged Kittiwakes (<u>Rissa tridactyla</u>), feeding on small fish. On August 7, only 5,000 shearwaters were seen in Chiniak Bay from the R/V SURVEYOR.

On August 7-9, 1975, R/V SURVEYOR cruised around Afognak Island and through Shelikof Strait to the Trinity Islands. About 3,000 shearwaters were seen in the Barren Islands, but in Shelikof Strait the largest number seen during a single record period was 225. In the Trinity Islands the largest number seen during a single record period was 1900, and on August 10 no shearwaters were seen near Chirikof Island. Only Sooty Shearwaters were identified (Fig. 8).

During August 1976, sailing out of (or into) Kodiak Harbor took place during night time, and no data were obtained in that month. A small boat was launched east of Long Island, Chiniak Bay, on August 19, but only four shearwaters were seen.

3. NORTHWESTERN GULF OF ALASKA (NWGOA) (Figures 9-13)

Unfortunately, there were no visits to this region in the month of May.

(1). June 1975-1976

In June 1975, the NWGOA region between Unimak Pass and the Trinity Islands was crossed only once and mainly during the night. Some observations were made south of Unimak Pass on June 17 and beyond the 1,000 fathoms isobath south of Kodiak Island on June 18, but as was noted earlier recorded only low numbers of shearwaters (Fig. 9). No identifications to species could be made.

In 1976, the NWGOA was crossed twice, on June 7 and 19, but no shearwaters were seen along the Inside Passage between Cold Bay and the Shumagin Islands (but see the Kodiak Island Shelf Section). On June 8, about 46,000 shearwaters were seen from the ship's helicopter during a 30-minutes flight in the southern sector of Unimak Pass. The birds were in three aggregations (16,000; 10-15,000; 15-20,000 birds) separated from each other by about 1000m (Table 2; Fig. 10).

(2). July 1975

In 1975, the NWGOA was crossed twice: (i) entirely along the Shelf Break (100 fathom line) on the outward journey to the Bering Sea on July 16, and (ii) on the return trip, from Unimak Pass to the Shumagin Islands through the inner passage on July 28-30, and then over the Kodiak Shelf on July 31. Along the NWGOA Shelf Break west of 155 degrees W and in the inside passage behind the Shumagin Islands no shearwaters were seen. Small flocks of Sooty Shearwaters were seen over Davidson Bank (east of Unimak Pass) and Sanak Bank (Fig. 11).

(3). August 1975-1976

In 1975, during a cruise from Kodiak to Unimak Pass, one aggregation of 16,000 shearwaters only 1.2 nautical miles off the coast of the Shumagin Islands was seen on August 11 (Table 1) of which some were identified as Sooty Shearwaters, but otherwise only small flocks were sighted in the NWGOA during the month of August (Fig. 12).

In August 1976, en route to the Bering Sea, the vessel followed the 100 fathoms isobath west from Chirikof Island on August 1. There were fewer than 10 birds per sighting. After leaving the Bering Sea, R/V SURVEYOR followed along the Shelf Break at about the 100 fathoms isobath to Kodiak Island. Shearwaters numbers were again low. Seven flocks of 1,000 - 4,000 shearwaters (mainly Short-tailed) were found between the Sanak Islands and a point south of the Shumagin Islands on August 18 (Fig. 13). Besides them, only small flocks were recorded. Very few Sooty Shearwaters were encountered except on Sanak Bank.

4. BERING SEA (Figures 9-13)

There were no visits to the Bering Sea in the month of May.

(1). June 1975-1976

During June 1975, the southeastern Bering Sea, right up to the Shelf Break, was widely covered. A few observations were also made, only on this cruise, over the deep Bering Sea Basin beyond the 1,000 fathom contour.

Between Adak and the Pribilof Islands, around the Pribilof Islands, over Pribilof Canyon and on the outer (western) portion of the shelf south of Nunivak Island, west of 165 degrees W and north of 57 degrees N, no shearwaters were seen. Over St. George's Basin on June 5, four shearwaters were seen. On June 16, east of the Pribilof Islands, no more than 83 shearwaters were recorded during any record period. Short-tailed Shearwaters were, however, present farther east in the Bering Sea. Four aggregations that varied from 15,000 - 70,000 birds (for a total of over 200,000) were located from June 8-12, all of them along the north side of Bristol Bay: off Kuskokwim Bay, Cape Newenham and in inner Bristol Bay (Table 1, Fig. 9). Flock sizes ranged from 150 - 17,500 with a mean between 1000 - 1500 birds per flock (Table 1).

Almost no Sooty Shearwaters were found during June 1975, except for a few birds in the Southern Bering Sea off the Alaska Peninsula.

During June 1976, the waters along the north side of the Alaska Peninsula were surveyed from Unimak Pass to Amak Island, and the area near the Pribilof Islands was visited. Unfortunately, Bristol Bay and Cape Newenham were not visited in June 1976. The Pribilof Islands area was totally lacking in shearwaters from June 9-13. Two birds were seen over deep water 30nm N of Unalaska Island on June 14. Shearwaters were abundant, however, from Unimak Pass to Amak Island, and six aggregations that varied in size from 10,000 to 55,000 shearwaters were seen on June 15-17 (Table 2, Fig. 10), for a total of about 135,000 birds. Flock sizes within and composing these aggregations ranged from 100 - 250 birds up to feeding flocks of several thousands circling and plunging together. Estimated maximum densities ranged up to 17,500 birds/square Km only 2000 - 3000 meters from the shore of Amak Island on June 16 (Table 2). In the northeastern sector of Unimak Pass there was a long line of about 25,000 shearwaters sitting on an area of water 3,000 m long and 50 m wide on June 17 (Table 2).

(2). July 1975

In July 1975, only Bering Sea waters along the north sides of the outermost portion of the Alaska Peninsula and eastern Aleutian Islands, and off Cape Newenham, were visited. No observations were made in the shelf edge area near the Pribilof Islands. Off Cape Newenham, observations were carried out along the 10 fathoms isobath, and no shearwaters were seen there. An aggregation of 42,000 shearwaters was found in Urilia Bay (Unimak Island), another of 51,000 on the northern sector of Unimak Pass on July 24. A third aggregation of 57,000 was seen in fog on July 27 in the northern sector of Akutan Pass (Table 1, Fig. 11). Densities were the highest ever recorded by J.R.G., 37,000 birds/square Km at the most concentrated locations (Table 1) on these two days. The shearwaters were all identified as Short-tailed Shearwaters, except for some Sooty Shearwaters seen in Akutan Pass.

(3). August 1975-1976

There was a quick foray over the western sector of the continental shelf of the Southeastern Bering Sea, from Unalaska Island to the Pribilof Islands and Nunivak Island from August 13-19, 1975.

The largest concentration of shearwaters seen, during the whole period of this study, was found on August 17, 1975, over the continental shelf between Nunivak Island and the Pribilof Islands. R/V SURVEYOR was travelling south from Nunivak Island towards Dutch Harbor. It had travelled NE from the Pribilof Islands towards Nunivak Island on the previous day, during which no more than 200 birds were seen during a single record period. On August 17, east of the previous day's track, the vessel passed through a "super-aggregation" for five and one-half hours between 59 degrees 03 minutes N, 167 degrees 58 minutes W and 58 degrees 39 minutes N, 167 degrees 42 minutes W. Birds extended to beyond the horizon. Individual flocks varied greatly in size, from 100 - 6,000 birds and in their distances apart from each other. This concentration contained 6-10 million shearwaters over a 30 nm distance and both species under study were present (Table 1; Fig. 12). Short-tailed Shearwaters predominated, and probably made up 70-80% of the total seen. There were however, estimated to be well over 100,000 Sooty Shearwaters in this concentration. Although the total number was quite exceptional, the estimated area covered was large (1150 square Km) and the estimated maximum density was less than half of that recorded in Urilia Bay or North Akutan Pass (over a smaller area) in July.

A second aggregation of 68,000 birds, also believed to consist of both species, was found due south of the first one, east of the Pribilof Islands, on August 18 (Table 1; Fig. 12). Unfortunately, Bristol Bay was not visited in August in either 1975 or 1976.

During August 1976, all the observations were made while in transit to Norton Sound and back to Kodiak. Just north of Unimak Pass, 5,000 birds crossed the bow on August 2, but otherwise the largest number seen during a single record period on the voyage to Nome was only 100 birds. The only bird seen in Norton Sound from August 5-15, 1976 was one Short-tailed Shearwater. The same western shelf region between 165 - 170 degrees W and 55 - 60 degrees N, as in August 1975, was crossed briefly. Although shearwaters were seen during almost every transect record, their numbers were low in August 1976 (Fig. 13) and flocks ranged from 130 - 2000 (mean: 564 birds).

