Environmental Assessment of the Alaskan Continental Shelf

Final Reports of Principal Investigators

Volume 4. Biological Studies

Outer Continental Shelf Environmental Assessment Program
Boulder, Colorado

March 1979

U.S. DEPARTMENT OF COMMERCE
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Juanita M. Kreps, Secretary

National Oceanic and Atmospheric Administration
Richard A. Frank, Administrator

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FINAL REPORT

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DISTRIBUTION AND ABUNDANCE OF SOME EPIBENTHIC INVERTEBRATES OF THE NORTHEASTERN GULF OF ALASKA WITH NOTES ON THE FEEDING BIOLOGY OF SELECTED SPECIES

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August 1978

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I. SUMMARY OF OBJECTIVES, CONCLUSIONS, AND IMPLICATIONS WITH RESPECT TO OCS OIL AND GAS DEVELOPMENT

The objectives of this study were to obtain: 1) a qualitative and quantitative inventory of dominant epibenthic species within the study area; 2) a description of spatial distribution patterns of selected benthic invertebrate species, and 3) preliminary observations of biological interrelationships between selected segments of the benthic biota.

The trawl survey was effective, and excellent spatial coverage was obtained. One hundred and thirty-three (133) stations were successfully occupied yielding a mean epifaunal invertebrate biomass of 2.6 g/m^2. Taxonomic analysis delineated nine (9) phyla, 19 classes, 82 families, 124 genera, and 168 species of invertebrates.

Three phyla - Mollusca, Arthropoda (Crustacea), and Echinodermata - dominated in species representation with 47, 42, and 36 species taken, respectively. The same phyla dominated in biomass, with Arthropoda contributing 71.4% of the total, Echinodermata with 19%, and Mollusca with 4.6%.

The snow crab, *Chionoecetes bairdi*, contributed 66.2% of the total epifaunal invertebrate biomass. Other arthropods of significant biomass were the pink shrimp, *Pandalus borealis*, and the box crab, *Lopholithodes foraminatus*.

Important echinoderms were the brittle star, *Ophiura sarsi*, the sea stars, *Ctenodiscus crispatus* and *Pycnopodia helianthoides*, and the heart urchin, *Brisaster townsendi*.

Of the molluscs, the scallop, *Pecten caurinus*, and the snails, *Neptunea lyrata* and *Fusitriton oregonensis*, dominated.

Some areas of biological interest were identified. Stations 74-C and D, south of Hinchinbrook Entrance had a high diversity of fishes and invertebrates. Most species found here were abundant. Stations 94-A and B, located off Icy Bay, were characterized by an abundance of three species of fishes and the near absence of epifaunal invertebrates.

The highest biomass values for *Chionoecetes bairdi, Pandalus borealis, Ophiura sarsi,* and *Ctenodiscus crispatus* were recorded southeast of Kayak Island, in the vicinity of the Copper River delta. Large concentrations of fishes were also found here. The productivity of this area is thought to be enhanced by the nutrients supplied by the Copper River and/or the presence of clockwise and counter-clockwise gyres.

Limited trophic interaction data were compiled during this survey. However, inferences from other Outer Continental Shelf Assessment Program (OCSEAP) investigations suggest that food groups used by the dominant northeast Gulf of Alaska (NEGOA) invertebrates are somewhat similar throughout their ranges.

A large number of the epifaunal species collected in the study area were either sessile or slow-moving forms. It is probable that many of these organisms prey upon deposit-feeding infauna as they do in the waters of Cook Inlet, Kodiak, the Bering Sea, and the southeast Chukchi Sea. Many of these epifaunal species would be affected by oil spills either because of their inability to leave the area or as a result of their food dependence on deposit-feeding species that incorporate sediment in the feeding process. Experimentation on toxic effects of oil on snow crabs, king crabs and pandalid shrimps have been carried out by other investigators.

Initial assessment of the data suggests that a few unique, abundant, and/or large benthic species (snow crabs, shrimps, brittle stars, sea stars) are characteristic of the areas investigated and that these species may represent organisms that could be useful for monitoring purposes. Two biological parameters that should be addressed in conjunction with petroleum-related activities are feeding and reproductive biology of important species. It is suggested that an intensive program designed to examine these parameters be initiated well in advance on industrial activity in the oil lease areas.

II. INTRODUCTION

General Nature and Scope of Study

The operations connected with oil exploration, production, and transportation in the northeast Gulf of Alaska (NEGOA) will present a wide spectrum of potential dangers to the marine environment (see Olson and Burgess, 1967; and Malins, 1977, for general discussion of marine pollution problems). Adverse effects on the marine environment cannot be quantitatively assessed, or even predicted, unless background data are recorded prior to industrial development. Insufficient long-term information about an environment, and the basic biology of species in that environment, can lead to erroneous interpretations of changes in species composition and abundance that might occur if the area becomes altered by industrial activity (see Baker, 1976; Nelson-Smith, 1973; Pearson, 1971, 1972, 1975; Rosenberg, 1973, for general discussions on benthic biological investigations in industrialized marine areas). Populations of marine species fluctuate over a time span of a few to 30 years (Lewis, 1970, and personal communications), but such fluctuations are typically unexplainable because of absence of long-term data (Lewis, 1970).

Benthic invertebrates (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 have frequently been chosen to monitor long-term pollution effects, and are believed to reflect the biological health of a marine area (see Pearson, 1971, 1972, 1975; and Rosenberg, 1973, for discussion on long-term usage of benthic organisms for monitoring pollution). The presence of large numbers of benthic epifaunal species of actual or potential commercial importance (crabs, shrimps, snails, fin fishes) in NEGOA further dictates the necessity of understanding benthic communities since many commercially important species feed on infaunal and small epifaunal residents of the benthos (see Zenkevitch, 1963; and Feder, 1977a, 1978a; and Feder *et al.*, 1978; Feder and Jewett, 1977a, b) for discussions of the interaction of commercially important species and the benthos). Any drastic changes in density of the food benthos could affect the health and numbers of these economically important species.

Experience in pollution-prone areas of England (Baker, 1976; Smith, 1968), Scotland (Pearson, 1972, 1975), and California (Straughan, 1971) suggests that at the completion of an exploratory study, selected stations should be examined regularly on a long-term basis to monitor species content, diversity, abundance and biomass. Such long-term data acquisition in NEGOA should make it possible to differentiate between normal ecosystem variation and pollutant-induced alteration. Furthermore, intensive investigation of the food habits of benthic species of NEGOA are also essential in order to understand trophic interactions there and to predict changes that might take place once oil-related activities are initiated.

The intensive trawl study considered in this report delineates the major epifauna on the northeastern Gulf of Alaska shelf. The information obtained on faunal composition and abundance in this investigation now represents a general data base to which future changes can be compared. A major portion of this data is presented in Jewett and Feder (1976). Long-term studies on life histories and trophic interactions should ultimately define functional aspects of communities and ecosystems vulnerable to environmental damage, and should help determine rates at which damaged environments can recover.

Relevance to Problems of Petroleum Development

Lack of adequate data on a world-wide basis makes it difficult to predict the effects of oil-related activity on the subtidal benthos. However, the recent expansion of research activities in NEGOA should ultimately enable us to point with some confidence to certain species or areas there that might bear closer scrutiny once industrial activity is initiated. It must again be emphasized that a broad time frame is needed to comprehend long-term fluctuations in composition and density of benthic species; thus, it cannot be expected that short-term research programs will result in adequate predictive capabilities. Assessment of any ecological system must always be a continuing endeavour.

As indicated above, infaunal species tend to remain in place and, consequently, have been useful as indicator species for disturbed areas. Thus, close examination of stations with substantial complements of infaunal species is warranted (see Feder and Matheke, in press, for comments on infaunal benthos). Changes in the environment at these and other stations with a relatively large number of species might be reflected in a decrease in diversity of species with increased dominance of a few (see Nelson-Smith, 1973, for further discussion of oil-related changes in diversity). Likewise, stations with substantial numbers of epifaunal species should be assessed on a continuing basis. The effect of loss or reduced numbers of specific epifaunal species to the overall trophic structure in NEGOA can be conjectured on the basis of available food studies (Feder, 1977a; Feder and Jewett, 1977a,b; Smith *et al.*, 1978; Feder, 1978a; Jewett, in press; Paul *et al.*, in press).

Data indicating the effect of oil on subtidal benthic invertebrates are fragmentary (Nelson-Smith, 1973; Boesch *et al.*, 1974; Malins, 1977), but it is known that echinoderms are "notoriously sensitive to any reduction in water quality" (Nelson-Smith, 1973). Echinoderms (ophiuroids: brittle stars; asteroids: sea stars; holothuroids: sea cucumbers) are conspicuous members of the benthos of NEGOA and could be affected by oil activities there. Two echinoderm groups, asteroids and ophiuroids, are often components of the diet of large crabs (Cunningham, 1969; Feder, 1977a; Feder, 1978b; G. Powell, ADF&G, pers. comm.) and a few species of demersal fishes (Smith *et al.*, 1978; Wigley and Theroux, 1965).

King crabs (*Paralithodes camtschatica*), snow crabs (*Chionoecetes bairdi*) and pandalid shrimps (e.g. *Pandalus borealis*) are conspicuous members of the shallow shelf of NEGOA and support commercial fisheries of considerable importance there. The effects of Cook Inlet crude oil water soluble fractions on the survival and molting of king crab and coonstripe shrimp (*Pandalus hypsinotus*) larvae were examined by Mecklenburg *et al.* (1976). Low concentrations (<0.54 ppm) of oil produced a moribund condition (cessation of swimming) in all larval stages and ultimately caused death. Molting of both species was permanently inhibited by exposing larvae for 72 hours at crude oil concentration of 0.8 to 0.9 ppm. Larvae that failed to molt, died in seven days. Laboratory experiments with postlarval *C. bairdi* have shown that postmolt individuals lose most of their legs after exposure to Prudhoe Bay crude oil (Karinen and Rice, 1974).

Little other direct data based on laboratory experiments are available for subtidal benthic species (see Nelson-Smith, 1973). Thus, experimentation on toxic effects of oil on other common members of the subtidal benthos should be strongly encouraged in future Outer Continental Shelf (OCS) programs.

A direct relationship between trophic structure (feeding type) and bottom stability has been demonstrated (Rhoads, 1974). A diesel fuel spill resulted in oil becoming adsorbed on sediment particles with the resultant mortality of many deposit feeders living 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. Many NEGOA infaunal species are deposit feeders; thus, oil-related mortality of these species could likewise result in a changed near-bottom sedimentary regime with subsequent alteration of species composition. An understanding of these species as well as epifaunal organisms and their interactions with each other is essential to the development of predictive capabilities required for the NEGOA outer continental shelf.

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 that Outer Continental Shelf Environmental Assessment Program (OCSEAP) studies were initiated there, although a compilation of some relevant data on the Gulf of Alaska was available (Rosenberg, 1972). A short but intensive survey in the summer of 1975 added some benthic biological data for a specific area south of the Bering Glacier (Bakus and Chamberlain, 1975). Results of the latter ongoing study are similar to those reported by Feder and Mueller (1975) in their OCSEAP investigation. Some scattered data based on trawl surveys by the Bureau of Commercial Fisheries (now National Marine Fisheries Service) were available, but much of the information on the invertebrate fauna was so general as to have little value.

In the summer and fall of 1961 and spring of 1962 otter trawls were used to survey the shellfishes and bottomfishes on the continental shelf and upper continental slope in the Gulf of Alaska (Hitz and Rathjen, 1965). The surveys were part of a long-range program begun in 1950 to determine the size of bottomfish stocks in the northeastern Pacific Ocean between southern Oregon and northwest Alaska. Invertebrates taken in the trawls were of secondary interest, and only major groups and/or species were recorded. Invertebrates that comprised 27 percent of the total catch were grouped into eight categories; heart urchins (Echinodermata:Echinoidea), snow crab (*Chionoecetes bairdi*), sea stars (Echinodermata:Asteroidea), Dungeness crab (*Cancer magister*), scallop (*Pecten caurinus*), shrimps (*Pandalus borealis*, *P. platyceros*, and *Pandalopsis dispar*), king crab (*Paralithodes camtschatica*), and miscellaneous invertebrates (shells, sponges, etc.) (Hitz and Rathjen, 1965). Heart urchins accounted for about 50% of the invertebrate catch and snow crab ranked second, representing about 22%. Approximately 20% of the total invertebrate catch was composed of sea stars.

Further knowledge of invertebrate stocks in the north Pacific is scant. The International Pacific Halibut Commission (IPHC) surveys parts of the Gulf of Alaska annually and records selected commercially important invertebrates; however, non-commercial species are discarded. The benthic investigations of Feder and Mueller (1975), Feder (1977a), and this report represent the first broad-based qualitative and quantitative examinations of the benthic infauna and epifauna on the shelf of the Gulf of Alaska. Ronholt *et al.* (1976), review the history of commercial fisheries in the northeast Gulf of Alaska, and give data from fishing activities there.

Information in the literature has uncovered data that will aid in the interpretation of the biology of some dominant organisms in the Gulf of Alaska (see Feder, 1977b).

Examination of trophic relationships of selected infaunal and epifaunal species was initiated in 1976 as a part of the lower Cook Inlet and Kodiak investigations (Feder, 1977a; Feder and Jewett, 1977a). Food studies by Smith *et al.* (1978) and the present report will contribute to an understanding of trophic relationship in NEGOA.

IV. STUDY AREA

One hundred and forty (140) stations were occupied in conjunction with the National Marine Fisheries Service Resource Assessment trawl survey (Ronholt *et al.*, 1976) which sampled a grid extending from the western tip of Montague Island (148°W Longitude) to Yakutat Bay (140°W Longitude) (Fig. 1). Samples were taken to a maximum depth of approximately 500 meters (274 fathoms).

V. SOURCES, METHODS, AND RATIONAL OF DATA COLLECTION

Epifauna was collected onboard the M/V *North Pacific* in the northeastern Gulf of Alaska (NEGOA) from April 25 to August 7, 1975. One-hour tows (a standard tow) were made at predetermined stations (Fig. 1) using a commercial sized 400-mesh Eastern otter trawl with a 12.2 meter horizontal opening. All

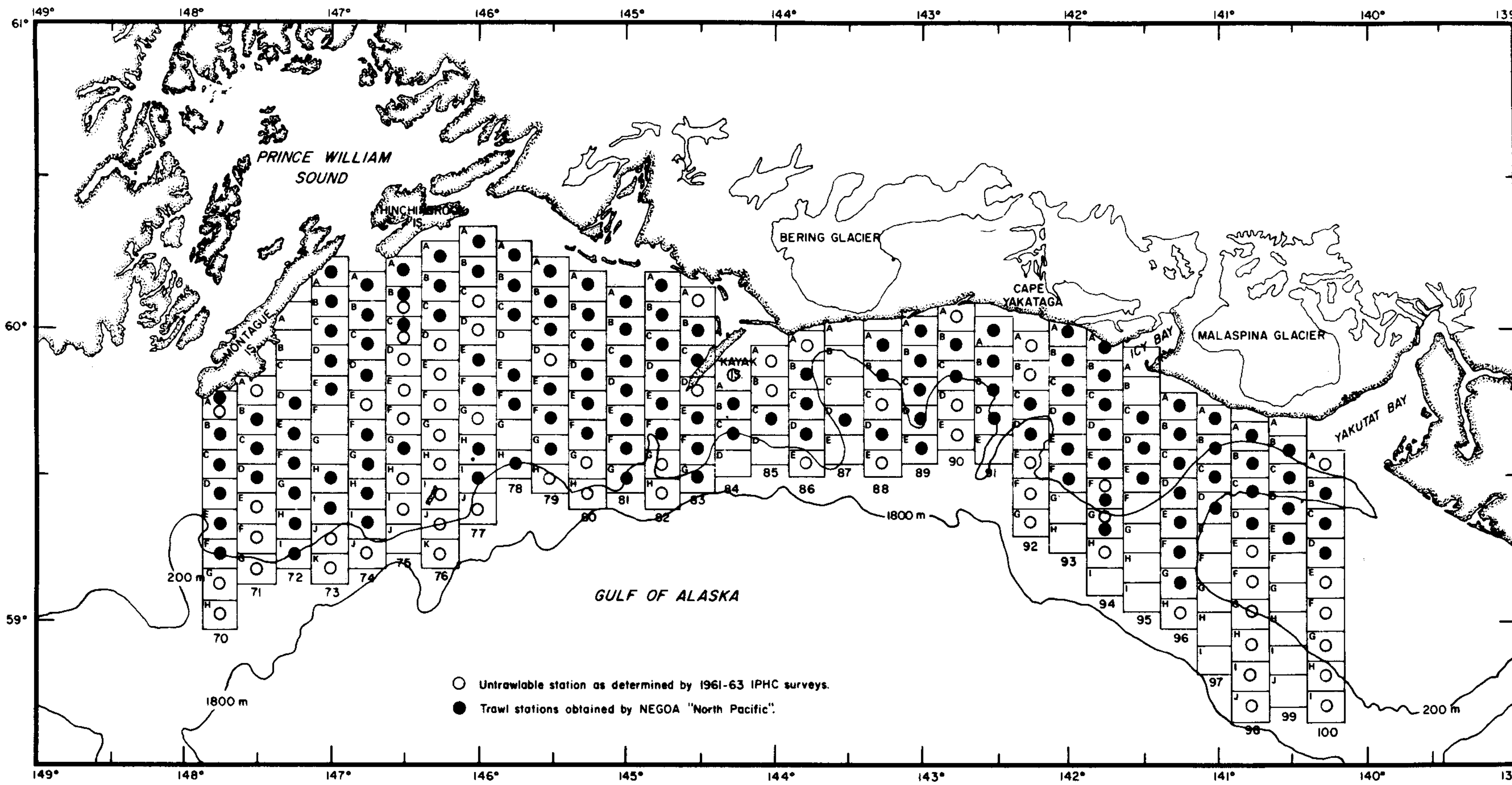

Figure 1. Station grid established for the trawl survey on the continental shelf of the northeastern Gulf of Alaska (NEGOA), summer 1975.

invertebrates currently of non-commercial importance were sorted on shipboard, given tentative identifications, counted, weighed, and aliquot samples preserved and labeled for final identification at the Institute of Marine Science, University of Alaska. Hermit crab weights included shell weights. Counts and weights of commercially important invertebrate species were recorded by National Marine Fisheries Service personnel, and the data made available to the benthic invertebrate program.

Biomass per unit area (g/m^2) was calculated as follows:

$\frac{W}{Tw(Dx1000)}$; where W = weight (grams), Tw = width of trawl opening (meters), and (Dx1000) = distance fished (kilometers x 1000). The data basis for all tcalculations of biomass per m^2 are included with the station data submitted to the National Oceanographic Data Center (NODC). Data from selected stations are included in the Appendix.

When laboratory examination revealed more than a single species in a field identification, the counts and weights of the species in question were arbitrarily expanded from the laboratory species ratio to encompass the entire catch of the trawl.

Limited feeding data was obtained and recorded whenever time permitted. The frequency of occurrence method was used.

VI. RESULTS

Distribution, Abundance, and Biomass

The benthic trawl program in the northeast Gulf of Alaska (NEGOA) permitted the successful occupation of 133 stations. A distance of 732.24 kilometers (km) were fished (8,933,328 m^2) in 127.43 hours of trawling. The total epifaunal invertebrate biomass collected was 23,447.8 kilograms (kg), yielding a mean of 2.6 g/m^2.

Taxonomic analysis delineated nine (9) phyla, 19 classes, 82 families, 124 genera, and 168 species of invertebrates. Three phyla, Mollusca, Arthropoda (Crustacea), and Echinodermata, dominated in species representation with 47, 42, and 36 species taken, respectively (Tables I and II).

The same phyla dominated in biomass also, with Arthropoda contributing 71.4% of the total, Echinodermata with 19.0%, and Mollusca with 4.6% (Tables II and III).

TABLE I

INVERTEBRATES TAKEN BY TRAWL FROM THE NORTHEAST GULF OF ALASKA (NEGOA) ON BOARD THE M/V *NORTH PACIFIC*

Phylum Porifera
unidentified species

Phylum Cnidaria
Class Hydrozoa
unidentified species
Class Scyphozoa
Family Pelagiidae
Chrysaora melanaster Brandt
Class Anthozoa
Subclass Alcyonaria
Eunephthya rubiformis (Pallas)
Family Primnoidae
Stylatula gracile (Gabb)
Family Pennatulidae
Ptilosarcus gurneyi (Gray)
Family Actiniidae
Tealia crassicornis (O. F. Müller)

Phylum Annelida
Class Polychaeta
Family Polynoidae
Arctonoe vittata (Grube)
Eunoe depressa Moore
Eunoe oerstedi Malmgren
Harmothoe multisetosa Moore
Hololepida magna Moore
Lepidonotus squamatus (Linnaeus)
Lepidonotus sp.
Polyeunoa tuta (Grube)
Family Polynodontidae
Peisidice aspera Johnson
Family Euphrosinidae
Euphrosine hortensis Moore
Family Syllidae
unidentified species
Family Nereidae
Ceratonereis paucidentata (Moore)
Ceratonereis sp.
Cheilonereis cyclurus (Harrington)
Nereis pelagica Linnaeus
Nereis vexillosa Grube
Nereis sp.
Family Nephtyidae
unidentified species
Family Glyceridae
Glycera sp.

TABLE I

CONTINUED

Family Eunicidae
Eunice valens (Chamberlin)
Family Lumbrineridae
Lumbrineris similabris (Treadwell)
Family Opheliidae
Travisia pupa Moore
Family Sabellariidae
Idanthyrsus armatus Kinberg
Family Terebellidae
Amphitrite cirrata O. F. Müller
Family Sabellidae
Euchone analis (Kröyer)
Family Serpulidae
Crucigera irregularis Bush
Family Aphroditidae
Aphrodita japonica Marenzeller
Aphrodita negligens Moore
Aphrodita sp.
Class Hirudinea
Notostomobdella sp.

Phylum Mollusca
Class Polyplacophora
Family Mopaliidae
unidentified species
Class Pelecypoda
Family Nuculanidae
Nuculana fossa Baird
Family Mytilidae
Mytilus edulis Linnaeus
Musculus niger (Gray)
Modiolus modiolus (Linnaeus)
Family Pectinidae
Chlamys hastata hericia (Gould)
Pecten caurinus Gould
Delectopecten randolphi (Dall)
Family Astartidae
Astarte polaris Dall
Family Carditidae
Cyclocardia ventricosa (Gould)
Family Cardiidae
Clinocardium ciliatum (Fabricius)
Clinocardium fucanum (Dall)
Serripes groenlandicus (Bruguière)
Family Veneridae
Compsomyax subdiaphana Carpenter
Family Mactridae
Spisula polynyma (Stimpson)

TABLE I

CONTINUED

Family Myidae
  unidentified species
Family Hiatellidae
  Hiatella arctica (Linnaeus)
Family Teredinidae
  Bankia setacea Tryon
Family Lyonsiidae
  unidentified species

Class Gastropoda
  Family Bathybembix
    Solariella obscura (Couthouy)
    Lischkeia cidaris (Carpenter)
  Family Naticidae
    Natica clausa Broderip and Sowerby
    Polinices monteronus Dall
    Polinices lewisii (Gould)
  Family Cymatiidae
    Fusitriton oregonensis (Redfield)
  Family Muricidae
    Trophonopsis stuarti (Smith)
  Family Buccinidae
    Buccinum plectrum Stimpson
    Beringius kennicotti (Dall)
    Colus halli (Dall)
    Morrisonella pacifica (Dall)
    Neptunea lyrata (Gmelin)
    Neptunea pribiloffensis (Dall)
    Plicifusus sp.
    Pyrulofusus harpa (Mörch)
    Volutopsius filosus Dall
  Family Columbellidae
    Mitrella gouldi (Carpenter)
  Family Volutidae
    Arctomelon stearnsii (Dall)
  Family Turridae
    Oenopota sp.
    Aforia circinata (Dall)
  Family Dorididae
    unidentified species
  Family Tritoniidae
    Tritonia exsulans Bergh
    Tochuina tetraquetra (Pallas)
  Family Flabellinidae
    Flabellinopsis sp.

Class Cephalopoda
  Family Sepiolidae
    Rossia pacifica Berry

TABLE I

CONTINUED

Family Gonatidae
Gonatopsis borealis Sasaki
Gonatus magister Berry
Family Octopodidae
Octopus sp.

Phylum Arthropoda
Class Crustacea
Order Thoracica
Family Lepadidae
Lepas pectinata pacifica Henry
Family Balanidae
Balanus hesperius
Balanus rostratus Hoek
Balanus sp.
Order Isopoda
Family Aegidae
Rocinela augustata Richardson
Family Bopyridae
Argeia pugettensis Data
Order Decapoda
Family Pandalidae
Pandalus borealis Kröyer
Pandalus jordani Rathbun
Pandalus montagui tridens Rathbun
Pandalus platyceros Brandt
Pandalus hypsinotus Brandt
Pandalopsis dispar Rathbun
Family Hippolytidae
Spirontocaris lamellicornis (Dana)
Spirontocaris arcuata Rathbun
Eualus barbata (Rathbun)
Eualus macrophthalma (Rathbun)
Eualus suckleyi (Stimpson)
Eualus pusiola (Kröyer)
Family Crangonidae
Crangon communis Rathbun
Argis sp.
Argis dentata (Rathbun)
Argis ovifer (Rathbun)
Argis alaskensis (Kingsley)
Paracrangon echinata Dana
Family Paguridae
Pagurus ochotensis (Benedict)
Pagurus aleuticus (Benedict)
Pagurus kennerlyi (Stimpson)
Pagurus confragosus (Benedict)
Elassochirus tenuimanus (Dana)
Elassochirus cavimanus (Miers)

TABLE I

CONTINUED

Labidochirus splendescens (Owen)
Family Lithodidae
Acantholithodes hispidus (Stimpson)
Paralithodes camtschatica (Tilesius)
Lopholithodes foraminatus (Stimpson)
Rhinolithodes wosnessenskii Brandt
Family Galatheidae
Munida quadrispina Benedict
Family Majiidae
Oregonia gracilis Dana
Hyas lyratus Dana
Chionoecetes bairdi Rathbun
Chorilia longipes Dana
Family Cancridae
Cancer magister Dana
Cancer oregonensis (Dana)

Phylum Ectoprocta
unidentified species

Phylum Brachiopoda
Class Articulata
Family Cancellothyrididae
Terebratulina unguicula Carpenter
Family Dallinidae
Laqueus californianus Koch
Terebratalia transversa (Sowerby)

Phylum Echinodermata
Class Asteroidea
Family Asteropidae
Dermasterias imbricata (Grube)
Family Astropectinidae
Dipsacaster borealis Fisher
Family Benthopectinidae
Luidiaster dawsoni (Verrill)
Nearchaster pedicellaris (Fisher)
Family Goniasteridae
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 aspera Fisher
Henricia sp.
Poraniopsis inflata Fisher

TABLE I

CONTINUED

Family Pterasteridae
Diplopteraster multipes (Sars)
Pteraster tesselatus
Family Solasteridae
Crossaster borealis (Fisher)
Crossaster papposus (Linnaeus)
Lophaster furcilliger Fisher
Lophaster furcilliger vexator Fisher
Solaster dawsoni Verrill
Family Asteridae
Leptasterias sp.
Lethasterias nanimensis (Verrill)
Stylasterias forreri (de Loriol)
Pycnopodia helianthoides (Brandt)
Class Echinoidea
Family Schizasteridae
Brisaster townsendi
Family Strongylocentrotidae
Allocentrotus fragilis (Jackson)
Strongylocentrotus droebachiensis (O. F. Müller)
Class Ophiuroidea
Family Amphiuridae
Unioplus macraspis (Clark)
Family Gorgonocephalidae
Gorgonocephalus caryi (Lyman)
Family Ophiactidae
Ophiopholis aculeata (Linnaeus)
Family Ophiuridae
Amphiophiura ponderosa (Lyman)
Ophiura sarsi Lütkin
Class Holothuroidea
Family Molpadiidae
Molpadia sp.
Family Cucumariidae
unidentified species
Family Psolidae
Psolus chitinoides H. L. Clark
Class Crinoidea
unidentified species

Phylum Chordata
Class Phlebobranchia
Family Rhodosomatiidae
Chelyosoma columbianum Huntsman
Class Stolidobranchia
Family Pyuridae
Halocynthia helgendorfi igaboja Oka

TABLE II

MISCELLANEOUS DATA FOR INVERTEBRATES COLLECTED BY COMMERCIAL TRAWL IN THE NORTHEAST GULF OF ALASKA (NEGOA) ON THE M/V *NORTH PACIFIC*

Phylum	Number of Species	% of Species	Wt (kg)	% Total Wt
Mollusca	47	28.0	1089.2	4.6
Arthropoda (Crustacea)	42	25.0	16748.6	71.4
Echinodermata	36	21.4	4462.0	19.0
Annelida	30	17.8	2.8	<0.1
Cnidaria	6	3.6	513.4	2.2
Brachiopoda	3	1.8	49.8	0.2
Chordata (Tunicata)	2	1.2	322.2	1.4
Ectoprocta	1	0.6	3.7	<0.1
Porifera	1	0.6	256.2	1.0
TOTAL	168	100.0%	23,447.9	100.0%

Phylum	Subgroup	Wt (kg)	% of Phylum Wt	% Total Wt
Arthropoda	Decapoda	16692.60	99.7%	71.4%
Echinodermata	Asteroidea	1575.99	35.3%	6.7%
	Ophiuroidea	1492.81	33.5%	6.4%
	Holothuroidea	709.60	15.9%	3.0%
	Echinoidea	644.15	14.4%	2.7%
Mollusca	Gastropoda	557.70	51.2%	2.4%
	Pelecypoda	488.36	44.8%	2.1%
	Cephalopoda	36.91	3.4%	0.1%

TABLE III

PERCENTAGE COMPOSITION BY WEIGHT OF LEADING INVERTEBRATE SPECIES COLLECTED DURING NORTHEAST GULF OF ALASKA (NEGOA) TRAWLING INVESTIGATIONS

Phyla	Percentage of Total Weight	Leading Species	Average Weight per Individual		Percentage Weight within Phylum	Percentage Weight from all Phyla
Arthropoda	71.4	*Chionoecetes bairdi*	454 g		92.6	66.2
		Pandalus borealis	8 g		4.0	2.9
		Lopholithodes foraminatus	420 g		0.6	0.4
				Total	97.2	69.5
Echinodermata	19.0	*Ophiura sarsi*	6 g		23.2	4.4
		Ctenodiscus crispatus	10 g		15.7	2.9
		Brisaster townsendi	10 g		11.2	2.1
		Pycnopodia helianthoides	482 g		10.3	2.0
				Total	60.4	11.4
Mollusca	4.6	*Pecten caurinus*	350 g		43.4	2.0
		Neptunea lyrata	180 g		12.5	0.6
		Fusitriton oregonensis	100 g		11.5	0.5
Total	95.0			Total	67.4	3.1

Of the crustaceans, the families Majidae, Pandalidae, and Lithodidae were most important in terms of biomass. The snow crab (*Chionoecetes bairdi*) of the family Majidae contributed 66.2% of the total epifaunal invertebrate biomass and 92.6% of the arthropod biomass (Table III). This species was widely distributed over the area sampled, with the greatest density found at Station 82-A[1] (see Appendix) where 892 kg of *Chionoecetes bairdi* (1984 individuals) were taken in a standard tow, or 19.8 g/m^2 (Fig. 2). The mean catch per unit effort (CPUE) of the snow crab was 122 kg/hr (268 lbs/hr).

The pink shrimp (*Pandalus borealis*) was also widespread, and accounted for 2.9% of the total invertebrate biomass (Table III). The highest biomass was taken at Station 83-C with 2.4 g/m^2 or 167.7 kg (370 lbs) taken in a standard tow (Fig. 3). The mean CPUE was 5.3 kg/hr (11.7 lbs/hr).

Of the lithode crabs, the box crab (*Lopholithodes foraminatus*) was most abundant. This crab was the third most important crustacean in terms of weight (Table III). The greatest density was found at Station 86-D, where 55 of these crabs weighed 25.4 kg (56 lbs), the equivalent of 0.3 g/m^2 (Fig. 4). The average CPUE of *L. foraminatus* was 0.19 kg/hr (2 lbs/hr).

Four echinoderm species, a brittle star (*Ophiura sarsi*), two sea stars (*Ctenodiscus crispatus* and *Pycnopodia helianthoides*), and the heart urchin (*Brisaster townsendi*) were found in large quantities (Table III). The percent-weight composition of sea stars as a percentage of all echinoderms and all invertebrates was 35.3% and 6.7% respectively (Table II). Brittle stars (Ophiuroidea) were the second largest class of echinoderms collected, accounting for 33.5% of the echinoderm biomass and 6.4% of the total invertebrate biomass (Table II). Sea cucumbers (Holothuroidea), and sea urchins and sand dollars (Echinoidea) comprised 15.9% and 14.4% of the echinoderm biomass, respectively (Table II). *Ophiura sarsi* was the most abundant echinoderm comprising 23.2% of the total echinoderm biomass and 4.4% of the total invertebrate biomass. The largest catch of this brittle star, at Station 81-D, was 750 kg (1653 lbs) in an hour tow, equivalent to 11.4 g/m^2 (Fig. 5). Average CPUE was 8.1 kg/hr (18 lbs/hr). Greatest biomass for the small sea star *Ctenodiscus crispatus* was found at Station 80-B, with 0.8 g/m^2 or 55.8 kg

[1]The data from fourteen stations (74-C, 74-D, 80-B, 81-D, 82-A, 83-C, 83-E, 86-D, 89-A, 93-C, 94-A, 94-B, 97-C, 99-D) referred to in the text are compiled separately in the Appendix.

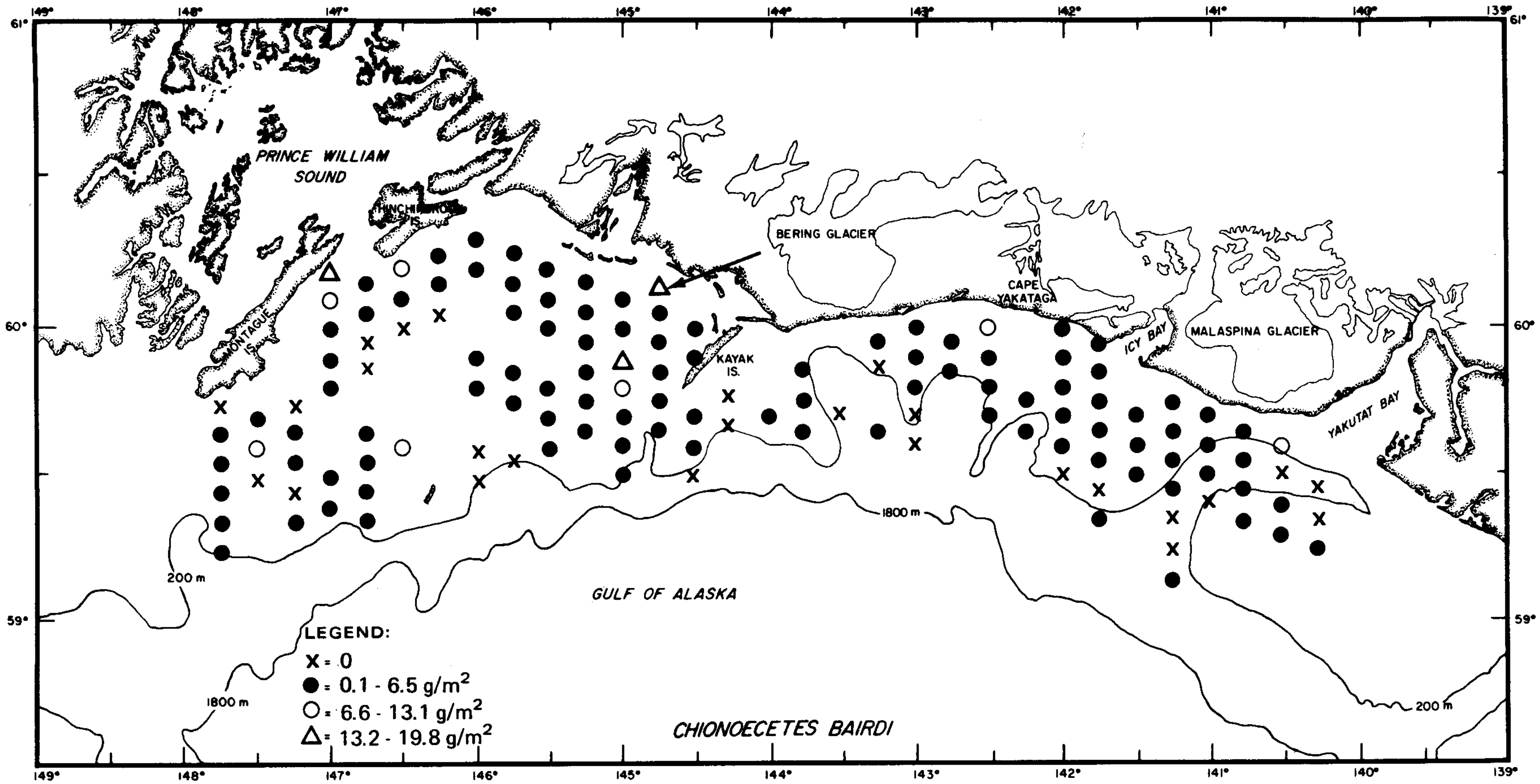

Figure 2. Distribution and abundance of the snow crab, *Chionoecetes bairdi*, from the northeastern Gulf of Alaska (NEGOA) trawl survey, summer 1975. Arrow indicates highest density of *C. bairdi*.

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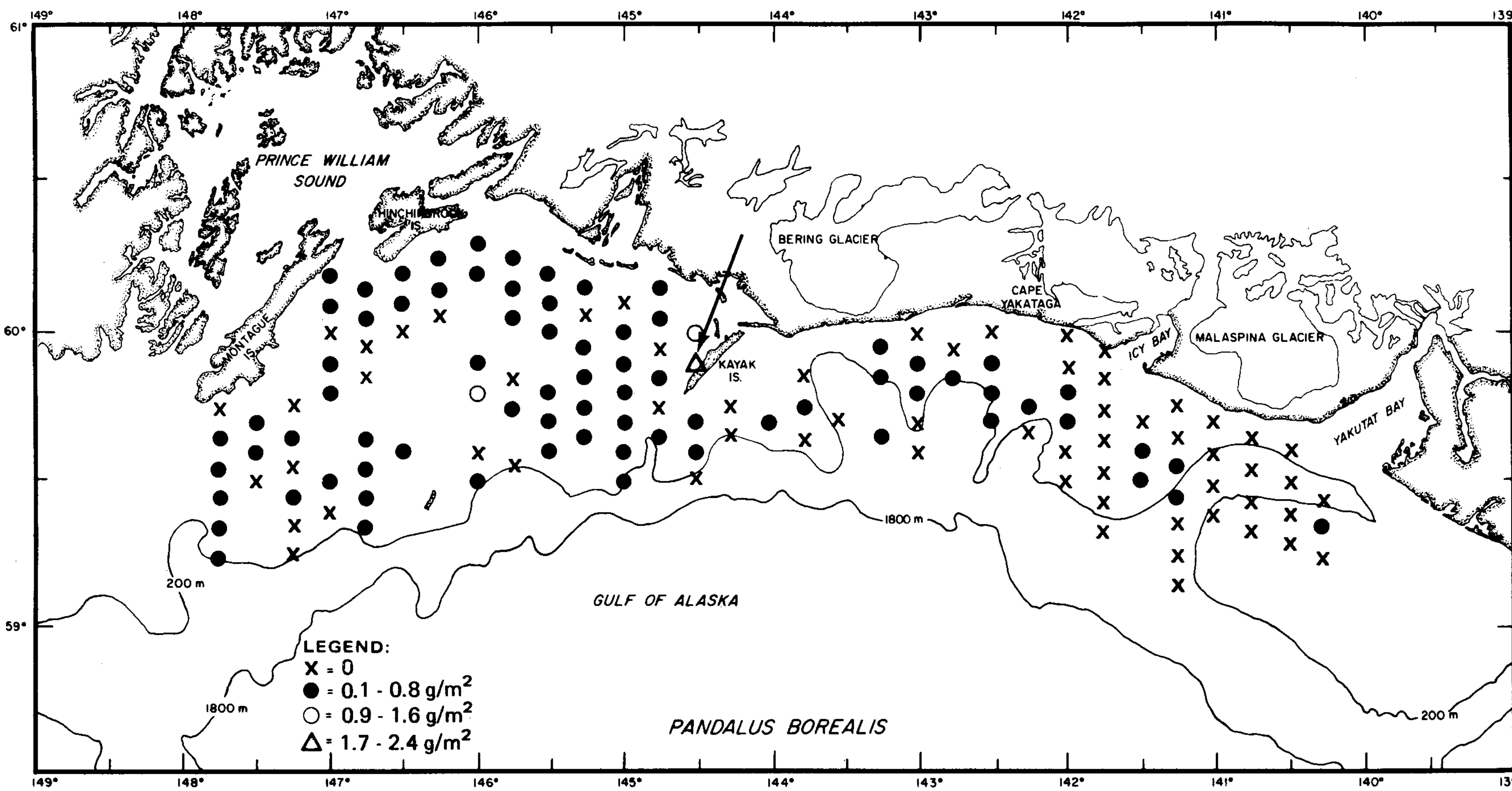

Figure 3. Distribution and abundance of the pink shrimp, *Pandalus borealis*, from the northeastern Gulf of Alaska (NEGOA) trawl survey, summer 1975. Arrow indicates highest density of *P. borealis*.

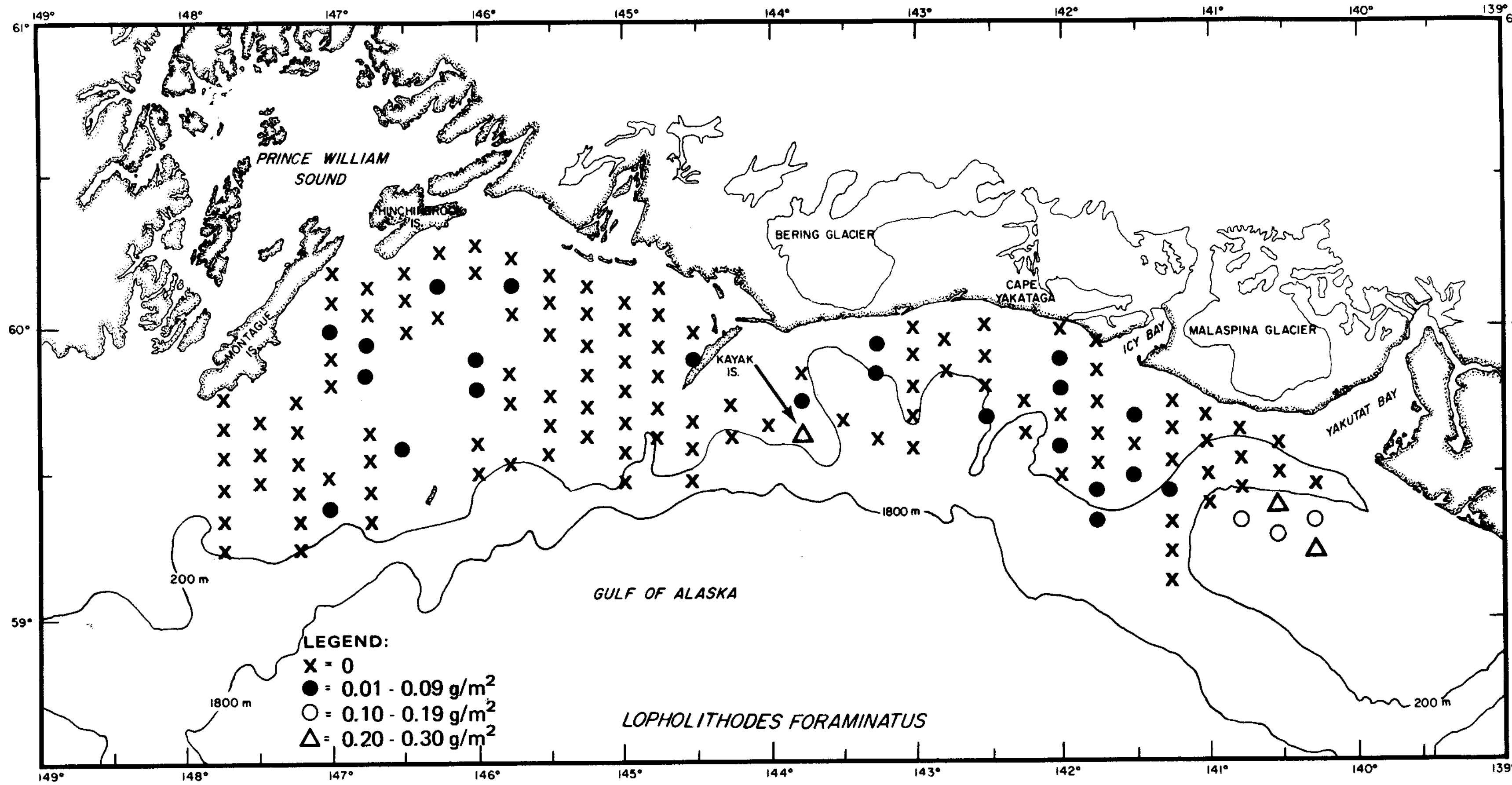

Figure 4. Distribution and abundance of the box crab, *Lopholithodes foraminatus*, from the northeastern Gulf of Alaska (NEGOA) trawl survey, summer 1975. Arrow indicates highest density of *L. foraminatus*.

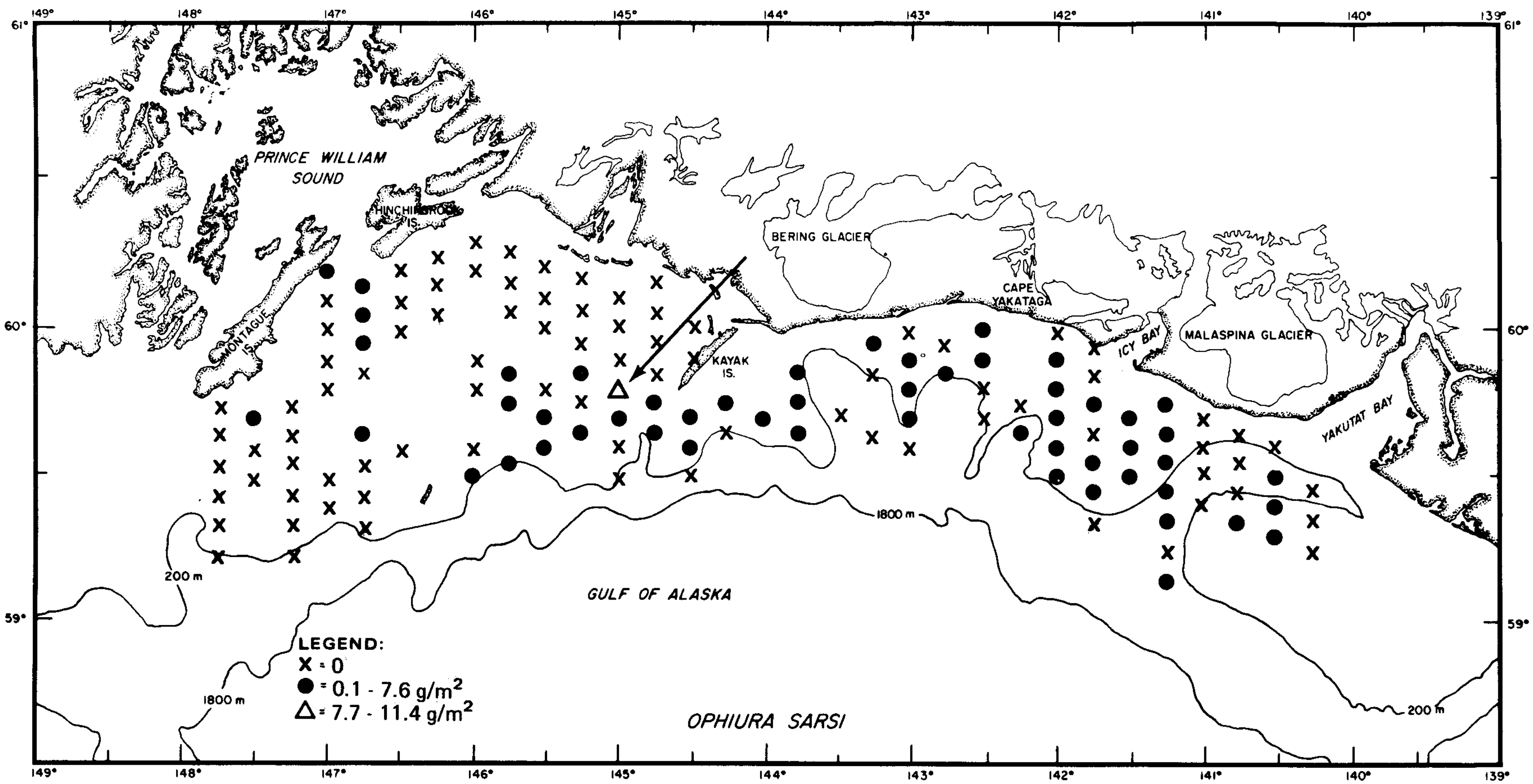

Figure 5. Distribution and abundance of the brittle star, *Ophiura sarsi*, from the northeastern Gulf of Alaska (NEGOA) trawl survey, summer 1975. Arrow indicates highest density of *O. sarsi*.

(123 lbs) taken per hour (Fig. 6). The average CPUE of this species was 5.5 kg/hr (12 lbs/hr). *Pycnopodia helianthoides* was another widely distributed sea star. One hundred and seventy of these large sea stars (average weight 0.453 kg) were taken at Station 93-C (Fig. 7). At this station the biomass of *Pycnopodia* was 1.3 g/m^2 or 85.5 (188 lbs) taken per hour. The average CPUE was 3.6 kg/hr (8 lbs/hr). The heart urchin *Brisaster townsendi* accounted for approximately 11% of the echinoderm biomass taken in the trawl survey (Table III). Station 97-C yielded the largest catch of this urchin with 2.9 g/m^2 or 213 kg (469 lbs) per hour; this represented 21,272 urchins collected during the tow (Fig. 8). The average CPUE was 3.9 kg/hr (8.6 lbs/hr).

Although sea cucumbers (family Cucumariidae) were found at only seven stations, they ranked high in echinoderm weight composition. For example, the tow at Station 99-D contained approximately 2600 of these holothuroids weighing 650 kg (1433 lbs), equivalent to 9.6 g/m^2 (Fig. 9). The average CPUE was 5.3 kg/hr (11.6 lbs/hr).

Of the 47 species of molluscs collected, the scallop *Pecten (=Patinopecten) caurinus* was dominant. This large bivalve accounted for two percent of the total epifaunal invertebrate biomass, and 43% of the molluscan biomass (Table III). Station 83-E provided the largest catch of scallops with 1.7 g/m^2 or 116 kg (370 lbs) per standard tow (Fig. 10). The average CPUE was 3.7 kg/hr (8 lbs/hr).

Snails of the family Buccinidae were the dominant gastropods in the NEGOA area. *Neptunea lyrata* was the most abundant, with the greatest biomass being taken at Station 89-A (Fig. 11). Here, 32.4 kg/hr (71 lb/hr) or 0.4 g/m^2 were taken. The average CPUE for this snail was 1.0 kg/hr (2 lb/hr). Other common buccinid snails were *Pyrulofusus harpa* and *Colus halli*.

The Oregon triton, *Fusitriton oregonensis* (family Cymatiidae), was another widespread and important gastropod (Fig. 12). It was most abundant at Station 74-C where the density was 0.4 g/m^2 or 4.5 kg (10 lbs) taken in a 35 minute (non-standard) tow. The average CPUE for this snail was 1.0 kg/hr (2 lbs/hr).

Two areas of biological interest in terms of species composition and diversity encompassed Stations 74-C and D, and Station 94-A and B (Fig. 1).

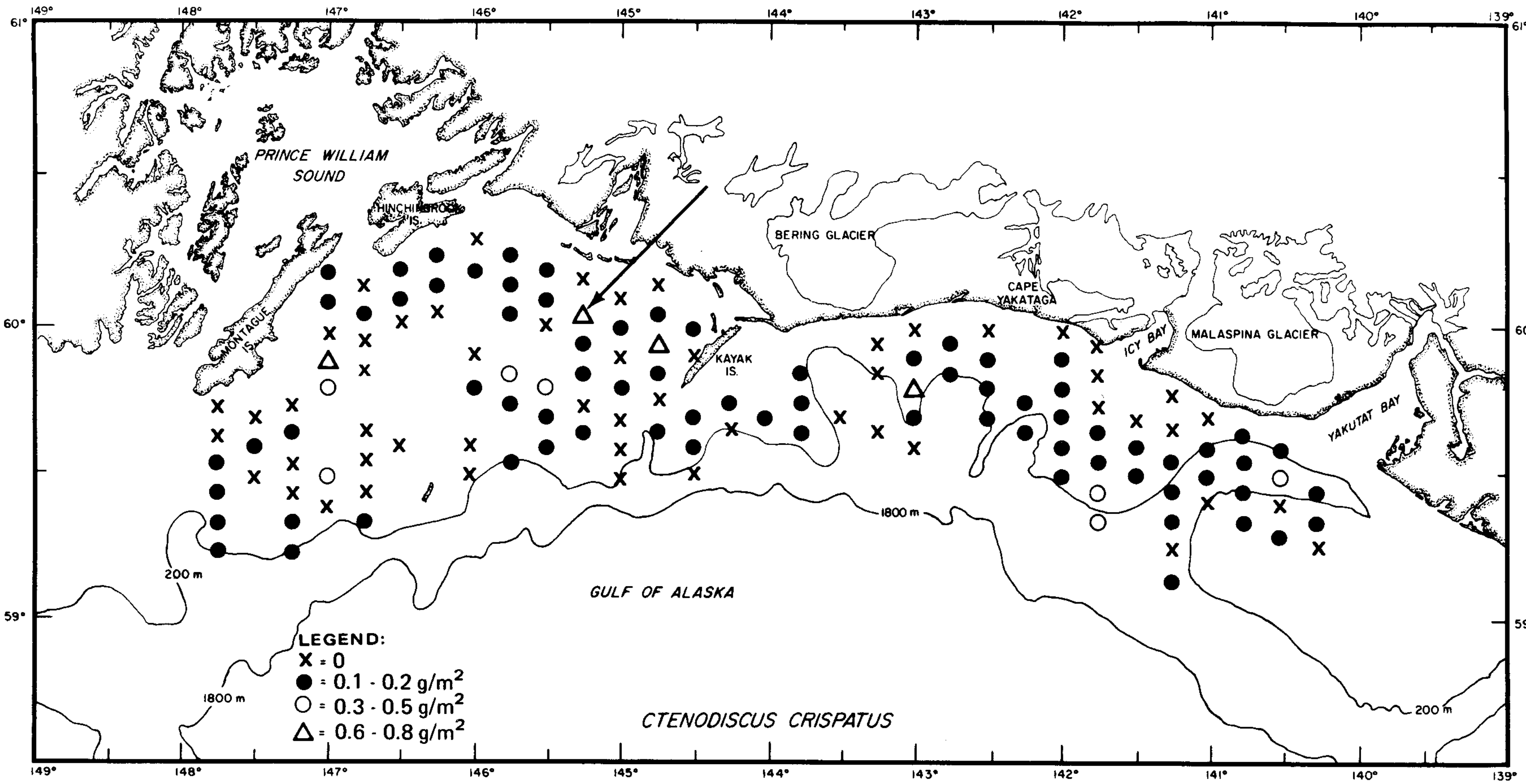

Figure 6. Distribution and abundance of the sea star, *Ctenodiscus crispatus*, from the northeastern Gulf of Alaska (NEGOA) trawl survey, summer 1975. Arrow indicates highest density of *C. crispatus*.

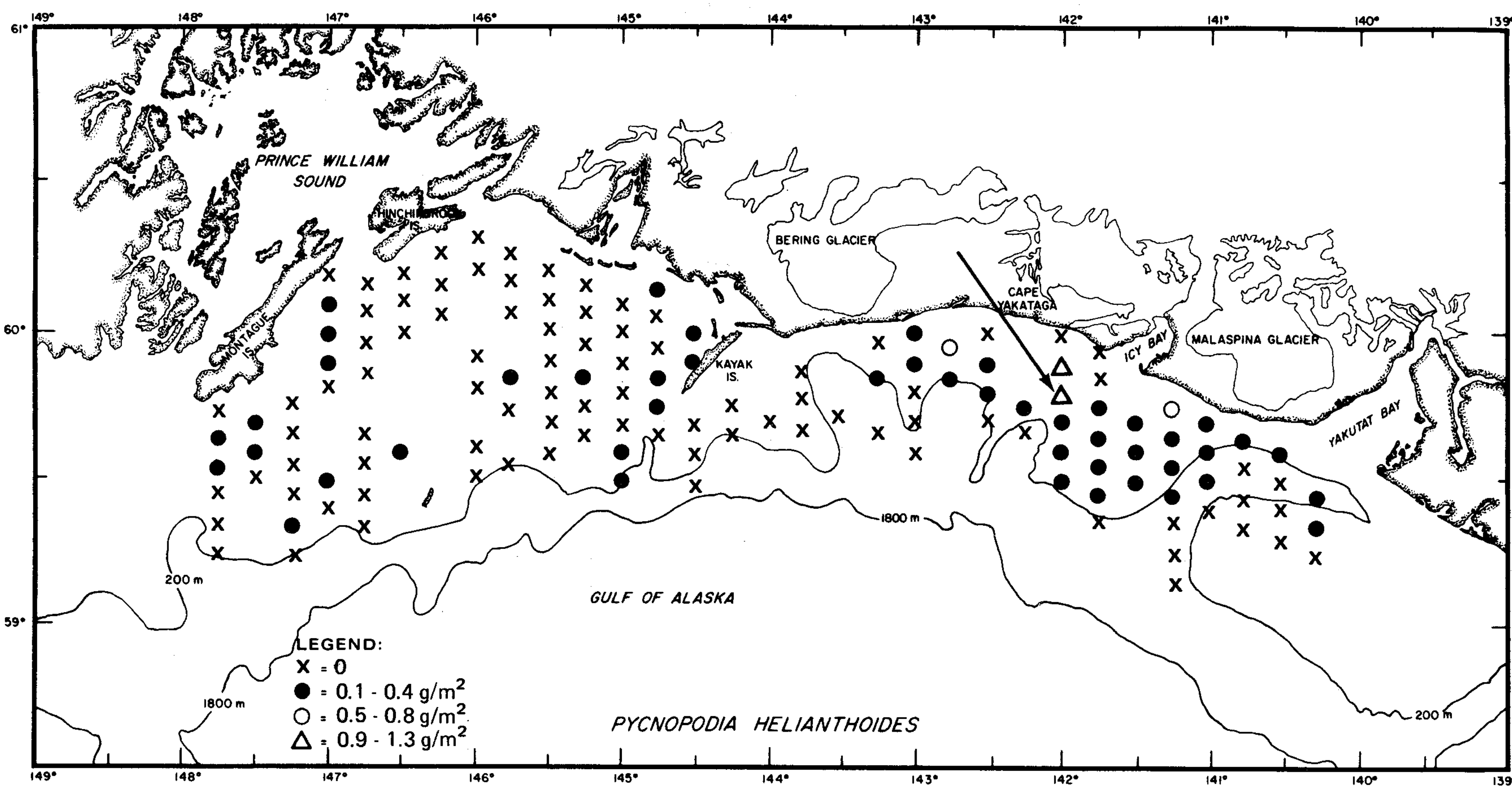

Figure 7. Distribution and abundance of the sea star, *Pycnopodia helianthoides*, from the northeastern Gulf of Alaska (NEGOA) trawl survey, summer 1975. Arrow indicates highest density of *P. helianthoides*.

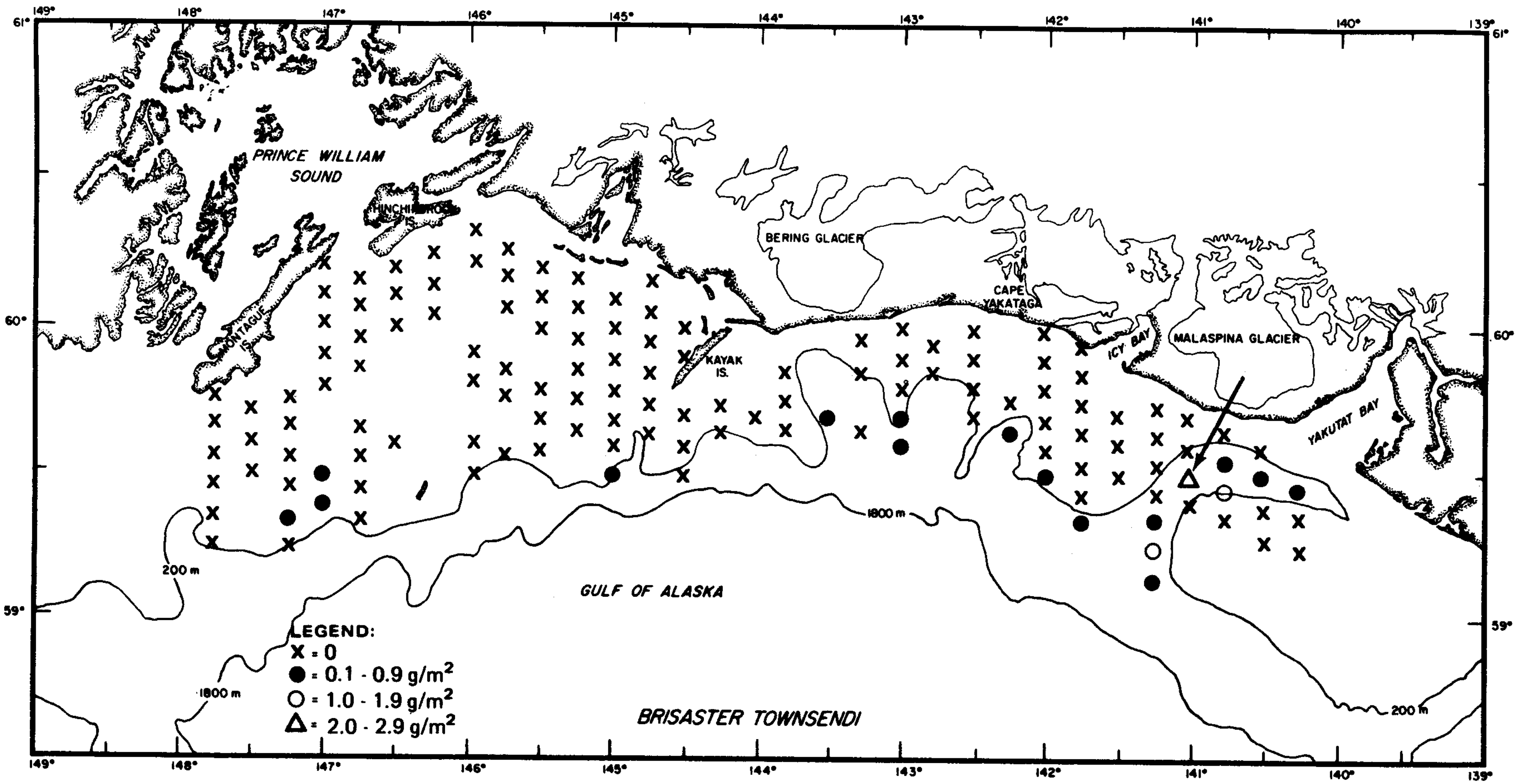

Figure 8. **Distribution and abundance of the heart urchin, *Brisaster townsendi*, from the northeastern Gulf of Alaska (NEGOA) trawl survey, summer 1975.** Arrow indicates highest density of *B. townsendi*.

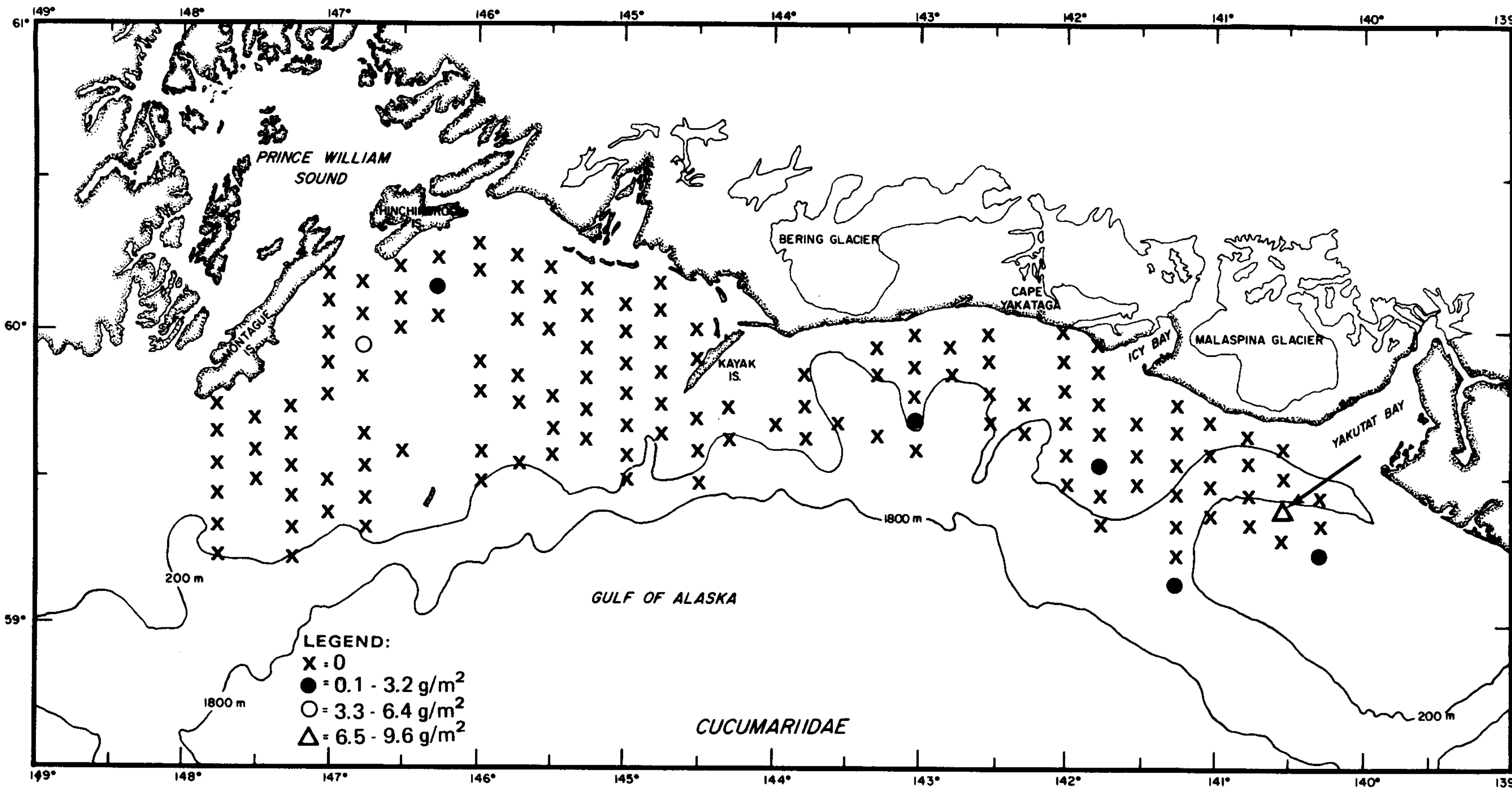

Figure 9. **Distribution and abundance of the sea cucumber, family Cucumariidae, from the northeastern Gulf of Alaska (NEGOA) trawl survey, summer 1975.** Arrow indicates highest density of Cucumariidae.

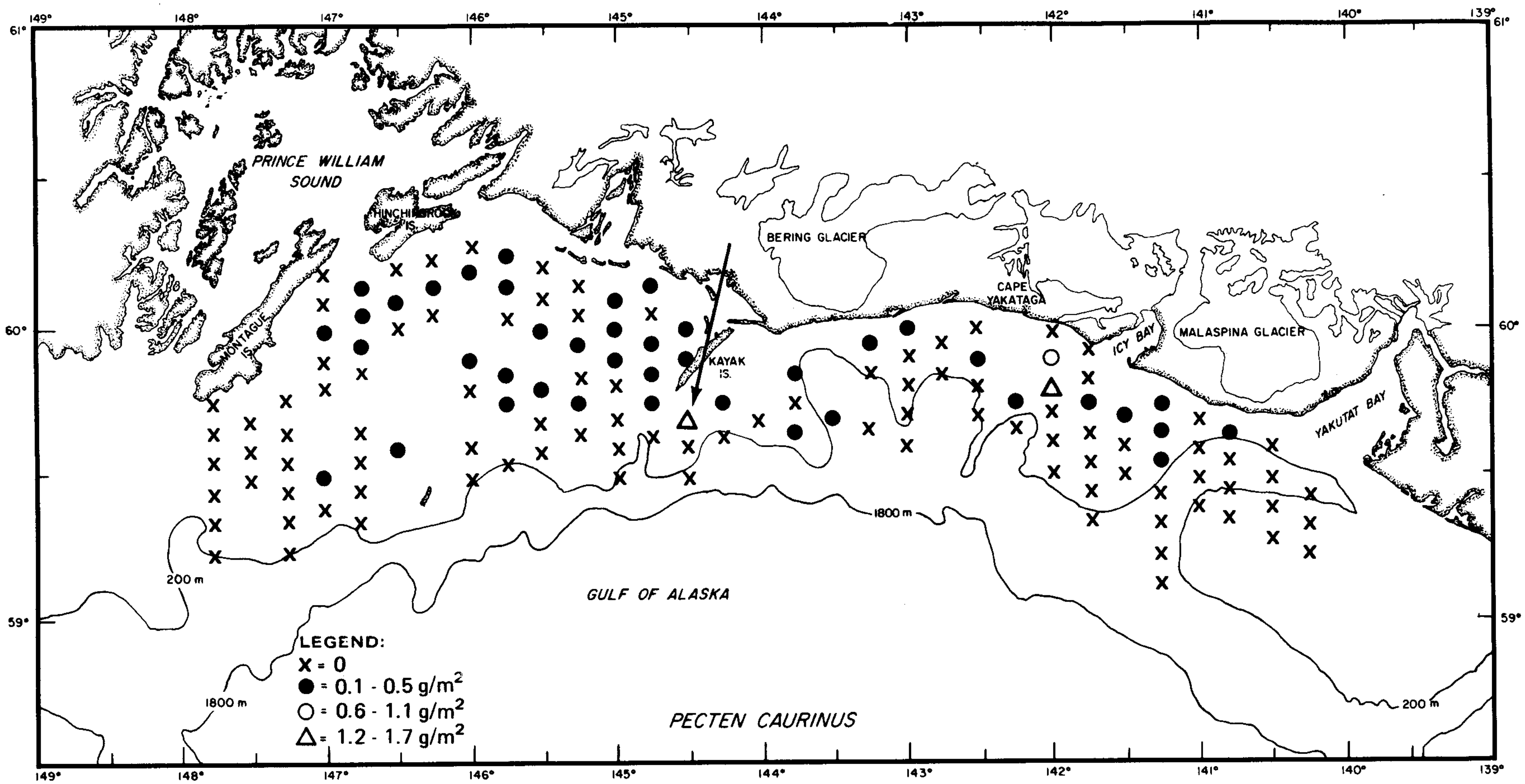

Figure 10. Distribution and abundance of the scallop, *Pecten caurinus*, from the northeastern Gulf of Alaska (NEGOA) trawl survey, summer 1975. Arrow indicates highest density of *P. caurinus*.

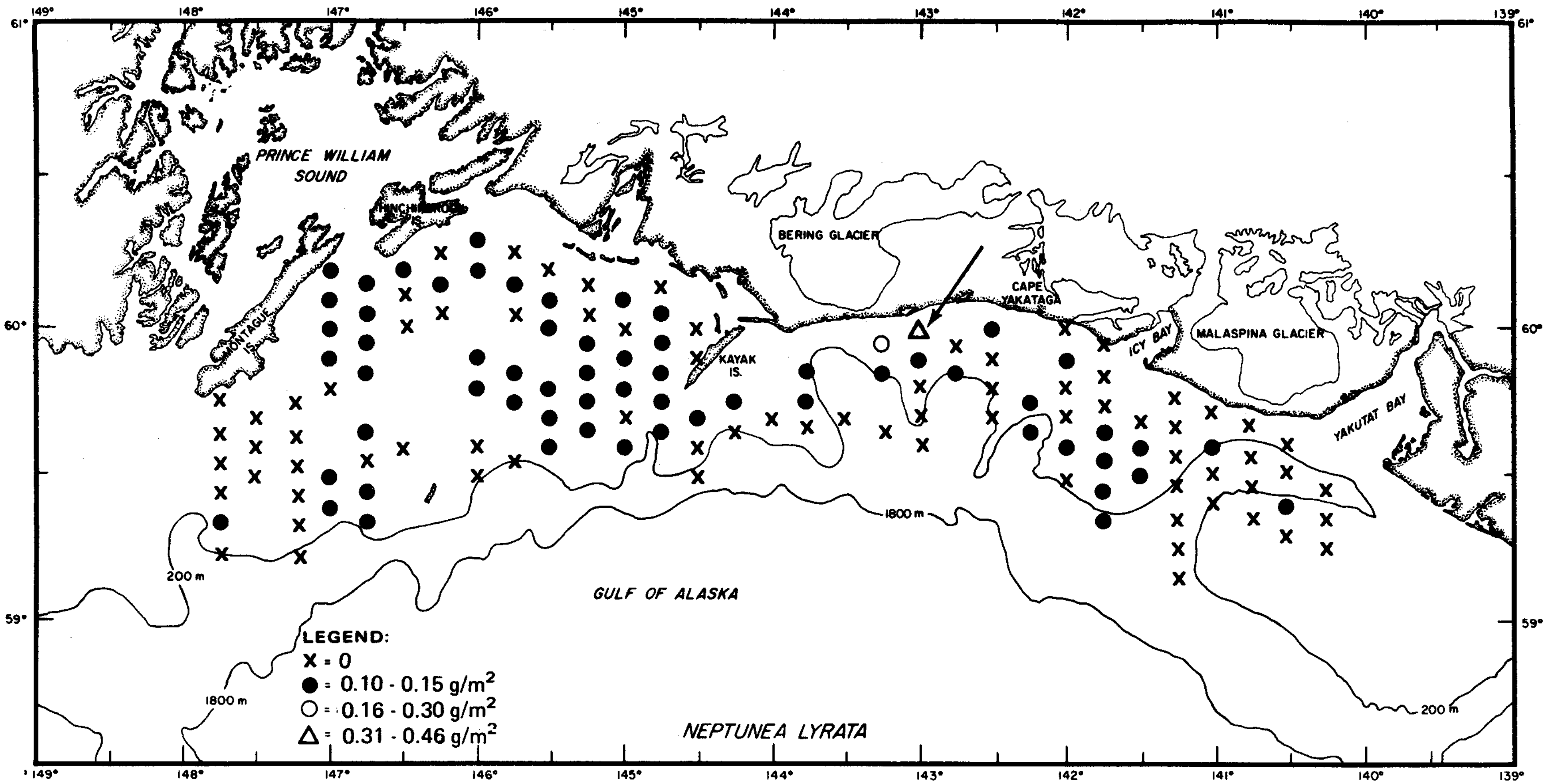

Figure 11. Distribution and abundance of the snail, *Neptunea lyrata*, from the northeastern Gulf of Alaska (NEGOA) trawl survey, summer 1975. Arrow indicates highest density of *N. lyrata*.

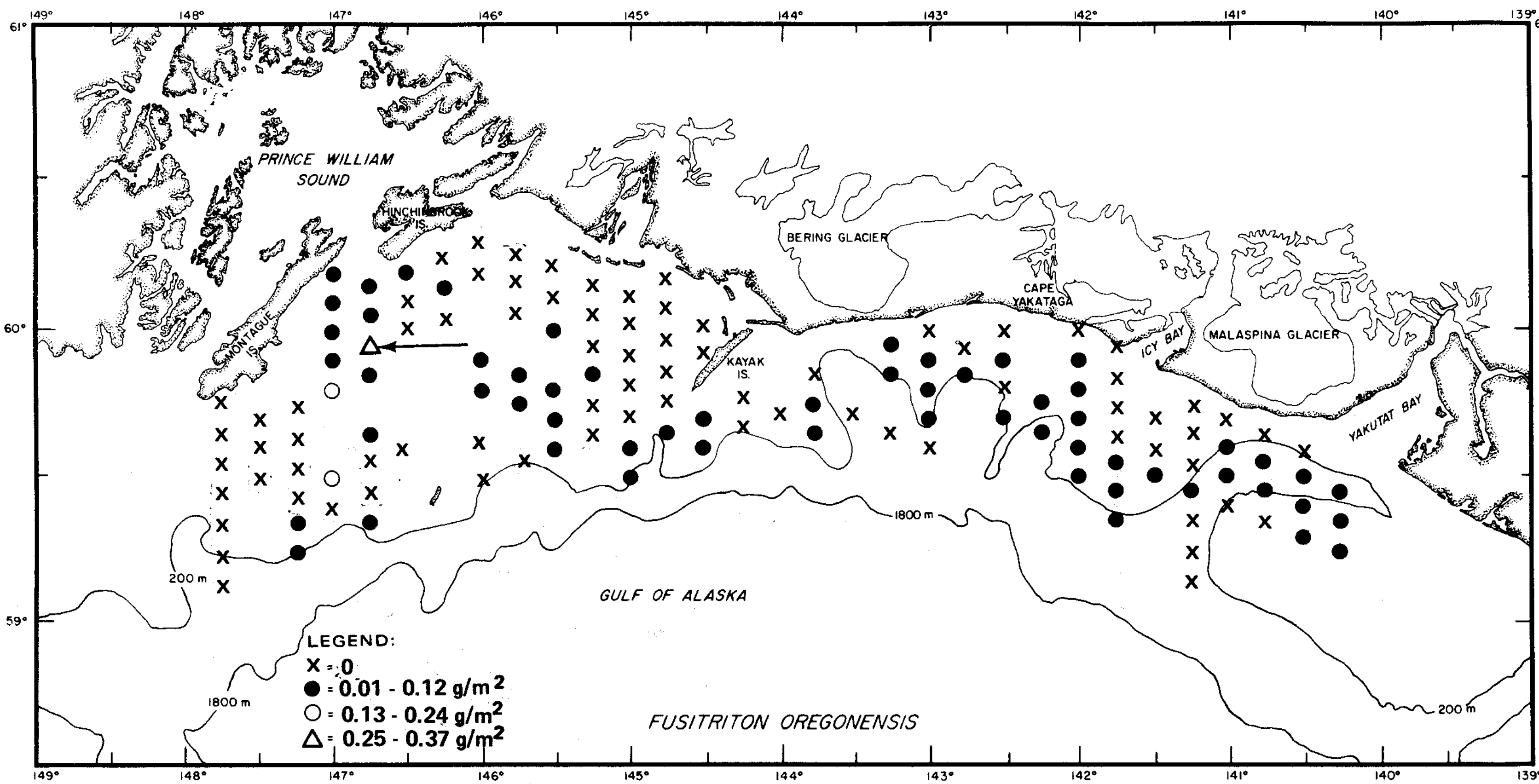

Figure 12. Distribution and abundance of the Oregon triton, *Fusitriton oregonensis*, from the northeastern Gulf of Alaska (NEGOA) trawl survey, summer 1975. Arrow indicates highest density of *F. oregonensis*.

Stations 74-C and D contained seven species of fishes (*Hippoglossus stenolepis, Bathymaster signatus, Lepidopsetta bilineata, Gadus macrocephalus, Hemilepidotus jordani, Atheresthes stomias,* and *Glyptocephalus zachirus*), and had the highest diversity of invertebrates of all of the stations sampled. Crustaceans (14 species), echinoderms (13 species) and molluscs (13 species) made up 85% of the 47 species found there. The biomass of the ascidian, *Halocynthia helgendorfi igaboja,* at Station 74-C was 4.5 g/m^2 or 419.8 kg (925 lbs) taken per hour. The Pacific halibut, *Hippoglossus stenolepis*, dominated the fish catch at Station 74-C with 1299 kg (3084 lbs) taken per hour; each fish averaged 18.5 kg (41 lbs). Stations 94-A and B, off Icy Bay, were characterized by an abundance of three species of fishes (*Platichthys stellatus, Theragra chalcogramma,* and *Isopsetta isolepis*), and the near-absence of epifaunal invertebrates. Although the number of species of fishes was low, biomass was high. At Station 94-B, 4309 kg (9499 lbs) of fishes were taken in the one-hour tow.

Feeding Observations

Limited observations on the food habits of three species of sea stars and two species of flatfishes were made in the study area (Table IV).

The forcipulate sea star *Pycnopodia helianthoides*, a predatory echinoderm, was the most commonly encountered member of the family Asteridae. Eighty-six specimens were examined for feeding habits, 69 (80.2%) of which had been feeding. By frequency of occurrence, the brittle star, *Ophiura sarsi*, was the dominant prey species found in 39.1% of the *Pycnopodia* stomachs examined (Table IV). *Ctenodiscus crispatus* occurred in 18.8% of the stomachs examined, and was second in importance as a prey species. Seventy-eight percent (78%) of the stations at which *Pycnopodia* was found also contained *C. crispatus* and/or *O. sarsi*. Other prey consumed by *Pycnopodia* in order of diminishing frequency of occurrence, were the gastropods *Colus halli, Mitrella gouldi, Solariella obscura, Oenopota* sp. and *Natica clausa*, and the pelecypods *Serripes groenlandicus* and *Clinocardium ciliatum*.

The sea star, *Ctenodiscus crispatus*, a non-selective deposit feeder, was typically found with its stomach full of sediment.

Three specimens of *Luidia foliolata*, a moderately sized (to 12 inches in diameter) sea star were examined. The brittle star, *Ophiura sarsi*, and

TABLE IV

STOMACH CONTENTS OF SELECTED EPIFAUNAL INVERTEBRATES AND FISHES FROM THE NORTHEAST GULF OF ALASKA, 1975

Predator		Percent Frequency of Occurrence: % of feeding fishes	Percent Frequency of Occurrence: % of total fishes
Pycnopodia helianthoides (Twenty-rayed star)			
Stomachs examined: 86			
Stomachs with food: 69		-	80.2%
Stomach contents:	*Ophiura sarsi* (27)	39.1%	31.4%
	Ctenodiscus crispatus (13)	18.8%	15.1%
	Natica clausa (5)	7.2%	5.8%
	Colus halli (3)	4.3%	3.5%
	Cardiidae (3)	4.3%	3.5%
	Mitrella gouldi (3)	4.3%	3.5%
	Sediment (3)	4.3%	3.5%
	Buccinum plectrum (1)	1.4%	1.2%
	Solariella obscura (1)	1.4%	1.2%
	Oenopota sp. (1)	1.4%	1.2%
	Serripes groenlandicus (1)	1.4%	1.2%
	Clinocardium ciliatum (1)	1.4%	1.2%
	Lyonsiidae (1)	1.4%	1.2%
	Mediaster aequalis (1)	1.4%	1.2%
	Gorgonocephalus caryi (1)	1.4%	1.2%
	Unidentified gastropoda (1)	1.4%	1.2%
	Unidentified pelecypoda (1)	1.4%	1.2%
	Unidentified ophiuroidea (1)	1.4%	1.2%
Luidia foliolata (sea star)			
Stomachs examined: 3			
Only stomachs with food recorded			
Stomach contents:	*Ophiura sarsi* (2)	66.6%	66.6%
	Unidentified polychaeta (1)	33.3%	33.3%
Crossaster papposus (rose star)			
Stomachs examined: 1			
Only stomach with food recorded			
Stomach contents:	*Ophiura sarsi*	100%	100%
Platichthys stellatus			
Stomachs examined: 30			
Stomachs with food: 30		-	100%
Stomach contents:	*Yoldia seminuda* (30)	100%	100%
	Siliqua sloati (30)	100%	100%
	Macoma dexiosttera (30)	100%	100%
Hippoglossoides elassodon			
Stomachs examined: 2			
Stomachs with food: 2		-	100%
Stomach contents:	*Ophiura sarsi*	100%	100%

an unidentified polychaetous annelid were found in the stomachs of *Luidia*. *Ophiura sarsi* was also found in the stomach of the rose star, *Crossaster papposus*.

Starry flounders (*Platichthys stellatus*) dominated the catch off Icy Bay (Stations 94-A and B) (Fig. 1). Thirty of these starry flounders were examined for feeding habits. All were feeding heavily on three species of clams: *Yoldia seminuda, Siliqua alta,* and *Macoma dexiosttera*. All stomachs were full.

Another common flatfish in NEGOA, the flathead sole (*Hippoglossoides elassodon*), was feeding on *Ophiura sarsi*.

Pollutants Taken by Trawl

Pollutants were recorded on the first two legs of the M/V *North Pacific* cruise which covered an area from Montague Island to Yakutat Bay. Thirty-three (33) stations out of 58 (57%) contained debris which consisted primarily of plastic materials such as brown and green trash bags, pieces of clear plastic (bait wrappers), and plastic binding straps. Numerous plastics of Japanese or Korean origin were found. A variety of other pollutants consisted of tarred paper, bottles, a steel cable, rubber gloves, a rubber tire, and two derelict snow crab pots. This high frequency of occurrence of pollutants within the surveyed area may give some indication of the amount of pollution throughout the north Pacific (Jewett, 1976).

VII. DISCUSSION

This investigation represents the first intensive qualitative and quantitative study of the epifaunal invertebrates of the northeast Gulf of Alaska (NEGOA). Hitz and Rathjen (1965) surveyed bottom fishes and invertebrates of the continental shelf in the NEGOA area; however, invertebrates were of secondary interest. Only major invertebrate species and/or groups were recorded. Additional data on commercially important shellfish species can be found in Ronholt *et al.* (1976).

The mean estimate of biomass, 2.6 g/m^2, for the northeast Gulf of Alaska is similar to estimates of 3.3 g/m^2 for the inner portions of the continental shelf (<80 m) of the southeastern Bering Sea and 4.9 g/m^2 for the outer portion of the continental shelf (mainly 80-400 m) of the southeastern Bering Sea (Feder *et al.*, 1978). Benthic trawl studies of the Norton Sound area and the Chukchi Sea-Kotzebue Sound area yielded biomass estimates of 3.7 g/m^2 and 3.3 g/m^2, respectively (Feder and Jewett, 1977b). Benthic investigations by Feder and Matheke (in prep.) provide biomass estimates based on grab samples for infauna and small epifauna from NEGOA. The lowest value, 7 g/m^2, and the highest value, 638 g/m^2, differ from our estimates based on epifauna only from NEGOA. The reason for difference in estimates is the type of gear used. Use of a commercial bottom trawl results in the loss of many small epibenthic species, and does not usually collect infauna, both of which are important components of benthic biomass. Therefore, a more accurate estimate of benthic standing stock will always be gained by combining both grab and trawl values.

The Outer Continental Shelf Environmental Assessment Program (OCSEAP) trawl surveys in the southeastern Bering Sea and Norton Sound-southeastern Chukchi Sea-Kotzebue Sound areas provided extensive information on epifauna that can be compared with data from NEGOA (Jewett and Feder, 1976; Ronholt *et al.*, 1976; Feder and Jewett, 1977b). The southeastern Bering Sea exhibited greater epifaunal diversity (233 species) than NEGOA (168 species) and Norton Sound-Chukchi Sea-Kotzebue Sound (187 species). NEGOA epifaunal invertebrate biomass was dominated by Arthropoda (71.4%), Echinodermata (19.0%), and Mollusca (4.6%). The biomass in the southeastern Bering Sea stations that were less than 80 m in depth was likewise dominated by Arthropoda (58.0%), Echinodermata (22.0%), and Mollusca (6.5%) (Feder *et al.*, 1978). At southeastern Bering Sea stations between 80 and 400 m, the biomass was also dominated by Arthropoda (66.9%), Echinodermata (11.1%), and Mollusca (4.6%) (Feder *et al.*, 1978). In contrast, the Norton Sound region was dominated by Echinodermata (80.3%), Arthropoda (9.6%), and Mollusca (4.4%) and the Chukchi Sea-Kotzebue Sound region was dominated by Echinodermata (59.9%), Mollusca (12.8%), and Arthropoda (12.5%) (Feder and Jewett, 1977b). In general, arthropod biomass decreased toward higher latitudes and the echinoderm biomass increased.

The highest biomass values for the snow crab, *Chionoecetes bairdi*, the pink shrimp, *Pandalus borealis*, the brittle star, *Ophiura sarsi*, and the mud star, *Ctenodiscus crispatus* were recorded southeast of Kayak Island, in the vicinity of the Copper River Delta (Fig. 1). Large concentrations of fishes were also present in this area (see Ronholt *et al.*, 1976, for distribution and density data for fishes there). Little is known about the productivity of this area, but primary and secondary production may be higher there as a result of nutrients supplied by the Copper River. Also, enhanced productivity may be related to the presence of gyres that extend vertically from the ocean surface to the bottom (Galt, 1976).

The two dominant arthropods, the snow crab (*Chionoecetes bairdi*) and the pink shrimp (*Pandalus borealis*) are widespread and commercially important in the northeast Gulf of Alaska. Snow crabs are major food of the Pacific cod (*Gadus macrocephalus*) (Feder, 1977a; Jewett, in press) and sculpins (*Myoxocephalus* spp.) (Jewett and Powell, unpubl.)[2]. Pink shrimps are also a major food of Pacific cod (Feder, 1977a; Jewett, in press) as well as the turbot (*Atheresthes stomias*) and rex sole (*Glyptocephalus zachirus*) (Smith *et al.*, 1978).

Although determination of the food of snow crabs was not a part of the NEGOA study, inferences from other investigations suggest that food groups used by snow crabs (*Chionoecetes* spp.) are somewhat similar throughout their range. *Chionoecetes opilio* examined in the Bering Sea fed mainly on unidentified polychaetes and brittle stars, mainly *Ophiura* sp. (Feder *et al.*, 1978). The deposit-feeding clam, *Nucula tenuis*, dominated the diet of *Chionoecetes opilio* from Norton Sound and the Chukchi Sea (Feder and Jewett, 1978b). *Chionoecetes opilio* from the Gulf of St. Lawrence fed mainly on clams (*Yoldia* sp.) and polychaetes (Powles, 1968). *Chionoecetes opilio elongatus* from Japanese waters fed primarily on brittle stars (*Ophiura* sp.), young *C. opilio elongatus*, and protobranch clams (Yasuda, 1967). Most of the items consumed by *C. bairdi* from two bays of Kodiak Island were polychaetes, clams (Nuculanidae), shrimps, plants, and sediment (Feder and Jewett, 1977a). Paul *et al.* (in press), examined stomachs of *C. bairdi* from lower Cook Inlet and found the main items to be clams (*Macoma* spp.), hermit crabs (*Pagurus* spp.), barnacles (*Balanus* spp.) and sediment. *Chionoecetes bairdi*

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[2]Detailed feeding information on Pacific cod and sculpins from the Kodiak shelf will be included in the Kodiak OCSEAP final report.

in Port Valdez (Prince William Sound) contained polychaetes, clams, *C. bairdi*, other crustaceans, and some detrital material (Feder, unpub. data). Further data on the distribution and abundance of potential prey species are necessary in order to better identify food species for better comparison of food from different areas.

The large sea star, *Pycnopodia helianthoides*, preyed almost entirely upon gastropod molluscs and echinoderms. *Pycnopodia* examined in Kodiak shallow waters preyed mainly on gastropods and pelecypods (Feder and Jewett, unpubl.). Intertidal and shallow sub-tidal *Pycnopodia helianthoides* from Prince William Sound were found to feed primarily on small bivalve molluscs (Paul and Feder, 1975). This sea star is also capable of excavating for large clams (Mauzey *et al.*, 1968; Paul and Feder, 1975). King crabs have been observed (*via* SCUBA) near Kodiak to feed on *Pycnopodia* (S. Jewett and G. Powell, unpubl. observ.).

The mud star, *Ctenodiscus crispatus*, and the heart urchin, *Brisaster townsendi*, were encountered in large numbers within the study area. Both of these echinoderms use carbon associated with bottom sediments as their major source of nutrition (Feder, unpubl.). As deposit feeders, *Ctenodiscus* and *Brisaster* are continuously reworking and ingesting sediments, and probably have an important role in recycling nutrients. A large proportion of the NEGOA infaunal species is comprised of deposit feeders (Matheke *et al.*, in press).

Although the feeding habits of the common brittle star, *Ophiura sarsi*, were not extensively examined in this study, it probably uses a combination of browsing, detritus feeding, and prey-capture techniques (Gentleman, 1964; Kyte, 1969). A few *O. sarsi* examined in NEGOA, the southeastern Bering Sea and Port Valdez (Prince William Sound) mainly contained detrital material and sediment but also fragments of a variety of small benthic invertebrates (Feder, unpubl.). In turn, this brittle star is important food for the dover sole (*Microstomus pacificus*) and the flathead sole (*Hippoglossoides elassodon*) (Smith *et al.*, 1978).

All of the specimens of the starry flounder (*Platichthys stellatus*) examined in this study had been feeding intensively and exclusively on three species of clams (*Yoldia seminuda*, *Siliqua sloati*, and *Macoma dexiosttera*). Clams, especially thin shelled species, have been found to be important components in the diet of starry flounders by other investigators (Villadolid, 1927; Orcutt, 1950; Moiseev, 1953; Miller, M.S., 1965). Starry flounders from the northern Bering Sea and the southeastern Chukchi Sea were found to feed heavily on *Yoldia hyperborea* and the brittle star *Diamphiodia craterodmeta* (Feder and Jewett, 1977b). A definite seasonality in feeding intensity has been found to exist for this flounder: during the months of January through late May a cessation of feeding occurs; feeding resumes in late May or early June (Feder and Jewett, unpub. OCSEAP data; Miller, M.S., 1965). The degree of fullness of the starry flounders examined in this study may be evidence of a recently terminated fasting period. All of the specimens were taken at Stations 94-A and B on 3 June 1975. Clam populations in the Icy Bay area obviously play a vital role in the trophic dynamics of *P. stellatus*.

VIII. CONCLUSIONS

The major limitations of the survey were those imposed by the selectivity of the otter trawl used and the seasonal movements of certain species taken. In addition, rocky-bottom areas were not sampled since otter trawls of the type used can only be fished on a relatively smooth bottom. However, the study reported here was effective for determining the epibenthic invertebrates present on sediment bottom and for achieving maximum spatial coverage of the area. This report, in conjunction with the NEGOA infaunal investigation (Feder and Matheke, in prep.), will enhance our understanding of the shelf ecosystem.

Availability of many readily identifiable, biologically well-understood organisms is a preliminary to the development of monitoring programs. Sizeable biomasses of taxonomically well-known molluscs, crustaceans, and echinoderms were typical of most of our stations, and many species of these phyla were sufficiently abundant to represent organisms potentially useful as monitoring tools. The present investigation should clarify some aspects of the biology of many of these organisms, and should increase the reliability of future monitoring programs for the Gulf of Alaska.

IX. NEEDS FOR FURTHER STUDY

The extensive trawl program permitted complete coverage of the benthos for epifaunal invertebrates. However, considerable effort is still needed to understand the NEGOA benthic system. It is especially important that chemical, physical and geological data be collected in conjunction with all future biological investigations.

Selected epifaunal species should be chosen for intensive study as soon as possible so that basic information will be available to a monitoring program. Specific biological parameters that should be examined are reproduction, recruitment, growth, age, feeding biology, and trophic interactions with other invertebrates and vertebrates.

Grouping techniques, such as cluster or recurrent group analysis, provide methods for delineating station and species groups. The outcome of such analyses can be used to delimit areas of monitoring programs. Future application of grouping techniques to epifaunal species should be strongly encouraged.