The same general area where the 1975 aggregation of millions was seen was traversed exactly a year later on the night of August 16/17, but this time only a very few birds were seen. Actually, it would be fairly easy to miss them if they are congregated in a relatively small area; a vessel might pass only a few miles away from them and see nothing. They may congregate in the same general region year after year, but in different patches depending on where food is available. Food distribution could easily change in space and/or time from one year to the next one, depending on the predominant oceanographical and meteorological conditions. The point is that in 1976 the chances of seeing them again were probably no higher than they were of missing them.

North of Nunivak Island only a very few birds were seen (no more than 10, with only one bird seen in Norton Sound). Only a very few Sooty Shearwaters were identified in the Bering Sea.

5. SUMMARY OF FIGURES 3-13

Wherever a latilong contains no cluster of symbols, no observational effort at all was made there. Further, where an open circle occurs at the top of a cluster of symbols, only a single 10-minute record period of observation was made in that latilong.

There are relatively few latilongs on the maps in which black squares or triangles (average of over 1000 birds/10 minute record period) occur at the bottom of a cluster of symbols (representing all shearwaters counted). Generally, when these occur, they are the result of one-time aggregations having been seen there. Although coverage was quite extensive in other latilongs, more often the average number of shearwaters seen in 10 minutes was fewer than 10 or less than 100 birds, i.e. shearwaters are usually not seen in more than very small numbers at sea off Alaska, despite their aggregate preponderance over other Alaskan seabirds during the summer months. In many latilongs the average was recorded as zero, perhaps through lack of enough repeated efforts (as in the case of open circles for both top and bottom symbols in a series).

The places where shearwaters have been seen in large numbers, and months in which they were there seen, can be summarized from our previous reports, as follows:

(1) NEGOA	Off Icy Cape and SE and S of Kayak Island.	May (1 year)
(2) Kodiak I.	Off Chugach Island	May (1 year)

	Shelf		
(3)	Kodiak I. Shelf	Inner Kennedy Entrance and Amatuli Trough	May (1 year)
(4)	Kodiak I. Shelf	Kiliuda Trough	June (2 years) and August (1 year)
(5)	Kodiak I. Shelf	Marmot Bay, Kodiak Island	July (2 years) and August (1 year)
(6)	NWGOA	Chirikof Island	June (1 year)
(7)	NWGOA	Semidi Islands	August (1 year)
(8)	Aleutian Islands	Unimak Pass	June (1 year) and July (1 year) and August (1 year)
(9)	Aleutian Is.	Akutan Pass	July (1 year)
(10)	Bering Sea	N. Bristol Bay	June (1 year)
(11)	Bering Sea	Amak Island	June (2 years)
(12)	Bering Sea	SW of Cape Newenham	June (1 year)
(13)	Bering Sea	S. of Nunivak Island	August (1 year)

Unfortunately, in only three locations (Marmot Bay, Kiliuda Trough and Amak Island) were large numbers of shearwaters seen in the same month in both years of this study. This was because of the "ship-of-convenience" logistics available to us. However, we believe that shearwaters probably occur in several widely separated locations (e.g. Unimak Pass in the Aleutian Islands and off Kodiak Island) in large numbers fairly regularly. During an independent study in 1977-1978 (Guzman 1981), off Kodiak Island, shearwaters were found in large numbers over Stevenson Entrance and Chiniak Trough and off the Barren Islands and Ugak Island, in addition to Marmot Bay and Kiliuda Trough.

The NEGOA is apparently not a favored location for shearwaters after May and/or June. Dated aggregations have been reported only occasionally (Isleib and Kessel 1973).

There are several places (Inner Kennedy Entrance and Amatuli Trough) south of the Kenai Peninsula (NE of Afognak Island) where aggregations of shearwaters can be found fairly regularly at least in May, and off the NE, SE and SW coasts of Kodiak Island where aggregations can be found from June-August (Marmot and Chiniak Bays, Kiliuda Trough and N and NE of Chirikof Island). But west of Chirikof Island shearwaters are scarce along the south side of the Alaska Peninsula until Unimak Pass is reached. Unimak Pass exceeds the Kodiak Shelf area as a place for shearwaters to congregate from June-August (and perhaps in May, though we have no data for that month).

Our sampling of the huge and wide expanse of the Continental Shelf in the Southeastern Bering Sea was inadequate to establish locations in which shearwaters regularly aggregate, apart from near Amak Island where birds were found in June of both 1975 and 1976. North Bristol Bay, which produced aggregations in June 1975, was not revisited in June 1976, and although the area south of Nunivak Island, that produced a "super-aggregation" on August 17, 1975, was revisited on the anniversary date in 1976, such aggregations could have been missed if they had been a few miles farther east or west of the transit line.

Often when the bottom symbol of a cluster is a blackened circle (100-1000 birds/10 min.) the latilong in which this occurs is often next to one with an aggregation. It is ironic that this is a fairly widespread rate of bird observation, but that equally (if not more) common are the open circles and squares indicating less than 10 birds/10 minutes, i.e. very sparse shearwaters.

Analysis of the symbols by region in Figures 3-13 shows that, combining all months for each region and excluding all occasions when there is only one record period in any latilong in any month, the mean number of birds is less than 10 birds/10 minutes in the following proportions and percentages of latilongs by region:

NEGOA	16/26	(61.5%)
Kodiak Shelf	14/34	(41%)
NWGOA	13/22	(59%)
Bering Sea	19/47	(40%)

These rise to the following proportions when the mean number of birds is not more than 100 birds/10 minutes:

NEGOA	19/26	(73%)
Kodiak Shelf	22/34	(64.7%)
NWGOA	17/22	(77.3%)
Bering Sea	31/47	(65.9%)

Finally, a mean of over 1000 birds/10 minutes occurs in only the following proportions of the latilongs:

NEGOA	3/26	(11.5%)
Kodiak Shelf	4/34	(11.7%)
NWGOA	3/22	(13.6%)
Unimak Pass	4/4	(100%)
Bering Sea	12/47	(25%)

C. DISTRIBUTION OF SHEARWATERS IN RELATION TO DISTANCE FROM THE COAST AND WATER DEPTH

1. Distance from the coast

In the analysis of shearwater observations in terms of their distance from the shore the Kodiak Island Shelf area is combined with the NWGOA. The vast majority of shearwaters counted were not identified, hence Figures 14 - 17 are headed "unidentified shearwaters".

What Figure 14 shows is that, despite the huge numbers of shearwaters present in Alaskan waters each summer, the frequency with which shearwaters are seen during a 10-minute watch at sea is very low, from almost never within 8 miles of the coast (except in NWGOA) to only 30-65 percent of occasions at various distances over the continental shelf. Flocks of over 100 birds are seldom seen during more than one count in every four (25%). So, shearwaters are by no means ubiquitous, and to many observers might appear to be quite scarce on many days.

In Figures 15 - 17, the total numbers of unidentified shearwaters (from all groups of over 100 birds) and the mean numbers of all birds seen per record (including negative periods) are plotted. Each one of these records has been identified with the 1 degree x 1 degree Latilong in which it took place. The distance of each latilong from land has been taken as the mean of the maximum and minimum distances from land of the farthest and nearest points within the latilong.

The Distance Zones (0-8, 8-16, 16-32, 32-64, 64-128 nautical miles, etc.) have been given decreasing relative space as distance from land increases because tha purpose was to determine whether the birds were attracted to, or avoided, the coast. So, the separation of the waters in the first 8, 16 or 32 nautical miles from land is exaggerated.

The mean distance to the edge of the Continental Shelf is indicated, as well as the distances of seamounts in the Central Gulf of Alaska, which had the effect of attracting shearwaters at distances from land beyond the Continental Shelf at which the birds would not usually otherwise be found (Fig. 15).

Two months of observations in 1976 (May and July) were mainly devoted to NEGOA, and some data was collected during three transits across the Gulf of Alaska from Seattle to Kodiak.

The distribution of total numbers of all shearwaters seen in relation to distance from land in NEGOA (east of, and not including, Kodiak Island) shows a peak in the number of shearwaters seen between 32 and 128 nm offshore, spanning the mean distance to the Shelf Edge (57 nm)(Fig. 15). The mean number of birds per record (Fig. 15) shows low numbers in waters close to shore, then no great variation from 8 nm to 128 nm. Since this kind of analysis does not discriminate for habitat selection in relation to depth, the zone from 8 to 128 nm, is a mixture of Offshore Waters with some Inshore and Oceanic Waters, which when analyzed together would not show too much change. At about 128 nm, there is a dropping in the number of birds because of Oceanic Waters. Nevertheless, numbers do not drop off completely because of the presence of shearwaters over the Gulf of Alaska seamounts. In the NEGOA in 1976 most shearwaters were not identified. Some Sooty Shearwaters were identified in the first 8 nm from the coast line (Fig. 15). Some Short-tailed Shearwaters were identified around the 16 nm interval from shore (Fig. 15), which is due to the aggregation of that species seen in May 1976, east of Kayak Island at the Shelf Break Front (Fig. 3).

The distribution of total numbers of all shearwaters seen in relation to distance from land in NWGOA (including the Kodiak Island Shelf (Fig. 16) shows that shearwaters are mostly found over the rather narrow continental shelf along the south side of the Alaska Peninsula, and that beyond the NWGOA Shelf Edge (at a mean distance of 78.5 nm) the numbers decrease sharply. This allows one to compare shelf and oceanic waters.

In Figure 17 which was drawn soon after the field work, most of the birds were considered as unidentified, and only those positively identified in the field as Short-tailed Shearwaters were treated separately.

Eight aggregations of shearwaters were encountered fairly close to the coastline between Akutan Pass and Amak Island (including Unimak Pass), in 1975 and 1976 (Tables 1 and 2), and these explain the peaks at 8-32 nm in Fig. 17. This area seems to be one of the most heavily visited by shearwaters in Alaskan waters during the northern summer.

The analysis of observations in terms of their distance from shore was complicated by the great width of the Continental Shelf in the Southeastern Bering Sea. The mean distance of the Shelf Edge is 238 nm, 3-5 times greater than in the Gulf of Alaska. Shearwaters are rare that far out, however. The peak distance for shearwaters was only 16-32 nm, if the August 1975 aggregation of millions at 64-128 nm is excluded.

2. Water Depth.

The objective of the depth analysis is (i) to determine the zonal preferences of each species under study, and (ii) at the same time to find out what habitats they prefer as a group, considering that both species together constitute more than 80% of the seabird population in Alaskan waters during the summer months.

In Figures 18 - 20 the distribution of shearwaters each month has been analysed according to the depth of the water, in order to determine their zonal preference. Zones B,C,D, and E were described in Figure 2. As shearwaters did not visit the Nearshore Zone, the analysis has been done for the Inshore (Zone B), Offshore (Zones C and D) and Oceanic (Zone E) Zones. Zone C is the Middle Shelf Zone, and Zone D is the Outer Shelf Zone.

Zone B goes up to 50 metres (25 fathoms) of depth, Zone C from 51 to 100 metres of depth, Zone D from 101 to 200 metres of depth and Zone E covers all waters over 200 metres of depth. The mean depth of each latilong "block" was used.

Figures 18 - 20 have been divided into three sections as follows:

A. Sooty Shearwater
B. Short-tailed Shearwater
C. All shearwaters, which includes Sooty, Short-tailed and also unidentified Shearwaters.

(1) Northeastern Gulf of Alaska (NEGOA) and Kodiak Island Shelf

For the purpose of relating shearwater observations to water depth in NEGOA, some data collected on the Kodiak Island Shelf in 1978, as part of an independent project, have been combined with the NEGOA data from 1976.

An analysis of the numbers of shearwaters per unit-effort in relation to depth, for all shearwaters in the NEGOA and off Kodiak Island taken together, is presented in Figure 18C. The occurrence of shearwaters in the Outer Shelf Zone may depend on the influence of oceanic waters from the Alaska Current, bringing nutrients to the surface along the shelf break and at the edges of troughs.

Dunn et al. (1979) studied the food web and seasonal composition of marine organisms over the Kodiak Shelf. They found that the euphausiid crustaceans *Thysanoessa inermis* and *Th. spinifera* occurred at more stations in spring than fall, but the density per catch was about the same. Both species were particularly abundant near the edge of the shelf over Kiliuda Trough. *Euphausia pacifica* was found in low densities in the spring along the Shelf Break Front,but was very abundant over the shelf during the fall (mainly on Northern Albatross Bank and over Stevenson Trough). Finally, *Thysanoessa longipes* was found to be more abundant during the fall and in waters deeper than 100 fathoms.

Sooty Shearwaters seemed to prefer the Middle Shelf Zone waters (C) in May, but to extend their range to the Outer Shelf Zone (D) in June.

In contrast, the Short-tailed Shearwater was most abundant in the Outer Shelf Zone (D) in May 1976. It is evident that large aggregations were associated with the edges of troughs. In May 1976, Short-tailed Shearwaters were found almost exclusively associated with the Shelf Break Front east of Kayak Island (Fig. 3). This concentration must be associated with sources of food, available to them as a consequence of a high spring productivity (Fucik,1980). The causes responsible for a high productivity here could be either (i) the start of a weak summer upwelling, stirring of nutrients by changes in the longshore currents, and inshore movement of deep waters along the troughs, or (ii) fresh water runoff from nearby glaciers. A change of direction of the Alaska Stream caused by the geographical presence of Kayak Island also produces eddies and possible stirring of bottom waters along the Shelf Break.

There are no June data from NEGOA proper. In July 1976 the NEGOA region east of Kodiak was almost devoid of

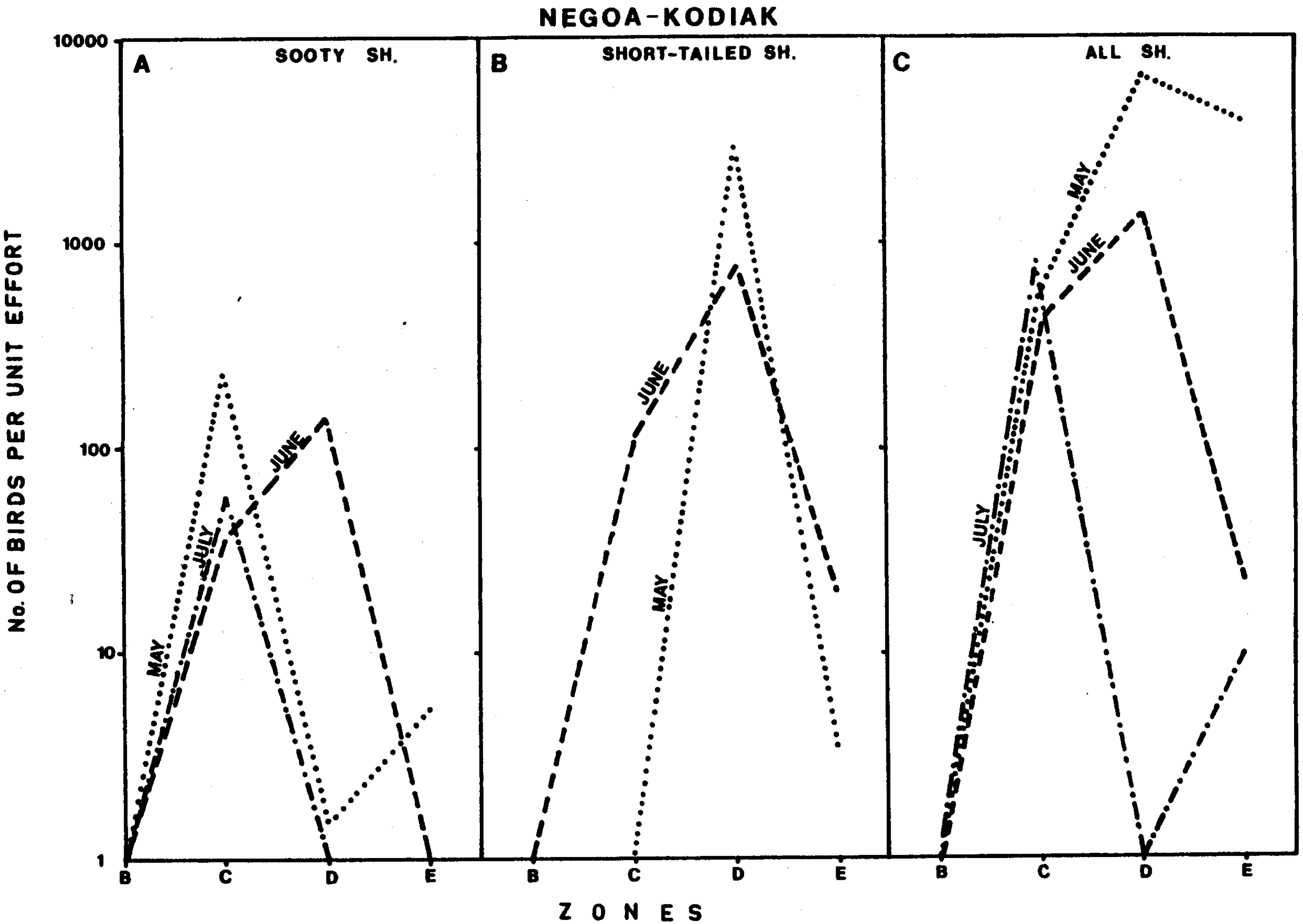


Figure 18. Monthly distribution of shearwaters in the NEGOA and Kodiak Shelf in relation to Depth Zones, during May-July 1976 (and also 1978). All shearwaters (C) includes unidentified shearwaters.