REFERENCES

Baker, J. M. (ed.) 1976. *Marine Ecology and Oil Pollution.* John Wiley and Sons, New York, N. Y. 566 p.

Bakus, G. J., and D. W. Chamberlain. 1975. An oceanographic and marine biological study in the Gulf of Alaska. Report submitted to Atlantic Richfield Co. 57 pp.

Boesch, D. F., C. H. Hershner and J. H. Milgram. 1974. *Oil Spills and the Marine Environment.* Ballinger Publ., Co., Cambridge, Mass. 114 p.

Cunningham, D. 1969. A study of the food and feeding relationships of the Alaskan king crab, *Paralithodes camtschatica.* M.S. Thesis, San Diego State College. 78 pp.

Feder, H. M. 1977a. The distribution, abundance, diversity, and biology of benthic organisms in the Gulf of Alaska and the Bering Sea. Annual Report to NOAA, R.U. No. 281/5/303. 340 pp.

Feder, H. M. 1977b. Summarization of existing literature and unpublished data on the distribution, abundance, and productivity of benthic organism of the Gulf of Alaska and Bering and Chukchi Seas. Final Report to NOAA, R.U. No. 282/301. 7 pp. (Full Report Submitted to NOAA on Magnetic Tape).

Feder, H. M. 1978a. Distribution, abundance, community structure, and trophic relationships of the nearshore benthos of the Kodiak shelf, Cook Inlet, Northeast Gulf of Alaska and the Bering Sea. Annual Report to NOAA, R.U. No. 281/5/303. 296 pp.

Feder, H. M. 1978b. Distribution, abundance, community structure and trophic relationships of the nearshore benthos of the Kodiak shelf, Cook Inlet, Northeast Gulf of Alaska, and the Bering Sea. Quarterly Report to NOAA, R.U. No. 5. 13 pp.

Feder, H. M. and S. C. Jewett. 1977a. The distribution, abundance, and diversity of the epifaunal benthic organisms in two bays (Alitak and Ugak) of Kodiak Island, Alaska. Final Report to NOAA, R.U. No. P29. 79 pp.

Feder, H. M. and S. C. Jewett. 1977b. Trawl survey of the epifaunal invertebrates of Norton Sound, Southeastern Chukchi Sea, and Kotzebue Sound. Final Report to NOAA, R.U. No. 502. 138 pp.

Feder, H. M. and G. Matheke. In prep. Distribution, abundance, and feeding biology of the benthic infauna in the northeast Gulf of Alaska. Final Report to NOAA, R. U. No. 5.

Feder, H. M., and G. Mueller. 1975. Environmental assessment of the northeast Gulf of Alaska: Benthic Biology. First Year Final Report to NOAA. Inst. Mar. Sci. 200 pp.

Feder, H. M., J. Hilsinger, M. Hoberg, S. C. Jewett, and J. R. Rose. 1978. Survey of the epifaunal invertebrates of the southeastern Bering Sea. Final Report to NOAA, R.U. No. 5. 119 pp.

Galt, J. A. 1976. Circulation studies on the Alaskan Continental Shelf off the Copper River Shelf. NOAA Tech. Rept. U.S. Government Printing Office, Washington, D.C. 36 pp.

Gentleman, S. 1964. Feeding mechanisms of *Ophiura sarsi*. Friday Harbor Lab., University of Washington, Zool. 533. Res. Paper 69.

Hitz, C. R., and W. F. Rathjen. 1965. Bottom trawling surveys of the northeastern Gulf of Alaska. *Comm. Fish. Rev.* 27(9):1-15.

Jewett, S. C. 1976. Pollutants of the northeast Gulf of Alaska. *Mar. Pollut. Bull.* 7:169.

Jewett, S. C. and H. M. Feder, 1976. Distribution and abundance of some epibenthic invertebrates of the Northeast Gulf of Alaska with notes on the feeding biology of selected species. Inst. Mar. Sci. Rept. R76-8, Univ. of Alaska, Fairbanks. 61 pp.

Jewett, S. C. In press. Summer food of the Pacific cod, *Gadus macrocephalus*, near Kodiak Island, Alaska. *Fish. Bull.*

Karinen, J. F. and S. D. Rice. 1974. Effects of Prudhoe Bay crude oil on molting tanner crabs, *Chionoecetes bairdi*. *Mar. Fish. Rev.* 36(7):31-37.

Kyte, M. A. 1969. A synopsis and key to the recent ophiuroidea of Washington state and Southern British Columbia. *J. Fish. Res. Bd. Canada* 26:1727-1741.

Lewis, J. R. 1970. Problems and approaches to base-line studies in coastal communities. FAO Technical Conference on Marine Pollution and its Effect on Living Resources and Fishing. FIR:MP 70/E-22. 7 pp.

Malins, D. C. (ed.) 1977. *Effects of petroleum on arctic and sub-arctic marine environments and organisms*. Biological Effects. Academic Press, Inc., New York, N. Y., Vol. 2. 512 pp.

Matheke, G. E. M., H. M. Feder, and G. Mueller. In press. Numerical analysis of the benthic infauna in the Northeastern Gulf of Alaska. *In*: D. N. Norton (ed.) Proc. 27th Ann. Ak. Sci. Conf., Vol. II.

Mauzey, K. P., C. Birkeland, and P. K. Dayton. 1968. Feeding behavior of asteroids and escape responses of their prey in the Puget Sound region. *Ecology* 49:603-619.

Mecklenburg, T. A., S. D. Rice, and J. F. Karinen. 1976. Effects of Cook Inlet crude oil water soluble fractions on survival and molting of king crab (*Paralithodes camtschatica*) and coonstripe shrimp (*Pandalus hypsinotus*) larvae. *In*: Proceeding of the 27th Ak. Sci. Conf. Vol. I Resource Development - Processes and Problems. 249 pp.

Miller, B. S. 1965. Food and feeding studies on adults of two species of pleuronectids (*Platichthys stellatus* and *Psettichthys melanosticus*) in East Sound, Orcas Island (Washington). M.S. Thesis, Univ. of Washington, Seattle. 131 pp.

Moiseev, P. A. 1953. Cod and flounders of the far eastern seas. Izvestiia Tikhookeanskovo N. -I. Inst. Rybnovo Khozinistva i Okeanografii, 40:1-287. (*Fish. Res. Bd. Can.* Trans. Ser. 119).

Nelson-Smith, A. 1973. *Oil Pollution and Marine Ecology*. Paul Elek (Scientific Books) Ltd., London. 260 pp.

Olson, T. A., and F. J. Burgess, eds. 1967. *Pollution and Marine Ecology*. Interscience, New York. 364 pp.

Orcutt, H. G. 1950. The life history of the starry flounder, *Platichthys stellatus* (Pallas). Calif. Fish & Game. *Fish Bull*. No. 78. 64 pp.

Paul, A. J., and H. M. Feder. 1975. The food of the sea star *Pycnopodia helianthoides* (Brandt) in Prince William Sound, Alaska. *Ophelia* 14:15-22.

Paul, A. J., H. M. Feder, and S. C. Jewett. In press. Food of the snow crab, *Chionoecetes bairdi* Rathbun 1924, from Cook Inlet, Alaska. *Crustaceana*

Pearson, T. H. 1971. The benthic ecology of Loch Linnhe and Loch Eil, a sea loch system on the west coast of Scotland. III. The effect on the benthic fauna of the introduction of pulp mill effluent. *J. Exp. Mar. Biol. Ecol.* 6:211-233.

Pearson, T. H. 1972. The effect of industrial effluent from pulp and paper mills on the marine benthic environment. *Proc. Roy. Soc. Lond. B*. 130-469-485.

Pearson, T. H. 1975. The benthic ecology of Loch Linnhe and Loch Eil, a sea loch system on the west coast of Scotland. IV. Changes in the benthic fauna attributable to organic enrichment. *J. Exp. Mar. Biol. Ecol.* 20:1-41.

Powles, H. 1968. Distribution and biology of the spider crab *Chionoecetes opilio* in the magdalen shallows, Gulf of St. Lawrence. *Fish. Res. Bd. Canada.* Mar. Rept. Ser. 997. 105 pp.

Rhoads, D. C. 1974. Organism-sediment relations on the muddy sea floor. *Oceanogr. Mar. Biol. Ann. Rev.* 12:263-300.

Ronholt, L. L., H. H. Shippen, and E. S. Brown. 1976. An assessment of the demersal fish and invertebrate resources of the northeastern Gulf of Alaska, Yakutat Bay to Cape Cleare, May - August 1975. Annual Rept. U.S. Dept. Commer., Nat'l. Oceanic Atmos. Admin., Nat'l. Mar. Fish. Serv. 184 pp.

Rosenberg, D. H., ed. 1972. A review of the oceanography and renewable resources of the northern Gulf of Alaska. IMS Report R72-23, Sea Grant Report 73-3. 690 pp.

Rosenberg, R. 1973. Succession in benthic macrofauna in a Swedish fjord subsequent to the closure of a sulphite pulp mill. *Oikos* 24:244-258.

Smith, J. E., ed. 1968. *Torrey Canyon Pollution and Marine Life.* Cambridge Univ. Press, Cambridge. 196 pp.

Smith, R., A. Paulson, and J. Rose. 1978. Food and feeding relationships in the benthic and demersal fishes of the Gulf of Alaska and Bering Sea. Final Rept. to NOAA, R.U. No. 284. 70 pp.

Straughan, D. 1971. Biological and oceanographical survey of the Santa Barbara Channel oil spill 1969-1970. Allan Hancock Foundation, Univ. of Southern California, Los Angeles. 425 pp.

Villadolid, D. V. 1927. The flatfishes (*Heterosomota*) of the Pacific coast of the United States. Ph. D. Dissertation. Stanford Univ. 332 pp.

Wigley, R. L. and R. B. Theroux. 1965. Seasonal food habits of highland ground haddock. *Trans. Am. Fish. Soc.* 94(3):243-251.

Yasuda, T. 1967. Feeding habit of the zuwaigani, *Chionoecetes opilio elongatus*, in Wakasa Bay. I. Specific composition of the stomach contents. *Bull. Jap. Soc. Sci. Fish.* 33(4):315-319. (Transl. from Japanese by Fish. Res. Bd. Can., Transl. Ser. No. 1111).

Zenkevitch, L. A. 1963. *Biology of the Seas of the USSR.* George Allen and Unwin., Ltd., London. 955 pp.

APPENDIX

GULF OF ALASKA - SELECTED BENTHIC TRAWL STATION DATA

3 MAY 1975 THROUGH 7 AUGUST 1975

CRUISE NUMBER NO817

TABLE I

TOW NUMBER 14; STATION NUMBER 74-C; PERCENT SAMPLED = 50.

(All counts and weights are projected to 100% of the sample).

Date Yr Mo Da	Time Hr/Min	Start Latitude Deg Min	Start Longitude Deg Min	Finish Latitude Deg Min	Finish Longitude Deg Min	Time Fished Min	Time Zone	Distance Fished (km)	Depth Fished (m)
75 5 8	1400	58 57.0	146 45.0	59 59.0	146 43.0	35	9	4.44	63.7-67.3

TAXON	COUNT No.	COUNT %	COUNT Per km	WET WEIGHT (gm) Total	WET WEIGHT (gm) %	WET WEIGHT (gm) Per km
INVERTEBRATES						
Porifera	6.0	0.1	1.4	2700.0	0.6	608.1
Ptilosarcus gurneyi	46.0	0.7	10.4	2760.0	0.7	621.6
Actiniidae	12.0	0.2	2.7	2400.0	0.6	540.5
Modiolus modiolus	20.0	0.3	4.5	2200.0	0.5	495.5
Chlamys hastata hericia	400.0	6.3	90.1	3200.0	0.8	720.7
Pecten caurinus	12.0	0.2	2.7	1320.0	0.3	297.3
Astarte polaris	8.0	0.1	1.8	80.0	0.0	18.0
Clinocardium fucanum	2.0	0.0	0.5	8.0	0.0	1.8
Serripes groenlandicus	4.0	0.1	0.9	800.0	0.2	180.2
Lischkeia cidaris	150.0	2.4	33.8	1800.0	0.4	405.4
Fusitriton oregonensis	260.0	4.1	58.6	19940.0	4.7	4491.0
Buccinum plectrum	40.0	0.6	9.0	800.0	0.2	180.2
Neptunea lyrata	30.0	0.5	6.8	5440.0	1.3	90.1
Pyrulofusus harpa	4.0	0.1	0.9	400.0	0.1	90.1
Tritoniidae	4.0	0.1	0.9	600.0	0.1	135.1
Tochuina tetraquetra	4.0	0.1	0.9	600.0	0.1	135.1
Balanus sp.	302.0	4.7	68.0	9060.0	2.1	2040.5

TABLE I

CONTINUED

TAXON	COUNT No.	COUNT %	COUNT Per km	WET WEIGHT (gm) Total	WET WEIGHT (gm) %	WET WEIGHT (gm) Per km
Pandalus montagui tridens	12.0	0.2	2.7	96.0	0.0	21.6
Paracrangon echinata	24.0	0.4	5.4	168.0	0.0	37.8
Pagurus ochotensis	150.0	2.4	33.8	13600.0	3.2	3063.1
Pagurus aleuticus	12.0	0.2	2.7	1320.0	0.3	297.3
Pagurus kennerlyi	40.0	0.6	9.0	4520.0	1.1	1018.0
Elassochirus tenuimanus	40.0	0.6	9.0	4520.0	1.1	1018.0
Elassochirus cavimanus	38.0	0.6	8.6	4520.0	1.1	1018.0
Labidochirus splendescens	24.0	0.4	5.4	1200.0	0.3	270.3
Lopholithodes foraminatus	2.0	0.0	0.5	840.0	0.2	189.2
Rhinolithodes wosnessenskii	16.0	0.3	3.6	2880.0	0.7	648.6
Oregonia gracilis	14.0	0.2	3.2	2520.0	0.6	567.6
Hyas lyratus	20.0	0.3	4.5	3620.0	0.9	815.3
Cancer oregonensis	24.0	0.4	5.4	140.0	0.0	31.5
Terebratulina unguicula	864.0	13.5	194.6	6040.0	1.4	1360.4
Laqueus californianus	864.0	13.5	194.6	6040.0	1.4	1360.4
Terebratalia transversa	864.0	13.5	194.6	6040.0	1.4	1360.4
Ceramaster paragonicus	14.0	0.2	3.2	980.0	0.2	220.7
Henricia sp.	50.0	0.8	11.3	3500.0	0.8	788.3
Henricia aspera	12.0	0.2	2.7	1200.0	0.3	270.3
Poraniopsis inflata	6.0	0.1	1.4	1320.0	0.3	297.3
Pteraster tesselatus	90.0	1.4	20.3	19800.0	4.7	4459.5
Crossaster papposus	44.0	0.7	9.9	3520.0	0.8	792.8
Solaster dawsoni	24.0	0.4	5.4	4800.0	1.1	1081.1
Lethasterias nanimensis	20.0	0.3	4.5	4000.0	0.9	900.9
Stylasterias forreri	16.0	0.3	3.6	640.0	0.2	144.1
Strongylocentrotus droebachiensis	496.0	7.8	111.7	14880.0	3.5	3351.4
Gorgonocephalus caryi	12.0	0.2	2.7	480.0	0.1	108.1
Ophiura sarsi	24.0	0.4	5.4	140.0	0.0	31.5
Cucumariidae	36.0	0.6	8.1	12240.0	2.9	2756.8
Halocynthia hilgendorfi igaboja	1224.0	19.2	275.7	244940.0	57.7	55166.7

TABLE I

CONTINUED

TAXON	COUNT No.	COUNT %	COUNT Per km	WET WEIGHT (gm) Total	WET WEIGHT (gm) %	WET WEIGHT (gm) Per km
VERTEBRATES						
Bathymaster signatus	-	-	-	64860.0	7.1	14608.1
Hippoglossus stenolepis	-	-	-	816480.0	88.9	183891.9
Lepidopsetta bilineata	-	-	-	37180.0	4.0	8373.9

COMMENTS

Weights of hermit crabs include their shells. This tow contains many small round rocks (4 cm in diameter), weights of some asidians include several small rocks which the asidians are attached.

TABLE II

TOW NUMBER 146; STATION NUMBER 74-D; PERCENT SAMPLED = 100.

Date Yr Mo Da	Time Hr/Min	Start Latitude Deg Min	Start Longitude Deg Min	Finish Latitude Deg Min	Finish Longitude Deg Min	Time Fished Min	Time Zone	Distance Fished (km)	Depth Fished (m)
75 8 6	1305	59 53.0	146 51.0	59 51.0	146 53.0	30	9	3.52	67.3-71.0

TAXON	COUNT No.	COUNT %	COUNT Per km	WET WEIGHT (gm) Total	WET WEIGHT (gm) %	WET WEIGHT (gm) Per km
INVERTEBRATES						
Ptilosarcus gurneyi	50.0	1.0	14.2	3000.0	2.0	852.3
Artonoe vittata	1.0	0.0	0.3	1.0	0.0	0.3
Nereis pelagica	2.0	0.0	0.6	20.0	0.0	5.7
Eunice valens	2.0	0.0	0.6	2.0	0.0	0.6
Modiolus modiolus	6.0	0.1	1.7	660.0	0.4	187.5
Hiatella arctica	1.0	0.0	0.3	3.0	0.0	0.9
Lischkeia cidaris	1.0	0.0	0.3	12.0	0.0	3.4
Fusitriton oregonensis	20.0	0.4	5.7	2000.0	1.4	568.2
Trophonopsis stuarti	2.0	0.0	0.6	20.0	0.0	5.7
Neptunea lyrata	20.0	0.4	5.7	3600.0	2.4	1022.7
Dorididae	40.0	0.8	11.4	6000.0	4.1	1704.5
Tritonia exsulans	2.0	0.0	0.6	300.0	0.2	85.2
Balanus hesperius	11.0	0.2	3.1	330.0	0.2	93.8
Pandalus hypsinotus	200.0	4.0	56.8	1600.0	1.1	454.5
Paracrangon echinata	1.0	0.0	0.3	7.0	0.0	2.0
Pagurus kennerlyi	20.0	0.4	5.7	2200.0	1.5	625.0
Elassochirus cavimanus	4.0	0.1	1.1	480.0	0.3	136.4
Lopholithodes foraminatus	3.0	0.1	0.9	1260.0	0.9	358.0
Hyas lyratus	9.0	0.2	2.6	1620.0	1.1	460.2
Terebratulina unguicula	1000.0	20.1	284.1	7000.0	4.8	1988.6
Laqueus californianus	1000.0	20.1	284.1	7000.0	4.8	1988.6

TABLE II

CONTINUED

TAXON	COUNT			WET WEIGHT (gm)		
	No.	%	Per km	Total	%	Per km
Terebratalia transversa	1000.0	20.1	284.1	7000.0	4.8	1988.6
Luidiaster dawsoni	2.0	0.0	0.6	440.0	0.3	125.0
Ceramaster patagonicus	2.0	0.0	0.6	140.0	0.1	39.8
Henricia aspera	8.0	0.2	2.3	800.0	0.5	227.3
Poraniopsis inflata	1.0	0.0	0.3	220.0	0.1	62.5
Pteraster tesselatus	30.0	0.6	8.5	6600.0	4.5	1875.0
Crossaster papposus	40.0	0.8	11.4	3200.0	2.2	909.1
Solaster dawsoni	3.0	0.1	0.9	600.0	0.4	170.5
Leptasterias sp.	3.0	0.1	0.9	27.0	0.0	7.7
Strongylocentrotus droebachiensis	1288.0	25.8	365.9	46720.0	31.7	13272.7
Gorgonocephalus caryi	9.0	0.2	2.6	3420.0	2.3	971.6
Halocynthia hilgendorfi igaboja	200.0	4.0	56.8	40000.0	27.2	11363.6
Chelyosoma columbianum	4.0	0.1	1.1	800.0	0.5	227.3
Halocynthia aurantium	1.0	0.0	0.3	200.0	0.1	56.8
<u>VERTEBRATES</u>						
Gadus macrocephalas	-	-	-	3180.0	3.7	903.4
Hemilepidotus jordani	-	-	-	3630.0	4.2	1031.3
Bathymaster signatus	-	-	-	33110.0	38.3	9406.3
Atheresthes stomias	-	-	-	17240.0	20.0	4897.7
Glyptocephalus zachirus	-	-	-	2940.0	3.4	835.2
Hippoglossus stenolepis	-	-	-	17240.0	20.0	2897.7
Lepidopsetta bilineata	-	-	-	9070.0	10.5	2576.5

COMMENTS

Halocynthia aurantium attached to pebbles, *Halocynthia hilgendorfi igaboja* with 3 species of Brachiopoda attached. Hermit crabs weighed with shell. Gulf of Alaska - Benthic trawl data - 3 May 1975 thru 7 August 1975. Hung up, web ripped. Pollutants were not recorded.

TABLE III

TOW NUMBER 35; STATION NUMBER 80-B; PERCENT SAMPLED = 65.

(All counts and weights are projected to 100% of the sample).

Date Yr Mo Da	Time Hr/Min	Start Latitude Deg Min	Start Longitude Deg Min	Finish Latitude Deg Min	Finish Longitude Deg Min	Time Fished Min	Time Zone	Distance Fished (km)	Depth Fished (m)
75 5 24	1055	60 6.0	145 20.0	60 5.0	145 13.0	60	9	5.55	91.0-112.8

TAXON	COUNT No.	COUNT %	COUNT Per km	WET WEIGHT (gm) Total	WET WEIGHT (gm) %	WET WEIGHT (gm) Per km
INVERTEBRATES						
Ptilosarcus gurneyi	173.8	2.7	31.3	10446.2	3.0	1882.2
Buccinum plectrum	4.6	0.1	0.8	92.3	0.0	16.6
Octopus sp.	6.2	0.1	1.1	200.0	0.1	36.0
Pagurus ochotensis	6.2	0.1	1.1	553.8	0.2	99.8
Chionoecetes bairdi	615.4	9.6	110.8	279138.5	80.6	50295.2
Ctenodiscus crispatus	5581.5	87.4	1005.7	55815.4	16.1	10056.8
VERTEBRATES						
Gadus macrocephalus	-	-	-	55123.1	16.1	9932.1
Theragra chalcogramma	-	-	-	170261.5	49.7	30677.8
Atheresthes stomias	-	-	-	68384.6	20.0	12321.6
Hippoglossoides elassodon	-	-	-	48846.2	14.3	8801.1

COMMENTS

Weight of hermit crab includes their shells. Plastic found.

TABLE IV

TOW NUMBER 110; STATION NUMBER 81-D; PERCENT SAMPLED = 40.

(All counts and weights are projected to 100% of the sample).

Date Yr Mo Da	Time Hr/Min	Start Latitude Deg Min	Start Longitude Deg Min	Finish Latitude Deg Min	Finish Longitude Deg Min	Time Fished Min	Time Zone	Distance Fished (km)	Depth Fished (m)
75 7 15	1305	59 49.0	145 0	59 46.0	145 2.0	60	9	5.37	182.0-193.0

TAXON	COUNT No.	COUNT %	COUNT Per km	WET WEIGHT (gm) Total	WET WEIGHT (gm) %	WET WEIGHT (gm) Per km
INVERTEBRATES						
Actiniidae	2.5	0.0	0.5	500.0	0.0	93.1
Neptunea lyrata	2.5	0.0	0.5	450.0	0.0	83.8
Neptunea pribiloffensis	117.5	0.1	21.9	21150.0	1.5	3938.5
Tritonia exsulans	50.0	0.0	9.3	7500.0	0.5	1396.6
Gonatidae	2.5	0.0	0.5	50.0	0.0	9.3
Octopus sp.	2.5	0.0	0.5	225.0	0.0	41.9
Pandalus borealis	125.0	0.1	23.3	1000.0	0.1	186.2
Pandalopsis dispar	50.0	0.0	9.3	500.0	0.0	93.1
Pagurus aleuticus	25.0	0.0	4.7	275.0	0.0	51.2
Chionoecetes bairdi	1300.0	1.0	242.1	585000.0	42.3	108939.5
Pseudarchaster parelii	2.5	0.0	0.5	225.0	0.0	41.9
Ctenodiscus crispatus	1562.5	1.2	291.0	15625.0	1.1	2909.7
Ophiura sarsi	125000.0	97.5	23277.5	750000.0	54.2	139664.8
VERTEBRATES						
Raja rhina	-	-	-	32875.0	8.4	6122.0
Gadus macrocephalas	-	-	-	79375.0	20.3	14781.2
Sebastolobus alascanus	-	-	-	17575.0	4.5	3272.8

TABLE IV

CONTINUED

TAXON	COUNT No.	COUNT %	COUNT Per km	WET WEIGHT (gm) Total	WET WEIGHT (gm) %	WET WEIGHT (gm) Per km
Anoplopoma fimbria	-	-	-	19275.0	4.9	3589.4
Atheresthes stomias	-	-	-	46475.0	11.9	8654.6
Glyptocephalus zachirus	-	-	-	92975.0	23.8	17313.8
Hippoglossoides elassodon	-	-	-	2825.0	0.7	526.1
Microstomus pacificus	-	-	-	99775.0	25.5	18580.1

COMMENTS

Hermit crabs weighed with shell. Pollutants were not recorded.

TABLE V

TOW NUMBER 106; STATION NUMBER 82-A; PERCENT SAMPLED = 50.

(All counts and weights are projected to 100% of the sample).

Date Yr Mo Da	Time Hr/Min	Start Latitude Deg Min	Start Longitude Deg Min	Finish Latitude Deg Min	Finish Longitude Deg Min	Time Fished Min	Time Zone	Distance Fished (km)	Depth Fished (m)
75 7 14	1300	60 7.0	144 46.0	60 6.0	144 41.0	55	9	3.70	49.1-51.0

TAXON	COUNT No.	COUNT %	COUNT Per km	WET WEIGHT (gm) Total	WET WEIGHT (gm) %	WET WEIGHT (gm) Per km
INVERTEBRATES						
Ptilosarcus gurneyi	324.0	10.7	87.6	19440.0	2.1	5254.1
Actiniidae	2.0	0.1	0.5	400.0	0.0	108.1
Nuculana fossa	8.0	0.3	2.2	8.0	0.0	2.2
Pecten caurinus	4.0	0.1	1.1	1400.0	0.1	378.4
Tritonia exsulans	2.0	0.1	0.5	300.0	0.0	81.1
Pandalus borealis	600.0	19.9	162.2	4800.0	0.5	1297.3
Pandalus hypsinotus	36.0	1.2	9.7	280.0	0.0	75.7
Eualis barbata	2.0	0.1	0.5	14.0	0.0	3.8
Eualis suckleyi	2.0	0.1	0.5	14.0	0.0	3.8
Crangon communis	4.0	0.1	1.1	28.0	0.0	7.6
Pagurus ochotensis	6.0	0.2	1.6	540.0	0.1	145.9
Chionoecetes bairdi	1984.0	65.8	536.3	892800.0	95.2	241297.3
Cancer magister	34.0	1.1	9.2	15300.0	1.6	4135.1
Pycnopodia helianthoides	6.0	0.2	1.6	2700.0	0.3	729.7
VERTEBRATES						
Theragra chalcogramma	-	-	-	32200.0	17.2	8702.7
Anoplopoma fimbria	-	-	-	4080.0	2.2	1102.7

TABLE V

CONTINUED

TAXON	COUNT			WET WEIGHT (gm)		
	No.	%	Per km	Total	%	Per km
Agonus acipenserinus	-	-	-	15860.0	8.5	4286.5
Lumpenus sagitta	-	-	-	6160.0	3.3	1664.9
Atheresthes stomias	-	-	-	70760.0	37.9	19124.3
Hippoglossoides elassodon	-	-	-	57700.0	30.9	15594.6

COMMENTS

Hermit crabs weighed with shell. *Pycnopodia helianthoides* feeding on *Mitrella gouldi*. Pollutants were not recorded.

TABLE VI

TOW NUMBER 104; STATION NUMBER 83-C; PERCENT SAMPLED = 10.

(All counts and weights are projected to 100% of the sample).

Date Yr Mo Da	Time Hr/Min	Start Latitude Deg Min	Start Longitude Deg Min	Finish Latitude Deg Min	Finish Longitude Deg Min	Time Fished Min	Time Zone	Distance Fished (km)	Depth Fished (m)
75 7 14	0745	59 52.0	144 38.0	59 56.0	144 34.0	60	9	5.55	54.6-54.6

TAXON	COUNT No.	COUNT %	COUNT Per km	WET WEIGHT (gm) Total	WET WEIGHT (gm) %	WET WEIGHT (gm) Per km
INVERTEBRATES						
Ptilosarcus gurneyi	222.0	1.0	39.6	13200.0	3.0	2378.4
Nuculana fossa	30.0	0.1	5.4	30.0	0.0	5.4
Pecten caurinus	30.0	0.1	5.4	10500.0	2.4	1891.9
Balanus herperius	10.0	0.0	1.8	300.0	0.1	54.1
Pandalus borealis	20970.0	95.8	3778.4	167700.0	38.5	30216.2
Pandalus hyspinotus	30.0	0.1	5.4	240.0	0.1	43.2
Eualis suckleyi	30.0	0.1	5.4	210.0	0.0	37.8
Lopholithodes foraminatus	10.0	0.0	1.8	4200.0	1.0	756.8
Chionoecetes bairdi	500.0	2.3	90.1	225000.0	51.6	40540.5
Cancer magister	10.0	0.0	1.8	4500.0	1.0	810.8
Pycnopodia helianthoides	20.0	0.1	3.6	9000.0	2.1	1621.6
Strongylocentrotus droebachiensis	30.0	0.1	5.4	900.0	0.2	162.2
Molpadia sp.	10.0	0.0	1.8	200.0	0.0	36.0
VERTEBRATES						
Raja binoculata	-	-	-	226800.0	52.1	40864.9
Theragra chalcogramma	-	-	-	54430.0	12.5	9807.2

TABLE VI

CONTINED

TAXON	COUNT No.	COUNT %	COUNT Per km	WET WEIGHT (gm) Total	WET WEIGHT (gm) %	WET WEIGHT (gm) Per km
Anoplopoma fimbria	-	-	-	22600.0	5.2	4072.1
Atheresthes stomias	-	-	-	104320.0	24.0	18796.4
Hippoglossus stenolepis	-	-	-	27210.0	6.3	4902.7

TABLE VII

TOW NUMBER 142; STATION NUMBER 83-E; PERCENT SAMPLED = 100.

Date Yr Mo Da	Time Hr/Min	Start Latitude Deg Min	Start Longitude Deg Min	Finish Latitude Deg Min	Finish Longitude Deg Min	Time Fished Min	Time Zone	Distance Fished (km)	Depth Fished (m)
75 8 4	0800	59 43.0	144 37.0	59 41.0	144 33.0	60	9	5.55	129.2-131.0

TAXON	COUNT No.	COUNT %	COUNT Per km	WET WEIGHT (gm) Total	WET WEIGHT (gm) %	WET WEIGHT (gm) Per km
INVERTEBRATES						
Porifera	0.0	0.0	0.0	7900.0	4.7	1423.4
Nereis pelagica	1.0	0.0	0.2	10.0	0.0	1.8
Nereis vexillosa	1.0	0.0	0.2	10.0	0.0	1.8
Hirudinae	1.0	0.0	0.2	2.0	0.0	0.4
Mytilus edulis	100.0	2.4	18.0	2000.0	1.2	360.4
Pecten caurinus	330.0	7.8	59.5	115500.0	68.9	20810.8
Hiatella arctica	1.0	0.0	0.2	3.0	0.0	0.5
Fusitriton oregonensis	6.0	0.1	1.1	600.0	0.4	108.1
Buccinum plectrum	1.0	0.0	0.2	20.0	0.0	3.6
Neptunea lyrata	4.0	0.1	0.7	720.0	0.4	129.7
Pyrulofusus harpa	1.0	0.0	0.2	100.0	0.1	18.0
Octopus sp.	1.0	0.0	0.2	90.0	0.1	16.2
Lepas pectinata pacifica	1.0	0.0	0.2	30.0	0.0	5.4
Pandalus borealis	1100.0	26.1	198.2	8800.0	5.2	1585.6
Crangon communis	3.0	0.1	0.5	21.0	0.0	3.8
Argis dentata	1.0	0.0	0.2	7.0	0.0	1.3
Pagurus aleuticus	29.0	0.7	5.2	3190.0	1.9	574.8
Pagurus confragosus	12.0	0.3	2.2	1320.0	0.8	237.8
Elassochirus cavimanus	1.0	0.0	0.2	120.0	0.1	21.6
Hyas lyratus	6.0	0.1	1.1	1080.0	0.6	194.6

TABLE VII

CONTINUED

TAXON	COUNT No.	COUNT %	COUNT Per km	WET WEIGHT (gm) Total	WET WEIGHT (gm) %	WET WEIGHT (gm) Per km
Chionoecetes bairdi	17.0	0.4	3.1	7650.0	4.6	1378.4
Pseudarchaster parelii	1.0	0.0	0.2	90.0	0.1	16.2
Ctenodiscus crispatus	600.0	14.2	108.1	6000.0	3.6	1081.1
Henricia aspera	1.0	0.0	0.2	100.0	0.1	18.0
Gorgonocephalus caryi	1.0	0.0	0.2	380.0	0.2	68.5
Ophiura sarsi	2000.0	27.4	360.4	12000.0	7.2	2162.2
VERTEBRATES						
Raja kincaidi	-	-	-	2270.0	1.2	409.0
Raja rhina	-	-	-	3860.0	2.1	695.5
Thaleichthys pacificus	-	-	-	1360.0	0.7	245.0
Theragra chalcogramma	-	-	-	47170.0	25.9	8499.1
Ulca bolini	-	-	-	4540.0	2.5	818.0
Atheresthes stomias	-	-	-	82560.0	45.3	14875.7
Glyptocephalus zachirus	-	-	-	19500.0	10.7	3513.5
Hippoglossoides elassodon	-	-	-	5900.0	3.2	1063.1
Microstomus pacificus	-	-	-	14970.0	8.2	2697.3

COMMENTS

C. bairdi sexed, 12 males, 2 nongravid females, 3 gravid females. *Mytilus edulis* attached to Kelp holfast. Hermit crabs weighed with shell. Pollutants were not recorded.

TABLE VIII

TOW NUMBER 42; STATION NUMBER 86-D; PERCENT SAMPLED = 100.

Date Yr Mo Da	Time Hr/Min	Start Latitude Deg Min	Start Longitude Deg Min	Finish Latitude Deg Min	Finish Longitude Deg Min	Time Fished Min	Time Zone	Distance Fished (km)	Depth Fished (m)
75 5 30	1240	59 40.0	143 44.0	59 41.0	143 47.0	65	9	7.22	127.4-140.1

TAXON	COUNT No.	COUNT %	COUNT Per km	WET WEIGHT (gm) Total	WET WEIGHT (gm) %	WET WEIGHT (gm) Per km
INVERTEBRATES						
Notostomobdella sp.	1.0	2.7	0.1	2.0	0.0	0.3
Pecten caurinus	1.0	0.2	0.1	350.0	1.0	48.5
Astarte polaris	90.0	17.6	12.5	900.0	2.5	124.7
Fusitriton oregonensis	4.0	0.8	0.6	400.0	1.1	55.4
Pyrulofusus harpa	1.0	0.2	0.1	100.0	0.3	13.9
Arctomelon stearnsii	1.0	0.2	0.1	180.0	0.5	24.9
Octopus sp.	1.0	0.2	0.1	90.0	0.2	12.5
Eualis barbata	8.0	1.6	1.1	56.0	0.2	7.8
Lopholithodes foraminatus	55.0	10.7	7.6	25400.0	70.2	3518.0
Chionoecetes bairdi	45.0	8.8	6.2	5890.0	16.3	818.8
Laqueus californianus	5.0	1.0	0.7	15.0	0.0	2.1
Ctenodiscus crispatus	136.0	26.6	18.8	1360.0	3.8	188.4
Allocentrotus fragilis	13.0	2.5	1.8	520.0	1.4	72.0
Strongylocentrotus droebachiensis	1.0	0.2	0.1	30.0	0.1	4.2
Ophiura sarsi	150.0	29.3	20.8	900.0	2.5	124.7
VERTEBRATES						
Atheresthes stomias	-	-	-	249480.0	57.2	34554.0

TABLE VIII

CONTINUED

TAXON	COUNT No.	COUNT %	COUNT Per km	WET WEIGHT (gm) Total	WET WEIGHT (gm) %	WET WEIGHT (gm) Per km
VERTEBRATES (continued)						
Hippoglossoides elassodon	-	-	-	186880.0	42.8	25883.7

COMMENTS

Lopholithodes foraminatus - 48 males and 7 females

TABLE IX

TOW NUMBER 100; STATION NUMBER 89-A; PERCENT SAMPLED = 100.

Date Yr Mo Da	Time Hr/Min	Start Latitude Deg Min	Start Longitude Deg Min	Finish Latitude Deg Min	Finish Longitude Deg Min	Time Fished Min	Time Zone	Distance Fished (km)	Depth Fished (m)
75 7 12	1455	60 1.0	143 1.0	60 0.	142 55.0	60	9	5.74	67.3-71.0

TAXON	COUNT No.	COUNT %	COUNT Per km	WET WEIGHT (gm) Total	WET WEIGHT (gm) %	WET WEIGHT (gm) Per km
Eunoe depressa	1.0	0.2	0.2	1.0	0.0	0.2
Aphrodita sp.	2.0	0.3	0.3	12.0	0.0	2.1
Aphrodita japonica	1.0	0.2	0.2	10.0	0.0	1.7
Nuculana fossa	13.0	2.1	2.3	13.0	0.0	2.3
Pecten caurinus	3.0	0.5	0.5	1050.0	0.9	182.9
Astarte polaris	12.0	2.0	2.1	120.0	0.1	20.9
Natica clausa	3.0	0.5	0.5	36.0	0.0	6.3
Polinices monteronis	2.0	0.3	0.3	80.0	0.1	13.9
Buccinum plectrum	2.0	0.3	0.3	40.0	0.0	7.0
Beringius kennicotti	45.0	7.3	7.8	4950.0	4.3	862.4
Colus halli	2.0	0.3	0.3	36.0	0.0	6.3
Neptunea lyrata	180.0	29.3	31.4	32400.0	28.1	5644.6
Neptunea pribiloffensis	2.0	0.3	0.3	360.0	0.3	62.7
Pagurus ochotensis	39.0	6.3	6.8	3510.0	3.0	611.5
Pagurus aleuticus	24.0	3.9	4.2	2640.0	2.3	459.9
Pagurus kennerly	12.0	2.0	2.1	1320.0	1.1	230.0
Pagurus confragosus	130.0	21.1	22.6	14300.0	12.4	2491.3
Elassochirus tenuimanus	11.0	1.8	1.9	1320.0	1.1	230.0
Elassochirus cavimanus	4.0	0.7	0.7	440.0	0.4	76.7
Labidochirus splendescens	1.0	0.2	0.2	50.0	0.0	8.7
Oregonia gracilis	1.0	0.2	0.2	180.0	0.2	31.4
Hyas lyratus	13.0	2.1	2.3	2340.0	2.0	407.7
Chionoecetes bairdi	103.0	16.7	17.9	46350.0	40.2	8074.9

TABLE IX

CONTINUED

TAXON	COUNT			WET WEIGHT (gm)		
	No.	%	Per km	Total	%	Per km
Pseudarchaster parelii	1.0	0.2	0.2	90.0	0.1	15.7
Luidia foliolata	3.0	0.5	0.5	1350.0	1.2	235.2
Pycnopodia helianthoides	5.0	0.8	0.9	2250.0	2.0	392.0
<u>VERTEBRATES</u>						
Raja binoculata	-	-	-	51250.0	18.3	8928.6
Raja rhina	-	-	-	10430.0	3.7	1817.1
Raja stellulata	-	-	-	24490.0	8.7	4266.6
Gadus macrocephalas	-	-	-	91170.0	32.5	15883.3
Theragra chalcogramma	-	-	-	37190.0	13.3	6479.1
Atheresthes stomias	-	-	-	12700.0	4.5	2212.5
Glyptocephalus zachirus	-	-	-	48080.0	17.2	8376.3
Hippoglossoides elassodon	-	-	-	4980.0	1.8	867.6

<u>COMMENTS</u>

Hermit crabs weighed with shell. Pollutants were not recorded.

TABLE X

TOW NUMBER 89; STATION NUMBER 93-C; PERCENT SAMPLED = 100.

Date Yr Mo Da	Time Hr/Min	Start Latitude Deg Min	Start Longitude Deg Min	Finish Latitude Deg Min	Finish Longitude Deg Min	Time Fished Min	Time Zone	Distance Fished (km)	Depth Fished (m)
75 7 9	1550	59 51.0	142 3.0	59 50.0	141 57.0	60	9	5.55	81.9-85.5

TAXON	COUNT No.	COUNT %	COUNT Per km	WET WEIGHT (gm) Total	WET WEIGHT (gm) %	WET WEIGHT (gm) Per km
INVERTEBRATES						
Actiniidae	2.0	0.3	0.4	180.0	0.1	32.4
Pecten caurinus	290.0	44.6	52.3	101500.0	52.5	18288.3
Cyclocardia ventricosa	1.0	0.2	0.2	4.0	0.0	0.7
Compsomya subdiaphana	1.0	0.2	0.2	4.0	0.0	0.7
Fusitriton oregonensis	1.0	0.2	0.2	70.0	0.0	12.6
Rocinela augustata	1.0	0.2	0.2	1.0	0.0	0.2
Pandalus borealis	1.0	0.2	0.2	4.0	0.0	0.7
Pandalus montagui tridens	6.0	0.9	1.1	50.0	0.0	9.0
Pandalus platyceros	1.0	0.2	0.2	45.0	0.0	8.1
Crangon communis	2.0	0.3	0.4	14.0	0.0	2.5
Argis ovifer	1.0	0.2	0.2	4.0	0.0	0.7
Pagurus ochotensis	1.0	0.2	0.2	90.0	0.0	16.2
Pagurus confragosus	2.0	0.3	0.4	180.0	0.1	32.4
Lopholithodes foraminatus	1.0	0.2	0.2	420.0	0.2	75.7
Chionoecetes bairdi	9.0	1.4	1.6	4050.0	2.1	729.7
Ctenodiscus crispatus	100.0	15.4	18.0	1000.0	0.5	180.2
Pycnopodia helianthoides	190.0	29.2	34.2	85500.0	44.2	15405.4
Ophiura sarsi	40.0	6.2	7.2	240.0	0.1	43.2

TABLE X

CONTINUED

TAXON	COUNT No.	COUNT %	COUNT Per km	WET WEIGHT (gm) Total	WET WEIGHT (gm) %	WET WEIGHT (gm) Per km
VERTEBRATES						
Raja stellulata	-	-	-	4980.0	1.9	897.3
Gadus macrocephalas	-	-	-	20380.0	7.8	3672.1
Theragra chalcogramma	-	-	-	138160.0	52.8	24893.7
Atheresthes stomias	-	-	-	59110.0	22.6	10650.5
Hippoglossoides elassodon	-	-	-	17660.0	6.8	3182.0
Hippoglossus stenolepis	-	-	-	21290.0	8.1	3836.0

COMMENTS

Hermit crabs weighed with shells. *Pycnopodia helianthoides* feeding on *Ophiura sarsi* and *Ctenodiscus crispatus*. Pollutants were not recorded.

TABLE XI

TOW NUMBER 54; STATION NUMBER 94-A; PERCENT SAMPLED = 60.

(All counts and weights are projected to 100% of the sample).

Date	Time	Start		Finish		Time Fished	Time	Distance Fished	Depth Fished
Yr Mo Da	Hr/Min	Latitude Deg Min	Longitude Deg Min	Latitude Deg Min	Longitude Deg Min	Min	Zone	(km)	(m)
75 6 3	0950	59 54.0	141 47.0	59 55.0	141 48.0	30	9	2.96	27.3-29.1

TAXON	COUNT No.	COUNT %	COUNT Per km	WET WEIGHT (gm) Total	WET WEIGHT (gm) %	WET WEIGHT (gm) Per km
INVERTEBRATES						
Pagurus aleuticus	6.7	50.0	2.3	750.0	20.0	253.4
Chionoecetes bairdi	3.3	25.0	1.1	1500.0	40.0	506.8
Cancer magister	3.3	25.0	1.1	1500.0	40.0	506.8
VERTEBRATES						
Theragra chalcogramma	-	-	-	127000.0	14.4	42905.4
Isopsetta isolepis	-	-	-	27200.0	3.1	9189.2
Platichthys stellatus	-	-	-	725750.0	82.5	245185.8

COMMENTS

All female *Cancer magister* had purple eggs with orange eyes. Weights of *Pagurus aleuticus* include their shells.

TABLE XII

TOW NUMBER 53; STATION NUMBER 94-B; PERCENT SAMPLED = 12.

(All counts and weights are projected to 100% of the sample).

Date Yr Mo Da	Time Hr/Min	Start Latitude Deg Min	Start Longitude Deg Min	Finish Latitude Deg Min	Finish Longitude Deg Min	Time Fished Min	Time Zone	Distance Fished (km)	Depth Fished (m)
75 6 3	0730	59 50.0	141 42.0	59 52.0	141 46.0	60	9	5.55	58.2-61.8

TAXON	COUNT No.	COUNT %	COUNT Per km	WET WEIGHT (gm) Total	WET WEIGHT (gm) %	WET WEIGHT (gm) Per km
INVERTEBRATES						
Eunephthya rubiformis	0.	0.	0.	3750.0	71.4	675.7
Chionoecetes bairdi	100.0	100.0	18.0	1500.0	28.6	270.3
VERTEBRATES						
Theragra chalcogramma	-	-	-	544250.0	12.6	98063.1
Isopsetta isolepis	-	-	-	215416.7	5.0	38813.8
Platichthys stellatus	-	-	-	3549416.7	92.4	639534.5

COMMENTS

All *Theragra chalcogramma* was approximately 10 cm long. *Platichthys stellatus* stomachs examined - all stomachs were full of three clams, *Yoldia seminuda, siliqua sloati*, and *Macoma dexiosttera*.

TABLE XIII

TOW NUMBER 78; STATION NUMBER 97-C; PERCENT SAMPLED = 100.

Date Yr Mo Da	Time Hr/Min	Start Latitude Deg Min	Start Longitude Deg Min	Finish Latitude Deg Min	Finish Longitude Deg Min	Time Fished Min	Time Zone	Distance Fished (km)	Depth Fished (m)
75 7 5	1410	59 30.0	141 3.0	59 32.0	140 58.0	60	8	5.93	252.9-254.8

TAXON	COUNT No.	COUNT %	COUNT Per km	WET WEIGHT (gm) Total	WET WEIGHT (gm) %	WET WEIGHT (gm) Per km
Actiniidae	104.0	0.5	17.5	2630.0	1.1	443.5
Hirudinae	1.0	0.0	0.2	1.0	0.0	0.2
Fusitriton oregonensis	70.0	0.3	11.8	850.0	0.4	143.3
Neptunea pribiloffensis	7.0	0.0	1.2	1040.0	0.4	175.4
Tritonia exsulans	91.0	0.4	15.3	1365.0	5.7	2301.9
Gonatidae	12.0	0.1	2.0	270.0	0.1	45.5
Octopus sp.	1.0	0.0	0.2	90.0	0.0	15.2
Pandalopsis dispar	10.0	0.0	1.7	450.0	0.2	75.9
Eualis barbata	1.0	0.0	0.2	4.0	0.0	0.7
Eualis macrophthalma	21.0	0.1	3.5	180.0	0.1	30.4
Crangon communis	21.0	0.1	3.5	140.0	0.1	23.6
Pagurus confragosus	4.0	0.0	0.7	440.0	0.2	74.2
Chionoecetes bairdi	2.0	0.0	0.3	450.0	0.2	75.9
Hippasterias spinosa	1.0	0.0	0.2	220.0	0.1	37.1
Pseudarchaster parelii	16.0	0.1	2.7	1450.0	0.6	244.5
Ctenodiscus crispatus	80.0	0.4	13.5	1350.0	0.5	227.7
Pycnopodia helianthoides	3.0	0.0	0.5	1350.0	0.6	227.7
Brisaster townsendi	21273.0	97.9	3587.4	212730.0	89.6	35873.5
Holothuroidea	2.0	0.0	0.3	90.0	0.0	15.2
Molpadia sp.	2.0	0.0	0.3	90.0	0.0	15.2

TABLE XIII

CONTINUED

TAXON	COUNT			WET WEIGHT (gm)		
	No.	%	Per km	Total	%	Per km
VERTEBRATES						
Squalus acanthias	-	-	-	49370.0	9.2	8325.5
Raja binoculata	-	-	-	41670.0	7.8	7027.0
Sebastes alutus	-	-	-	4070.0	0.8	686.3
Sebastolobus alascanus	-	-	-	81080.0	15.2	13672.8
Atheresthes stomias	-	-	-	138390.0	25.9	23337.3
Glyptocephalus zachirus	-	-	-	101920.0	19.1	17187.2
Microstomus pacificus	-	-	-	82670.0	15.5	13941.0
Platichthys stellatus	-	-	-	35560.0	6.7	5996.6

COMMENTS

Hermit crabs weighed with shell. Pollutants were not recorded.

TABLE XIV

TOW NUMBER 70; STATION NUMBER 99-D; PERCENT SAMPLED = 100.

Date Yr Mo Da	Time Hr/Min	Start Latitude Deg Min	Start Longitude Deg Min	Finish Latitude Deg Min	Finish Longitude Deg Min	Time Fished Min	Time Zone	Distance Fished (km)	Depth Fished (m)
75 7 2	1635	59 25.0	140 29.0	59 25.0	140 32.0	60	8	5.55	141.9-154.7

TAXON	COUNT No.	COUNT %	COUNT Per km	WET WEIGHT (gm) Total	WET WEIGHT (gm) %	WET WEIGHT (gm) Per km
INVERTEBRATES						
Actiniidae	8.0	0.1	1.4	1810.0	0.2	326.1
Euphrosine hortensis	1.0	0.0	0.2	1.0	0.0	0.2
Crucigera irregularis	1.0	0.0	0.2	1.0	0.0	0.2
Aphrodita japonica	14.0	0.3	2.5	630.0	0.1	113.5
Fusitriton oregonensis	26.0	0.5	4.7	1990.0	0.2	358.6
Neptunea lyrata	20.0	0.4	3.6	2260.0	0.3	407.2
Pyrulofusus harpa	14.0	0.3	2.5	3170.0	0.4	571.2
Arctomelon stearnsii	14.0	0.3	2.5	1580.0	0.2	284.7
Dorididae	80.0	1.5	14.4	14490.0	1.7	2610.8
Octopus sp.	26.0	0.5	4.7	2340.0	0.3	421.6
Pandalus montagui tridens	429.0	8.0	77.3	3400.0	0.4	612.6
Spirontocaris arcuata	14.0	0.3	2.5	90.0	0.0	16.2
Argis ovifer	102.0	1.9	18.4	510.0	0.1	91.9
Elassochirus cavimanus	13.0	0.2	2.3	580.0	0.1	104.5
Acantholithodes hispidus	1.0	0.0	0.2	10.0	0.0	1.8
Lopholithodes foraminatus	40.0	0.7	7.2	16800.0	2.0	3027.0
Munida quadrispina	45.0	0.8	8.1	240.0	0.0	43.2
Oregonia gracilis	10.0	0.2	1.8	1800.0	0.2	324.3
Hyas lyratus	140.0	2.6	25.2	12680.0	1.5	2284.7
Chionoecetes bairdi	20.0	0.4	3.6	2260.0	0.3	407.2

TABLE XIV

CONTINUED

	COUNT			WET WEIGHT (gm)		
TAXON	No.	%	Per km	Total	%	Per km
Chorilia longipes	10.0	0.2	1.8	600.0	0.1	108.1
Dipsacaster borealis	14.0	0.3	2.5	630.0	0.1	113.5
Ceramaster patagonicus	30.0	0.6	5.4	2710.0	0.3	488.3
Pseudarchaster parelii	200.0	3.7	36.0	18120.0	2.1	3264.9
Henricia aspera	653.0	12.2	117.7	59160.0	6.9	10659.5
Diplopteraster multipes	78.0	1.5	14.1	11770.0	1.4	2120.7
Crossaster papposus	40.0	0.7	7.2	3620.0	0.4	652.3
Lophaster furcilliger	4.0	0.1	0.7	450.0	0.1	81.1
Solaster dawsoni	40.0	0.7	7.2	9060.0	1.1	1632.4
Allocentrotus fragilis	41.0	0.8	7.4	1640.0	0.2	295.5
Strongylocentrotus droebachiensis	92.0	1.7	16.6	2760.0	0.3	497.3
Gorgonocephalus caryi	20.0	0.4	3.6	4530.0	0.5	816.2
Ophiura sarsi	400.0	7.4	72.1	900.0	0.1	162.2
Cucumariidae	2600.0	48.4	468.5	650000.0	76.2	117117.1
Halocynthia aurantium	130.0	2.4	23.4	20300.0	2.4	3657.7
VERTEBRATES						
Raja binoculata	-	-	-	15400.0	3.2	2774.8
Raja stellulata	-	-	-	10870.0	2.3	1958.6
Gadus macrocephalas	-	-	-	78140.0	16.4	14079.3
Sebastolobus alascanus	-	-	-	94220.0	19.8	16976.6
Sebastes alutus	-	-	-	27180.0	5.7	4897.3
Atheresthes stomias	-	-	-	219700.0	46.2	39585.6
Glyptocephalus zachirus	-	-	-	30500.0	6.4	5495.5

COMMENTS

Hermit crabs weighed with shell. *Crucigera irregularis* present on snail shell. Pollutants were not recorded.

FINAL REPORT

Research Unit #19
March 1976 - September 1978

Alaska Marine Environmental Assessment Project

FINFISH RESOURCE SURVEYS IN NORTON SOUND AND KOTZEBUE SOUND

Principal Investigator

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September, 1978

SUMMARY

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

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

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

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

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

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INTRODUCTION

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

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

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

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

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

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

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

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

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

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

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

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

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

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

CURRENT STATE OF KNOWLEDGE

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

STUDY AREA

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

SOURCES, METHODS AND RATIONALE OF DATA COLLECTION

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

Subsistence Utilization Surveys

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

Herring Aerial Surveys

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

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

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

1. Observer, type aircraft, speed, altitude and time.
2. Weather and sea conditions.
3. Species identity and location of fish schools.
4. Number and surface area estimates of fish schools.

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

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

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

Nearshore Finfish Surveys

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

Unalakleet

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

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

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

Golovin

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

Port Clarence

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

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

Anuk River

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

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

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

Catch Sampling and Data Analysis

Catch sampling by nearshore pelagic finfish crews included the following:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Herring data are often grouped as follows in comparing results:

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

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

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

Offshore Finfish Surveys

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

Gillnetting Studies - Large Vessel

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

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

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

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

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

Townetting Studies - Large Vessel

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

Catch Sampling and Data Analysis

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

RESULTS

Subsistence Utilization Surveys

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

Herring Aerial Surveys

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

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

Cape Stebbins to Unalakleet

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

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

Unalakleet to Cape Denbigh

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

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

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

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

Norton Bay (East of Cape Darby)

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

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

Golovin Bay (Cape Darby to Rocky Point)

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

Rocky Point to Nome

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

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

Nome to Cape Prince of Wales

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

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

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

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

Cape Prince of Wales to Cape Espenberg

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

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

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

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

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

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

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

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

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

The only success with the snag line produced two egg-bearing shrimp (sp. ukn) near Glass Ball Bluffs on July 15. One glaucous gull (Larus *hyperboreus*) was obtained for stomach analysis about five kilometers southwest of Cape Coke. Contents consisted of three isopods (*Mesidotea entomon*) and one large shrimp (sp. ukn).

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

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

Cape Espenberg to Choris Peninsula (Eschscholtz Bay)

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

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

Nearshore Finfish Surveys

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

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

Pacific Herring

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Juvenile Salmon

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

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

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

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

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

Larval Fish Catches

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

Other Finfish Catches

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Physical and Chemical Data

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

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

Stomach Analysis

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

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

Offshore Finfish Surveys

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

Gillnetting Studies

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

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

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

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

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

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

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

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

Lengths and weights of other species captured were:

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

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

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

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

Townetting Studies

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

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

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

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

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

Anuk River

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

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

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

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

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

DISCUSSION

Subsistence Utilization Surveys

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

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

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

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

Herring

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

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

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

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

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

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

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

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

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

Clupeidae (Herring)

Timing and Distribution

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

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

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

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

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

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

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

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

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

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

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

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

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

Relative Abundance

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

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

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

Spawning Habitat Types

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

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

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

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

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

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

Age and Growth

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

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

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

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

Stock Considerations

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

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

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

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

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

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

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

<u>Salmonidae (Salmon and Trout)</u>

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

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

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

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

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

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

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

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

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

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

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

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

Stichaeidae (Pricklebacks)

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

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

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

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

Ammodytidae (Sand Lance)

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

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

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

Osmeridae (Smelts)

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

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

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

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

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

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

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

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

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

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

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

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

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

Gadidae (Cods)

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

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

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

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

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

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

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

Pleuronectidae (Flat Fishes)

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

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

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

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

Coregonidae (Whitefishes)

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

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

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

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

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

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

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

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

Other Fish Species

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

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

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

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

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

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

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

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

AREAS OF CONCERN AND NEEDS FOR FURTHER STUDY

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

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

1. Straight, rocky headlands:

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

2. Eroding wave-cut platforms:

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

3. Flat, fine-grained sandy beaches:

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

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

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

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

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

6. Mixed sand and gravel beaches:

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

7. Gravel beaches:

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

8. Sheltered rocky headlands:

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

9. Protected estuarine tidal flats:

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

10. Protected estuarine salt marshes:

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

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

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

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

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

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

c. The distribution of species is widespread;

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

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

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

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

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

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

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

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

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

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

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

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

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

CONCLUSIONS

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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BIBLIOGRAPHY

Alaska Department of Fish and Game.
1968. 1968 Annual Report Arctic-Yukon-Kuskokwim Area, Section I Management. ADF&G, Div. Comm. Fish, Anchorage, Alaska.

1969. Annual Management Report 1969 Arctic-Yukon-Kuskokwim Area. ADF&G, Div. Comm. Fish, Anchorage, Alaska.

1976. A Compilation of Fish and Wildlife Resource Information for the State of Alaska. Vol. 3, Comm Fish, ADF&G, Anchorage, Alaska.

1977. Status of Bering Sea Herring Stocks and Fisheries. A report to the Alaska Board of Fisheries. December, 1977, ADF&G, Div. Comm. Fish, Anchorage, Alaska.

Alt, K. T.
1971. A Life History Study of Sheefish and Whitefish in Alaska. Annual Progress Report, Study R-11, ADF&G, Div. Sport Fish, Anchorage, Alaska.

1972. A Life History Study of Sheefish and Whitefish in Alaska. Annual Progress Report, Study R-11, ADF&G, Div. Sport Fish, Anchorage, AK.

1977. Inconnu, Stenodus lencichthys, Migration Studies in Alaska 1961-74. J.F.R.B.C, Vol. 34, No. 1, 1977, pp 129-133.

Alverson, D. L. and N. J. Wilimovsky.
1966. Fishery Investigations of the Southeastern Chukchi Sea. From Environment of Cape Thompson Region, Alaska. N. J. Wilimovsky, editor, 1966. U.S. Atomic Energy Commission, Div. Tech. Info.

Anderson, A. W. and C. B. Carlson.
1945. A Preliminary Report on the fishery possibilities of the Nome area. U.S.F.W.; Dept. of Interior, Sept., 1945, Wash, D.C.

Averinzev, S.
1926. Herring of the White Sea. Wissenschaftliche Meeresuntersuchungan, neue Folge, Abteilunz Helgoland, XV Band, Heft 3, Abteilung 18, 24 pp., 1 map. Keil and Leipzig.

Barton, L. H.
1977. Finfish Resource Surveys in Norton Sound and Kotzebue Sound. Outer Continental Shelf Environmental Assessment Program, Annual Report, (Mar-Sept, 1976) May 1977.

Barton, L. H., I. M. Warner and P. Shafford.
1977. Herring Spawning Surveys in the Southern Bering Sea. Outer Continental Shelf Environmental Assessment Program, Project Report, (May 1975-Sept, 1976), April 1977.

Bendock, T. N.
1977. Beufort Sea Estuarine Fishery Study. Outer Continental Shelf Environmental Assessment Program, Annual Report (July 1975 - March 1976), April 1977.

Craig, P. C. and P. McCart.
1975. Fish utilization of nearshore coastal waters between Colville and Mackenzie Rivers with an emphasis on anadromous species. Canadian Arctic Gas Study Ltd., Calgary. Biological Report Series.

Crawford, D.
1978a. Lower Yukon Sheefish Study, ADF&G, Comm. Fish Div. Anchorage, Alaska, Progress Report (April 5-16, 1977), Unpublished Report.

1978b. Lower Yukon Sheefish Study, ADF&G, CFD, Anchorage, Alaska, Progress Report. (Oct - Dec, 1977), Unpublished Report.

Cunningham, P. B.
1975. Annual Management Report, 1975. Norton Sound - Port Clarence - Kotzebue Area. ADF&G, Comm. Fish. Div, Nome, Alaska.

Dmitriev, N. A.
1958. Biological Differences and Similarities Between the White Sea Herring and the Baltic Herring. From: Trudy Vsesoyuznoga nauchno-issledovatel'skogo instituta morskogo rybnogo khozyaistva i okeanografii, Vol. XXXIV, 1958, pp. 178-184. (transl by IPST, Jerusalem).

Dudnik, Y. I. and E. A. Usol'tsev.
1972. The Herring of the Eastern Part of the Bering Sea. Soviet Fisheries Investigation in Northeastern Pacific, Part II, pp. 236-240. (transl by IPST, Jerusalem).

Galkina, L. A.
1957. Effect of Salinity on the Sperm, Eggs, and Larvae of the Okhotsk Herring. From: Izvestiya Tikhookeanskogo nauchno-issledovatel'skogo instituta rybnozo khozyaistva i okeanozrafii, Vol. XLV, 1957, pp. 37-50 (transl by IPST, Jerusalem).

Hart, J. L.
1973. Pacific Fishes of Canada. Fish. Res. Bd. Canada Bull. 180. Ottawa.

Hayes, M. O., P. J. Brown and J. Michel.
1977. Coastal Morphology and Sedimentation, Lower Cook Inlet, Alaska. From: Environmental Studies of Kachemak Bay and Lower Cook Inlet, edited by L. L. Trasky, L. B. Flagg and D. C. Burbank, Vol. II, ADF&G, Marine/Coastal Habitat Mgt, Anchorage, Alaska.

Kendel, R. E., R. A. C. Johnston, U. Lobsiger and M. D. Kozak.
1975. Fishes of the Yukon Coast. Fisheries and Marine Service, Department of Environment Canada. Beaufort Sea Technical Report #6, Dec. 1975.

Low, L. L.
1976. Status of Major Demersal Fishery Resources of the Northeastern Pacific, Bering Sea and Aleutian Islands. U.S. Dept. Comm., National Marine Fisheries Service, Northwest and Alaska Fisheries Center, Seattle, Unpublished.

McPhail, J. D. and C. C. Lindsey.
1970. Freshwater Fishes of Northwestern Canada and Alaska. Fish. Res. Bd. of Canada, Bull. No-173, 381 pp.

McRoy, C. P.
1968. The Distribution and Biogeography of Zosteria marina (Eelgrass) in Alaska. From: Pacific Science, Vol. XXII, No. 4, October 1968, pp. 507-512.

Mauney, J. L.
1977. Yukon River King and Chum Salmon Escapement Studies 1975. ADF&G, Div. Comm. Fish, A-Y-K Regional Fishery Bull. No. 32, Project No. AFC-54-2.

Neimark, L. M., R. T. Cooney and C. R. Geist.
1978. Feeding Behavior of Bering Sea Coastal Fish Species. Institute of Marine Science, University of Alaska, Fairbanks (In press).

North Pacific Fisheries Management Council.
1977. Trawl and Herring Gillnet Fishery of the Bering Sea and Aleutian Islands. Pre. Fish. Mgmt. Plan, U.S. Dept. of Comm, NOAA, NMFS, Juneau, Alaska January 1977.

Randall, R. C.
1975. Bristol Bay Herring Fishery - A Summary of Commercial Harvest and Catch Sampling Data, 1967-75. ADF&G Div. Comm. Fish, Anchorage, Alaska.

Reid, G. M.
1971a. Alaska's Fisheries Resources, The Pacific Herring (Clupea pallasi). Prepared by Auke Bay Biological Laboratory, Auke Bay, Alaska, p. 20.

1971b. Age Composition, Weight, Length and Sex of Herring, Clupea pallasi, Used for Reduction in Alaska, 1929-66. U.S. Dept of Commerce, NOAA, NMFS, Special Scientific Report - Fisheries No. 634.

Rounsefell, G. A.
1930. Contribution to the Biology of the Pacific Herring, (Clupea pallasi) and the condition of the fishery in Alaska. Bull. of Bureau of Fisheries, Vol. XLV (1080) pp. 227-320.

Rumyantsev, A. I. and M. A. Darda.
1970. Summer Herring in the Eastern Bering Sea. From: Soviet Fisheries Investigations in Northeastern Pacific, Part V: 409-441. (transl by IPST, Jerusalem).

Shaboneev, I.E.
1965. Biology and Fishing of Herring in the Eastern part of the Bering Sea. From: Soviet Fisheries Investigations in Northeastern Pacific, Part IV: 130-154 (transl by IPST, Jerusalem).

Svetovidov, A. N.
1944. Similarities and Differences in the Distribution, Ecology, and some other Characteristics of Cod and Oceanic Herring. From: Zoologicheskii zhurnal, Vol XXIII, No. 4, 1944, pp. 146-155. (transl by IPST, Jerusalem).

Trasky, L. L., L. B. Hagg and D. C. Burbank.
1977. Impact of oil on the Kachemak Bay Environment. From: Environmental Studies of Kachemak Bay and Lower Cook Inlet, Vol. I, ADF&G, Marine/Coastal Habitat Management, Anchorage, AK.

Warner, I. M. and P. Shafford.
1977. Forage Fish Spawning Surveys in the Southern Bering Sea. Outer Continental Shelf Environmental Shelf Environmental Assessment Program, Project Report (May-Sept. 1977).

Wespestad, V. G.
1978. A Review of Pacific Herring Studies with Special Reference to the Bering Sea. Northwest and Alaska Fisheries Center, NMFS, Seattle.

Wigutoff, N. B. and C. J. Carlson.
1950. A Survey of the Commercial Fishery Possibilities of Seward Peninsula area, Kotzebue Sound, and certain inland rivers and lakes in Alaska. U.S. Dept. Interior, Fish Leaflet No. 375, May.

Wolotira, R. J. (Jr.), T. M. Sample and M. Morin Jr.
1977. Baseline Studies of Fish and Shellfish Resources of Norton Sound and the Southeastern Chukchi Sea. Outer Continental Shelf Environmental Assessment Program, Final Report Oct 21, 1977. NWFC, NMFS, Seattle, Washington.

Zagoskin, L. A. Lt.
1956. Survey of part of the Russian possessions in America done by Zagoskin in 1842, 1843 and 1844. From: A. I. Rumyantev and M. A. Darda, Summer Herring in the Eastern Bering Sea, Soviet Fisheries Investigations in Northeastern Pacific, Part V: 409-441, 1970 (transl by IPST, Jerusalem).

1967. Zagoskin's Travels in Russian America, 1843-1844. The first ethanographic investigation of the Yukon and Kuskokwim Valleys of Alaska, edited by H. N. Michael, Toronto publication for the Arctic Institute of North America, University of Toronto to Press, 358 pp.

Personal Communication

Drury, W. H. Principal Investigator R.U. 237/238. Birds of Coastal Habitats on the South Shore of Seward Peninsula, OCSEAP.

Fridgen, P., ADF&G, Div. Comm. Fish, Cordova, Alaska.

Frost, K. J., ADF&G, Division of Game, Fairbanks.

Neimark, L. M., Institute Marine Service, Univ. of Alaska, Fairbanks.

Nelson, M. L., Dillingham Area Biologist (Bristol Bay), ADF&G, Div. Comm. Fish., Dillingham, Alaska.

APPENDIX TABLES

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

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

Summary: 10/

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

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

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

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

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

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

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

1/ All harvests expressed in metric tons. Source of Japanese catches from INPFC documents while USSR catches furnished under provisions of US-USSR bilateral agreements.
2/ Trawl fishery normally occurs from Nov to Apr while the gillnet fishery lasted from April to June.
3/ The USSR trawl fishery began in 1961, but harvest data was not available until 1967.
4/ Preliminary.
5/ Japanese gillnet fishery closed.

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

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

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

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

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

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

* Latitude and Longitude of mid point of census area.

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

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

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

Area Surveyed 1/	Date	Survey Rating Index 2/	Fish School Size 3/					Spawn Observations		Remarks
			small	medium	large	unc.	total	No.	Su. Area (m2)	
Stuart Island (34a - 34d)	6/15	F					none			
	6/22	P					none			
Cape Stebbins to Unalakleet	6/9	G-E					none			
(35, 36, 37)	6/15	G-F					none			
	6/17	G-P					none			
	6/22*	F-P	1				1			
Total			1				1			
Unalakleet to Shaktoolik River	6/9	E-G					none			
(38a, 38b)	6/14	G					none			
	6/15*	G-F	23				23			3 small schools near Egavik; remainder between Shaktoolik & Shaktoolik River.
	6/17	G					none			
	6/22	P					none			
	6/25	F						1		Adjacent to Beeson Slough.
	7/21	F					none			
Total			23				23	1		
Shaktoolik River to Island Point (Cape Denbigh)	6/9	E-G					none			
(38c, 39a, 39b)	6/14	G	20	2			22			2 small schools south of Cape Denbigh; remainder between Cape Denbigh & Pt. Dexter.
	6/15	G-F	23	3	3		29			5 small and 1 med school near Pt. Dexter, remainder between C. Denbigh & Shaktoolik R.
	6/17*	G	41	12	4		57			2 large & 1 med school just south of Cape Denbign; remainder between Cape Denbigh and Pt. Dexter.
	6/22	P	1	2			3			Schools all on N. side of Cape Denbigh.
	6/25	F		3			3			Schools all on N. side of Cape Denbigh.
	7/21	G					none			
Total			35	22	7		114			
Kuiukruilk River to Kwik R. (Bald Head)	6/14	G					none			
(39d, 40a)	6/15*	F	5	1			6			Schools at Bald Head.
	6/17	E	2				2			Schools at Bald Head.
	6/25*	F	4	3			7			Schools between Bald Head & Kuiukrulik R
	7/21	G					none			
Total			11	4			15			
Kwik River to Cape Darby	6/9	E-G					none			
(40b, 40c, 40d)	6/14	G					none			
	6/15	F					none			
	6/17	E					none			
	6/22	U					none			
	6/25*	F	3	5			8			4 med schools at Elim; remainder off-shore at Moses Pt.
	7/21	G					none			
Total			3	5			8			
Cape Darby to Rocky Point (Golovin Bay)	6/14*	G	3				3			Schools at Carolyn Island.
(41a, 41b, 42a)	6/17	F					none			
	6/22	U					none			
	6/25*	F	4	7			11			One med at Rocky Pt; remainder on east side of bay between Cape Darby and Golovin
	7/21	G					none			
Total			7	7			14			
Rocky Point to Cape Nome	6/14*	G	5				5			Schools near Topkok Head.
(42b, 42c, 43a)	6/17*	F	10	2			12			Schools from Rocky Pt. to Topkok Head.
	7/10	F					none			
	7/21	G					none			
	8/29	U								Several small schools seen (Rocky Pt. to Topkok Head) believed to be sand-lance.
	9/1						none			
Total			15	2			17			
Cape Nome to Point Spencer	6/21	F					none			
(43b, 43c, 43d)	6/28*	G	5				5			Schools at mouth of Cripple Cr. Species unknown.
	7/10	F	2	4			6			Schools between Cape Wooley & Cape Douglas.
	7/11*	F	8	14	1		23			Schools from Sinuk R. to Cape Douglas.
	7/21*	G	21	15	10		46			Schools from Cripple Cr. to Pt. Spencer.
	8/4	U					none			Capelin carcass survey.
	8/6	G					none			Ft. Davis - Penny R.
	8/23*	F	2				2			Schools about 2 miles east of Sinuk R.
	10/16	U					none			
Total			38	33	11		32			

(Table Continued)

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

Area Surveyed 1/	Date	Survey Rating Index 2/	Fish School Size 3/ small	medium	large	unc.	total	Spawn Observations No.	Su. Area (m2)	Remarks	Remarks
Point Spencer to Wales (Port Clarence/Grantley Harbor) (44a - 44f)	6/21	U					none			Shore ice - too early.	
	6/28	P					none				
	7/10	F					none				
	7/11	F	1				1			School near Lost River (No survey Pt. Clarence).	
	7/21*	G	18	6	2		26			Two small & 1 med inside Pt. Clarence & Pt. Spencer: 10 small & 1 med. from Brevig to Grantley Harbor; remainder in Grantley Harbor @ Teller & Tuksuk Channel. Believed to be herring.	
	8/6	G					none				
	8/13	P					none			Survey of Lost R. area only.	
	8/20	U					none			Survey of Lost R. area only. Poor water visibility - turbid.	
	8/23	F					none				
	9/9	G					none				
	10/16	U					none				
Total			19	6	2		27				
Wales to Shishmaref (45a and 45c)	7/11*	E	16	16	11		43			Schools migrating north; believed herring.	
	8/6*	P	9	3			12			Schools believed to be herring.	
	8/13	P					none				
	8/20*	U	1	1			2			Turbid water - species unknown.	
	9/9	F					none				
	10/8	U					none			Turbid water & high winds.	
	10/26	U					none			Blowing snow - survey aborted.	
	10/28	U					none			Blowing snow - survey aborted.	
Total			26	20	11		57				
Shishmaref to Cape Espenberg (45e and 45h)	7/11*	E	15	17	16		48			Schools all along coastline. Many in lagoon entrance to Shishmaref Inlet and Cowpack Inlet. Fish believed to be herring.	
	7/15	E	10	8	4		22			Surveyed only Shishmaref to Kividlo.	
	8/6	U					none				
	8/20*	U	6	2			8			Turbid water - species unknown.	
	9/9	F					none				
	10/8	U					none			Turbid water and high winds.	
	10/26	U					none			Blowing snow-survey aborted.	
	10/28	U					none			Blowing snow-survey aborted.	
Total			31	27	20		78				
Cape Espenbert to Good Hope (River (46a)	7/11	F-P					none			Turbid water and shallow. Poor surveyable area.	
	9/9	U					none				
Goodhope River to Kiwalik (46b, 46c, 46d, 46e)	7/11	G					none				
	7/20*	E	9	8	2		19			Schools from Rex Pt. to Ninemile Pt.	
	8/13	U		1	1		3	1(?)		Schools & possible spawn just east of Cape Deceit & Deering.	
	8/20*	P	17	1			18	1(?)		One med & 1 small just east of Clifford Pt. 16 small about 2 miles east of Ninemile Pt. Possible spawn at Ninemile Pt. Fish believed to be herring	
Total			26	10	3	1	40	2(?)			
Kiwalik to Point Garnet on Choris Peninsula (47a, 47b, 47c)	7/11	G					none			Partial survey to Buckland.	
	7/20*	F	1	2	1		4			One med & 1 large school in Kiwalik; One small & 1 med school on east side of Choris Pen. 56 Beluga moving west on south side of Baldwin Pen.	
	8/20	P					none			Partial survey to Buckland.	
Total			1	2	1		4				
TOTAL 1977 COUNT			286	138	55	1	480	1			

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

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

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

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

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

				AREA CAPTURED																		
				A		B		C		D		E		F		G	H	I	FI	AR	URL	
CODE	CLASSIFI-CATION 1/	COMMON NAME	SCIENTIFIC NAME	76	77	76	77	76	77	76	77	76	77	76	77	77	77	77	76	77	76	77
PS	A	Pink Salmon	Oncorhynchus gorbuscha	x	x	x		x	x	x		x			x	x	x	x	x	x	x	
CS	A	Chum Salmon	Oncorhynchus keta	x	x	x	x	x	x	x	x				x	x	x	x	x	x	x	x
SS	A	Coho Salmon	Oncorhynchus kisutch	x	x	x		x	x	x		x				x		x	x	x		
KS	A	King Salmon	Oncorhynchus tshawytscha	x		x		x											x	x	x	x
RS	A	Sockeye Salmon	Oncorhynchus nerka													x	x					
HW	F	Humpback whitefish	Coregonus pidschian	x	x	x	x	x	x	x	x				x	x		x	x		x	x
BW	F	Broad whitefish	Coregonus nasus	x	x		x	x	x	x		x				x	x	x	x		x	x
RW	F	Round whitefish	Prosopium cylindraceus					x	x				x			x		x			x	
BC	A	Bering cisco	Coregonus laurettа	x	x	x	x	x	x	x	x				x	x	x	x	x		x	x
LC	A	Least cisco	Coregonus sardinella	x	x	x	x	x	x	x	x	x				x	x	x	x		x	
SF	M	Starry flounder	Platichthys stellatus	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x		x	x
AF	M	Arctic flounder	Liopsetta glacialis	x	x	x	x	x	x		x				x	x	x				x	x
RF	M	Rock flounder	Liopsetta bilineata														x					
AP	M	Alaska plaice	Pleuronectes quadrituberculatus	x	x	x		x	x						x	x	x					
YS	M	Yellowfin sole (muddab)	Limanda aspera	x	x	x	x	x	x	x							x					
LD	M	Longhead dab	Limanda proboscidea			x		x														
TP	M	Tubenose poacher	Pallasina barbata aix	x	x	x	x	x	x						x	x	x					x
SP	M	Sturgeon poacher	Agonus acipenserinus	x						x												
BP	M	Bering poacher	Ocella dodecaedria	x	x	x		x	x	x												
MV	M	Capelin	Mallotus villosus	x				x									x					
PH	M	Pacific herring	Clupea harengus pallasi	x	x	x	x	x	x	x	x				x	x	x	x			x	x
BS	A	Boreal smelt (American, toothed)	Osmerus eperlanus (mordax dentex)	x	x	x	x	x	x	x	x			x	x	x	x	x	x		x	x
HO	A	Pond smelt	Hypomesus olidus		x	x		x	x						x	x	x	x			x	
SL	M	Sandlance	Ammodytes hexapterus	x	x		x				x			x	x	x	x					
S3	F	Threespine stickleback	Gasterosteus aculeatus	x												x	x	x				
S9	F	Ninespine stickleback	Pungitius pungitius	x	x	x		x		x	x	x			x	x	x	x	x			x
RG	M	Rock greenling (terpug)	Hexagrammus lagocephalus	x		x		x	x	x	x					x	x					
WG	M	Whitespotted greenling	Hexagrammus stelleri	x	x	x		x														
AC	A	Arctic char	Salvelinus alpinus	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x		x	x
SC	M	Saffron cod	Eleginus gracilis	x	x	x	x	x	x	x	x			x	x	x	x	x			x	x
LR	M	Ringtail snailfish	Liparis rutteri					x														
SH	F	Sheefish	Stenodus leucichthys																x	x		
NP	F	Northern pike	Esox lucius															x	x	x		
NS	F	Northern sucker (longnose)	Catostomus catostomus															x	x	x		
LL	F	Burbot	Lota lota leptura																x	x		
PR	M	Pricklebacks 2/	Stichaeidae 2/			x	x	x		x				x								
CT	-	Sculpins	Cottidae	x	x	x	x	x	x	x	x	x	x		x	x	x	x			x	x
WF	M	Bering wolffish	Anarhichas orientalis		x																	
			Total number species (less cottidae)	26	22	24	16	28	20	19	13	7	2	6	15	22	22	18	16	0 3/	15	13

AREA IDENTIFICATION:

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

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

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

3/ Juvenile Coregonidae were also captured.

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

Species	A BS	A GNF	A GNS	B BS	B GNF	B GNS	C BS	C GNF	C GNS	D BS	D GNF	D GNS	F BS	F GNF	F GNS	G BS	G GNF	G GNS	H BS	H GNF	H GNS	I BS	I GNF	I GNS	Totals BS	Totals GNF	Totals GNS	Unalakleet River Lagoon Catches 1/ BS
Pink salmon (adult)	0	5	0	0	5	0	0	6	0				0	2	0	0	2	0	0	7	0				0	27	0	0
Pink salmon (juvenile)	4,584	0	0				12	0	0				165	0	0				1	0	0	4	0	0	4,766	0	0	1
Chum salmon (adult)	0	20	0	0	3	0	0	7	0	0	1	0	0	35	0	0	1	0	0	5	0				0	72	0	0
Chum salmon (juvenile)	1,710	0	0				7	0	0				14	0	0	1	0	0				3	0	0	1,735	0	0	47
King salmon (juvenile)																												15
Coho salmon (adult)	0	3	0				0	4	0							0	1	0	0	3	0				0	11	0	
Coho salmon (juvenile)	12	0	0																						12	0	0	
Sockeye salmon (adult)																0	1	0	0	1	0				0	2	0	
Pacific herring (adult)	1	192	51	1	19	0				0	10	27	0	11	3	0	620	395	156	338	142	36	34	29	194	1,224	647	
Pacific herring (juvenile)	62	0	0	0	0	4	6	0	0							45	1	4	17	0	2	123	2	1	273	3	11	
Humpback whitefish	269	109	3	4	1	0	5	1	0	0	4	0	0	1	0	5	11	0	1	0	0	0	0	1	284	135	4	3
Broad whitefish	22	3	0	0	1	0	11	2	0							21	5	1	3	2	0	34	2	2	91	15	3	2
Round whitefish							0	1	0							4	1	0				13	0	1	17	10	1	
Bering cisco	174	35	4	47	16	2	20	30	0	0	10	0	1	0	0	29	24	4	63	35	10	23	30	6	357	180	26	4
Least cisco	631	104	9	3	23	0	0	24	0	1	25	0				31	42	0	5	34	1	160	27	12	831	274	22	
Arctic flounder	44	36	1	3	18	1	2	19	0	2	3	1	0	2	0	13	15	8	5	2	0				69	95	3	14
Rock flounder																			0	1	0				0	1	0	
Starry flounder	217	86	45	6	37	0	1	79	7	14	50	4	25	1	7	12	33	16	9	34	26	7	2	0	291	372	105	9
Alaska plaice	3	0	0				0	0	1				4	0	0	1	0	0	2	1	0				10	1	1	
Yellowfin sole (muddab)	1	0	11	0	2	0	10	0	1				0	0	1				0	1	0				11	3	13	
Tubenose poacher	75	1	0	1	0	0	2	0	0							9	0	0	11	0	0				99	1	0	1
Bering poacher	1	0	0				26	0	0																27	0	0	
Capelin																			1	0	0				1	0	0	
Boreal smelt	427	35	11	83	5	0	38	1	0	2	0	0	1	11	11	40	11	6	68	6	194	56	0	0	715	69	222	4
Pond smelt	1,554	7	1				3	2	0				25	0	0	3,830	2	13	2,543	1	1	3,962	11	8	11,917	73	73	
Sandlance	4,454	0	0	600	0	0				130	0	0	43,874	0	0	102	0	0	243	0	0				49,401	0	0	
Threespine stickleback																1	0	0	3	0	0	128	0	0	132	0	0	
Ninespine stickleback	251	0	0							1	0	0	1	0	0	12	0	0	36	0	0	318	0	0	619	0	0	3
Rock greenling							0	5	0	0	9	2				0	0	3	2	4	1				2	18	6	
Whitespotted greenling	5	5	26										0	0	1										5	5	27	
Arctic char	26	30	0	0	59	0	1	90	0	0	9	0	1	0	0	16	8	0	0	7	0	0	1	0	44	204	0	17
Saffron cod	392	179	69	375	11	2	62	2	2	0	20	5	1	7	3	252	48	36	221	56	29	7	17	31	1,310	340	167	27
Sculpin	13	29	0	2	7	0	1	7	0	1	2	2	2	0	0	7	4	2	1	7	0	12	0	0	39	64	12	7
Pricklebacks				71	2	0																			71	2	0	
Northern pike																						1	0	0	1	0	0	
Northern sucker																						1	0	0	1	0	0	
Wolffish	0	0	1																						0	0	1	
TOTALS	14,920	879	230	1,196	209	9	207	280	11	151	143	41	44,114	70	26	4,431	830	480	3,411	545	406	4,888	145	91	73,326	3,101	1,294	149

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

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

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

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

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

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

A - Golovin Bay
B - Cape Denbigh to Egavik
C - Egavik to Tolstoi Point
D - Tolstoi Point to Cape Stebbins
F - Rocky Point to Bluff
G - Grantley Harbor
H - Port Clarence
I - Imuruk Basin
FI - Flat Island (South Mouth Yukon River - Delta Area)
URL - Unalakleet River Lagoon

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

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

* Includes both adults and juveniles.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

	increase in length per day (28 days)	increase in length per day (62 days)
Pink	0.79 mm	1.79 mm
Chum	0.86 mm	2.00 mm

	Average % increase in growth per day (28 days)	Average % increase in growth per day (62 days)
Pink	2.46%	3.32%
Chum	2.45%	3.39%

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

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

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

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

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

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

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

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

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

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

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

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

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

AREA	SPECIES	SAMPLING PERIOD I 76	I 77	II 76	II 77	III 76	III 77	IV 76	IV 77	V 76	V 77	VI 76	VI 77	VII 76	VII 77	VIII 76	VIII 77	IX 76	IX 77
BEACH SEINES																			
A	BC		7.2		0.3	0.6	0.1	1.0		3.8		2.4	1.4	4.8	1.0		5.9		1.0
	average	7.2		0.3		0.4		1.0		3.8		1.9		2.9		5.9		1.0	
	LC		1.3		1.9	0.1	0.6	11.8		23.2		0.4	40.9	0.8	3.4		3.7		1.3
	average	1.3		1.9		0.4		11.8		23.2		20.7		2.1		3.7		1.3	
	SC		0.3		1.0	1.7	0.1	2.8		36.9		24.0	22.1	4.8	13.0		1.7		2.7
	average	0.3		1.0		0.9		2.8		36.9		23.1		8.9		1.7		2.7	
	SF		5.5		3.9	0.8	0.5	1.1		0.5		1.4	3.6	1.2	1.8		2.6		0.7
	average	5.5		3.9		0.7		1.1		0.5		2.5		1.5		2.6		0.7	
	PH		0.1		0.0	0.0	0.0	0.0		0.0		0.0	0.0	0.0	12.0		0.3		0.0
	average	0.1		0.0		0.0		0.0		0.0		0.0		6.0		0.3		0.0	
	BS		1.4		3.3	4.6	0.0	11.3		34.3		32.1	25.2	3.7	0.2		1.4		7.0
	average	1.4		3.3		2.3		11.3		34.3		28.7		1.9		1.4		7.0	
	SL		0.0		4.4	327.1	4.5	589.0		114.0		328.9	157.4	55.0	458.2		0.3		0.0
	average	0.0		4.4		165.8		589.0		114.0		243.2		256.6		0.3		0.0	
	PS*		37.3		270.7	1.1	0.1	0.0		0.0		0.0	0.0	0.0	0.0		0.0		0.0
	average	37.3		270.7		0.6		0.0		0.0		0.0		0.0		0.0		0.0	
	CS*		62.1		54.9	0.3	1.5	0.0		0.0		0.0	0.0	0.0	0.0		0.0		0.0
	average	62.1		54.9		0.9		0.0		0.0		0.0		0.0		0.0		0.0	
GILLNETS																			
A	BC		0.3		0.2	0.2	0.1	0.1		0.04		0.2	0.1	0.4	0.2		0.5		0.0
	average	0.3		0.2		0.2		0.1		0.04		0.2		0.3		0.5		0.0	
	LC		0.1		0.2	0.5	0.1	1.1		0.2		0.6	0.5	0.4	0.8		2.5		0.0
	average	0.1		0.2		0.3		1.1		0.2		0.6		0.6		2.5		0.0	
	SC		0.8		0.5	0.7	0.4	1.0		0.2		0.6	0.4	1.0	1.4		3.0		1.0
	average	0.8		0.5		0.6		1.0		0.2		0.5		1.2		3.0		1.0	
	SF		0.7		0.8	0.2	0.7	0.2		1.0		0.4	0.2	0.3	0.4		0.2		0.1
	average	0.7		0.8		0.5		0.2		1.0		0.3		0.4		0.2		0.1	
	PH		0.6		1.7	0.03	1.2	0.0		0.0		0.0	0.0	0.1	0.5		4.7		0.5
	average	0.6		1.7		0.6		0.0		0.0		0.0		0.3		4.7		0.5	
	BS		0.0		0.0	0.0	0.1	0.0		0.0		0.04	0.1	0.0	0.2		0.2		0.4
	average	0.0		0.0		0.05		0.0		0.0		0.1		0.1		0.2		0.4	

* juvenils only

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

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

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

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

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

	BEACH SEINE				FLOATING GILLNET				SINKING GILLNET				FLOATING+SINKING			
SPECIES	N	LENGTH RANGE	MEAN	SD	N	LENGTH RANGE	MEAN	SD	N	LENGTH RANGE	MEAN	SD	N	LENGTH RANGE	MEAN	SD
PINK SALMON	404	27 71	39	8.1	0	0- 0	0	0.	0	0- 0	0	0.	0	0- 0	0	0.
CHUM SALMON	374	25 68	42	7.2	0	0- 0	0	0.	0	0- 0	0	0.	0	0- 0	0	0.
SILVER SALMON	5	105 126	119	6.7	0	0- 0	0	0.	0	0- 0	0	0.	0	0- 0	0	0.
RED SALMON																
HUMPBACK WHITEFISH	179	73 390	159	100.2	109	114-415	315	76.4	3	172-371	279	100.3	112	114-415	314	76.8
BROAD WHITEFISH	22	146 378	273	67.8	3	194-447	316	126.8	0	0- 0	0	0.	3	194-447	316	126.8
ROUND WHITEFISH																
BERING CISCO	106	88 358	142	69.1	33	100-365	216	79.7	4	117-248	178	53.7	37	100-36	212	77.6
LEAST CISCO	263	68 285	139	60.4	104	100-285	202	41.6	9	178-235	197	17.8	113	100-285	202	40.2
STARRY FLOUNDER	244	36 440	150	62.3	78	105-340	164	40.7	40	177-465	312	79.7	118	105-465	214	90.2
ARCTIC FLOUNDER	50	24 298	99	61.7	43	69-300	177	55.2	1	72- 72	72	0.	44	69-300	175	56.8
ALASKA PLAICE	7	66 93	80	12.0	0	0- 0	0	0.	0	0- 0	0	0.	0	0- 0	0	0.
YELLOWFIN SOLE (MUDDAB)	1	125 125	125	0.	0	0- 0	0	0.	12	93-254	150	41.0	12	93-254	150	41.0
TUBENOSE POACHER	71	37 120	80	17.8	1	131-131	131	0.	0	0- 0	0	0.	1	131-131	131	0.
BERING POACHER	1	120 120	120	0.	0	0- 0	0	0.	0	0- 0	0	0.	0	0- 0	0	0.
CAPELIN																
BOREAL SMELT	595	10 160	51	17.5	46	122-250	170	31.1	22	136-251	174	37.0	68	122-251	171	32.9
POND SMELT	189	31 136	60	13.0	7	110-146	123	11.6	1	116-116	116	0.	8	110-146	122	11.0
SANDLANCE	251	47 137	70	17.2	0	0- 0	0	0.	0	0- 0	0	0.	0	0- 0	0	0.
THREESPINE STICKLEBACK																
NINESPINE STICKLEBACK	158	20 71	46	9.7	0	0- 0	0	0.	0	0- 0	0	0.	0	0- 0	0	0.
WHITESPOTTED GREENLING	5	88 216	151	62.3	5	111-274	204	60.6	26	153-310	222	45.1	31	111-310	219	47.2
ROCK GREENLING																
ARCTIC CHAR	21	99 640	335	175.2	24	264-560	404	74.2	0	0- 0	0	0.	24	264-560	404	74.2
SAFFRON COD	158	32 292	108	59.5	255	110-394	243	47.4	63	109-355	246	48.8	318	109-394	243	47.7
SCULPIN	14	40 435	192	114.3	23	100-520	253	108.9	10	127-480	279	112.1	33	100-520	261	108.7
PRICKLEBACK																
NOTHERN PIKE																
NORTHERN SUCKER																
WOLFFISH	0	0 0	0	0.	0	0- 0	0	0.	1	540-540	540	0.	1	540-540	540	0.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

* Indicates juvenile fish.

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

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

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

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

1/ Wsp - represents whitefish species.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

2/ Measurements taken from September 29 to October 5.

3/ Measurements taken on September 8.

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

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

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

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

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

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

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

* Indicates juveniles.

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

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

* Indicates juveniles.

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

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

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

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

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

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

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

BEACH SEINES*

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

GILLNETS *

AREA	I 76	I 77	I average	II 76	II 77	II average	III 76	III 77	III average	IV 76	IV 77	IV average	V 76	V 77	V average	VI 76	VI 77	VI average	VII 76	VII 77	VII average	VIII 76	VIII 77	VIII average	IX 76	IX 77	IX average
A	-	0.1	0.1	-	0.2	0.2	0.5	0.1	0.3	1.1	-	1.1	0.2	-	0.2	0.6	0.5	0.6	0.4	0.8	0.6	-	2.5	2.5	-	0.0	0.0
B	-	0.5	0.5	0.0	-	0.0	0.0	-	0.0	0.1	1.2	0.7	0.4	0.3	0.4	0.3	-	0.3	-	-	-	-	-	-	-	-	-
C	-	0.1	0.1	0.3	-	0.3	0.2	-	0.2	0.2	1.6	0.9	0.1	0.0	0.1	0.05	-	0.05	0.1	-	0.1	-	-	-	-	-	-
D	-	0.8	0.1	-	-	-	0.2	-	0.2	0.3	0.4	0.4	0.3	-	0.3	-	-	-	-	-	-	-	-	-	-	-	-
G	-	-	-	-	2.0	2.0	-	-	-	-	0.0	0.0	-	-	-	-	1.0	1.0	-	-	-	-	0.1	0.1	-	-	-
H	-	-	-	-	-	-	-	2.9	2.9	-	0.6	0.6	-	0.0	0.0	-	0.3	0.3	-	-	-	-	0.2	0.2	-	0.0	0.0
I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.0	3.0	-	-	-	-	4.0	4.0	-	-	-

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

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

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

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

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

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

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

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

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

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

APPENDIX FIGURES

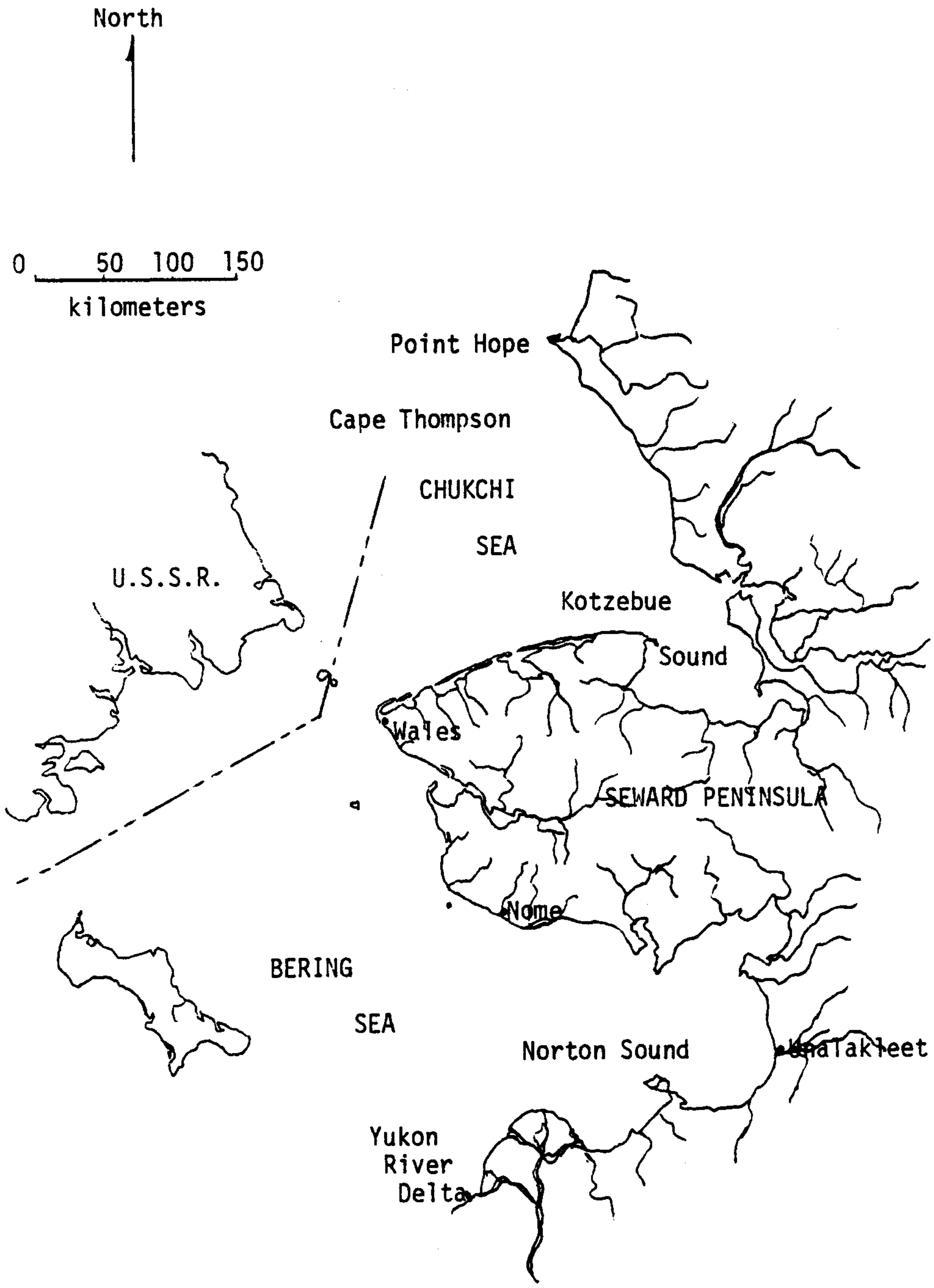


Figure 1. Study area for Research Unit 19 , Finfish Resource Surveys in Norton Sound and Kotzebue Sound, 2,496 kilometers, 1976 -77.

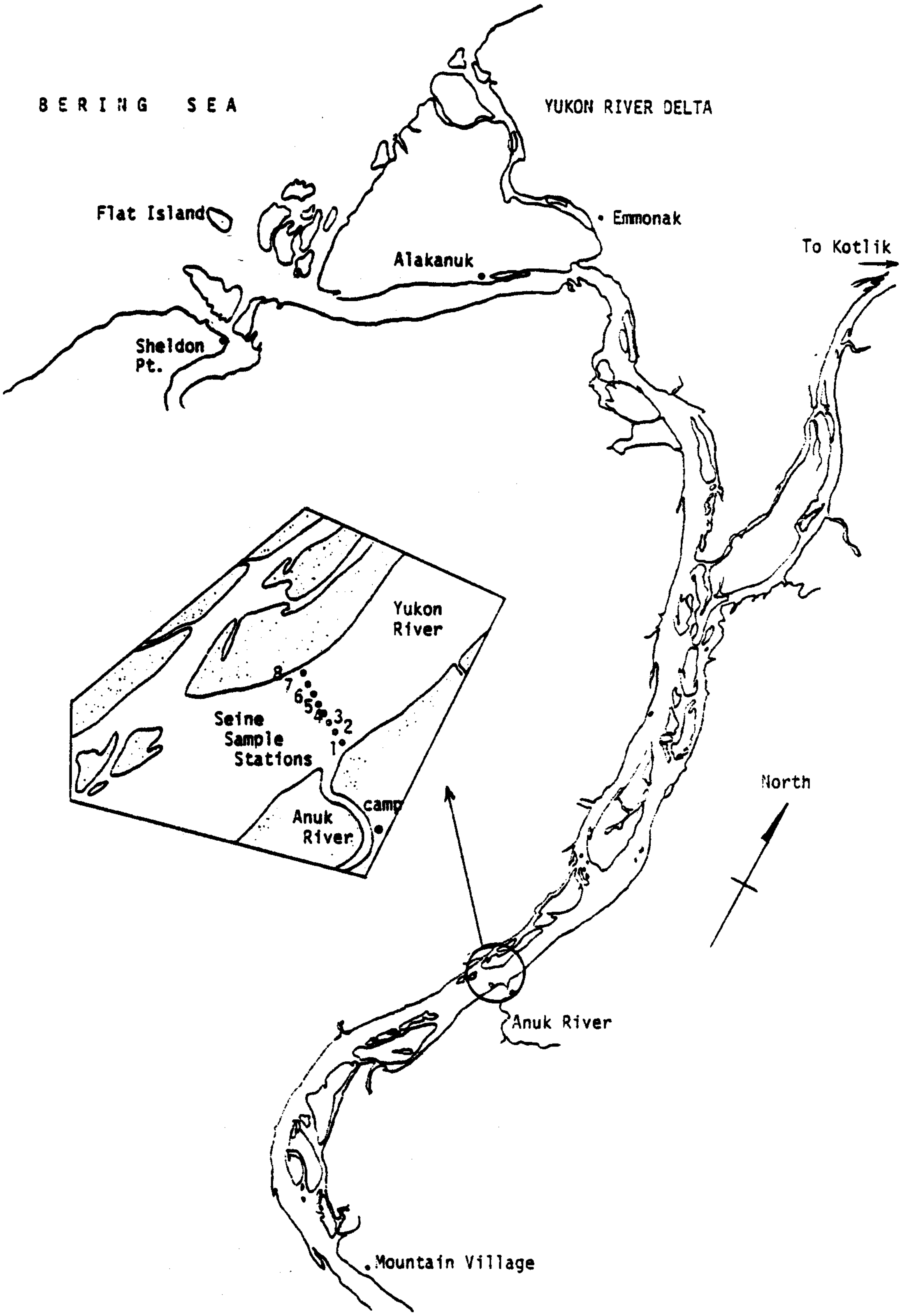


Figure 2. Yukon River smolting site June 7 through July 7, 1977. Site was located 101 kilometers upriver from Flat Island at the confluence of the Anuk River.

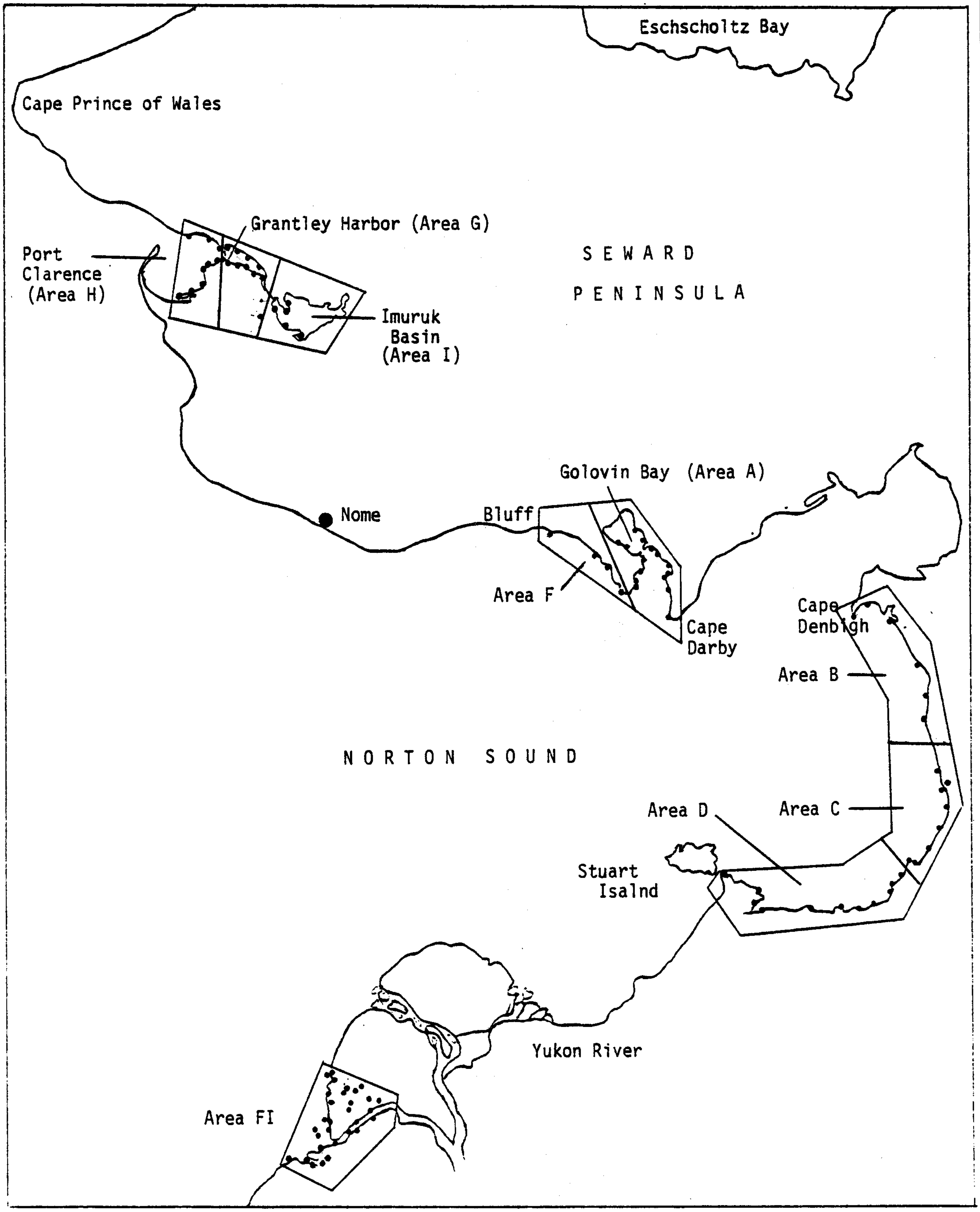


Figure 3. Sample locations for nearshore studies conducted under R.U. 19 throughout Norton Sound and the Yukon River Delta, 1976-77.

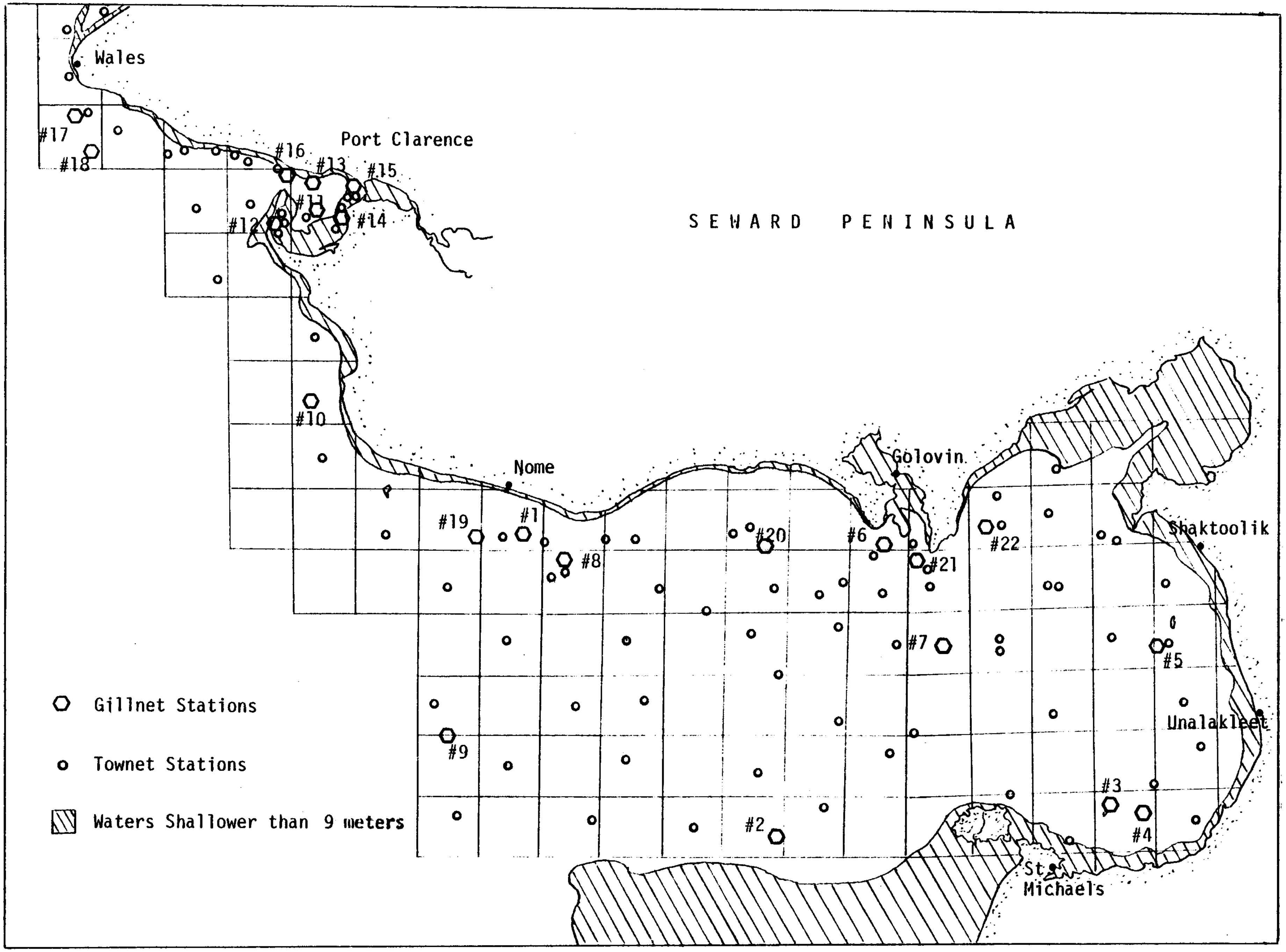


Figure 4. Surface townet and gillnet sample stations from June 22 through July 12 in Norton Sound, 1977.

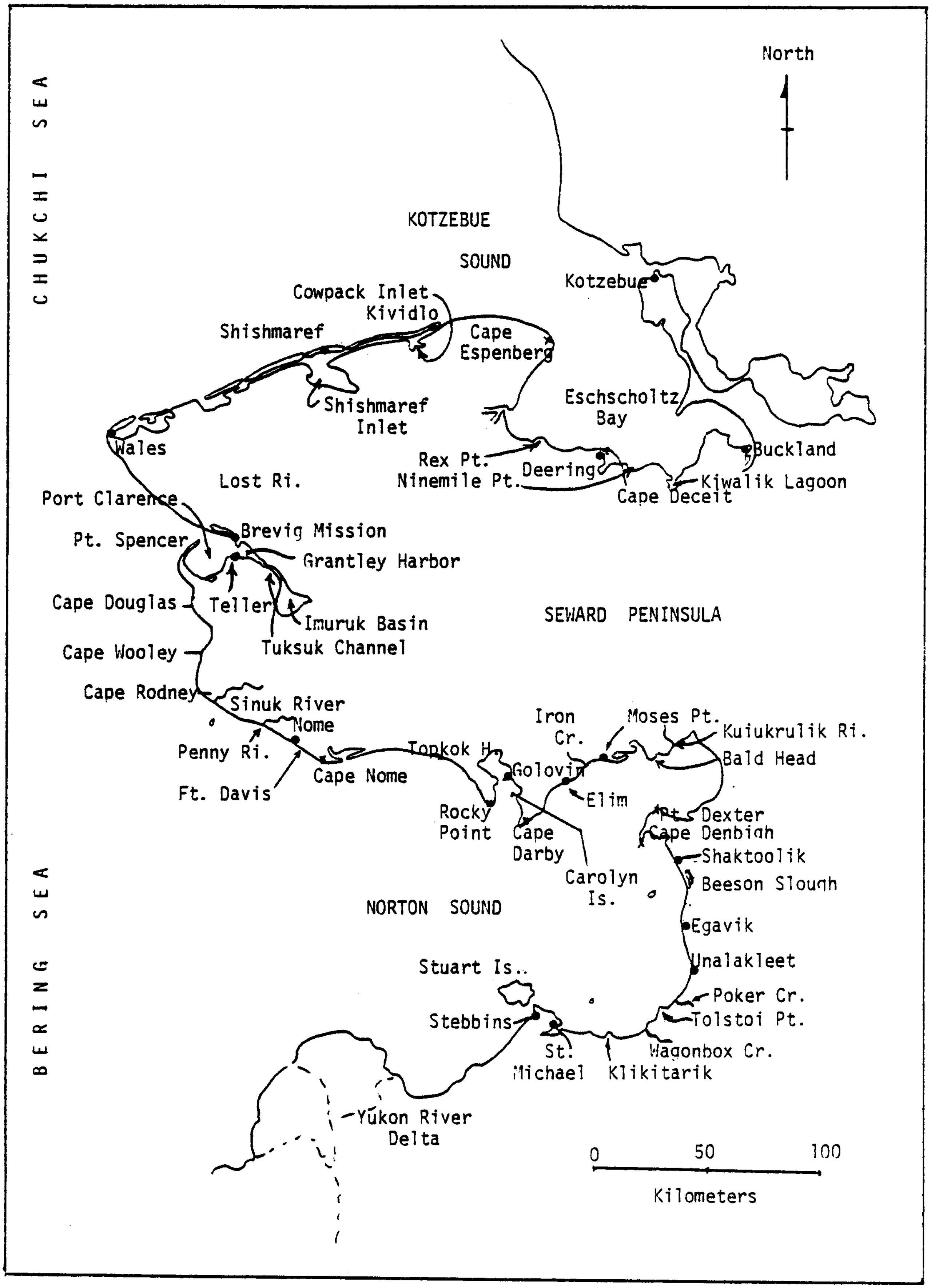


Figure 5. Study area for aerial herring surveys.

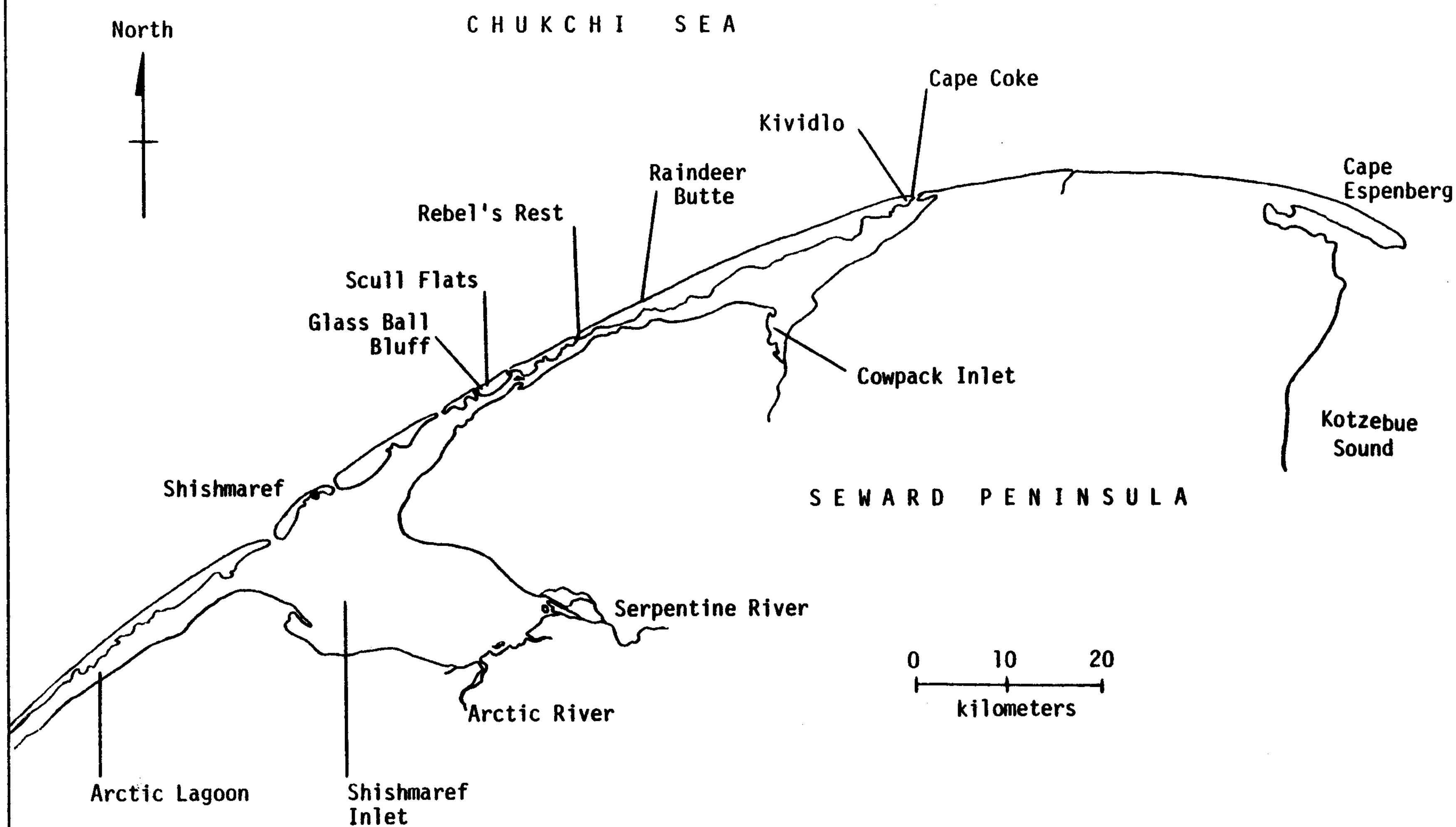


Figure 6. Study area on northwest coast of Seward Peninsula, 1977.

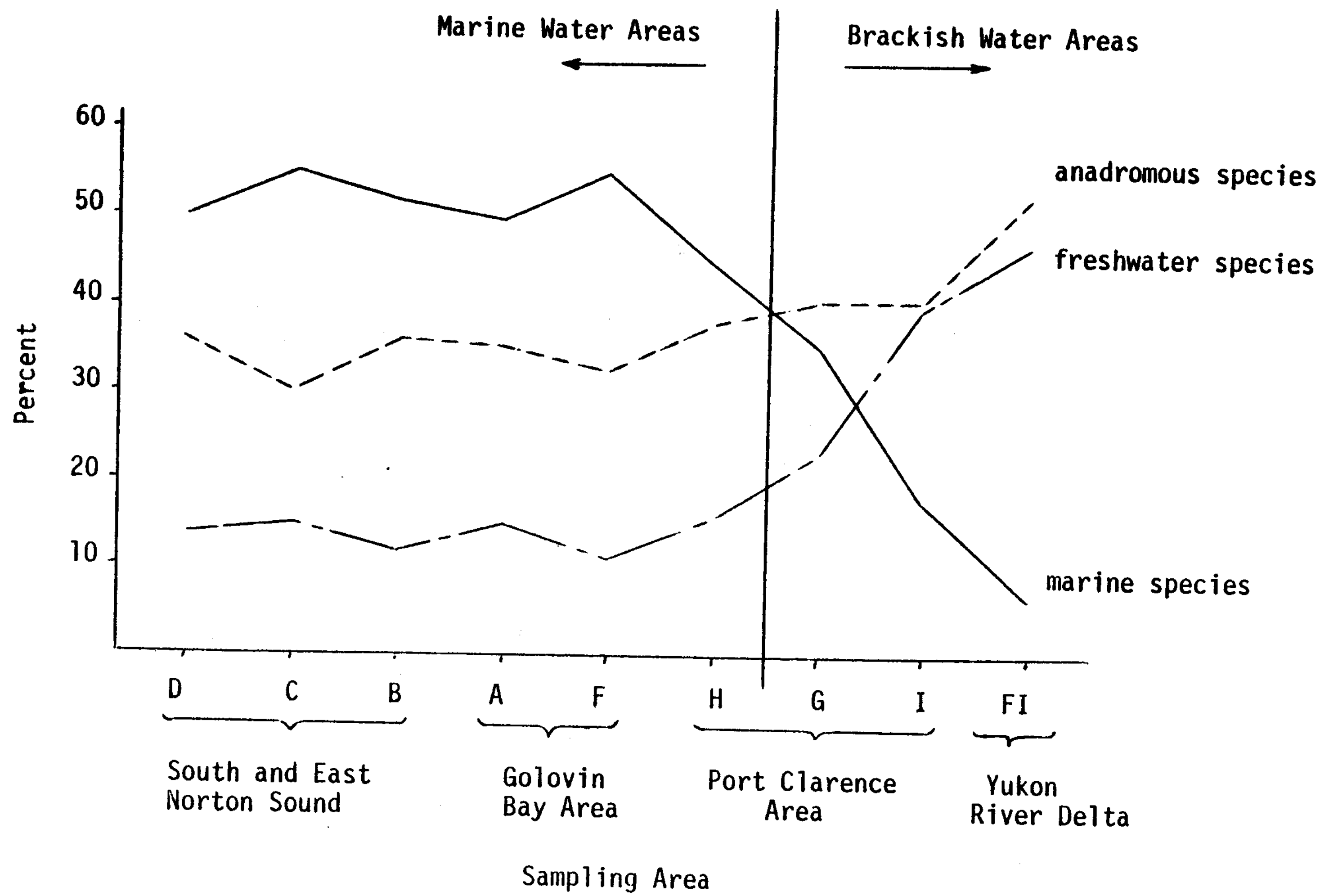


Figure 7 Species diversification by area of finfish captured in the coastal waters of Norton Sound from the Yukon River Delta to Port Clarence, 1976-77.

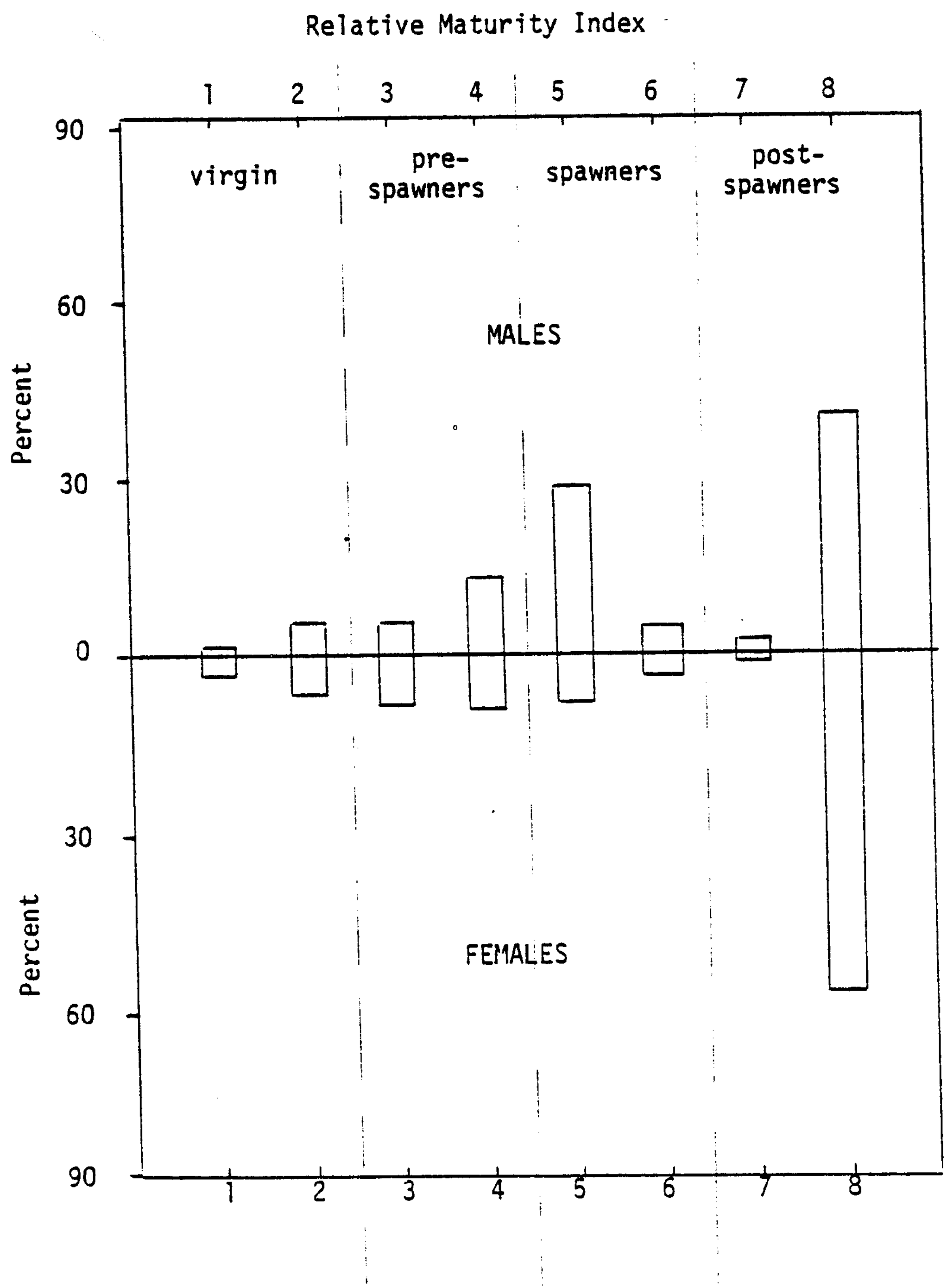


Figure 8 . Relative maturity by sex of herring captured in the Port Clarence area from ice breakup (late June) through freezeup (late October), 1977.

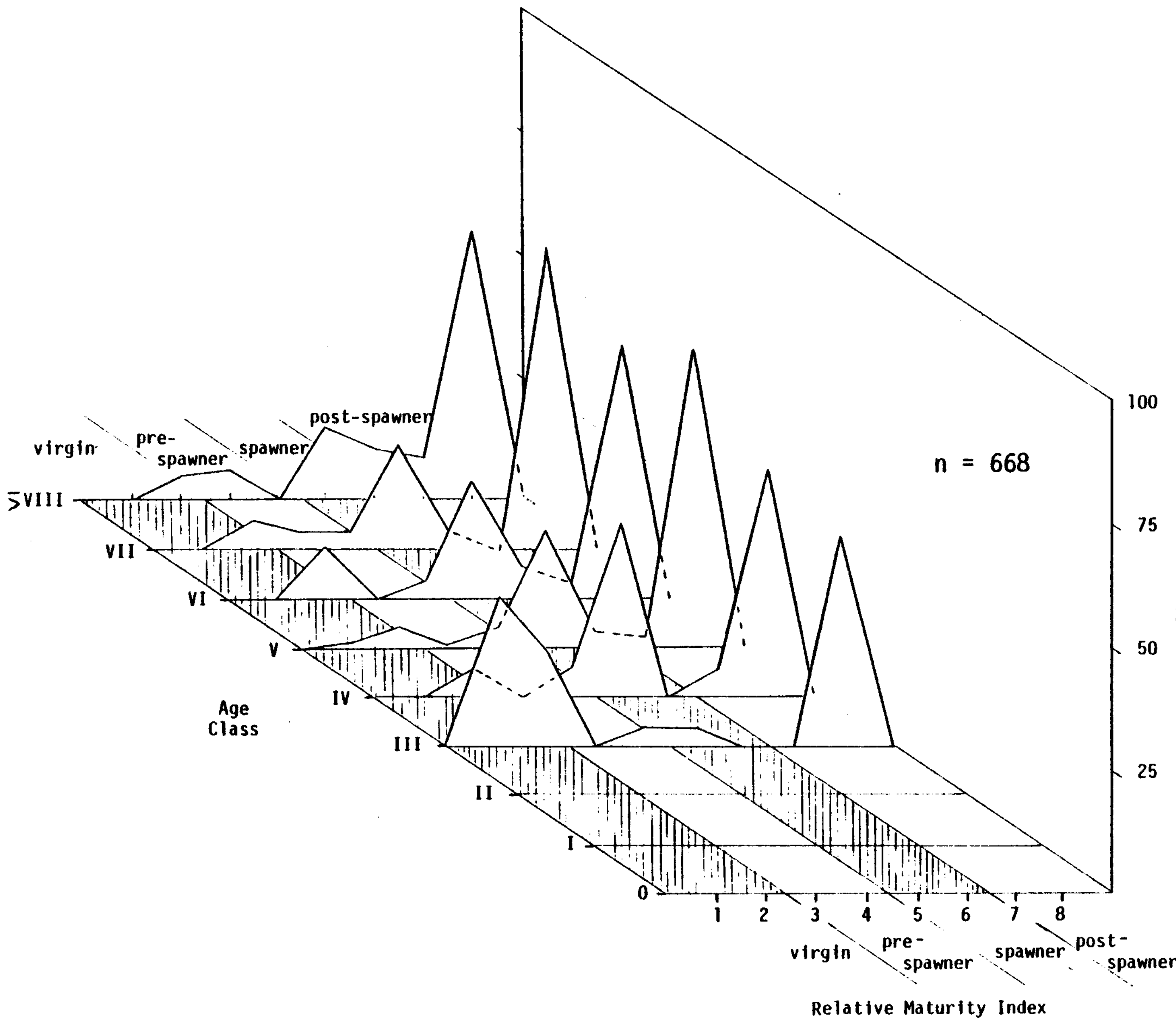


Figure 9. Relative maturity by age of herring captured in the Port Clarence area from ice breakup (late June) through July 21, 1977.

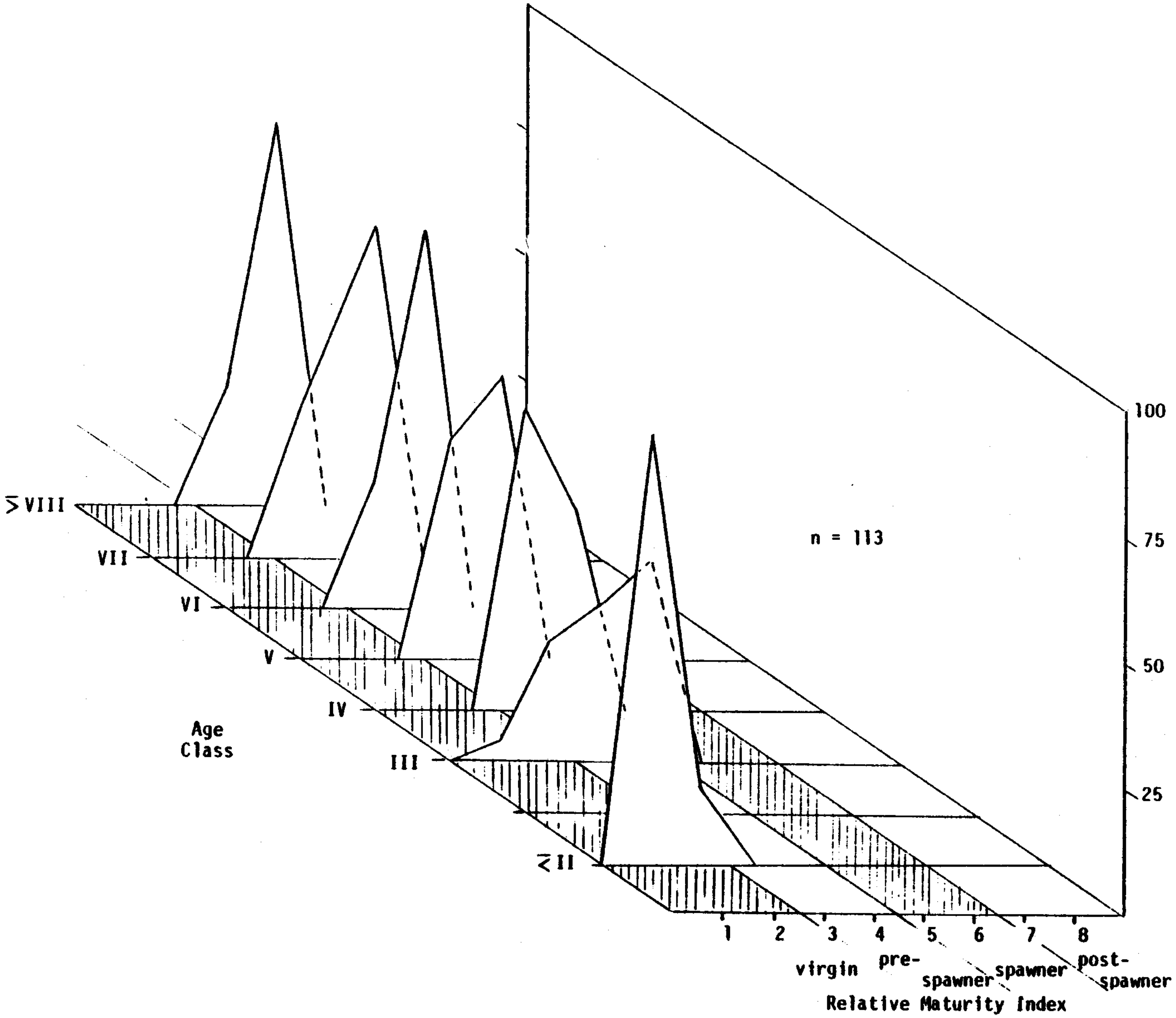


Figure 10. Relative maturity by age of herring captured in the Port Clarence area from September 7 through freezeup (late October), 1977.

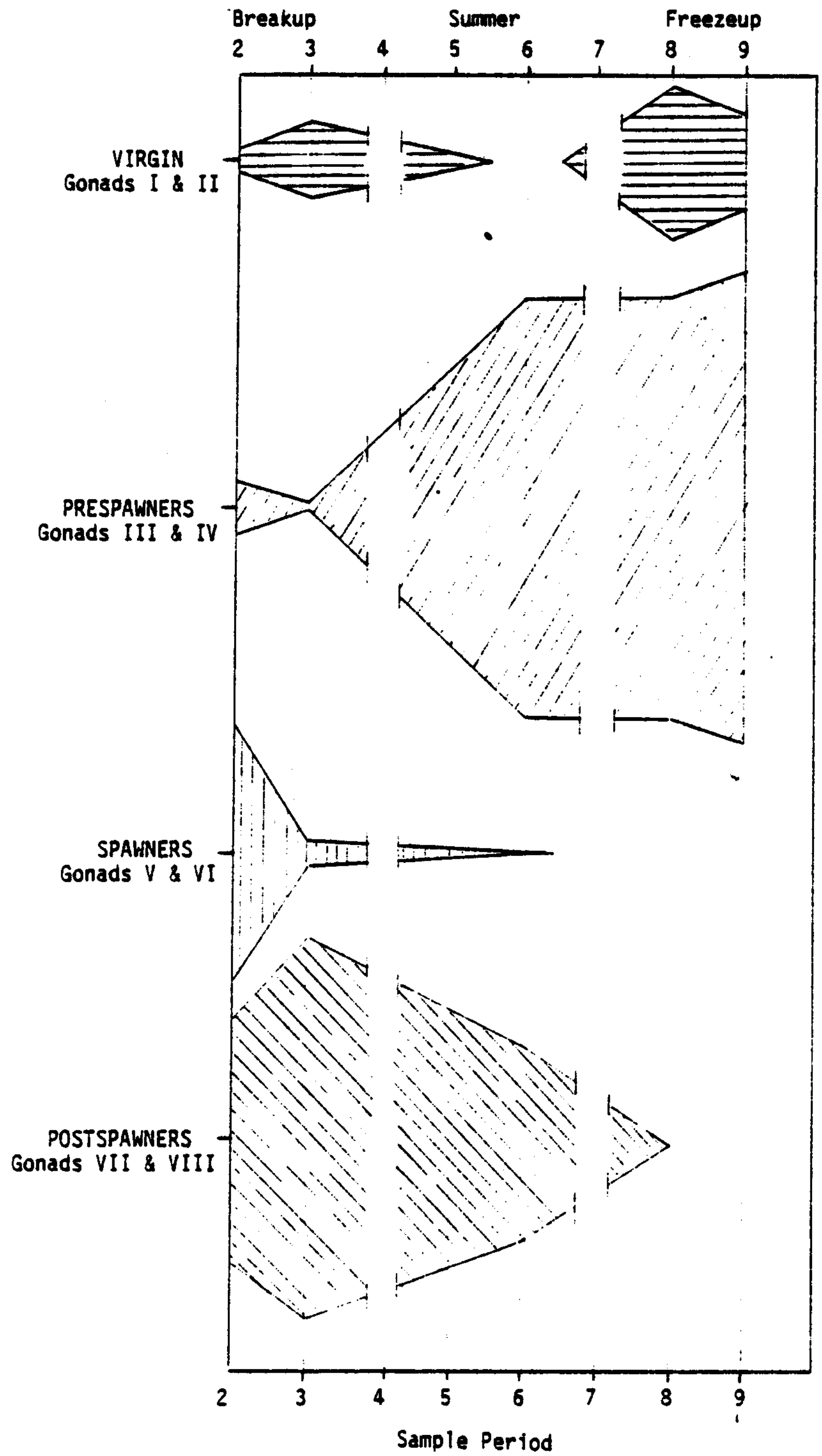


Figure 11. Relative maturity of herring captured in the Port Clarence area from ice breakup (late June) through freezeup (late October), 1977.

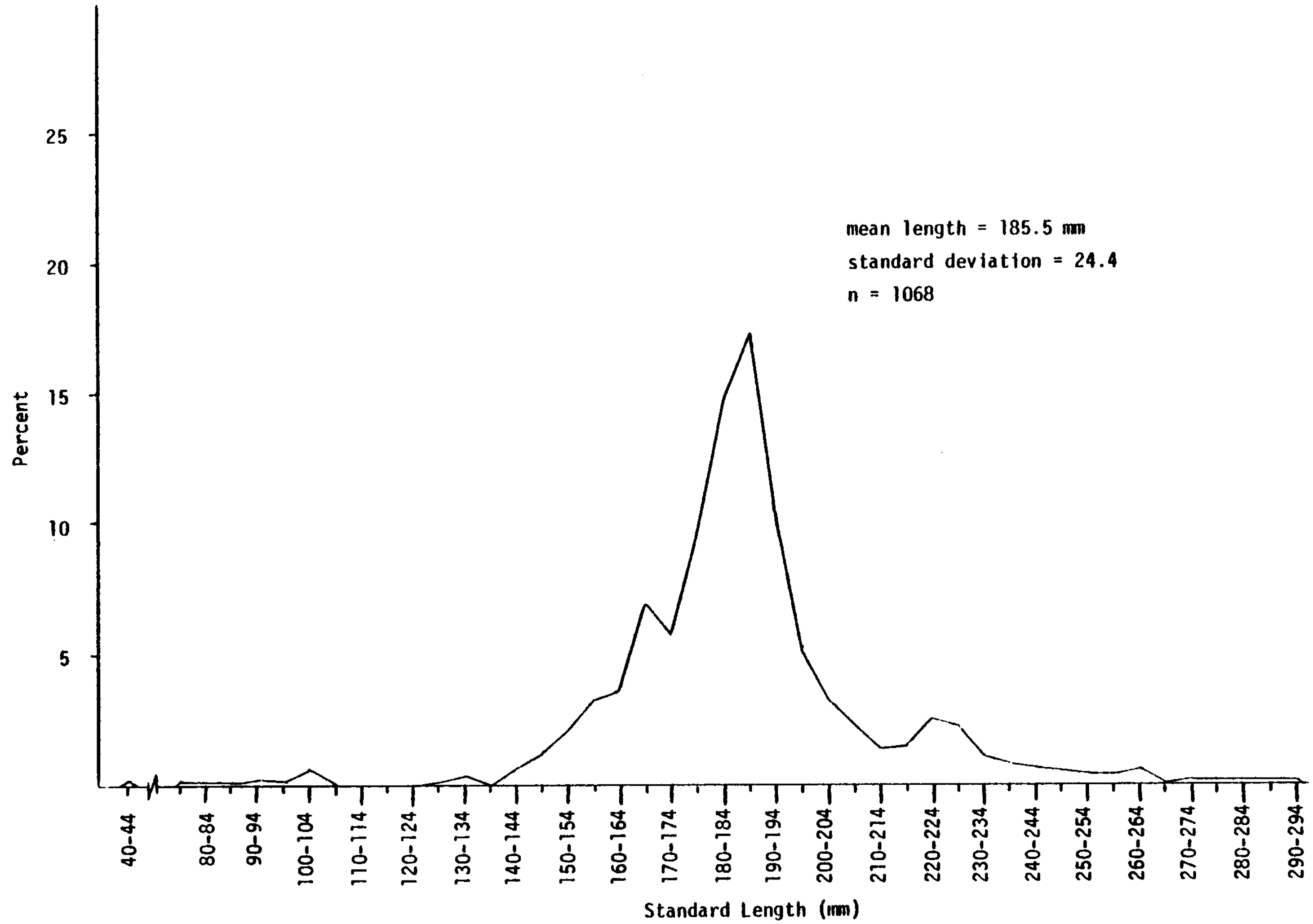


Figure 12. Length frequency (percent) of herring captured in the Port Clarence area from ice breakup (late June) through freezeup (late October), 1977.

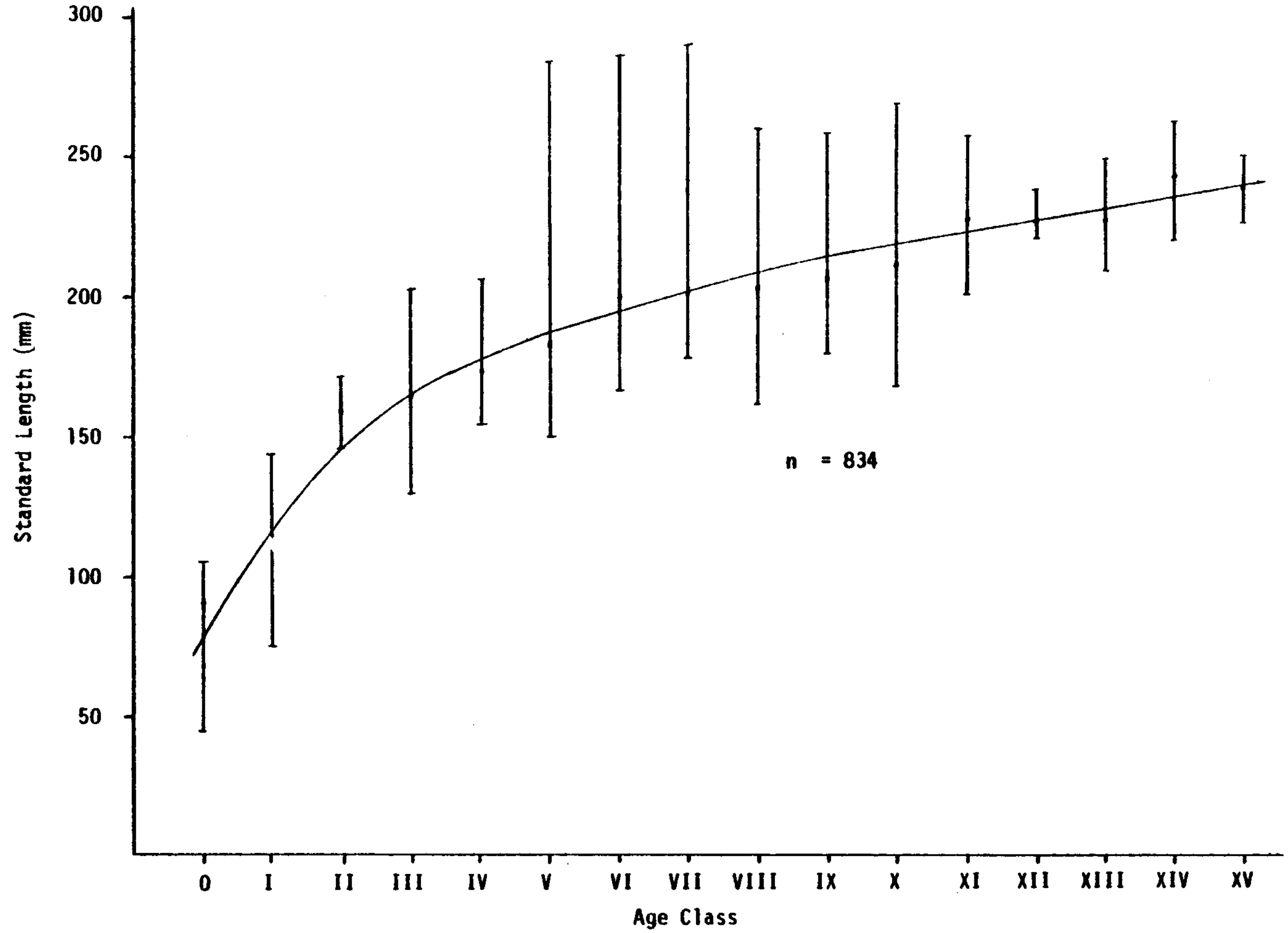


Figure 13. Mean length-at-age (shown with ranges) for herring captured in the Port Clarence area, 1977.

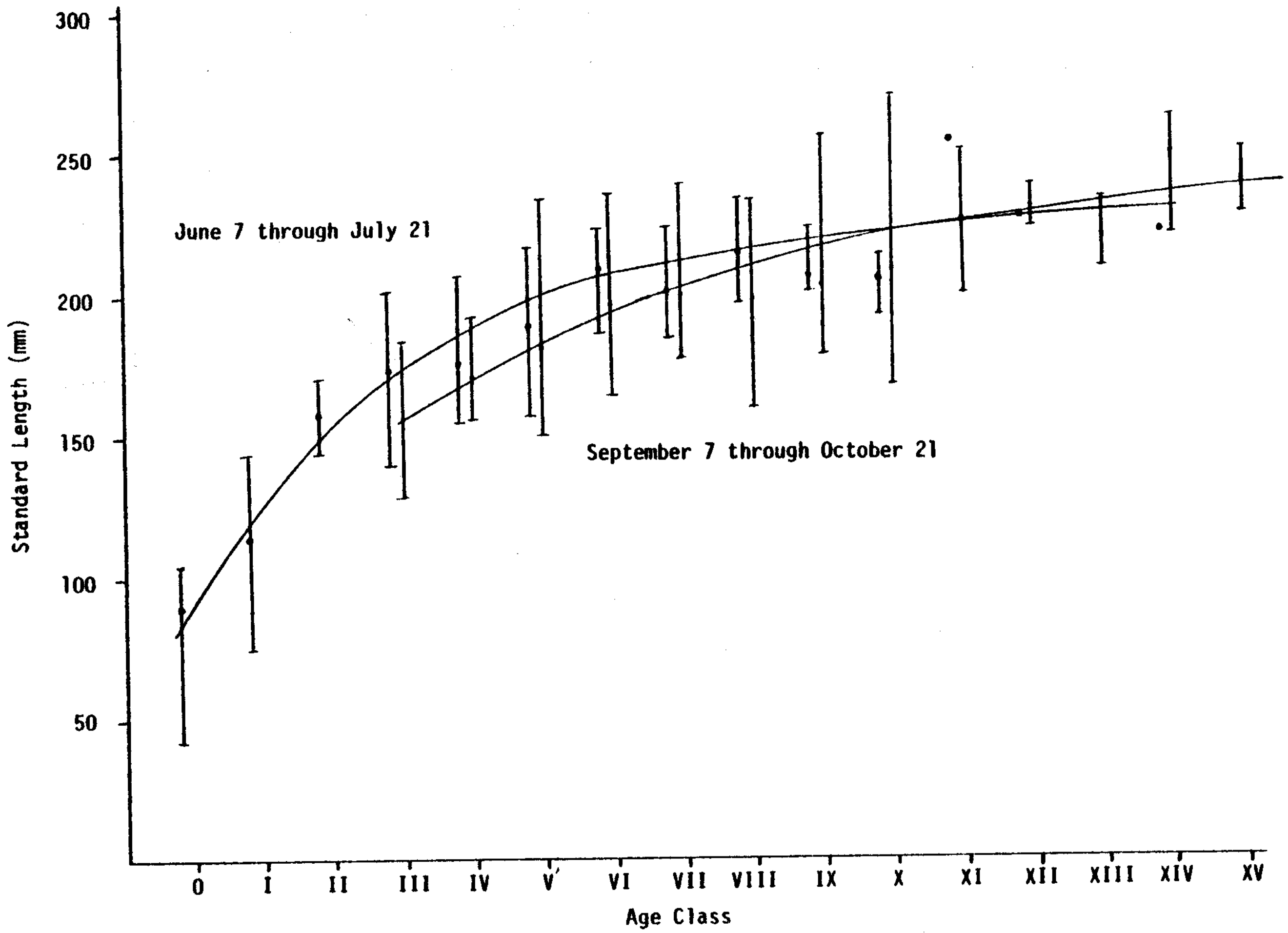


Figure 14. Mean length-at-age for herring captured in the spring (June 7 - July 21) and fall (September 7 - October 21) in the Port Clarence area in 1977. Mean lengths are shown with ranges.

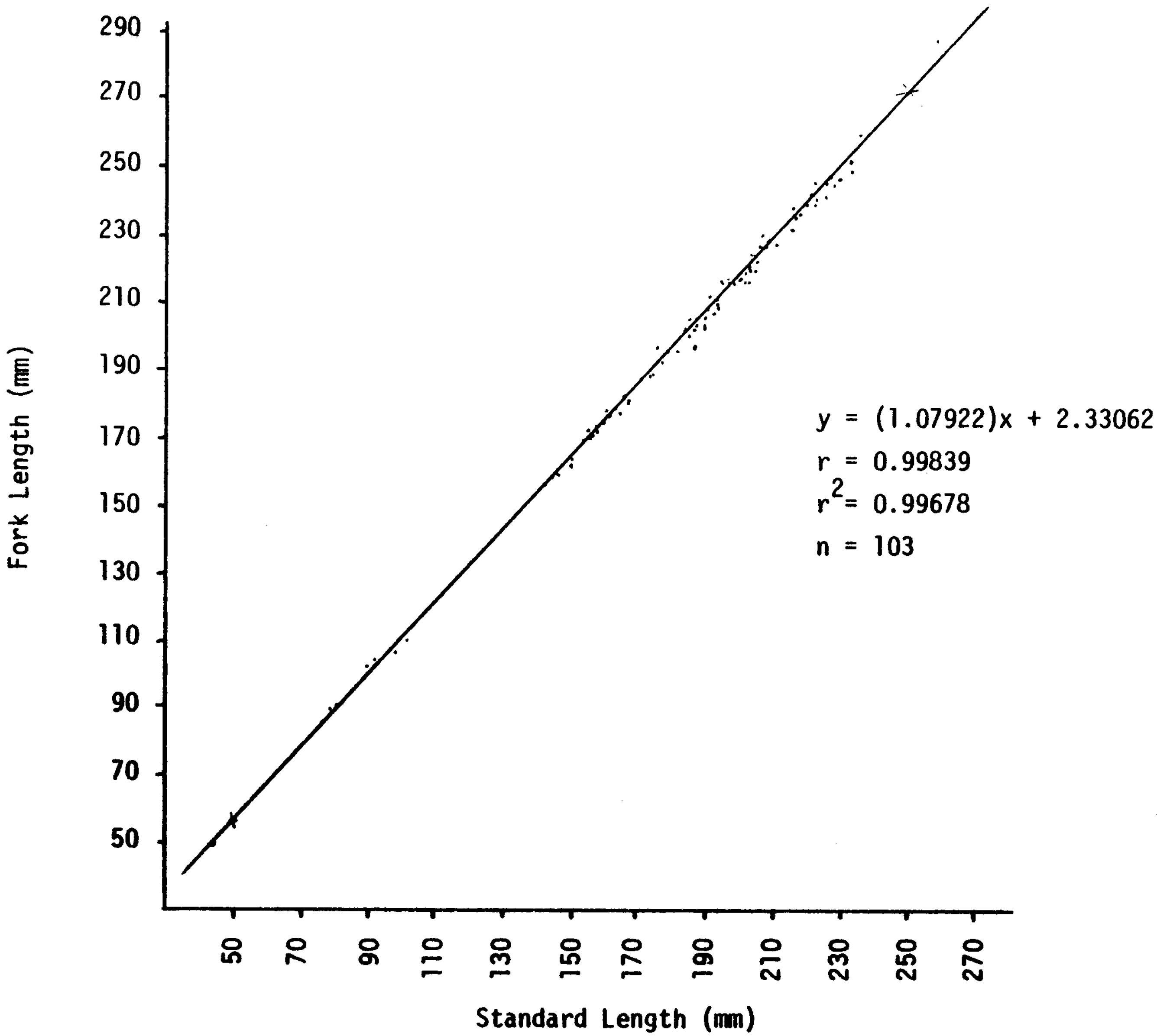


Figure 15. Relationship between fork length and standard length of Pacific herring captured in Port Clarence June through October, 1977.

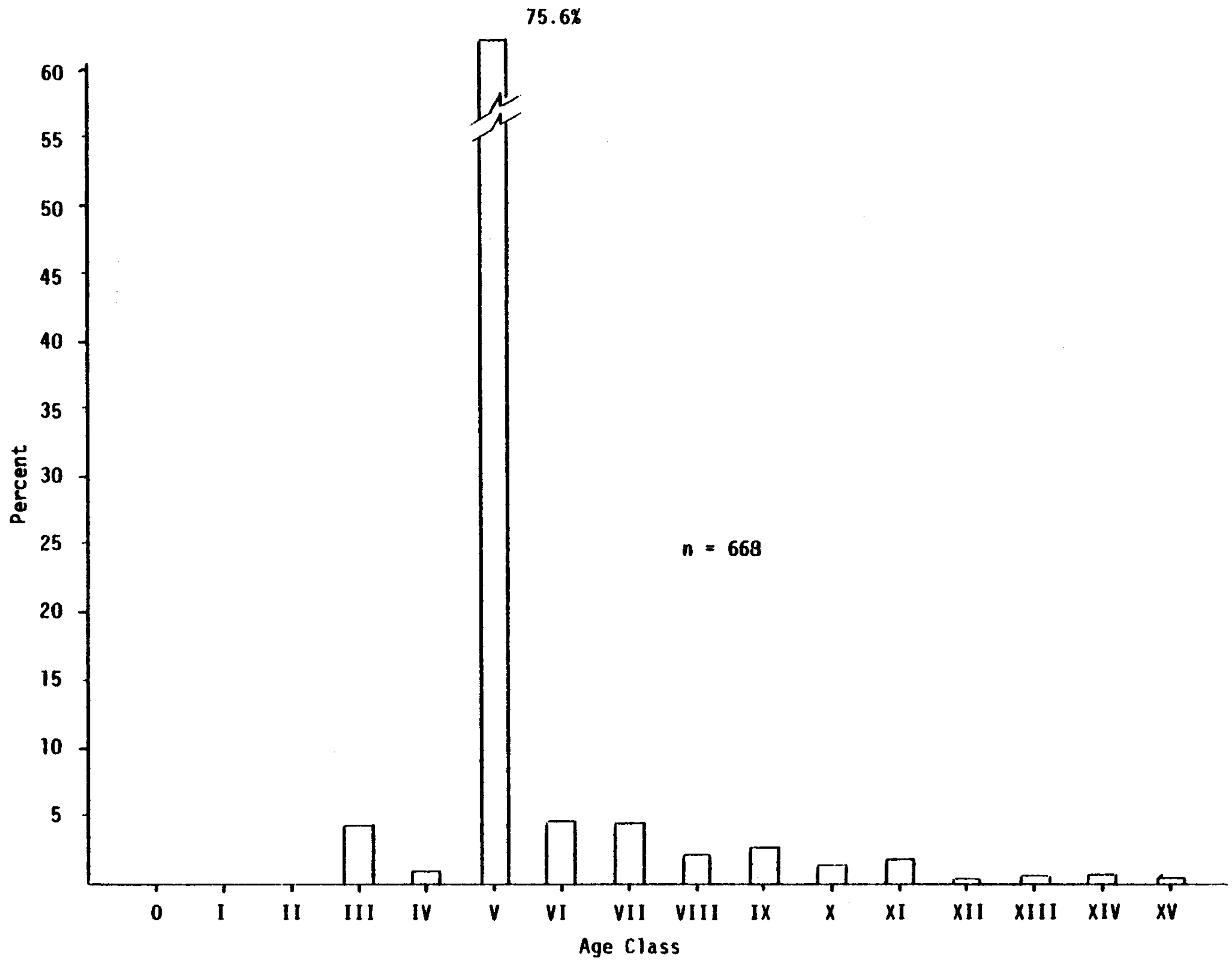


Figure 16. Percent age composition of herring captured in the Port Clarence area from ice breakup to July 21, 1977.

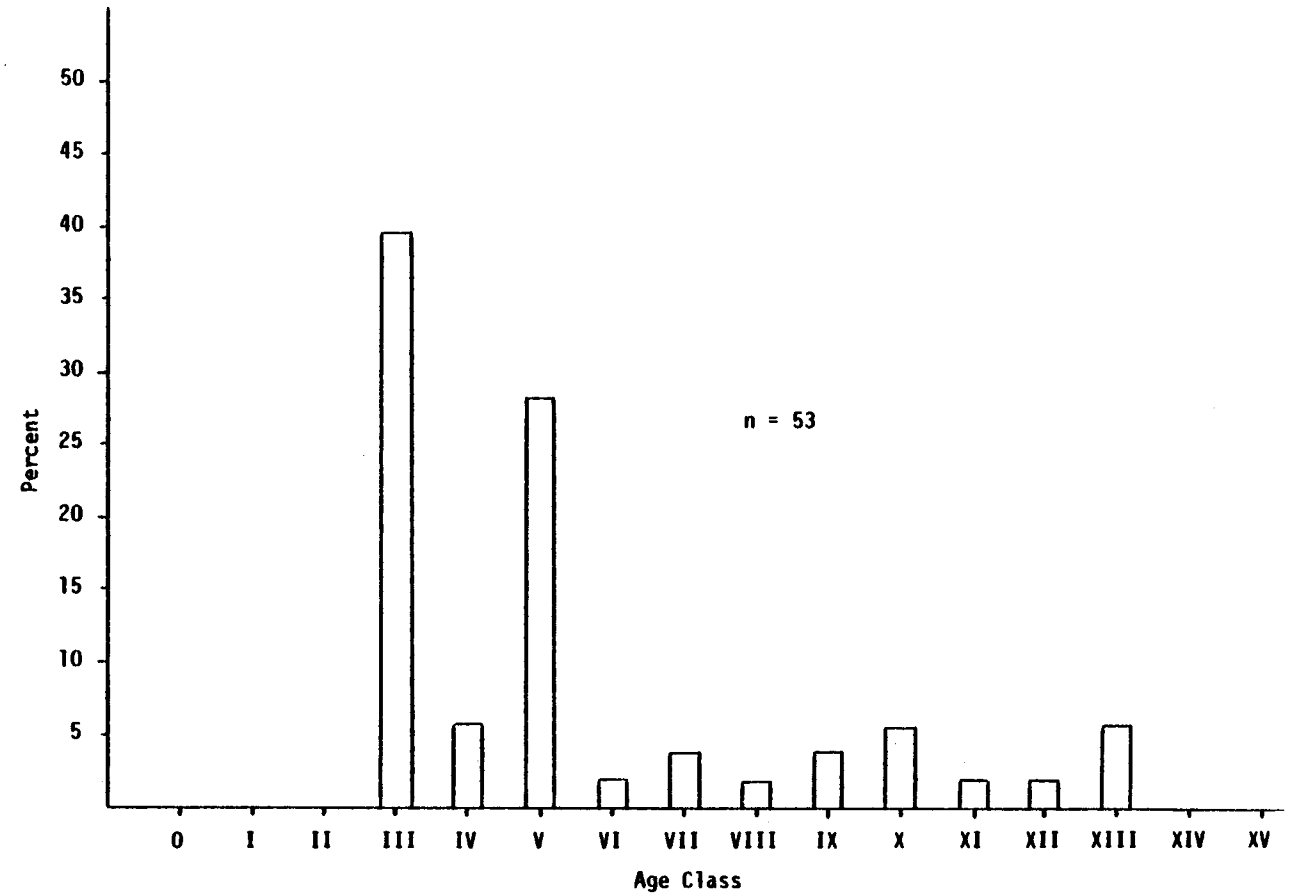


Figure 17. Percent age composition of herring captured in the Port Clarence area from July 22 through Spetember 6, 1977.

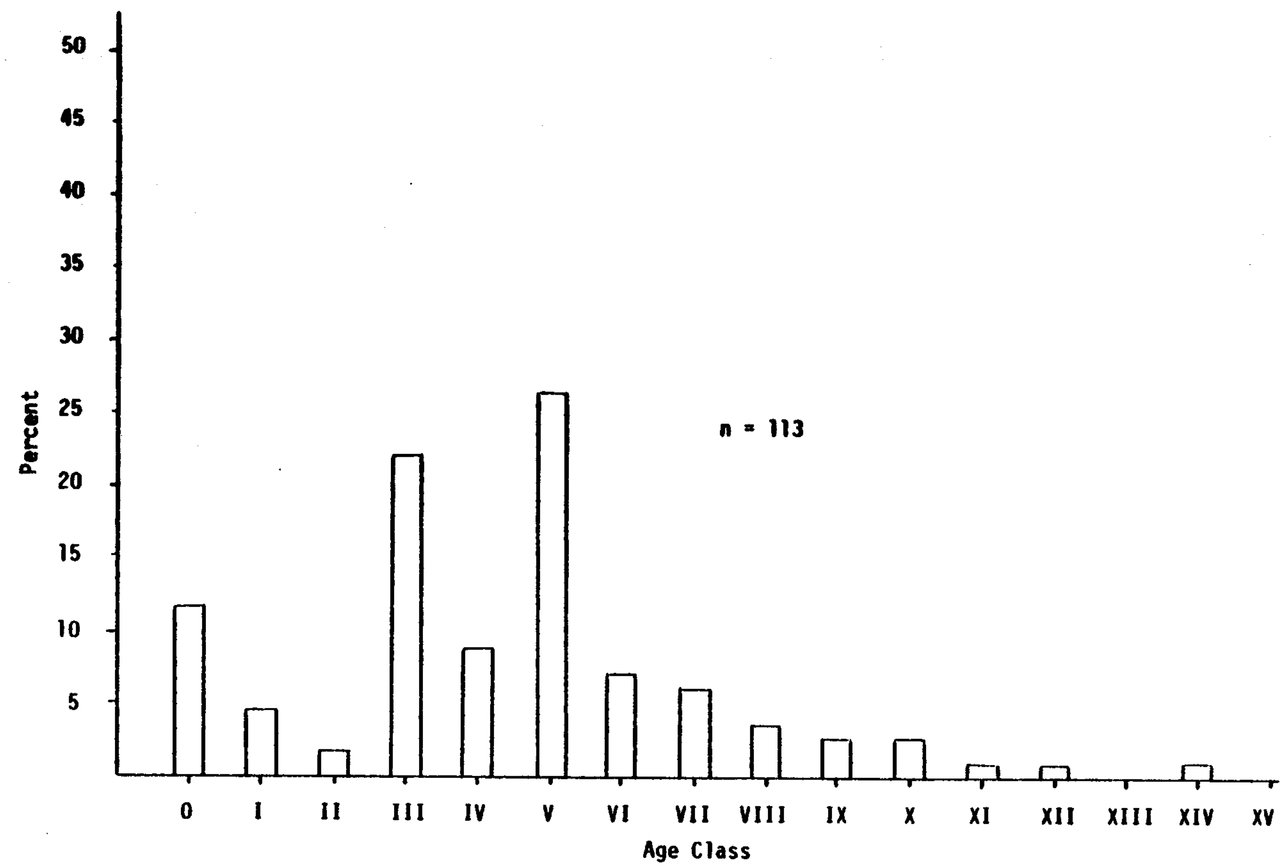


Figure 18. Percent age composition of herring captured in the Port Clarence area from September 7 through freezeup, 1977.

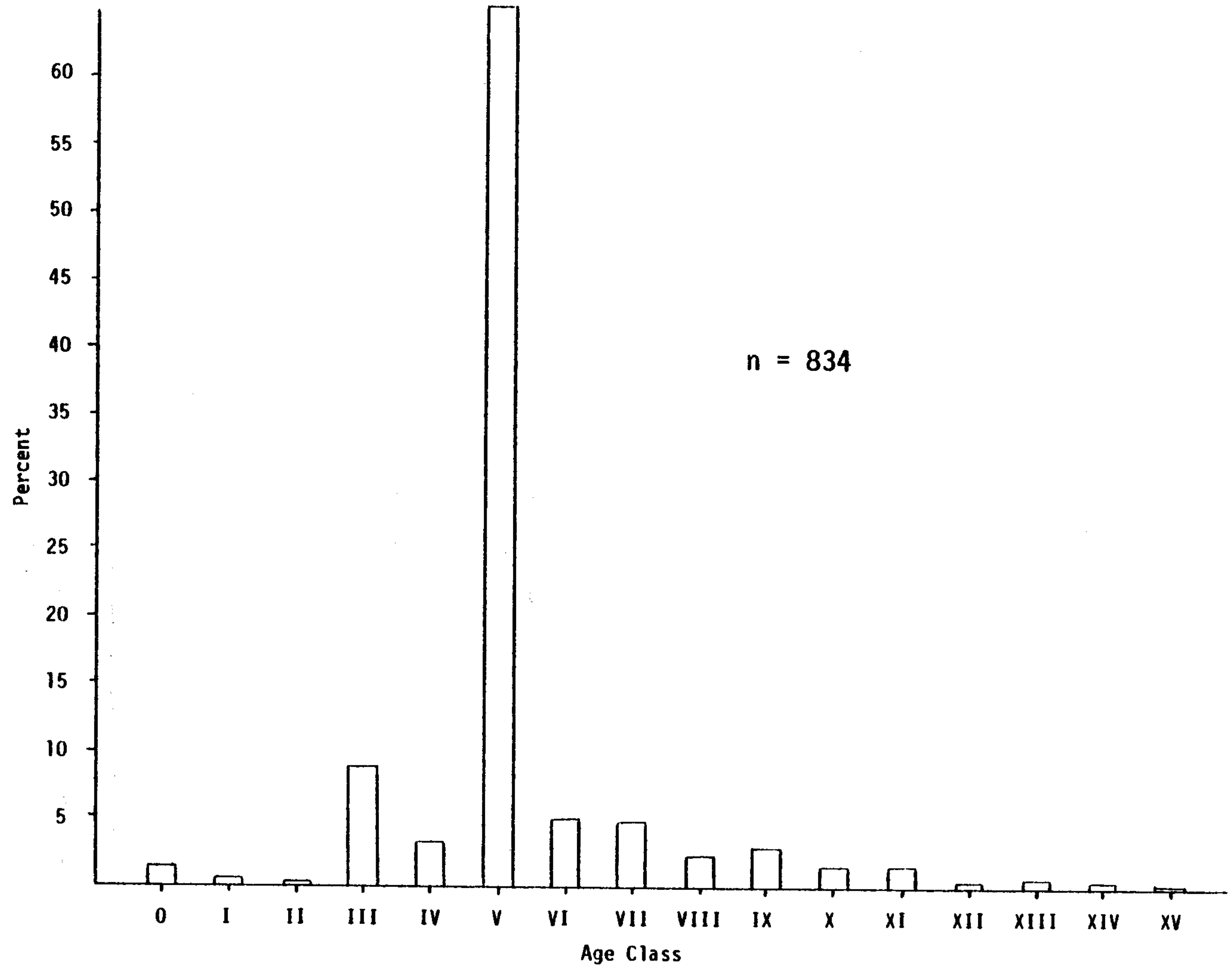


Figure 19. Percent age composition of herring captured in the Port Clarence area from ice breakup (late June) through freezeup (late October), 1977.

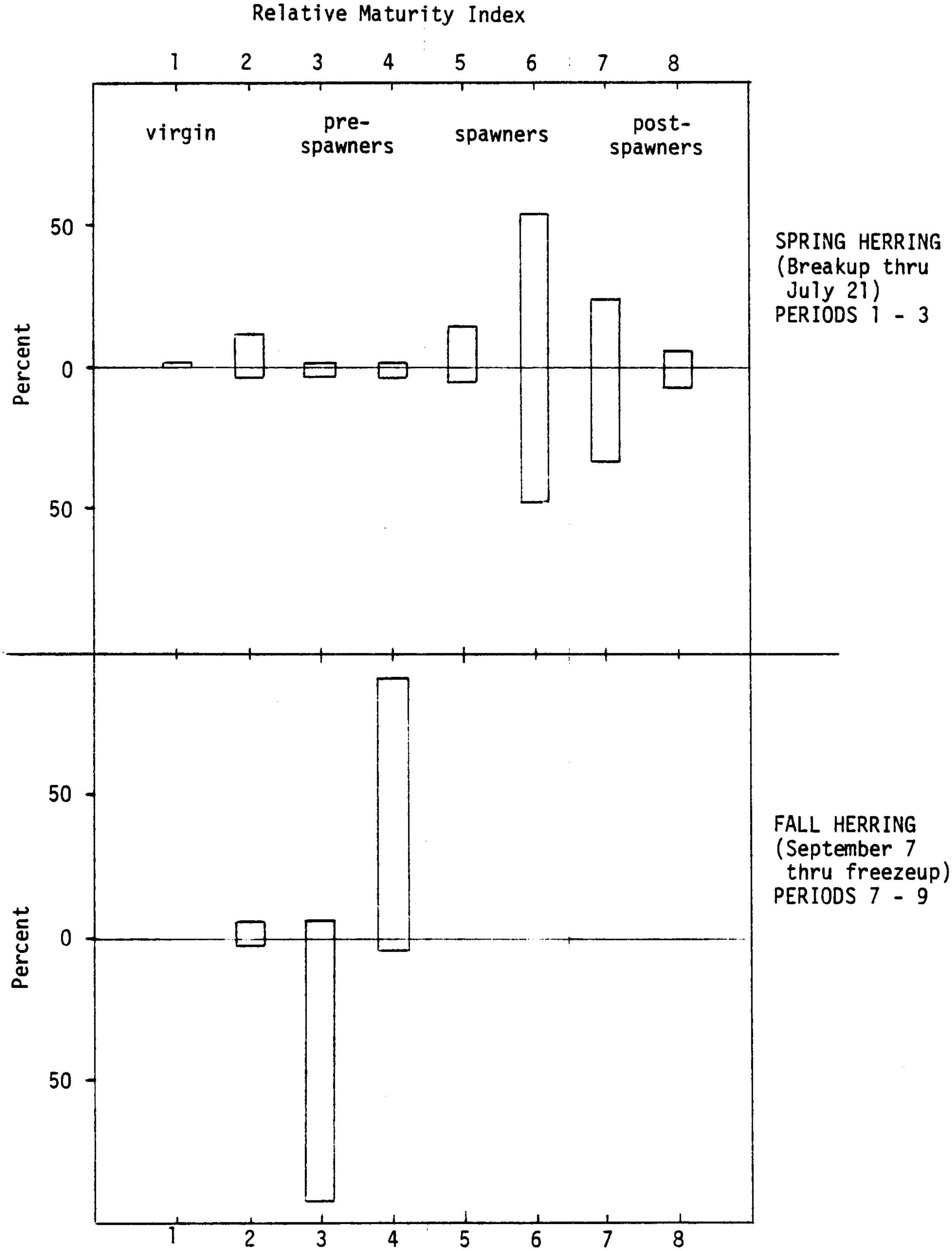


Figure 20. Comparison of the relative maturity of spring and fall herring captured in Golovin Bay 1977.

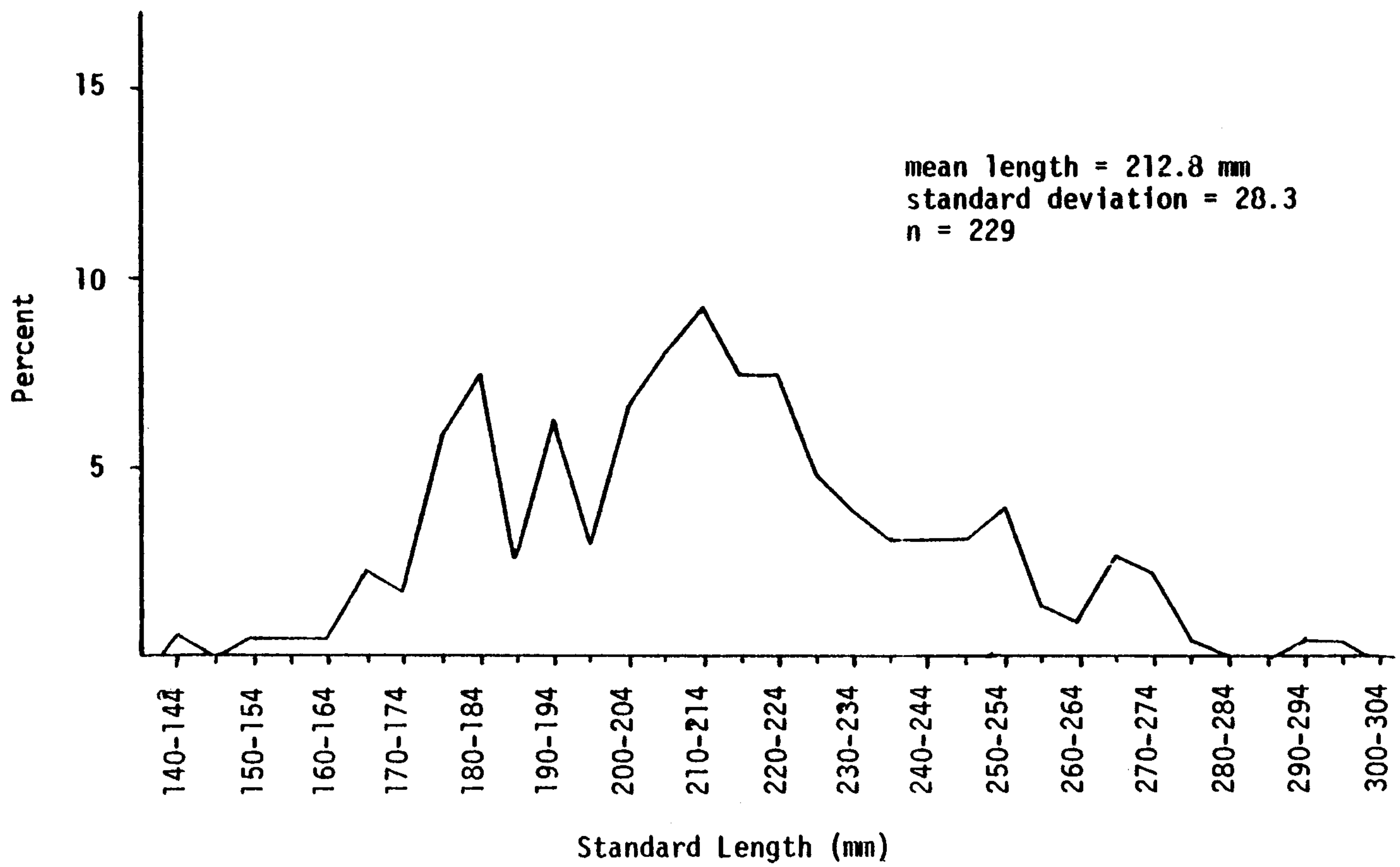


Figure 21. Length frequency (percent) of herring captured in Golovin Bay from ice breakup (June) through freezeup (October), 1977.

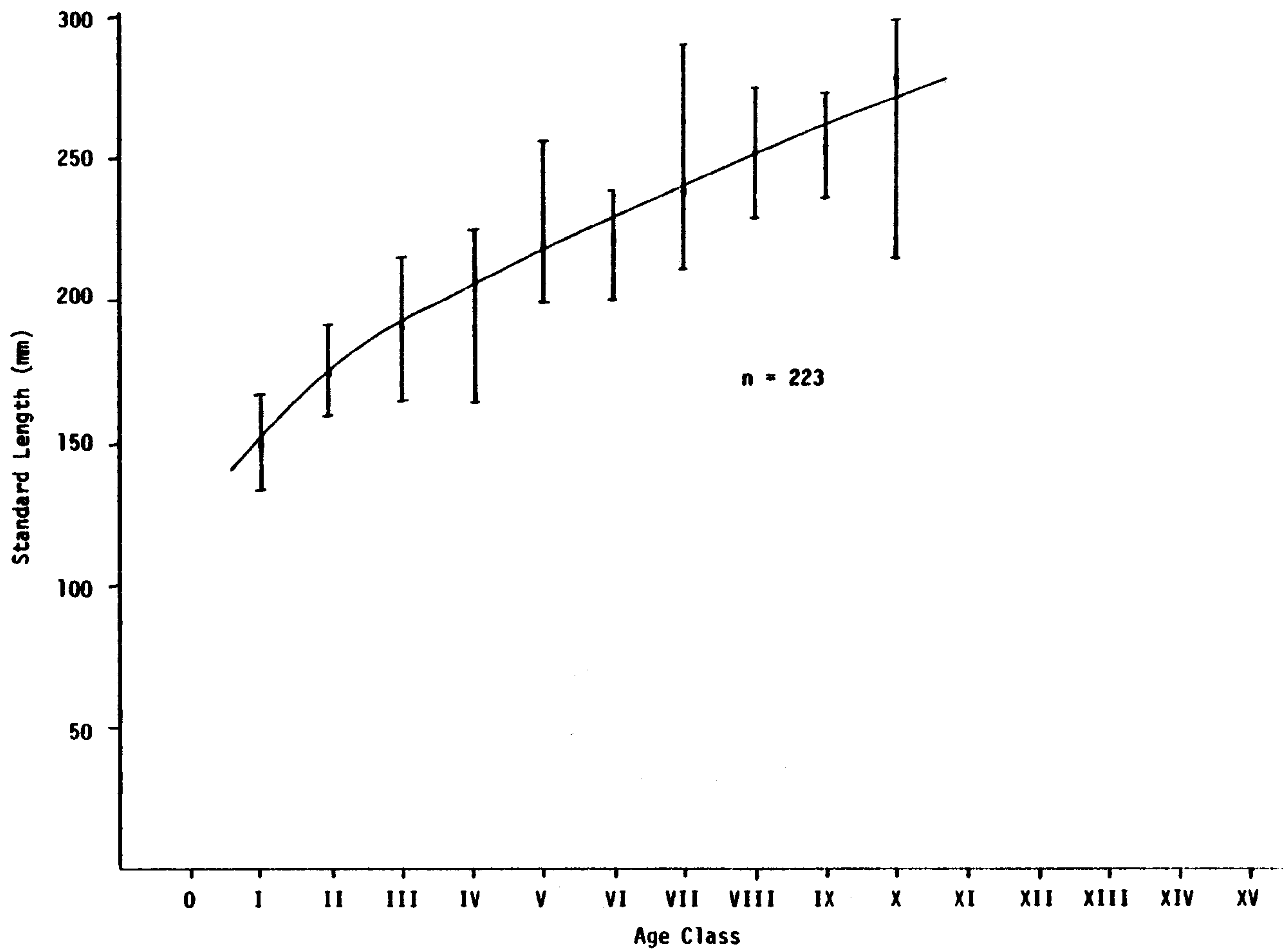


Figure 22. Mean length-at-age (shown with ranges) for herring captured in Golovin Bay, 1977.

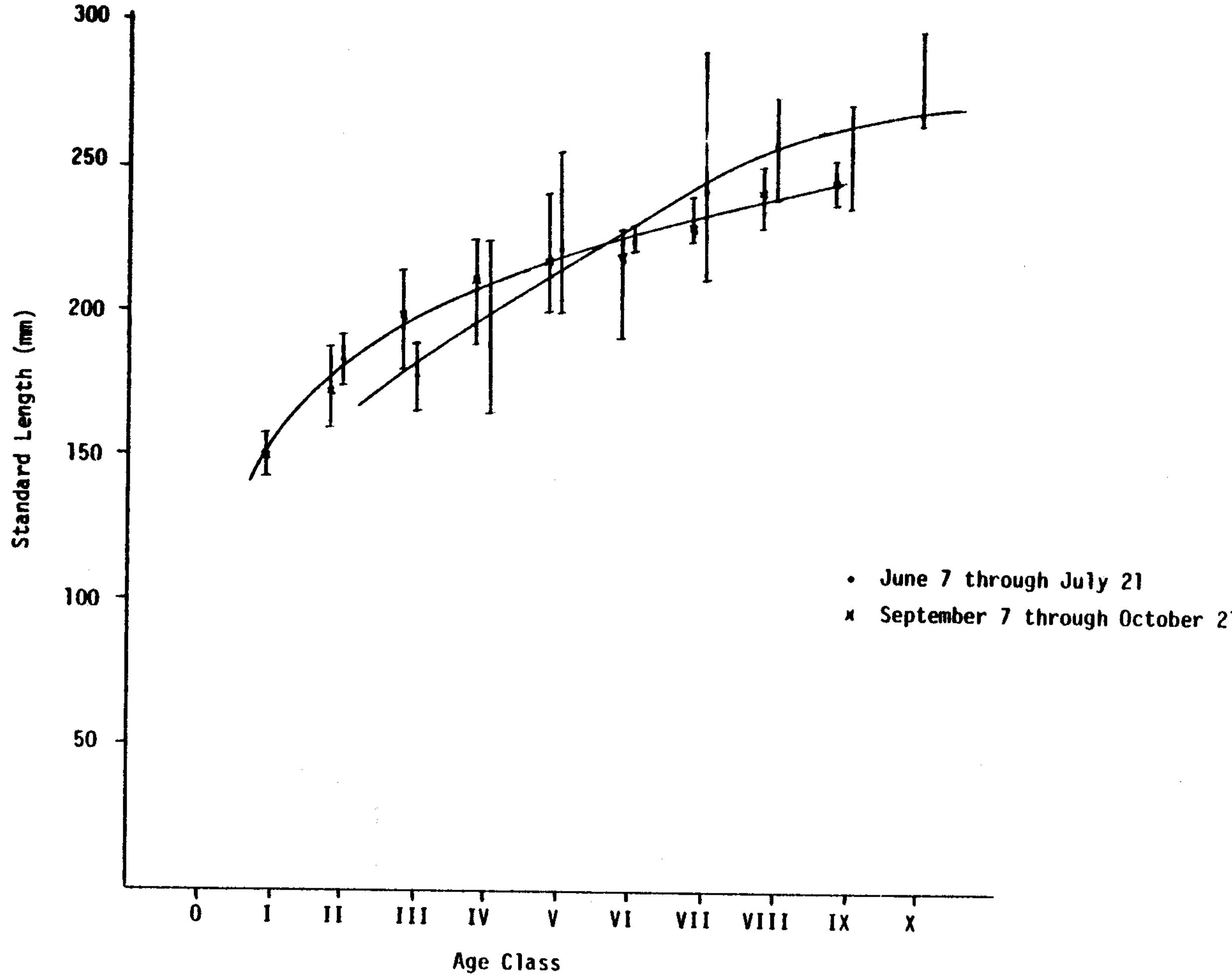


Figure 23. Mean length-at-age for herring captured in the spring (June 7 - July 21) and fall (September 7 - October 21) in Golovin Bay, 1977. Mean lengths are shown with ranges.

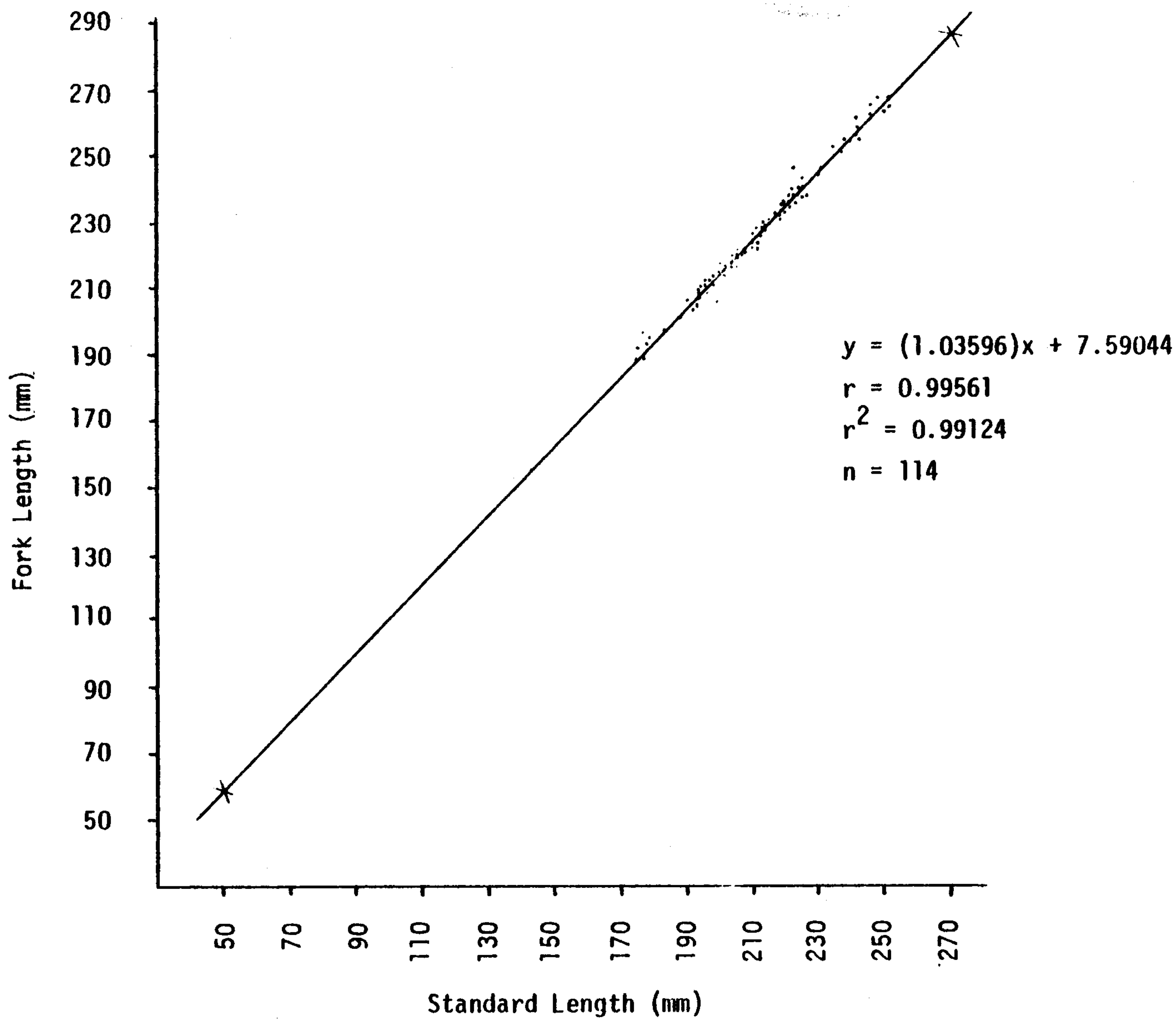


Figure 24. Relationship between fork length and standard length of Pacific herring captured in Golovin Bay June through October, 1977.

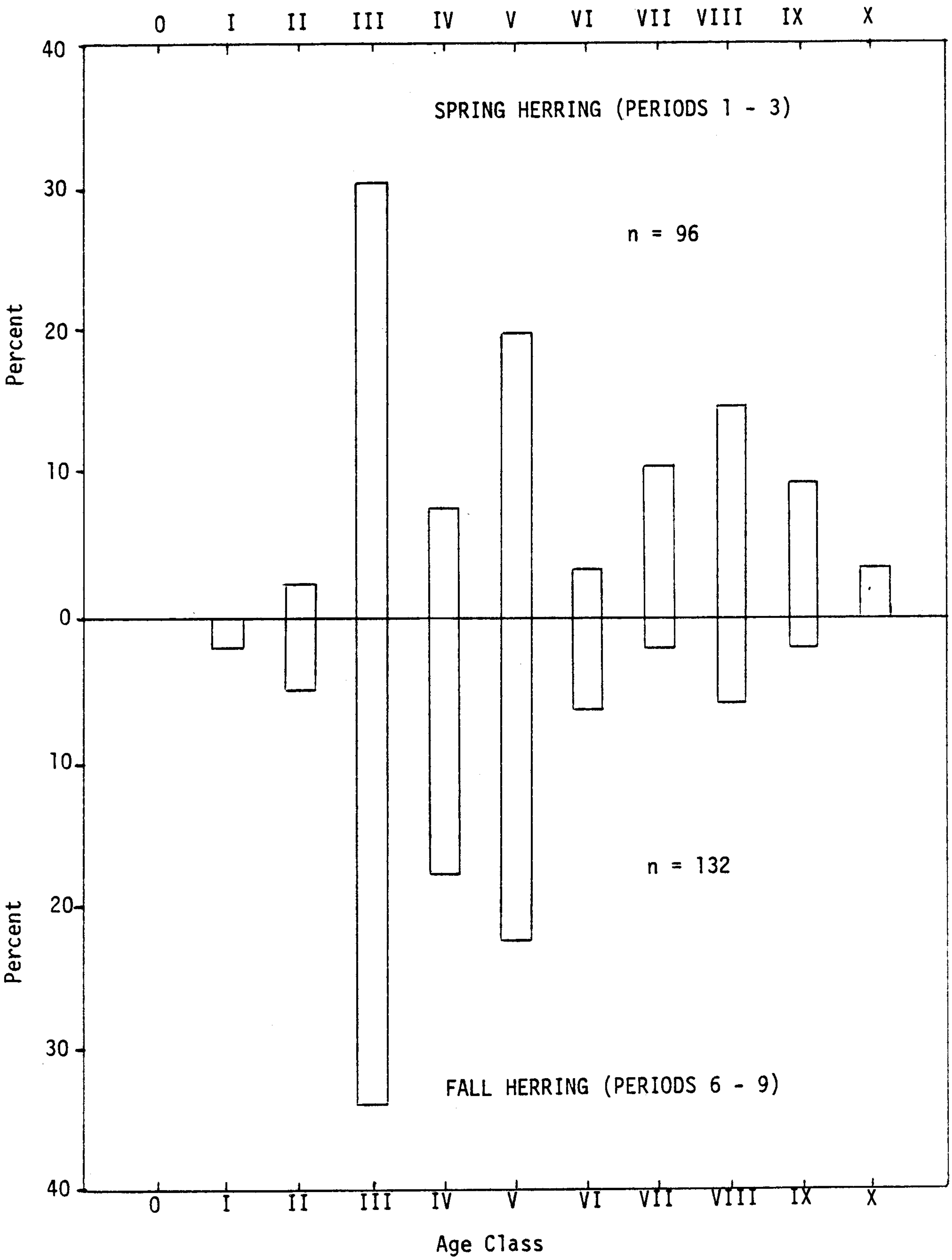


Figure 25. Comparison of percent age composition between spring and fall herring populations in Golovin Bay, 1977.