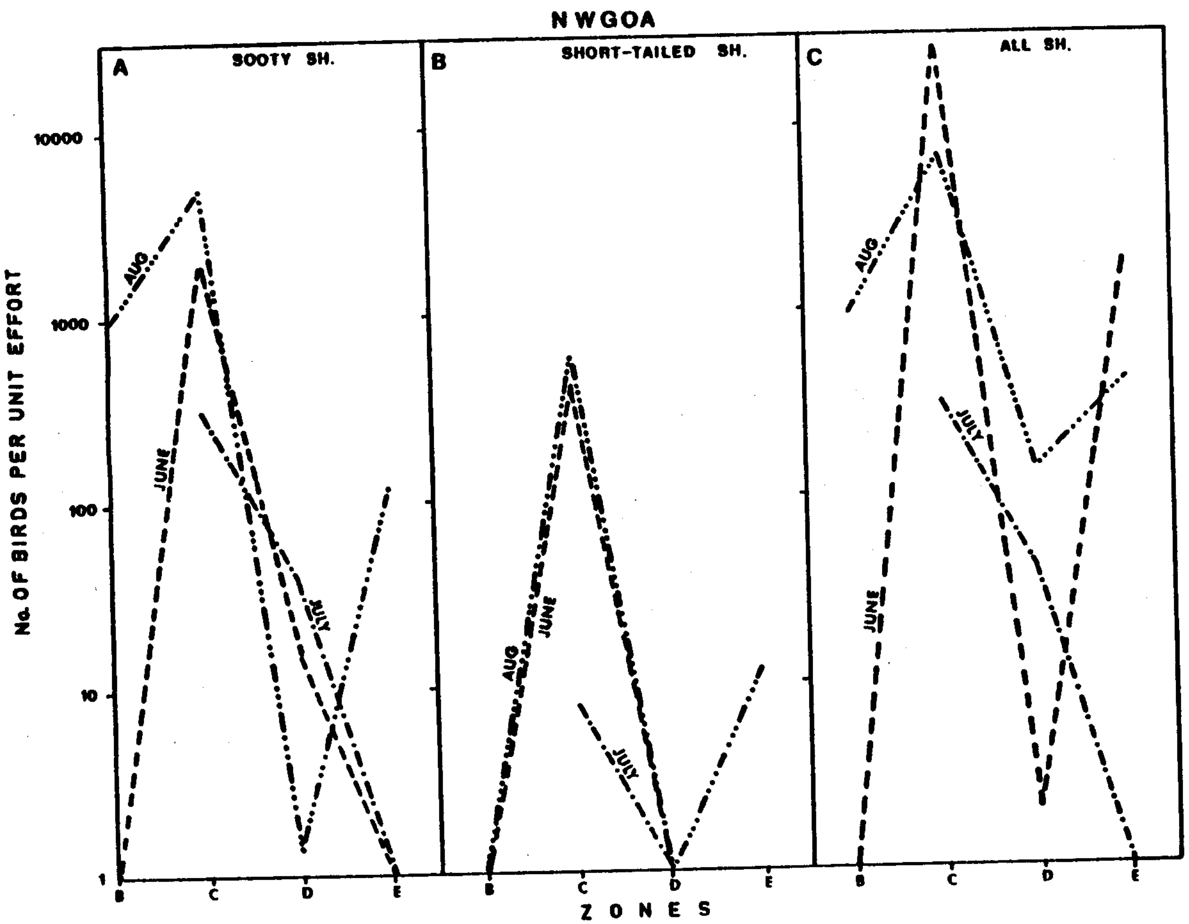


Figure 19. Monthly distribution of shearwaters in the NWGOA, in relation to Depth Zones during June-August 1975-1976.

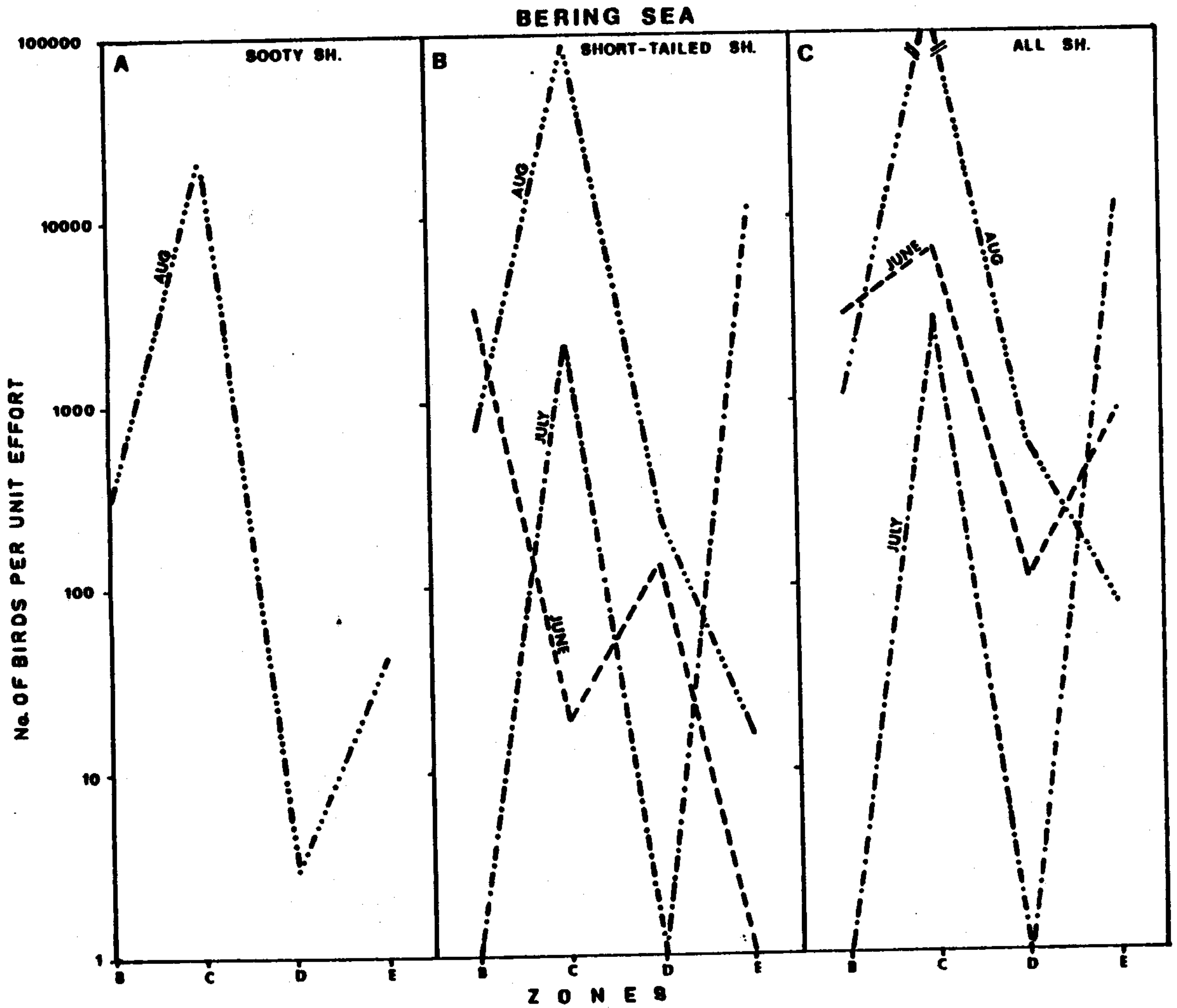


Figure 20. Monthly distribution of shearwaters in the Bering Sea, in relation to Depth Zones, during June-August 1975-1976.

Short-tailed Shearwaters. It is possible that after the spring bloom of plankton in NEGOA both species of shearwaters move to more productive waters off Kodiak Island and in NWGOA, during the mid- and late summer. Damkaer (in Fucik,1980) stated that the zooplankton in NEGOA appear to reach maximum numbers from late May through mid-June.

In contrast, Dunn et al. (1979) and Dunn et al. (in Strauch et al., 1980) found that zooplankton were more abundant on the Kodiak shelf during the fall than during the spring.

(2) Northwestern Gulf of Alaska

The Northwestern Gulf of Alaska, west of Kodiak Island, was visited only while in transit between Kodiak Island and the Bering Sea. The analysis of all shearwaters together, whether identified or not (Fig. 19), shows that there was a considerable number of birds in the Middle Shelf Zone (C), because of several aggregations west of the Trinity Islands in June 1976 (Fig. 10). They were also seen over Oceanic waters (E) just beyond the Shelf Break Front, during August 1976 (Fig. 13) east of Unimak Pass.

It seems that the habitat selection of shearwaters in NWGOA follows a very similar pattern to that observed in NEGOA, with big aggregations at the 50 fathoms or 100 fathoms isobaths, mainly related to troughs or canyons across the shelf.