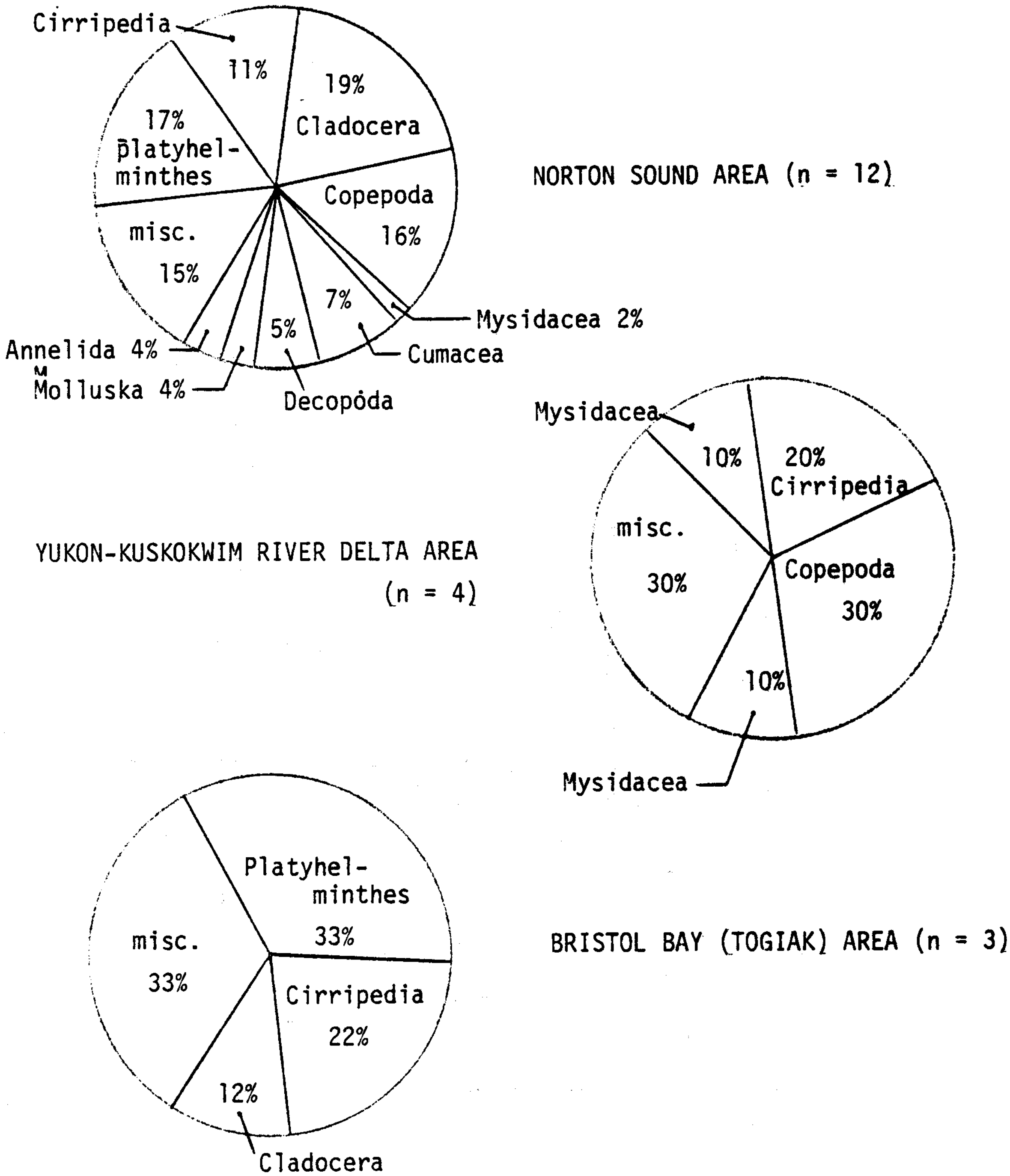


Figure 26. Percent occurrence of the total number of food items in herring stomachs examined along the western Alaska coastline, 1976.

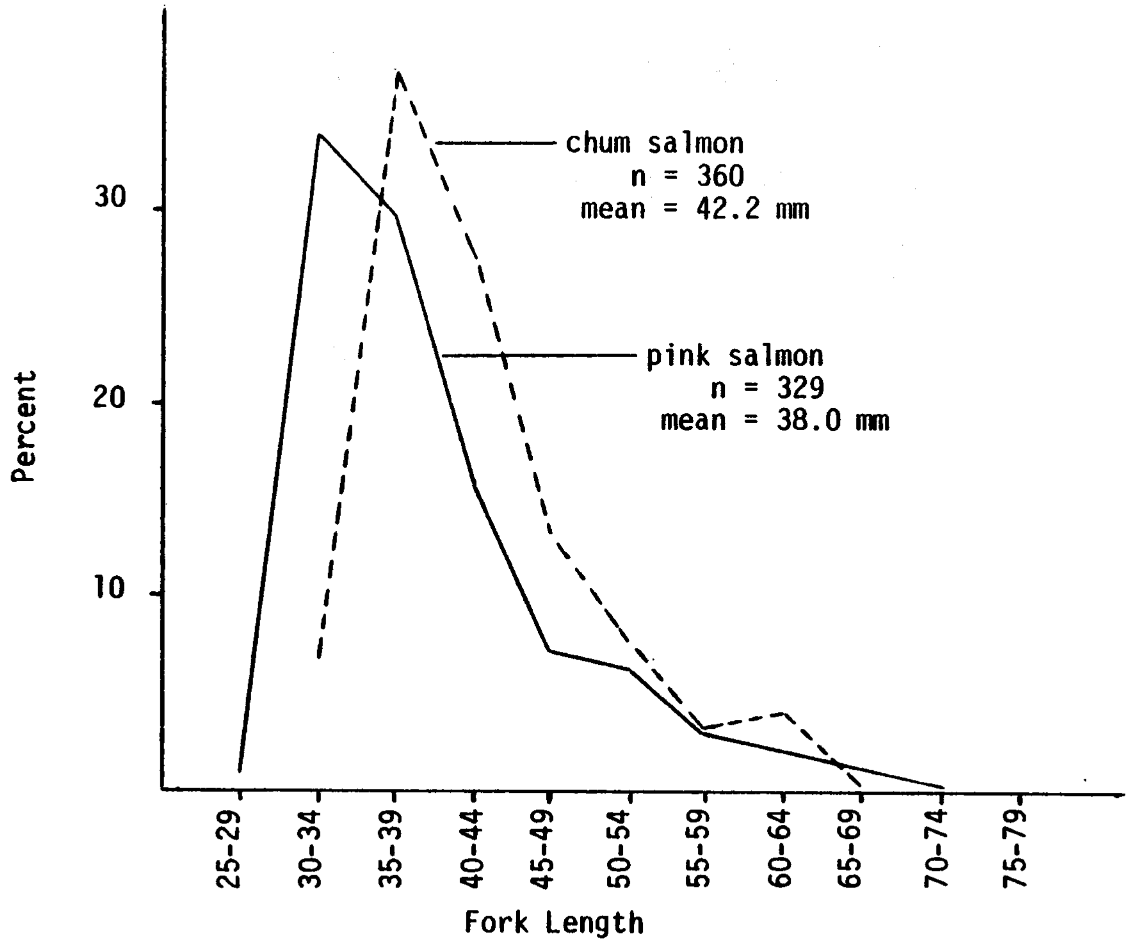


Figure 27. Length frequency (percent) of juvenile pink and chum salmon captured in Golovin Bay June 9 through July 9, 1977.

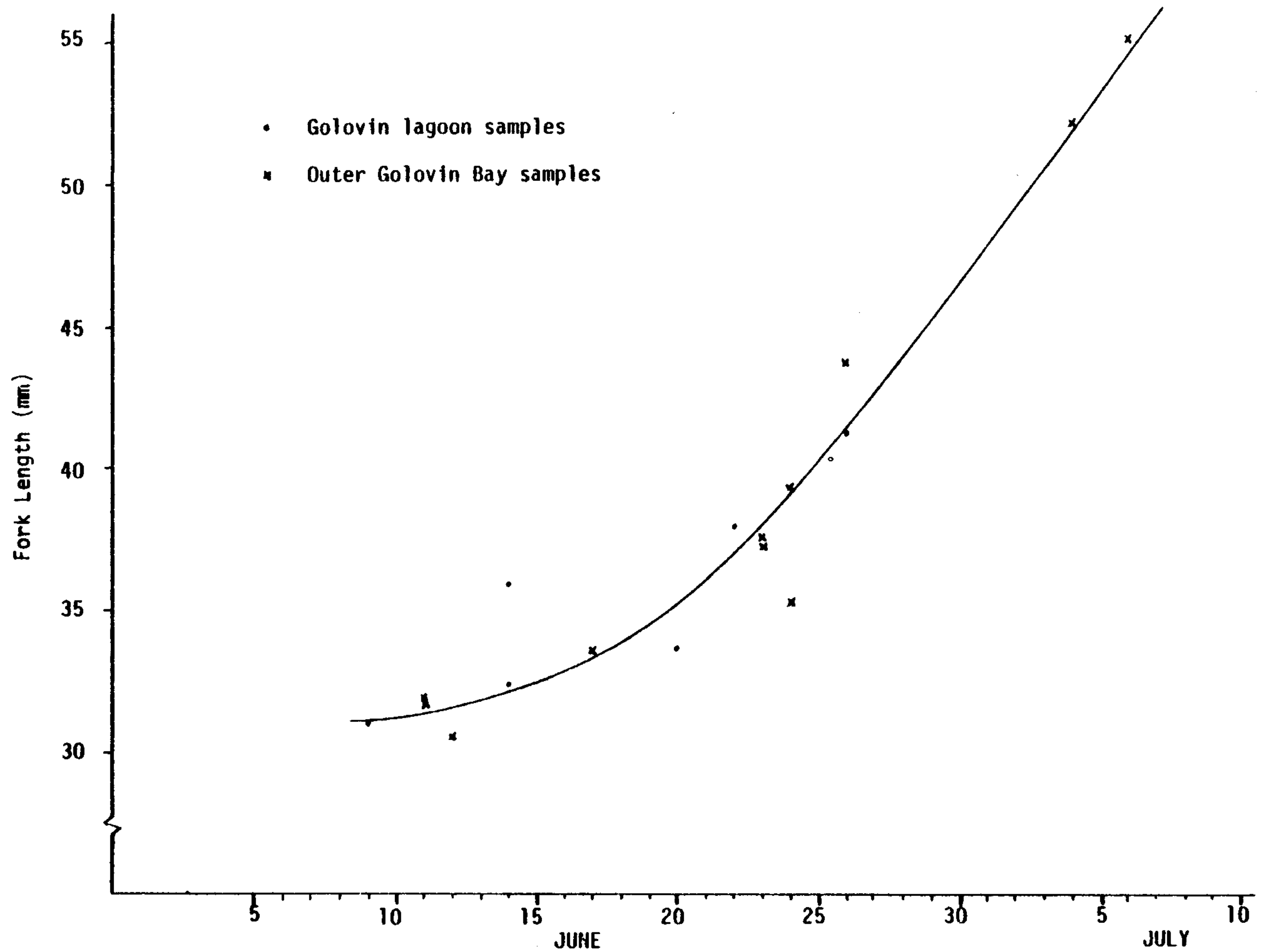


Figure 28. Growth of juvenile pink salmon captured in the nearshore waters of Golovin Bay from June 9 through July 9, 1977.

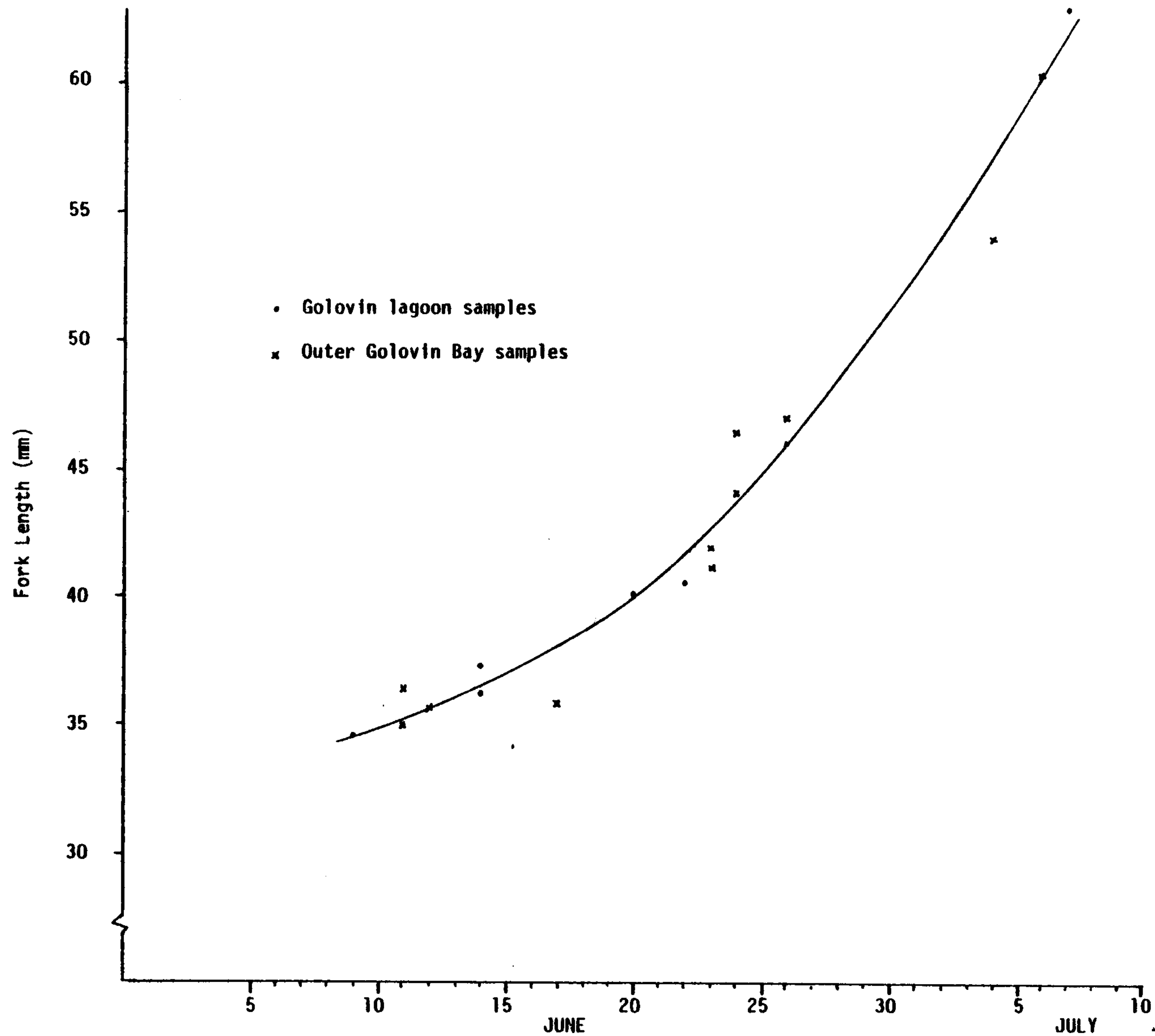


Figure 29. Growth of juvenile chum salmon captured in the nearshore waters of Golovin Bay from June 9 through July 9, 1977.

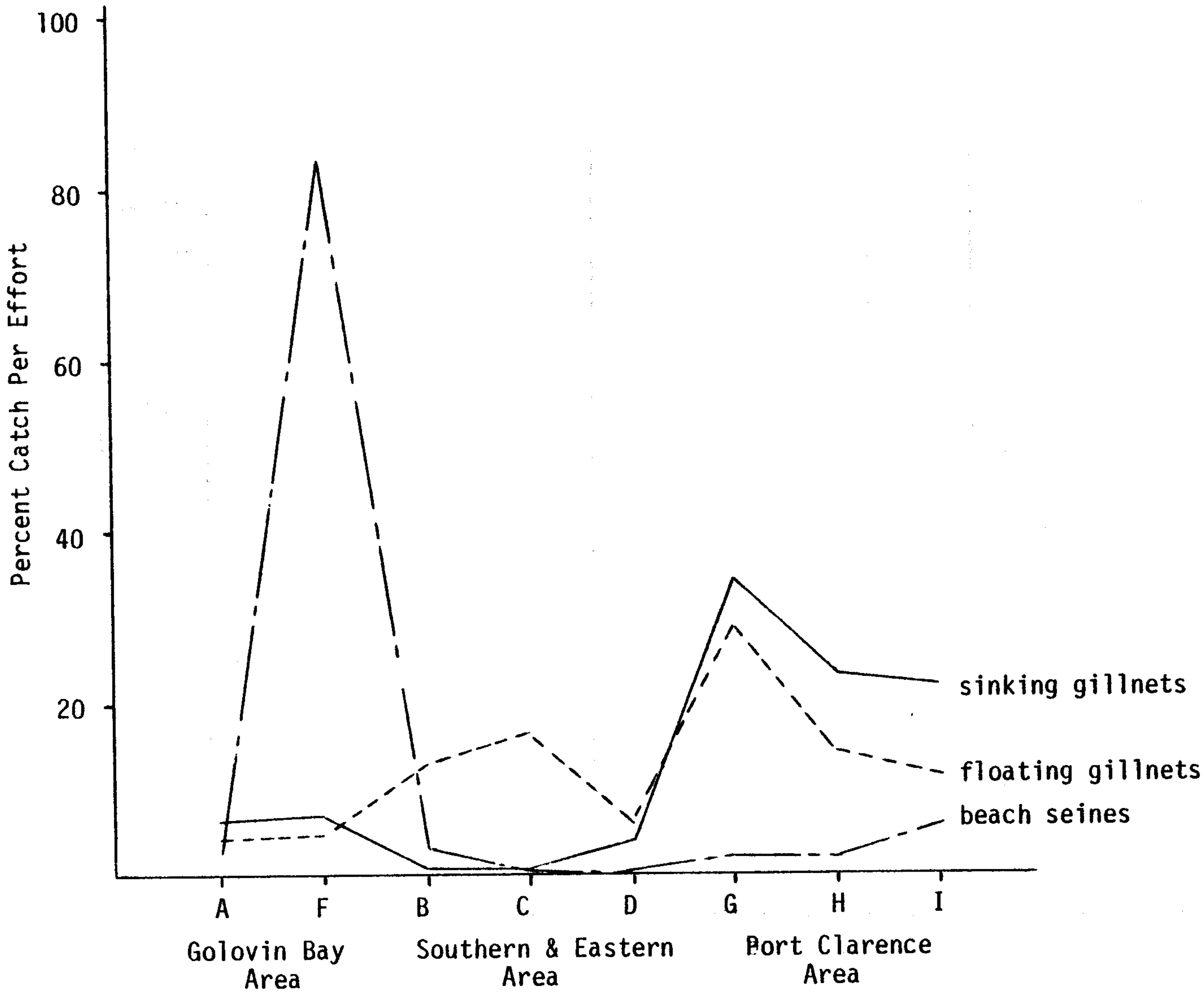


Figure 30. Percent catch per effort for finfish captured in the nearshore waters of Norton Sound from June 7 through October 21, 1977.

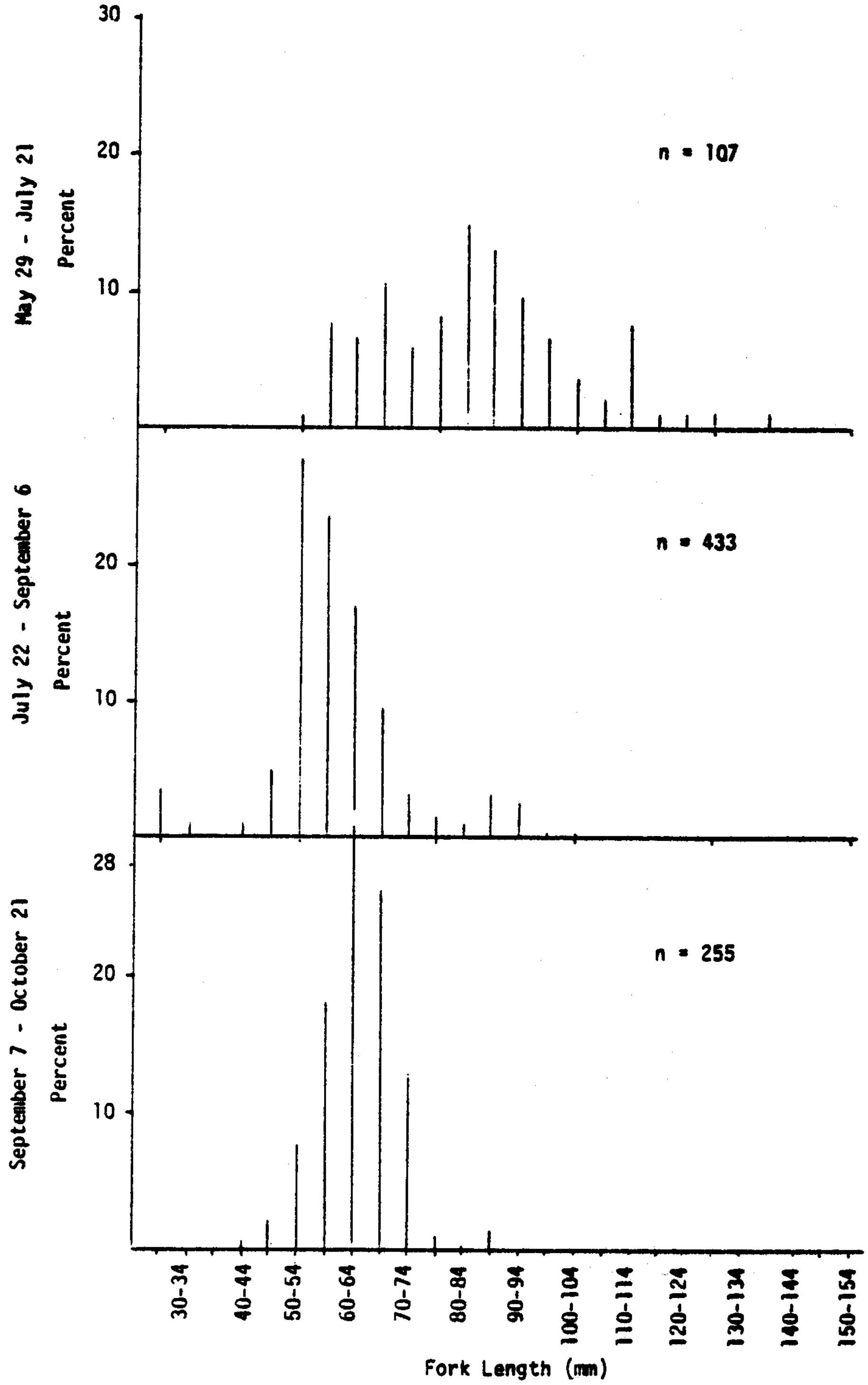


Figure 31. Length frequency (percent) of sand lance captured in Golovin Bay, 1977.

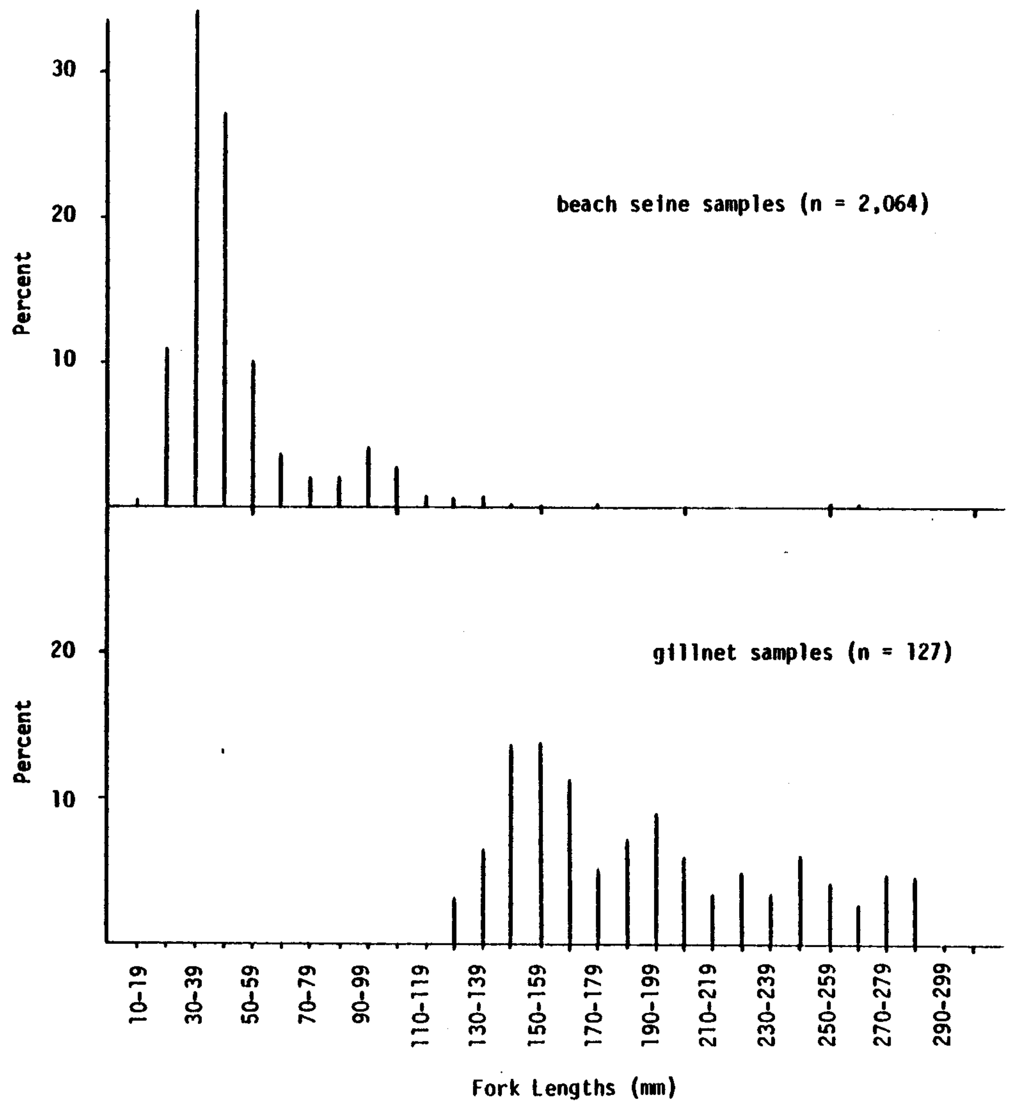


Figure 32. Length frequency (percent) of boreal smelt by gear type captured in nearshore waters of Norton Sound from June through October, 1977.

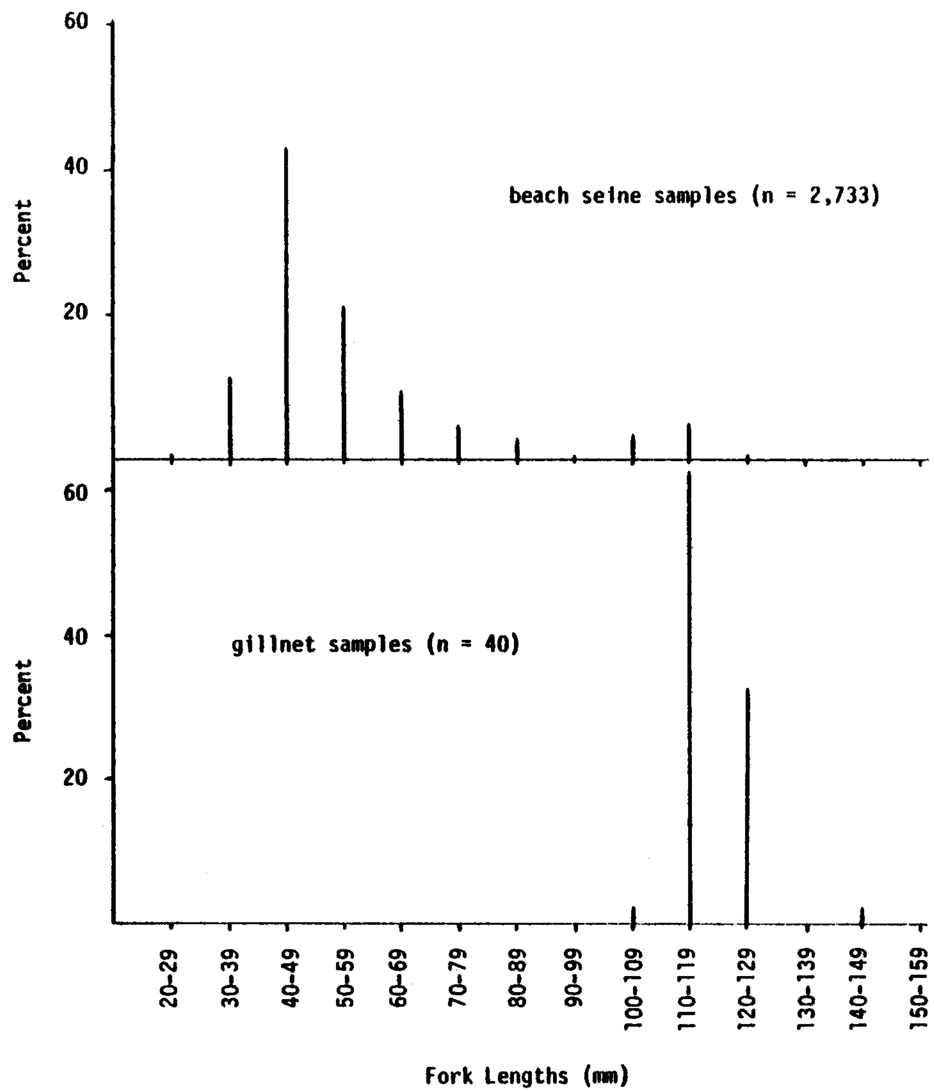


Figure 33. Length frequency (percent) of pond smelt by gear type captured in nearshore waters of Norton Sound from June through October, 1977.

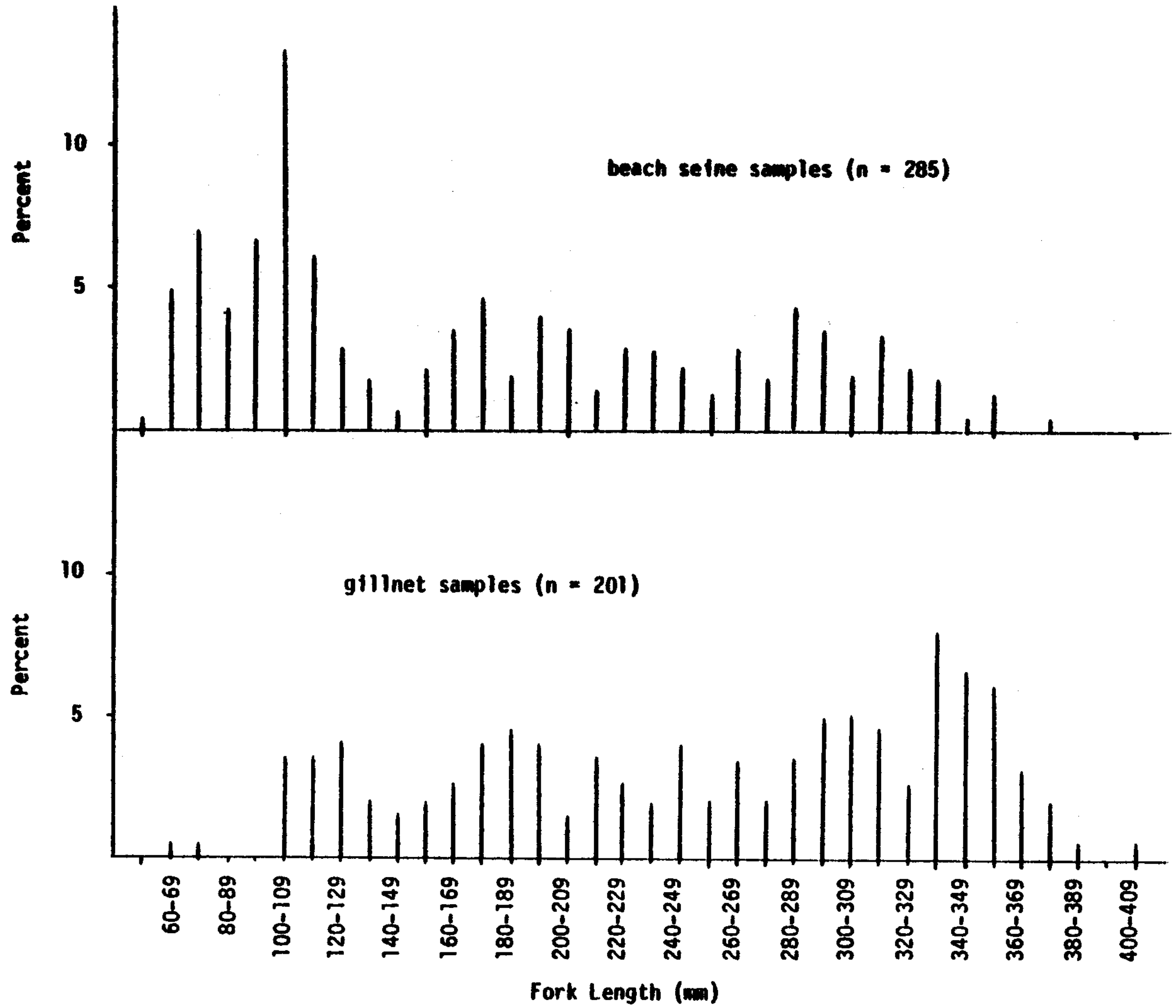


Figure 34. Length frequency (percent) of Bering cisco by gear type captured in nearshore waters of Norton Sound from June through October, 1977.

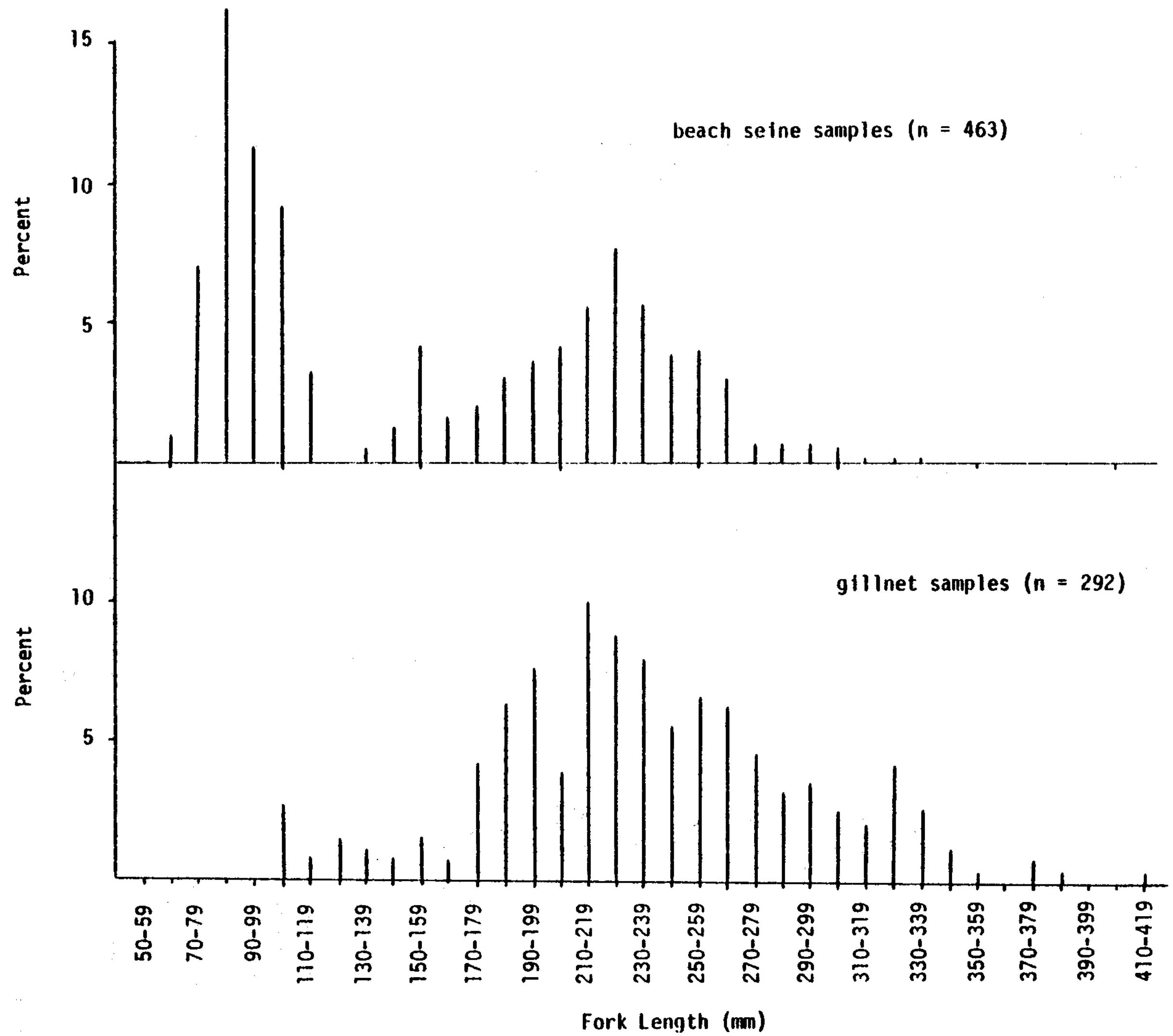


Figure 35. Length frequency (percent) of least cisco by gear type captured in nearshore waters of Norton Sound from June through October, 1977.

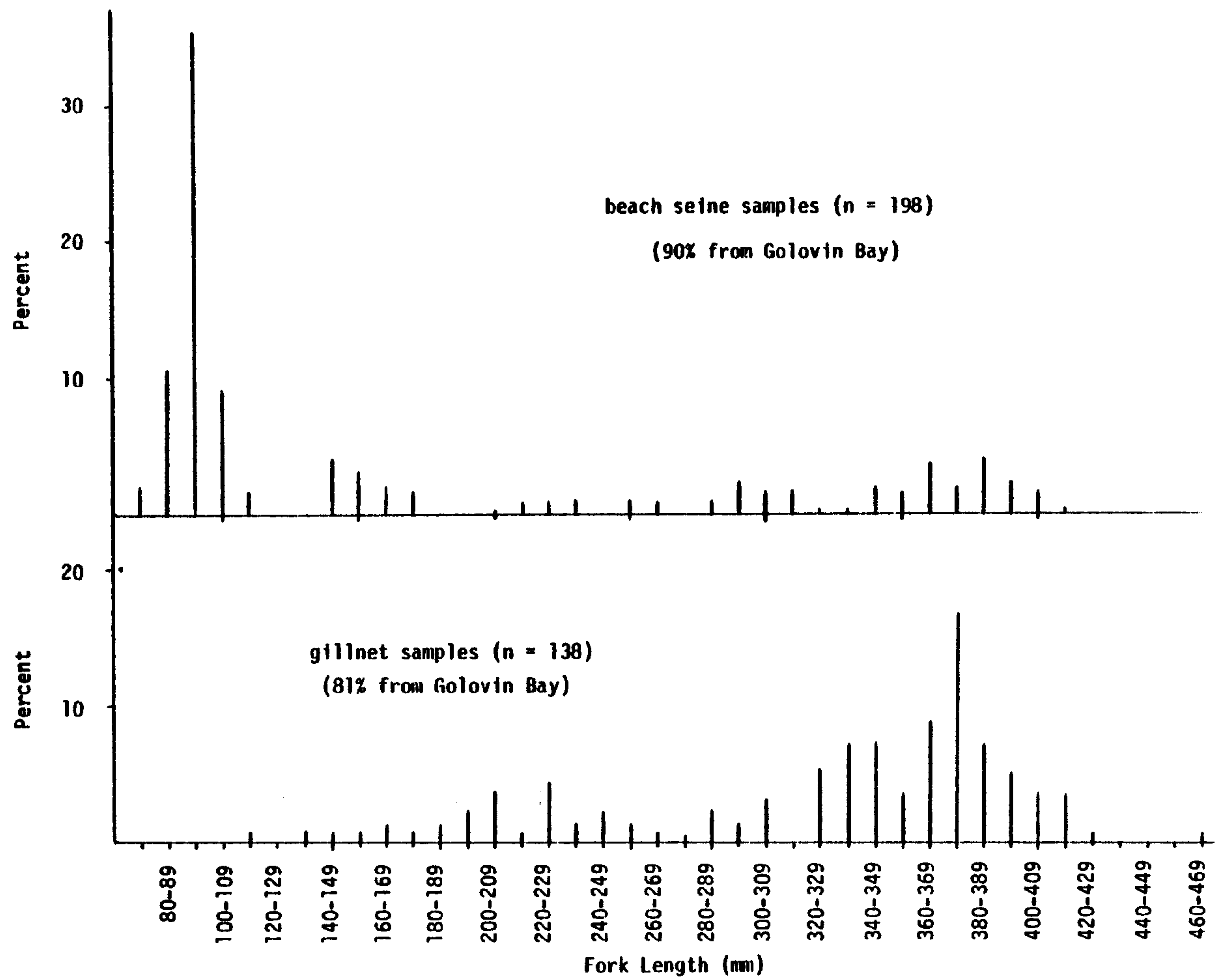


Figure 36. Length frequency (percent) of humpback whitefish by gear type captured in nearshore waters of Norton Sound from June through October, 1977.

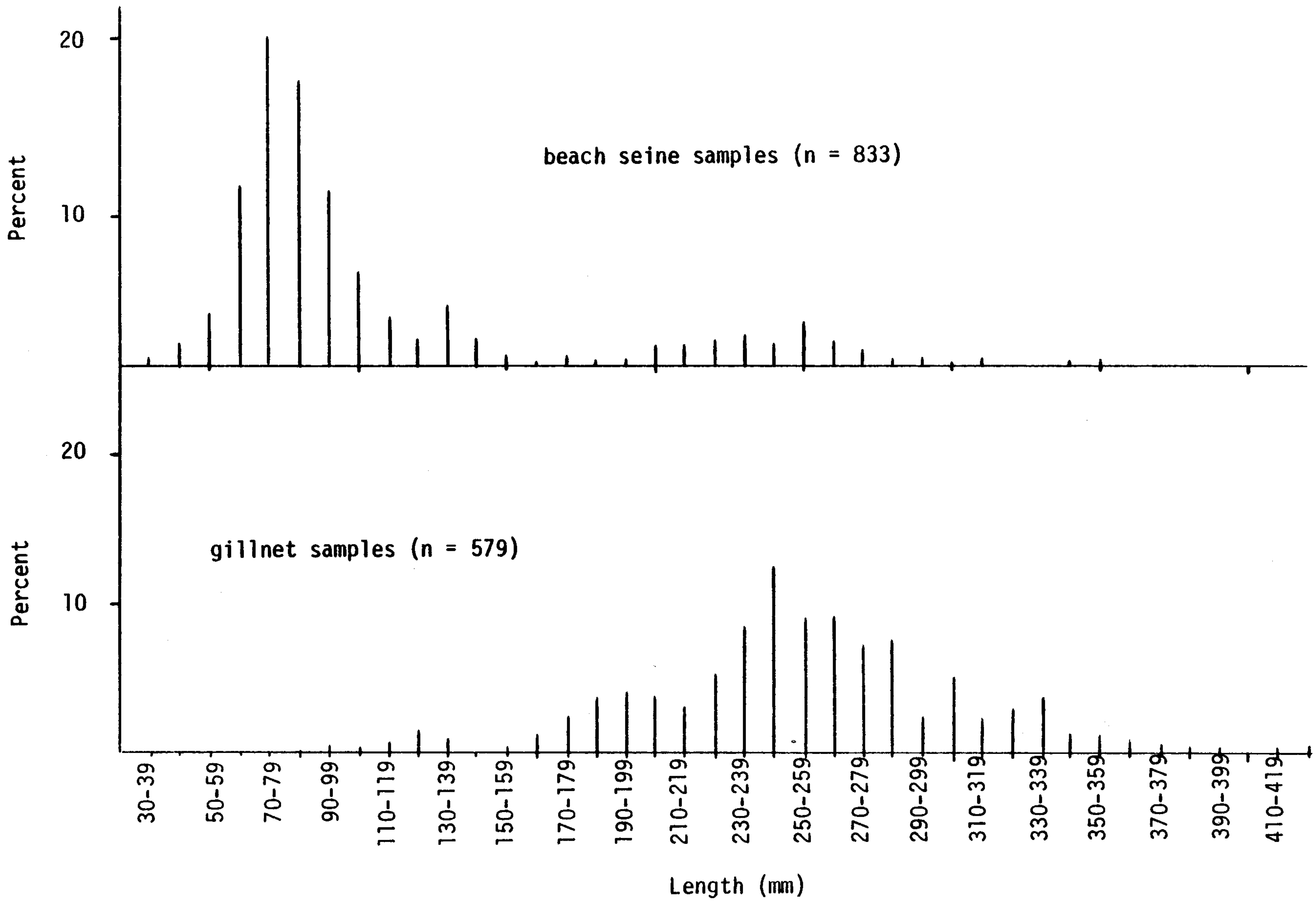


Figure 37. Length frequency (percent) of saffron cod captured in beach seines and gillnets in the near-shore waters of Norton Sound, 1977.

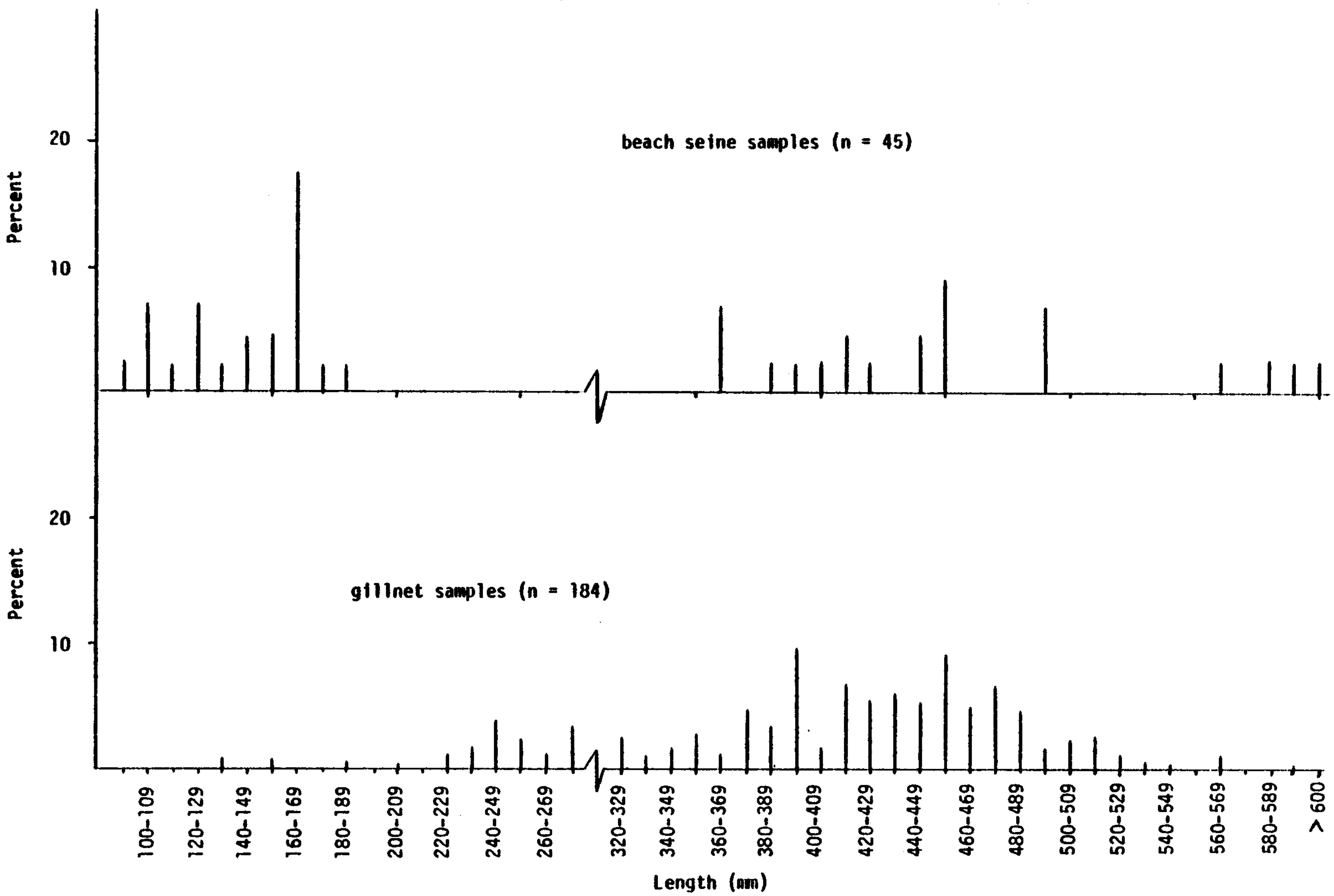


Figure 38. Length frequency (percent) of Arctic char by gear type captured in nearshore waters of Norton Sound from June through October, 1977.

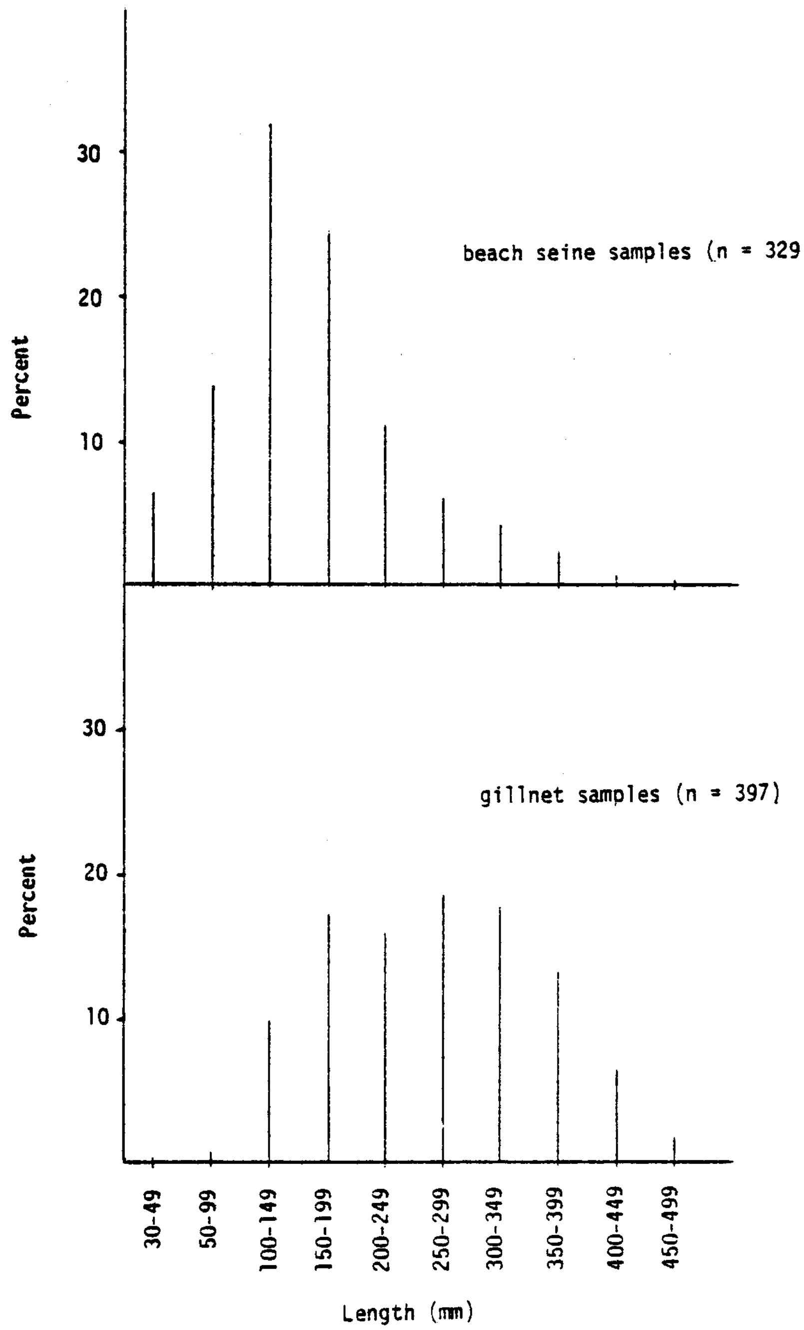


Figure 39. Length frequency (percent) of starry flounder by gear type captured in near-shore waters of Norton Sound from June through October, 1977.

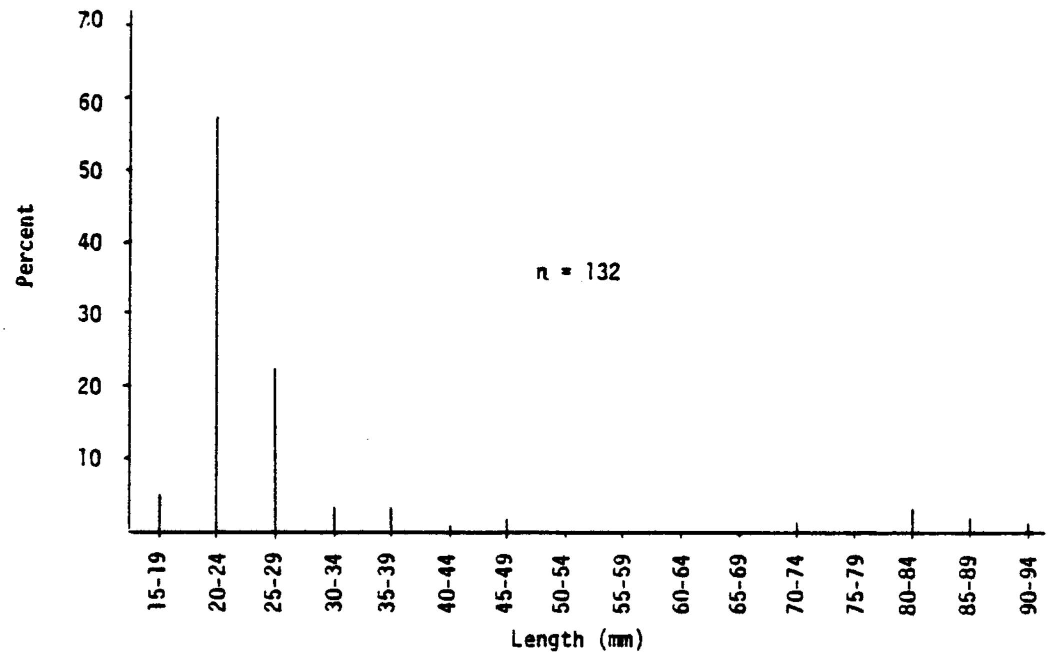


Figure 40. Length frequency (percent) of threespine stickleback captured in the nearshore waters of Norton Sound, 1977.

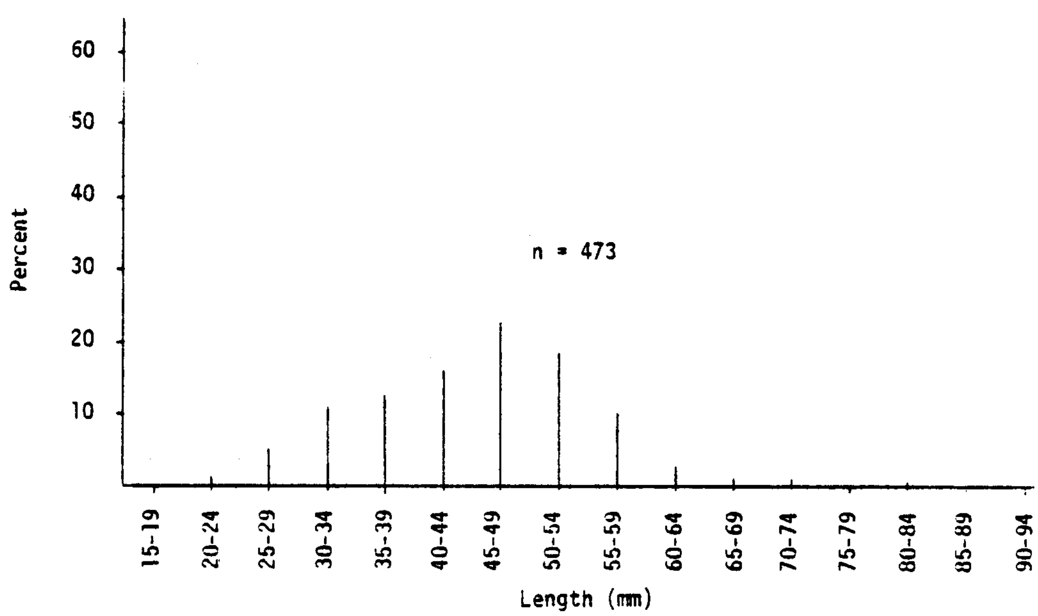


Figure 41. Length frequency (percent) of ninespine stickleback captured in the nearshore waters of Norton Sound, 1977.

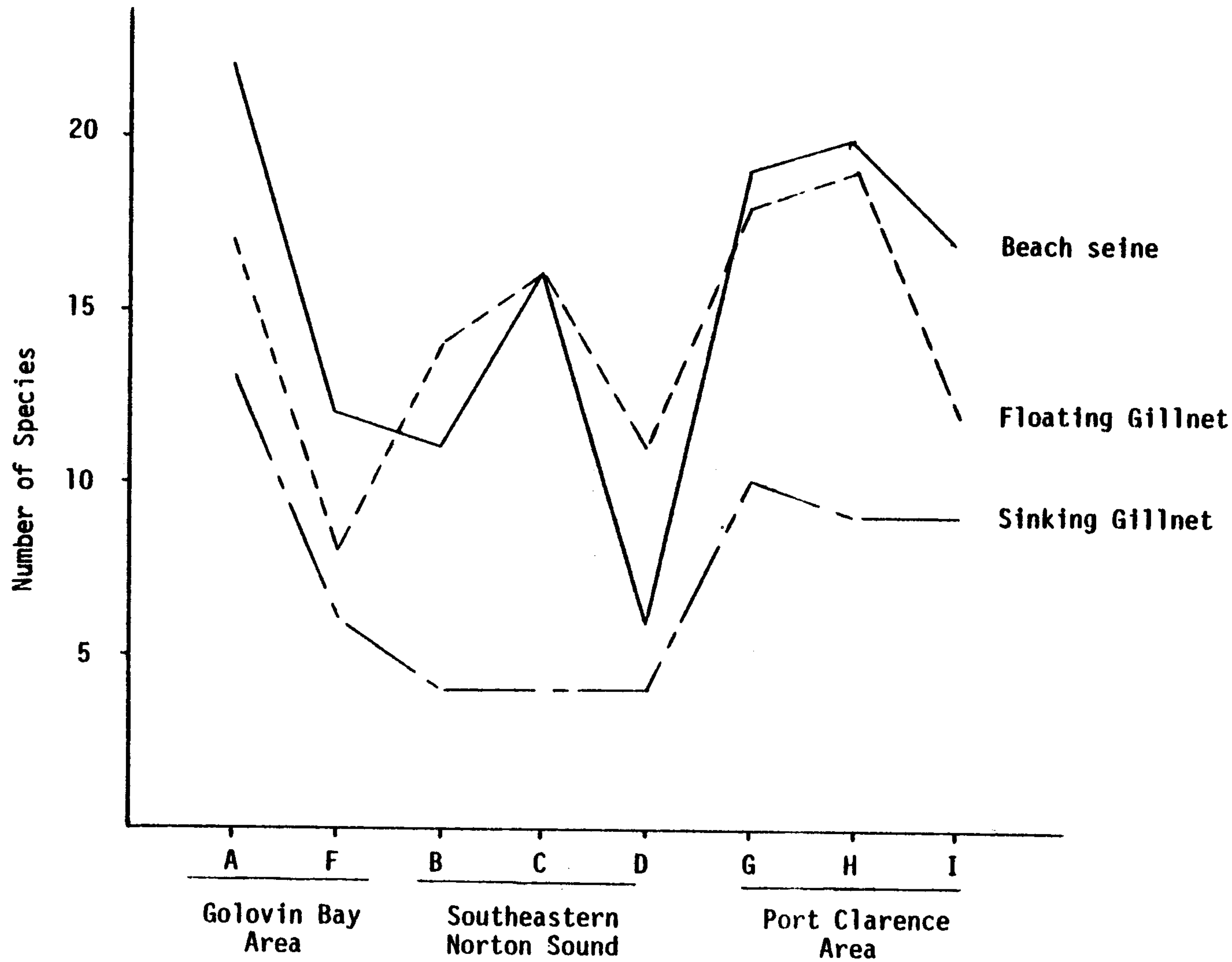


Figure 42. Species diversity by gear type of fish captured in the nearshore waters of Norton Sound from June through October, 1976-77.

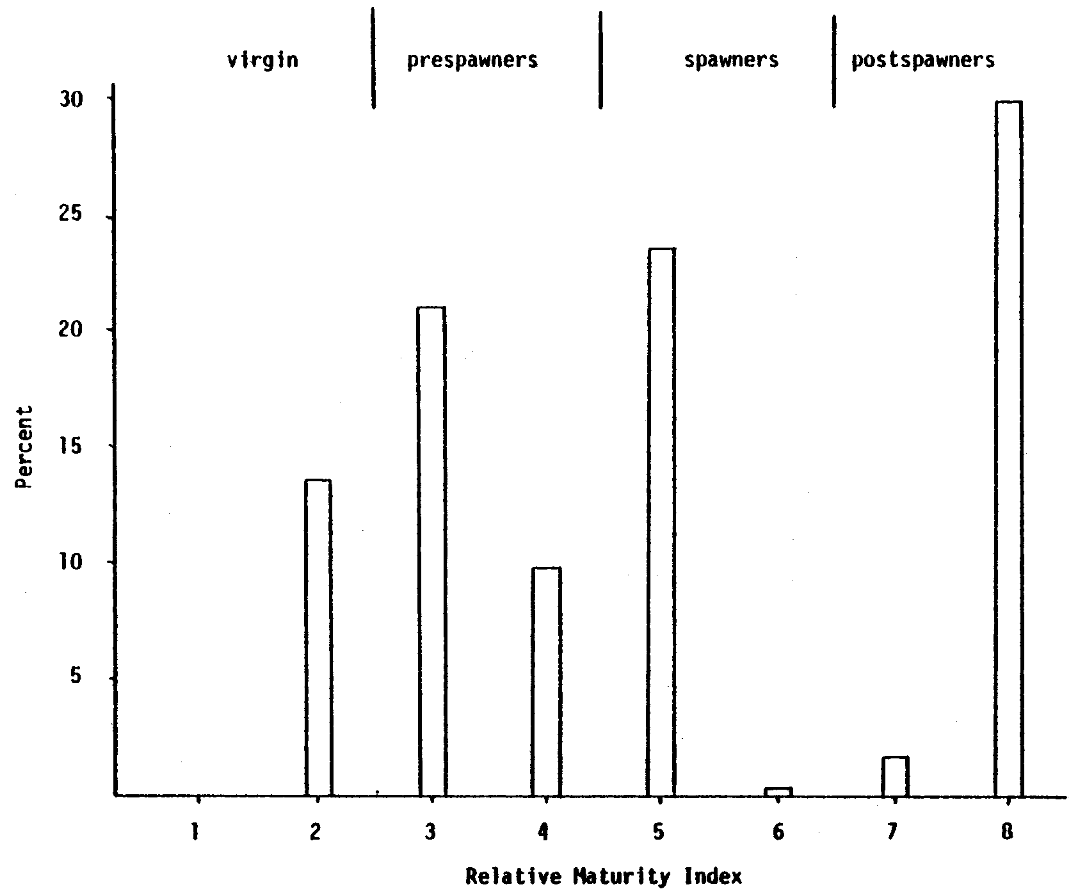


Figure 43. Relative maturity of herring captured in the offshore surface waters of Norton Sound from June 22 through July 12, 1977.

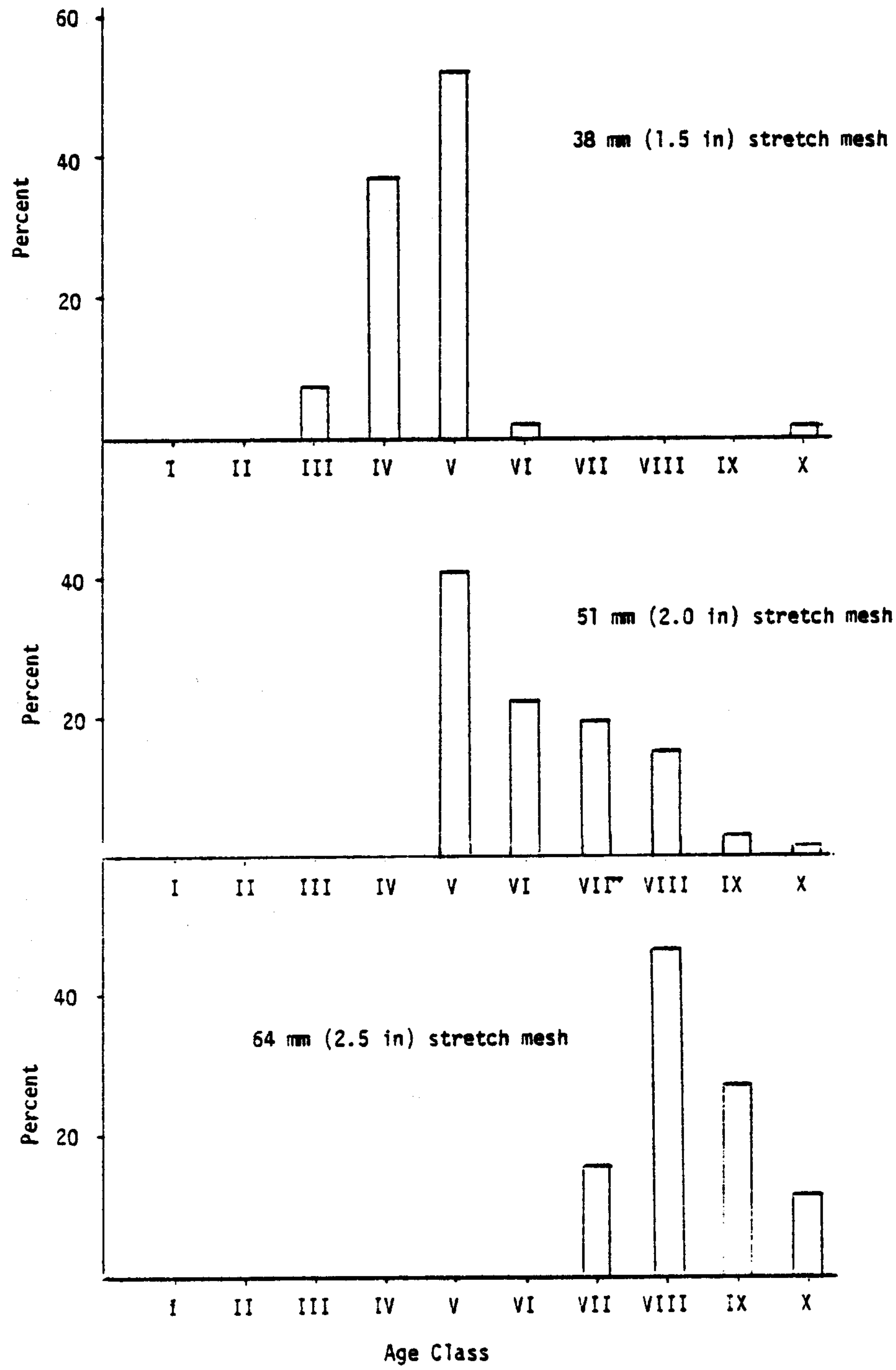


Figure 44. Mesh selectivity of gillnets to age classes of herring captured in the offshore waters of Norton Sound from June 22 through July 12, 1977.

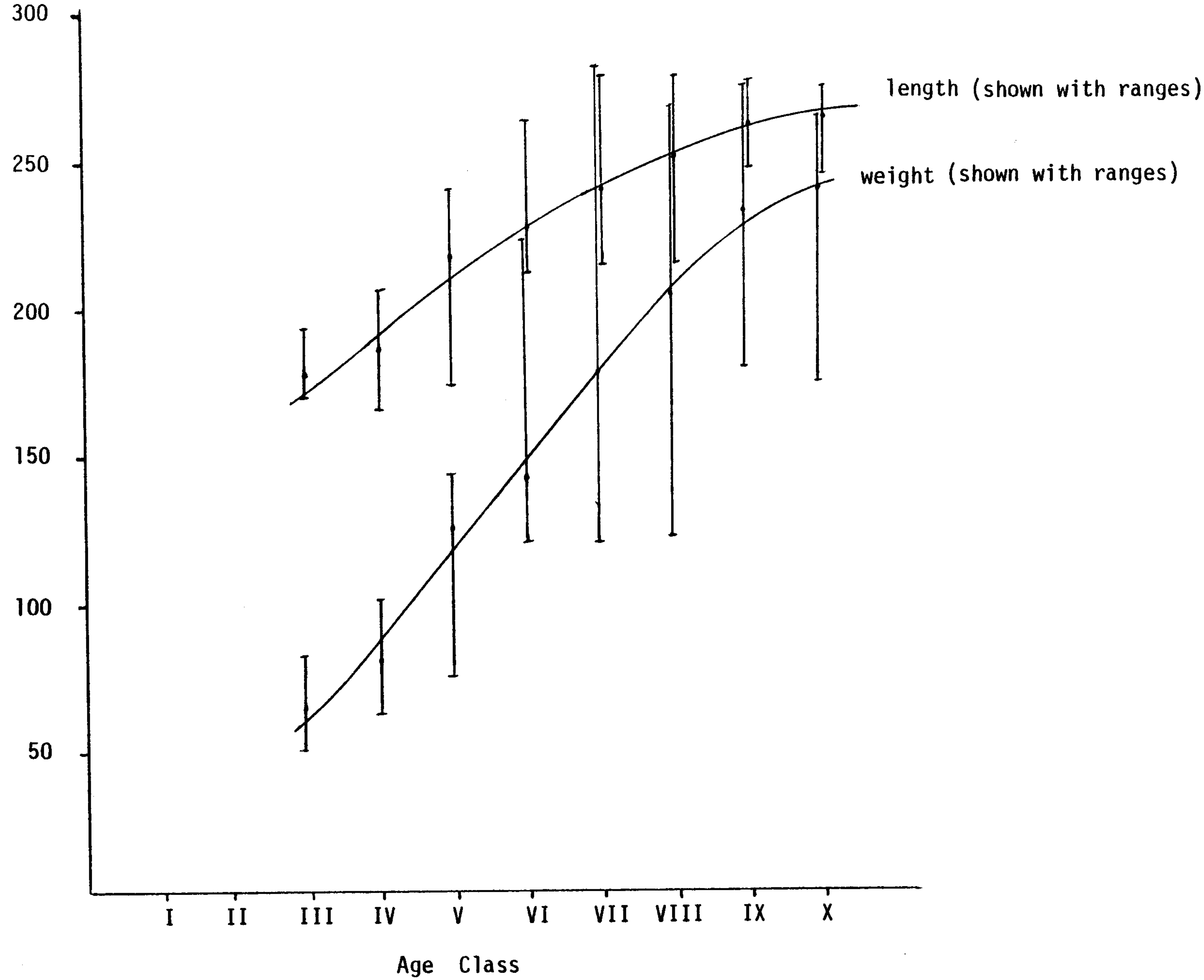


Figure 45. Mean length and weight-at-age for herring collected in the offshore surface waters of Norton Sound from June 22 through July 9, 1977.

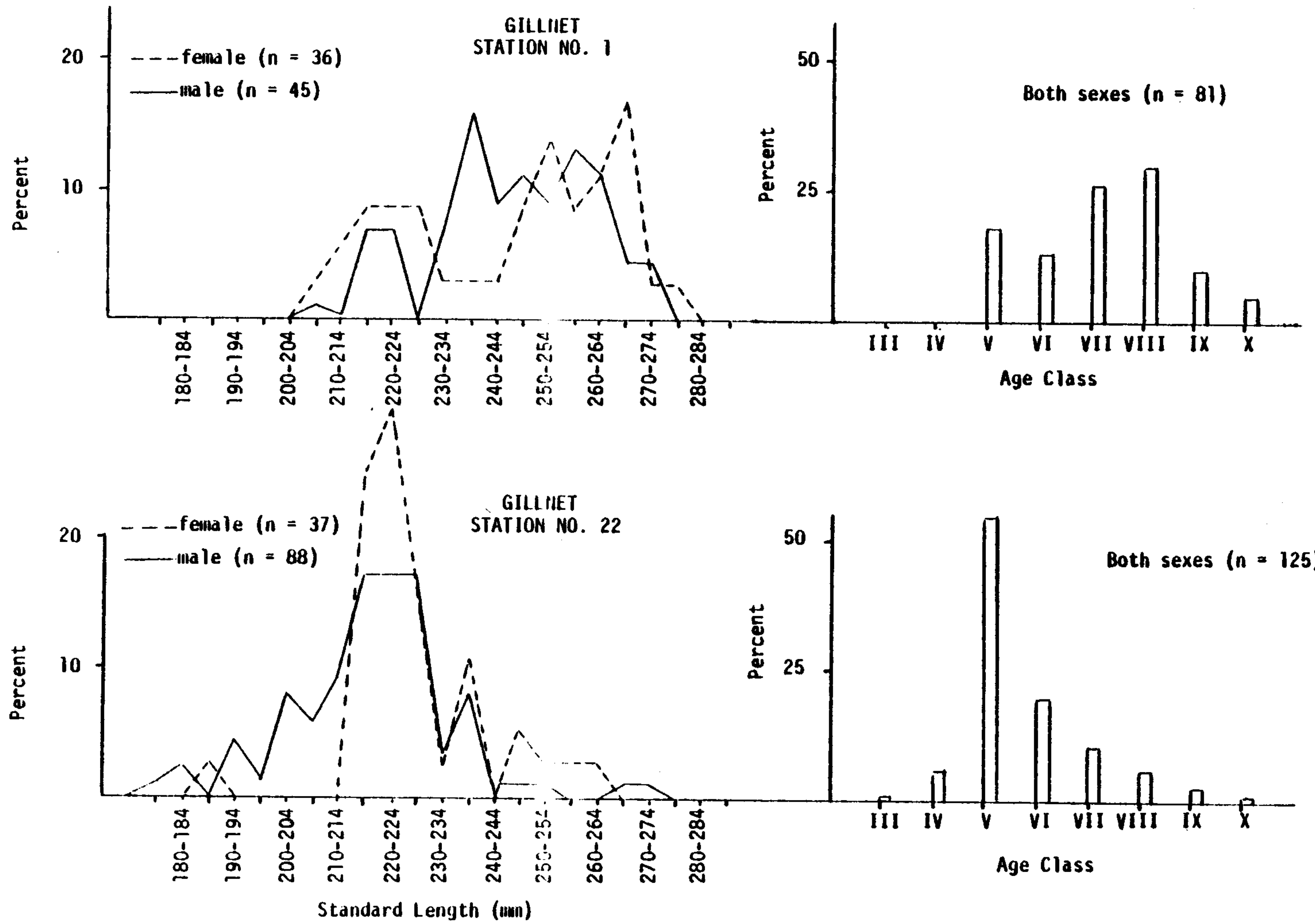


Figure 46. Length frequency and percent age composition of herring captured at stations 1 and 20 in Norton Sound during the M/V Royal Atlantic cruise from June 22 through July 12, 1977.

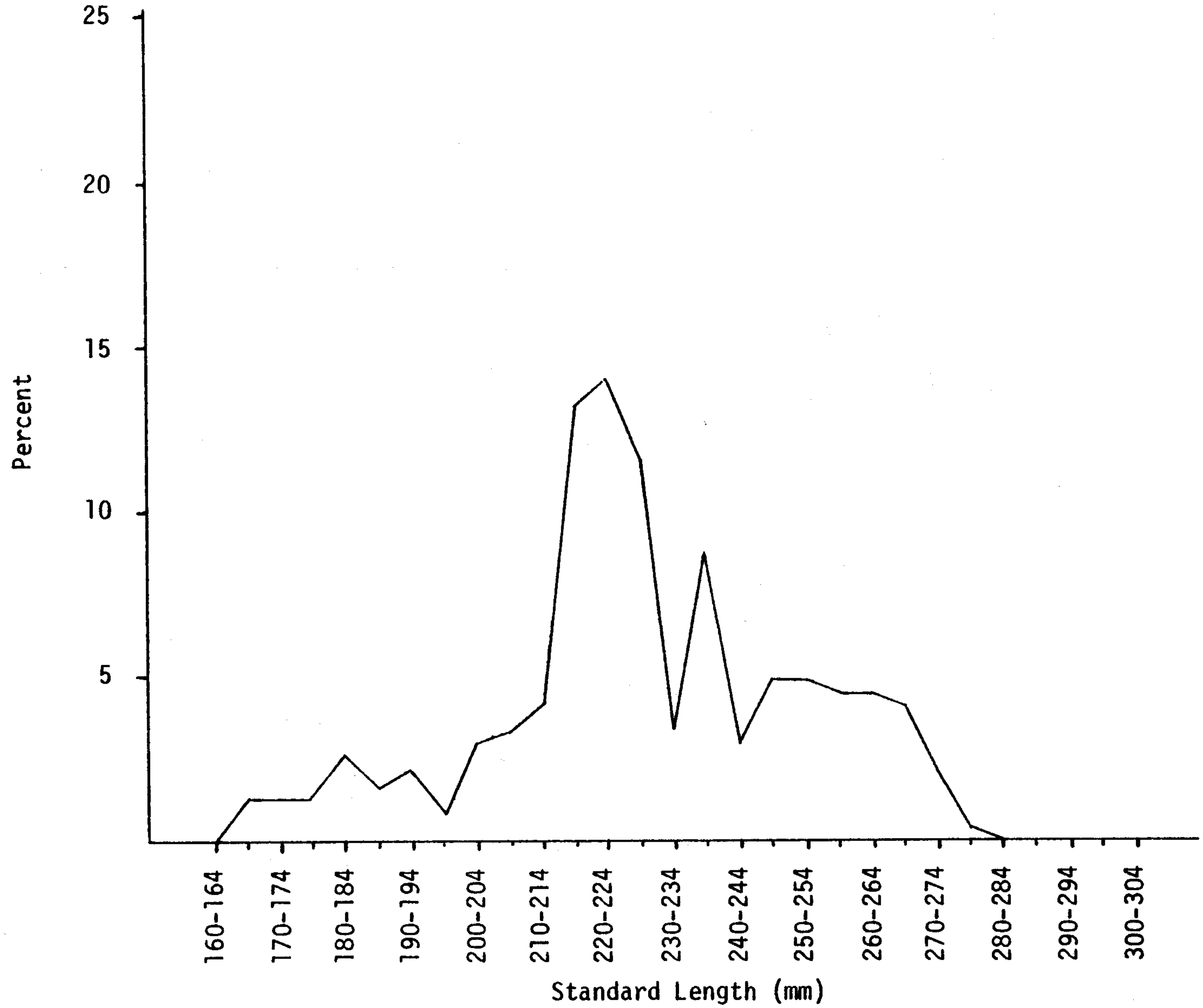


Figure 47. Length frequency (percent) of herring sampled in offshore surface waters of Norton Sound from June 22 through July 12, 1977.

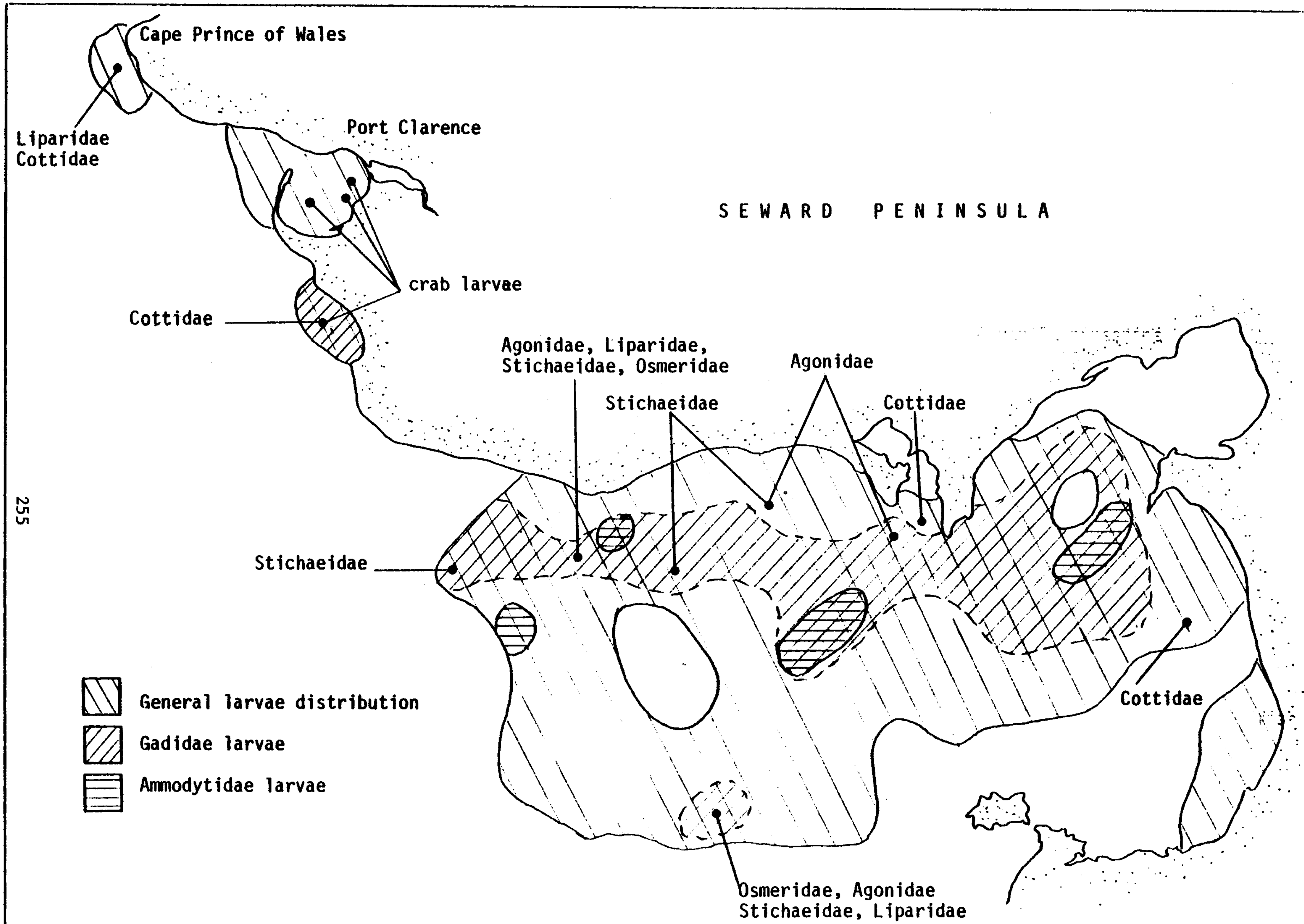


Figure 48. Larvae distribution in the offshore surface waters of Norton Sound June 22 through July 7, 1977.

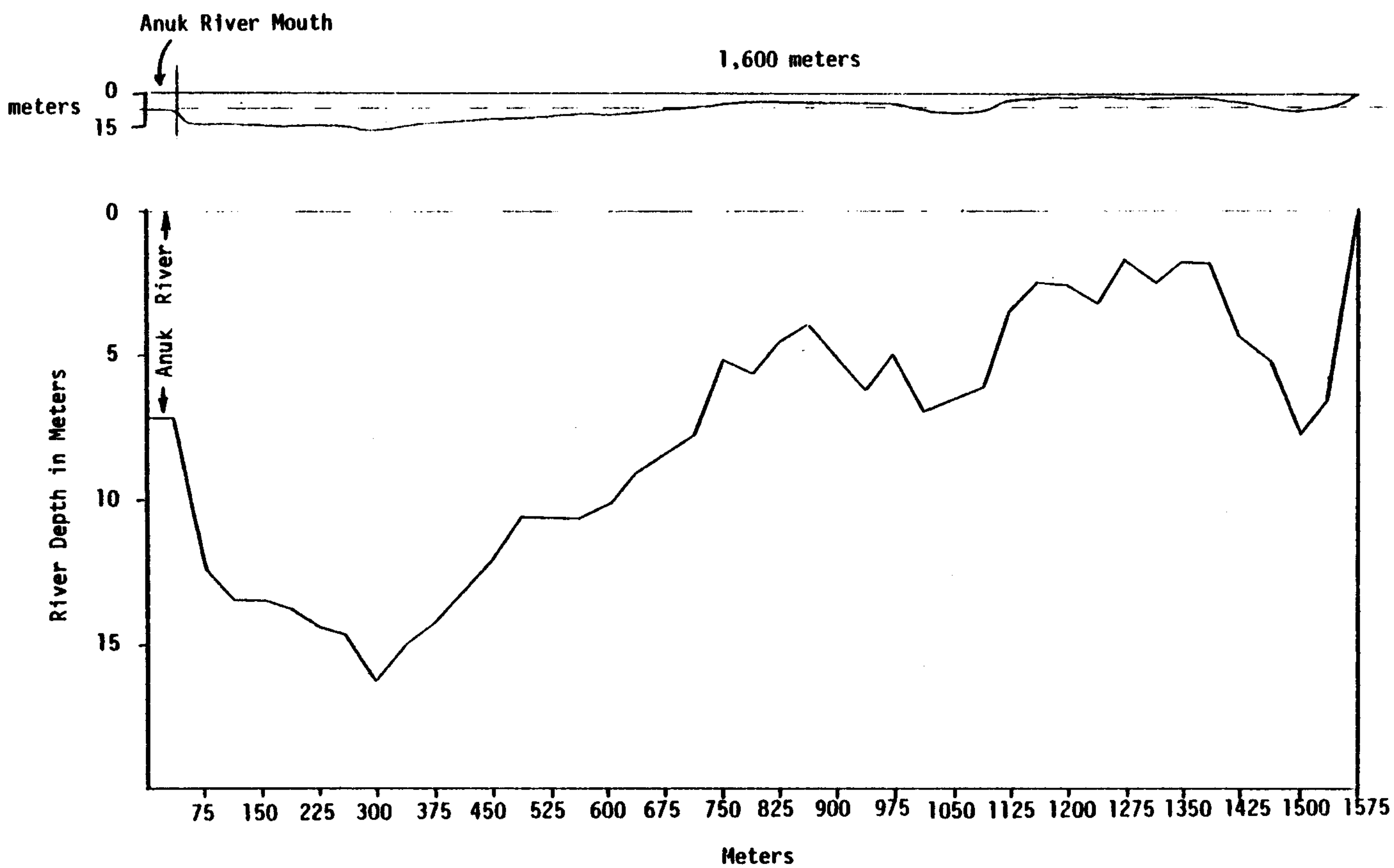


Figure 49. Exaggerated profile of the Yukon River 101 kilometers upriver from Flat Island, 1977. This site was location for smolting studies.

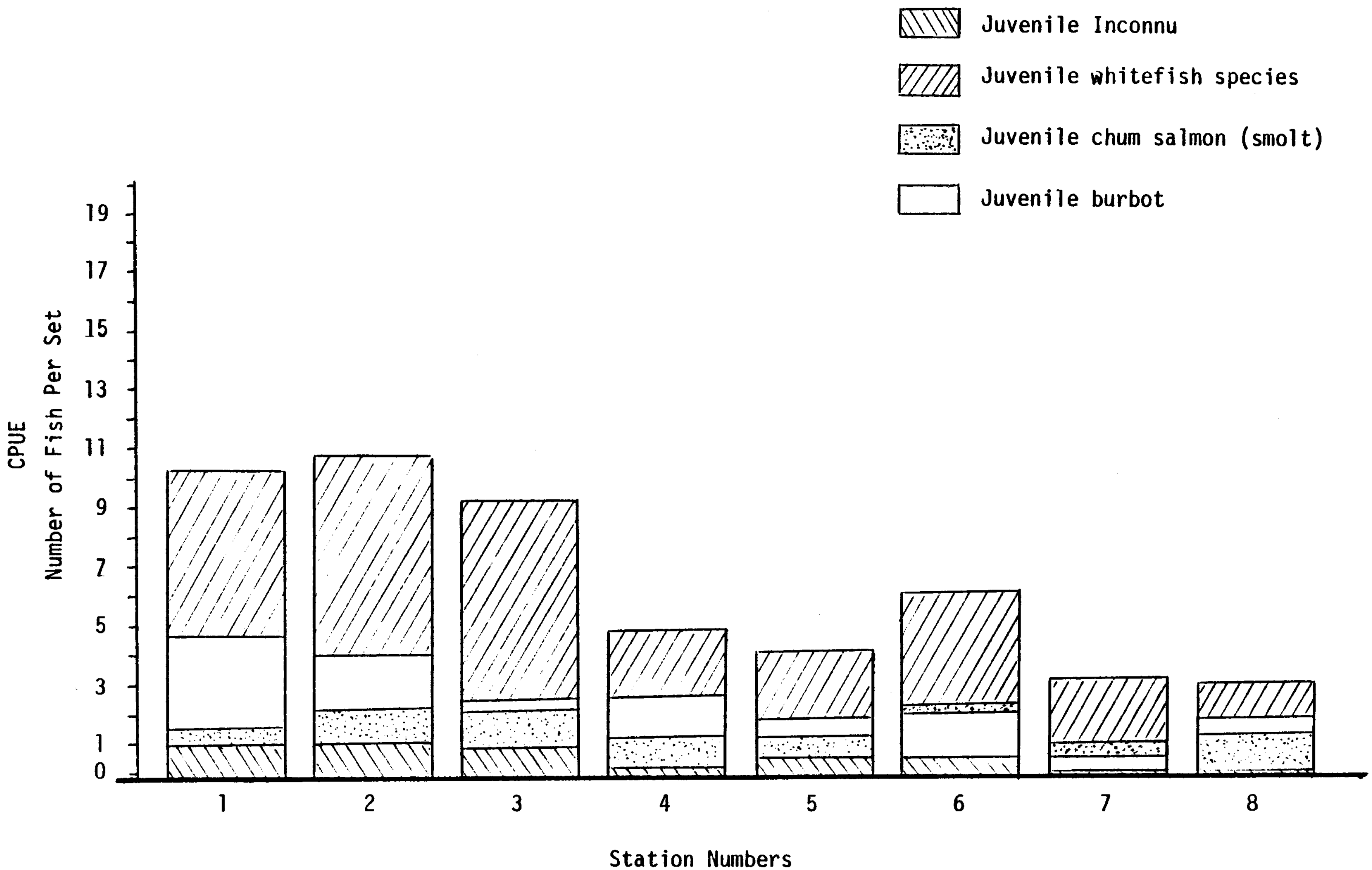


Figure 50. Catch per unit effort for four fish groups by station number captured in the Yukon River from June 7 through July 7, 1977. Site location was at the confluence of the Anuk River.

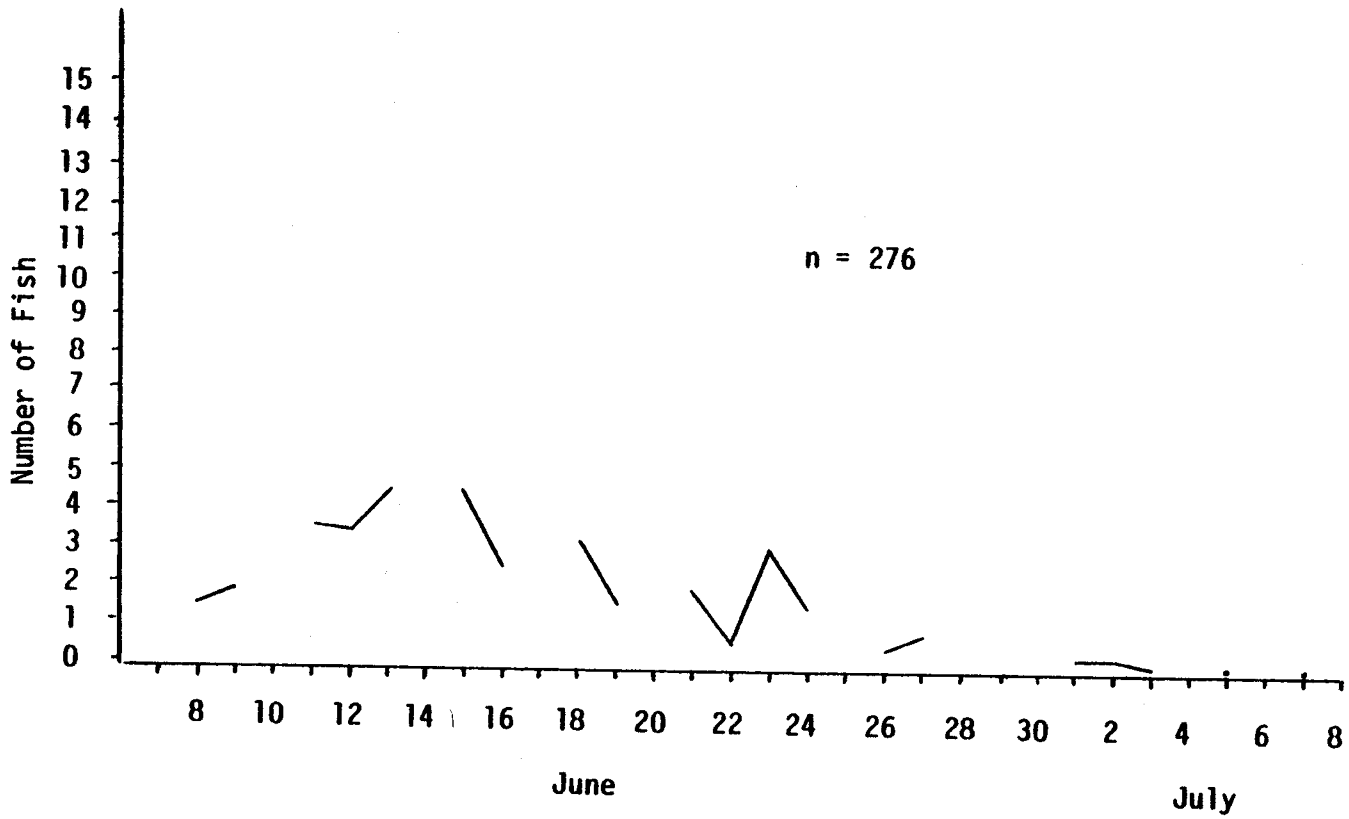


Figure 51. Timing and abundance of chum salmon smolt down the Yukon River 101 kilometers upriver from Flat Island in June, 1977.

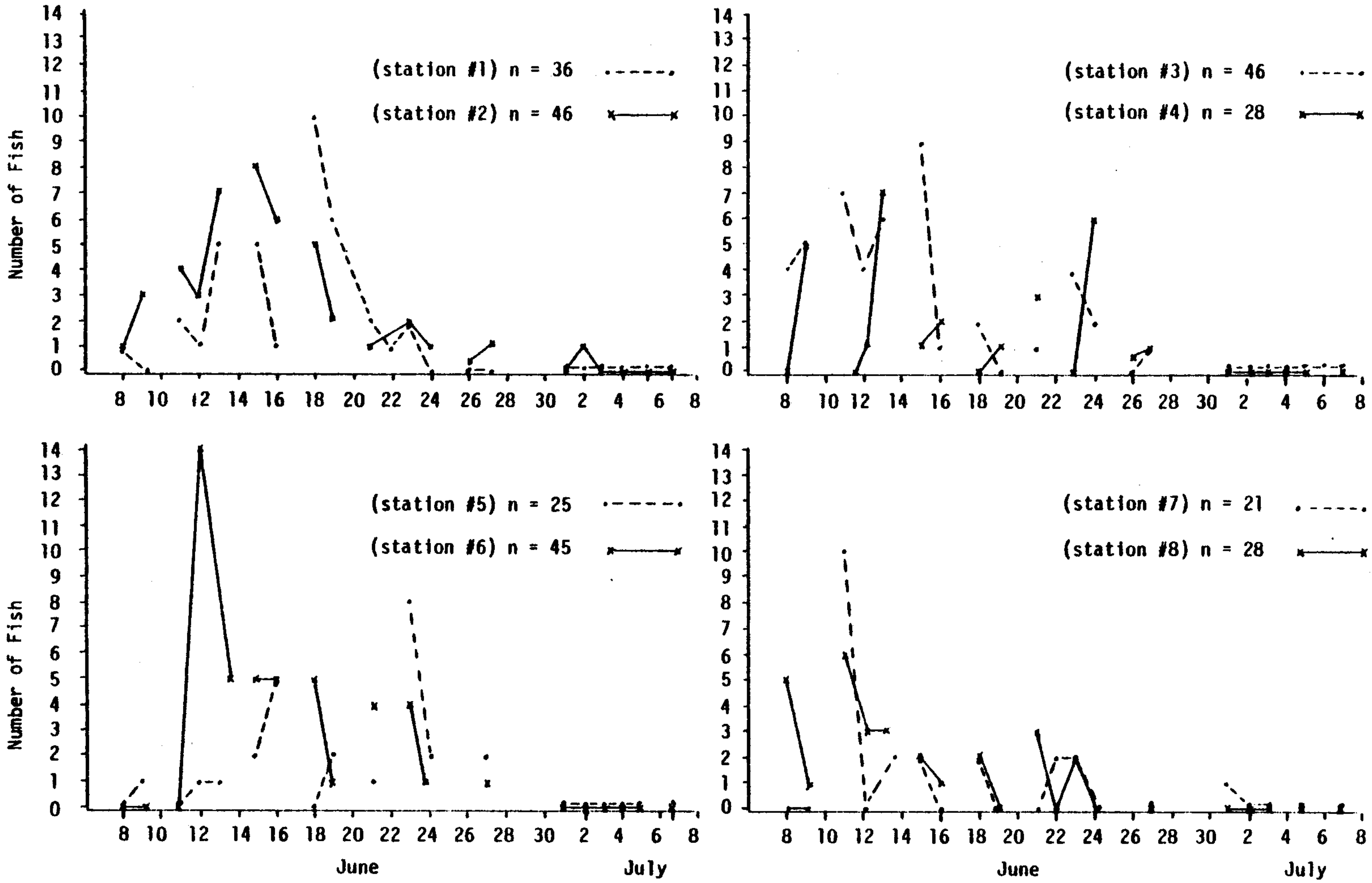


Figure 52. Spatial and temporal distribution of chum salmon smolt in the Yukon River 101 kilometers upriver from Flat Island in June, 1977.