Shearwaters were found over inshore waters during August 1975 (Fig. 19A) because of their occurrence in the Shumagin Islands on August 11, 1975.

Short-tailed Shearwater numbers were lower than those of Sooty Shearwaters in NWGOA.

(3) Southeastern Bering Sea

The only month that the Southeastern Bering Sea was well covered by surveys was June, 1975 (Fig. 9).

For the calculations in Figure 20, we have assumed that six million shearwaters were seen on August 17, 1975, of which 80% were Short-tailed Shearwaters (4.8 million) and 20% were Sooty Shearwaters (1.2 million).

Because most of the shearwaters seen in the Bering Sea were Short-tailed Shearwaters, the three month depth distribution patterns shown are basically similar in Figures 20C and 20B.

In general, Short-tailed Shearwaters prefer Middle Shelf waters (Zone C) in the southeastern Bering Sea, but they are also found in considerable numbers in Inshore and Shelf Break Front waters. Their numbers are definitely lower over the Outer Shelf Zone than in any other Bering Sea zone.

This habitat selection by shearwaters seems to be very similar to that of the distribution of phytoplankton in the southeastern Bering Sea (Sancetta,1981). PROBES workers have shown that in the Middle Shelf Zone "the thermocline is occasionally disturbed by wind and tidal vertical mixing in spring", which "results in higher nutrient concentrations, leading to a spring bloom of phytoplankton" (Sancetta, 1981), and that the concentration of chlorophyll persists below the surface until fall. This probably results in spring and summer concentrations of zooplankton in the Middle Shelf Zone.

Oceanic Waters just beyond the Shelf Break Front west of Unimak Pass seem to be frequently visited by shearwaters. In contrast, Oceanic waters and the Shelf Break near the Pribilof Islands were practically devoid of shearwaters. West of Unimak Pass, high productivity may well be caused by nutrients brought up to the euphotic zone by turbulence produced by the impact of the Bering Current System against the steep Shelf Break, and/or the input of water from the Alaska Stream in the North Pacific through the Aleutian Islands passes.

In the Outer Shelf Zone of the Bering Sea, shearwaters were never found to be very abundant, in contrast to the situation observed in the Gulf of Alaska where the Continental Shelf is so much narrower. This suggests that the coastline of the Bering Sea does have some undefined general influence on shearwater distributions.

The Oceanic Waters of the Bering Sea were surveyed beyond the Shelf Break only briefly. The Short-tailed Shearwaters shown over Oceanic Waters in Figure 20B are mainly shearwaters seen near the Shelf Break Front just west of Unimak Pass.

D. SEA-SURFACE TEMPERATURES AT SHEARWATER AGGREGATIONS

1. Reports in the Literature

There are few previously published measurements of the sea surface temperatures with which Sooty and Short-tailed Shearwaters have been precisely associated in the Northern Hemisphere. However, water temperatures for the same month may vary greatly from year to year in the eastern Bering Sea (Straty and Haight 1979) which is a shearwater wintering area so, unless high latitude shearwaters wander widely seeking a specific narrow range of temperature,it seems probable that they are adapted to living off waters that may be quite variable in their temperature range.

In the North Pacific the Short-tailed Shearwater goes farther north than the Sooty Shearwater, in both the Sea of Okhotsk and the Bering and Chukchi Seas. Kuroda (1957) saw Short-tailed Shearwaters in pack ice in the Sea of Okhotsk in late April 1950.

Tanaka and Kajihara (1979) described the presence of Short-tailed Shearwaters, from 10-25 July 1977, off the Sea of Okhotsk coast of Hokkaido in what they described as a "cold upwelling zone", but the water temperatures ranged from 9.5-17.5 degrees C, and the largest flocks of these birds (5,000-20,000) occurred at 11.0-12.0 degrees C., which might not be considered "cold" in Alaskan waters. The Continental Shelf there was narrow and the shearwaters were mainly close to, or outside, the 100 m (50 fathom) isobath in what we have called the Outer Shelf Zone. As will be seen shortly, these temperatures are warmer than any which we recorded as associated with large aggregations of Short-tailed Shearwaters in Alaska.

For Sooty Shearwaters there are a few previously published temperature records. Kuroda (1957) stated that Sooty Shearwaters "remain off Japan over the warm current sea surface (Kuroda 1956)". Off Northern Honshu, Japan, on 4 June and 14 July, 1954, Kuroda (1955) saw Sooty Shearwaters when the water was at 12.0 and 12.5 degrees C, respectively, and at various distances off Kushiro, Hokkaido, from 10-13 July, 1954, he saw a few birds only in waters ranging from 8.2-12.0 degrees C. In the Aleutian Islands, Sooty Shearwaters were reported on July 12 and August 6, 1966, in waters that were at 8.2 and 9.8 degrees C, respectively (Miscellaneous Reports of the Yamashina Institute of Ornithology and Zoology, 1967). The reported range for wintering Sooty Shearwaters has, therefore, spanned 8.2-12.5 degrees C. in the literature and, as will be seen below, the upper end of this range matches what we found. We recorded aggregations of Sooty Shearwaters at lower temperatures than 8.2 degrees C, but no Short-tailed Shearwater aggregations above 10.0 degrees C.

We know of no water temperature measurements having been made from southern Japan or from Washington, Oregon or California, but these are not strictly wintering areas.

2. Alaska 1975-1976

From Tables 1 and 2, we have extracted the sea surface temperatures, when known, that were recorded at aggregations of 10,000 or more shearwaters during the field seasons 1975-1976, and these are listed in Table 3.

The ranges of temperature at which aggregations were seen for each of the major regions are:

NEGOA	5.0 - 6.0 degrees C (May 1976)
Kodiak Island	5.6 degrees C (June 1976; Kiliuda Trough) 8.3 degrees C (July 1976)
NWGOA	5.6 - 7.8 degrees C (June 1976) 4.4 degrees C (June 1976; S Unimak Pass) 10.0 degrees C (August 1975)
Bering Sea	4.4 - 5.6 degrees C (June 1976; NE Unimak Pass to Alaska Peninsula) 1.6 - 3.6 degrees C (June 1975; Bristol Bay to Kuskokwim Bay) 6.7 - 7.8 degrees C (July 1975; North Unimak and Akutan Passes)

8.3 - 10.0 degrees C (August 1975;
Pribilof Islands to Nunivak Island)

What this shows is that:

(1) We recorded aggregations in waters ranging from 1.6 - 10.0 degrees C, in Alaska a fairly wide range, which suggests

(2) that the birds were not always voluntarily selecting these temperature but had to pass through these temperature zones at one time or another (e.g., even in the huge aggregation of millions in the Bering Sea on August 17-18, 1975); and

(3) favoured feeding locations, such as off Kodiak Island, experienced temperature variations: (i) from year to year, or (ii) in very different places (10.0 degrees C off the Shumagin Islands in August 1975 but 4.4 degrees C in Unimak Pass in June 1976 and 1.6 degrees C near Cape Newenham in June 1975).

These findings are rather unexpected, but fairly convincing. We had assumed that the optimal range of temperature for wintering shearwaters might be fairly narrow (perhaps as little as 3-4 degrees at most), but it appears that the sea surface temperature, as such, at which wintering shearwaters may commonly be found can vary over at least 8 degrees C (e.g. 2.0 C - 10.0 degrees C).

One is inclined, therefore, to conclude that various types of high secondary or tertiary food production (zooplankton and fish) can occur over a wide range of temperatures in the complex oceanographic conditions on either side of the Aleutian Islands Archipelago and Alaska Peninsula regions.

The actual partitioning of the marine environment by the two species of shearwaters is probably less related to water temperature than to a complex of environmental choices associated with differences in food preferences between them.

E. SHEARWATER DENSITIES IN AGGREGATIONS.

For aggregations of shearwaters that achieved an observed accumulated total of over 10,000 birds (those listed in Tables 1 and 2), there appear to be four broadly different levels of shearwater density, as follows:

	Max Density (birds/km2)	Census Area (km2)	Total No.of Birds
(1)L. D. spread out	421-1,701	28.7-121.0	(15,000-110,000)
(2) I.D.- more concentrated	1,905-15,432	1.95-12.96	(10,000-55,000)
(3) I.D.-			

spread out	5,210-8,680	1152.0	(6-10 million)
(4) V.H.D.- very concentrated	17,544-37,168	0.57-1.54	(10,00 0.57,000)

[L.D. = Low density
I.D. = Intermediate density
V.H.D. = Very high density]

The recorded maximum density of birds, in aggregations of over 10,000 altogether, can thus, for example, range from
(1) as few as 421 birds/km2 for 15,000 birds spread over 35.7 km2, through
(2) an overall 5,210 - 8,680 birds/km2 for the 6-10 million birds spread over 25-30 linear nautical miles on August 17, 1975, in the Bering Sea, to
(3) an absolute maximum of 37,013 birds/km2 for a flock of 57,000 birds in fog during a 5-minute observation of a dense concentration covering only 1.54 km2 of the north side of Akutan Pass on July 27, 1975, or
(4) 37,168 birds/km2 for 42,000 birds counted moving westward in a restricted location, 1.13 km2 of Urilia Bay, on the north side of Unimak Island, during a 75-minute period on July 24, 1975.

It is evident from the tabulated summary (above) that large total <u>numbers</u>, for example 10,000 - 110,000 birds, can be found <u>both (1)</u> in very concentrated aggregations within very small areas of less than 2 km2 each, and (2) at very much lower densities spread over areas ranging up to 120 km2. The most exceptionally large aggregation of all in terms of absolute numbers of birds, recorded on August 17, 1975 in the Bering Sea, was dispersed over so large an area as not to have a particularly high density per unit area, although the total area was over 1000 km2.

The highest <u>densities</u> per unit area were recorded either (1) in a <u>very small</u> and localized patch, e.g. in a favorable feeding site in a pass in the Aleutian Islands chain, or (2) when flocks are on the move from one location to another past a particular point, resulting in a much larger total count per unit time than when the birds are settled on the water. In fact the highest counts of shearwaters that occur anywhere are probably those made during the pre-breeding migration of Short-tailed Shearwaters southwards along the coast of New South Wales in September (<u>Australian Seabird Group Newsletters</u>; Guzman 1981).

It is evident from Tables 1 and 2 that most usual "maximum density" figures recorded were less than 10,000 birds/km2, spread over a census area of no more than 2 - 12 square kilometers. Thus 55,000 birds spread over 7.8 km2 had a maximum density of 6,410 birds/km2, and 50,000 birds spread over 11.85 km2 had a maximum density of 2,532 birds/km2, neither of which are high figures. There were only three occasions when the estimated total aggregation size exceeded 55,000 birds.

F. FLOCK SIZES IN AGGREGATIONS

Each aggregation is composed of more or less separate flocks, which have been brought together in one place as an aggregation. From Tables 1 and 2 it is possible to examine the size ((and size ranges) of the flocks that constitute these aggregations.

In the 6.10 million bird aggregation on August 17, 1975, flock sizes varied greatly, from 100 - 6,000 birds, and there was great variation also in the distance between each flock and the next one.

For aggregations of altogether 15,000 - 20,000 birds, the number of flocks ranged from 4 - 21 per aggregation, and for aggregations of altogether 30,000 - 70,000 birds the number of flocks ranged from 3 - 47 per aggregation. Regardless of the total number of birds in aggregations, flock sizes ranges from 100 - 5,000 birds, and mean flock sizes in aggregations were most commonly 1,000 - 1,500 birds. There was no apparent difference in either characteristic between smaller and larger aggregations.

An aggregation of shearwaters therefore apprears to be composed of fairly discrete groupings of several hundreds, or a few thousands, of birds. This is apparent not only in aggregations resting on the water on feeding but also in migrating birds or aggregations making single unidirectional shifts of location.

G. REPRODUCTIVE CONDITION.

In shearwaters mature females lay only one egg every breeding season, and for this reason only the largest ovarian follicle has been recorded. The mean sizes of the largest ovarian follicle and largest testis for all specimens each month are shown in Figure 21. In general, the gonads are larger in the Sooty Shearwater (Fig. 21), which is the bigger species.

Short-tailed Shearwater males showed a slight increase in the size of the testes from June to August (Fig. 21). Females showed a constant size of the largest ovarian follicle from June to August. In both sexes, the sizes decreased in September in the samples (Fig. 21), and this is interpreted as being due to mature birds having left on the return migration, so that the sample largely consists of subadults in September.

For Sooty Shearwaters gonad size seems to be biased by the small sample size (n=67). There was a decrease in size of both largest testis and largest ovarian follicle from May to June (Fig. 21), which could be attributed to the arrival of juvenile birds. The size increased from June to July and then decreased in August for both sexes, but the drastic drop in the female is due to a small sample size of one bird

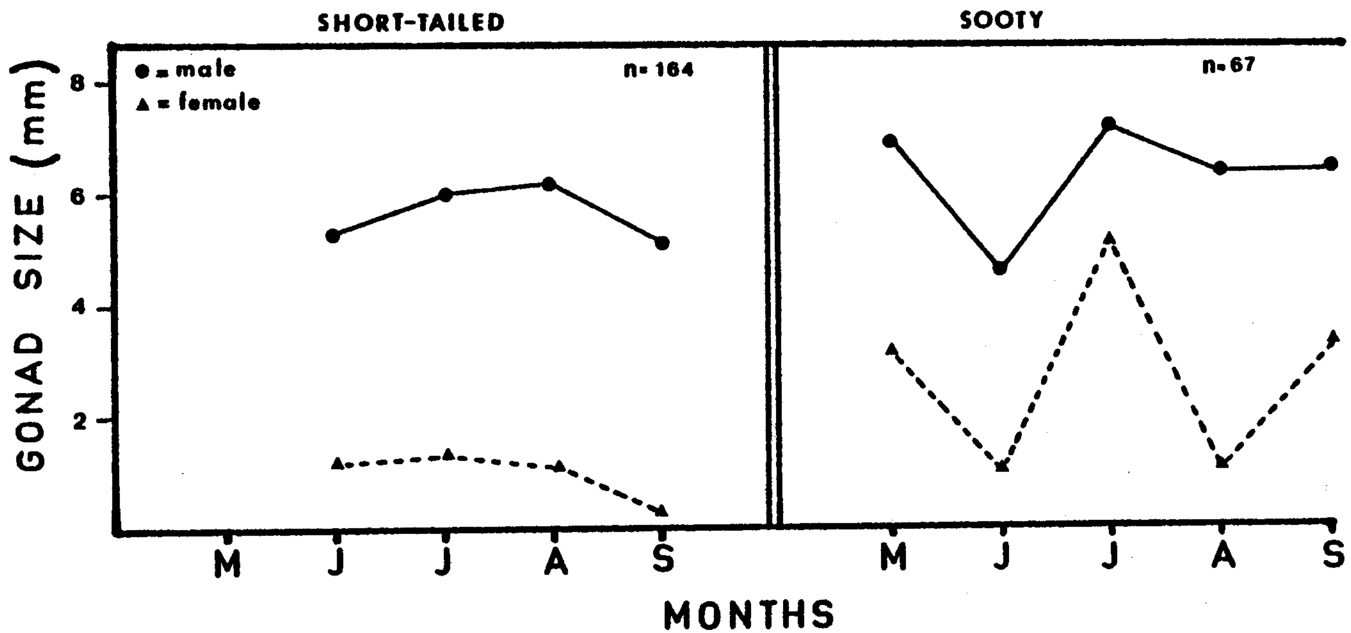


Figure 21. Mean sizes of the largest ovarian follicle and largest testis from all specimens each month.

only in that month.

Brood patches were found in only two females and a single male, all of them Sooty Shearwaters collected in August and September. Their gonads were developed and molt was already complete.

H. SHIPBOARD OBSERVATIONS OF MOLTING BY SHEARWATERS AT SEA

Molt (mainly of primaries and secondaries and sometimes upper coverts) was recorded at sea (i) by direct observation of the flight feathers being molted, in birds seen at close range, and (ii) indirectly by recording feathers seen floating in localities where shearwaters were present (or close by) at the time of the observation. A summary of these observations is presented in Table 4.

Floating feathers and molt of the flight feathers in live birds of both species were observed in both areas of study in 1975-1976: the Gulf of Alaska and the Southeastern Bering Sea. These shearwater molting records extended all through the summer from May to early August, with the number of separate occasions (locations) distributed as follows: May (8), June (4), July (5), August (3) and September (0) (Table 4).

Floating feathers provide information on the areas of the ocean where molting takes place. Since molt is a period of stress for birds, it is important that molting should not be taking place in areas where they may be exposed to oil spills. In fact, it appears that molt occurs gradually and over a very wide area (not in restricted areas) so this may not be a particularly serious problem in Alaskan waters.

VII. DISCUSSION

A. THE CIRCULATION OF SHEARWATERS IN THE WINTERING AREAS

Aside from seasonal shifts in the overall distribution of each of the two species of shearwaters in the North Pacific Ocean, and in and out of the Bering Sea, from month to month from April-September, the reasons for the discontinuous distribution of shearwaters, both in space and time, and the explanation for the "here today, gone tomorrow" phenomenon have not been elucidated.

As Figure 14 shows, the majority of record periods do not result in shearwaters being seen, so there are many empty sea areas at any one time. Also, major aggregations are found relatively infrequently (Tables 1 and 2) except in a few limited locations, and over most of the Continental Shelf sightings are as often of fewer than 100 birds as of more than that (Figure 14).