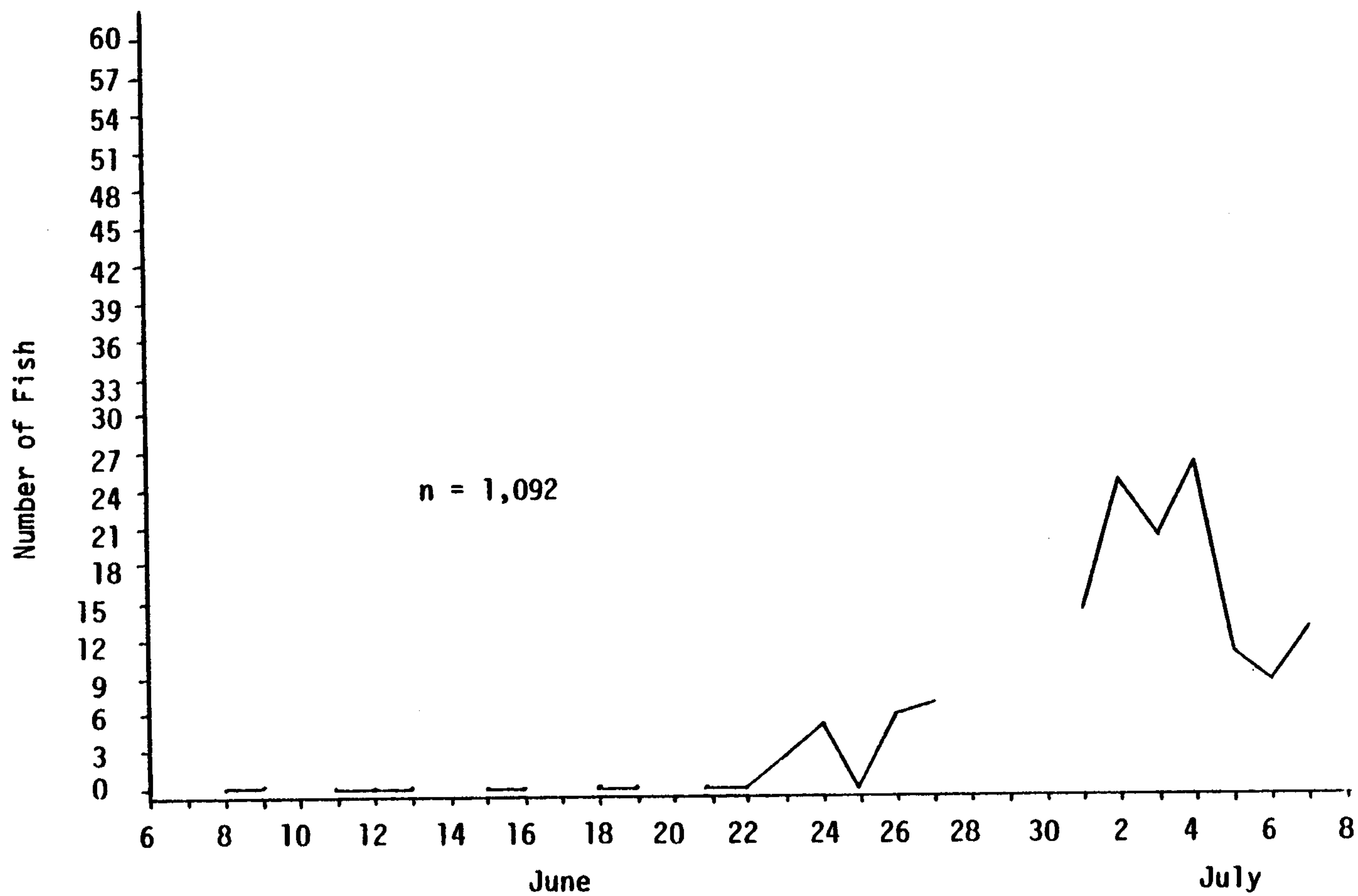


Figure 53. Timing and abundance of juvenile whitefish species down the Yukon River 101 kilometers upriver from Flat Island in June, 1977.

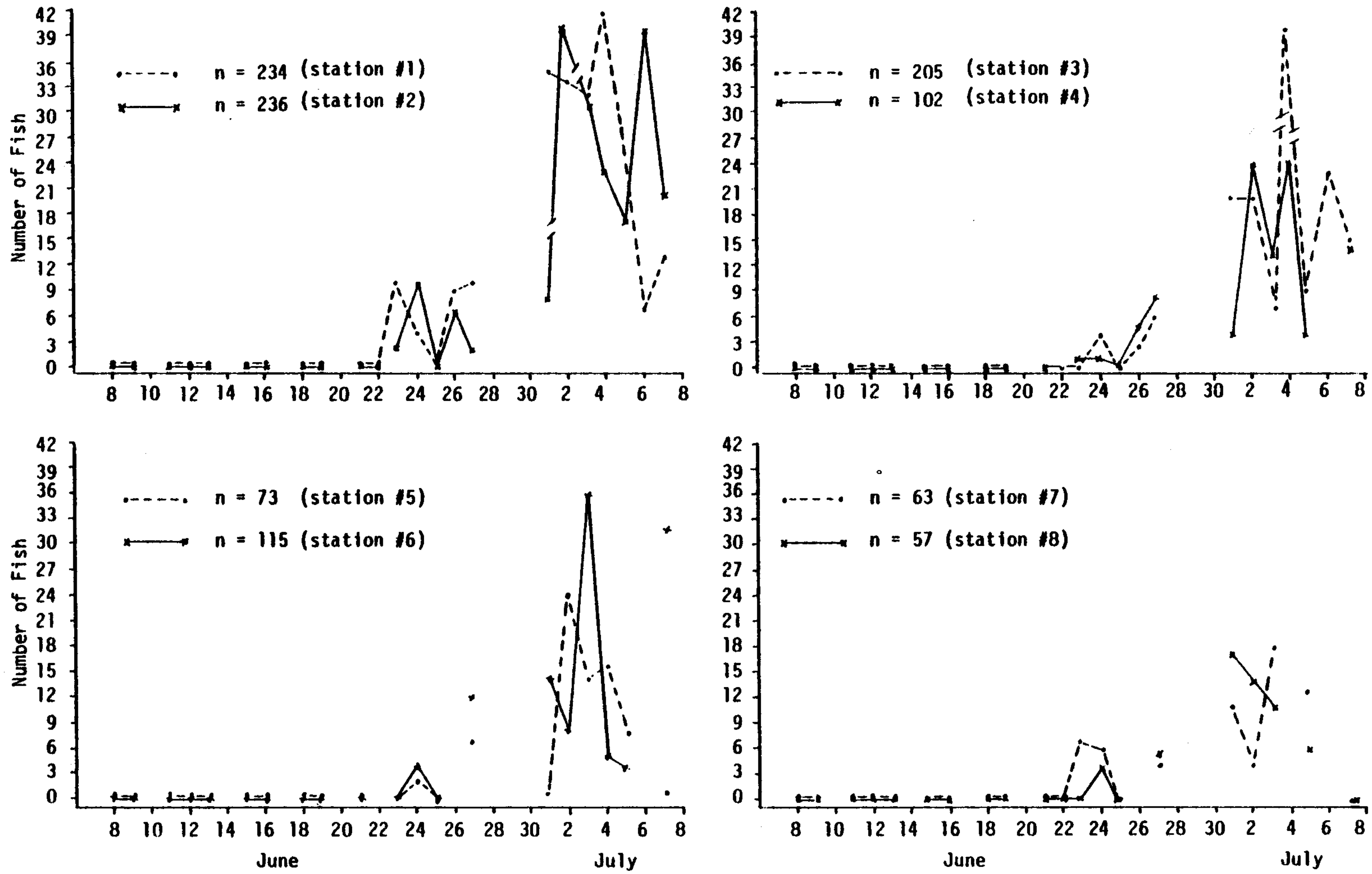


Figure 54. Spatial and temporal distribution of juvenile whitefish species down the Yukon River 101 kilometers upriver from Flat Island in June, 1977.

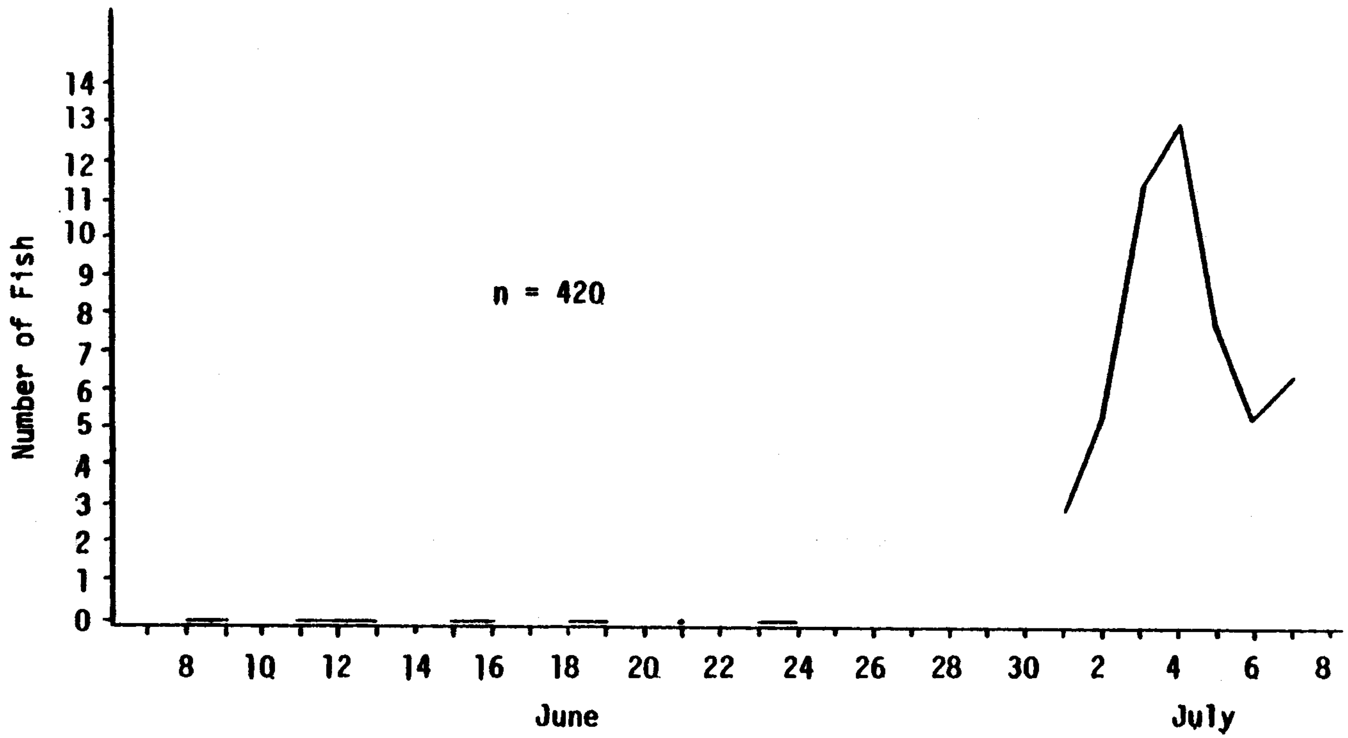


Figure 55. Timing and abundance of juvenile burbot down the Yukon River 101 kilometers upriver from Flat Island in June, 1977.

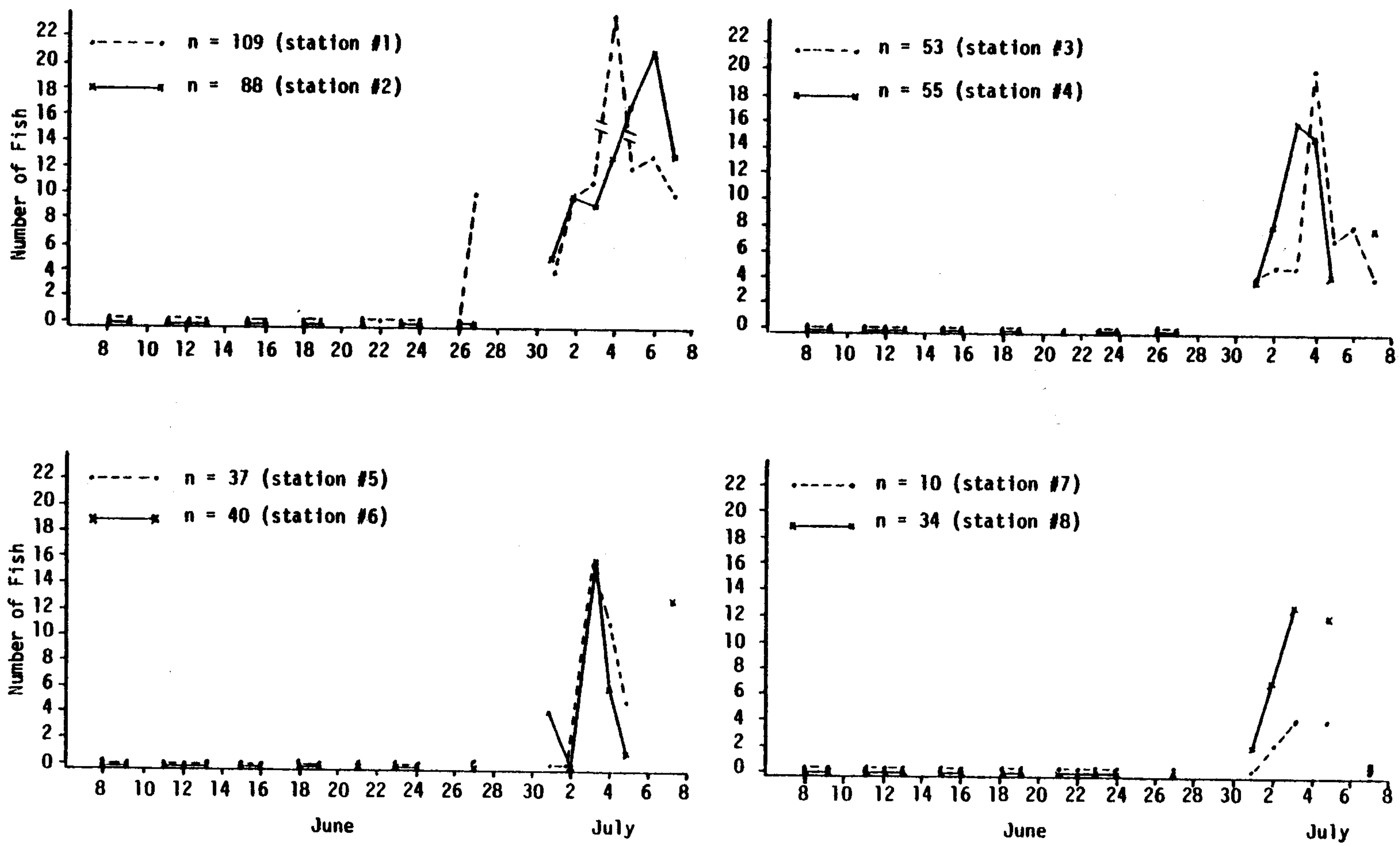


Figure 56. Spatial and temporal distribution of juvenile burbot down the Yukon River 101 kilometers upriver from Flat Island in June, 1977.

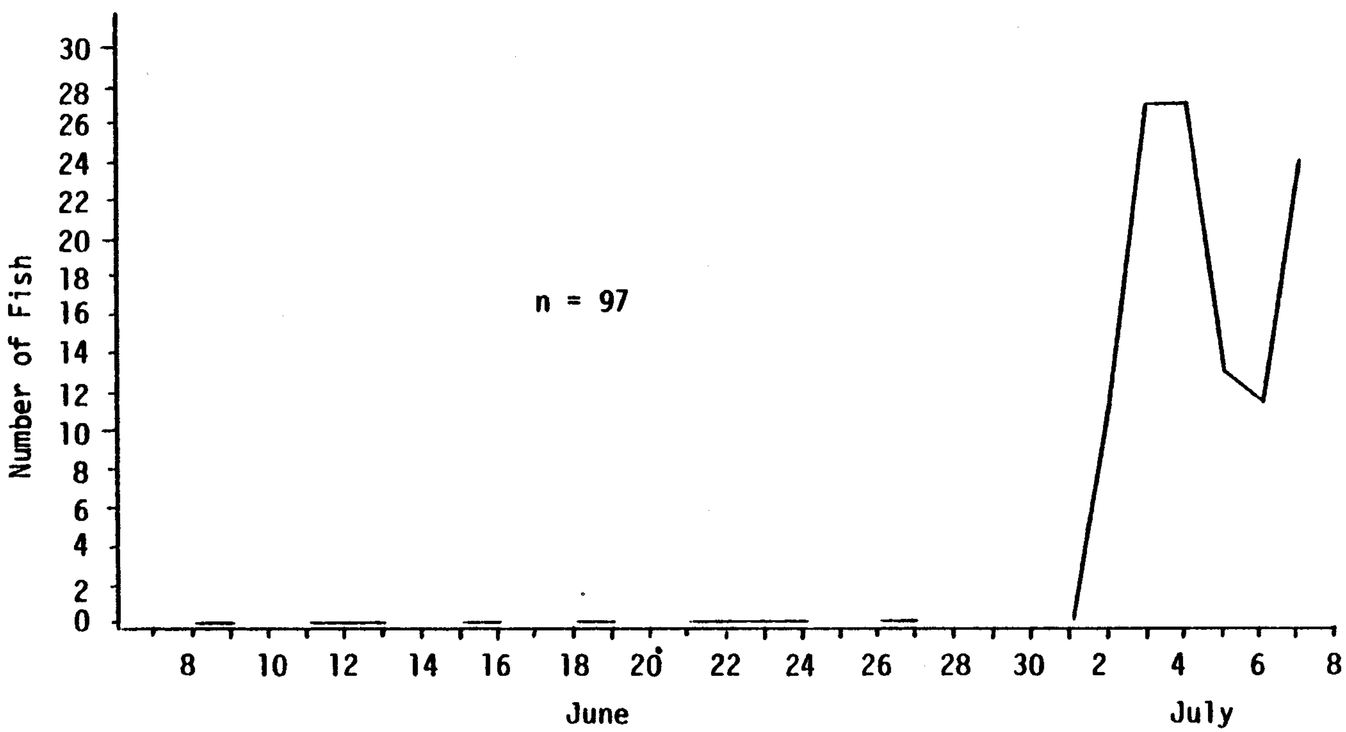


Figure 57 . Timing and abundance of juvenile sheefish (Inconnu) down the Yukon River 101 kilometers upriver from Flat Island in June, 1977.

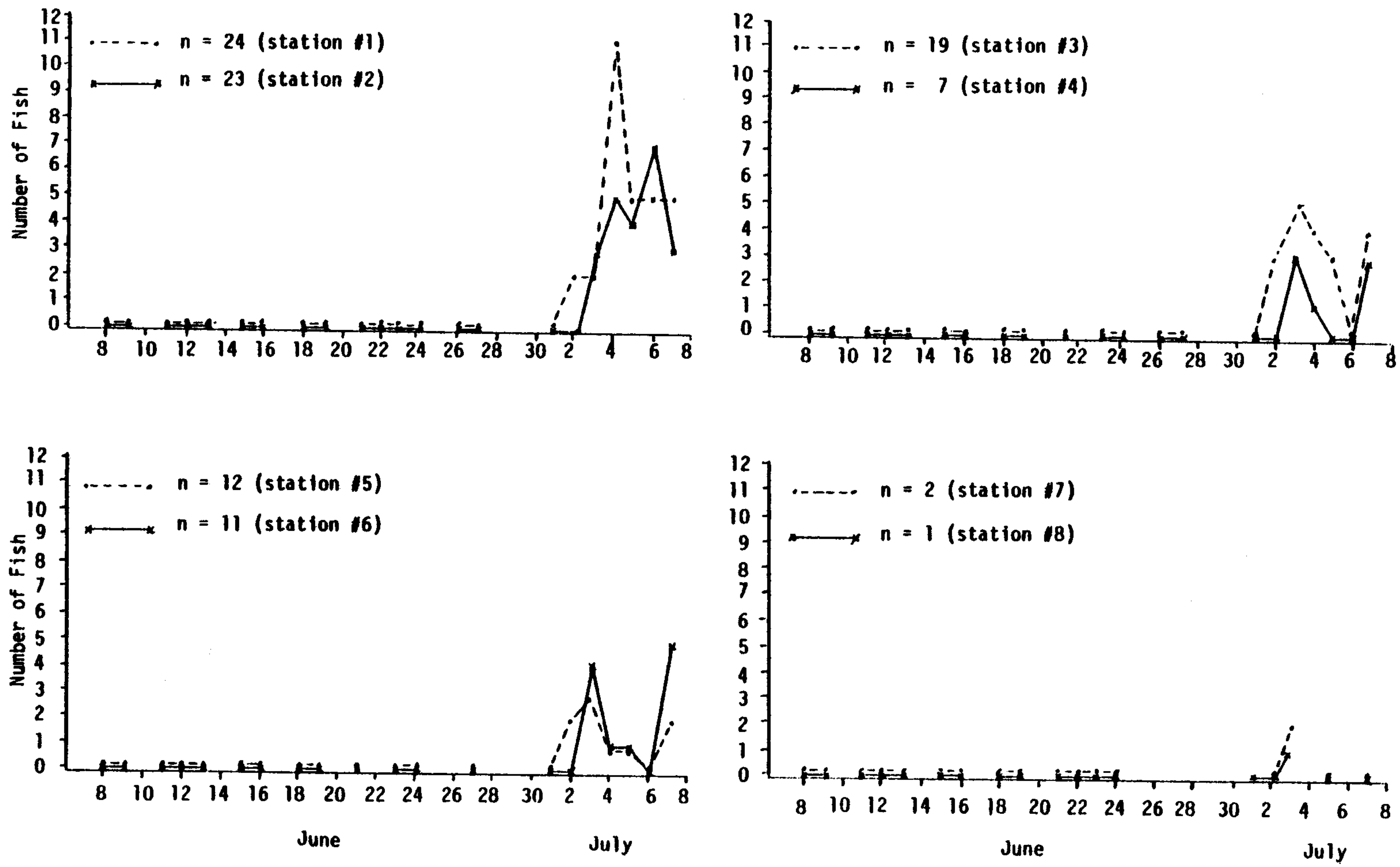


Figure 58. Spatial and temporal distribution of juvenile sheefish (Inconnu) down the Yukon River 101 kilometers upriver from Flat Island in June, 1977.

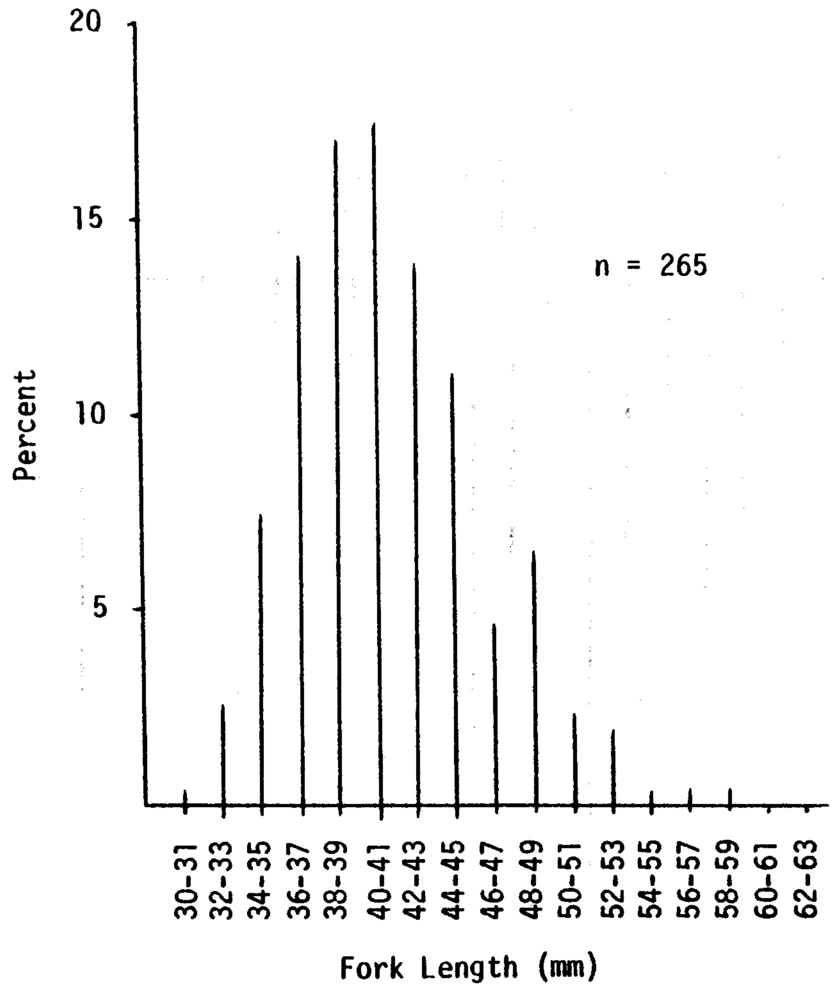


Figure 59. Length frequency (percent) of chum salmon smolt captured in the Yukon River 101 kilometers upriver from Flat Island, June 1977.

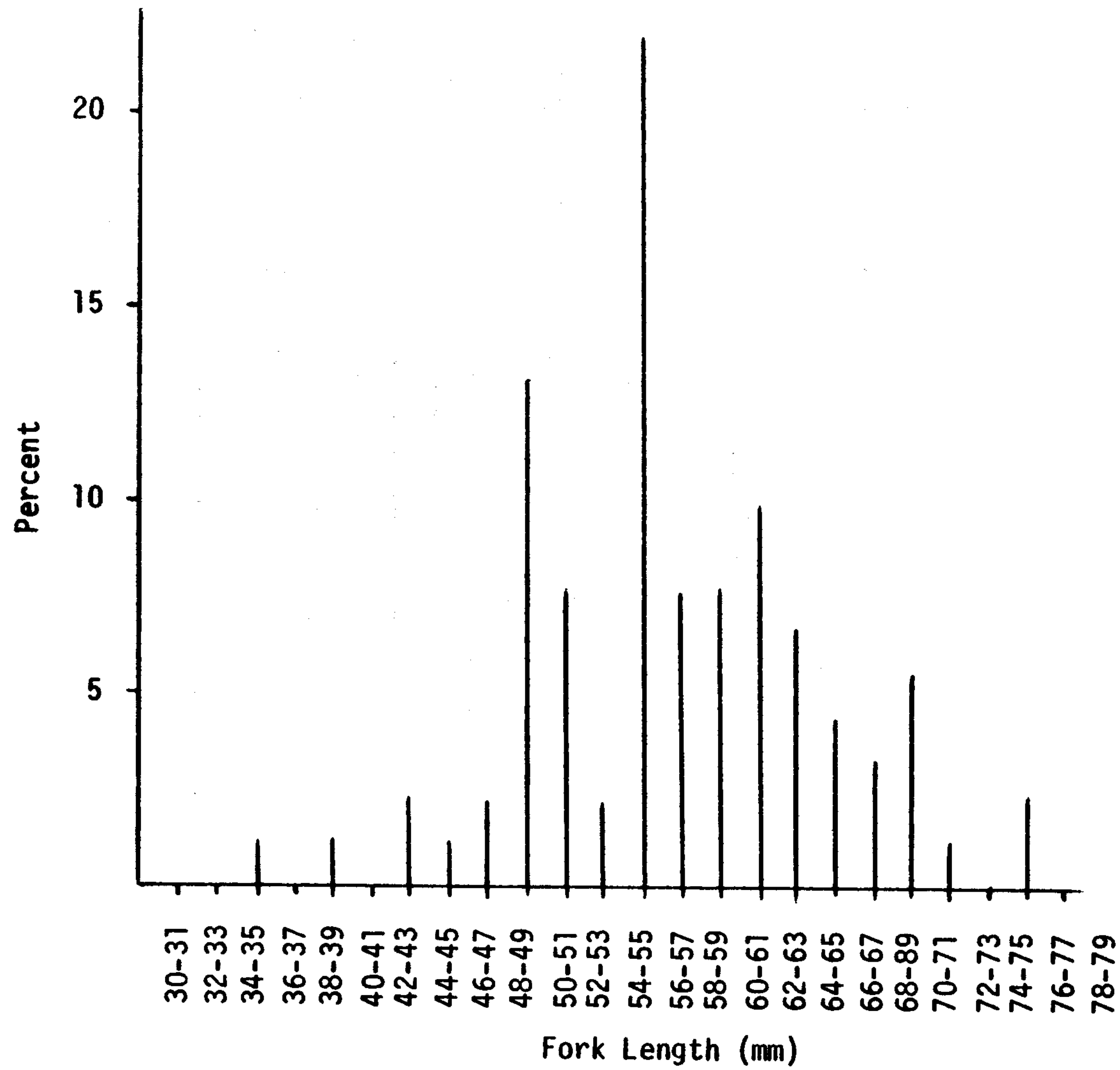


Figure 60. Length frequency (percent) of juvenile sheefish (Inconnu) captured in the Yukon River 101 kilometers upriver from Flat Island, June 1977.

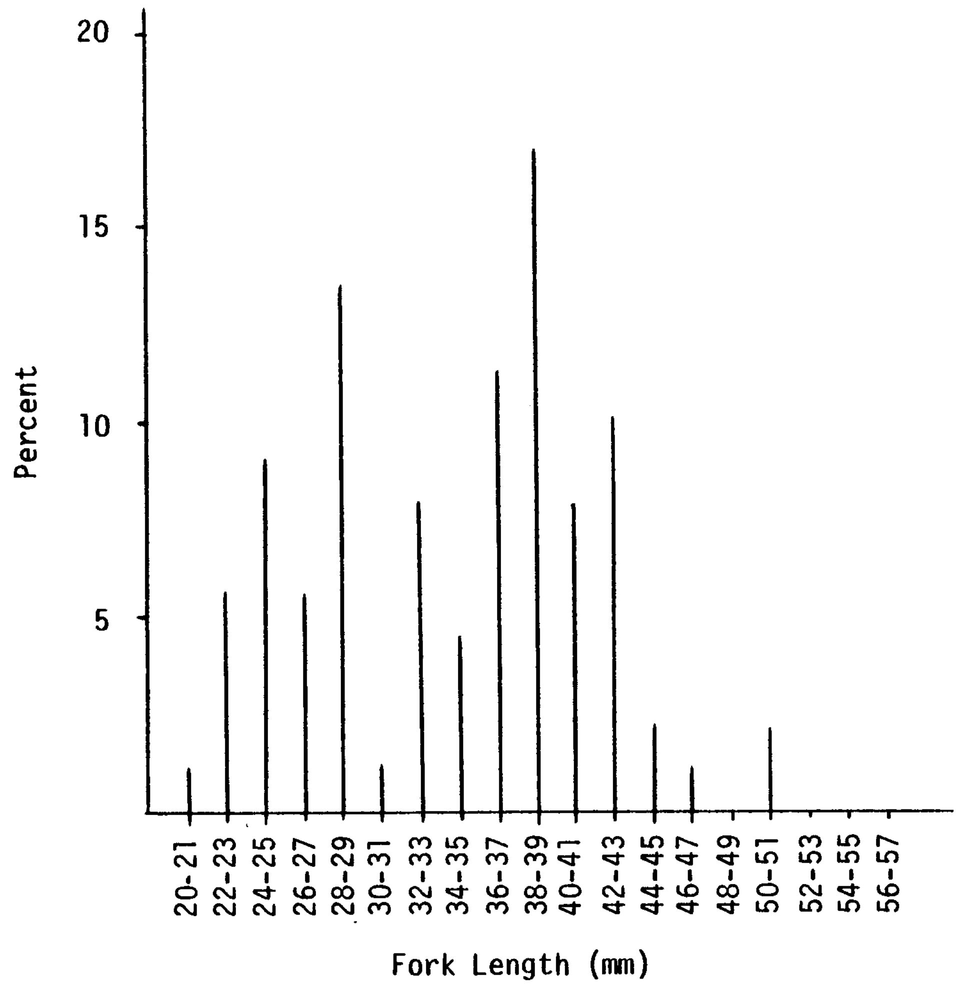


Figure 61. Length frequency (percent) of juvenile whitefish species captured in the Yukon River 101 kilometers upriver from Flat Island, June 1977.

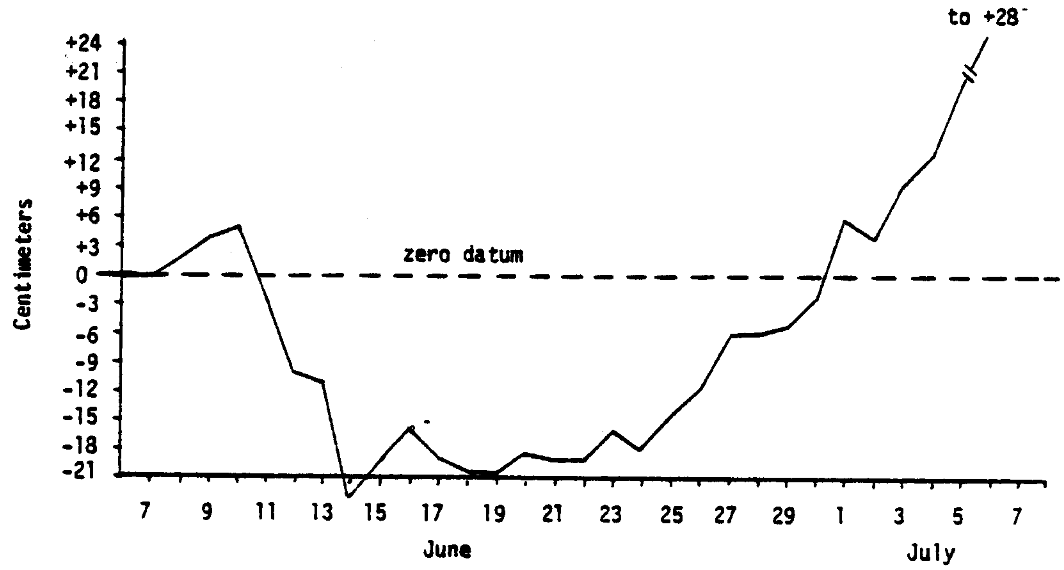


Figure 62. Water level fluctuations in the Anuk River one mile upriver from its confluence with the Yukon River, June 1977.

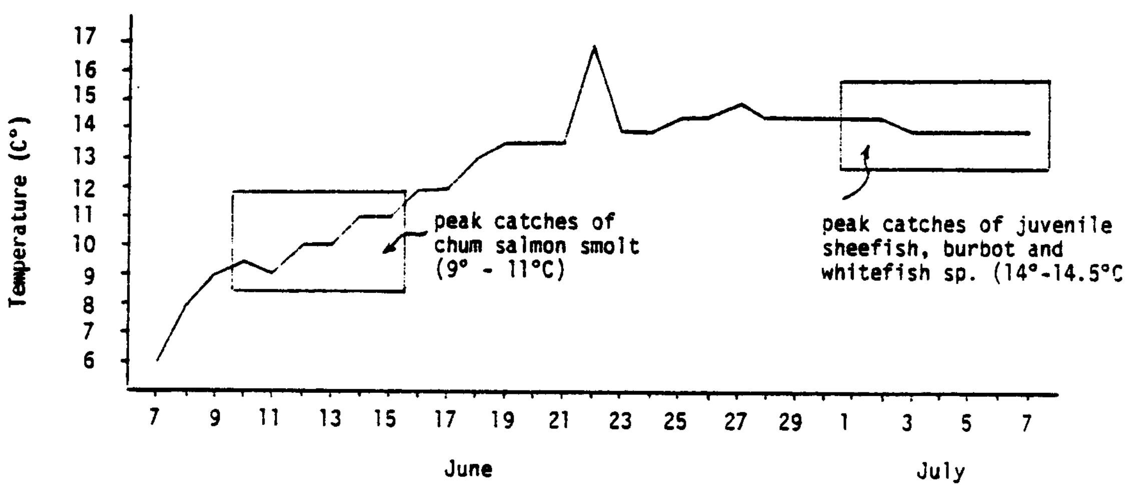


Figure 63. Yukon River surface water temperatures 101 kilometers upriver from Flat Island, June 1977.

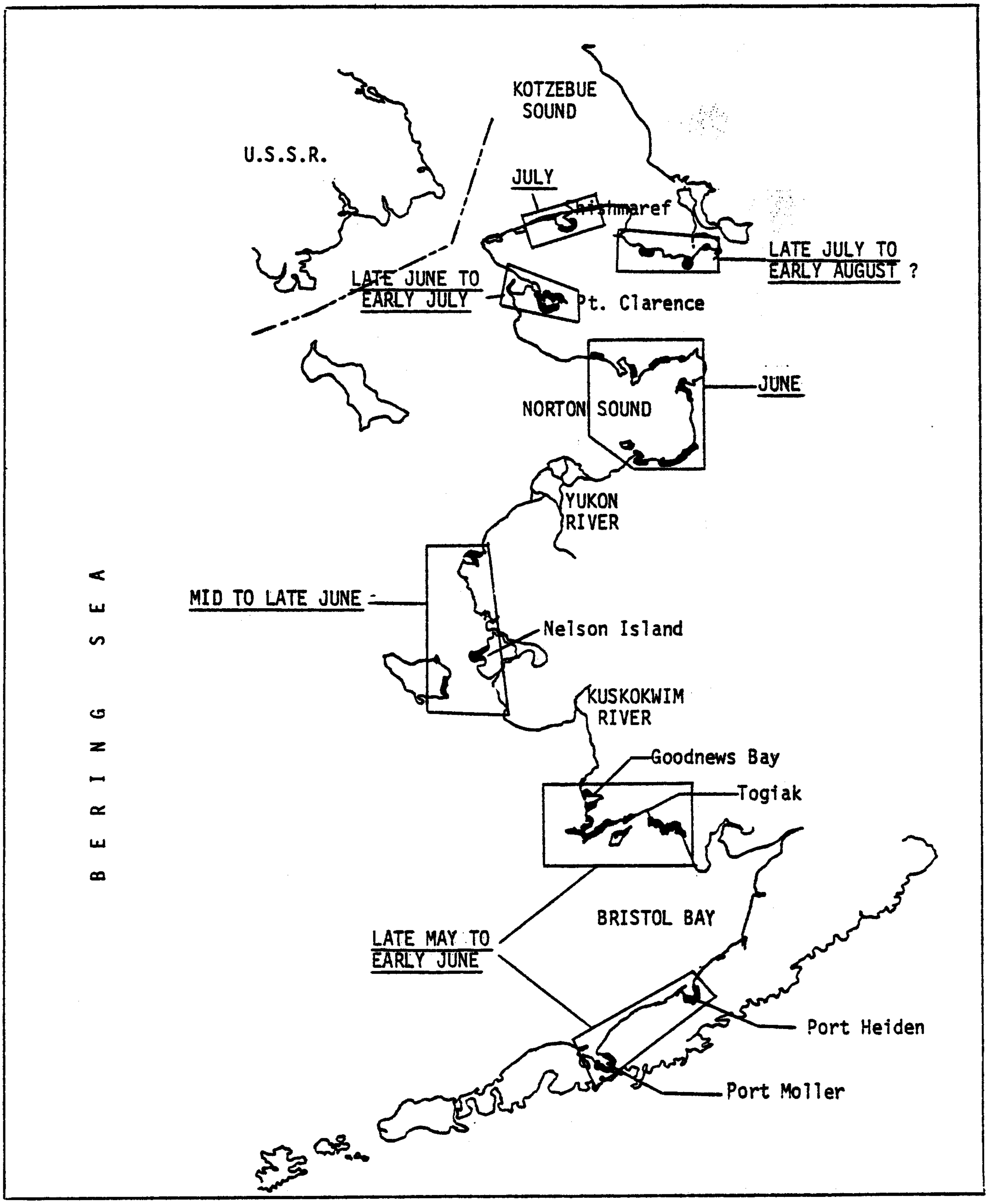


Figure 64 . Timing and distribution of Pacific herring spawning in the eastern Bering Sea.

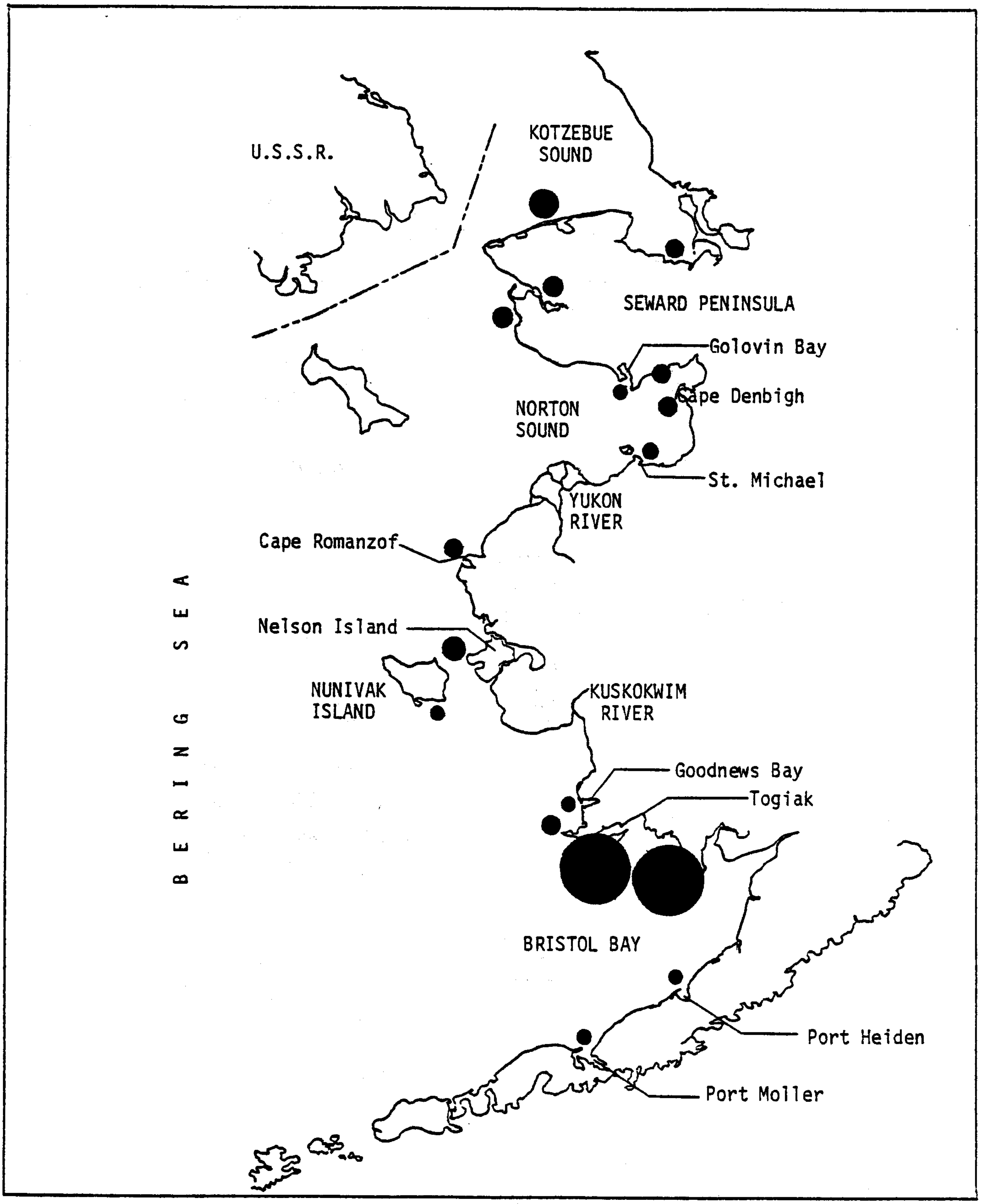


Figure 65. Relative abundance of Pacific herring based upon peak count surface area estimates of schools observed during aerial surveys, 1976 and 1977.

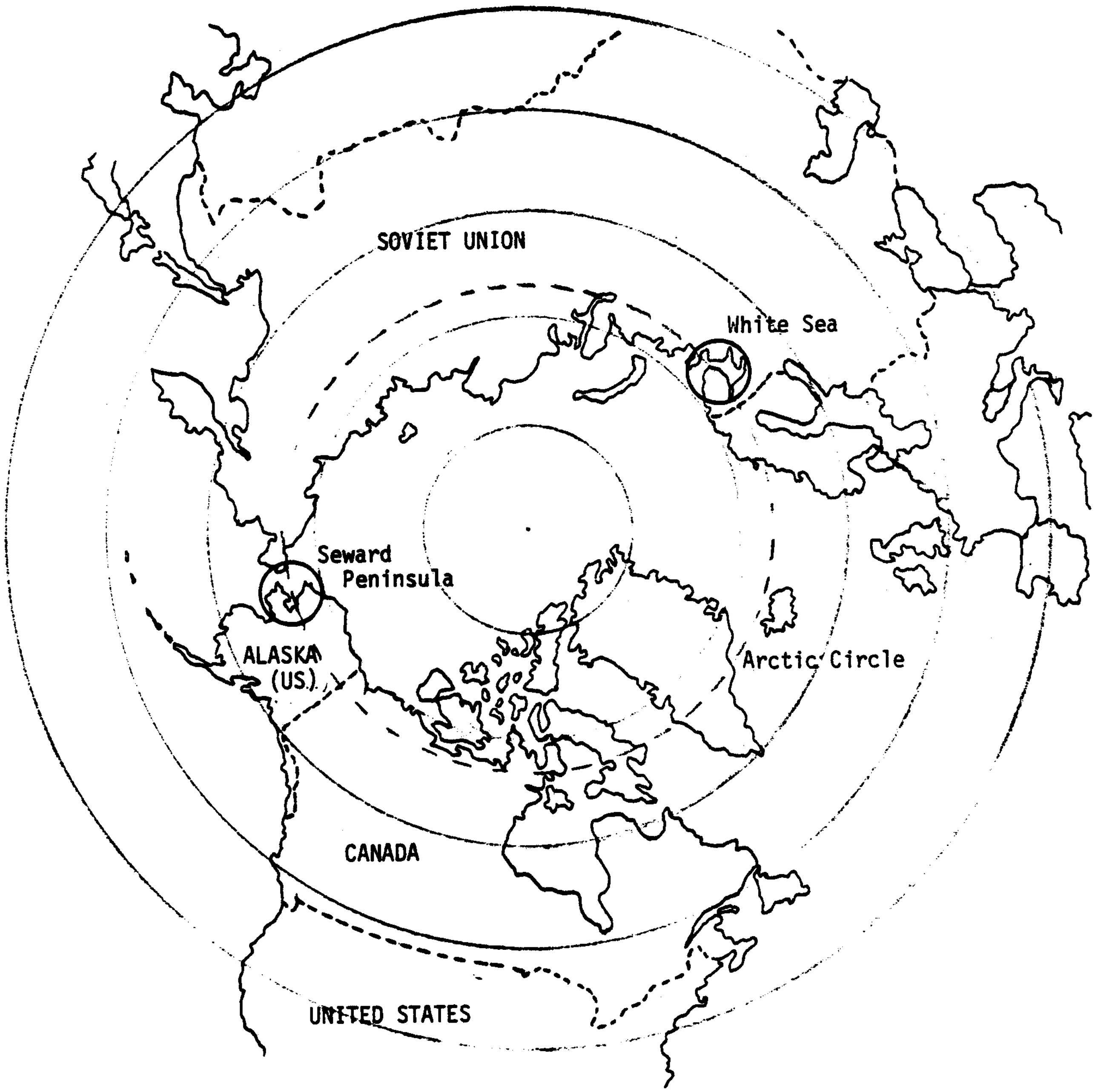


Figure 66. Comparative latitude of the Seward Peninsula and Kotzebue Sound with the White Sea.

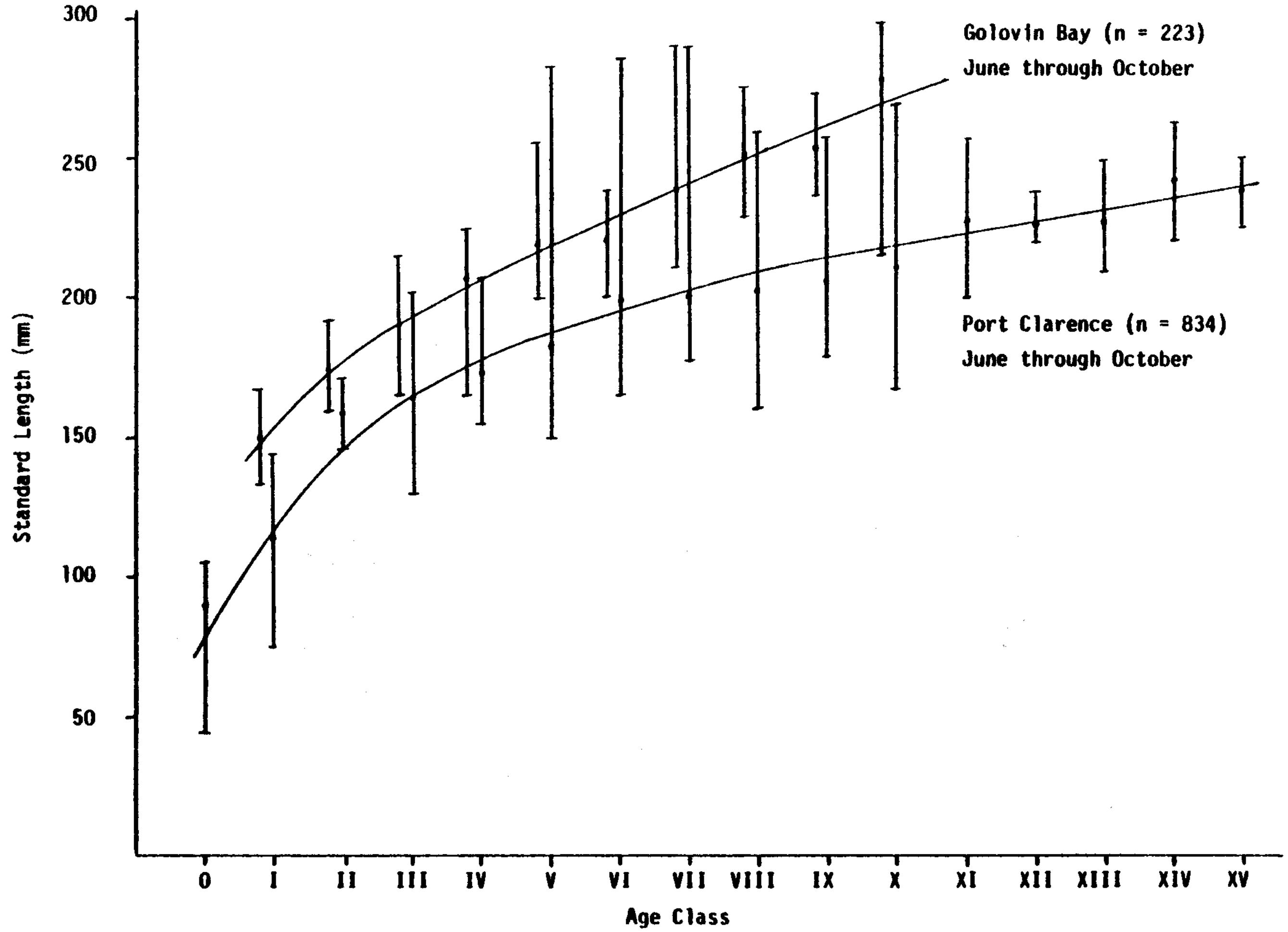


Figure 67. Comparison of mean lengths-at-age for herring sampled in Golovin Bay and the Port Clarence area in 1977. Mean lengths are shown with ranges.

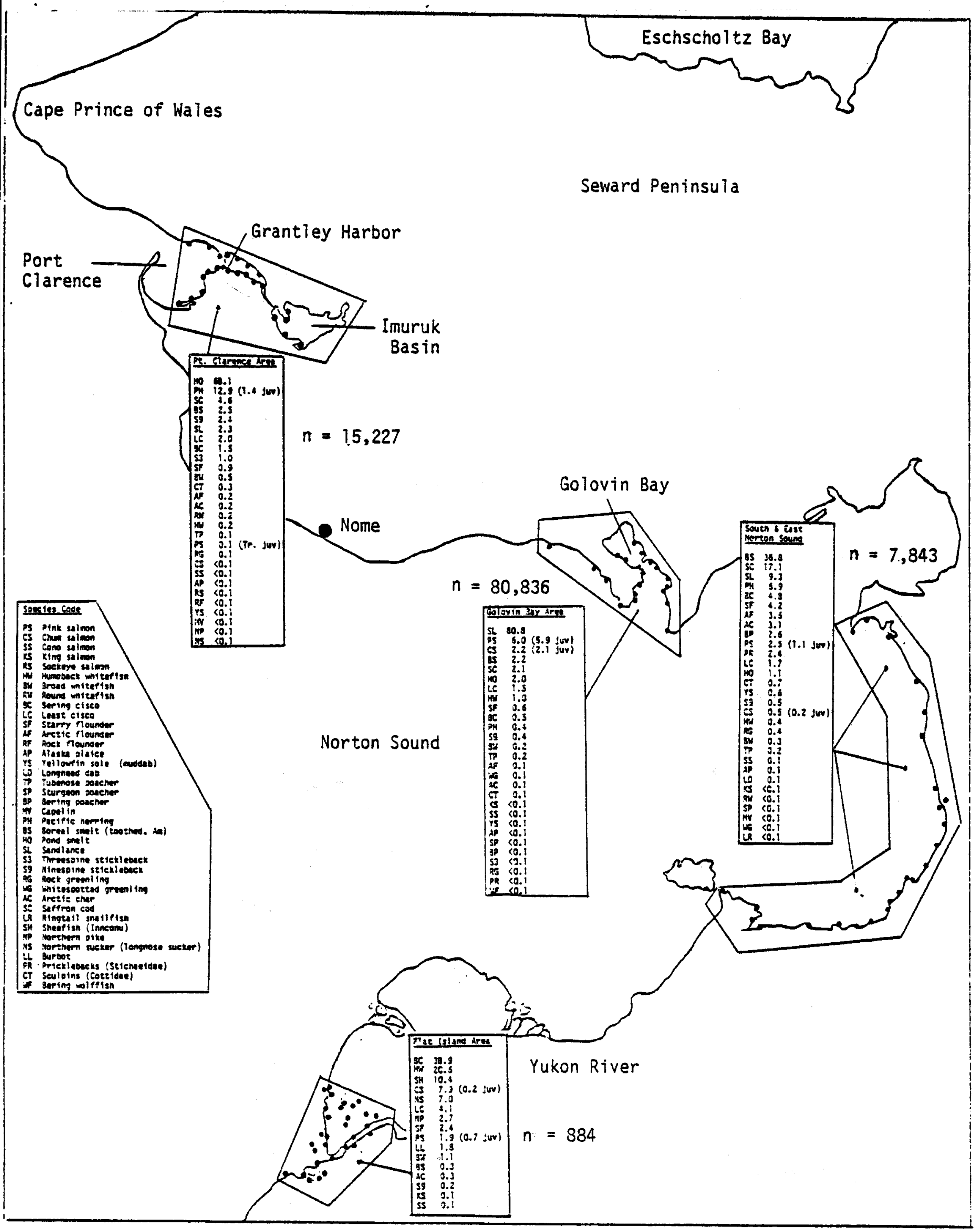


Figure 68. Relative abundance in percent composition of finfish captured throughout the nearshore waters of Norton Sound, 1976-77.

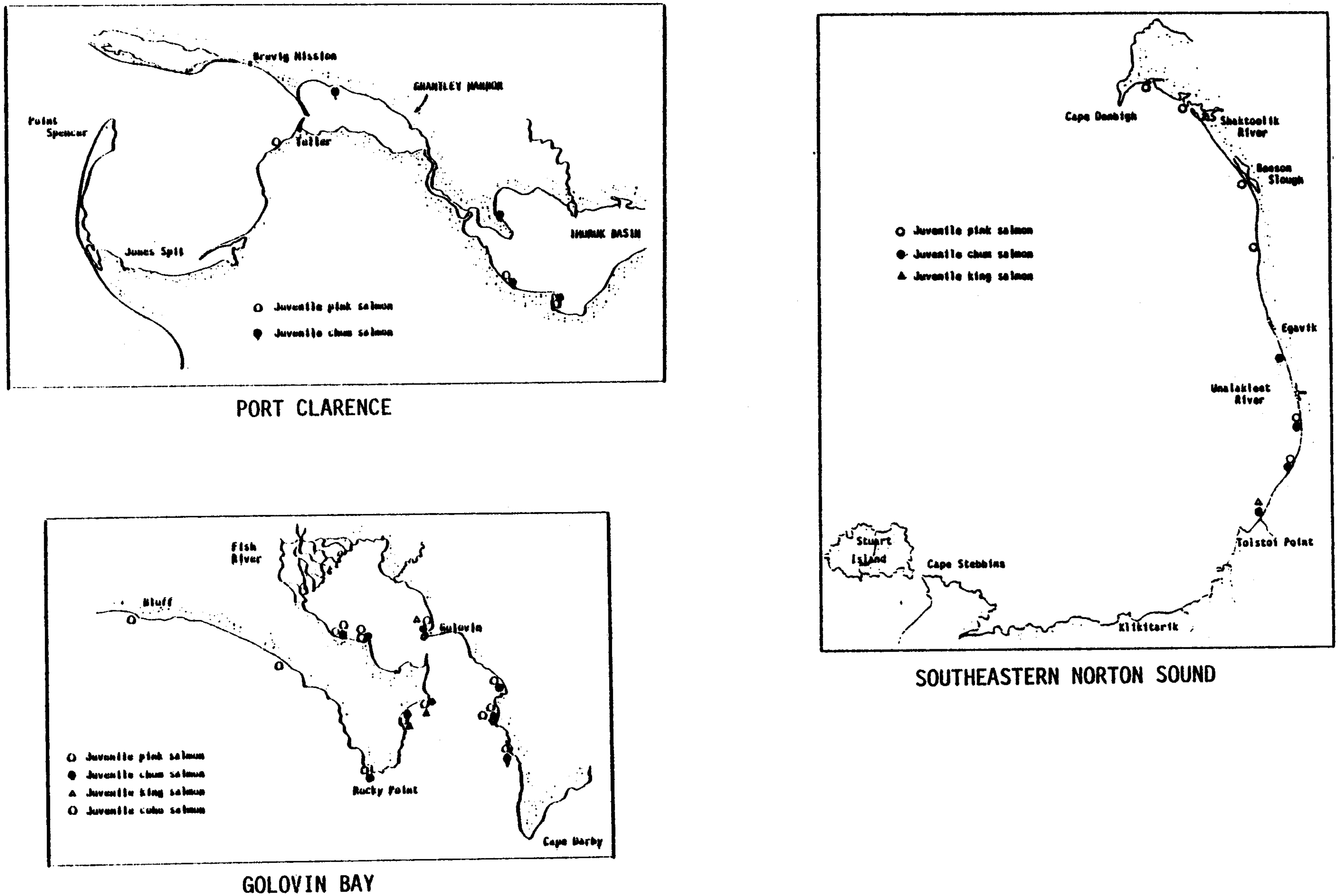
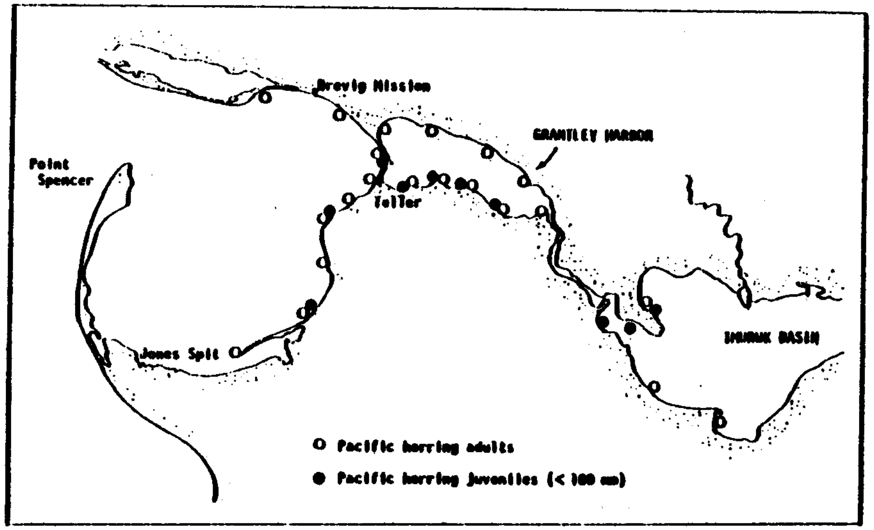
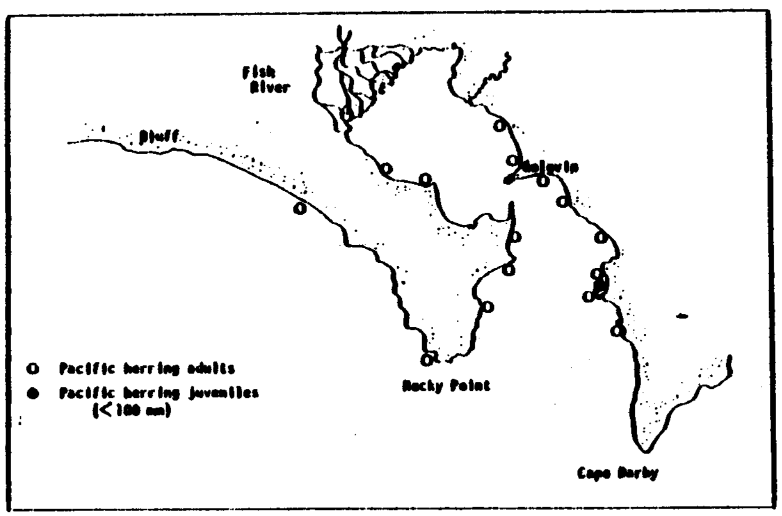


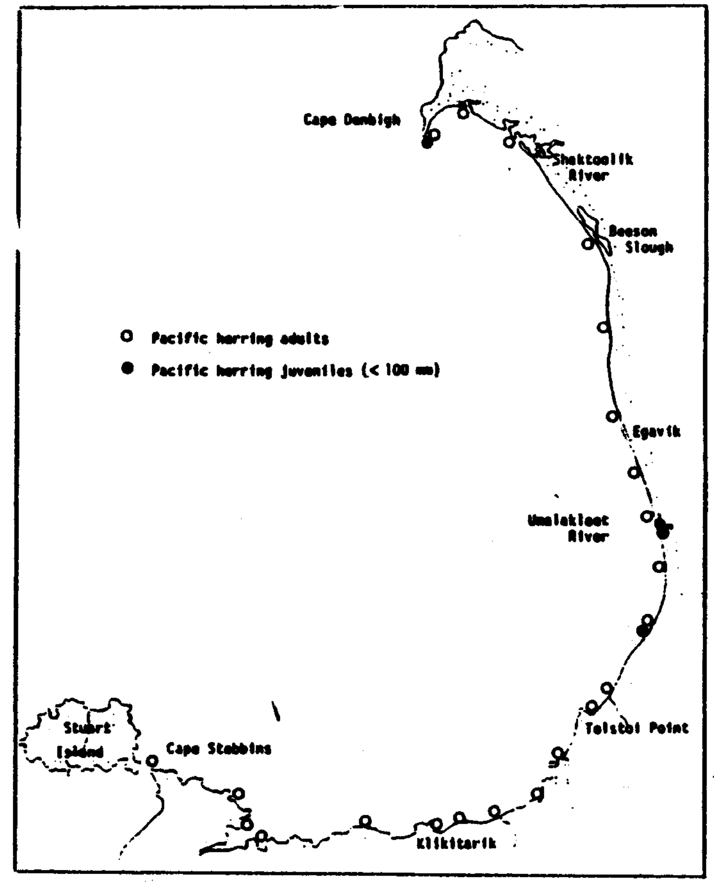
Figure 69. Distribution of juvenile salmon within the study area, 1976-77.



PORT CLARENCE



GOLOVIN BAY



SOUTHEASTERN NORTON SOUND

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

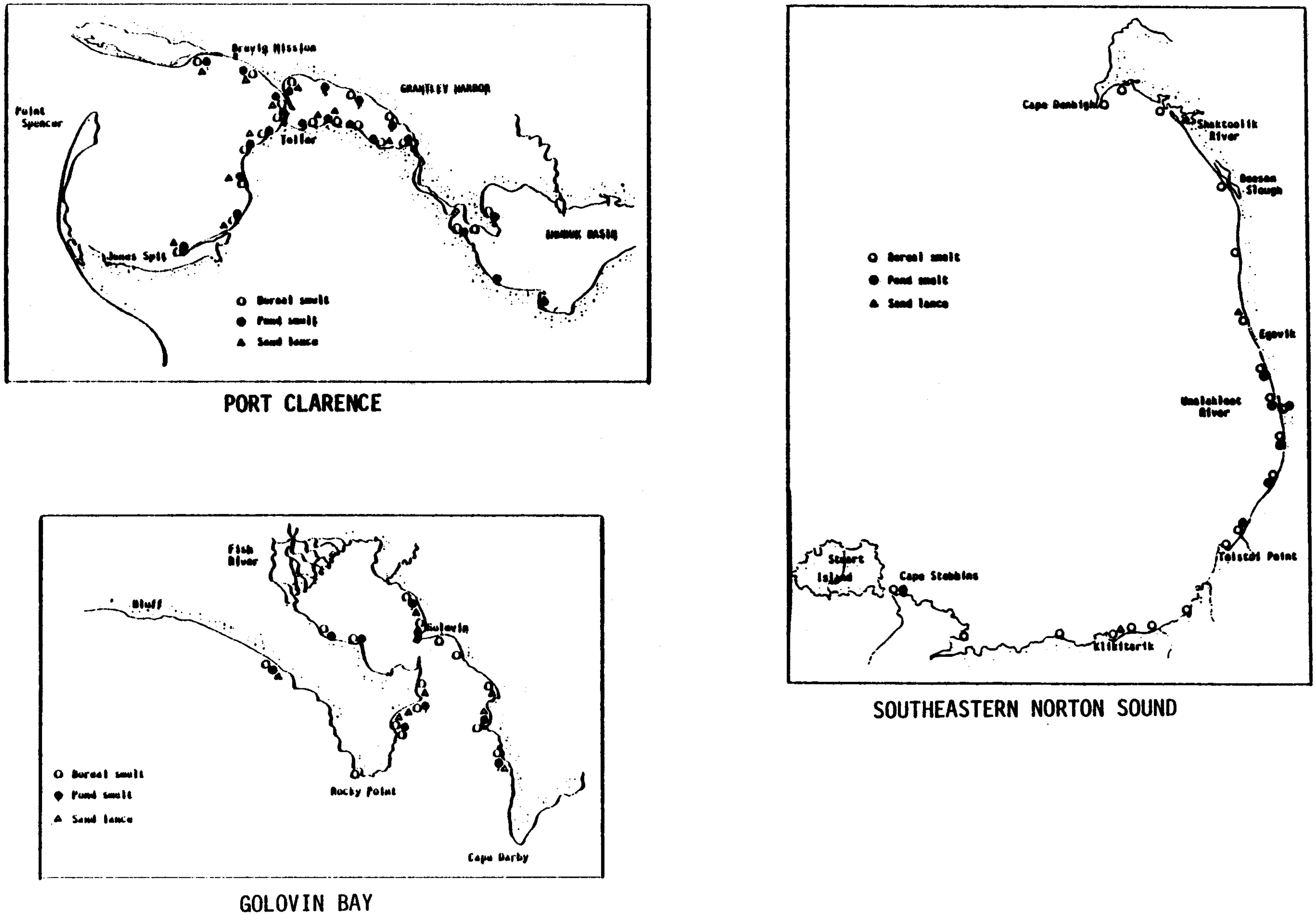
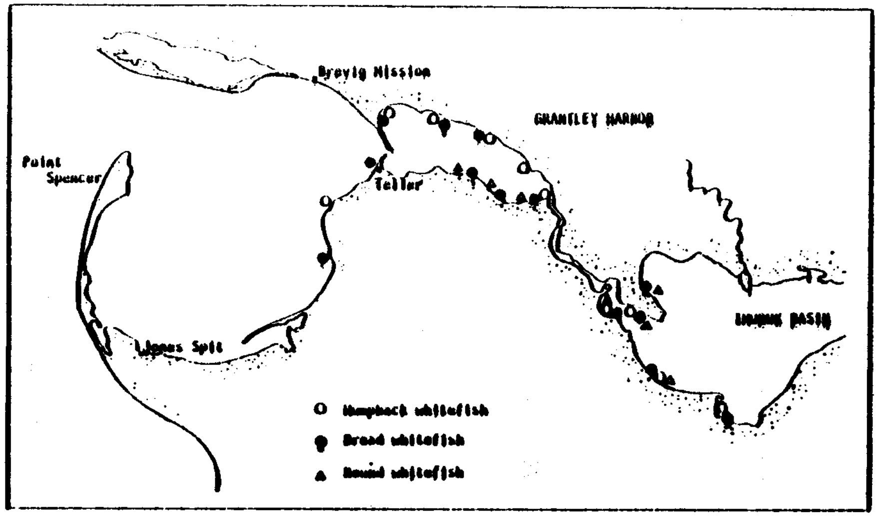
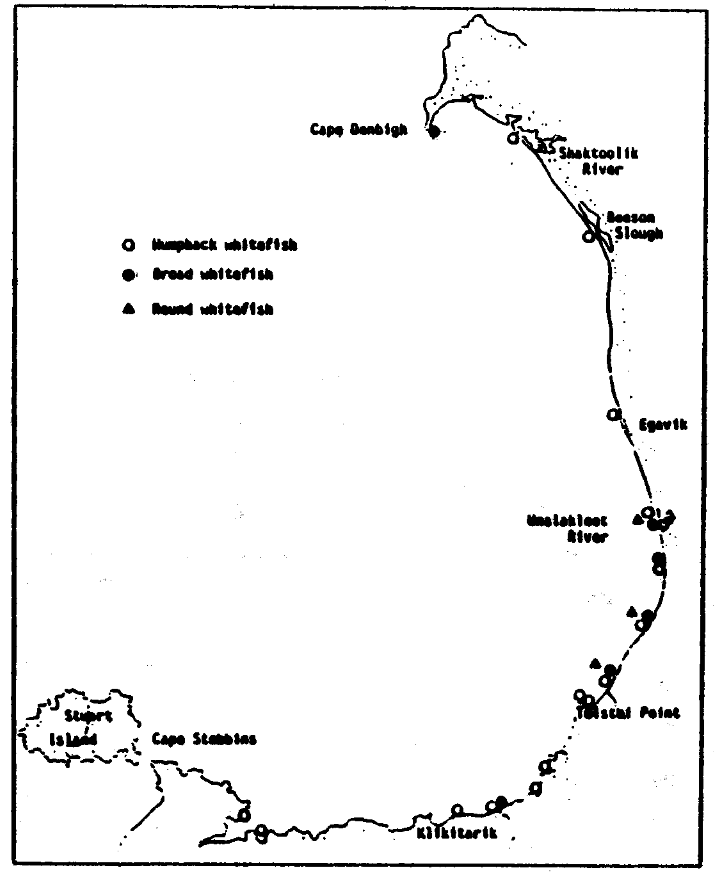


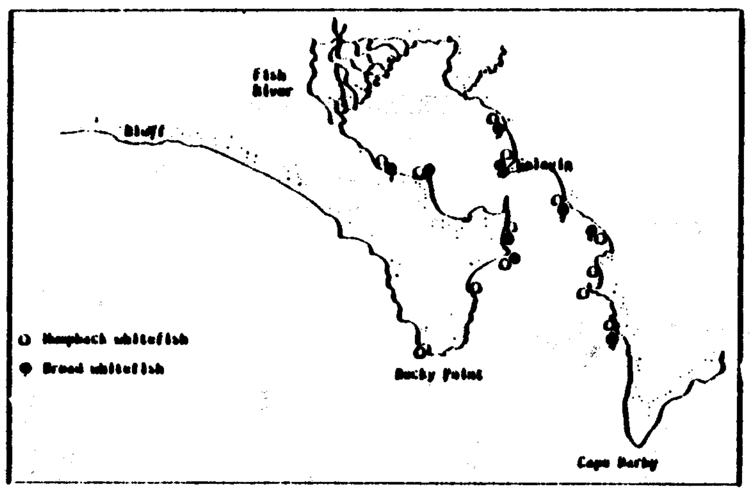
Figure 71. Distribution of boreal and pond smelt and sand lance within the study area, 1976-77.



PORT CLARENCE



SOUTHEASTERN NORTON SOUND



GOLOVIN BAY

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

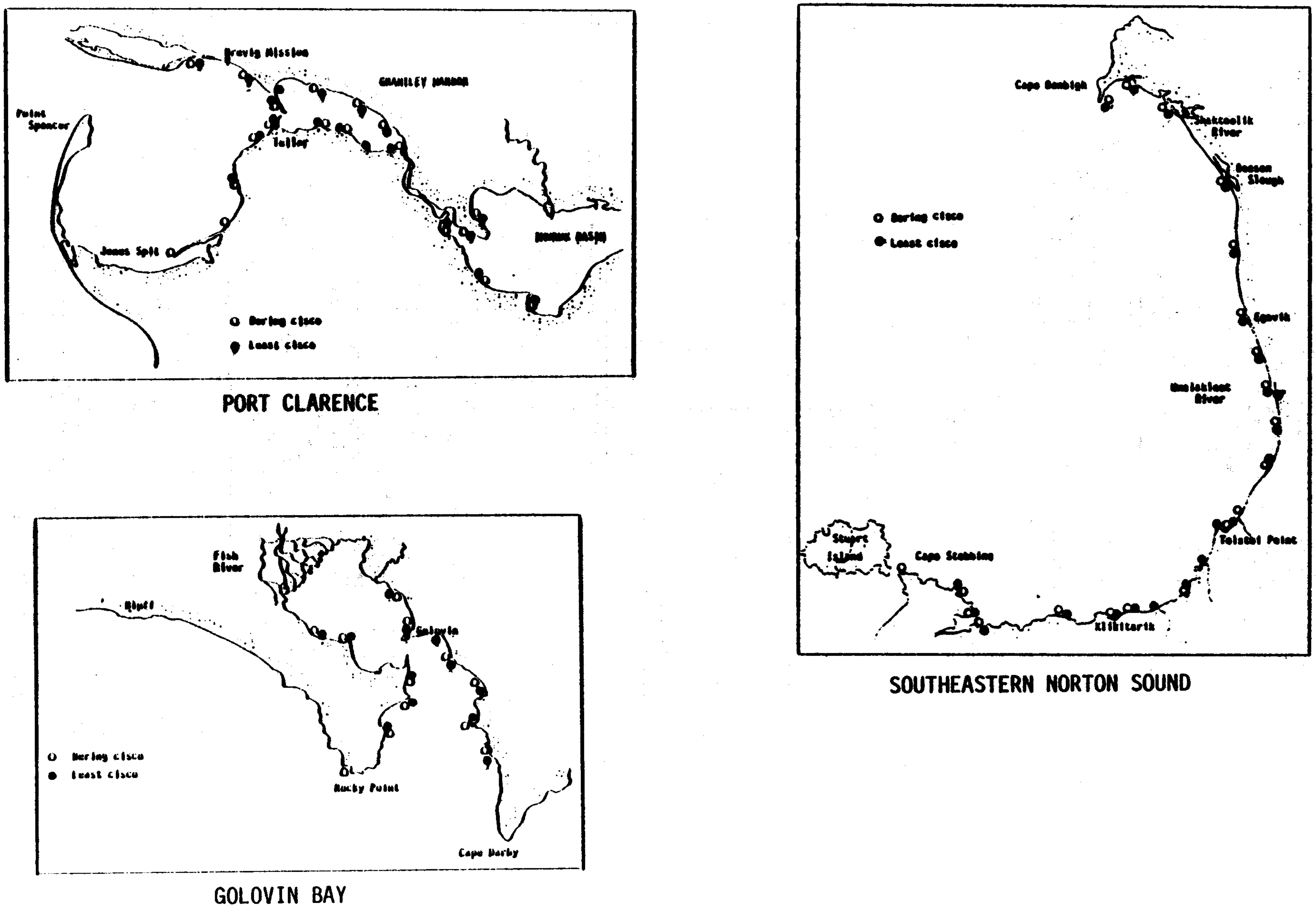


Figure 73. Distribution of Bering and least cisco within the study area, 1976-77.

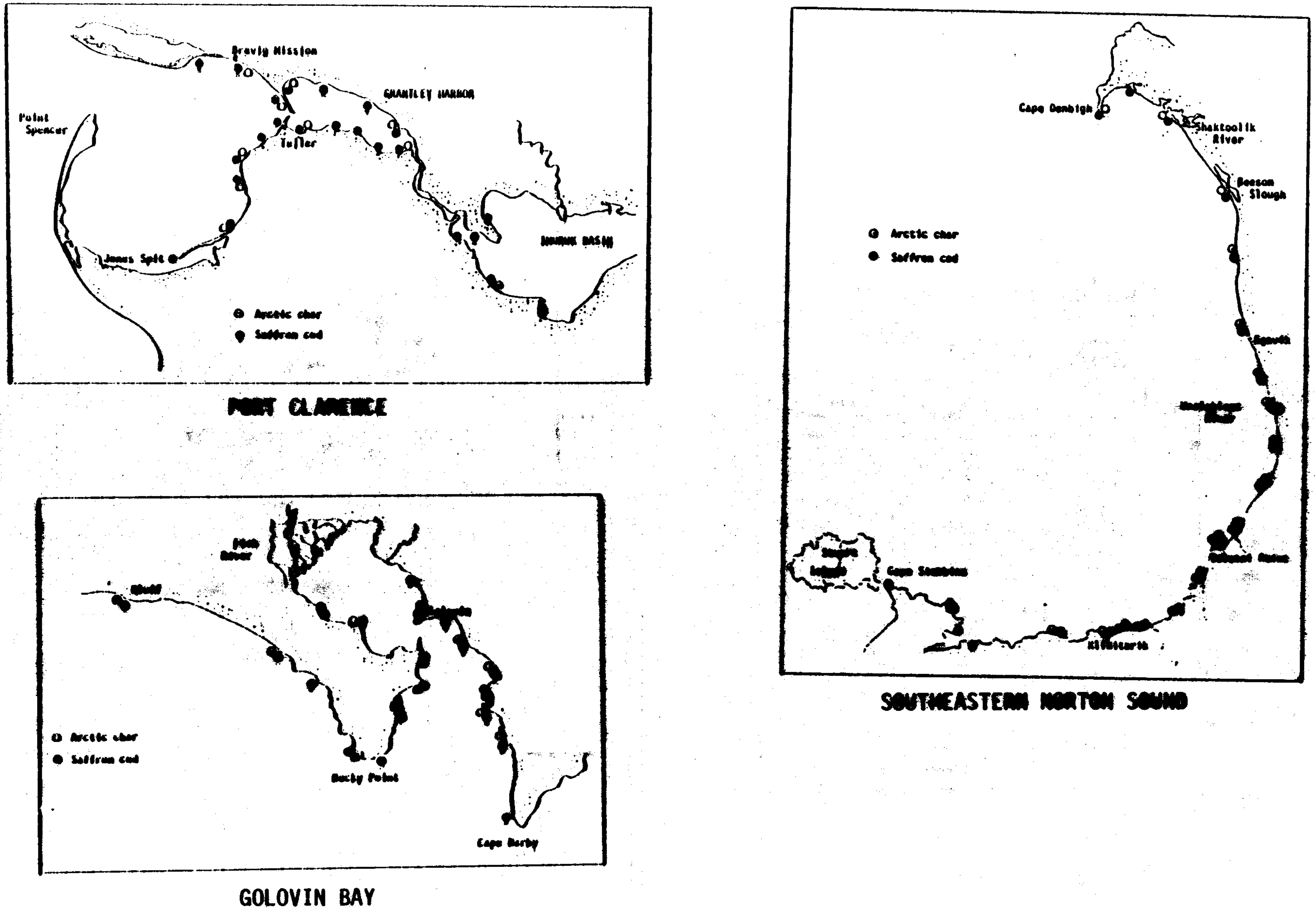


Figure 74 . Distribution of Arctic char and saffron cod within the study area, 1976-77.

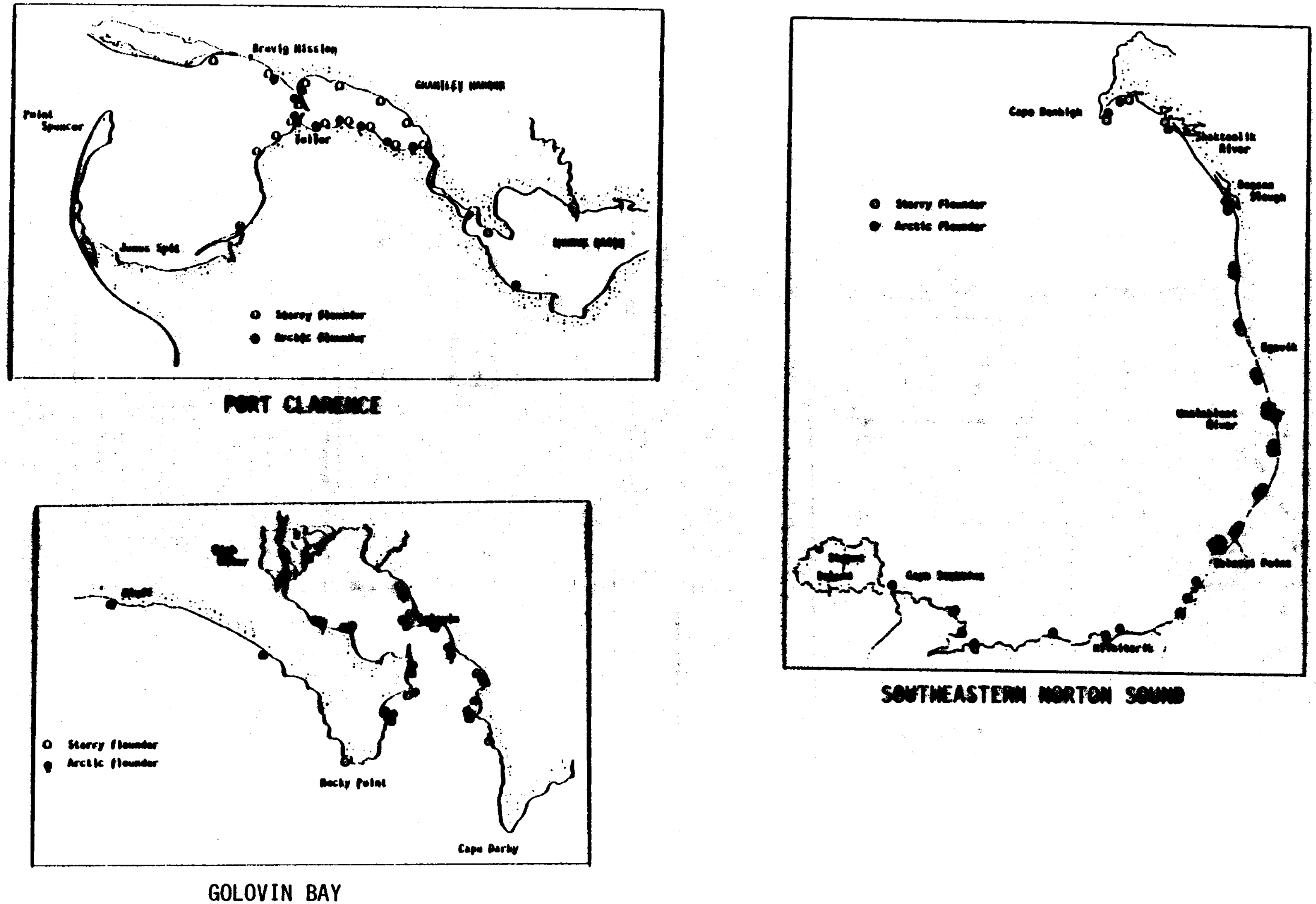


Figure 75. Distribution of starry flounder and Arctic flounder within the study area, 1976-77.

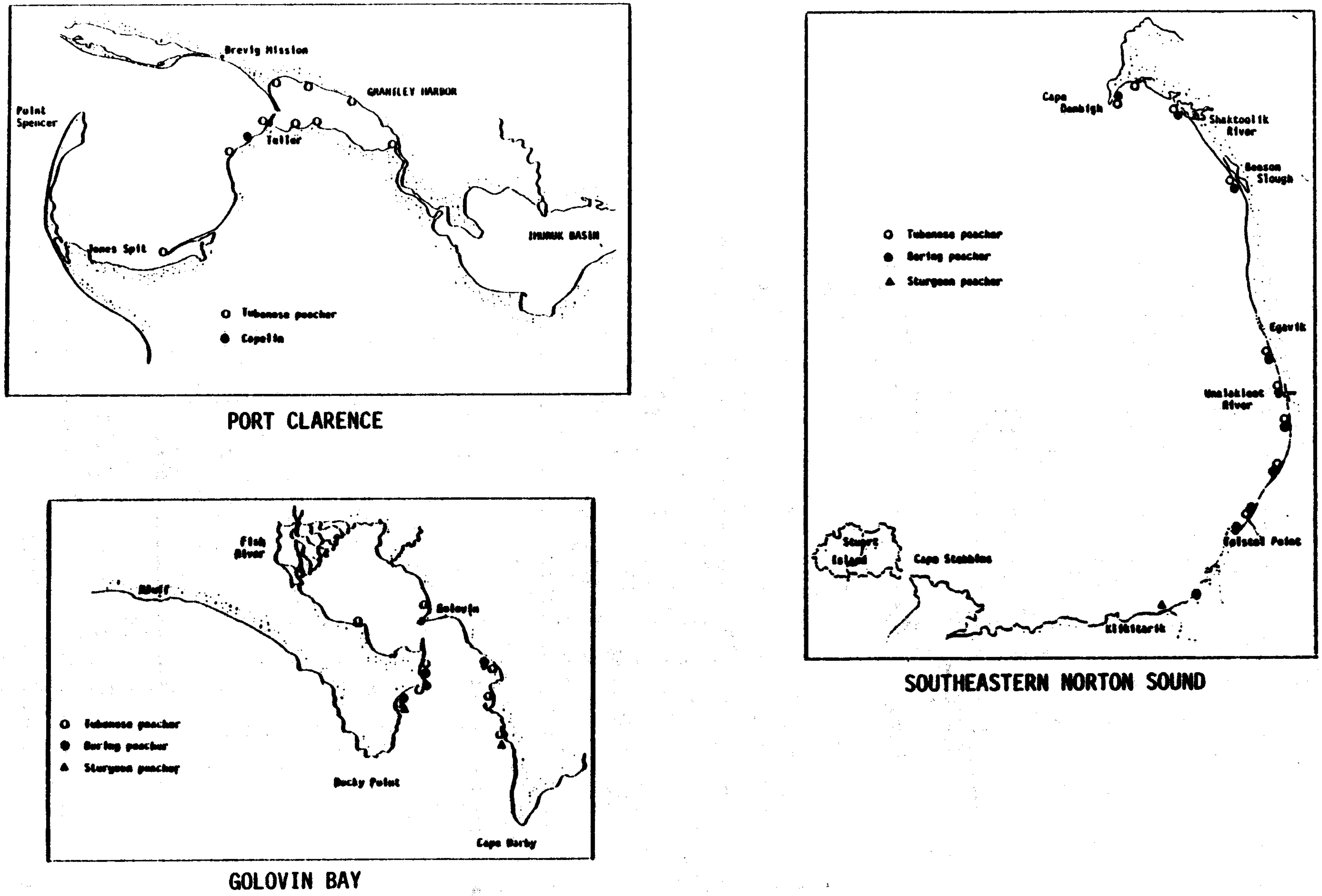


Figure 76. Distribution of sea poachers within the study area, 1976-77.

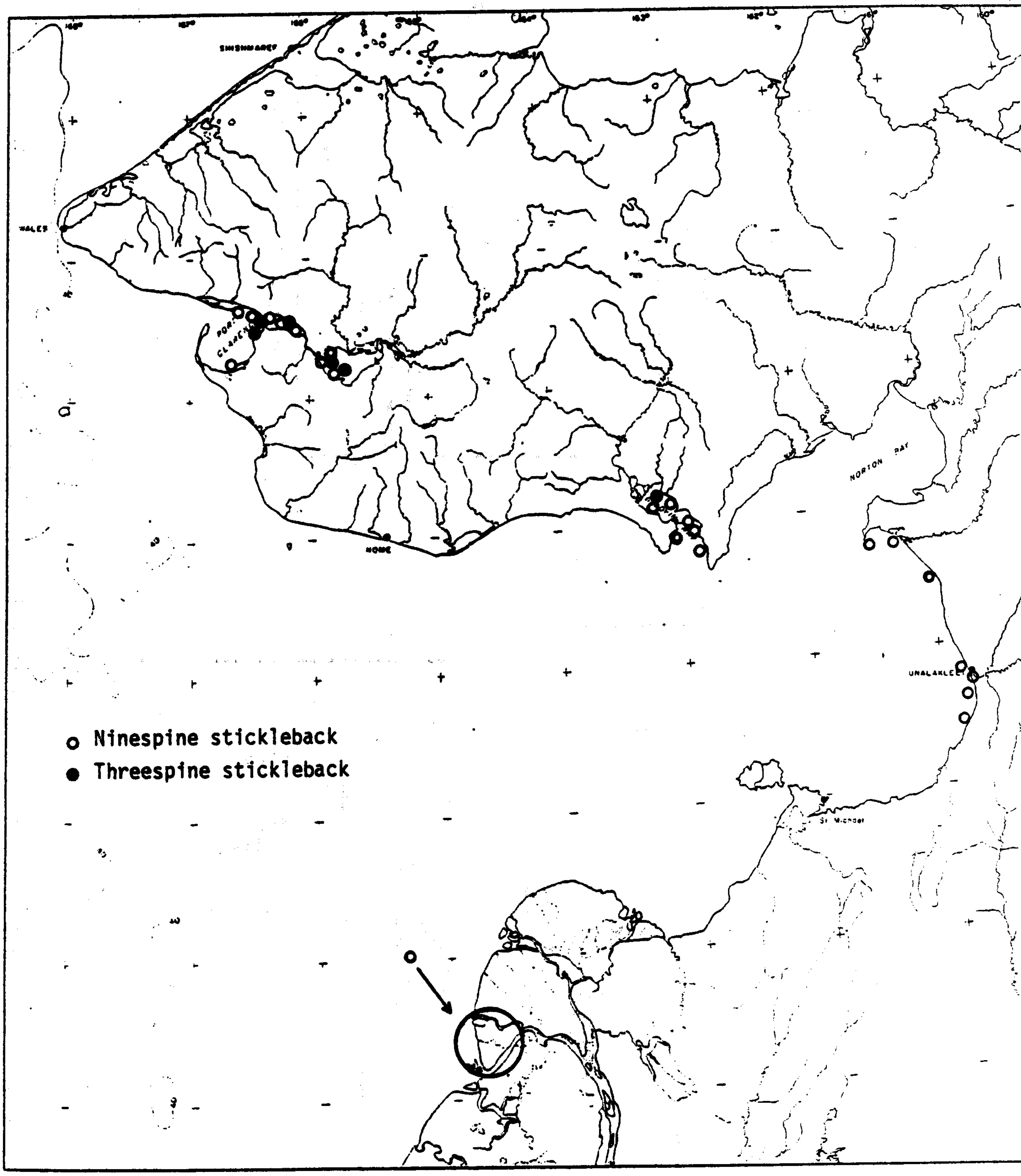


Figure 77. Distribution of ninespine and threespine stickleback within the study area, 1976-77.

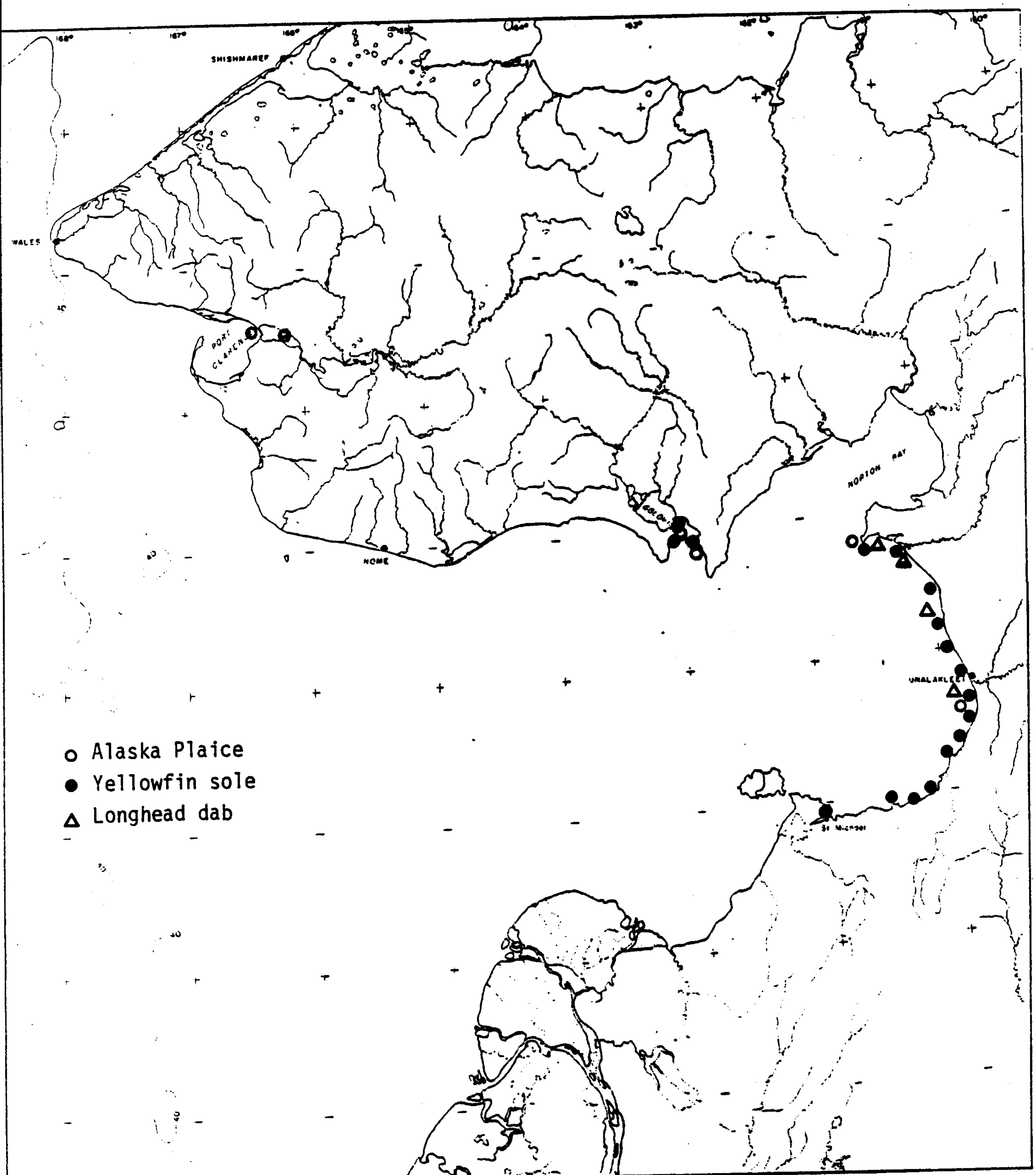


Figure 78. Distribution of Alaska plaice, yellowfin sole and longhead dab within the study area, 1976-77.