What determines the shifts or circulation of flocks or sub-populations within a region remains unresolved. It may be determined by feeding conditions or by weather patterns, as discussed in Section IIIC.

We had hoped to be able to correlate the distribution of shearwaters with currents (or tidal currents) at the

TABLE 4 : MOLT IN SHEARWATERS IN ALASKAN WATERS

Year	Region and Area	Date	Location	Description	Species Present in Area At Time (or Presumed Species Origin of the Feathers)
1975.					
GULF OF ALASKA.	Kodiak-Bowie sea-mount chain	July 13	(i) 55°21'N., 144°03'W.	"Feathers floating. Possibly of shearwaters."	Sooty Shearwaters
			(ii) 55°30'N., 144°27'W.	"Many feathers of shearwaters floating on the water."	Sooty Shearwaters
NEGOA.	No Data				
NWGOA.	No molting noted, June 17-18, July 16-18, 28-31, or August 5-11.				
BERING SEA.	Inner Bristol Bay	June 8	58°10'N., 159°44'W.	"Today saw many feathers of shearwaters. The birds are molting."	Short-tailed Shearwaters
	South of Cape Newenham	June 10	(i) 57°50'N., 162°11'W.	"All the observations show that the birds are molting."	Short-tailed Shearwaters
			(ii) 58°02'N., 161°52'W.	"Many feathers on the water."	Short-tailed Shearwaters
	North of Amak Island	July 19	56°05'N., 162°43'W.	"Many, many feathers floating."	Short-tailed Shearwaters
	Beyond Continental Shelf, South of St. George's Basin	August 14	(i) 55°09'N., 168°30'W.	"Many feathers of shearwaters or fulmars on the water."	Northern Fulmar ?
			(ii) 55°27'N., 168°42'W.	"Many feathers floating; probably fulmars."	Northern Fulmars ?
1976.					
GULF OF ALASKA.	Kodiak-Bowie sea-mount chain	July 18	55°23'N., 142°51'W.	"Brown feathers floating on the water....wing and/or tail feathers; from their color and size, they are shearwater feathers)", although no shear-waters were seen until 3 1/2 hours later at 55°57'N., 144°06'W.	Sooty Shearwaters ?

Table 4 (continued):

1976 (continued):

KODIAK SHELF.	Amatuli Trough	May 8	58°24'N.,148°13'W.	Molt seen in two birds seen within 100m.	Species unidentified
NEGOA.	NEGOA Shelf Edge (Bering Glacier)	May 16	(i) 59°40'N.,143°27'W.	"Molt".	Short-tailed Shearwaters
			(ii) 59°39'N.,143°53'W.	"Molt".	Short-tailed Shearwaters
NEGOA.	NEGOA Shelf Edge (Southwest of Kayak Island)	May 17	59°47'N.,145°40'W.	"Molting".	Short-tailed and Sooty Shearwaters
KODIAK SHELF.	Northeast of Afognak Island	May 20	58°26'N.,150°06'W.	"Molting."	Species unidentified
		May 24	(i) 58°22'N.,151°37'W.	"Feathers floating on the water, some of them white(gulls or murres),most of them shearwater-colored body feathers."	Species unidentified
			(ii) 58°27'N.,151°42'W.	"Molting."	Species unidentified
KODIAK SHELF.	Inner Kennedy Entrance	May 27	59°01'N.,150°56'W.	"Molting."	Short-tailed and Sooty Shearwaters
NWGOA.	Chirikof/Trinity Islands	June 19	56°01'N.,155°05'W.	"Molting:wings."	Short-tailed Shearwaters
KODIAK SHELF.	Outside Kodiak Harbor	July 19	58°43'N.,152°14'W.	"They show wing and body molting."	Sooty Shearwaters
ALEUTIANS.	Unimak Pass (North Unimak Pass)	August 2	54°40'N.,165°14'W.	"Wings molting".	Short-tailed Shearwaters
BERING SEA.	South of Nunivak Island	August 3	(i) 58°20'N.,167°26'W.	"Many shearwater feathers floating in the water."	Short-tailed Shearwaters
			(ii) 59°18'N.,167°56'W.	"Feathers of shearwaters floating."	Short-tailed Shearwaters

regional level, but the data contemporary with our shearwater observations were not adequate for this.

We conclude that biotelemetry provides the best hope of elucidating the extent and pattern of local and regional movements of shearwaters in Alaskan coastal areas.

B. THE FEEDING ECOLOGY OF SHEARWATERS IN THE WINTERING AREAS

As noted in section V.C., the foods eaten by the specimens collected in 1975 and 1976 during this Research Unit were studied by G.A. Sanger (Lensink et al. (1976), Sanger and Baird (1977)). Foods taken by shearwaters in the eastern Bering Sea have also been discussed by Hunt et al. (1981a), and foods taken in the Kodiak Island area of the Gulf of Alaska by Sanger et al. (1978) and Krasnow et al. (1979). Ogi et al. (1980) analysed 439 Short-tailed Shearwater stomachs and reported that "the diet....varied according to sea area...demonstrates high adaptability in prey and pelagic environment".

On the basis of a rather small sampling in 1975 and 1976, Sanger and Baird (1977) found that Sooty Shearwaters were feeding mainly on squids and fish, while Short-tailed Shearwaters were feeding mainly on euphausiids. But, with fewer than 50 stomachs altogether, from two species taken in both the Gulf of Alaska and the Bering Sea, it is clear that no breakdown reflecting differences in local feeding areas at different times was yet possible. In 1977 and 1978 over 300 more specimens were collected in the Kodiak Island area, yielding about 250 usable stomach samples (Sanger et al. 1978, Krasnow et al. 1979). Seasonal changes were found from June to September (1) from almost 50/50 squid and fish in June to 95% fish in Sooty Shearwaters, and (2) from 80% Thysanoessa euphausiids in June to 92% fish in September in Short-tailed Shearwaters (Sanger et al. 1978). Capelin (Mallotus villosus) was the predominant fish in 1977 (much more so in Sooty Shearwaters), but in 1978 Sooty Shearwaters taken in nearshore waters in Kiliuda Bay took few squids and switched from capelin to sandlance (Ammodytes hexapterus) between June and September (Krasnow et al. 1979). One can conclude that the separation between the feeding preferences of the two species of shearwaters is rather wide in early summer, but narrows rapidly in August. Therefore, their relative distributions must be reviewed in terms of the availability of their preferred invertebrate versus vertebrate foods, especially in May, June and July.

C. THE SIGNIFICANCE OF SHEARWATERS MOLTING IN ALASKAN WATERS

Flight may be affected by molt. Flight in shearwaters has been discussed by Warham (1977). Molt in shearwaters has been discussed by Watson (1971) and Guzman (1981).

1. Timing and Sequence of Molt

During the early part of the northern summer the aspect of the feather coat of shearwaters is old and worn on the wings and tail. During the northern summer, they acquire a new feather generation of flight and tail feathers.

Body molt starts on the breeding grounds, and is apparently completed on the wintering grounds. Brood patches appear in some individuals at the end of the northern summer, just before the start of the southbound migration. Groups of feathers that are entirely molted in the Northern Hemisphere are well correlated, but body molt does not show any correlation with them.

There is a high correlation between the replacement of upper greater coverts and the corresponding primaries (r=0.99 in Short-tailed and r=0.97 in Sooty). The upper greater coverts molt just 1 or 2 feathers ahead of their matching primary feathers (Guzman, 1981). This could be an adaptive strategy to reduce part of the gap left by the primary or primaries being molted. Gaps left at the trailing edge by shed primaries will increase the drag force, and affect the performance of the wing. The greater coverts protect the quill bases of the primaries from being damaged, and this must be particularly important as new primaries start to grow in.

The correlation between molt in tail and primary feathers is also significant (r=0.85 in Sooty Shearwaters and r=0.73 in Short-tailed Shearwaters). Although primary molt starts earlier than tail molt, they are completed at about the same time.

The alula provides a midwing slot. Saville (1957) reported that the alula "may be of substantial size" in oceanic soaring birds. In the present study, the alula of a sample of ten birds of each species of shearwater was measured, using for this purpose birds that had already finished their alula molt. In the Sooty Shearwater the alula was 14.1% of the wing length, and it was 13.5% in the Short-tailed Shearwater (Guzman, 1981). These ratios are comparatively much higher than those given by Saville for albatrosses.

The alula helps to reduce drag over the upper surface of the wing. This may explain the earlier molt of the alula compared with the outer primaries. Only when one "slot" (the alula) is totally molted, does the next one (the outer primaries) undergo molt. In this manner, unwanted drag over the upper surface of the wing is avoided.

2. Effect of Molt on Flight

(1) Powered Flight

Towards the wing tip primary feathers are longer, so the shedding of the outer primaries (7 to 10) must be critical in terms of wing area, propelling power and lift to drag ratio. Storer (1948) stated "It is demonstrable that a slight change in the position or shape of two key primary feathers can make it nearly impossible for a bird to fly".