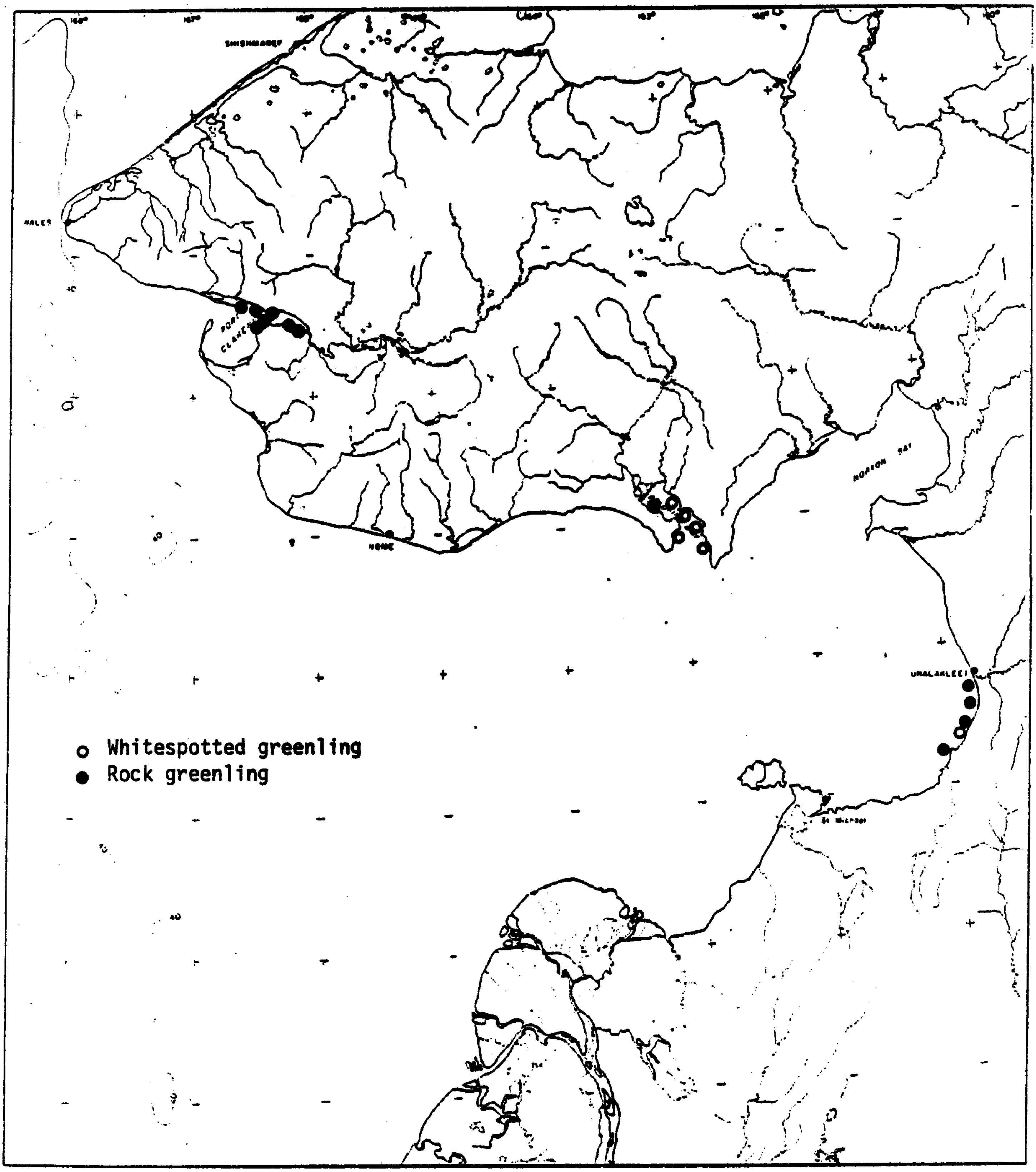


Figure 79. **Distribution of whitespotted and rock greenling within the study area, 1976-77.**

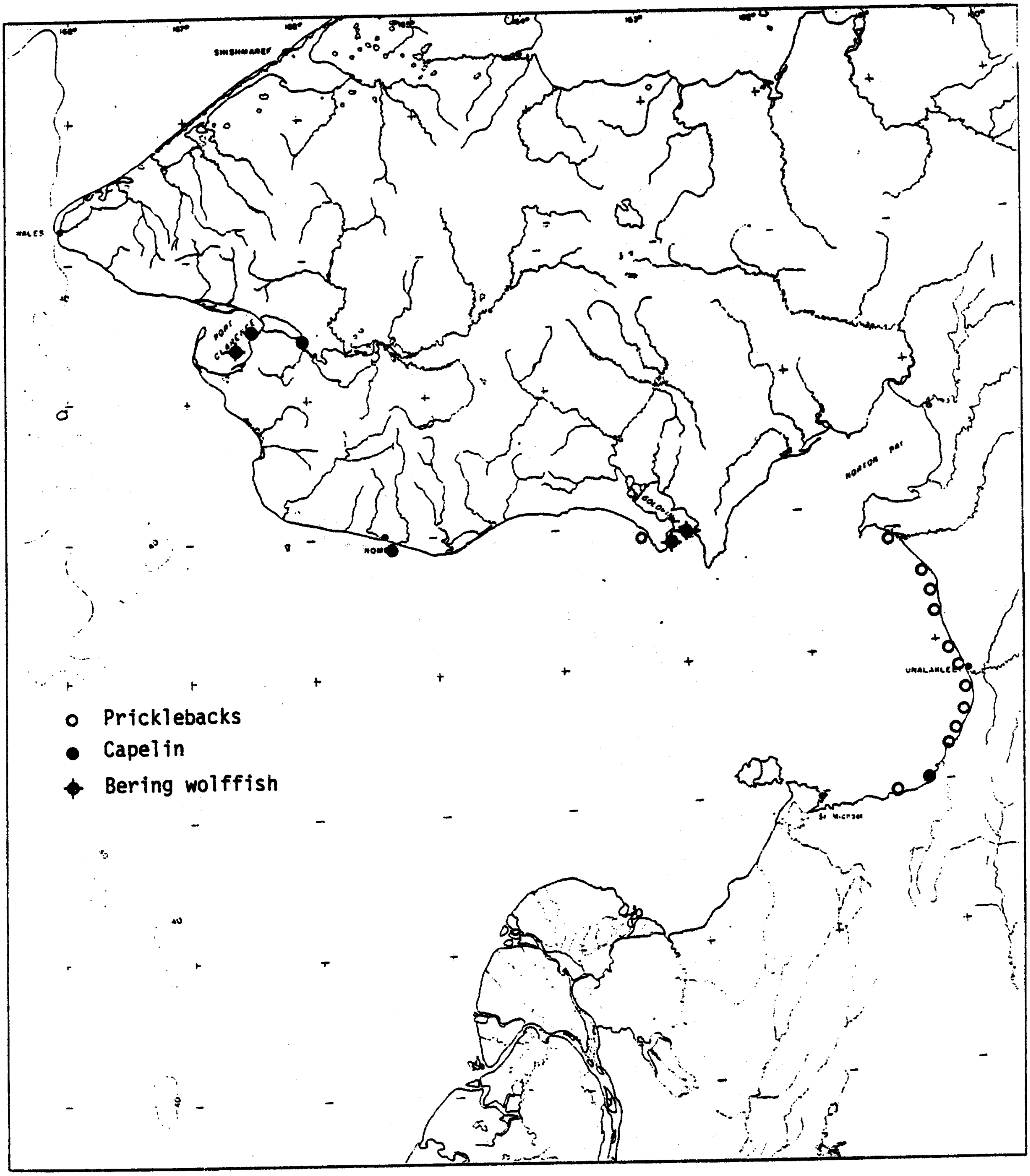


Figure 80. Distribution of pricklebacks, capelin and Bering wolffish within the study area, 1976-77.

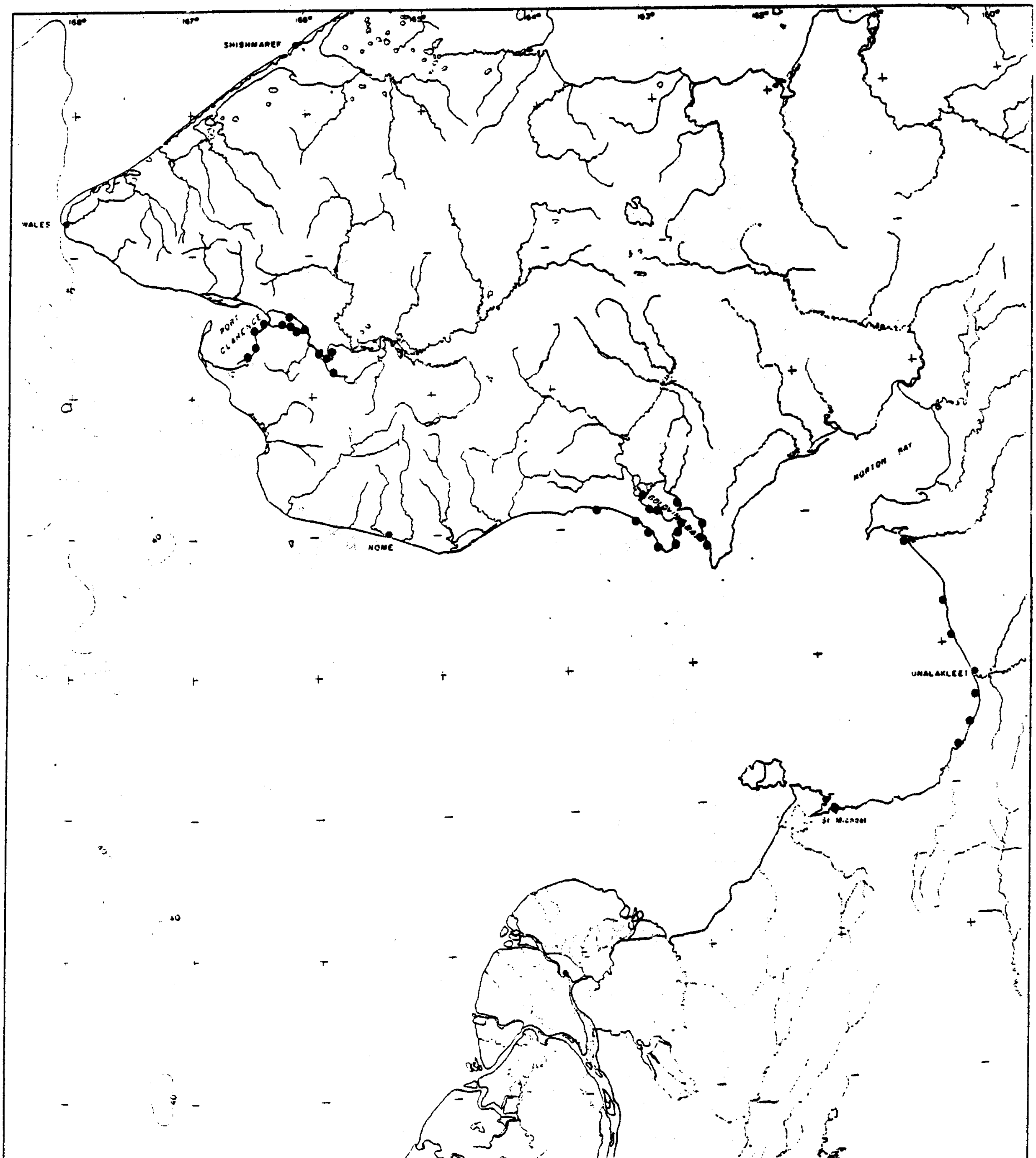


Figure 81. Distribution of larval boreal smelt in coastal waters within the study area, 1976-77.

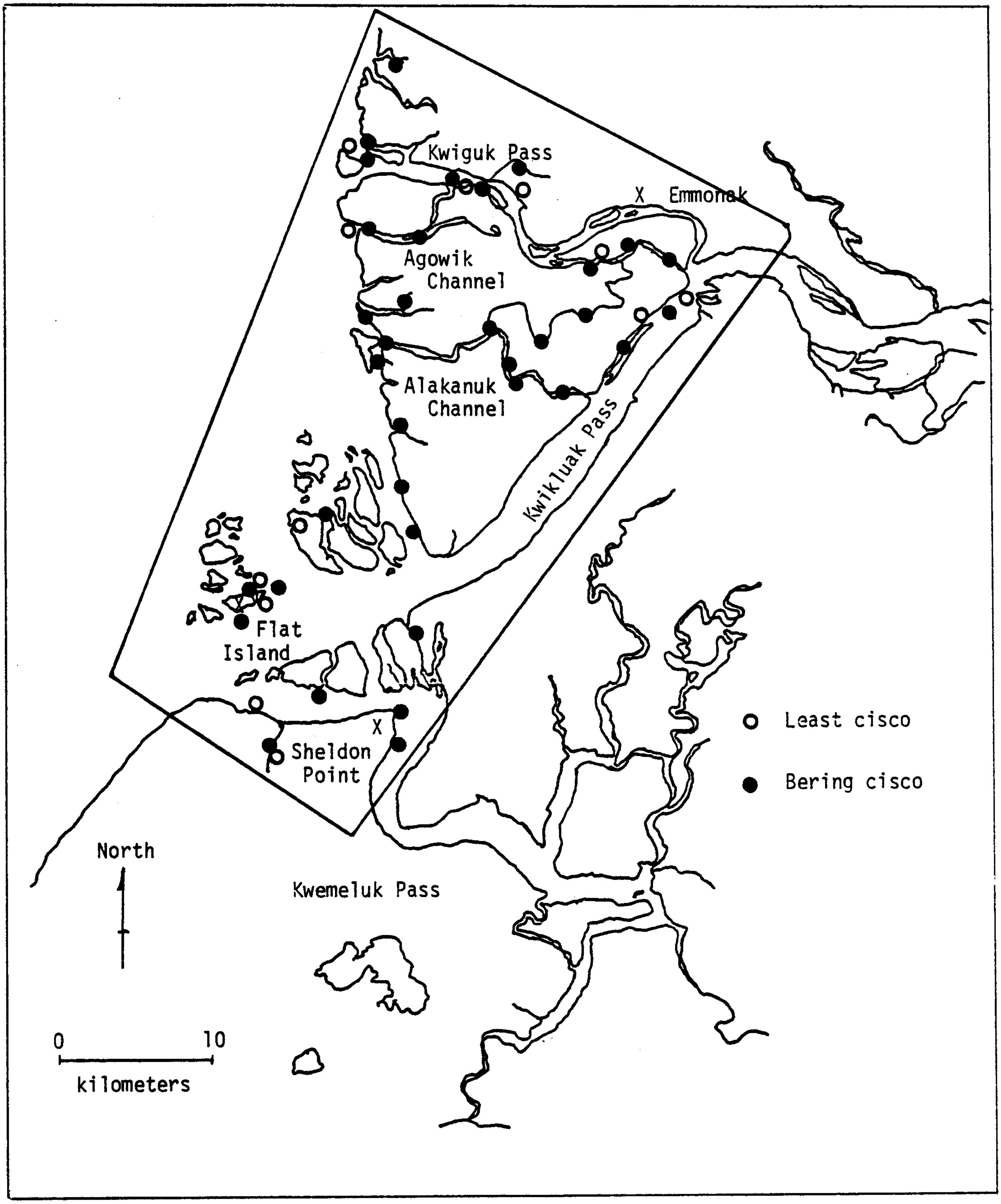


Figure 82. Distribution of least cisco and Bering cisco catches at the south mouth of the Yukon River, June 9 through August 5, 1976.

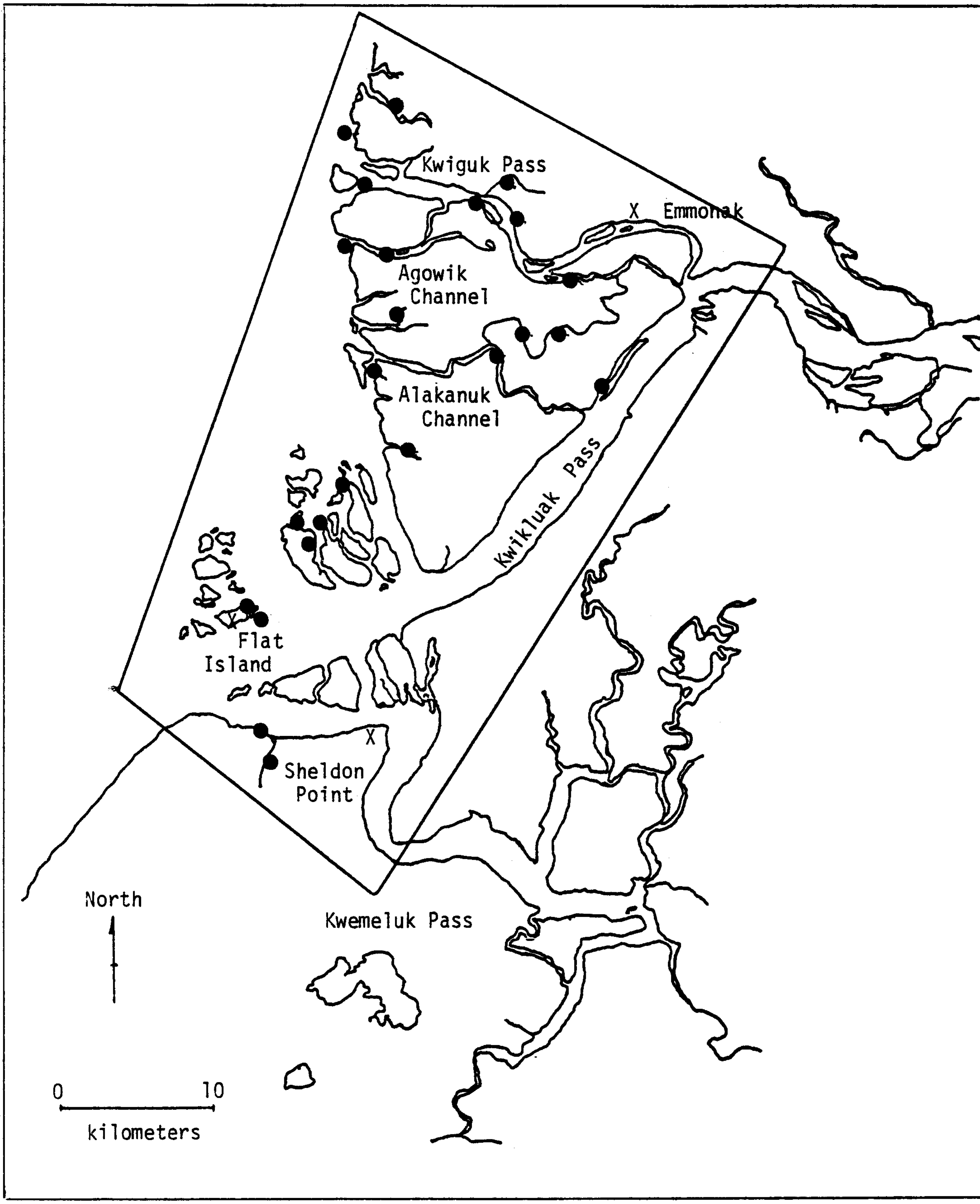


Figure 83. Distribution of humpback whitefish catches at the south mouth of the Yukon River, June 9 through August 5, 1976.

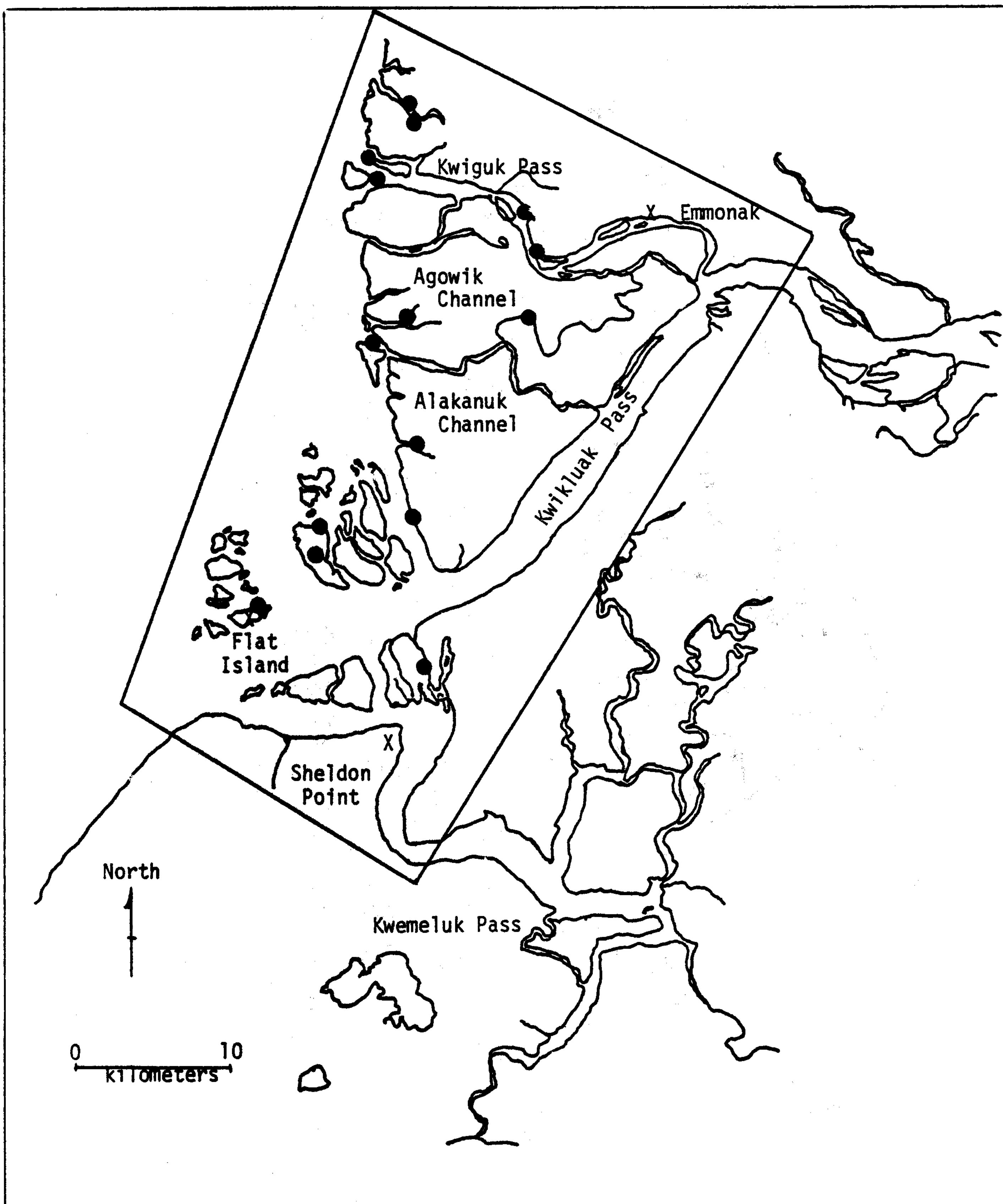


Figure 84. **Distribution of sheefish (Inconnu) catches at the south mouth of the Yukon River, June 9 through August 5, 1976.**

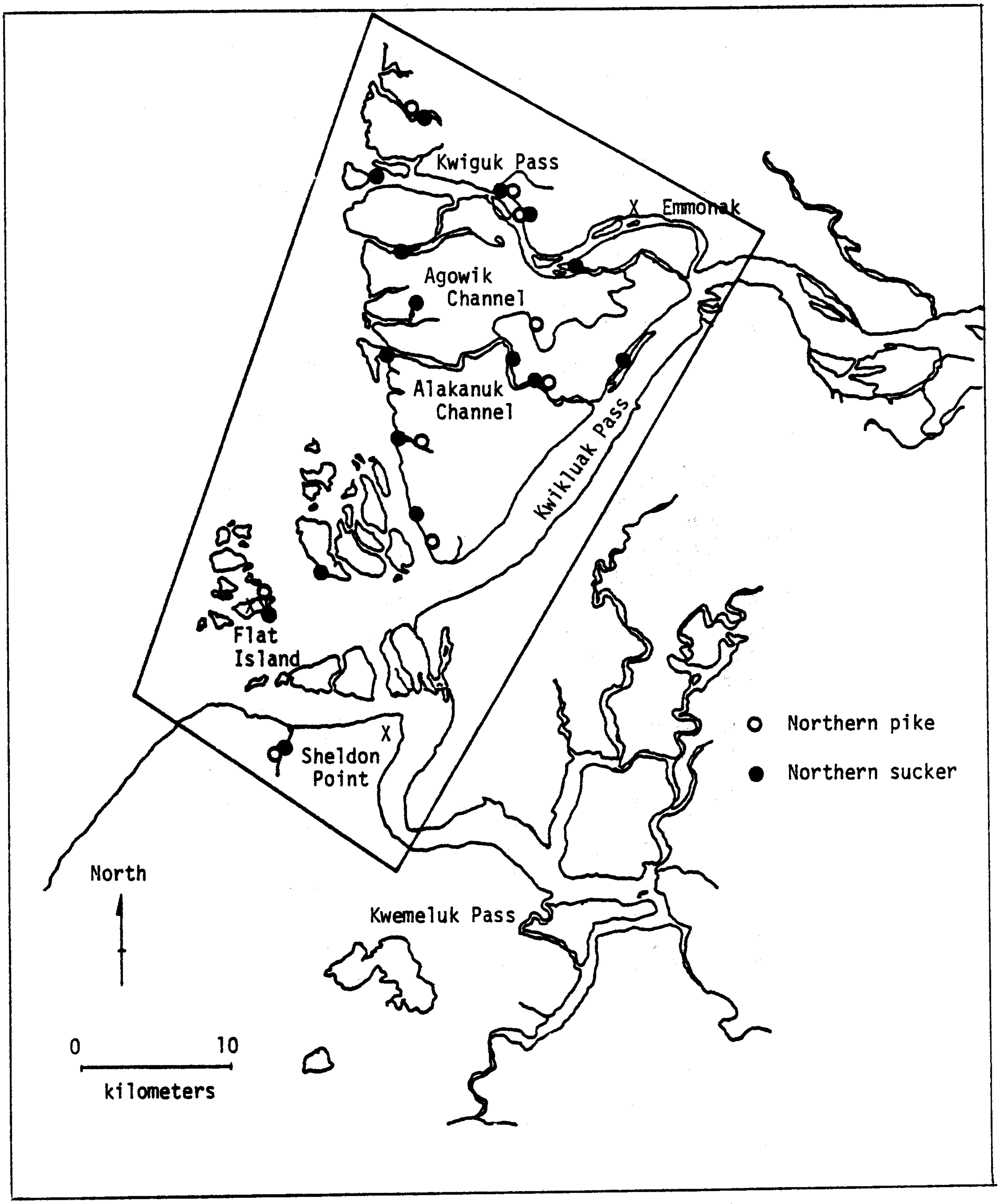


Figure 85. Distribution of northern pike and northern sucker catches at the south mouth of the Yukon River, June 9 through August 5,1976.

APPENDIX PHOTOGRAPHS

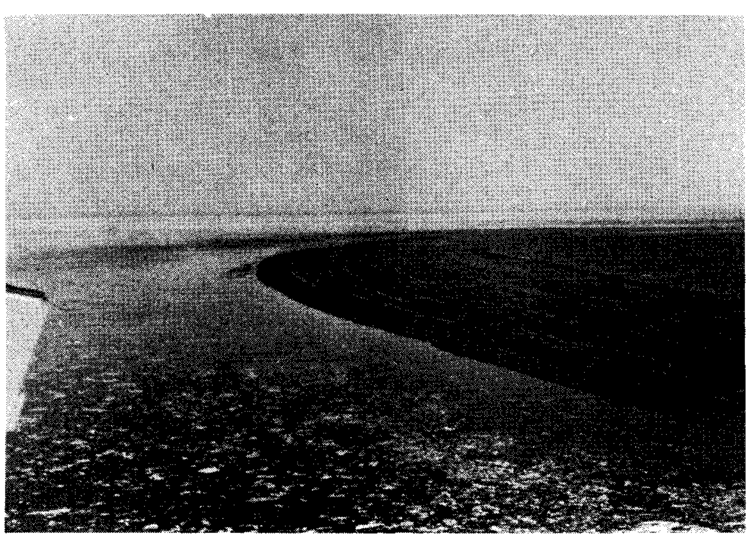
1. Norton Sound ice conditions, June 10, 1976. Looking east at Cape Stebbins.

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

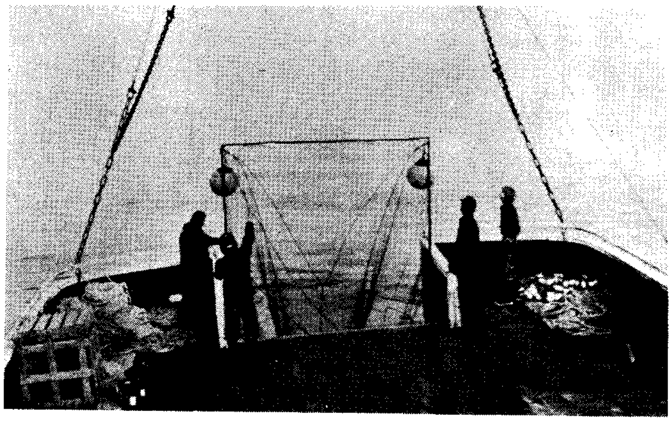
3. Norton Sound ice conditions, June 3, 1977. Looking west along southern coast toward Klikitarik.

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

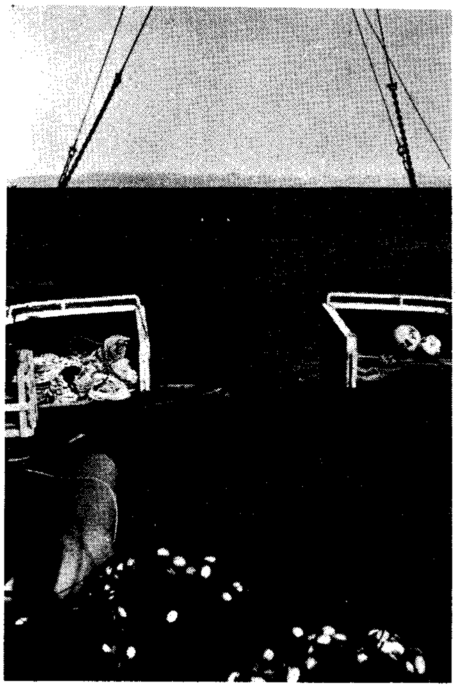
5. Ice conditions in Golovin Bay, June 9, 1977. Field sampling began in this area on June 9.



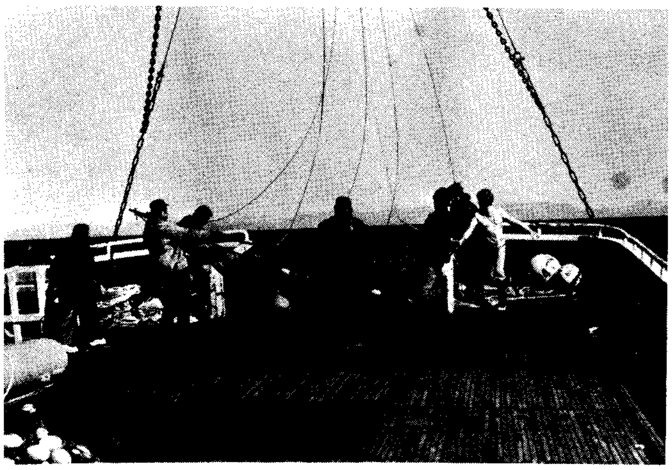
6. Bering Sea pack ice and pan ice conditions at Cape Epsenberg which blocked entry of the *MV Royal Atlantic* into Kotzebue Sound, July 11, 1977.



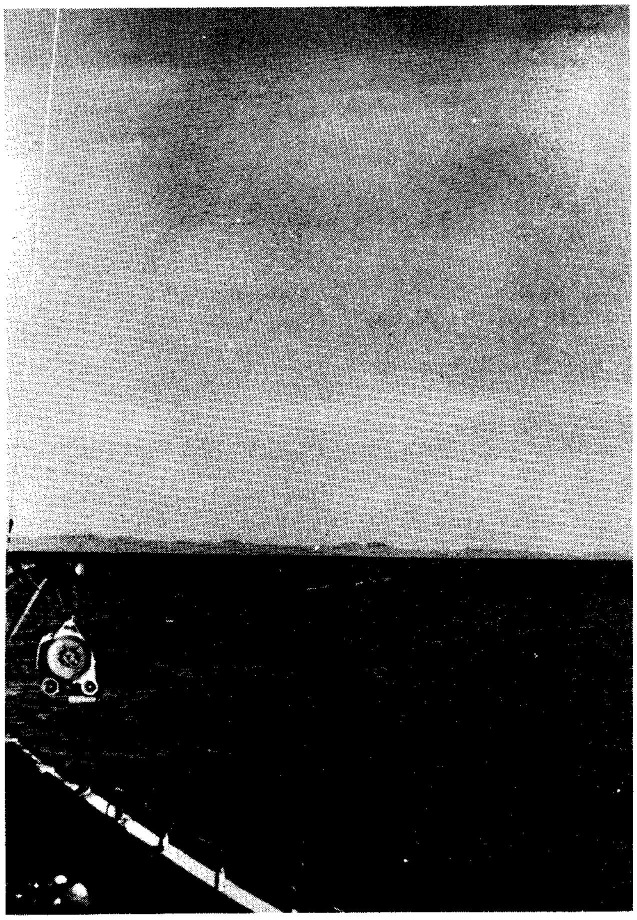
7. Launching the rigid frame surface townet from the MV *Royal Atlantic* near Tin City, July, 1977.



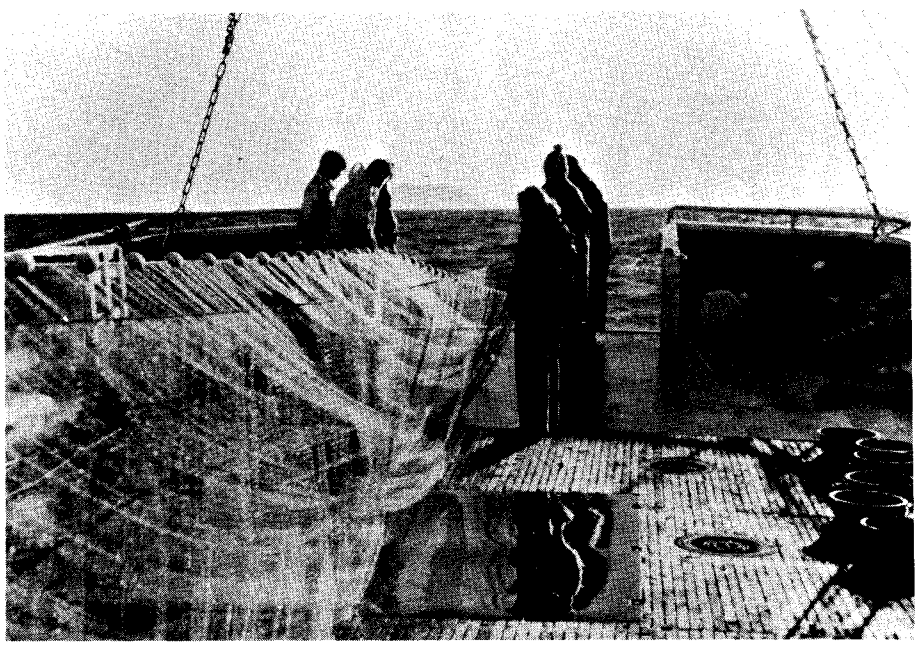
8. Surface tows in Norton Sound were 30 minutes in duration each, and towed at two to three knots.



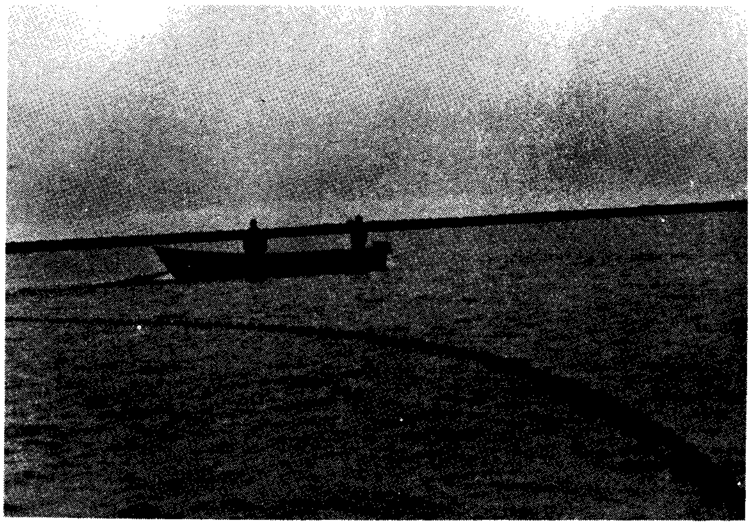
9. Retrieval of townet. Most catches consisted of
larbal Osmerics
larval Osmerids, Clupeids or Gadids.



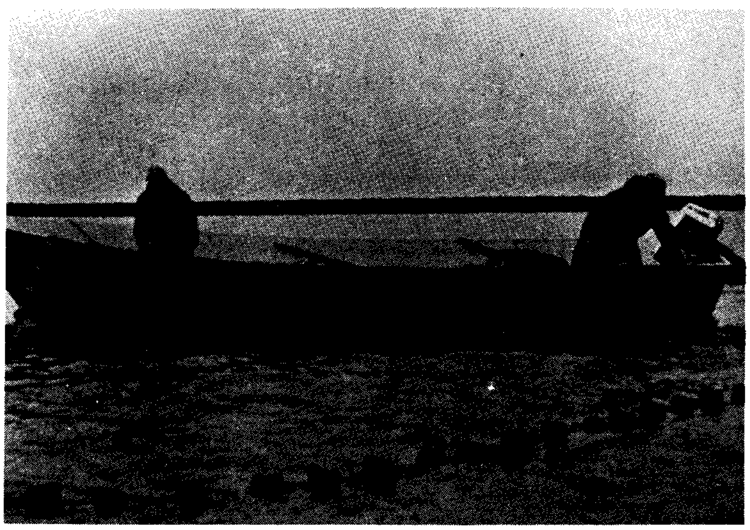
10. Fishing variable mesh, long line gillnets from the MV *Royal Atlantic* , June, 1977. Overnight soaks of 8 - 10 hours were made daily.



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

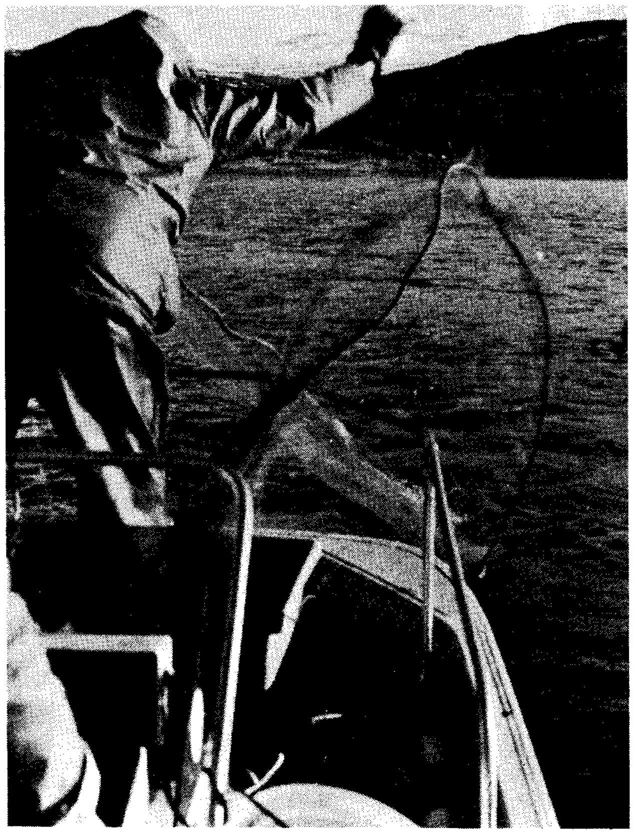


12. Deployment of 46x7 meters hand purse seine in Yukon River estuary.



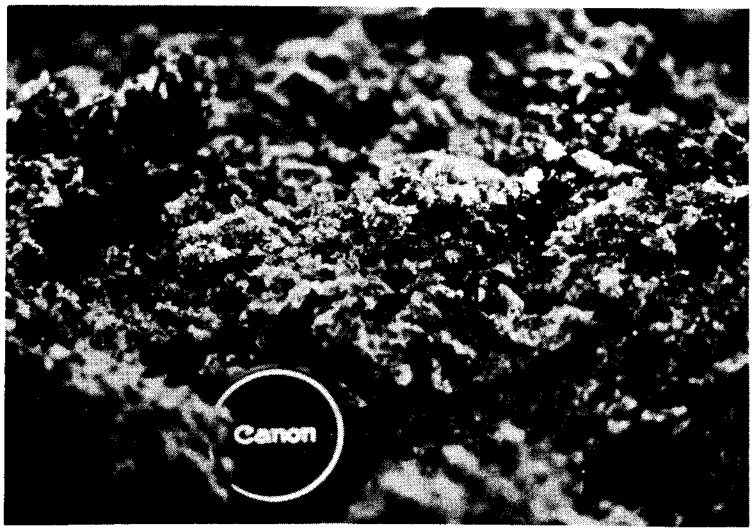
13. Retrieval of the hand purse seine used to sample the Yukon River estuary, 1977.

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

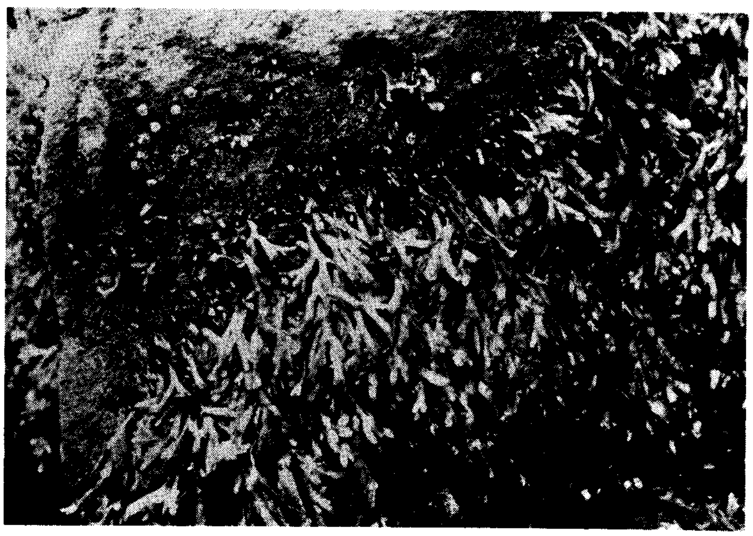


15. Setting one of the many offshore variable mesh gillnets in Golovin Bay, October,1977.

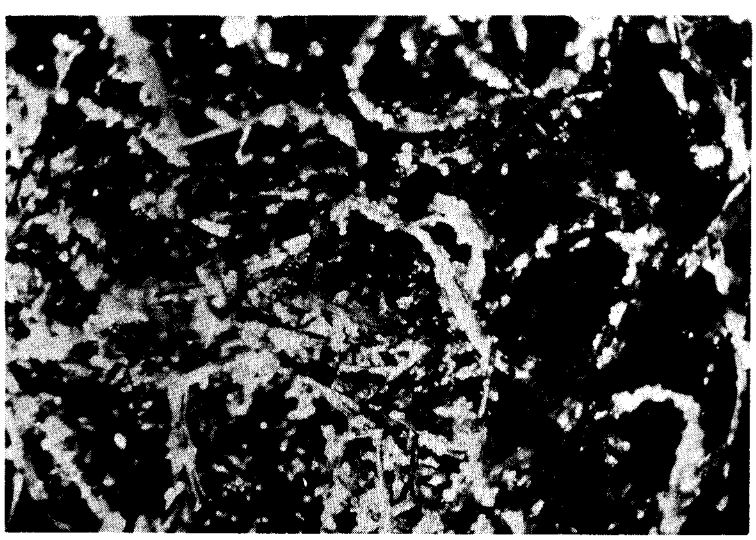
16. Retrieving a floating variable mesh gillnet in Grantley Harbor, July 1977. Catch included more than 600 Pacific herring.



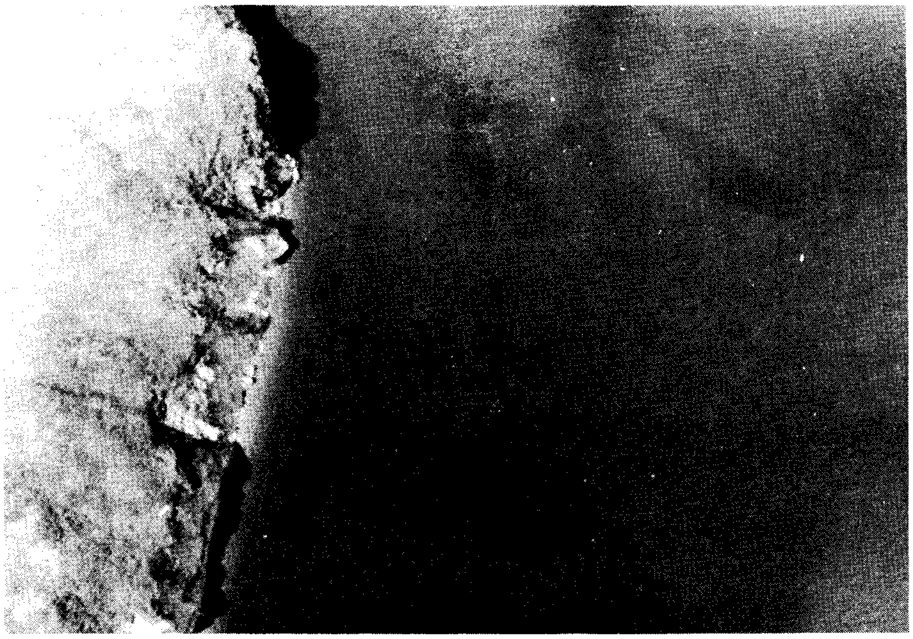
17. Herring spawn on rockweed kelp (*Fucus* sp.). *Fucus* was documented as a major spawning substrate for herring in most areas along the western Alaskan coastline.



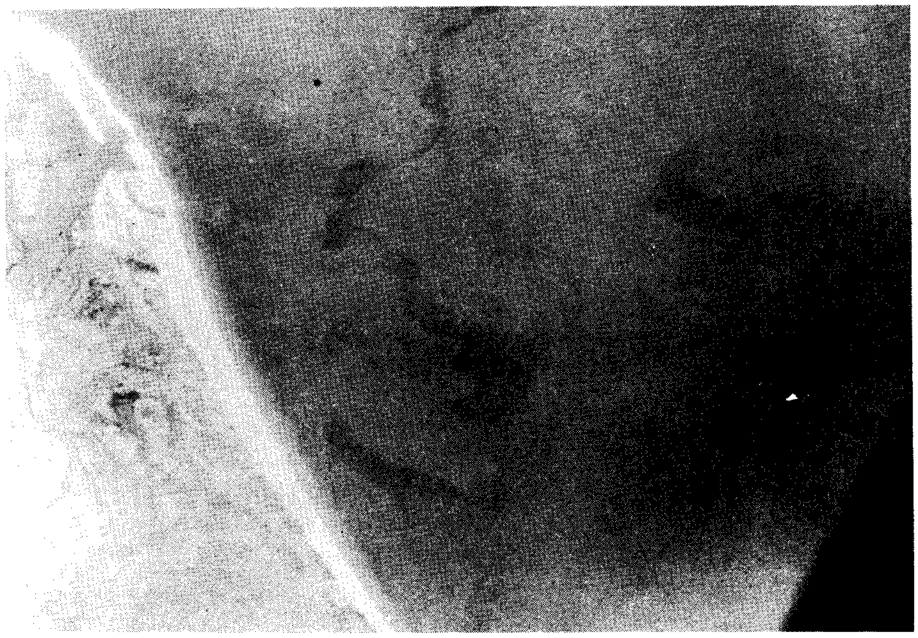
18. *Fucus* on exposed rocks near Klikitarik in southern Norton Sound, June 11, 1977. *Fucus* was common to exposed, rocky headlands and most other rocky coastal areas.



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

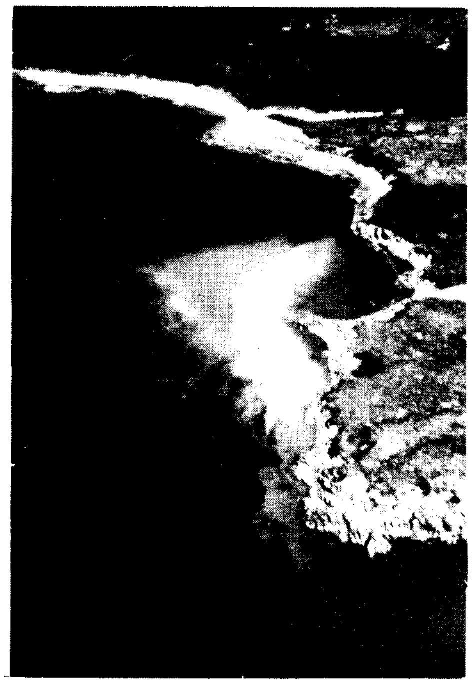


20. Schools of herring at Fourmile Point in Grantley Harbor, July 21, 1976. Herring occur in dense schools in deep water giving a dark appearance to individual schools.



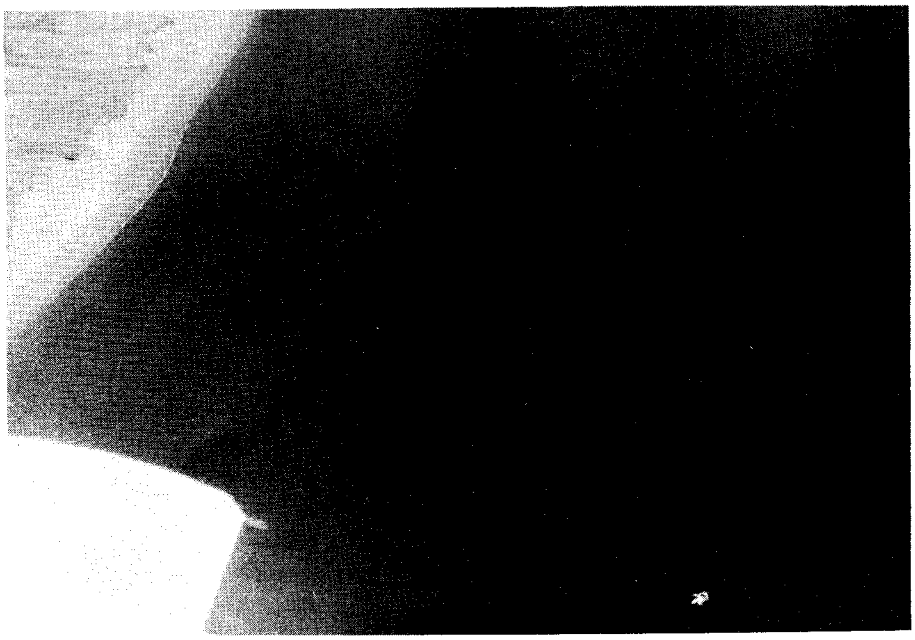
21. Herring schools at Coyote Creek in Grantley Harbor, July 21, 1976. Fish tend to disperse somewhat in shallow water and schools appear lighter in color. Banding is common under such conditions.

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

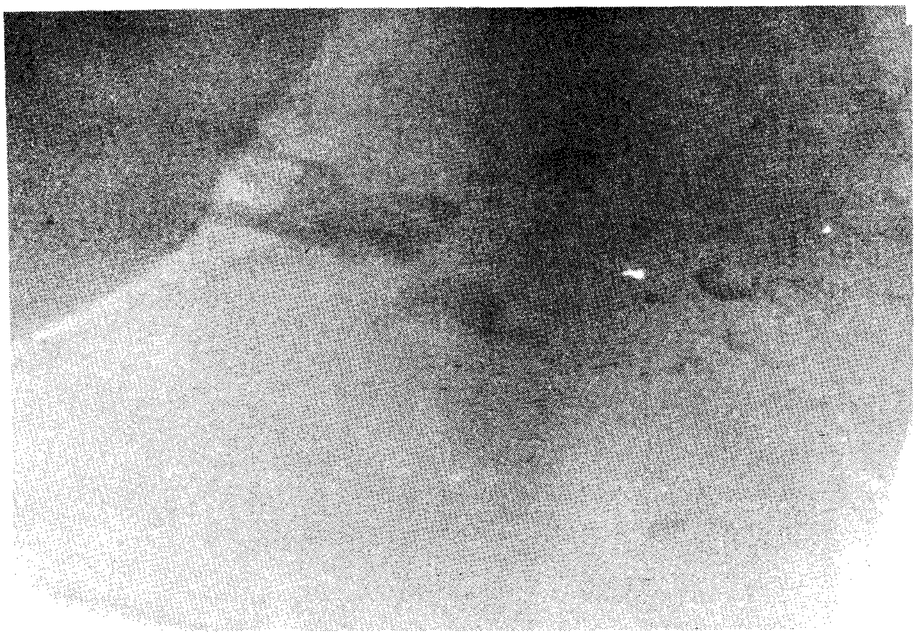


23. Typical rocky headland characteristic of major herring spawning areas along western Alaska. A white to yellow-white color is produced in the water from milt released by spawning males.

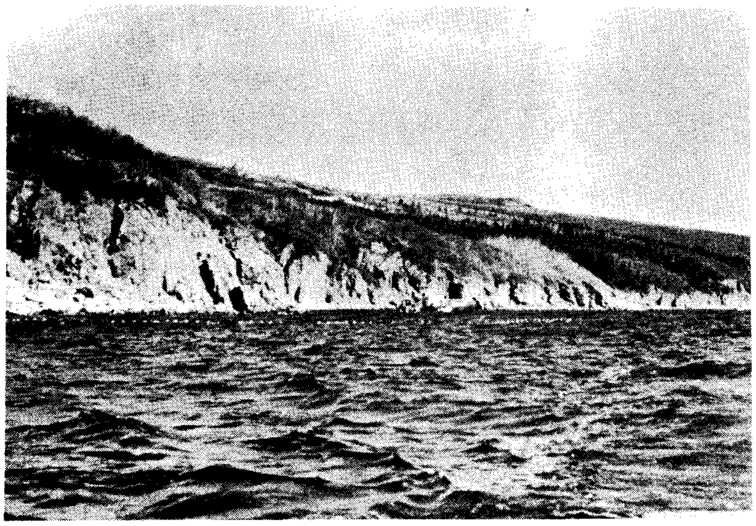
24. A large school of herring entering Shishmaref Inlet, July 1977.



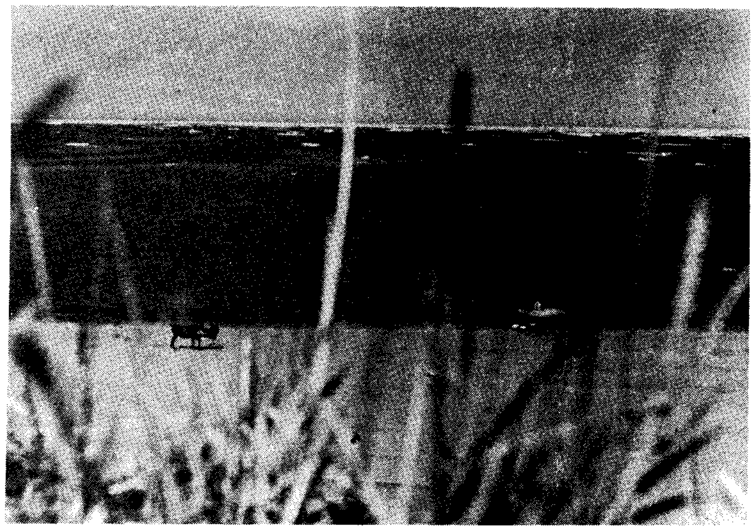
25. Unidentified fish schools (believed to be herring) near Shishmaref, July 1977.



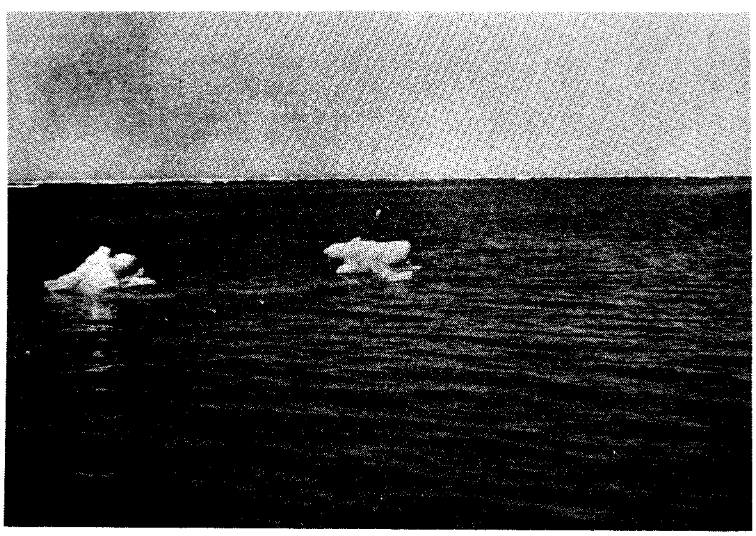
26. Unidentified fish schools in shallow water of Shishmaref Inlet, July 1977.



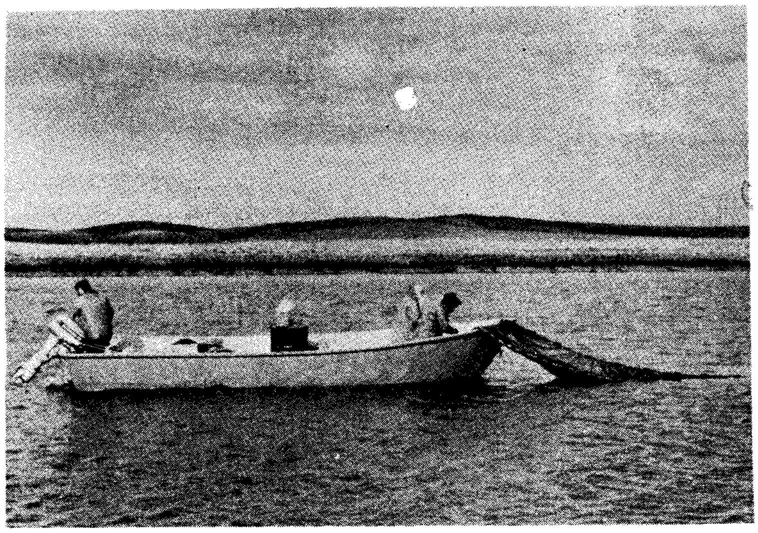
27. Commercial beach seine deployed at Cape Denbigh, June 1977. Approximately nine metric tons of herring were commercially harvested for sac roe production in Norton Sound in 1977.

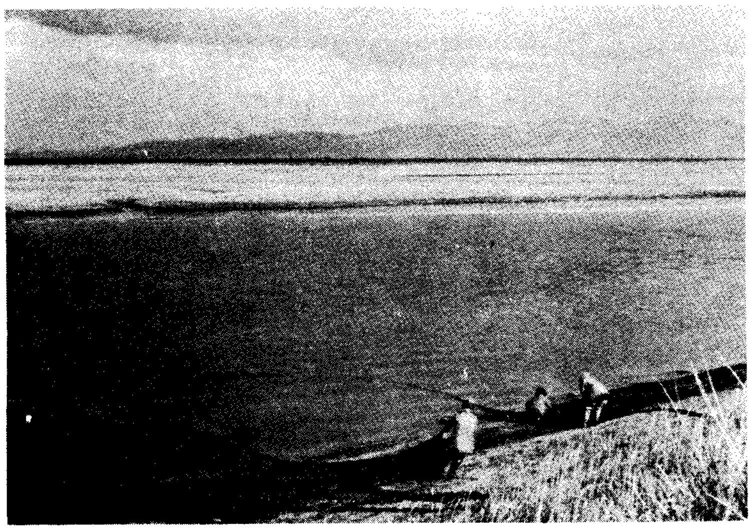


28. Ice conditions in the Chukchi Sea in July not only preclude entry of the *MV Royal Atlantic* into Kotzebue Sound but also severely hindered coastal test fishing efforts.



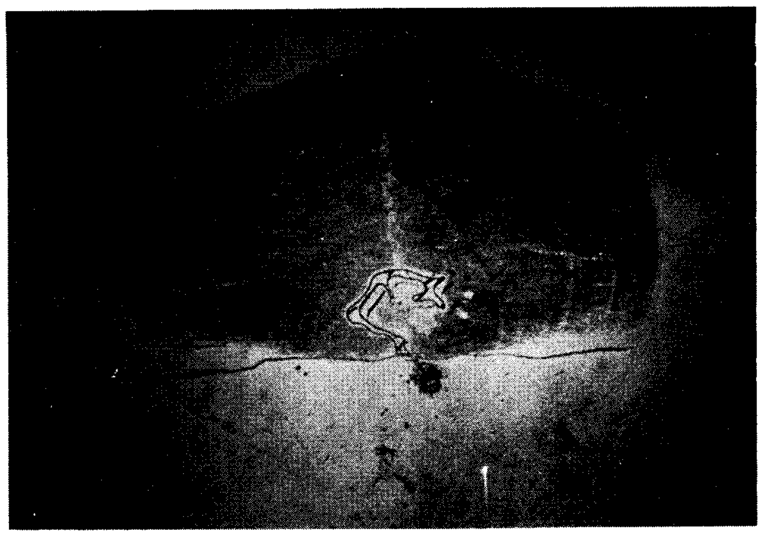
29. A common sampling problem encountered in the early spring. Drifting pan ice often reduced the soak time of many gillnet sets.





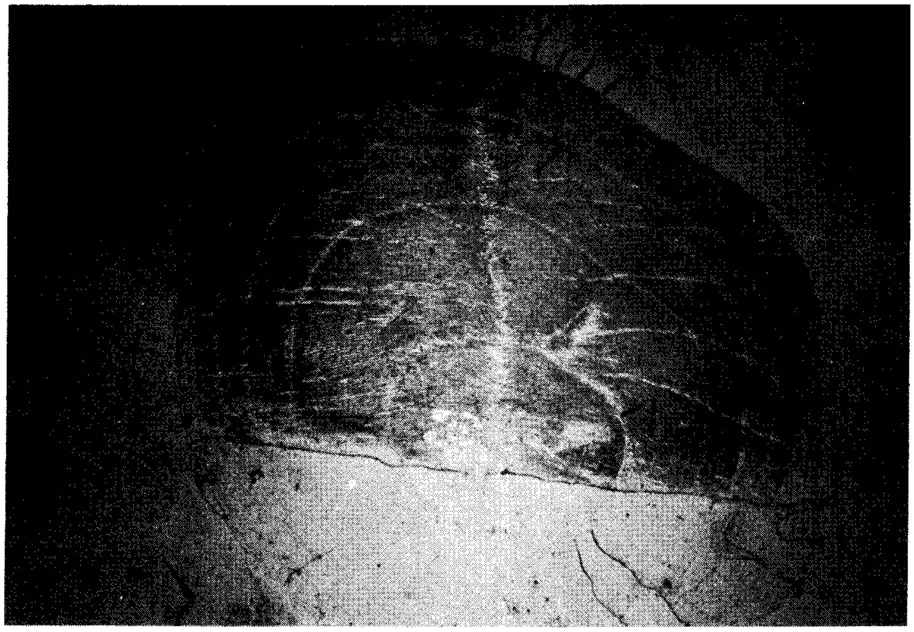
30, 31, 32. A typical set and catch with the 61 meter (3 mm mesh) beach seine near Shaktoolik, 1976.

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



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

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



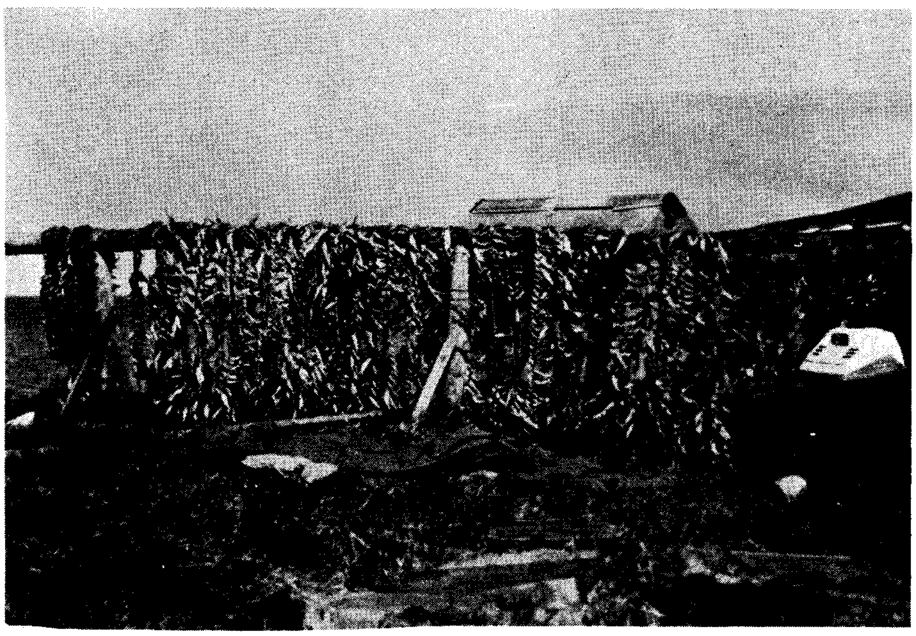
36. A nine-year-old herring; sampled in Port Clarence, July 10, 1977.

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

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

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

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

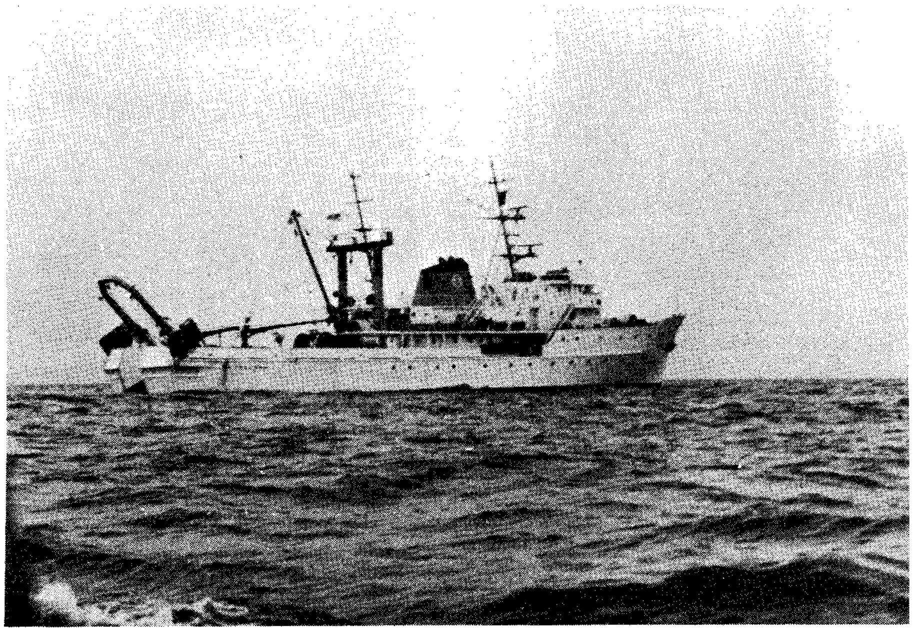


41. Herring are often woven into grass strings and allowed to sun-dry for several days. Herring are an important subsistence food item to many coastal residents of western Alaska.

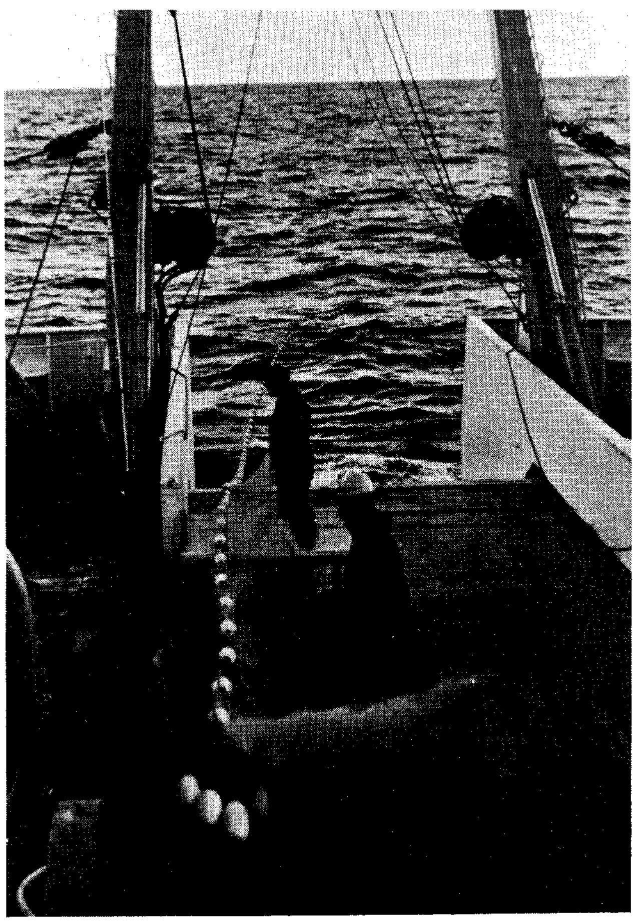
42. An OCS ground crew hand sampling spawning capelin near the village of Tununak, 1976. This is typical of capelin spawning habitats; fine sand and gravel beaches.

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

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



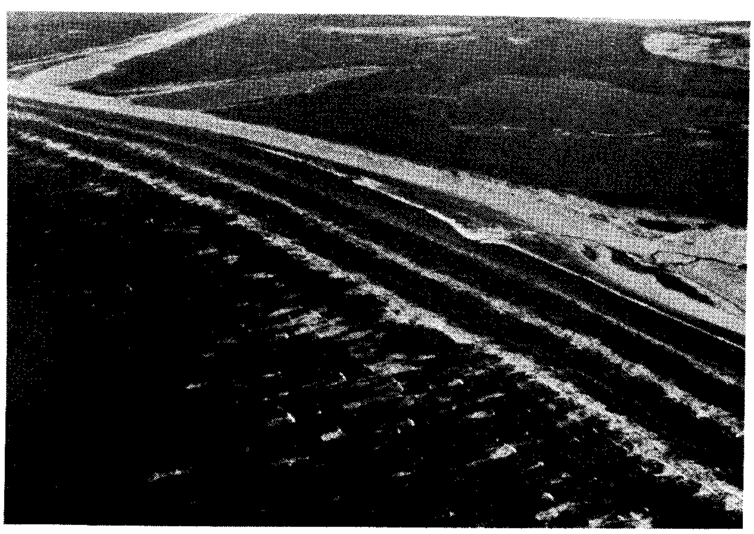
45. The NOAA ship *Miller Freeman* investigated fishery resources in the offshore waters of Norton Sound and Kotzebue Sound in September and October, 1977.



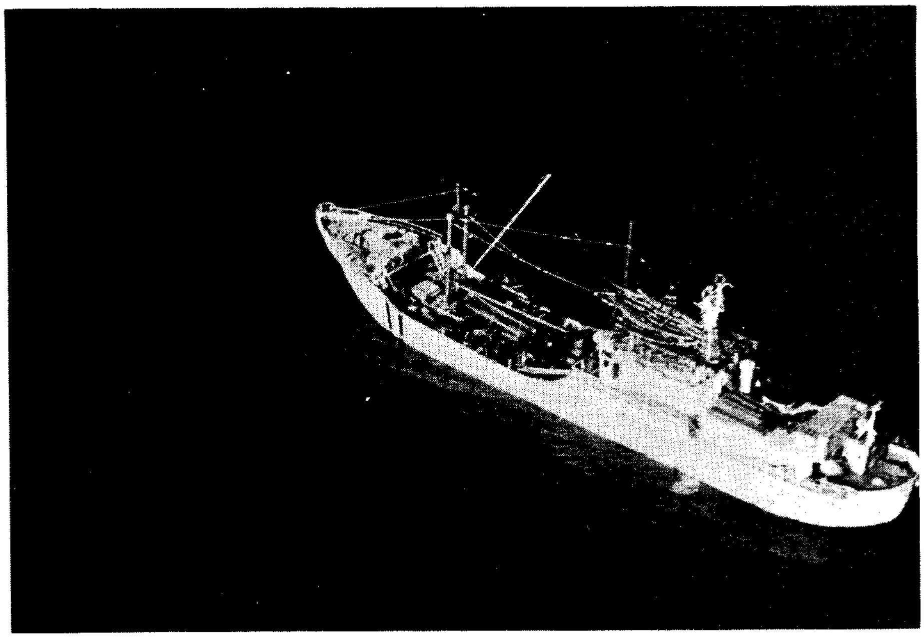
46. Retrieving variable mesh long-line gillnets aboard the NOAA Ship *Miller Freeman*, September 1976.

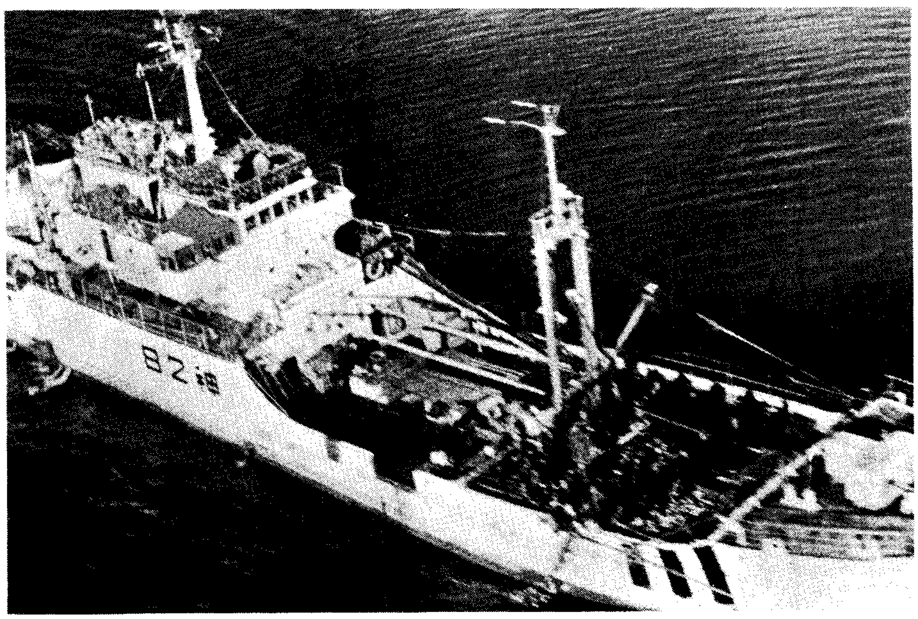
47. Freeze up of Grantley Harbor occurred overnight in 1977. Photograph shows village of Teller at the outlet of Grantley Harbor on October 16, 1977.

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

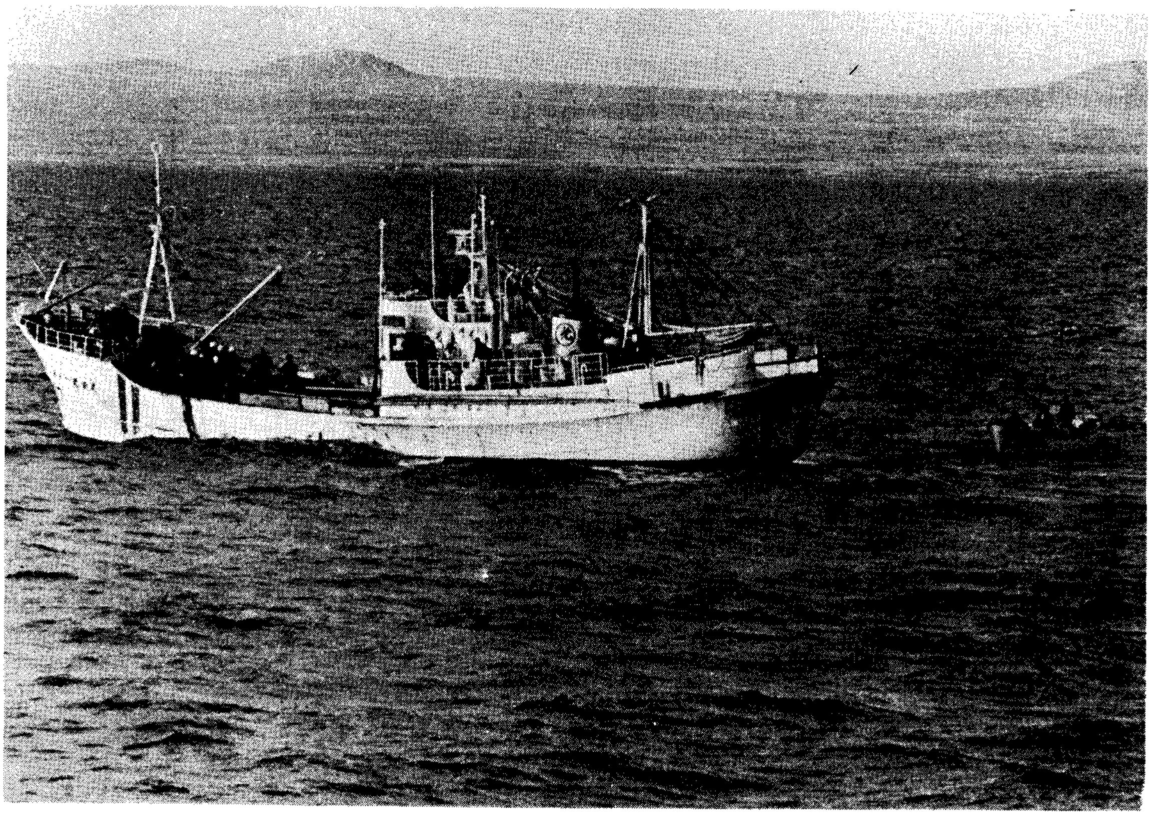


49. Turbid water conditions near Cape Wooley generated by fall storms which hampered aerial surveys.





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



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

RESEARCH UNIT 64

The following were submitted as the final report for this research unit:

Macy, Paul T., Janet M. Wall, Nickolas D. Lampsakis, and James E. Mason (1978). Resources of Non-Salmonid Pelagic Fishes of the Gulf of Alaska and Eastern Bering Sea, Northwest and Alaska Fisheries Center, NMFS, Seattle, Washington 98112.

Part 1 - Introduction; General Fish Resources and Fisheries; Review of Literature on Non-Salmonid Pelagic Fish Resources, pp. 1-356.

Part 2 - Historical Data Record of Non-Salmonid Pelagic Fishes, pp. 357-714.

Part 3 - Data Appendices, 329 pp.

RESEARCH UNIT 68

The following was submitted as part of the final report:

Mercer, Roger W., Bruce D. Krogman, Ronald M. Sonntag (1978). "Marine Mammal Data Documentation for the Platforms of Opportunity Project and Outer Continental Shelf Environmental Assessment Program", Northwest and Alaska Fisheries Center, NMFS, Seattle, Washington 98112, Processed Report, 92 pp.

INTERTIDAL BIOTA AND SUBTIDAL KELP COMMUNITIES
OF THE KODIAK ISLAND AREA

by

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Research Unit 78

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PREFACE

In 1974 the National Oceanic and Atmospheric Administration (NOAA), U.S. Department of Commerce, contracted with the Bureau of Land Management (BLM), U.S. Department of the Interior, to provide an environmental assessment of the northeastern Gulf of Alaska. This assessment was designed to provide a measure of the environmental risk associated with oil and gas exploration and development in the offshore areas of the region. NOAA, through its Environmental Research Laboratories, established the Outer Continental Shelf Environmental Assessment Program (OCSEAP). OCSEAP contracted with universities and state and federal government agencies to provide BLM with the data for preparation of an environmental impact statement for the northeastern Gulf of Alaska. The Northwest and Alaska Fisheries Center Auke Bay Laboratory, National Marine Fisheries Service (NMFS), NOAA, was contracted to assess the distribution of intertidal (littoral) communities in the eastern Gulf of Alaska in 1974 and expanded these studies to include the western Gulf of Alaska and eastern Bering Sea in 1975.

This report is an analysis of intertidal data from sites in the Kodiak Island area of the western Gulf of Alaska. The Kodiak Island area includes the Trinity Islands; Kodiak, Sitkalidak, Afognak, Shuyak, and closely-associated smaller islands; Chirikof Island to the southwest of the Trinity Islands; the Barren Islands at the mouth of Cook Inlet; and the Alaska Peninsula across Shelikof Strait from Kodiak Island.

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INTRODUCTION

The distribution (Harriman Alaska Expedition of 1899, Rigg 1915, Bousefield and McAllister 1962, Dreuhl 1970, Nickerson 1975) and composition (Nybakken 1969, Weinmann 1969, Hubbard 1971, Lebednik, Weinmann, and Norris 1971, O'Clair and Chew 1971, Calvin 1977, Rosenthal and Lees 1977) of intertidal species and assemblages in the Gulf of Alaska are relatively unstudied. Many of the available data have been reviewed and summarized by Feder and Mueller (1972) and the Arctic Environmental Information and Data Center (1974).

Intertidal communities in the Gulf of Alaska, and more specifically in the Kodiak Island area, have many features in common with those in other subarctic and northern temperate regions (Lewis 1964, Stephenson and Stephenson 1972, Kozloff 1973). For instance, Lewis' (1964) description of the Rhodyphyceae zone of northern Scotland and Ireland almost perfectly fits the situation we found at similar latitudes in the Kodiak Island area. Many of the species which Scagel (1971) and Kozloff (1973) described as being common in the Puget Sound and British Columbia regions are also common in Alaska. The known ranges of other intertidal species are being extended into the Gulf of Alaska as previously unstudied areas are surveyed (Lindstrom and Calvin 1976).

The overall objective of this study has been to generally describe the distribution of littoral habitats and their associated biota by a combination of qualitative and quantitative observations. Because of the immense area covered and limited time, our research has necessarily been extensive rather than intensive. The results generally reflect a "survey" approach rather than the more prediction-oriented baseline or monitoring approaches which are often used to study areas of potential impact. As these littoral areas are more clearly delineated, our research will be oriented toward monitoring changes in specific areas.

This report summarizes the results of our work in the Kodiak Island area and makes the information available before leasing decisions concerning that area are made. We have attempted to determine (1) the distribution and percent occurrence of each type of major intertidal habitat and (2) the assemblages of plants and animals that occur in these habitats.

The distribution of habitat types was determined by an observer in an airplane who surveyed the coastline from an altitude of 50-100 m (150-300 ft) (Sears and Zimmerman 1977). Concurrently, research teams based on the NOAA Vessel SURVEYOR* or working with Alaska Department of Fish and Game (ADF&G) on the OCSEAP Razor Clam Study† landed at several sites to quantitatively assess the types of organisms occurring in different intertidal habitats. Finally, in July 1976, an "overview" trip was made by helicopter to visit a large number of sites which were qualitatively assessed to describe apparent major differences between habitat types. The survey lasted over a year, beginning in May 1975 and ending in August 1976. Approximately 40 sites were visited (Figure 1) and over half were sampled quantitatively.

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* A total of three SURVEYOR trips were made in the Kodiak area.

† ADF&G biologists concentrated on species of commercial molluscs. The NMFS biologists were primarily responsible for collecting and identifying associated organisms.

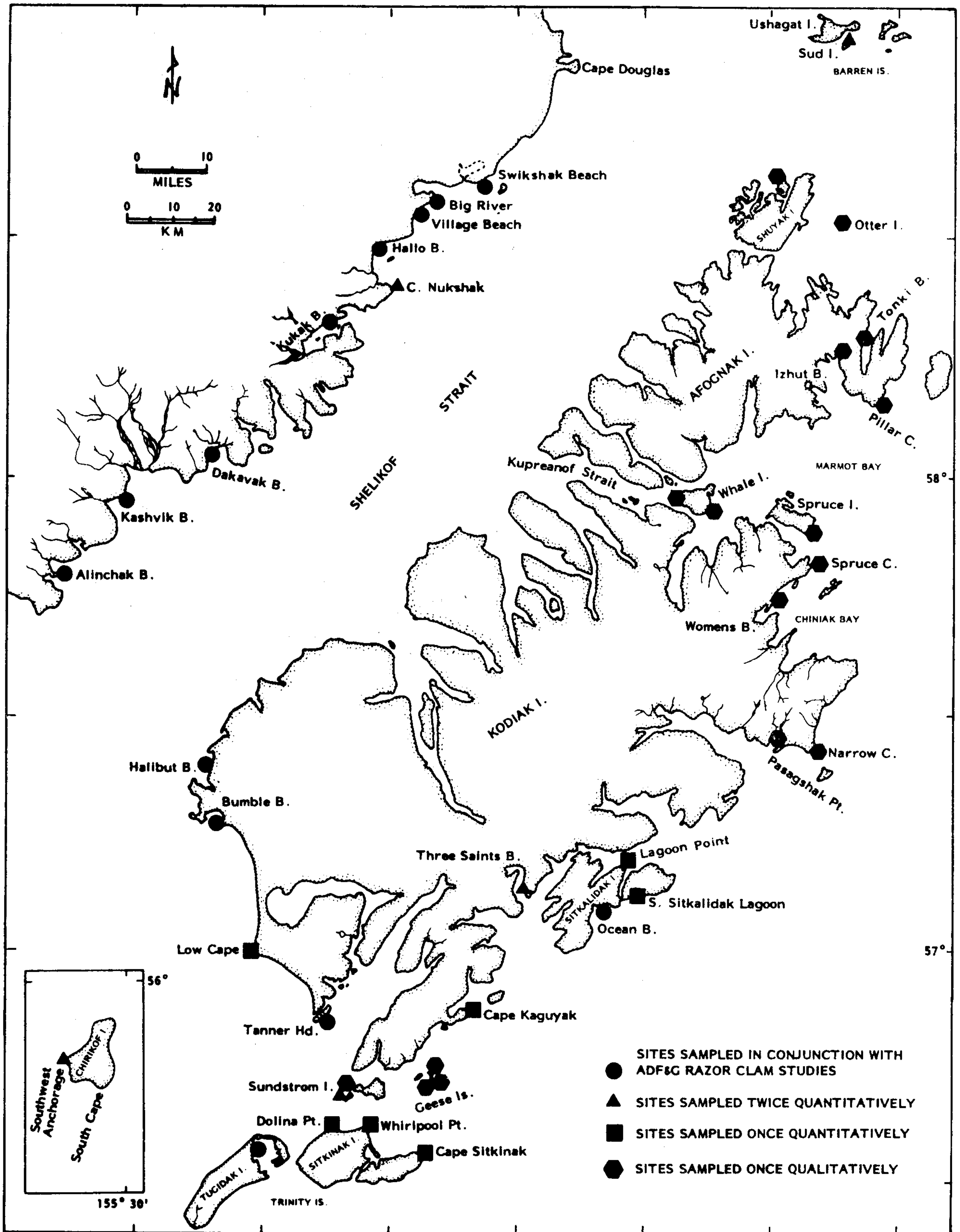


Figure 1. Intertidal sites sampled in the Kodiak area, 1975-76.

DESCRIPTION OF THE KODIAK ISLAND AREA

The area studied extends from Chirikof Island (55° 45'N, 155° 45'W) in the south to the Barren Islands (58° 55'N, 152° 01'W) in the north (Figure 1) and includes approximately 13,000 km^2 (5,000 mi^2; Capps 1937) of land. The largest land mass is Kodiak Island. Many long and narrow bays penetrate the islands, resulting in an irregular coastline almost 4,000 km (2,500 mi) long (Table 1). In the northern areas the slope of the beaches is generally quite steep. To the south the coastal shelf broadens and beaches are correspondingly lower in gradient (Capps 1937).

The tidal range is great. The mean diurnal range, or average difference between mean lower low water (MLLW) and mean higher high water (MHHW), averages about 3.4 m (11 ft) and exceeds 4.3 m (14 ft) in some areas. During spring tides the extreme difference may be as great as 6.7 m (22.5 ft) in Kupreanof Strait. Tidal ranges are slightly greater in the northern areas than in the southern.

Table 1. Number of kilometers and percent of major substrate types in the Kodiak Island area.

Substrate	Kodiak and Afognak islands	Barren Islands	Trinity Islands	Chirikof Island	Total km	Percent
Bedrock	1,775	90.0	15.3	26.5	1,907	48.1
Boulder	479	2.4	5.6	3.2	490	12.4
Gravel	1,191	2.4	55.0	0	1,248	31.5
Sand	127	6.4	151.0	23.3	308	7.8
Mud	9	0	0	0	9	0.2
Total km	3,581	101.2	226.9	53.0	3,962	100.0

AERIAL OBSERVATION METHODS

Aerial observations (Sears and Zimmerman 1977) provided information on beach slope, beach composition (bedrock, boulder, gravel, sand, mud), and density of biological cover. All flights were made in May 1976 during the period from 2 h before to 2 h after low tides ranging from -2.6 to +1.0 ft. Only beach types which extended for 50 to 100 m or more were noted on survey charts. Other biological data were also noted whenever possible, including the locations of sea bird rookeries, sea mammal haul-out areas, swimming sea mammals, dead sea mammals, eagles, land animals on beaches, large concentrations of surf grass, and offshore kelp beds.

INTERTIDAL FIELD METHODS

In May 1975 an aerial reconnaissance of the Kodiak Island area was made to choose intertidal sampling sites. Two weeks later the first quantitative sampling began at seven sites in the western Gulf of Alaska. Four of these (Sud Island, Three Saints Bay, Sundstrom Island, Chirikof Island) were all in close proximity to the Kodiak lease area and are extensively discussed in this report.

The NOAA vessel SURVEYOR (Figure 2) transported field parties to the previously chosen general areas. A ship-based helicopter (Figure 3) was then used to survey specific areas and to transport field parties to the sites to be sampled. A second cruise to the same sites was made in August 1975.

In May 1976 a third SURVEYOR cruise was made. Data from the aerial survey were used to choose seven new sites for quantitative sampling (Cape Kaguyak, Cape Sitkinak, Lagoon Point, Dolina Point, Low Cape, South Sitkalidak Lagoon, and Whirlpool Point). An additional area on Sundstrom Island was qualitatively examined by placing four field parties ashore at different sites to note major differences across large areas.

In July 1976 a final trip was made to observe general distribution of dominant littoral species in areas not visited previously. Approximately 15 sites in nine general areas were qualitatively examined by two observers noting the distribution of species with respect to exposure and substratum type and slope.

Rocky Beaches

Large Boulder and Bedrock Beaches

At each of the sites with large boulder or bedrock substrates, one to three transect lines (Figure 4) were extended across the beach from the highest area of tidal influence to the water's edge at low tide. The number of lines used at each site was determined by the slope and biological homogeneity of the beach: on a low-gradient beach often only one long line (75-200 m) was sampled, whereas on a steep beach as many as three short lines (15-50 m) were sampled.

Sampling frames (1/16 m^2) were laid at regular intervals along the line. The area under each frame was photographed, the percent of cover contributed by the dominant organisms was enumerated when time permitted, and then the biota were scraped from the rocks (Figure 5) and preserved in 10% formalin. The elevation of each sample was determined with a transit and stadia rod using standard survey procedures (Figure 6). Elevations were measured with respect to predicted low tide levels, and the heights of permanent bench marks were established for some beaches.

A second sampling method developed by Dr. Richard T. Myren, Auke Bay Laboratory, was used to study the faces of large boulders or hummocks. This method, hereafter referred to as the "arrow" method, involved sketching a facsimile of the area to be sampled and the biotic zonation on a sheet of Mylar* plastic. Numbered, homogeneously-arrayed dots were then placed on

* Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

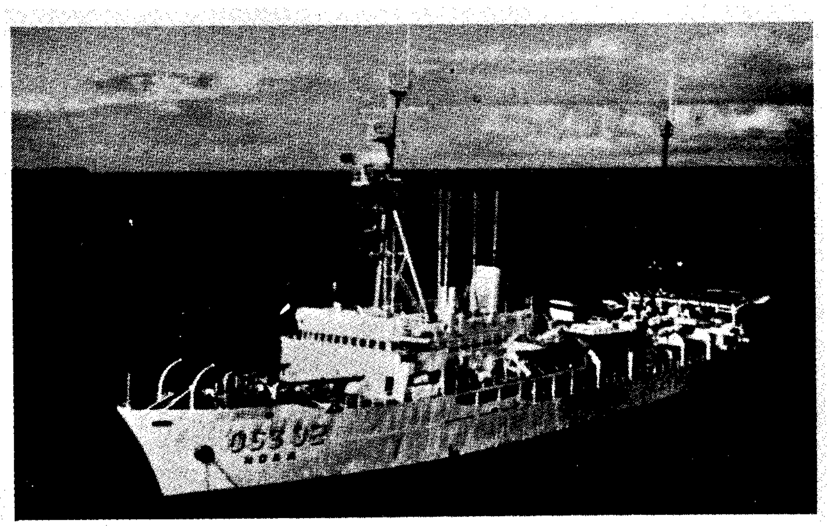


Figure 2. The NOAA vessel SURVEYOR was used to trans port field parties to remote locations during three of the sampling periods.

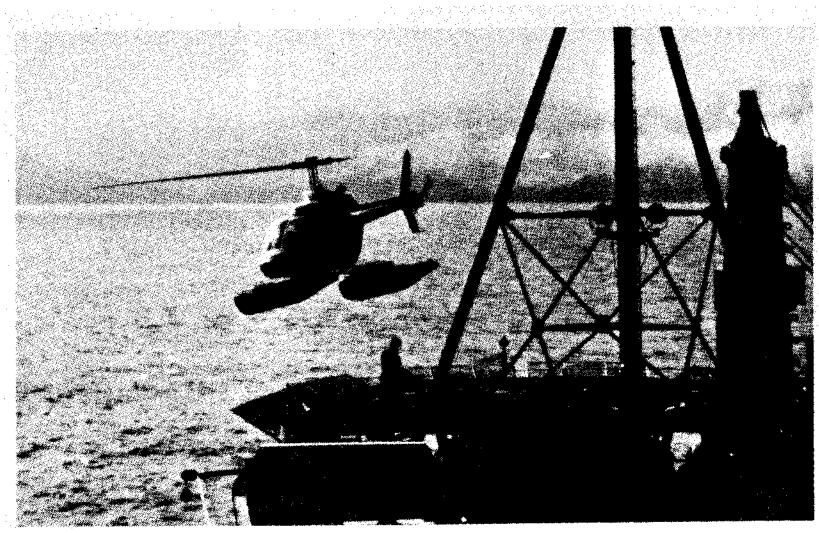


Figure 3. A NOAA helicopter was often used to transport field parties ashore.

Figure 4. Sampling a $1/16\ m^2$ quadrat along a transect line on a bedrock substrate.

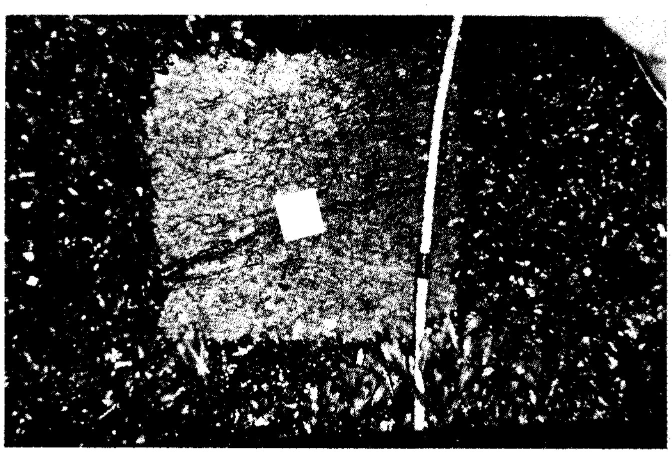


Figure 5. View of quadrat after collecting biota.

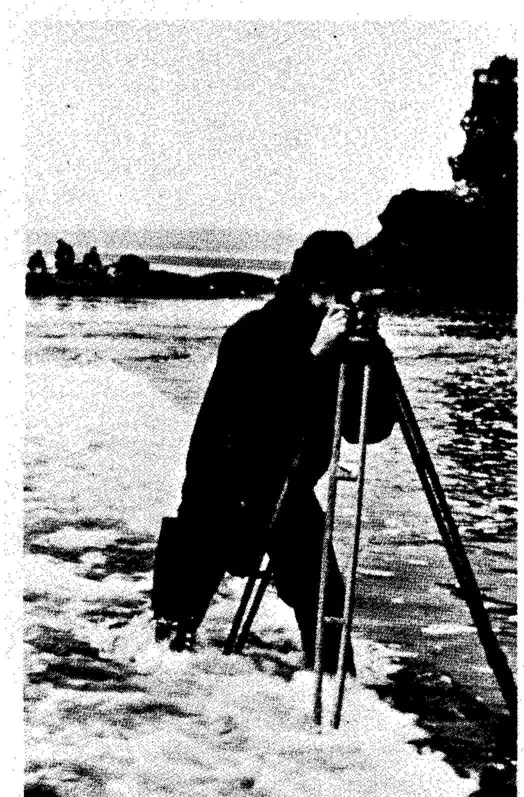


Figure 6. Measuring tidal elevations.

the sketch. A random-number table was used to choose dots (usually between 10-30 in number), and numbered arrows and 1/16 m^2 quadrat frames were then placed at the corresponding locations on the rock faces (Figure 7). Photography (Figure 8), determination of tidal heights of quadrats, and enumeration of cover followed, and quantitative collections (1/16 m^2) were taken in other areas with similar biota. The rock face itself was left undisturbed as a study site for future comparison.

Small Boulder Beaches

Areas composed almost entirely of small (<2 ft^2) boulders were generally uncommon. They were sampled at two sites using methods similar to the transect line sampling described in the preceding section. Where cover was sparse and patchy, 1-m^2 instead of 1/16-m^2 frames were used.

Gravelly and Sandy Beaches

A 1-liter (10 cm on a side) corer was initially used to sample gravelly and sandy beaches in the Kodiak Island area. It was immediately apparent from the paucity of visible organisms, however, that larger volumes should be sampled. Working in conjunction with the ADF&G Razor Clam Study, we were able to use a method that sampled much larger volumes of beach material. In this method 21- by 3-m plots were laid out with the long axis parallel to the beach. Positions differed by 1-ft tidal intervals (-2, -1, 0, +1 ft, etc.), and five to eight such plots were sampled on each of eight beaches. Three 1/3-m^2 subplots were randomly located within each plot and excavated to a depth of 0.3 m (1 ft). This large volume (101.6 liters per subplot) was then washed through a fiberglass screen with 1.59-mm openings (Figure 9) which was mounted on a cart. The cart (Figure 10) was equipped with a generator, pump, and long intake hose, which making it possible to wash large volumes of sediment in the field.

Muddy Beaches

Muddy beaches are relatively uncommon in the Kodiak Island area (Table 1). At South Sitkalidak Lagoon quantitative samples were collected along a transect line using a 1-liter (10 cm on a side) coring device (Figures 11 and 12). The corer was often used twice vertically, once to collect biota from the 1- to 10-cm depths and a second time to collect from the 10- to 20-cm levels. Replicate samples were also collected at each position along the line. In addition, qualitative sampling was done in South Sitkalidak Lagoon and at McDonald Slough in Izhut Bay on Afognak Island. These collections were made to determine species present after a general survey of the areas had located the major biological communities.

SORTING METHODS

All samples of sand, mud, and gravel were processed at the NMFS laboratory in Kodiak. After removing a small amount of sediment for analysis of particle size, each sample was examined for organisms, and all organisms were identified, counted, and weighed wet. Species were verified using the museum collection at the University of Alaska Marine Sorting Center in Fairbanks.

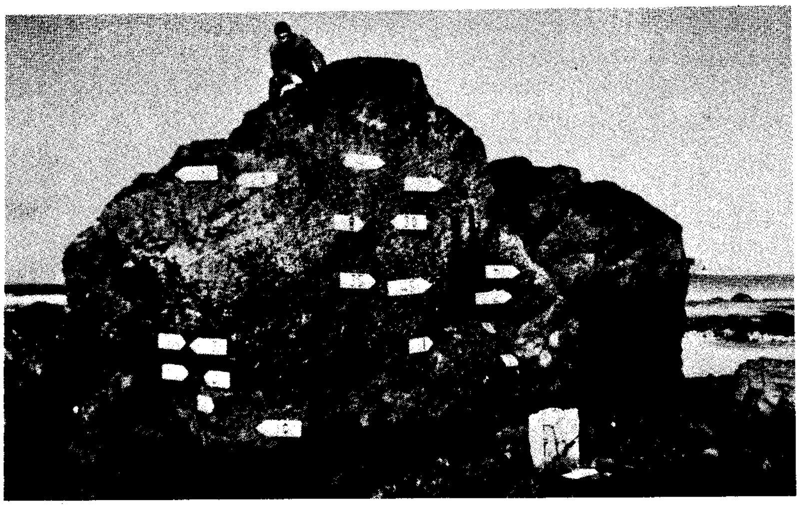


Figure 7. An example of a vertical rock face being sampled using the arrow method for randomization of samples.

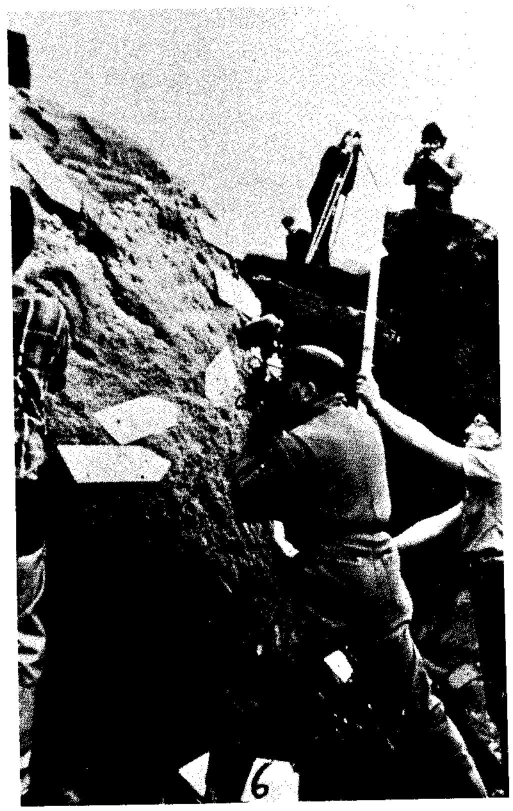


Figure 8. Measuring tidal elevations and photographing quadrats on a vertical rock face.

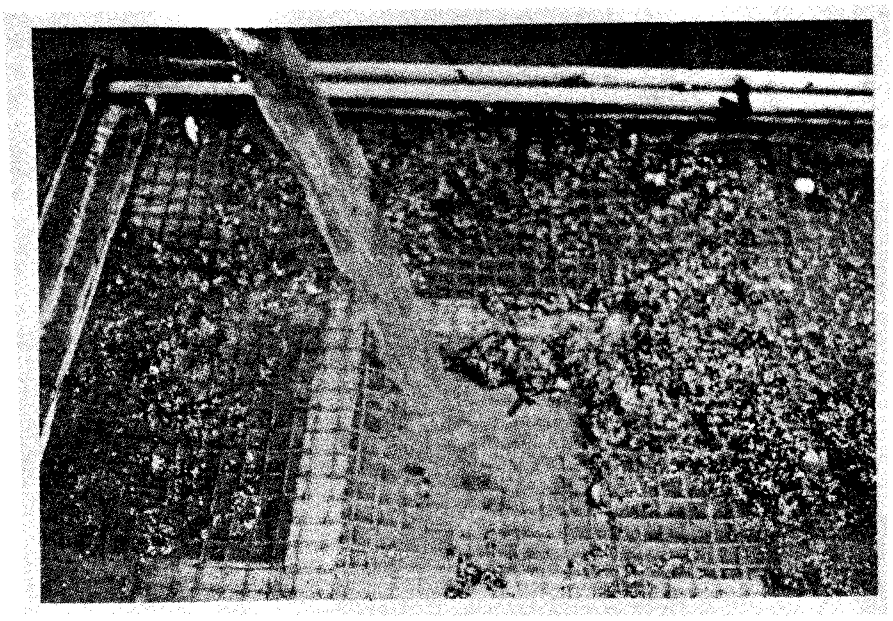


Figure 9. View of washing box for gravel and sand samples.

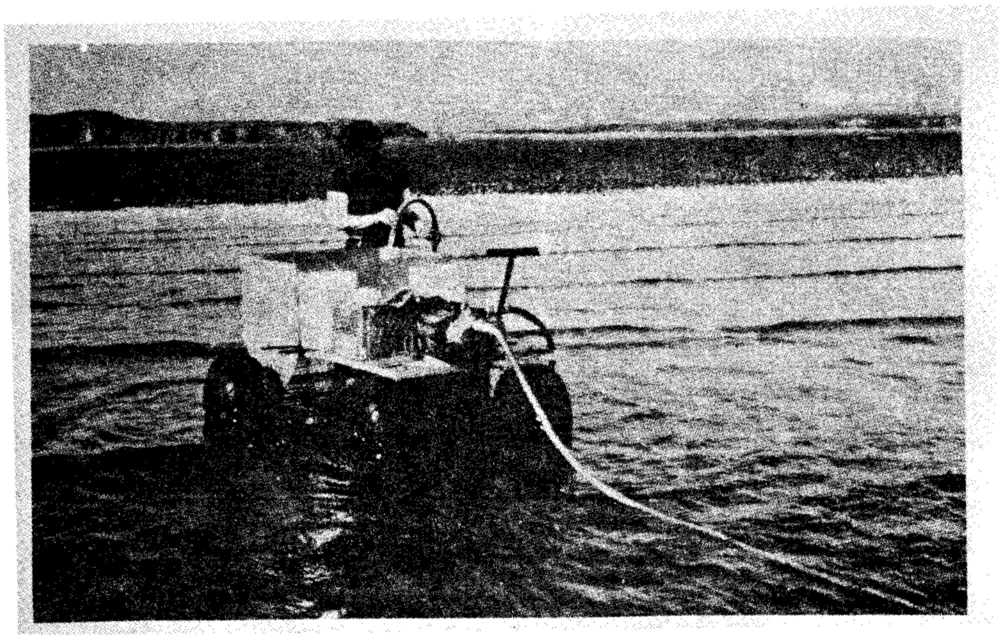
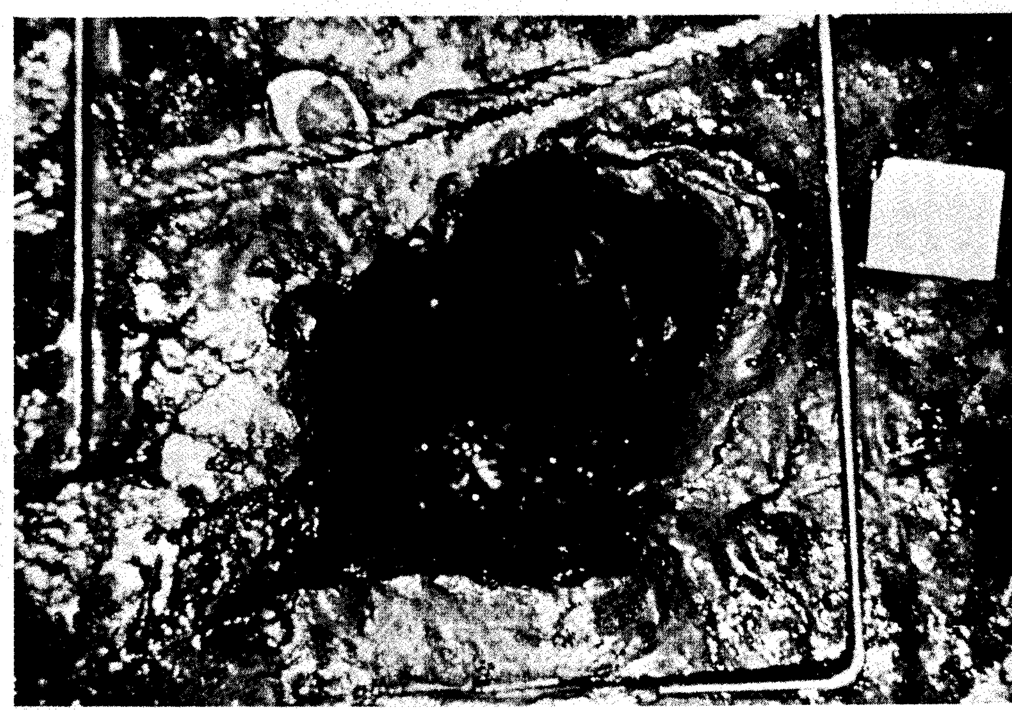


Figure 10. View of cart used to sieve gravel and sand samples in the field.

Figure 11. Sampling a muddy beach along a transect line.

Figure 12. View of quadrat after removing a 1-liter quantitative core of mud.



Samples from rocky beaches were sorted in two groups. All 1975 samples were sorted by University of Alaska Marine Sorting Center personnel and all 1976 samples were sorted by Auke Bay Laboratory biologists. Some differences between results from the two sorting groups occurred due to differing levels of expertise on specialized groups of organisms. The Marine Sorting Center, for instance, often carried annelid identifications to species while Auke Bay Laboratory biologists made identifications only to class or order. Collections of identified organisms were exchanged, however, and there were no major differences in identification of the common species.

Sorting by both groups was done in the following manner. Organisms were sorted, identified, counted, and weighed. Wet weights were recorded by Auke Bay Laboratory scientists, and both wet and dry weights were recorded by the Marine Sorting Center. Fertile and sterile plants of the two most common algae, Fucus and Alaria, were noted, and weights for the different stages were recorded separately. Data on mussels and limpets were divided into two or three categories based on animal size. Finally, after the dominant organisms had been removed, leaving a residual mass of small fragments, estimates of the remaining individuals were determined by subsampling.

AERIAL SURVEY

The coastline of the Kodiak Island area is approximately 3,900 km (2,500 mi) long (Table 1). Over half the coastline is composed of bedrock or large boulder beaches and the exposed coastline on the Gulf of Alaska side is almost entirely rock. Gravelly and sandy beaches make up much of the remaining coastline. Muddy beaches account for less than 1% of the coastline.

Using the aerial observations of biological cover, we determined which intertidal areas had been classified as having "heavy" cover on more than half of the rocky outer coastline (Figure 13)*. The areas used in this analysis are the same as those used to depict the Kodiak coastline in the intertidal atlas (Sears and Zimmerman 1977). Heavy cover occurred in the area of the Trinity and Geese islands, Kodiak Island south of Kupreanof Strait, and the northeastern side of Kodiak Island including Marmot Bay.

We also calculated the ratio between the sightings of offshore floating kelp beds and the miles of coastline (for instance, if five kelp beds were noted along 50 mi of beach the ratio would be 0.10). The data (Figure 14) indicate the greatest number of kelp beds are off the southeastern portion of Kodiak Island. In general, this part of the island has a wider shelf (Capps 1934) than the quite steep northern portion, and the more extensive kelp beds could be due to the wider shelf providing more substrate for attachment.

INTERTIDAL SURVEY--ROCKY BEACHES
Physical Parameters

The success of each species on rocky intertidal beaches is affected by many factors, such as differences in type and slope of substrate; occurrence of

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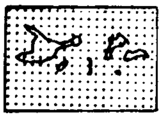
* Because heavy biological cover is sometimes not found in the upper parts of bays due to ice scouring, low salinity, siltation, and reduced currents, the rocky coastlines used for these calculations were limited to areas along the open coast or mouths of bays.

Figure 13. Distribution of heavy intertidal cover in the Kodiak area. Shaded areas represent coastline for which 50% or more of the intertidal beaches are heavily covered with biota.



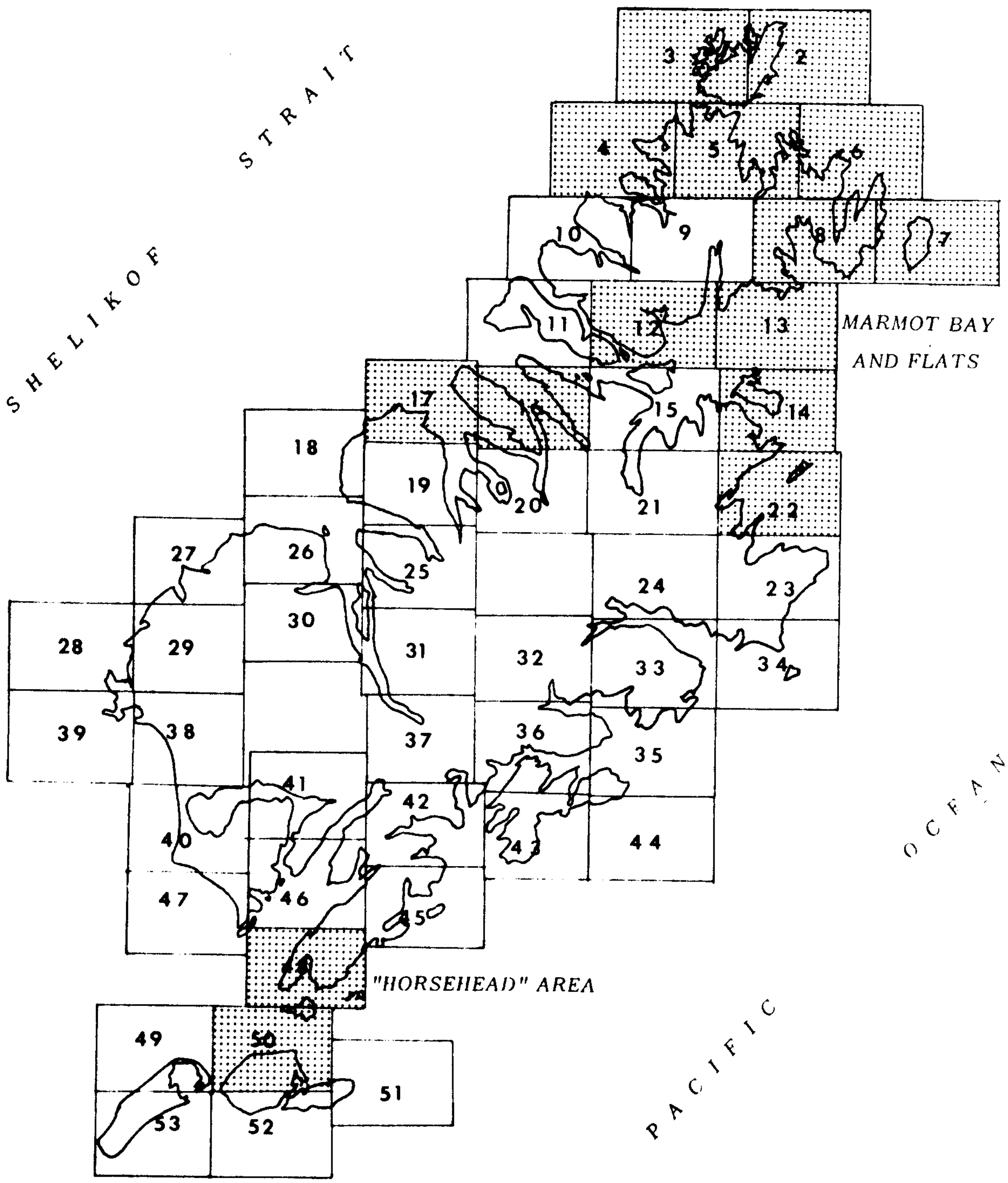
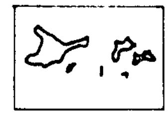
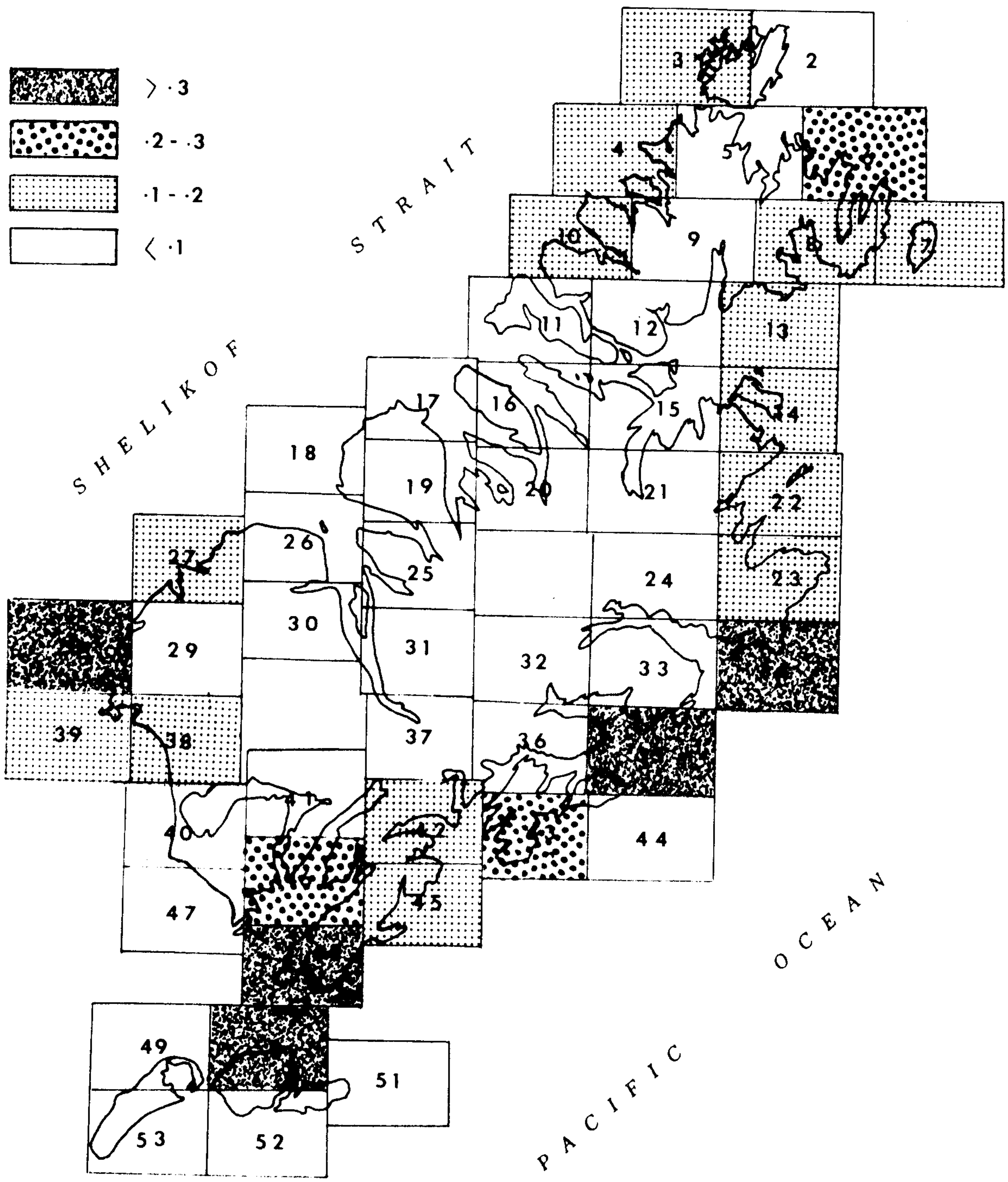


Figure 14. Distribution of beds of floating kelp in the Kodiak area. Ratio = $\frac{\text{number of kelp bed sightings}}{\text{number of miles of coastline}}$





crevices; amount of standing water; exposure to waves, winds, sand, and ice; and occurrence of competitors and predators. Our sites were only visited once or twice, and many of the major factors cannot be measured without several seasons of research at each site. We had hoped, however, to be able to account for part of the variability by correlating the occurrences of major biotic assemblages with two of the most obvious physical factors, substrate type and degree of exposure.

Substrate

We initially tried to follow the format developed in the aerial reconnaissance when designating habitat type by substrate (i.e., bedrock, boulder, gravel, sand, mud). Examination of several sites, however, indicated that some important habitat types are not accounted for by this system. The major categories of rocky habitat are described below.

Because of the low gradient of flat bedrock beaches, much of their area is usually covered by standing water after the tide has receded. This allows organisms from lower intertidal or subtidal zones to intermingle with species which normally occur higher on the beach (O'Clair and Chew 1971). In this situation, distance from the low water line may be more important than vertical elevation in determining zonation. Another feature of flat bedrock beaches is the lack of hummocks, crevices, and other vertical relief features which provide localized protection from surf.

Steep bedrock or boulder beaches have overhangs, crevices, various exposures to wind and waves, shading, and many other features which provide diverse microhabitats and thus some of the most biologically complex areas we encountered.

Beaches composed of small boulders at exposed locations (e.g., Low Cape, Dolina Point) have very little attached biota, probably as a result of lack of relief combined with battering of boulders during storms.

Exposure

Exposed, unprotected beaches have fewer animal species and lower biomass than do more protected areas (Rickets and Calvin 1968). Unfortunately, our brief one- or two-day reconnaissance at each site made it impossible to evaluate the effects of wind, storm surf, the presence of offshore bars, kelp beds, or other more subtle features which modify the amount of exposure of the biota. Therefore we chose simple descriptors, i.e., exposed, partly protected, and protected. We generally based the decision on the apparent amount of protection provided by adjacent land masses.

Exposed locations are those which have either little or no protection from physical oceanic forces. Partly protected sites lie inside bays or have protective offshore islands, reefs, or other topographic features. Protected sites usually lie well within bays and are shielded in several directions from oceanic forces.

We tried several statistical methods to determine and analyze the relationship between substrate, exposure, and biota. Before the methods and results are discussed, however, a general description of each site and its dominant biota is presented.

Quantitative Surveys: Description of Sites and Biota

Two types of surveys were made: "qualitative," which were quick surveys by two observers, and "quantitative," which extended over one or two entire low tide cycles and were done by a team of six or more biologists.

On quantitative surveys, organisms were collected from measured quadrats or cores as described in "Intertidal Field Methods." Summary descriptions of the sites we sampled quantitatively are given in Table 2. The organisms found in the quantitative collections at each site are shown in Tables 3-5. Each description of a quantitative survey site in this section of the report is accompanied by a map of the sampling location, photographs of the area, a graph of horizontal and vertical distributions of algae and invertebrates, and a graph showing the density of selected intertidal organisms.

Chirikof Island

Chirikof Island lies in the Gulf of Alaska about 50 km (80 mi) east of the Alaska Peninsula and about 50 km southwest of Kodiak Island (Figure 15). It is exposed to severe wave impact, somewhat moderated by offshore reefs. The area we sampled at West Point is characterized by a long, low reef system, most of it lying below mean low water (MLW) (Figures 16 and 17). The beach above the tideline is also low gradient and is entirely sand. The upper side of the sandy beach is covered by a jumble of large weathered logs stranded by storm surf.

We sampled part of the large reef area in May and August 1975 using (1) the arrow method on a high-relief area with elevations ranging from 3.6 ft to -1.4 ft (Figure 18), and (2) the transect line method on an area near the arrow site but lying entirely below MLW. The arrow site was bedrock and thus more stable than the transect line site which had small cobbles and sand over bedrock. The stable bedrock and greater range of elevation at the arrow site provided additional habitats in the form of crevices and overhangs, giving some protection for motile invertebrates; these habitats were not found along the low-lying transect line. Because of its low gradient, the transect line area had many small tidepools and areas of standing water, even at low tide.

The arrow site was an area of the bedrock reef with an eroded surface perpendicular to and facing the ocean. The arrows were placed on the top, side, and overhangs of this face in an area about 10 m long. Much of the area had a heavy cover of the large barnacle Balanus cariosus which in turn was covered with sponges, coralline algae, small-bladed red algae such as Iridaea cornicopiae, and large fertile Alaria sp. The Alaria were uneroded with large, entire blades. Laminaria longipes was also seen in the arrow site. We also saw Henricia leviuscula, Katharina tunicata, Collisella pelta, and large littorine snails.

The beach at the low end of the transect line was a bedrock substrate somewhat similar to the arrow site area and was covered with sponges and fertile, uneroded Alaria, Rhodomela larix, and Iridaea cornucopiae (Figures 19-22). Higher on the line, in an area of cobbles, large pebbles, and standing water, we observed a large amount of Odonthalia floccosa and Rhodomela larix in low areas, with Alaria sp. and Fucus distichus growing on the boulders. In this area some of the Alaria had eroded blades with only

Table 2.--Description of intertidal sites and types of samples taken in the Kodiak Island area, 1975-76: sites sampled quantitatively.

Location	Exposure	Substrate	Dates Sampled	Elevation Range Sampled (ft)	Sampling Method*	Sample Size	Number of Transects
Chirikof Is.	Exposed	Flat bedrock	5-27-75 8-10-75	+3.6 to -1.4	A Q	1/16 m^2	2
Sitkinak Is.	Exposed	Flat bedrock	5-13-76	+3.0 to -0.5	Q V	1/16 m^2	1
Sud Is.	Exposed	Hummocky bedrock or large boulder	5-23-75 8-8-75	+10.9 to -2.9	A Q	1/16 m^2	3
Cape Kaguyak	Partly protected	Hummocky bedrock or large boulder	5-12-76	+9.8 to -1.3	Q V	1/16 m^2	2
Three Saints Bay	Partly protected	Hummocky bedrock or large boulder	5-28-75 5-29-75 8- 7-75	+9.0 to -0.8	A Q	1/16 m^2	2
Lagoon Point	Partly protected	Hummocky bedrock or large boulder, sand	5-15-76 5-16-76	+8.1 to -3.2	Q V C	1/16 m^2 1 liter	4
Low Cape	Exposed	Small boulder	5-17-76	+7.1 to -1.0	Q V	1 m^2	1
Dolina Point	Exposed	Small boulder	5-14-76	+4.2 to +1.5	Q V	1 m^2 1/16 m^2	1

Table 2.--Continued.

Location	Exposure	Substrate	Dates Sampled	Elevation Range Sampled (ft)	Sampling Method*	Sample Size	Number of Transects
So. Sitkalidak Lagoon	Protected	Mud	5-19-76	+3.3 to +0.6	C	1 liter	1
Tanner Head	--	Small rock, sand	5-15-76	+6.0 to -1.0	C	304.8 l	1
Halibut Bay	--	Small rock, sand	5-30-76	+8.0 to -1.0	C	304.8 l	1
Swikshak Beach	--	Small rock, sand	6- 9-76	+4.0 to -1.0	C	304.8 l	1
Village Beach	--	Small rock, sand	6-11-76	-1.0 to -4.0	C	304.8 l	1
Big River Beach	--	Small rock, sand	6-12-76	+3.0 to -2.0	C	304.8 l	1
Hallo Bay	--	Small rock, sand	6-27-76	+3.0 to -3.0	C	304.8 l	1
Kukak Bay	--	Small rock, sand	6-30-76	+7.0 to -1.0	C	304.8 l	1
Bumble Bay	--	Medium-small rock, sand	7- 9-76	+3.0 to 0.0	C	101.5 l	1
Tugidak Is	--	Small rock, sand	7-11-76	+1.0 to -1.0	C	304.8 l	1
Dakavak Bay	--	Small rock, sand	7-26-76	+4.0 to -1.0	C	304.8 l	1
Kashvik Bay	--	Medium-small rock, sand	8-10-76	+5.0 to -1.0	C	101.5 l 304.8 l	1
Alinchak Bay	--	Sand	8-24-76	+3.0 to +1.0	C	203.2 l 304.8 l	1

* Sampling Method: A = Arrow, Q = Quadrat Collection, V = Visual Enumeration, C = Core.

Table 3. Presence (x) and absence of species at rocky intertidal sites in the Kodiak area.

	Chirikof Island	Cape Sitkinak	Sud Island	Sundstrom Island	Cape Kaguyak	Three Saints Bay	Lagoon Point	Low Cape	Dolina Point
CHLOROPHYTA									
Ulothrix sp.			X	X					
Ulothrix flacca							X		
Monostroma sp.	X	X	X	X	X	X	X		X
Monostroma fuscum	X		X	X		X			
Monostroma zostericola	X		X	X					
Enteromorpha compressa					X				
Enteromorpha linza	X								
Ulva sp.	X		X			X	X		
Ulva fenestrata	X								
Ulva lactuca	X			X					
Ulva rigida	X								
Prasiola meridionalis				X					
Rosenvingiella constricta				X					
Schizogonium murale				X					
Rhizoclonium sp.							X		
Lola lubrica	X					X			
Chaetomorpha sp.						X			
Cladophora sp.						X			
Cladophora seriacea						X			
Spongomorpha sp.			X				X		
Spongomorpha arcta			X				X		
Spongomorpha coalita			X						
Spongomorpha spinescens	X		X	X	X	X	X		X
BACILLARIOPHYCEAE	X	X		X	X	X			X
PHAEOPHYTA									
Ectocarpaceae			X						
Ectocarpus sp.	X		X						
Ectocarpus simulans			X			X			
Pylaiella littoralis	X		X			X			
Ralfsia sp.									
Ralfsia fungiformis	X		X	X					
Elachista fucicola			X	X					
Saundersella simplex	X								
Analipus japonicus	X				X				
Desmarestia aculeata	X								X
Soranthera ulvoidea	X		X	X					
Melanosiphon intestinale	X								
Petalonia sp.	X			X					
Petalonia fasciata	X		X						
Colpomenia bullosa	X								

Table 3. Continued

	Chirikof Island	Cape Sitkinak	Sud Island	Sundstrom Island	Cape Kaguyak	Three Saints Bay	Lagoon Point	Low Cape	Dolina Point
Phaeophyta--Cont.									
Phaeostrophion irregulare			X	X					
Scytosiphon lomentaria	X				X		X		
Dictyosiphon sp.	X								
Coilodesme sp.	X								
Coilodesme polygnampta	X								
Agarum sp.	X								
Hedophyllum sessile				X					
Laminariaceae	X		X				X		
Laminaria sp.	X	X	X	X			X	X	
Laminaria dentigera				X					X
Laminaria groenlandica					X		X		
Laminaria longipes	X		X	X					
Laminaria yezoensis	X		X	X					
Alaria sp.	X		X	X	X	X	X		X
Alaria crispa									
Alaria fistulosa			X						
Alaria marginata	X		X			X			
Alaria nana			X		X				X
Alaria praelonga				X					
Alaria pylaii			X						
Alaria taeniata	X		X	X			X		
Alaria tenuifolia							X		
Fucus distichus	X	X	X	X	X	X	X	X	X
RHODOPHYTA									
Bangia fuscopurpurea					X		X		
Porphyra sp.	X		X	X	X	X	X	X	X
Acrochaetium sp.	X		X	X		X			
Cryptonemiales				X					
Cryptosiphonia sp.		X							
Cryptosiphonia woodii			X	X			X	X	X
Dumontia incrassata									X
Endocladia sp.									X
Endocladia muricata	X		X			X	X	X	X
Gloiopeltis furcata			X		X				
Petrocelis sp.				X			X		
Petrocelis franciscana			X						
Petrocelis middendorffii				X					
Corallinaceae	X		X	X					
Tenarea sp.	X								
Mesophyllum lamellatum			X						
Bossiella sp.	X		X	X					

Table 3. Continued

	Chirikof Island	Cape Sitkinak	Sud Island	Sundstrom Island	Cape Kaguyak	Three Saints Bay	Lagoon Point	Low Cape	Dolina Point
Rhodophyta--Cont.									
Bossiella chiloensis	X		X	X		X			
Bossiella plumosa	X		X	X		X			
Corallina sp.	X		X	X		X			
Corallina vancouveriensis			X	X		X			
Lithothamnion sp.				X		X	X	X	X
Cryptonemiaceae			X						
Cryptonemia ovalifolia		X						X	X
Callophyllis sp.			X	X		X			
Callophyllis flabellulata			X	X		X			
Callophyllis pinnata			X						
Ahnfeltia sp.	X	X							
Ahnfeltia plicata	X	X	X	X				X	
Gigartinaceae				X					
Gigartina sp.	X		X	X					X
Gigartina papillata	X	X	X	X					
Gigartina latissima									
Gigartina stellata	X	X		X	X		X		
Iridaea sp.	X		X	X		X	X		X
Iridaea cornucopiae	X	X	X	X	X	X	X		
Iridaea heterocarpa		X			X				X
Iridaea punicea								X	
Rhodoglossum californicum			X						
Fauchea laciniata			X						
Halosaccion sp.	X								
Halosaccion glandiforme	X	X	X	X	X	X	X		
Halosaccion saccatum	X								
Rhodymenia sp.	X		X			X	X		
Rhodymenia palmata	X	X	X	X	X	X	X		X
Rhodymenia palmata f.sarnie					X		X		
Rhodymenia pertusa	X		X						
Ceramiaceae			X		X		X		
Antithamnion sp.				X			X		
Callithamnion sp.						X			
Callithamnion pikeanum				X		X			
Pleonosporium sp.						X	X		
Ceramium sp.									X
Ceramium pacificum									X
Microcladia borealis	X		X	X					X
Microcladia coulteri	X		X						
Ptilota sp.	X	X	X	X	X	X	X	X	X
Ptilota filicina	X		X						
Ptilota tenuis		X	X		X				

Table 3. Continued

	Chirikof Island	Cape Sitkinak	Sud Island	Sundstrom Island	Cape Kaguyak	Three Saints Bay	Lagoon Point	Low Cape	Dolina Point
Rhodophyta--Cont.									
Neoptilota sp.	X		X			X			
Neoptilota asplenioides	X		X	X					
Neoptilota hypnoides			X						
Delesseriaceae			X						
Tokidadendron bullata	X				X				
Phycodrys riggii						X			
Rhodomelaceae	X		X				X		X
Polysiphonia sp.								X	
Pterosiphonia sp.	X		X						
Pterosiphonia bipinnata	X		X	X		X			
Pterosiphonia dendroidea			X						
Pterosiphonia gracilis								X	
Rhodomela sp.		X							X
Rhodomela larix	X	X	X	X		X		X	X
Odonthalia sp.	X		X	X	X	X			X
Odonthalia aleutica				X					
Odonthalia floccosa	X	X	X	X		X	X	X	X
Odonthalia kamschatica						X			
Odonthalia lyallii		X							X
Odonthalia washingtoniensis	X	X		X			X		X
ANTHOPHYTA									
Potamogetonaceae	X		X	X					
Phyllospadix sp.		X		X					X
Phyllospadix scouleri									X
Phyllospadix serrulatus	X								
PORIFERA									
Demospongia					X	X	X	X	X
Halichondria panicea	X		X	X					
Haliclona permollis			X						
CNIDARIA									
Hydroidea		X	X		X	X	X		X
Eudendrium sp.						X			
Eudendrium annulatum			X						
Abientinaria sp.						X			
Anthozoa	X	X	X	X		X	X	X	X
Anthopleura sp.							X	X	
Tealia sp.								X	
Tealia crassicornis							X		

Table 3. Continued

	Chirikof Island	Cape Sitkinak	Sud Island	Sundstrom Island	Cape Kaguyak	Three Saints Bay	Lagoon Point	Low Cape	Dolina Point
TURBELLARIA	x	x	x	x	x	x	x	x	x
RHYNCHOCOELA		x			x		x	x	x
Emplectonema gracile	x		x	x		x			
NEMATODA	x		x	x	x	x	x	x	
ANNELIDA									
Polychaeta		x			x		x	x	x
Arctonoe sp.				x					
Halosydna brevisetosa			x						
Harmothoe imbricata				x					
Phloe minuta			x	x		x			
Paleanotus bellis						x			
Dysponetecus sp.				x					
Phyllodocidae	x		x	x					
Anaitides sp.	x		x	x					
Eteone sp.	x					x			
Eteone longa	x		x	x		x			
Eulalia sp.	x		x	x		x			
Eulalia viridis			x						
Eulalia bilineata	x		x	x					
Eulalia quadrioculata	x		x	x		x			
Syllidea	x		x	x		x			
Autolytus sp.				x		x			
Autolytus cornutus						x			
Autolytus prismaticus			x						
Autolytus trilineatus						x			
Autolytus convolutus						x			
Syllis sp.				x		x			
Typosyllis sp.	x		x	x		x			
Typosyllis alternata	x		x	x		x			
Typosyllis armillaris			x	x		x			
Typosyllis pulchra	x			x		x			
Typosyllis stewarti				x		x			
Typosyllis fasciata				x					
Typosyllis a adamantea			x	x		x			
Typosyllis hyalina				x					
Eusyllis sp.							x		
Eusyllis assimilis				x					

Table 3. Continued

	Chirikof Island	Cape Sitkinak	Sud Island	Sundstron Island	Cape Kaguyak	Three Saints Bay	Lagoon Point	Low Cape	Dolina Point
Annelida--Cont.									
Exogone sp.	x		x						
Exogone gemmifera	x		x			x			
Exogone lourei			x	x		x			
Sphaerosyllis sp.	x		x	x					
Sphaerosyllis pirifera	x		x	x		x			
Sphaerosyllis brandhorsti			x						
Syllides japonica	x		x	x					
Nereidae				x					
Nereis sp.	x		x	x		x			
Nereis pelagica	x		x	x		x			
Nereis vexillosa	x					x			
Nereis zonata	x		x						
Nereis grubei				x					
Sphaerodoridium gracilis				x					
Sphaerodoridium papillifera						x			
Sphaerodoropsis minutum	x			x		x			
Glycera capitata	x		x			x			
Onuphis iridescens			x						
Eunicidae			x						
Eunice valens				x					
Lumbrineris sp.	x		x	x					
Lumbrineris zonata			x	x					
Lumbrineris inflata	x		x	x					
Protodorvillea gracilis				x					
Naineris sp.	x		x			x			
Naineris quadricuspida	x		x			x			
Naineris laevigata	x			x					
Paraonidae			x			x			
Spionidae			x	x					
Polydora sp.	x		x	x					
Polydora ciliata	x			x					
Prionospio malmgreni						x			
Spio filicornis			x	x					
Boccardia sp.	x		x	x					
Boccardia columbiana				x					
Boccardia natrix	x		x	x					
Boccardia proboscidea			x						
Pygospio sp.						x			
Cirratulus sp.	x			x		x			
Cirratulus cirratus	x			x		x			

Table 3. Continued

	Chirikof Island	Cape Sitkinak	Sud Island	Sundstrom Island	Cape Kaguyak	Three Saints Bay	Lagoon Point	Low Cape	Dolina Point
Annelida--Cont.									
Tharyx sp.	x		x	x					
Capitellidae			x						
Capitella capitata	x		x	x		x			
Maldanidae			x						
Nicomache sp.	x								
Nicomache personata	x								
Owenia fusiformis						x			
Sabellariidae			x						
Idanthyrsus armatus			x						
Ampharetidae			x	x					
Asabellides littoralis				x					
Terebellidae			x						
Nicolea zostericola			x						
Polycirrus medusa	x			x		x			
Sabellidae	x		x	x		x			
Chone gracilis	x		x	x		x			
Chone infundibuliformis			x						
Potamilla neglecta			x	x					
Pseudopotamilla reniformis			x	x					
Schizobranchia insignis				x					
Amphiglena pacifica	x		x	x		x			
Fabricia sabella	x		x	x		x	x		
Fabricia pacifica						x			
Fabricia crenicollis	x		x	x		x			
Pseudosabellides littoralis	x		x	x					
Spirorbis sp.					x		x		
Spirorbis spirillum							x		
Dexiospira spirillum	x		x	x		x			
Oligochaeta			x			x	x		
Enchytraeidae	x		x	x		x			
Hirudinea	x		x	x					
POLYPLACOPHORA									
Cynoplax dentiens				x		x			
Lepidochiton sharpei				x					
Tonicella lineata			x	x		x	x		
Katharina tunicata	x		x	x	x	x	x		x
Mopalia ciliata				x			x		
Mopalia mucosa				x		x			
Schizoplax brandtii	x		x	x	x	x		x	

Table 3. Continued

	Chirikof Island	Cape Sitkinak	Sud Island	Sundstrom Island	Cape Kaguyak	Three Saints Bay	Lagoon Point	Low Cape	Dolina Point
PELECYPODA									
Mytilus edulis	x		x	x	x	x	x	x	x
Musculus sp.	x		x	x					
Musculus niger			x						
Musculus discors	x			x	x			x	x
Musculus vernicosus	x		x	x					
Musculus olivaceous				x		x			
Modiolus modiolus				x	x				x
Pododesmus macroschisma							x		
Mysella compressa							x		
Mysella planata						x			
Turtonia minuta		x			x			x	x
Turtonia occidentalis	x		x	x		x			
Transennella sp.							x		
Protothaca staminea	x		x	x		x	x	x	x
Hiatella arctica	x		x	x	x	x	x	x	x
GASTROPODA									
Acmaeidae			x		x				x
Acmaea mitra				x	x		x		
Collisella sp.	x			x			x		
Collisella pelta	x	x	x	x	x	x	x	x	x
Collisella digitalis	x		x	x	x	x	x	x	
Collisella instabilis							x		
Notoacmea scutum	x	x		x	x	x	x	x	x
Notoacmea persona		x					x		x
Notoacmea fenestrata								x	
Cryptobranchia alba						x			
Margarites sp.			x		x				
Margarites helicinus	x	x		x	x	x	x	x	x
Margarites pupillus			x	x	x	x	x	x	
Margarites beringensis				x					
Homalopoma sp.				x					
Littorina sp.			x				x		
Littorina sitkana	x	x	x	x	x	x	x	x	x
Littorina aleutica	x		x						
Littorina scutulata	x		x			x			
Littorina saxatilis							x		
Haloconcha reflexa	x		x	x					
Lacuna sp.		x		x	x		x		x
Lacuna carinata									x

Table 3. Continued

	Chirikof Island	Cape Sitkinak	Sud Island	Sundstrom Island	Cape Kaguyak	Three Saints Bay	Lagoon Point	Low Cape	Dolina Point
Gastropoda--Cont.									
Lacuna marmorata	x	x	x	x	x	x		x	x
Lacuna vincta	x		x	x		x			
Alvinia compacta			x	x			x		
Cingula sp.				x					
Barleeia sp.	x		x	x		x			
Bittium munitum							x		
Cerithiopsis sp.	x		x	x		x		x	
Melanella micrans				x					
Trichotropis insignis							x		
Trichotropis cancellata									x
Velutina velutina				x	x	x			
Fusitrition oregonensis					x		x		
Ocenebra interfossa								x	x
Trophonopsis pacificus							x		
Nucella sp.			x	x		x		x	x
Nucella canaliculata						x	x		x
Nucella lamellosa				x	x	x	x		
Nucella lima	x	x	x	x		x	x	x	x
Buccinum sp.		x	x			x			
Buccinum baeri	x	x	x	x	x	x	x	x	x
Searlesia dira	x		x	x	x		x	x	
Amphissa columbiana							x	x	
Odostomia sp.	x	x	x	x		x			
Odostomia elsa							x		
Cylichna occulta			x						
Acanthodoris sp.						x			
Hermissenda sp.							x		
Onchidella borealis			x	x		x	x		
Siphonaria sp.				x					
Siphonaria thersites			x	x	x	x	x		
ARACHNIDA									
Acarina			x	x		x			
Halacaridae	x		x	x	x	x	x		
Pseudoscorpionida			x	x		x	x		
PYCNOGONIDA						x			
Phoxichilidium quadradentat	x								
Phoxichilidium femoratum		x	x	x	x			x	
Ammothea gracilipes		x							

Table 3. Continued

	Chirikof Island	Cape Sitkinak	Sud Island	Sundstrom Island	Cape Kaguyak	Three Saints Bay	Lagoon Point	Low Cape	Dolina Point
Pycnogonida--Cont.									
Ammothea pribilofensis	X	X	X	X	X			X	
Achelia chelata									X
CRUSTACEA									
Platycopa	X		X						
Harpacticoida	X		X	X		X	X	X	
Thoracica			X	X	X	X			
Balanidae							X		X
Balanus sp.	X	X	X	X		X		X	
Balanus balanoides	X				X	X	X	X	X
Balanus cariosus	X	X	X	X	X	X	X	X	X
Balanus glandula	X		X	X	X	X	X	X	
Balanus rostratus			X		X				
Chthamalus dalli	X	X	X	X		X	X	X	X
Mysidacea			X						
Archaeomysis grebnitzkii						X			
Cumacea	X						X		
Cumella sp.	X		X						
Cumella vulgaris						X			
Tanidacea	X		X	X		X			
Tanaidae	X		X	X					
Tanais sp.			X						
Isopoda	X		X				X		
Synidotea sp.			X						
Pentidotea resecta								X	
Pentidotea wosensenskii	X	X	X	X	X	X	X	X	X
Idothea fewkesi	X		X	X					
Sphaeromatidae	X	X	X			X	X		
Gnorimosphaeroma sp.			X						
Gnorimosphaeroma oregonens	X		X	X	X	X			
Exosphaeroma sp.	X	X	X	X	X		X	X	X
Exosphaeroma amplicauda	X		X	X					
Dynamenella sheareri				X		X			
Ianiropsis kincaidi kincai	X		X	X		X	X		
Munna sp.	X	X	X	X		X	X		
Munna stephenseni				X		X			
Anthuridae		X							
Amphipoda	X	X	X	X	X	X	X	X	X
Ampithoe sp.	X		X			X			
Ampithoe rubricatoides				X					

Table 3. Continued

	Chirikof Island	Cape Sitkinak	Sud Island	Sundstrom Island	Cape Kaguyak	Three Saints Bay	Lagoon Point	Low Cape	Dolina Point
Crustacea--Cont.									
Ampithoe similans	x		x	x		x			
Ampithoe lindbergi	x		x	x					
Aoroides sp.			x						
Aoroides columbiae	x					x			
Calliopiidae			x						
Oligochinus lighti	x		x	x		x			
Calliopiella pratti	x		x	x					
Corophium sp.	x			x					
Corophium brevis	x			x					
Polycheria osborni				x					
Eusiridae	x		x	x		x			
Accedomoera sp.				x					
Accedomoera vagor	x		x	x					
Paramoera columbiana	x		x	x		x			
Pontogeneia sp.	x		x			x			
Gammaridae	x					x	x		
Anisogammarus sp.	x		x						
Melita sp.	x		x	x		x			
Haustorius eous						x			
Najna conciliorum	x		x	x		x			
Hyalidae	x		x	x		x			
Allorchestes maleolus						x			
Allorchestes angustus	x		x						
Allorchestes anceps				x		x			
Hyale sp.				x		x			
Hyale rubra	x		x	x		x			
Hyale rubra frequens						x			
Hyale grandicornis				x					
Parallorchestes ochotensis	x		x	x					
Parallorchestes anguipes			x						
Photis sp.			x	x					
Photis brevipes	x			x					
Photis bifurcata			x	x					
Ischyroceridae	x		x	x					
Ischyrocerus sp.	x		x			x			
Ischyrocerus anguipes	x		x	x		x			
Ischyrocerus rhodomelae						x			
Jassa sp.			x						
Jassa pulchella	x		x	x		x			
Anonyx sp.	x		x						
Orchomene sp.	x		x						

Table 3. Continued

	Chirikof Island	Cape Sitkinak	Sud Island	Sundstrom Island	Cape Kaguyak	Three Saints Bay	Lagoon Point	Low Cape	Dolina Point
Crustacea--Cont.									
Orchomene sp.	x		x						
Orchomene minuta			x						
Orchomene lipidula	x		x						
Orchomene obtusa			x						
Pleustidae	x		x	x					
Parapleustes nautilus	x		x	x		x			
Pleustes sp.			x						
Stenopleustes uncigera	x		x			x			
Stenothoidae	x		x	x		x			
Metopella sp.	x								
Talitridae			x						
Caprellidae	x	x	x	x	x	x		x	x
Cercops compactus			x						
Caprella sp.	x		x			x	x		
Caprella cristibranchium			x						
Caprella alaskana			x						
Caprella irregularis	x								
Caprella laeviuscula			x						
Decapoda			x					x	
Pagurus sp.		x		x		x	x	x	
Pagurus beringanus				x					
Pagurus hemphilli					x				
Pagurus h hirsutiusculus	x	x	x	x	x	x	x	x	x
Pugettia sp.			x						
Pugettia gracilis	x		x	x		x	x		
Cancer sp.	x								
Cancer oregonensis	x		x	x					
Telmessus cheiragonus	x							x	x
INSECTA									
Insecta								x	
Collembola							x		
Anurida maritima				x		x			
Diptera			x	x	x	x	x	x	
Tipulidae			x				x		
Chironomidae			x	x		x	x		
Culicidae			x						
Dolichopodidae							x		
Cicadellidae			x						
Coleoptera			x	x		x			

Table 3. Continued

	Chirikof Island	Cape Sitkinak	Sud Island	Sundstrom Island	Cape Kaguyak	Three Saints Bay	Lagoon Point	Low Cape	Dolina Point
Insecta--Cont.									
Staphinidae			x				x		
Amblopusa borealis							x		
SIPUNCULIDA						x			
BRYOZOA									
Bryozoan					x	x	x		
Microporina sp.	x								
Hippothea hyalina			x	x					
Filicrisia sp.				x					
Crisia sp.			x						
Flustrellidae				x					
Flustrella sp.			x						
BRACHIOPODA	x								
ASTEROIDEA									
Henricia sp.	x			x				x	
Henricia sanguinolenta				x					
Evasterias trochelii					x				
Leptasterias sp.	x		x	x		x			
Leptasterias hexactis	x	x	x	x	x	x	x	x	x
ECHINOIDEA									
Strongylocentrotus droebachiensis						x	x		
OPHIUROIDEA						x	x		
Ophiopholis aculeata			x	x	x				
HOLOTHUROIDEA									
Cucumaria sp.			x				x		
Cucumaria pseudocurata	x	x	x	x	x	x	x	x	x
UROCHORDATA									
Urochordata		x					x		x
Styela clavata				x					
Aplousobranchia			x						
Applidium (Amaroucium) glab			x						

Table 3. Continued

	Chirikof Island	Cape Sitkinak	Sud Island	Sundstrom Island	Cape Kaguyak	Three Saints Bay	Lagoon Point	Low Cape	Dolina Point
TELEOSTEI				x					
Cottidae			x				x		
Clinocottus embryum						x			
Gymnocanthus pistilliger						x			
Liparis sp.	x								

Table 4. Presence (x) and absence of species at sandy intertidal sites in the Kodiak area.

	Tanner Head	Halibut Bay	Swikshak Beach	Village Beach	Big River Beach	Hallo Bay	Kukak Bay	Bumble Bay	Tugidak Island	Dakavak Bay	Kashvik Bay	Alinchak Bay	Lagoon Point
RHYNCHOCOELA													
Rhynchocoela					x	x	x						
Rineidae		x					x			x			
Cerebratulus californiensis			x	x	x	x	x			x			
NEMATODA													
Nematoda													x
ANNELIDA													
Annelida													x
Polychaeta													x
Anaitides groenlandica				x		x	x						
Eteone longa		x	x			x	x		x	x	x		
Nephtys caeca	x	x	x	x	x	x	x	x			x	x	
Nephtys californiensis		x	x	x	x		x		x	x	x	x	
Glycinda picta		x					x		x		x		
Haploscoloplos elongatus		x	x	x	x	x	x		x		x		
Scolelepis squamatus	x	x	x	x	x	x	x	x		x	x	x	
Ophelia assimilis	x	x		x	x			x	x	x	x		
Travissia brevis					x								
Cistenides brevicoma				x		x							
Fabricia sabella													x
Oligochaeta													x
PELECYPODA													
Mytilus edulis	x												x
Clinocardium nuttallii	x					x	x						
Protothaca staminea							x						
Spisula polynyma	x		x	x	x		x				x		
Macoma calcarea						x							
Macoma loveni						x							
Macoma lama		x	x		x	x	x				x	x	
Macoma yoldiformis							x						
Macoma nasuta	x												
Macoma balthica						x	x				x		
Tellina lutea					x								
Tellina nucleoides			x										
Siliqua patula		x	x	x	x	x	x		x		x	x	
Siliqua alta		x	x		x	x	x						
GASTROPODA													
Littorina sitkana	x												

Table 4. Continued

	Tanner Head	Halibut Bay	Swikshak Beach	Village Beach	Big River Beach	Hallo Bay	Kukak Bay	Bumble Bay	Tugidak Island	Dakavak Bay	Kashvik Bay	Alinchak Bay	Lagoon Point
ISOPODA													
Isopod	X												
Cirolanidae					X	X							
Cirolana sp.	X												
AMPHIPOD													X
Eohaustorius	X	X		X	X	X	X			X	X	X	
TELEOSTEI													
Ammodytes hexapterus	X		X	X	X						X	X	

Table 5. Presence (x) and absence of species at muddy intertidal sites in the Kodiak area.

	South Sitkalidak Lagoon
RHYNCHOCOELA	
Rhynchocoela	x
ANNELIDA	
Polychaeta	x
Eteone longa	x
Nephtys caeca	x
Fabricia sabella	x
Oligochaeta	x
PELECYPODA	
Mytilus edulis	x
Macoma calcarea	x
Macoma balthica	x
GASTROPODA	
Turtonia occidentalis	x
AMPHIPODA	
Amphipoda	x

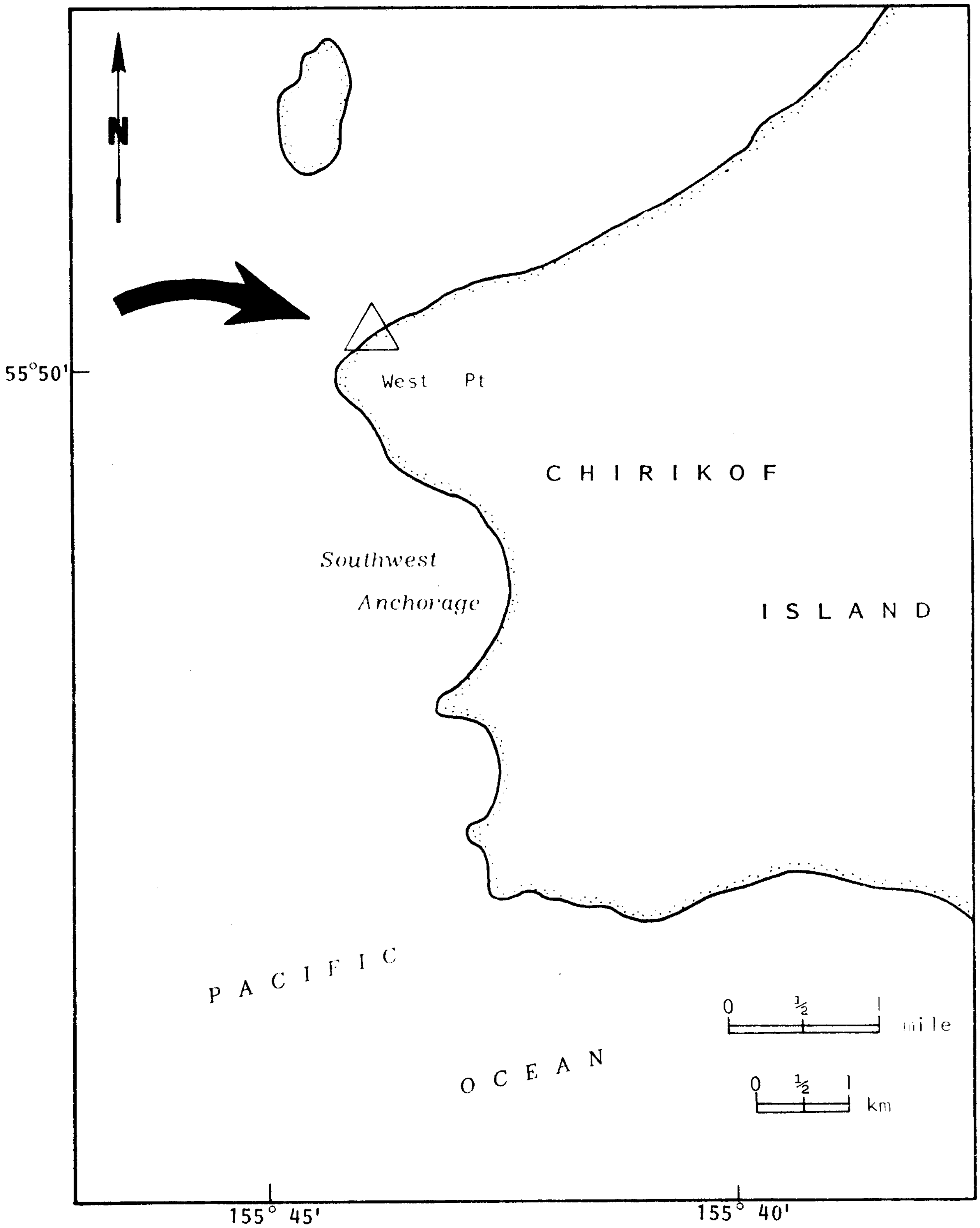


Figure 15. Chirikof Island site.

Figure 16. Chirikof Island. View along transect line looking shoreward toward sand beach.

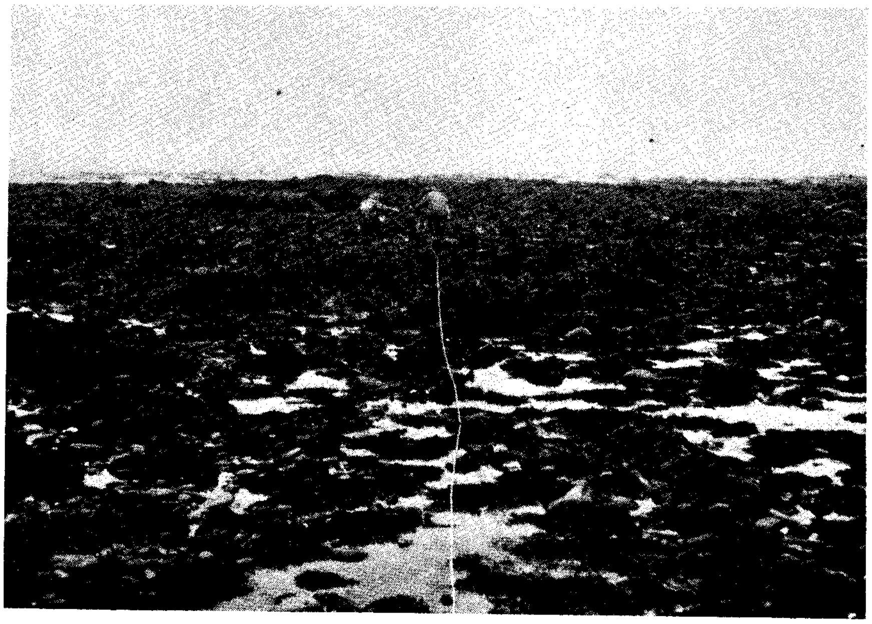
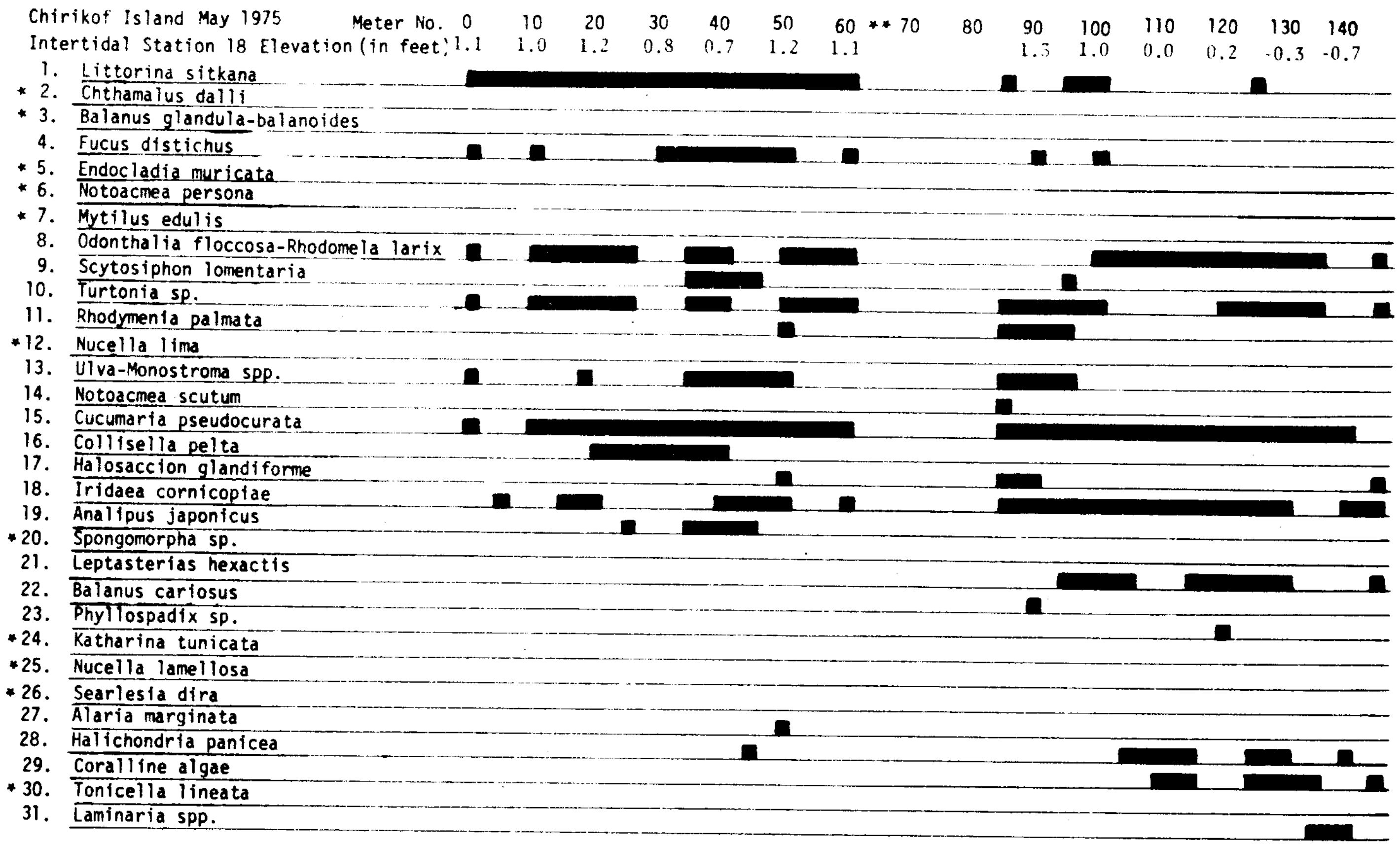


Figure 17. Chirikof Island. View along transect line looking toward the water.

Figure 18. Chirikof Island, Sampling part of the reef using the arrow method.



* Species not present in quadrat collections on this transect line.

**no samples collected for meters 65, 70, 75, and 80.

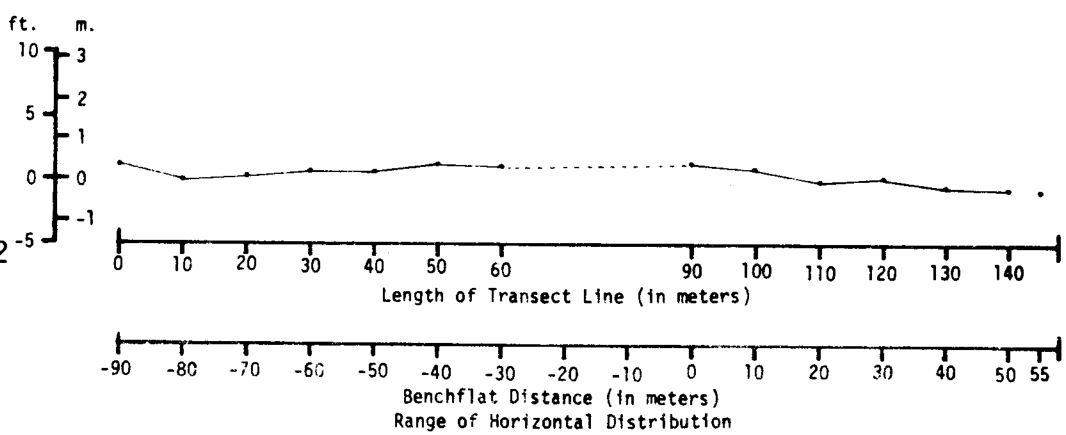
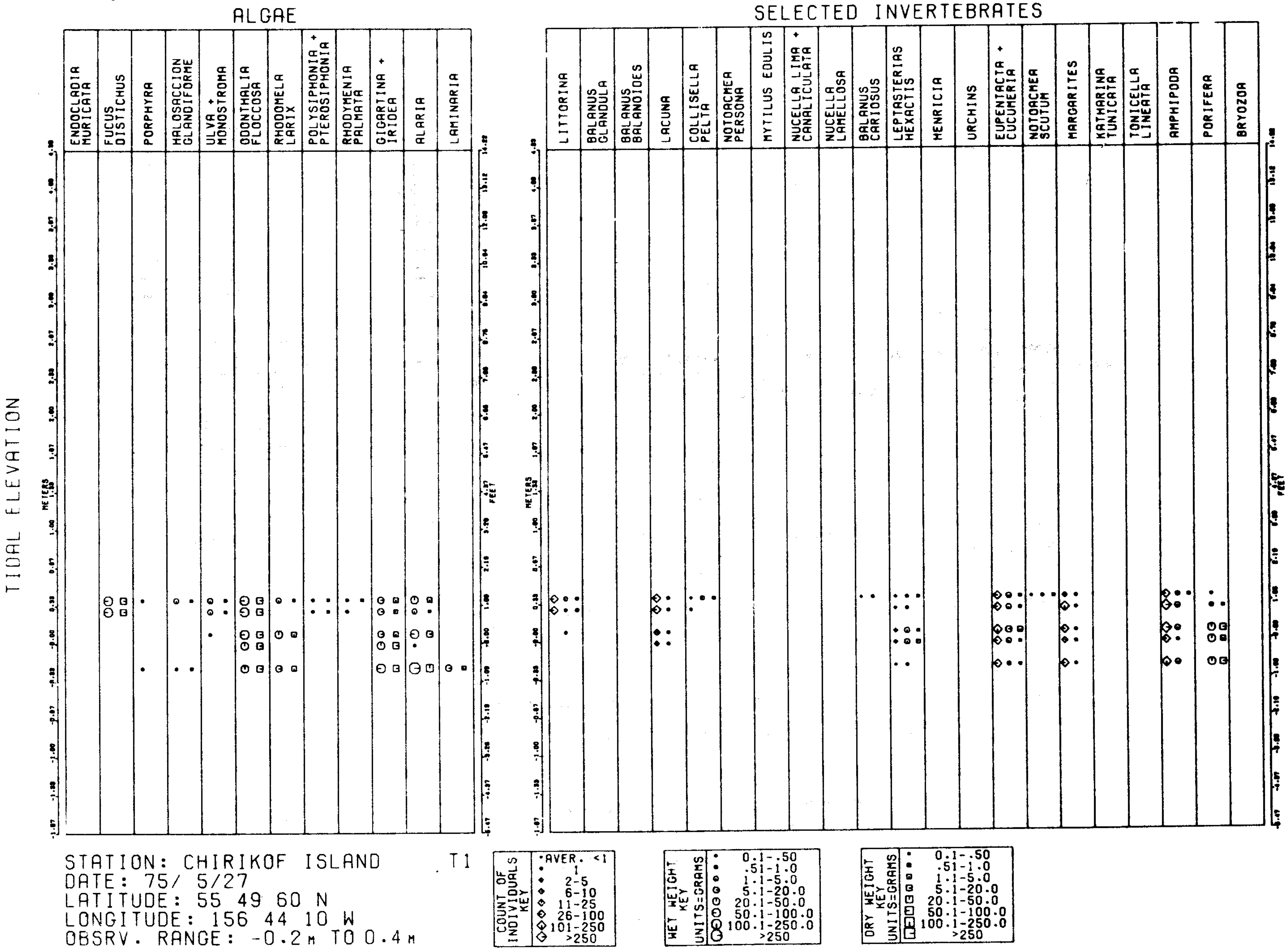


Fig. 19. Horizontal and vertical distribution of selected algae and invertebrates from 1/16 m^2 quadrats along transect line 1.

Fig. 20. Chirikof Island, May 1975. Densities of selected intertidal organisms along transect line 1.



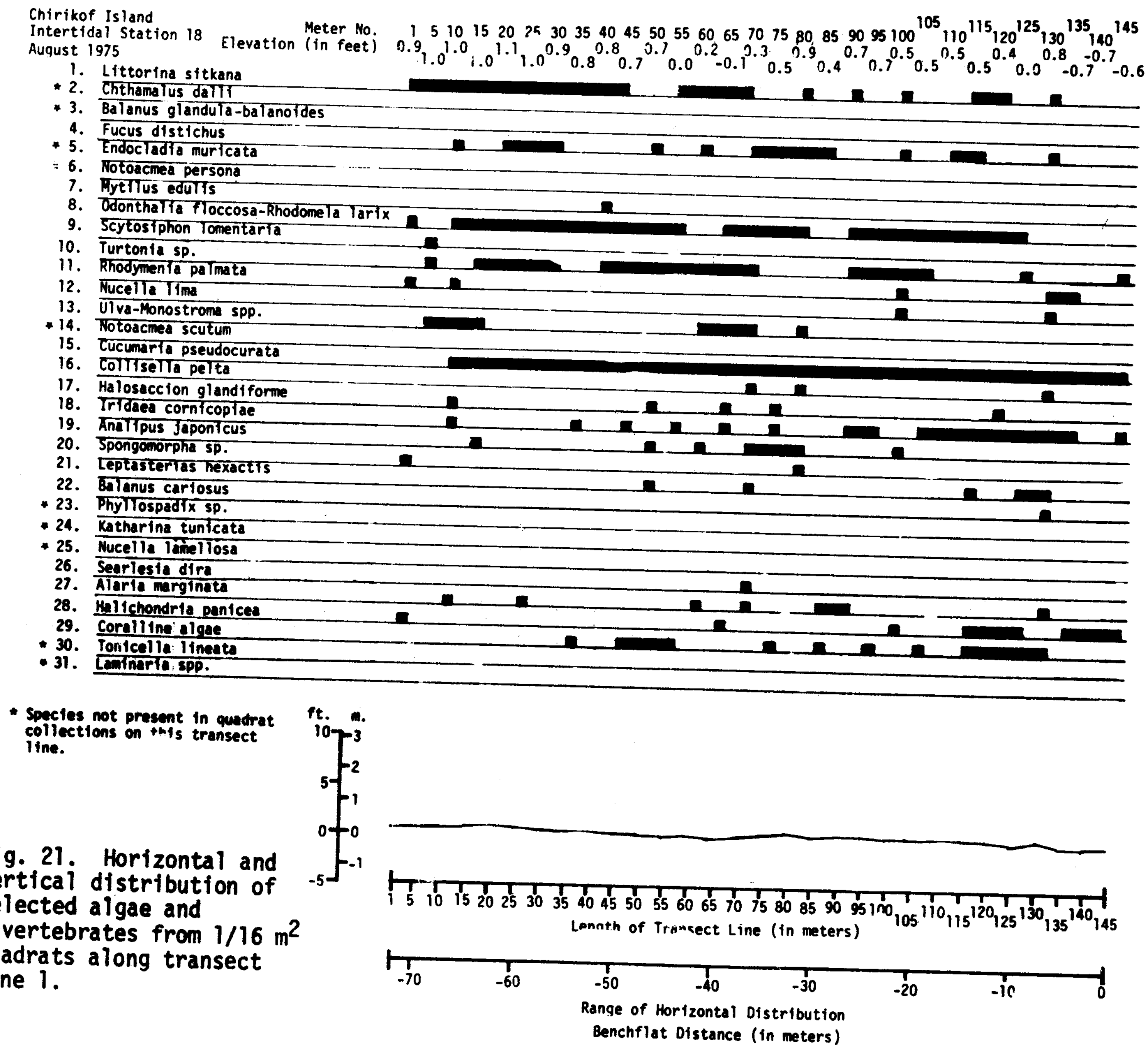
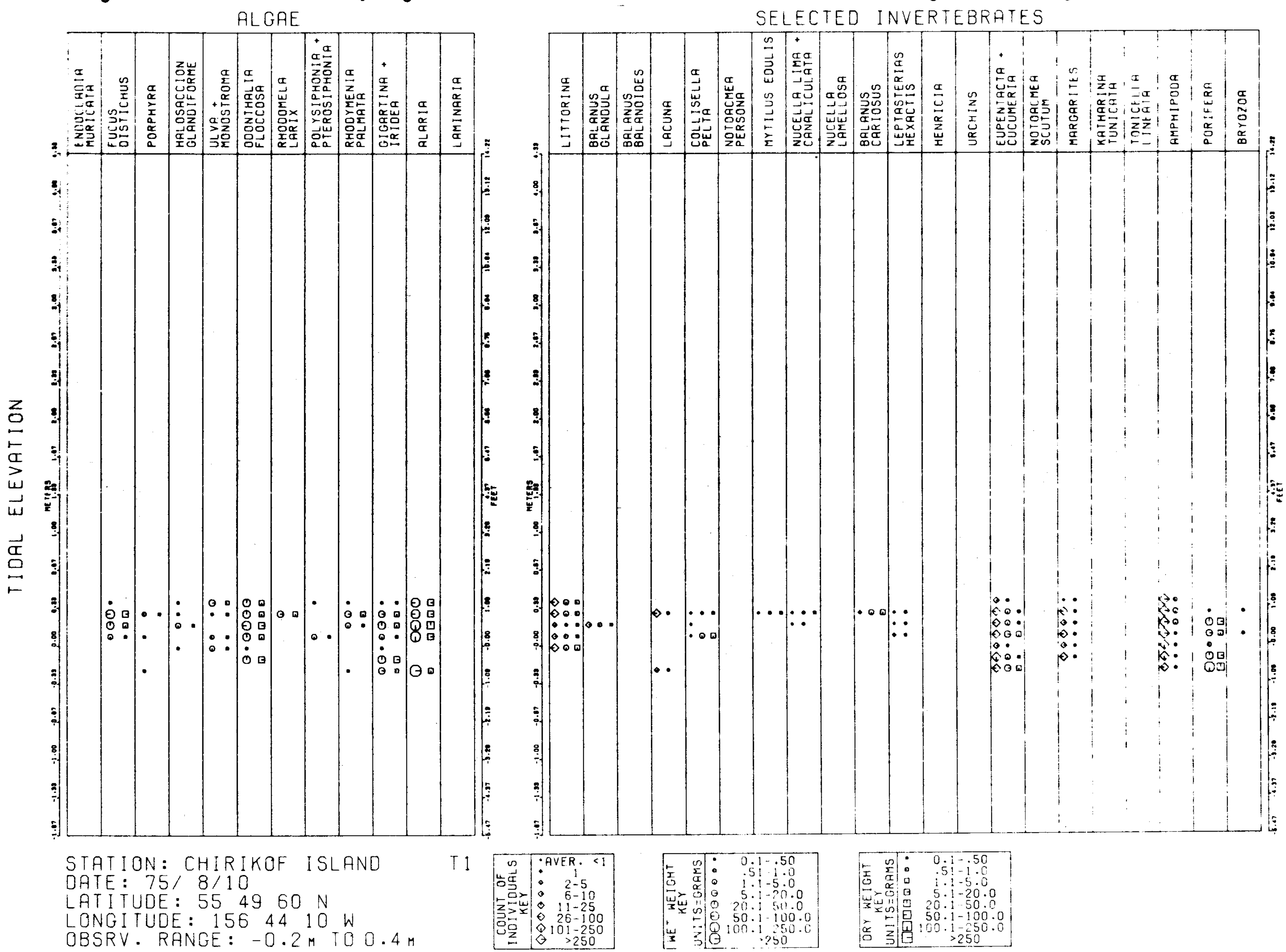


Fig. 21. Horizontal and vertical distribution of selected algae and invertebrates from 1/16 m^2 quadrats along transect line 1.

Fig. 22. Chirikof Island, August 1975. Densities of selected intertidal organisms along transect line 1.



midrib and sporophylls persisting. Farther along the line in an area with fewer cobbles, but with pebbles and sand, the Alaria began to thin out and most of it was eroded. Much of the Fucus was sterile. The distribution of all organisms was patchy.

Only a few differences were obvious between the May and August sampling periods. In May we saw a very heavy cover of drift material, mostly decaying algae, at the high tide line. In August the drift material was approximately 10% of what it had been in May. In August we found more species of brown algae (e.g., Analipus, Melanosiphon) than in May and noted a heavy cover of bladed green algae (family Ulvales) at the upper end of the transect line.

Cape Sitkinak (Trinity Islands)

Cape Sitkinak, on Sitkinak Island, is the easternmost point in the Trinity Island group (Figure 23). It lies in a highly exposed location, subject to the full force of southeasterly Pacific storms. Heavy tide rips in Sitkinak Strait and the full exposure to waves and winds make it a turbulent area.

The beach (Figures 24 and 25) is bounded by high bluffs which rise from a sandy slope above high water. The intertidal area is part of an extensive, almost flat reef area which extends far offshore. The upper part of the intertidal area is covered with large and small boulders. The lower part is exposed bedrock and is covered with pockets of sand in some places. Owing to the very slight gradient almost the entire lower area is covered by water, even when the tide is out. Large tide pools abound and are occupied by extensive beds of surf grasses (Phyllospadix serrulatus) and kelps (Alaria and Laminaria).

During May 1976 we studied the area using two transect lines. Quadrats along both lines were visually enumerated to determine percent coverage and species composition of algae. Along the first line we also collected quantitative samples. At the time the lines were laid, only the upper portions of the intertidal area were exposed. As the tide continued to recede, several hundred more meters of beach were exposed. This area was investigated qualitatively but it was not possible to make systematic quantitative collections during the short period of time the lower areas were exposed. Thus, the area dominated by kelp was not sampled.

A comparison of the two lines indicated that similar organisms were present at both locations. Since neither of the lines passed through the large area of Phyllospadix, there were several sources of variability which were not sampled.

Algal cover (Figures 26 and 27) was not heavy along the upper third of the transect. This was an area of small to medium boulders which are moved during storms. Along transect 1, where collections were made, Odonthalia and Rhodomela, which often occur together and may be difficult to differentiate, were the most abundant algae. Two other algae which often occur together, Gigartina and Iridaea, were the next most abundant in the quadrat collections. Phyllospadix were collected in only one quadrat along the transect but were abundant in the flat reef area beyond the end of the transect. Laminaria were not collected along the transect but were also abundant in the flat reef area.

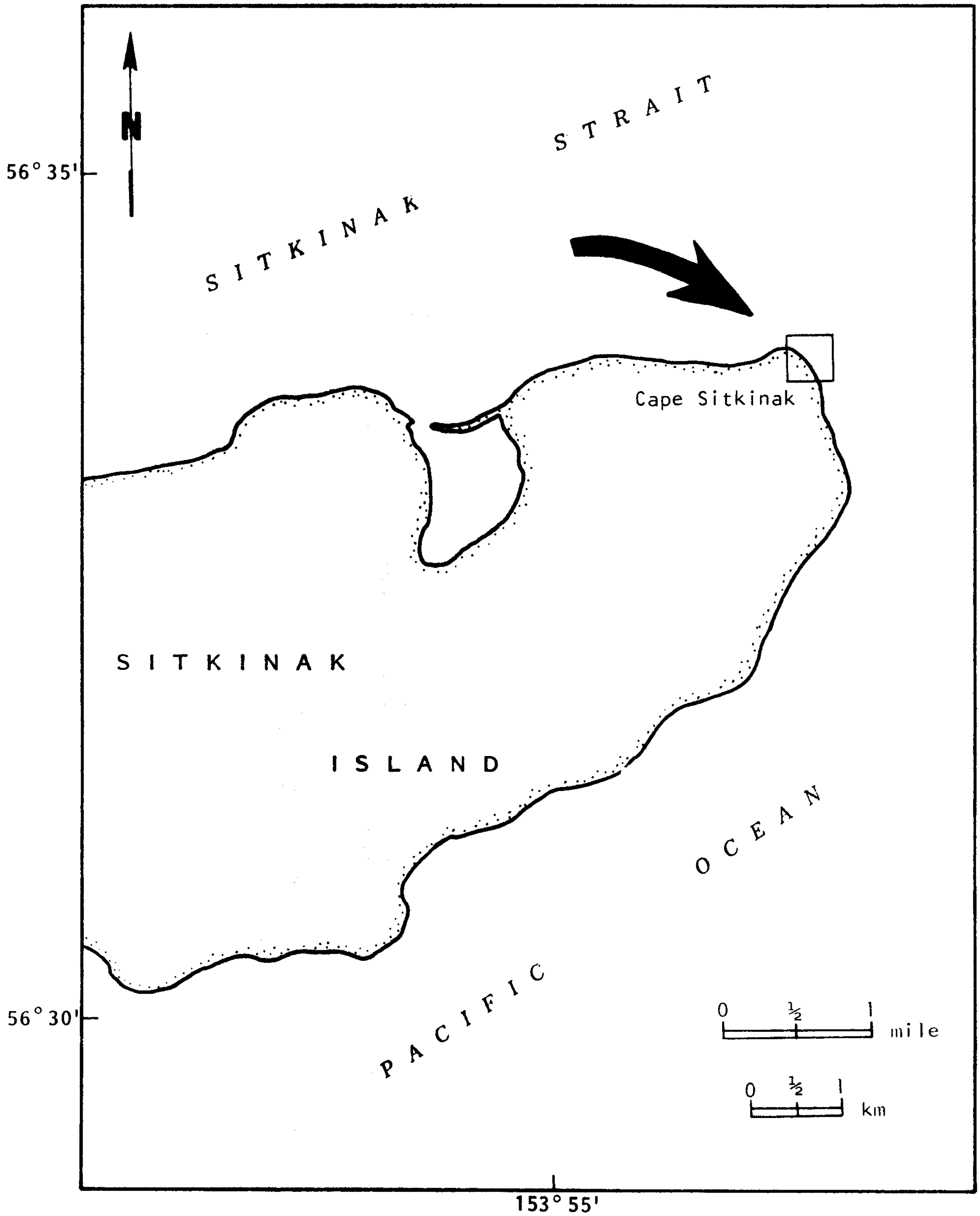


Figure 23. Cape Sitkinak site.

Figure 24. Cape Sitkinak, Sitkinak Island. General view of sampling area. Intertidal sampling began where the surveyors are standing.

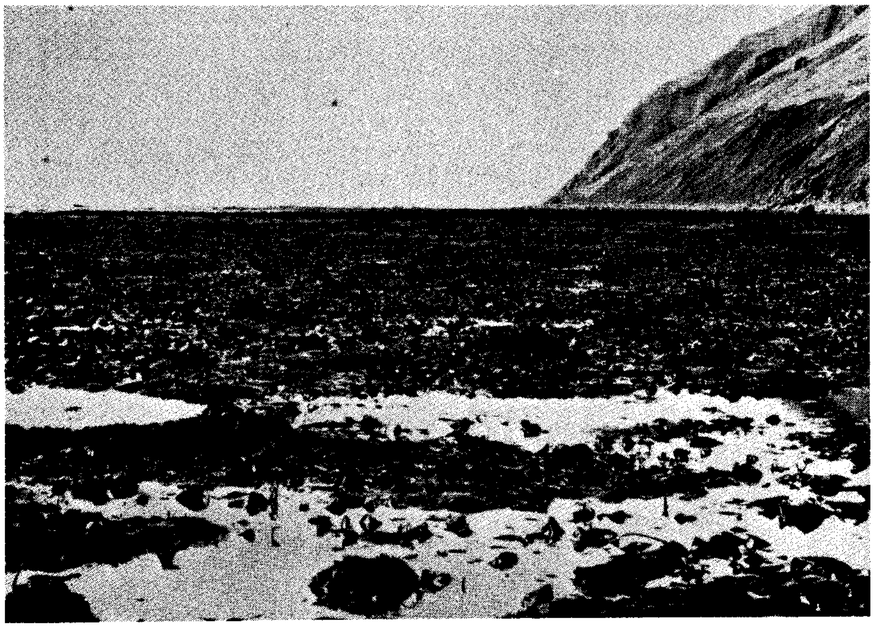


Figure 25. Cape Sitkinak, Sitkinak Island. General view of sampling area looking toward the upper part of the beach. Note standing water and *Laminaria* in foreground.

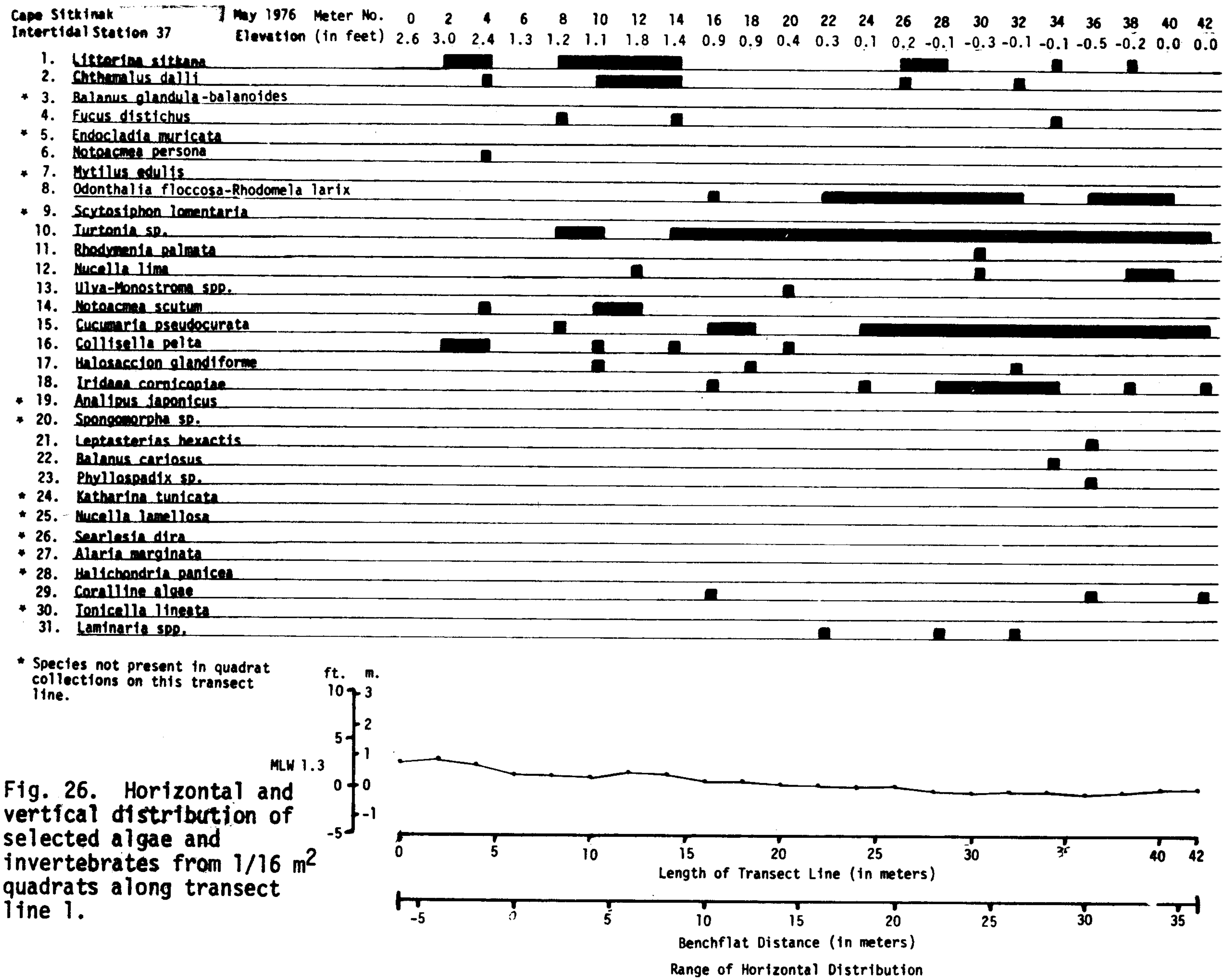
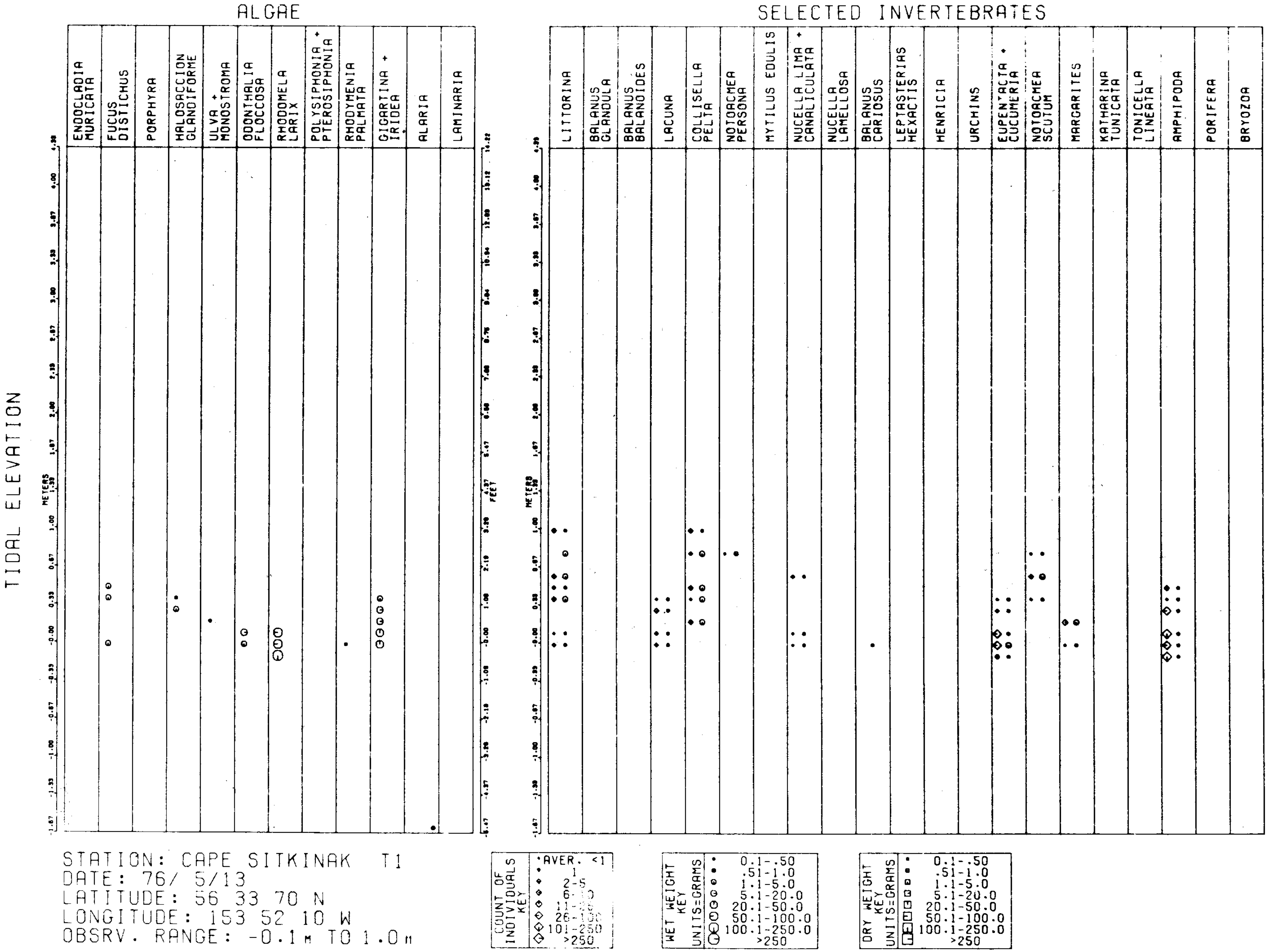


Fig. 26. Horizontal and vertical distribution of selected algae and invertebrates from 1/16 m^2 quadrats along transect line 1.