Shearwaters depend much more on powered flight than albatrosses. Thus (i) under calm weather conditions they rely almost exclusively on wing flapping to fly, (ii) wing flapping is of great importance in taking-off under almost all kinds of weather conditions, (iii) when climbing up over the crest of a swell, to initiate soaring, they usually depend on powered flight, and (iv) to correct flight direction when gliding they will flap the wings from 2 - 10 times.

It seems that, when molting the primary feathers, those that are left functional produce wider and deeper slots. Under these conditions thrust must be greatly reduced.

(2) Dynamic Soaring

When soaring above the swells or losing altitude by gliding, shearwaters normally keep the primaries together, showing a very narrow and pointed wing. But any change that requires an active action by the wing, will produce immediately a spreading of the primary feathers, opening slots between them. The size of these slots varies with the maneuver to be accomplished, and requires a great degree of efficiency of the outer primaries. So, it is probably greatly reduced during molt of the outer primary feathers.

(3) Take-off from Water

In both species under study, the slots at the tips of the wings are of importance for producing the necessary lift to raise shearwaters from the water during take-off. Birds molting their outer primaries might have serious difficulty in getting enough lift.

(4) Pre-dive Stalling

One of the actions performed by shearwaters that requires a high degree of maneuverability is the stall before initiating a dive. Once prey is located from the air by the bird, it stalls. To do this the bird needs all of its 'braking power', using wings, tail and feet to brake.

To perform effective plunge-dives for food from stall positions, shearwaters might require complete sets of tail and flight feathers (at least primaries and alula), to fully control their movements at those moments. In fact, this kind of diving behavior was never seen during mid-summer, when the molt is in progress, except in May when the old tail and outer primary feathers were still present.

3. Summary

The breeding populations of Sooty and Short-tailed Shearwaters do not molt flight and tail feathers on the breeding grounds, so by the end of the austral summer they have old, worn, feather coats. Other species of Procellariiformes that do not migrate across the equator into the North Pacific have different patterns of molt; in many of these species molt overlaps to some extent with the breeding season.

During molt, Sooty and Short-tailed Shearwater wing loadings do not change much. This is due to the fact that while there is a change in wing area there is also a compensating reduction in body weight. So, this does not seem to be critical for flight capabilities.

On the other hand, shearwater flight capabilities also depend on the glide ratio, or ratio of lift on drag (L/D), which can be drastically modified during molt (i) by changing the shape of the wing, (ii) by altering the aspect ratio, or (iii) by altering the slots that normally reduce drag. Powered flight can also be drastically affected if the primary feathers are reduced in number during molt, so that less thrust is possible. It can be concluded that shearwater flight is most affected during molt (i) when taking-off, (ii) when maneuvering in the air, and (iii) when stalling to initiate a dive.

Considering that during the molt shearwaters have difficulties in performing all the maneuvers required for plunge-diving, their feeding spectrum is probably reduced, as well as their capability of feeding in all kinds of weather conditions. Consequently, they are probably limited to feeding mainly by diving from the surface in relatively calm weather. Therefore, because they are molting then, Sooty and Short-tailed Shearwaters are vulnerable to any additional environmental stress (such as oiling) that may occur during their period of residence in Alaskan waters.

VIII. SUMMARY AND CONCLUSIONS

1. On their wintering grounds, in the Gulf of Alaska and Bering Sea, both species of shearwaters under study were present at least from May to August. Around Kodiak Island, they were still present in September when that area was visited.

2. The analysis of the data on the distribution of Sooty and Short-tailed Shearwaters indicates that they occur along the length of the Alaskan Coastal Domain described by Favorite et al. (1976).

3. They are mostly found over Offshore Waters (Middle and Outer Shelf Zones), but smaller numbers may be seen over Oceanic Waters, particularly near seamounts.

4. Aggregations occur regularly close to shore in Unimak Pass and in Marmot Bay, Kodiak Island.

5. Elsewhere, the birds are widely dispersed and occur in low densities, but they sporadically gather in large aggregations from time to time at various locations when local feeding conditions become good as over upwellings at the margins of troughs in the Continental Shelf.

6. It is evident that part of the population of Short-tailed Shearwaters (probably non-breeding subadults) moves immediately into the Northeastern Gulf of Alaska, as soon as they arrive from the Southern Hemisphere; they were common in the Hinchinbrook Island - Icy Bay sector in May, and over Kiliuda Trough after that month.

7. Sooty Shearwaters were abundant in Kennedy Entrance and over Stevenson Trough. Both species were commonly found in mixed aggregations offshore over Amatuli Trough and inshore in Chiniak and Marmot Bays, Kodiak Island.

8. By July, the Short-tailed Shearwaters were not found east of Kodiak Island, but they were abundant on the southeast Kodiak Shelf.

9. The distributional data for the Kodiak Shelf shows that, even when both species are common in some locations, they tended to be segregated in different flocks, some distance apart, and that when mixed together one species is always far more abundant than the other. Thus, in Chiniak and Marmot Bays, for example, both species were abundant, but generally they were found in different blocks, during the same period of time.

10. In the NWGOA shearwaters were found to be very patchy and scarce, particularly south of the Alaska Peninsula west of the trough that emerges from Shelikof Strait west of Chirikof Island. Besides the few aggregations sighted, only a few birds were seen dispersed in the NWGOA.

11. Aggregations of shearwaters were sometimes encountered in the Chirikof - Trinity Islands area and between the Shumagin Islands and the Sanak Islands.

12. In the Bering Sea, Short-tailed Shearwaters were by far the most abundant species. Sooty Shearwaters were sometimes also found.

13. Sooty Shearwaters were present in, or close to, Unimak Pass, and in Inshore and Middle Shelf Waters off certain of the eastern Aleutian islands, and also sometimes associated with the Shelf Break Front.

14. By the second part of August and early September the numbers of both species of shearwaters sharply decrease in Kodiak Island waters.

15. Sooty and Short-tailed Shearwaters were recorded aggregating in waters that had a wide range of temperatures, and favored feeding locations also had (or experienced) wide temperature differences.

16. Differences in the favored foods between Sooty and Short-tailed Shearwaters appear to be greater in early and mid-summer (May - July) than in September, so differences in their distributions may be related to differences in the availability of their food species in different offshore zones or geographical regions.

17. For a high percentage of observation periods, no shearwaters may be seen, or only low numbers.

When aggregations do occur, they may be brought about either by a very high density in a very concentrated area or by intermediate or relatively low densities of birds spread out over a wide area.

19. Biotelemetric studies of movements of individual birds are needed to demonstrate the extent and patterns of local and regional movements of shearwaters off Alaska.

20. Shearwaters molt their flight feathers in Alaskan waters. When molting, their ability to feed and their ability to take off from the water would be impaired by oiling.

21. Because they breed in and visit a number of nations in both Northern and Southern Hemispheres, Sooty and Short-tailed Shearwaters are of international interest and importance. They are the predominant species in terms of their numbers in Alaskan waters in the summer months. The extent to which they become contaminated by, or are at risk from, fossil fuel hydrocarbons in the sea needs continued monitoring.

ACKNOWLEDGEMENTS

We are sincerely grateful to the entire staff of the U.S. Fish and Wildlife Service in Anchorage, Alaska, for their support, encouragement and friendship during this study. In particular we wish to thank Dr. J. Bartonek and Dr. C. Lensink, for assisting in the initial project planning and in arranging for the 1975-76 contract with NOAA; Dr. Pat Gould and Mr. G. Sanger for advice and assistance throughout; and Mr. Doug Forsell, for providing many of the shearwater skins used in the analysis of molt. Their direct contribution to the study was in addition to the hospitality each of them showed to J.R.G. during his many visits to Anchorage.

The U.S. National Oceanographic and Atmospheric Administration (NOAA), provided financial support with a Research Contract through OCSEAP, during the 1975 and 1976 field seasons.

The officers and crew of the NOAA vessels R/V SURVEYOR and R/V DISCOVERER were very helpful in providing logistic support.

We wish to express thanks to the following NOAA people: Mr. Mauri Pelto, for his advice on data preparation; Ms. Cheryl Brower, for her help in getting data from NODC; and Dr. Herbert Bruce and Mr. Laurie Jarvela, who were responsible for directing and co-ordinating the bird research projects under contract with NOAA.

Understanding of seabird biology was greatly improved by discussions with Dennis Heinemann and Wayne Hoffman, who were also working on a seabird project for NOAA/OCSEAP in Alaskan waters. Their help and good judgement were invaluable in developing the censusing methodology used in the study.

Glenn Krahulic and Moray Lewis assisted with using computer services at different stages of this work.

Rich and Molly McIntosh, of Kodiak, Alaska, were generous in their hospitality to J.R.G.

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