Fig. 27. Cape Sitkinak, May 1976. Densities of selected intertidal organisms along transect line 1.



invertebrate populations were quite low (Figures 26 and 27). Mussels (Mytilus edulis) were almost entirely absent. Predatory snails (Nucella lamellosa, Searlesia), starfishes, and urchins were also generally missing. Even forms which were present at almost all of our sampling sites, such as chitons, sponges, and the barnacle Balanus cariosus, were absent or uncommon at Cape Sitkinak. Relatively common invertebrates included limpets, hermit crabs, sea cucumbers, and amphipods.

Sud Island (Barren Islands)

Sud Island (Figure 28) is one of the precipitous, windswept Barren Islands just below the entrance to Cook Inlet. These islands are exposed to the mixing of atmospheric and oceanic forces between Cook Inlet, Shelikof Strait, and the northwestern Gulf of Alaska. Winds there are stronger than in nearby areas, and heavy tide rips and ocean currents occur throughout the Barren Islands. NMFS divers commented that some of the densest communities of subtidal algae encountered in Alaska are present in this highly mixed and turbulent area (Louis Barr, personal communication).

Much of the littoral area is either bedrock or bedrock overlaid by large boulders. The site we sampled, on the northern side of Sud Island, was composed of large boulders which almost completely covered a substrate of moderately sloping bedrock. One transect line and the arrow method were used to collect quantitative samples in May 1975, and two transect lines in August (Figures 29 and 30).

Algal cover (Figures 31-36) was very dense in the intertidal areas. The middle and upper areas were dominated by heavy growths of Fucus distichus, the lower area by well-developed growths of the red algae Rhodymenia palmata, Callophyllis sp. (or possibly R. palmata f. sarniensis), and Iridaea sp. The sublittoral fringe had lush populations of Alaria sp. and Laminaria sp.

Among the invertebrates (Figures 31-36), Littorina sitkana was common in the upper zones and Balanus cariosus and Halichondria panicea were abundant in the lower zones. Mytilus edulis populations were confined to the protected sides of large boulders or bedrock outcroppings and did not generally occur where the transect lines were laid. Greater numbers of Mytilus were found in collections from transect 2, August 1975, possibly because the transect had a greater vertical range and was more hummocky than the other transects. Limpets, chitons, predatory snails, and starfishes were either absent or scarce.

Sundstrom Island

Sundstrom Island lies south of Kodiak Island between the Trinity Islands and Cape Trinity (Figure 37). The beach is basaltic bedrock with deep indentations. At the head of the rocky area there is a narrow strip of black sand beach which rises abruptly to steep rocky bluffs, some of which are covered with grass.

Sundstrom Island was quantitatively sampled in May and August 1975 and qualitatively surveyed in May 1976 (Figures 38-44).

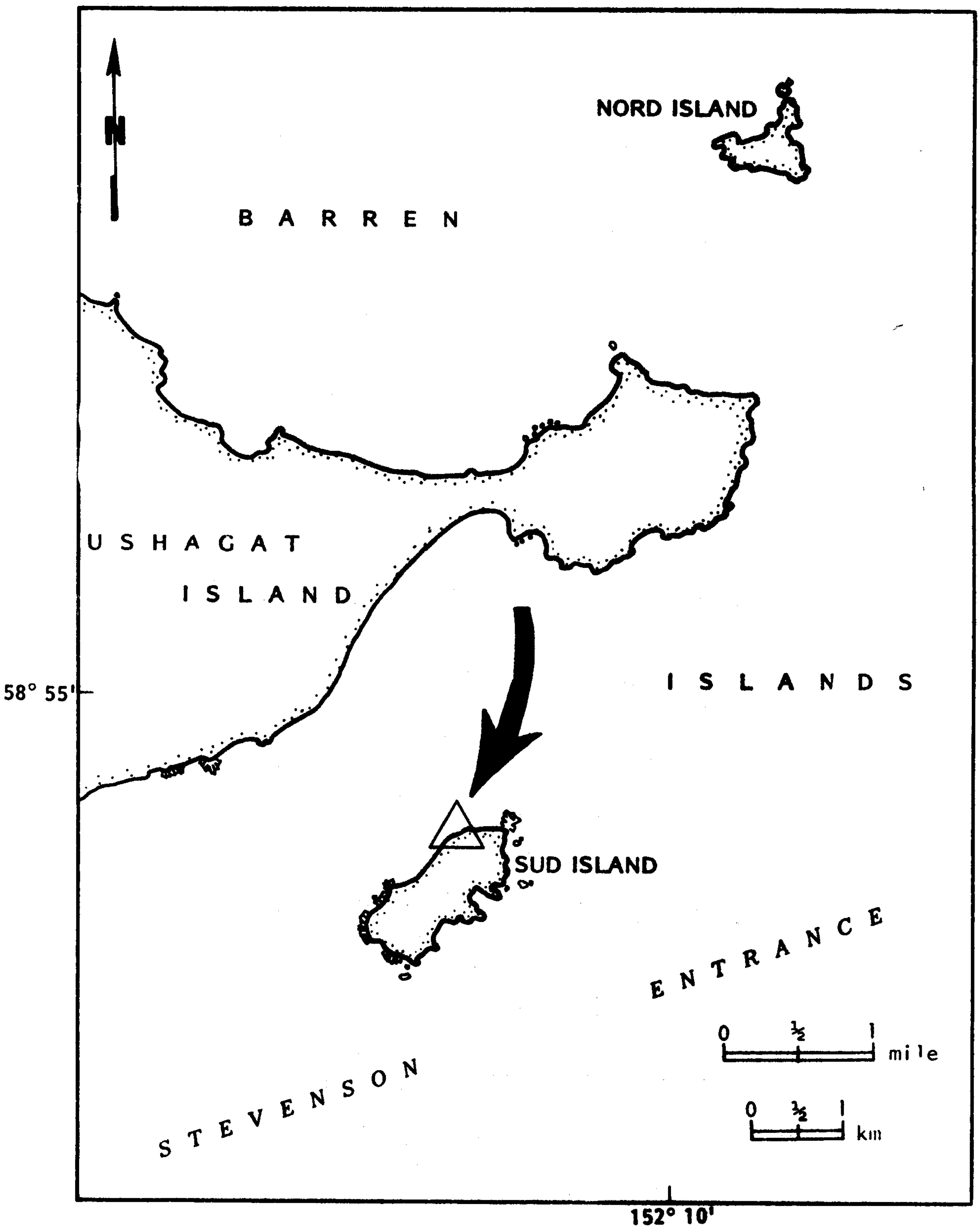
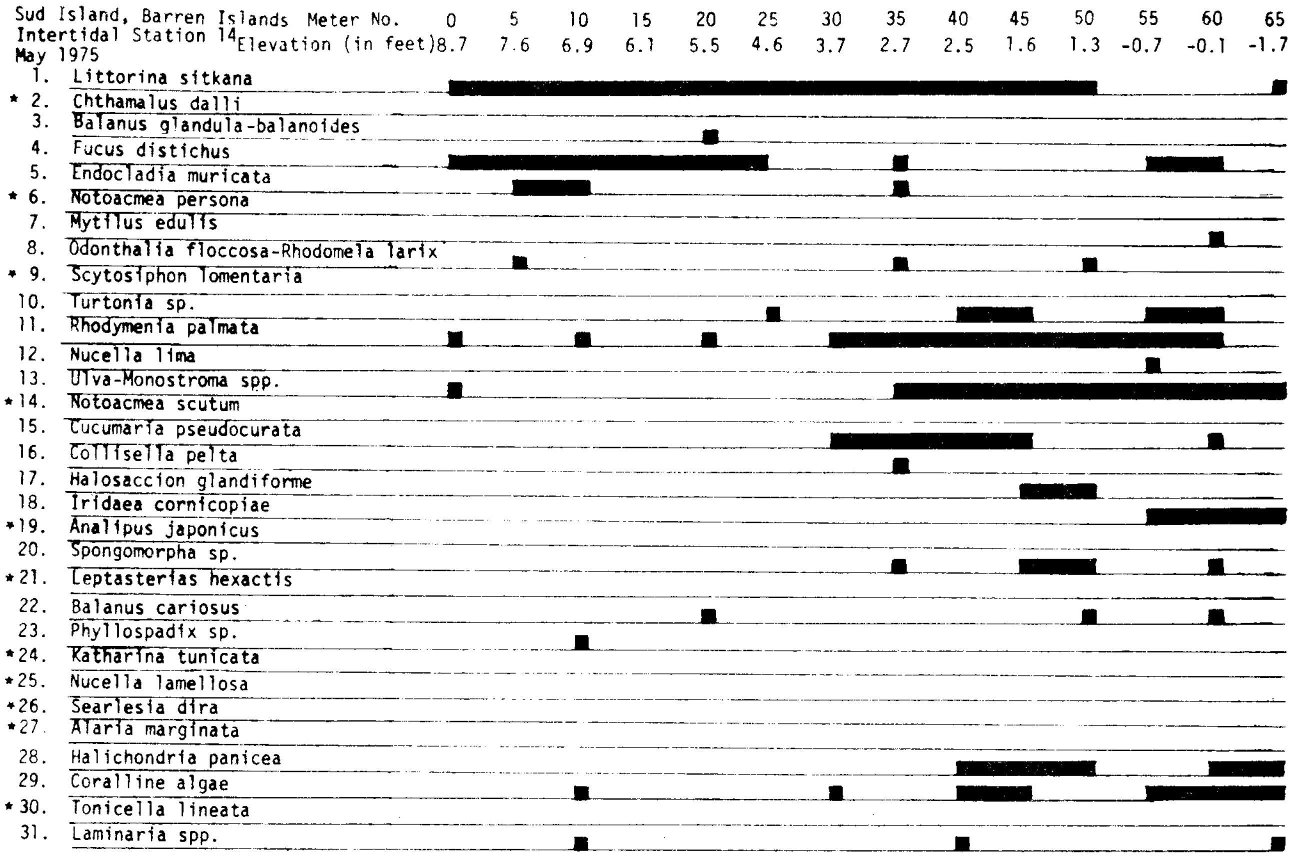


Figure 28. Sud Island site.

Figure 29. Sud Island, Barren Islands. View of transect line with Ushagat Island in background.

Figure 30. Sud Island, Barren Islands. Lower end of transect line. Note floating kelp offshore.



* Species not present in quadrat collections on this transect line.

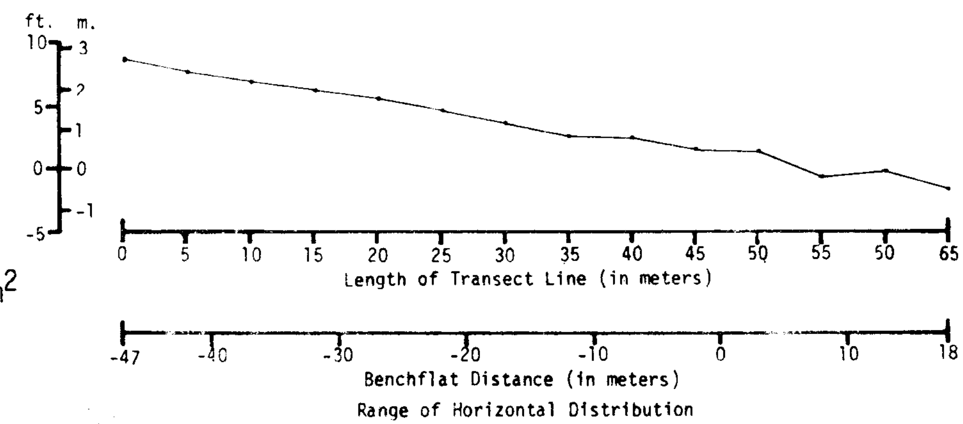
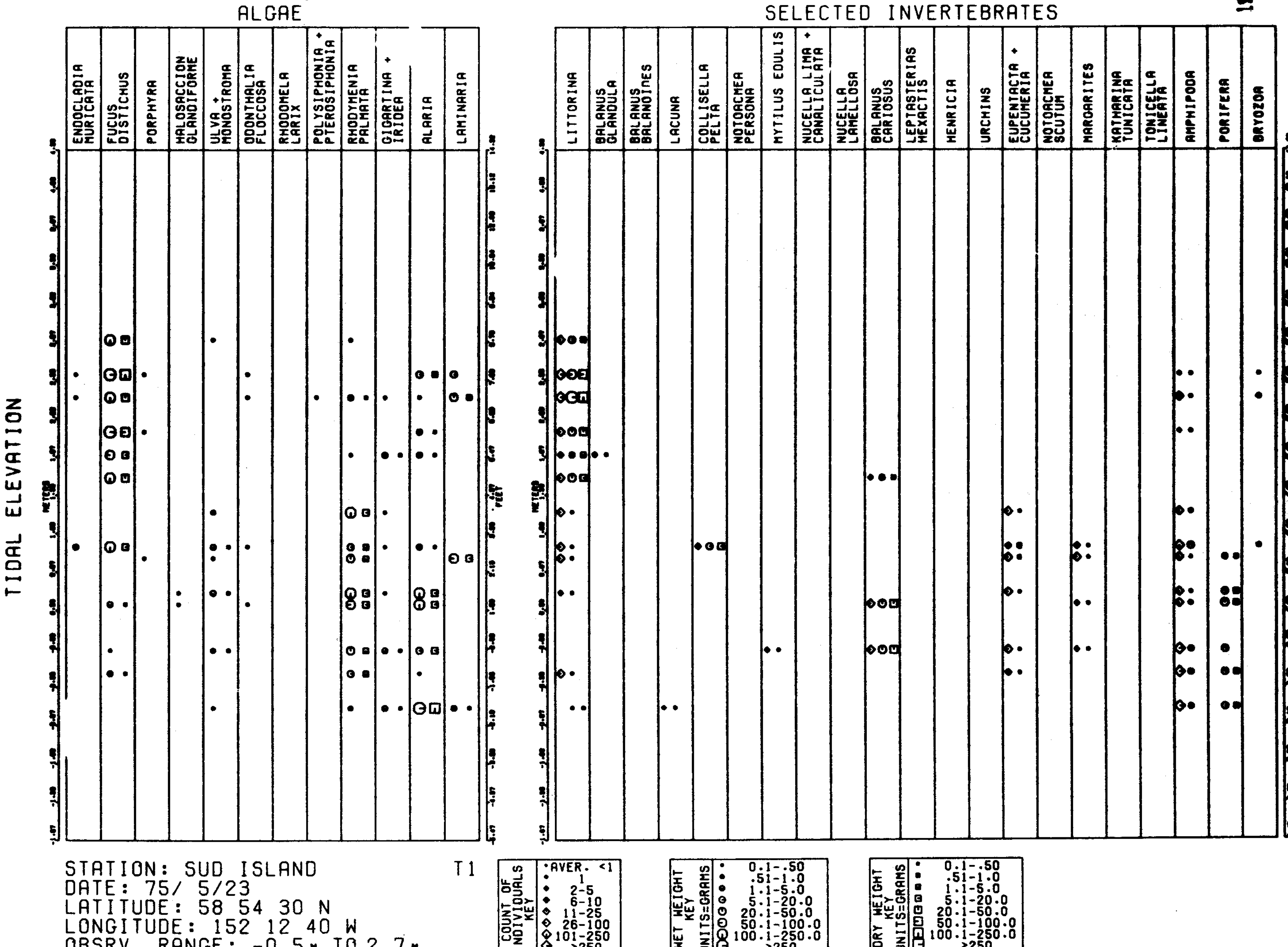


Fig. 31. Horizontal and vertical distribution of selected algae and invertebrates from 1/16 m^2 quadrats along transect line 1.

Fig. 32. Sud Island, Barren Islands, May 1975. Densities of selected intertidal organisms along transect line 1.



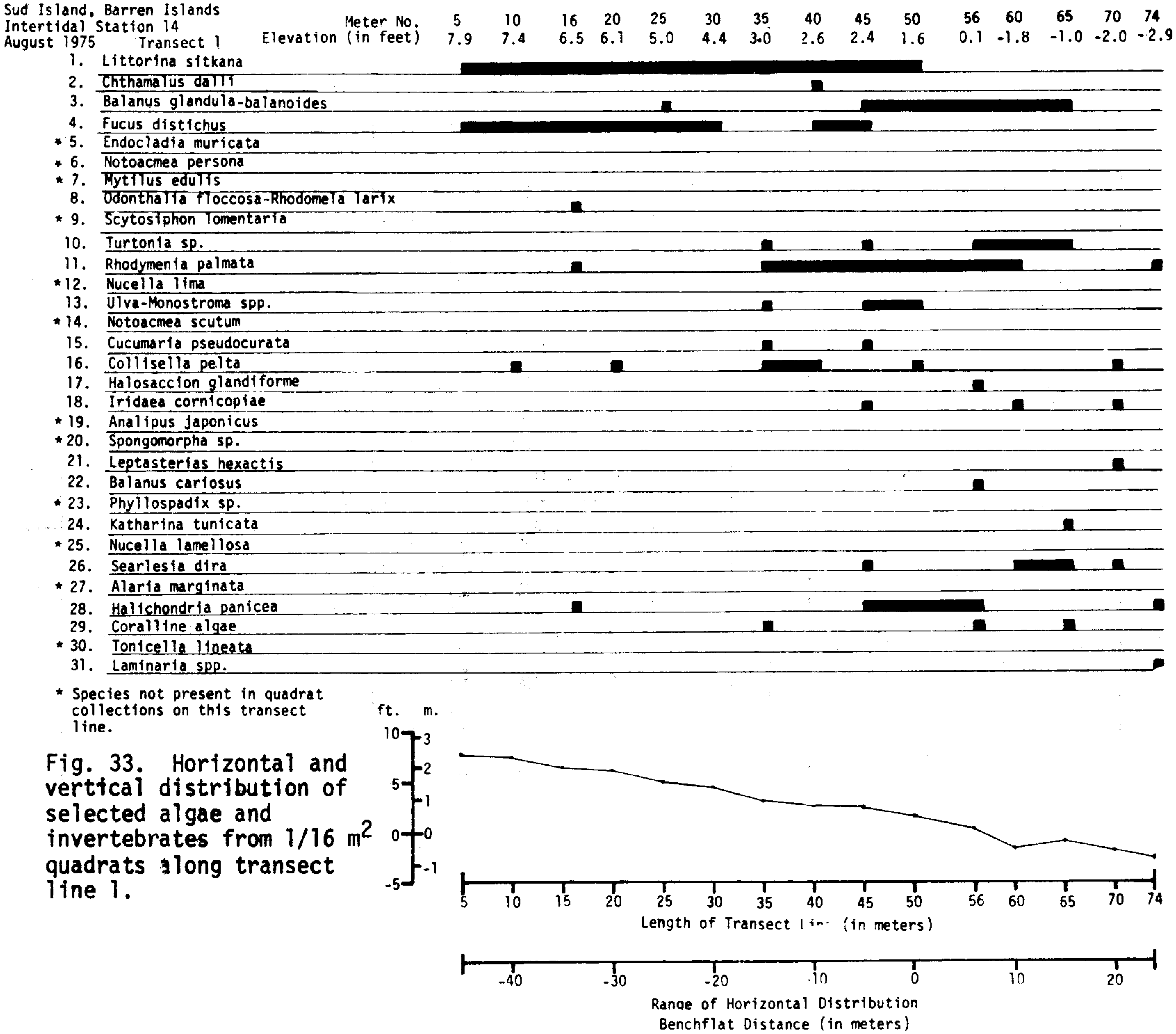


Fig. 33. Horizontal and vertical distribution of selected algae and invertebrates from 1/16 m^2 quadrats along transect line 1.

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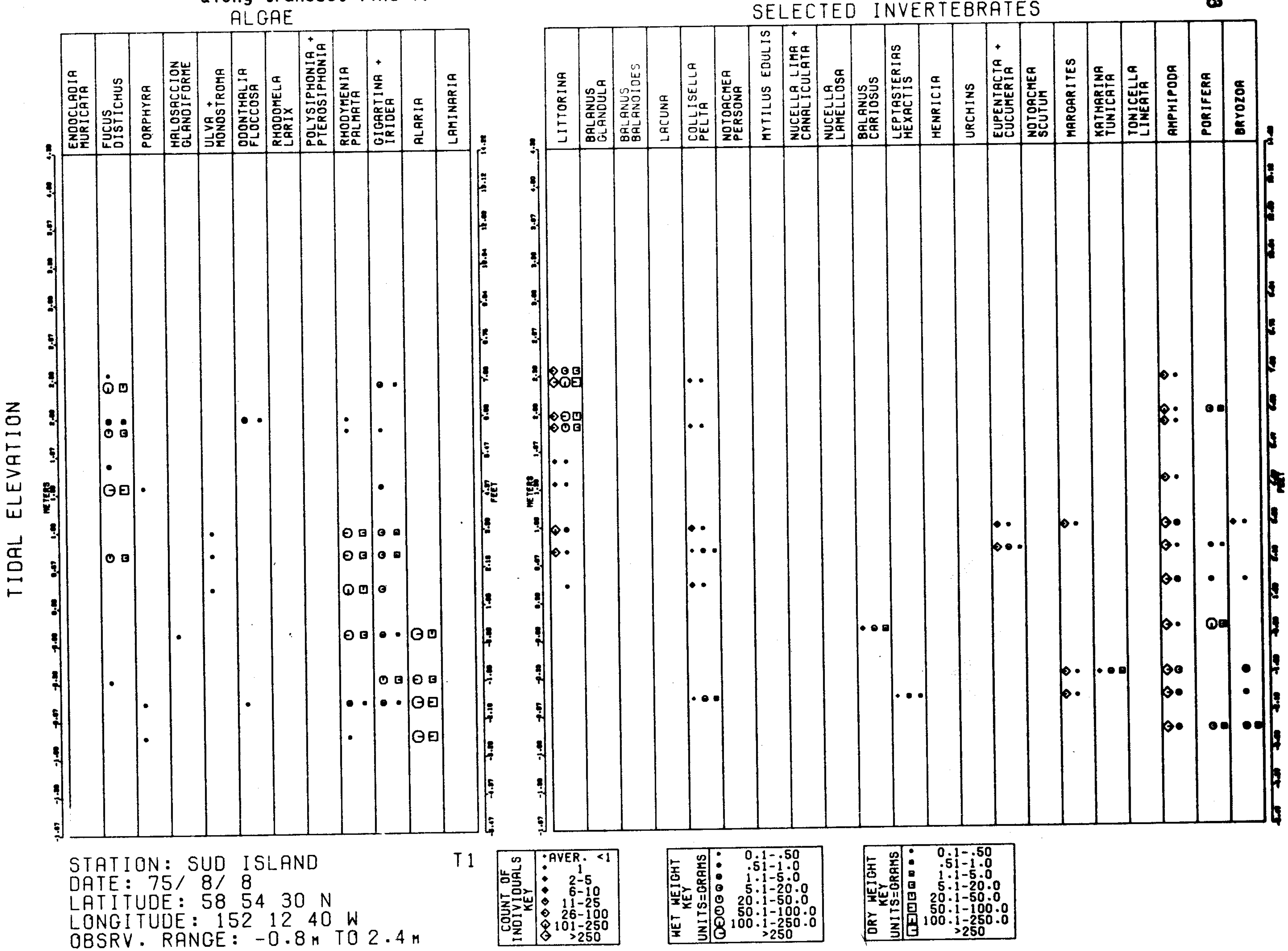
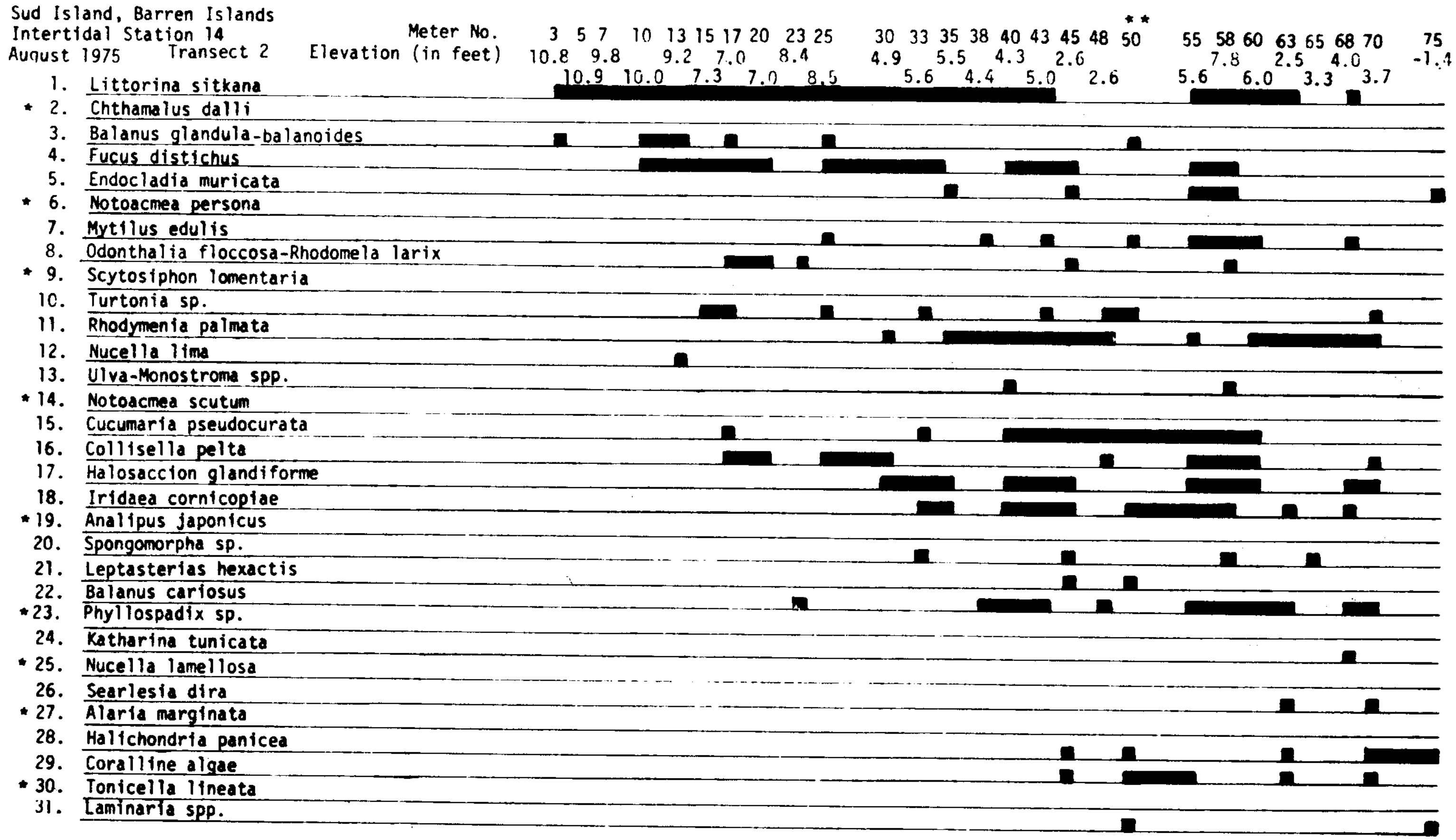
Figure 34. Sud Island, August 1975. Densities of selected intertidal organisms along transect line 1.





* Species not present in quadrat collections on this transect line.

**tidepool; half submerged

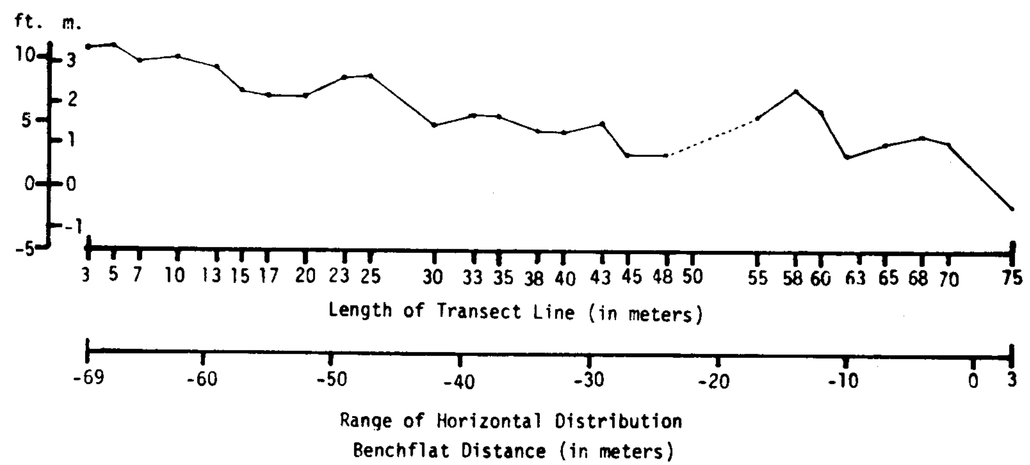
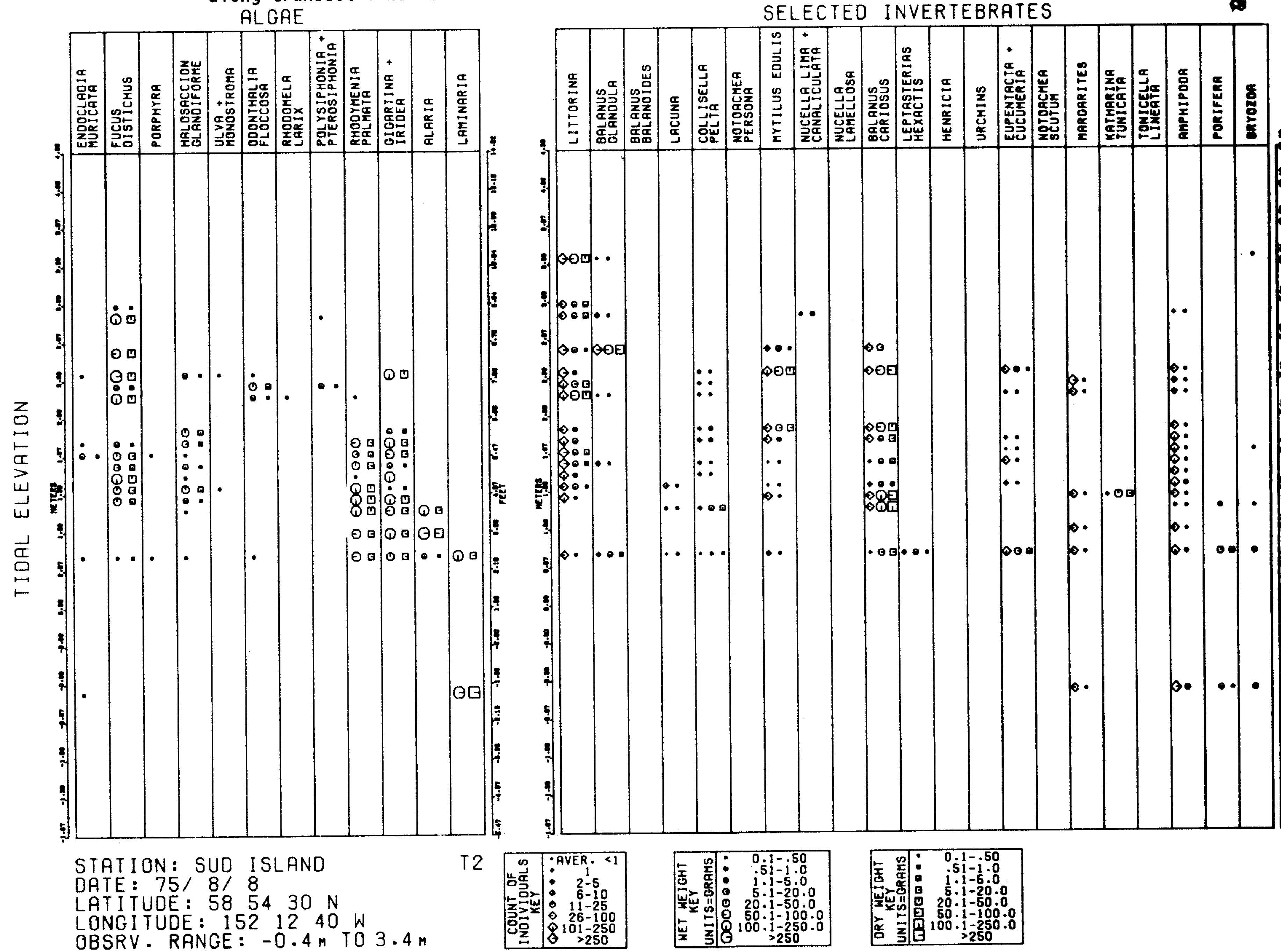


Fig. 35. Horizontal and vertical distribution of selected algae and invertebrates from 1/16 m^2 quadrats along transect line 2.

54

Figure 36. Sud Island, August 1975. Densities of selected intertidal organisms along transect line 2.



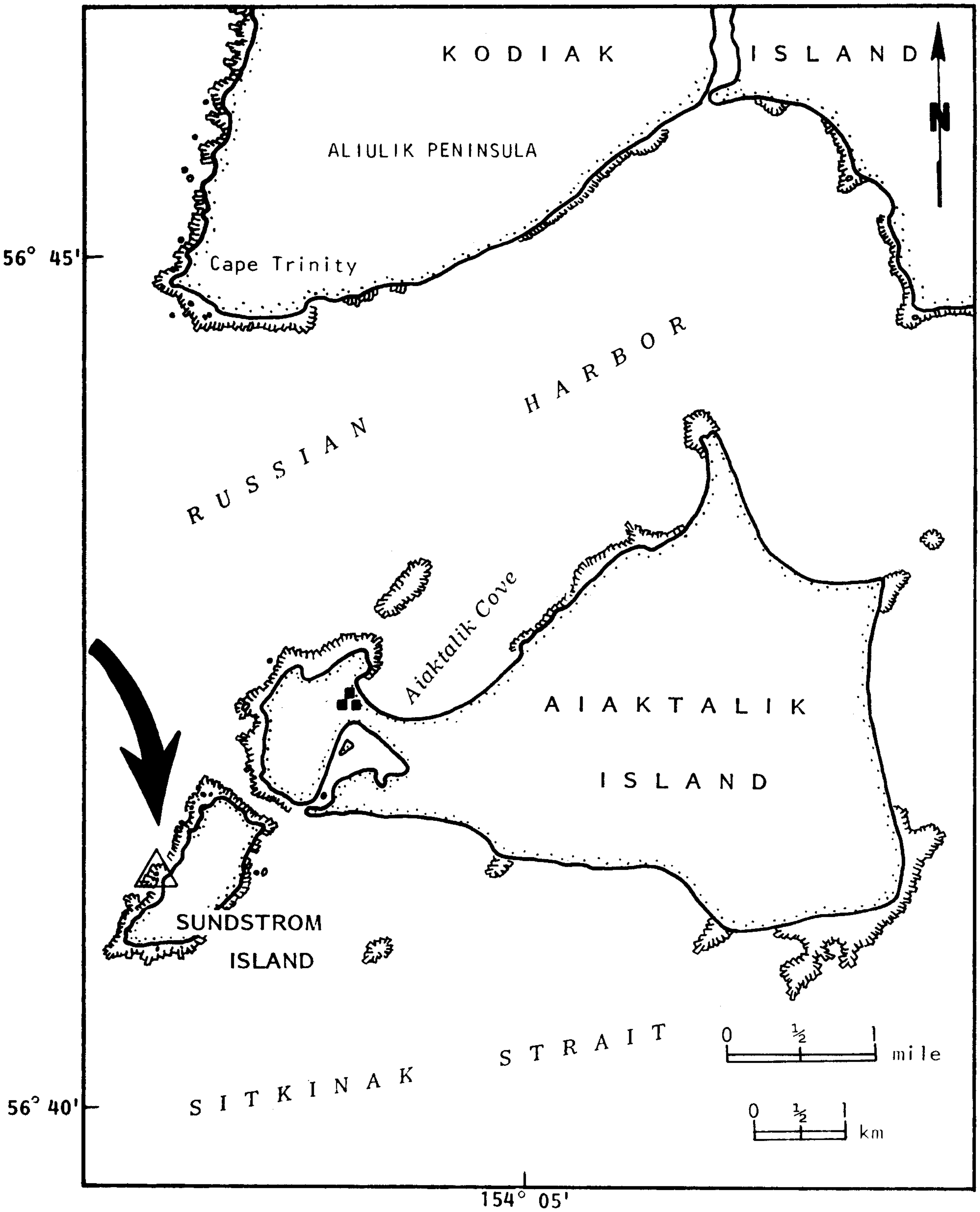


Figure 37. Sundstrom Island site.

Figure 38. Sundstrom Island. Middle of transect line showing Fucus cover.

Figure 39. Sundstrom Island. Sampling using arrow sampling method on vertical face. Most visible cover is Alaria.

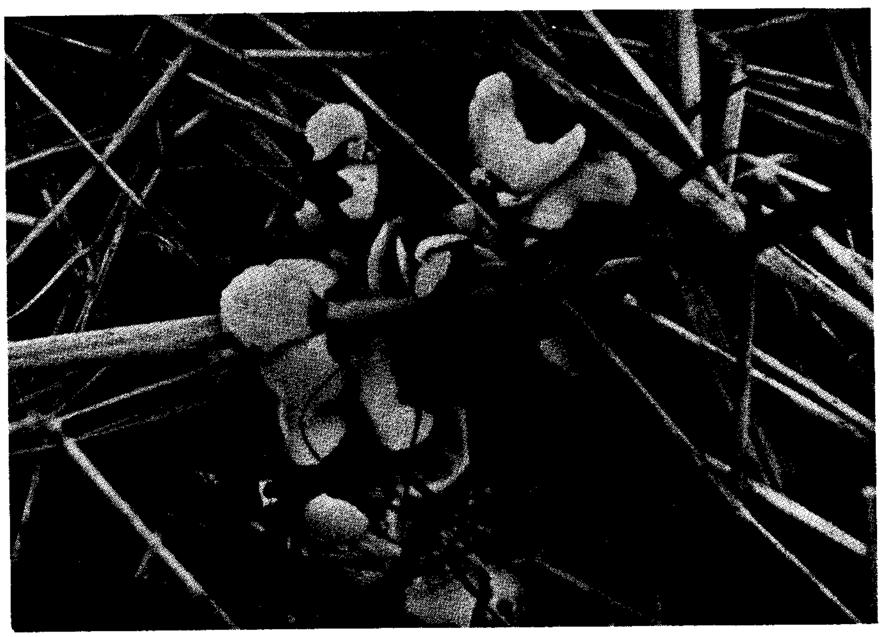
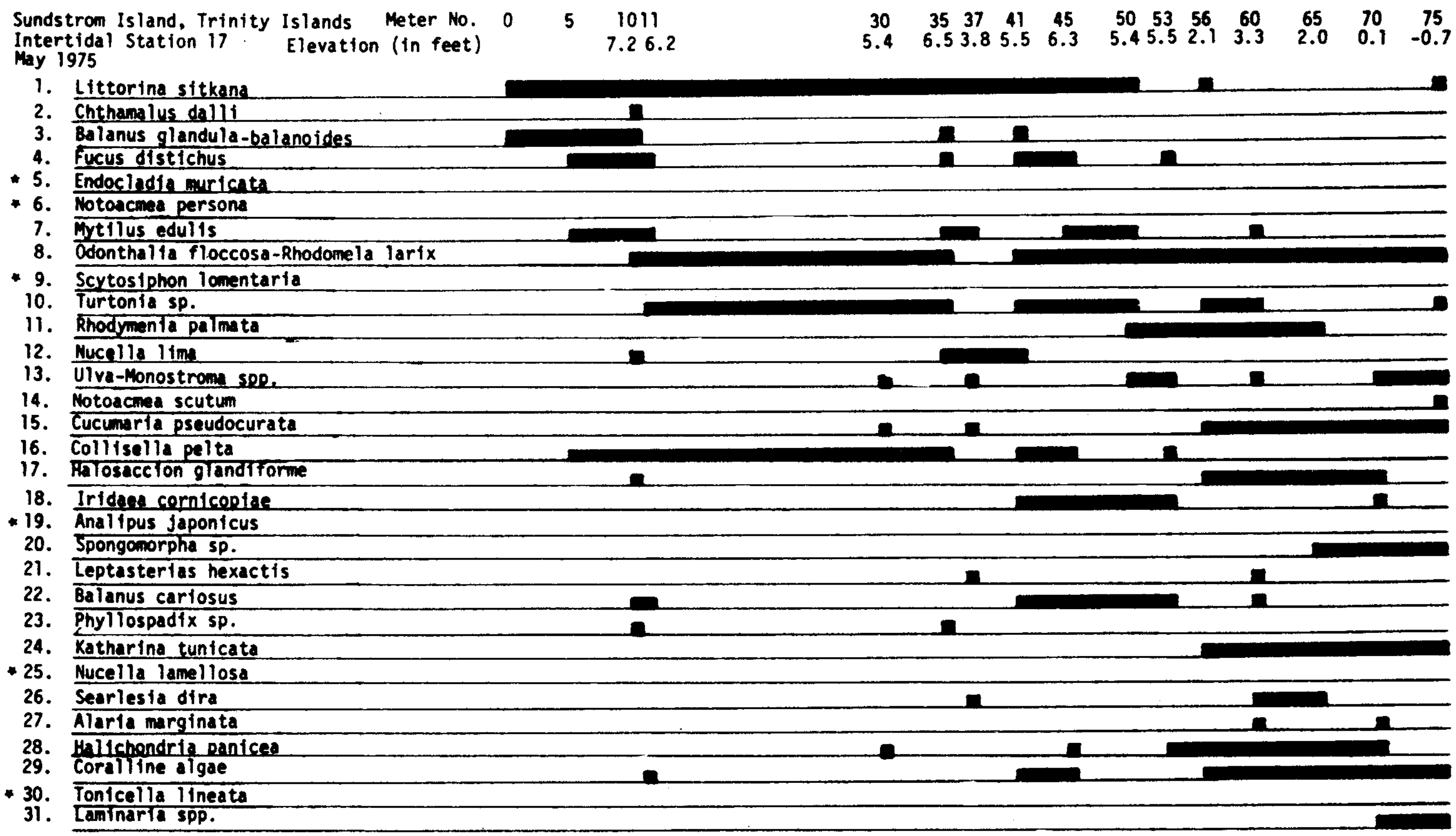


Figure 40. Plates of the chiton _Katharina tunicata_ in a gull nesting area on Sundstrom Island.



* Species not present in quadrat collections on this transect line.

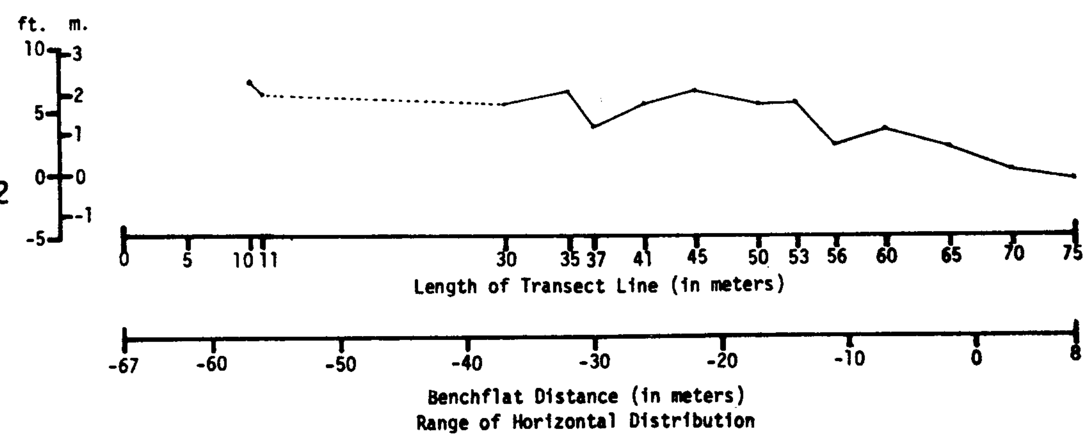
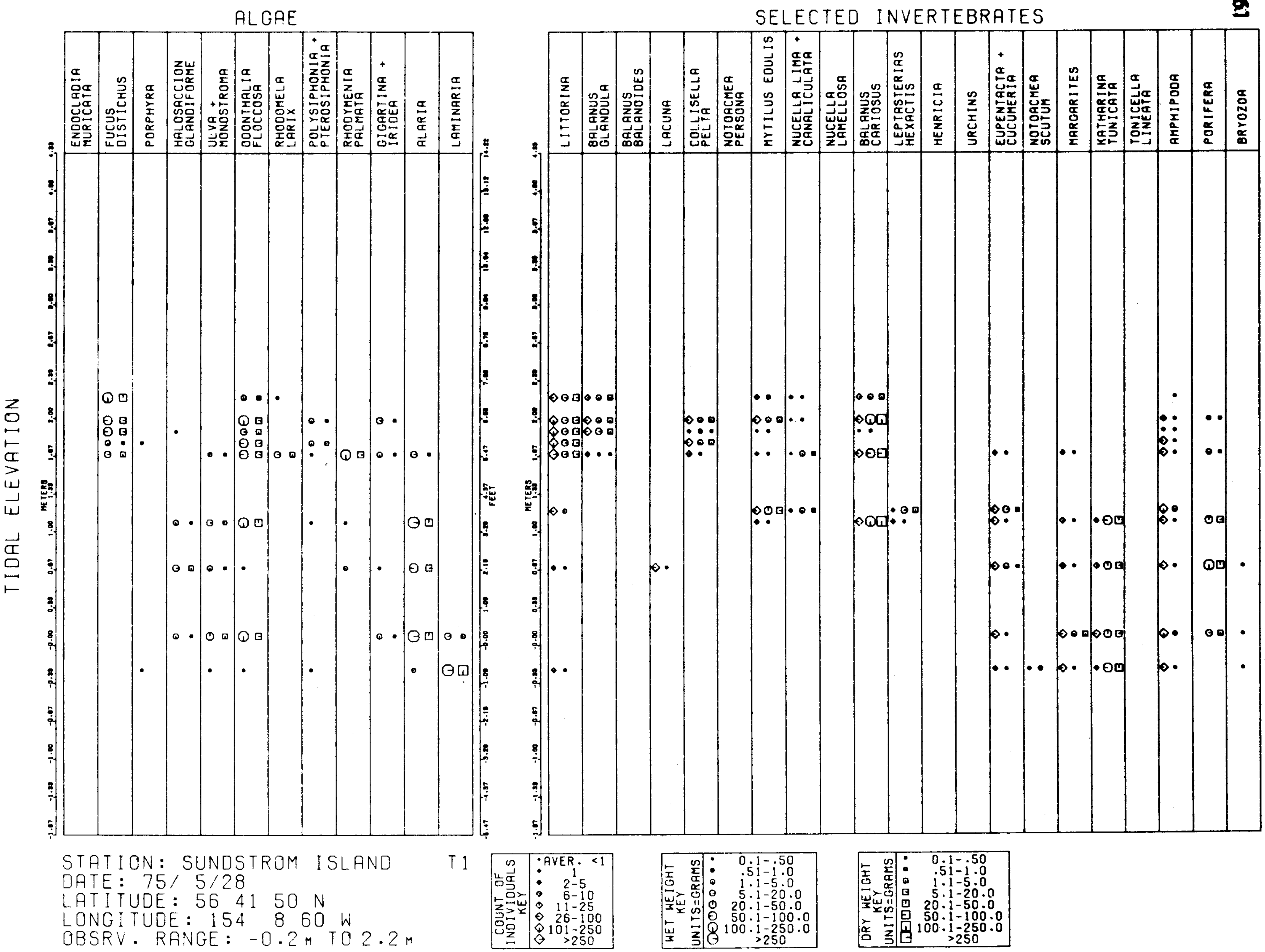
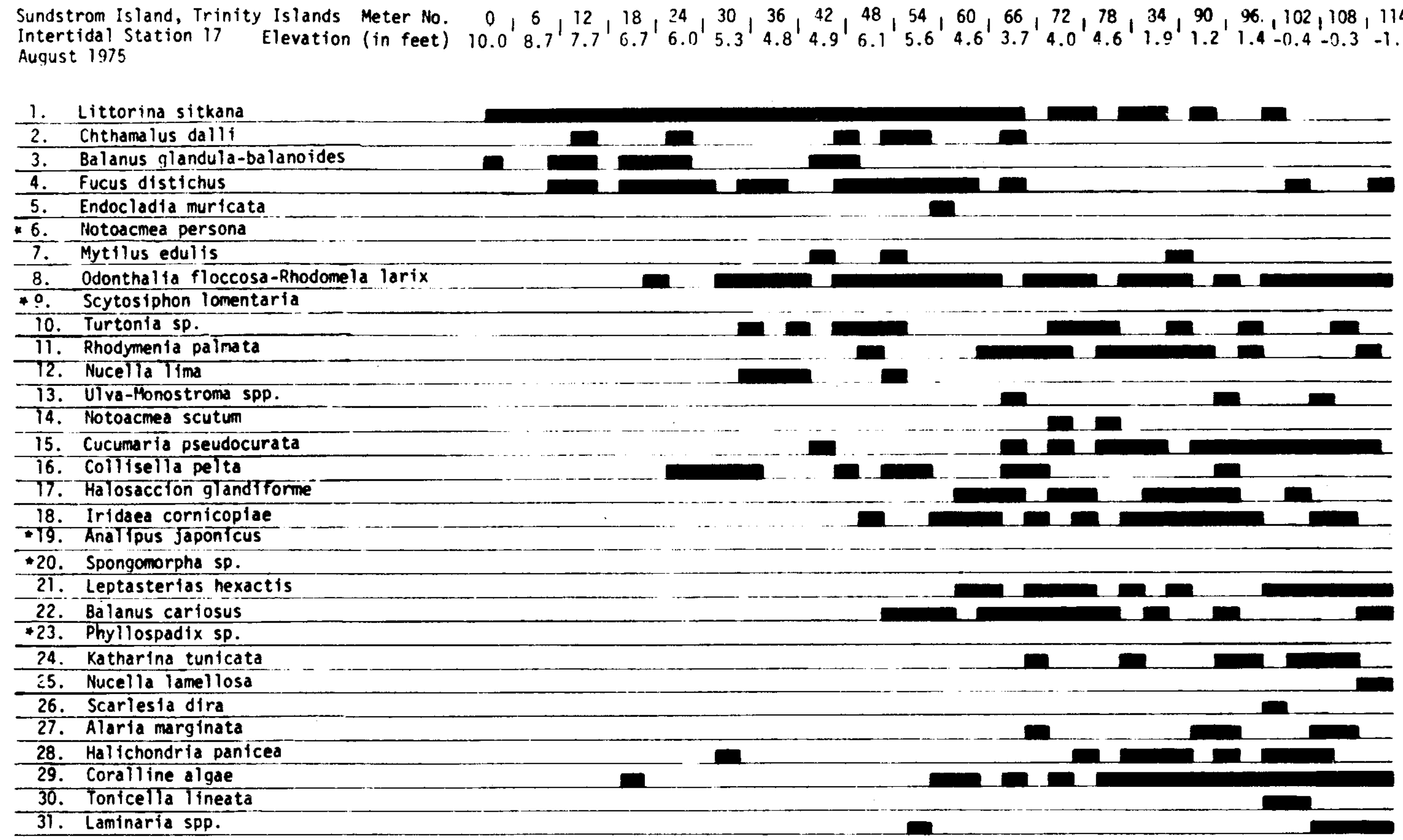


Fig. 41. Horizontal and vertical distribution of selected algae and invertebrates from 1/16 m^2 quadrats along transect line 1.

Fig. 42. Sundstrom Island May 1975. Densities of selected intertidal organisms along transect line 1.





* Species not present in quadrat collections on this transect line.

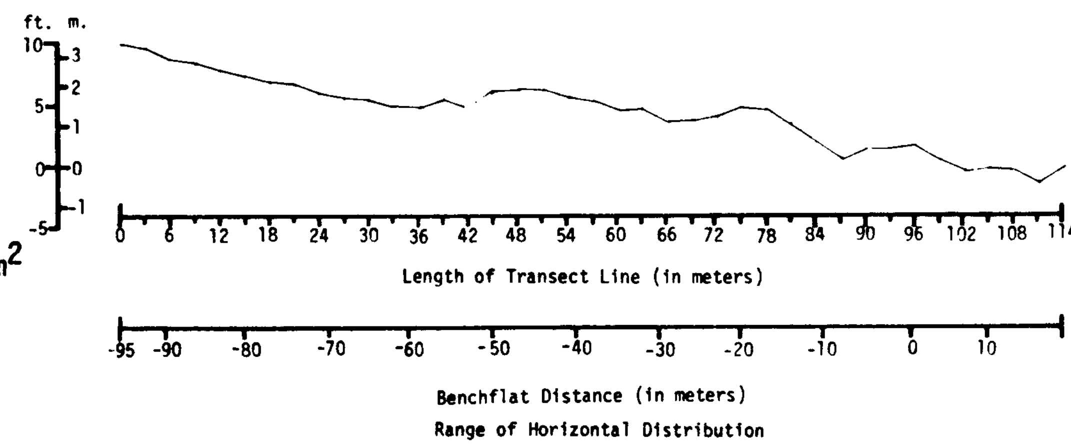
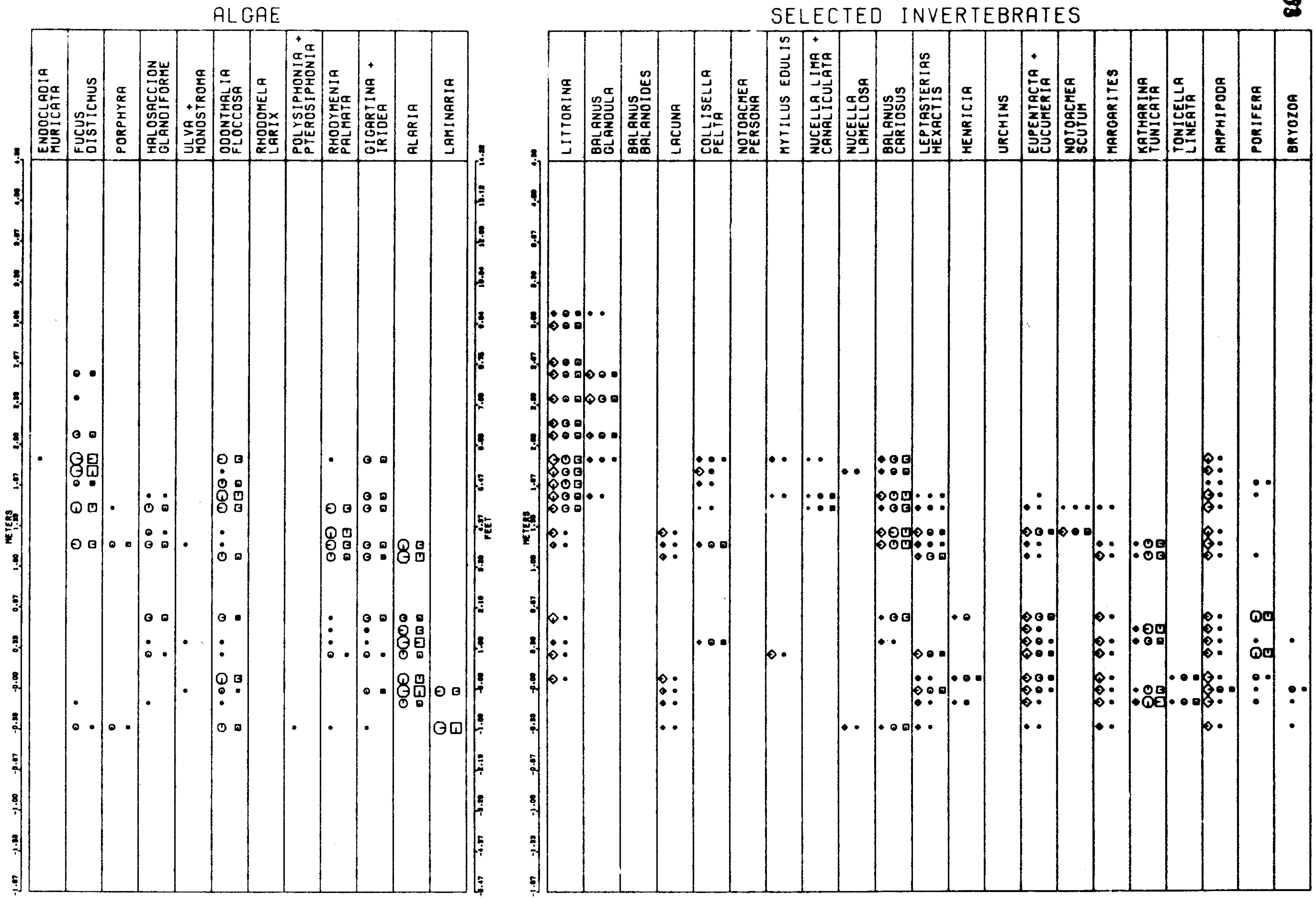


Fig. 43. Horizontal and vertical distribution of selected algae and invertebrates from 1/16 m^2 quadrats along transect line 1.

Fig. 44. Sundstrom Island, August 1975 Densities of selected intertidal organisms along transect line 1.



STATION: SUNDSTROM ISLAND T1
DATE: 75/ 8/ 9
LATITUDE: 56 41 50 N
LONGITUDE: 154 6 80 W
OBSRV. RANGE: -0.3M TO 3.1M

COUNT OF INDIVIDUALS KEY: AVER. <1; 1; 2-5; 6-10; 11-25; 26-100; 101-250; >250

WET WEIGHT KEY UNITS=GRAMS: 0.1-.50; .51-1.0; 1.1-5.0; 5.1-20.0; 20.1-50.0; 50.1-100.0; 100.1-250.0; >250

DRY WEIGHT KEY UNITS=GRAMS: 0.1-.50; .51-1.0; 1.1-5.0; 5.1-20.0; 20.1-50.0; 50.1-100.0; 100.1-250.0; >250

The lowest zone in our quantitative sampling area was almost entirely covered with long strands of fertile Alaria marginata. The substrate there was basaltic bedrock with deeply cut surge channels, and biota differed between these habitats. Laminaria longipes were often found filling the low channels. In low tidepool areas they were accompanied by Hedophyllum sessile. The area outside the channels and tidepools was characterized by Alaria, Balanus cariosus, and several species of coralline algae, both encrusting and articulated. Several large Katharina tunicata were often seen wedged in among the B. cariosus and were preyed on by sea birds, principally oyster catchers and gulls. Large patches of Halichondria panicea and another sponge also covered much of the low area. There were occasional Henricia leviuscula and Tonicella lineata as well. The red algae were represented by Rhodymenia palmata and Pterosiphonia bipinnata; in addition, Odonthalia sp. were found on the sides of some of the higher channels in the low zone. Spongomorpha spinescens and Monostroma sp. were the green algal species of the low zone. Kelps probably made up over 90% of the algal cover of the low zone.

The middle zone was variable. In general it may be characterized as the red algal belt, for several red algal species were found in their greatest abundance here. Two forms of Rhodymenia (R. palmata and R. palmata f. sarniensis) occurred throughout the zone and intergraded with the low zone as well. Various species of the Odonthalia-Rhodomela group were found along almost the entire length of the transect; the most abundant species was O. floccosa. In the low zone Odonthalia occurred principally on the sides of channels; in the middle zone they were most frequently observed on the bottom of channels or in very shallow areas of standing water. Often the Odonthalia plants were heavily covered with littorine snails. Halosaccion glandiforme were also found in the middle zone; in areas where this species was most abundant, plants of uniform size covered medium-gradient rock surfaces. On rock tops they often intergraded with Fucus distichus. In May 1976 we observed a heavy cover of epiphytic bladed green algae (probably Monostroma) growing on Rhodymenia and Halosaccion.

Balanus cariosus were found in the middle zone as well as in the low zone. In the middle zone they occurred principally in shaded or moist situations under overhangs or at the base of rocks. The common barnacle in the middle zone was B. glandula which was quite abundant on rock sides and tops. Groups of limpets were seen on irregularities in the rock surface and Collisella pelta was the common species. Mytilus edulis were seldom seen; they occurred only in very small clumps in protected locations.

The three dominant organisms of the high zone were Fucus, Balanus glandula, and Littorina sitkana. Odonthalia were found in areas of standing water. Fucus occurred on rock tops in the middle zone, grew abundantly through most of the high zone, and were found as isolated sprigs where the bedrock graded into pebbles and sand. Balanus glandula were found mixed with B. balanoides throughout the high zone and they both grew above the limit of the Fucus. In the upper part of the zone they grew just below Chthamalus dalli. In several quadrats as many as 25% of the barnacles were dead and only the empty plates remained on the rock. Littorina were found along the entire length of the transect and even beyond. Although their greatest concentrations were on Odonthalia plants, we observed a few Littorina on patches of lichens above the tide line.

We observed condensed vertical zonation on two vertical faces of a huge, high bedrock boulder near the low tide line. One side was exposed to the sea from the southwest while the other side faced the land and was shaded and fairly well protected from waves.

The exposed side was 100% covered with organisms. The base at this side was a flat shelf bared only during the lowest tides. This shelf was covered with a carpet of large B. cariosus which in turn was covered with several varieties of coralline algae, some of which were bleached at the edges. Alaria plants were found wherever there was room for their holdfasts to attach. The lowest zone of the vertical portion of the exposed face had a cover of B. cariosus, Alaria sp., Rhodymenia, and Odonthalia. The Odonthalia often completely covered the barnacles with a short, tuft-like form. The next higher zone was covered with Rhodymenia, Halosaccion, Fucus, and B. glandula. Both the Fucus and Halosaccion grew just below the summit of the boulder. Sundstrom Island has a large population of sea birds and the top of the boulder was crowned with a luxurient growth of Prasiola meridionalis, an alga which is usually found only in areas of high guano concentration.

The landward, protected side of the boulder had a very patchy distribution of organisms; everything grew in clumps with bare rock in between. The lowest zone had patches of Alaria sp. and B. cariosus. Odonthalia grew between and above this zone. The next zone was composed of clumps of Fucus and Mytilus. In an area where the rock formed a ridge and flattened out a little before the next vertical rise, the Mytilus had a more continuous distribution and formed a narrow band. The zone below the summit had a patchy distribution of B. glandula and Fucus.

Cape Kaguyak (Kodiak Island)

Cape Kaguyak is near the southern tip of Kodiak Island. Our sampling site, which lies slightly inside Cape Kaguyak on the north side, is partially protected from the full force of oceanic turbulence (Figure 45). We sampled in May 1976.

The beach is somewhat irregular, grading from large boulders near the point to gravel part of the way inside Kaguyak Bay. The large boulder area which is only a short distance from our site appears to be influenced by wave force from the open ocean side. Storm surf in this area appears able to roll across the land into Kaguyak Bay. The large boulders appear to have been shifted about recently, and several large tide pools at the highest elevations indicate that waves from the Pacific side inundate the area with spray.

The upper part of our sampling site was composed of sand, gravel, and small boulders which graded into larger boulders nearer the water. The beach had a moderate and fairly regular slope generally unbroken by large boulders or bedrock hummocks.

Two parallel transect lines were used at Cape Kaguyak during May 1976. Both were used to enumerate algal and invertebrate cover and also to make 15 quantitative collections. The transects ran through an area of small to medium boulders (Figures 46 and 47). Distribution of algae and invertebrates was patchy (Figures 48-51) as a result of physical battering of the boulders by surf during storms. The upper end of transect 1, or 32% of the transect,

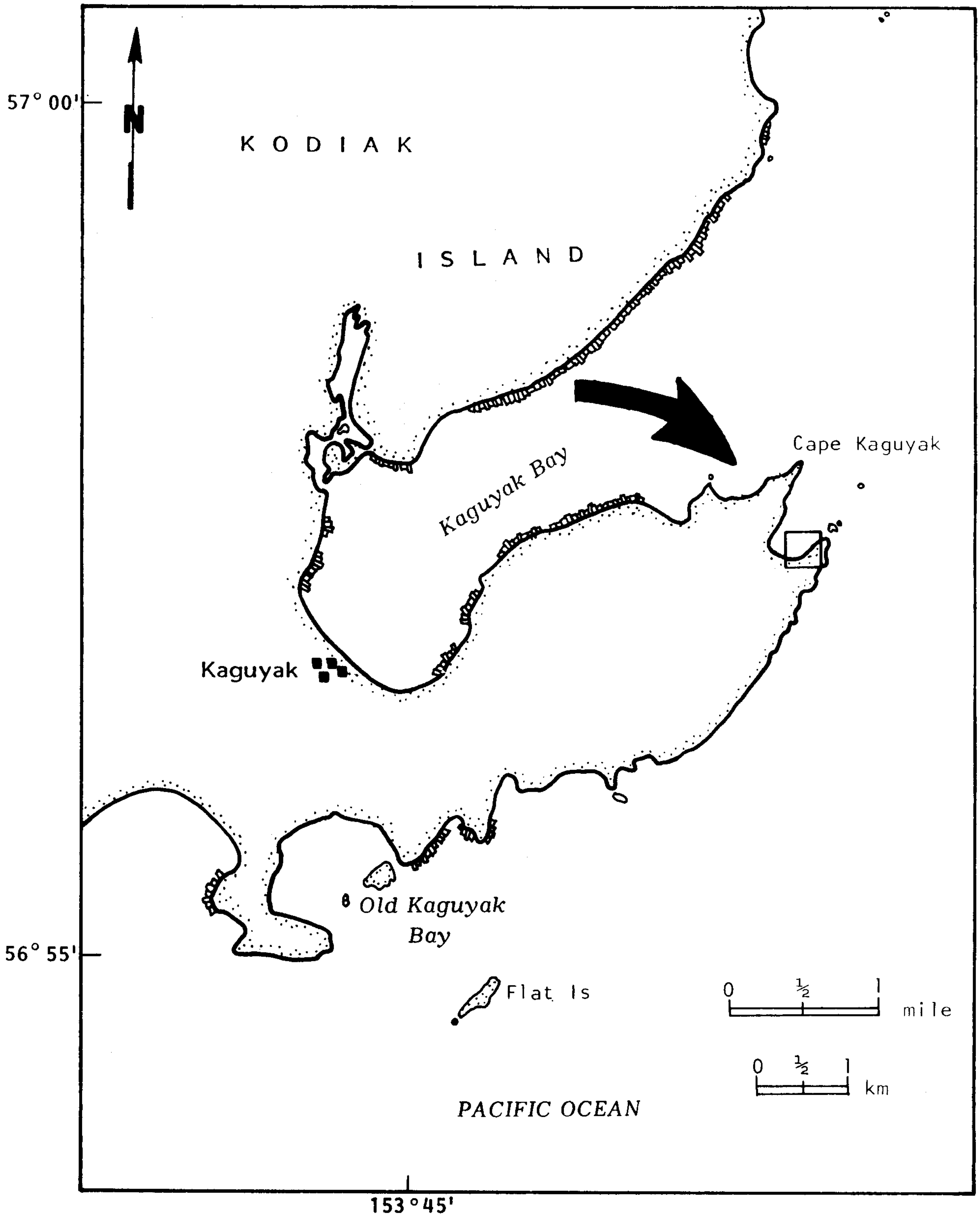


Figure 45. Cape Kaguyak site.

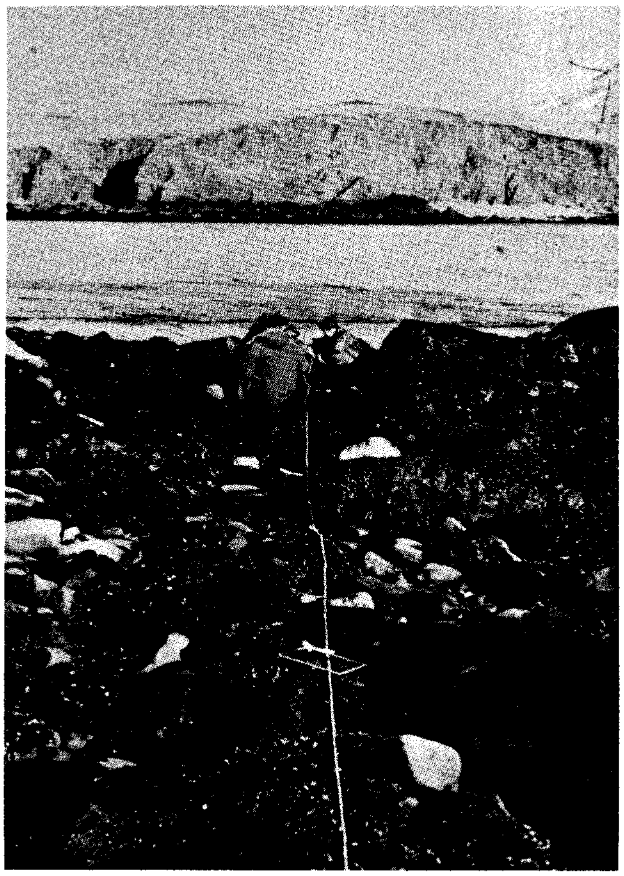


Figure 46. Cape Kaguyak. View of transect line.

Figure 47. Cape Kaguyak. View of transect lines. Sampling area showing transect lines 1 and 2.

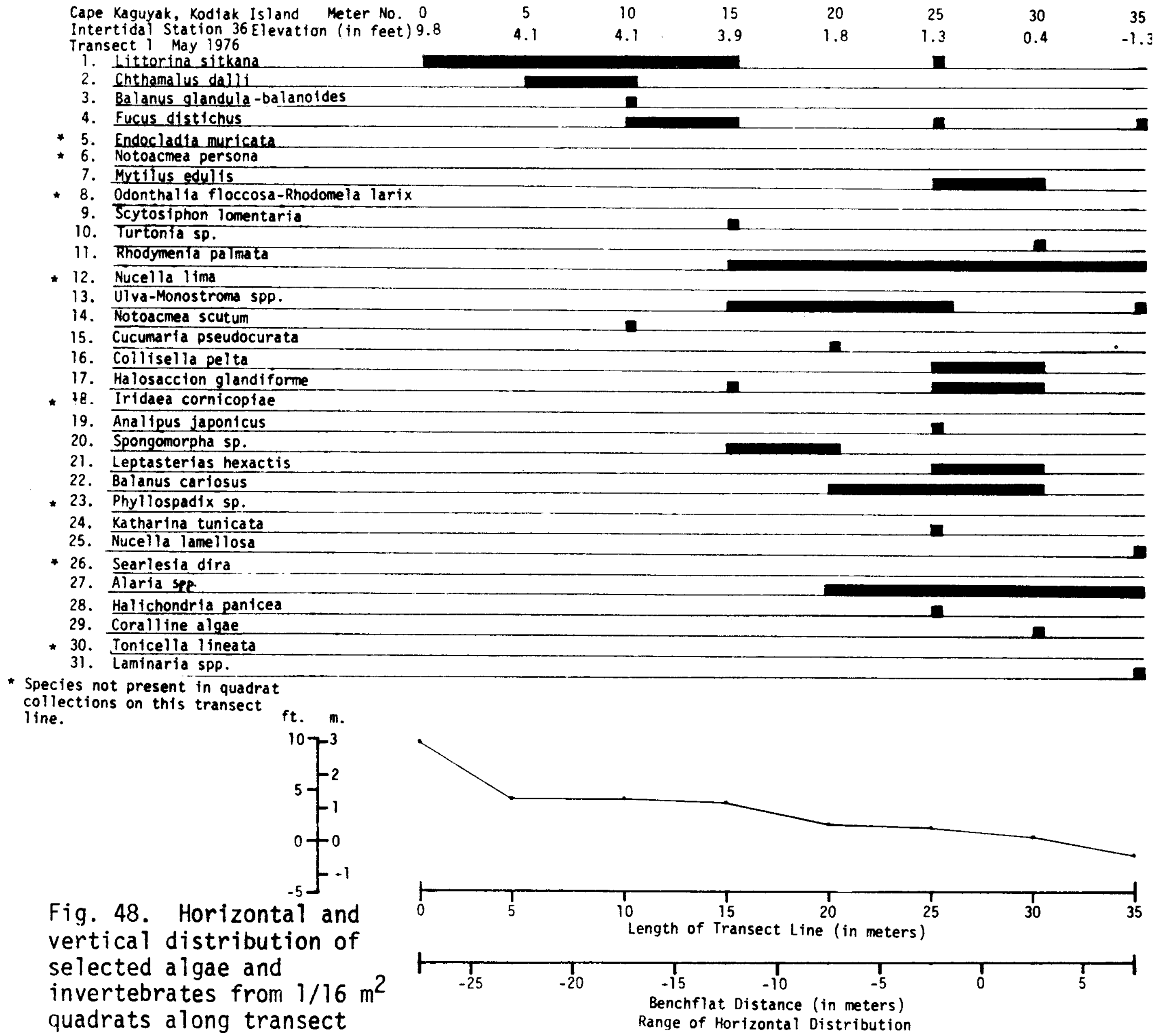
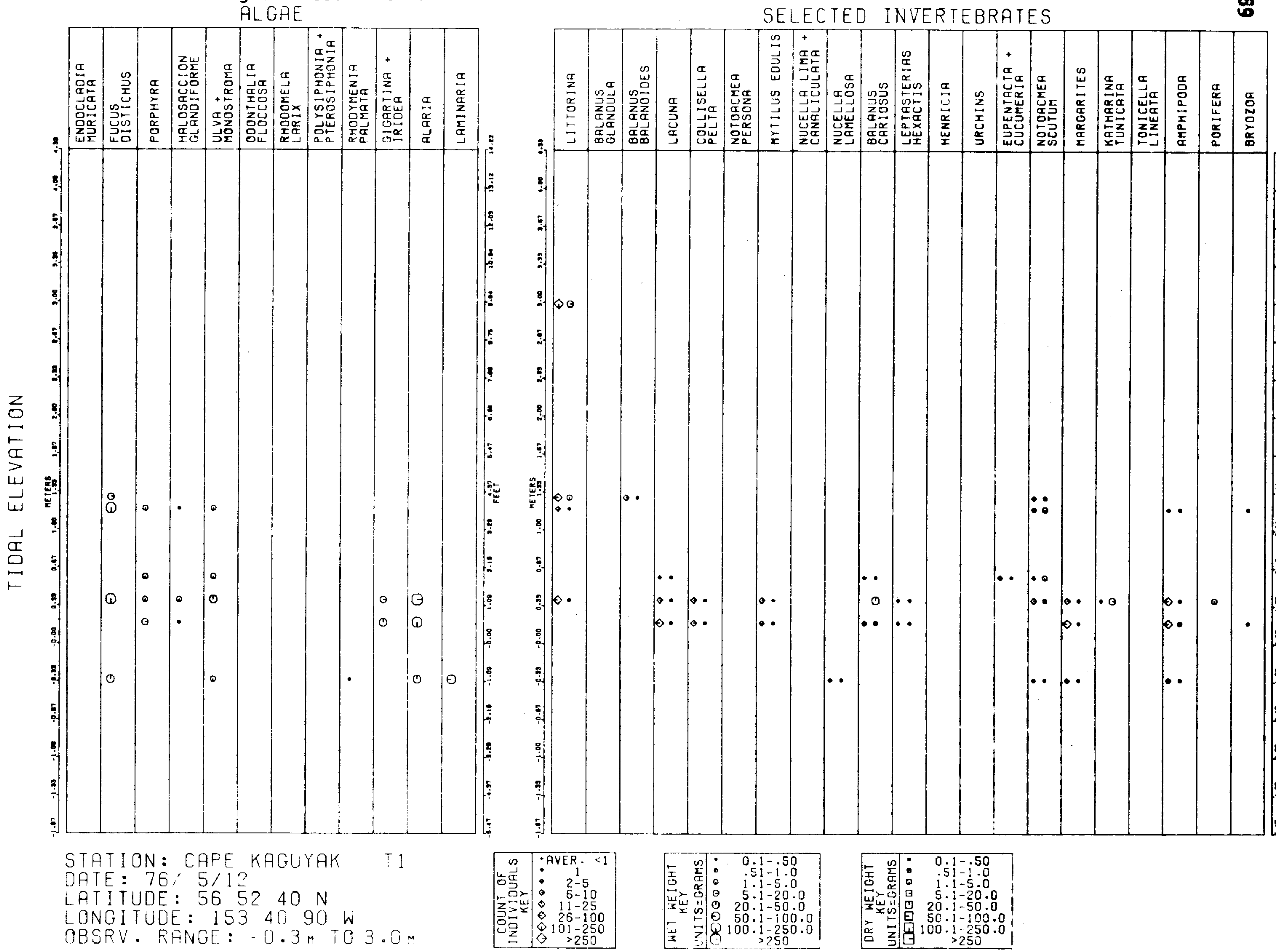


Fig. 48. Horizontal and vertical distribution of selected algae and invertebrates from 1/16 m^2 quadrats along transect line 1.

Figure 49. Cape Kaguyak, May 1976. Densities of selected intertidal organisms along transect line 1.



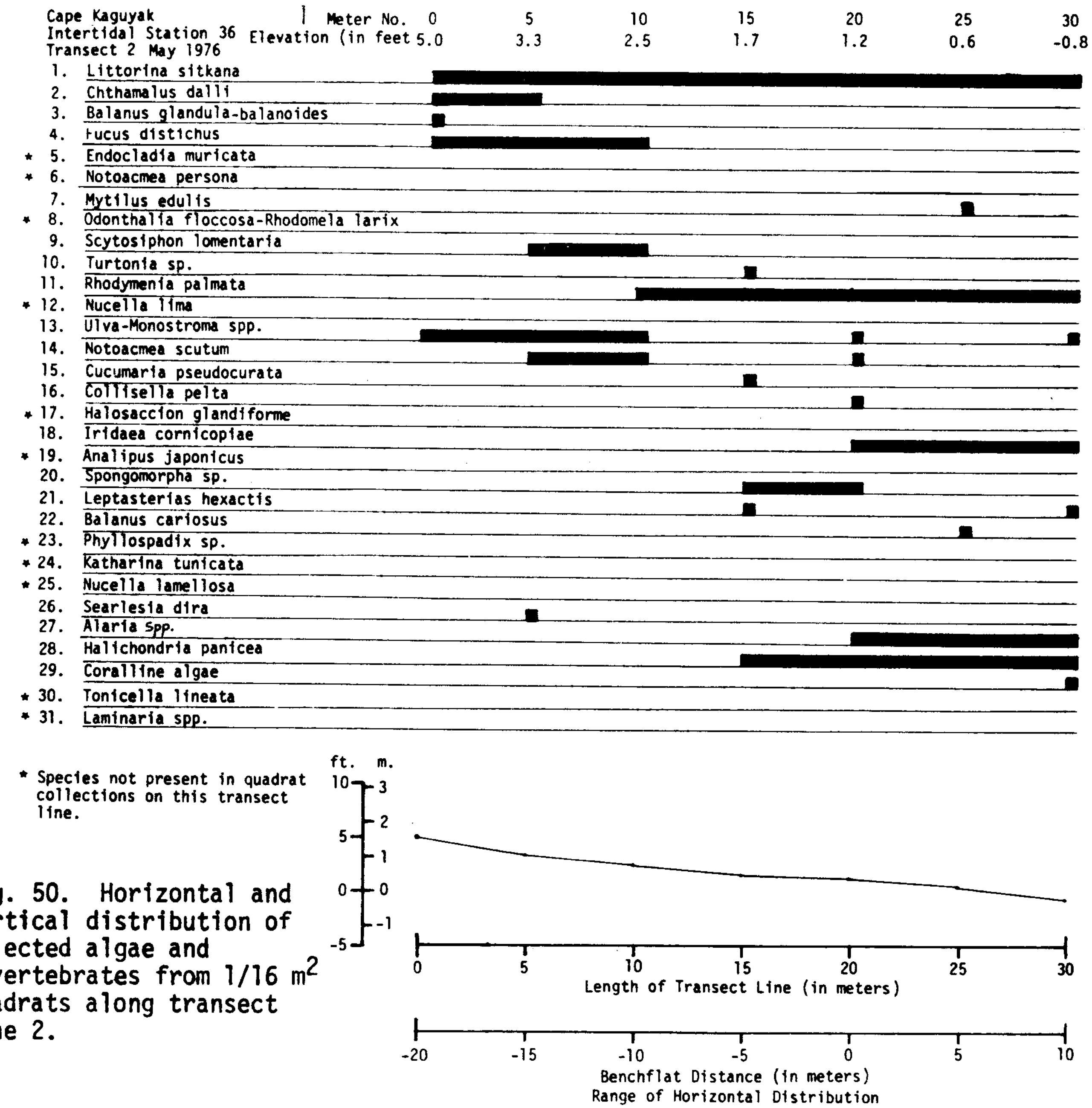
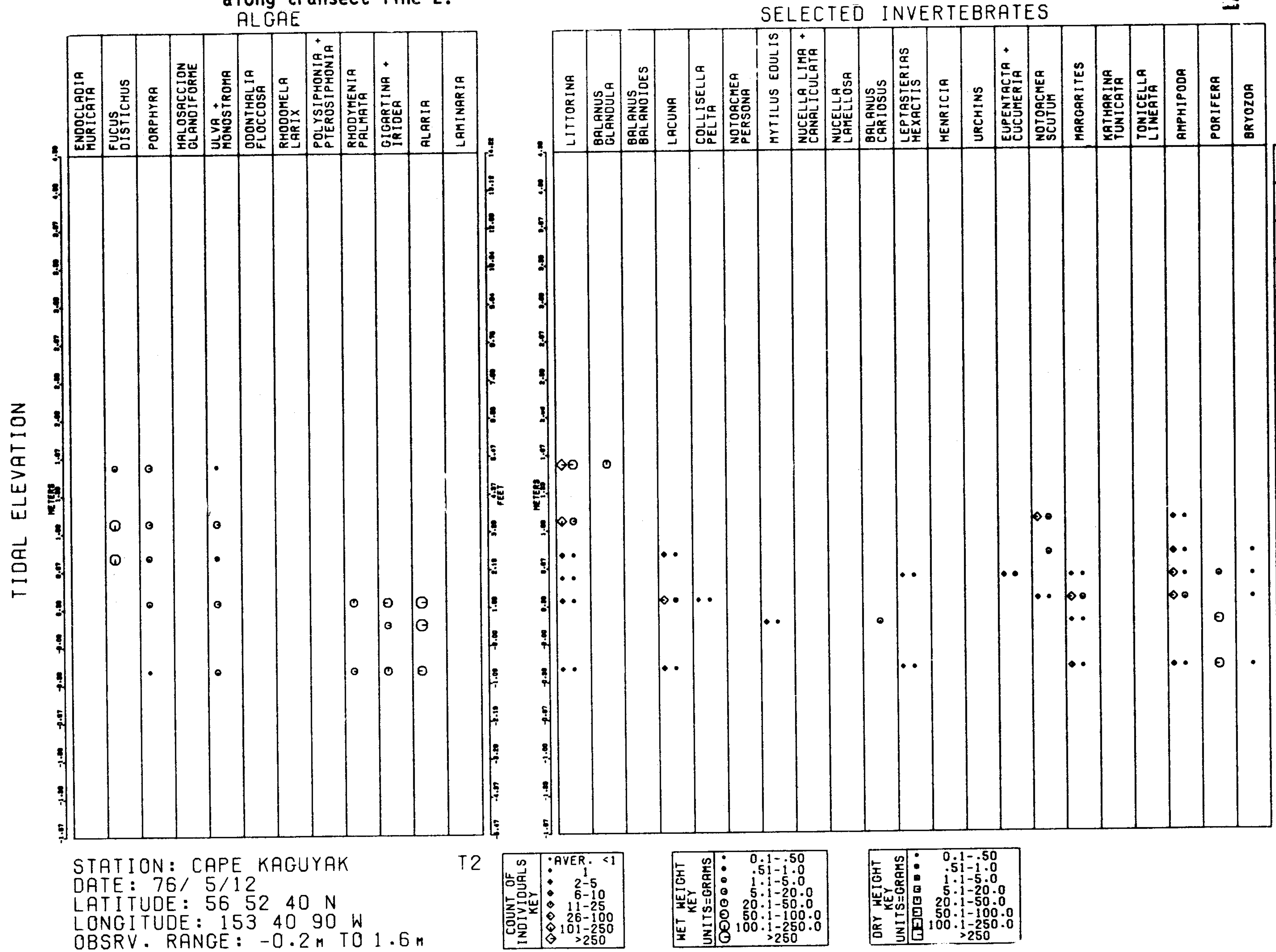


Fig. 50. Horizontal and vertical distribution of selected algae and invertebrates from 1/16 m^2 quadrats along transect line 2.

Figure 51. Cape Kaguyak, May 1976. Densities of selected intertidal organisms along transect line 2.



STATION: CAPE KAGUYAK T2
DATE: 76/ 5/12
LATITUDE: 56 52 40 N
LONGITUDE: 153 40 90 W
OBSRV. RANGE: -0.2 M TO 1.6 M

lacked algal cover. In the remaining quadrats, Alaria and Rhodymenia were spatially dominant. The spatial dominance of Rhodymenia is not reflected in Figure 49, as R. palmata f. sarniensis was not read as R. palmata by the computer. Distribution of algae along transect 2 was somewhat less variable; all of the quadrats had some algal cover. Fucus and Porphyra were spatially dominant along the upper end of the transect and Alaria and Rhodymenia were spatially dominant along the lower end. Bladed green algae were found at all levels along transect 2.

Invertebrate populations were small. Mussels, predatory molluscs, and sea stars were uncommon. The upper area of the beach was characterized by Littorina sitkana, Chthamalus dalli, Balanus glandula, Notoacmea scutum, and Collisella digitalis. Lower levels were characterized by B. cariosus, several species of gastropods (e.g., Margarites helicinus, Lacuna marmorata), Halichondria panicea, bryozoa, and serpulid worms (Spirorbis). Most of the non-colonial forms were small in size and, except for sponges, the biomass of invertebrates was generally small along both lines.

Three Saints Bay (Kodiak Island)

Three Saints Bay is on southeast Kodiak Island about 30 mi north of Cape Trinity. The area we sampled in May 1975, Cape Liakik, is at the entrance of Three Saints Bay and is directly exposed to wave action from the Gulf of Alaska from the south-southeast (Figure 52). Areas exposed to the west, north, and east are semi-protected. Cape Liakik is basaltic bedrock with steep cliffs, spires, and a low bedrock outcrop. We ran our transect line across the low bedrock area (Figures 53 and 54). The lowest part of the transect ran across an area cut with deep surge channels. Above this zone was an area of low-relief ridges and valleys of gradually-increasing gradient which merged into steep rock cliffs at the head of the transect. Nybakken (1969) sampled Three Saints Bay extensively in 1963, before the Alaskan earthquake in 1964, and provided species lists for a number of sites in the bay.

Some species which occurred in fair abundance are not represented in our transect line collections. For instance, a bed of the kelp Nereocystis luetkeana could be seen floating in the offshore area beyond the transect at Cape Liakik. High bedrock outcrops near the low tide line also occurred outside the area of the transect.

The lowest area of the transect began at the low tide line and had a dense cover of Alaria, principally A. marginata (Figures 55 and 56). Much of the Alaria was short, with eroded blades, with or without sporophylls. A heavy layer of Balanus cariosus grew on the bedrock with the Alaria holdfasts growing on or between them. The B. cariosus were large, often chimney-form, with heavy walls. When we pried clumps of B. cariosus from the rock, we found many small organisms sheltered between the large barnacles. These included the starfish Leptasterias hexactis, small gastropods, various polychaete worms, and the ubiquitous amphipods and isopods.

Other conspicuous organisms in the low zone along the transect line were the chitons Katharina tunicata and Tonicella lineata. K. tunicata were more abundant, with as many as eight per 1/16 m^2 quadrat. A patchy cover of sponge, mostly Halichondria panicea, was extensive. Various species of coralline algae, both encrusting and articulated, were also seen throughout this zone.

The spatially dominant animal in the middle intertidal zone was Mytilus, although barnacles were also abundant. A narrow area between the Alaria and Mytilus zones had a patchy distribution of barnacles, mostly medium to large B. cariosus with a few B. glandula. Large Mytilus formed only a narrow band on the rock tops near the lower boundary of its distribution on the transect, becoming, higher up on the transect, an almost solid band about a meter wide. The algae Porphyra sp. and Spongomorpha spinescens were often seen growing on the Mytilus band.

The high zone was characterized by a heavy cover of Fucus distichus. The lower end of the Fucus zone was characterized by M. edulis, small B. cariosus, and short, profusely-branched, fertile Fucus plants. The B. cariosus became interspersed with and were gradually replaced by B. glandula. Higher on the beach some Mytilus occurred through most of the zone but in the very highest area only littorines were found with small B. glandula and short, sterile Fucus growing in crevices. Patches of Odonthalia floccosa and Endocladia muricata were also common throughout the Fucus area.

A second, more protected site, was sampled farther inside Three Saints Bay in August 1975 (Figure 52). The lower end of the transect ran through an area of hummocky bedrock with tidepools. Alaria, Balanus cariosus, and Katharina tunicata were characteristic of the lower tidal zone, although less abundant than at Cape Liakik (Figures 57 and 58). Encrusting coralline algae and the small chiton Tonicella lineata, both found in the low zone, were more abundant than at Cape Liakik. The upper end of the transect graded into shale bedrock heavily covered with the barnacles Balanus glandula and Chthamalus dalli as well as littorine snails. Mytilus edulis were abundant in this high zone and also on the tops of bedrock hummocks in the low zone. The branched red algae Odonthalia floccosa and Rhodomela larix, uncommon at Cape Liakik, were abundant at the second site.

Lagoon Point (Sitkalidak Island)

Three transect lines were laid in the vicinity of Lagoon Point on Sitkalidak Island, Sitkalidak Straits, in May 1976 (Figures 59-62). Transect 1 was laid near Lagoon Point on a shore of moderate slope covered with large boulders. Transects 2 and 3 were approximately 100 and 200 m west of transect 1, in areas of progressively smaller boulders.

Algal cover was heaviest in the lowest zone of transect 1 (Figures 63 and 64). Alaria were most abundant in estimations of percent cover and also in terms of wet weight in quadrat collections. Laminaria were abundant in the lowest zone and continued seaward subtidally. Coralline algae, encrusting and articulated, were also abundant in the low zone. Encrusting corallines are not shown in the density figures because we did not collect them. Rhodymenia, Fucus, and Odonthalia were spatially dominant higher along the transect, although not as abundant as species of the low tide zone. Balanus cariosus, Mytilus edulis, and numerous gastropods are included among the dominant (ranked by wet weight) organisms in the samples. Populations of invertebrates seemed especially rich in this area but the data do not always

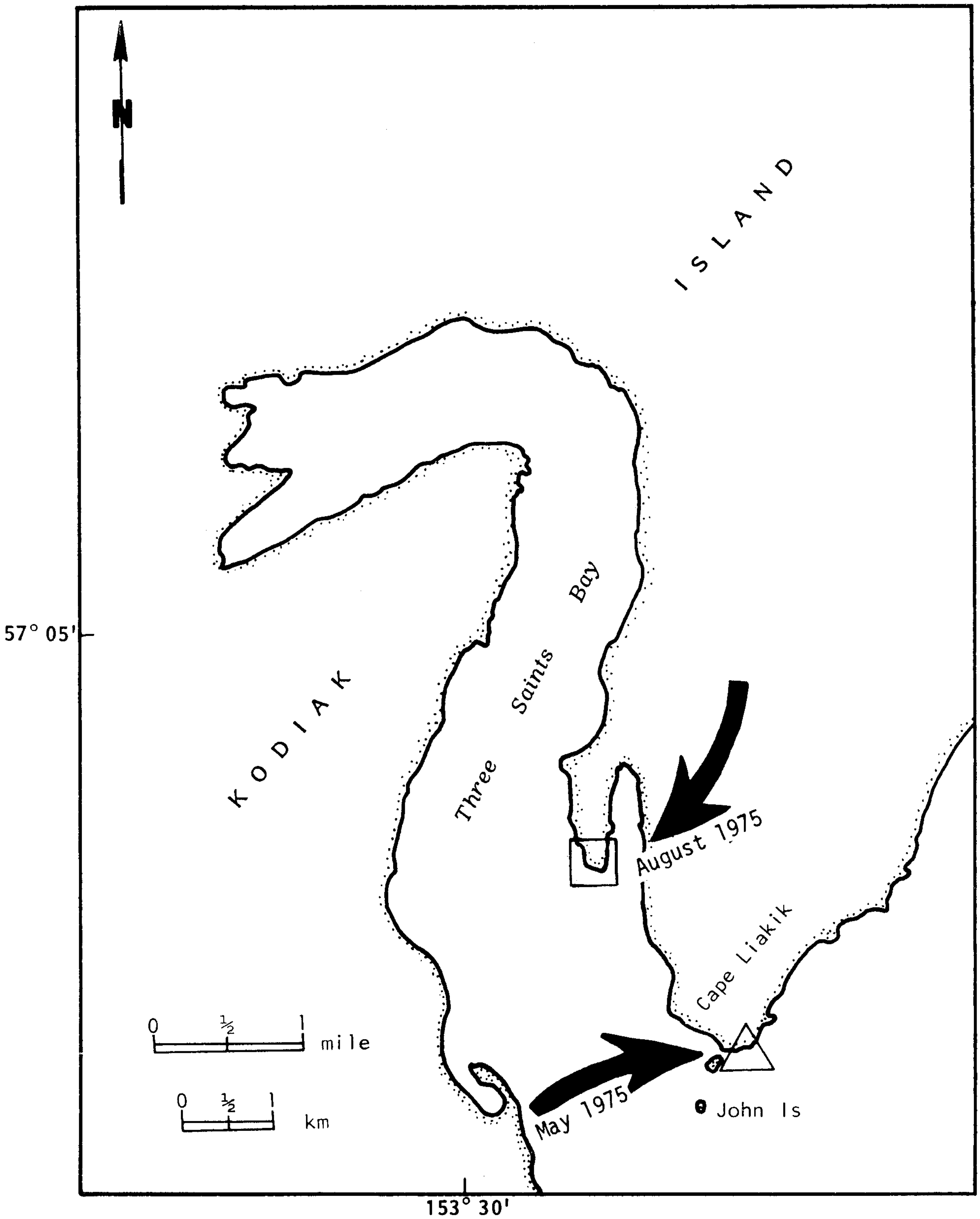


Figure 52. Three Saints Bay sites.

Figure 53. Three Saints Bay, May 1975. Upper end of transect line showing *Mytilus*, barnacle and *Fucus* cover.

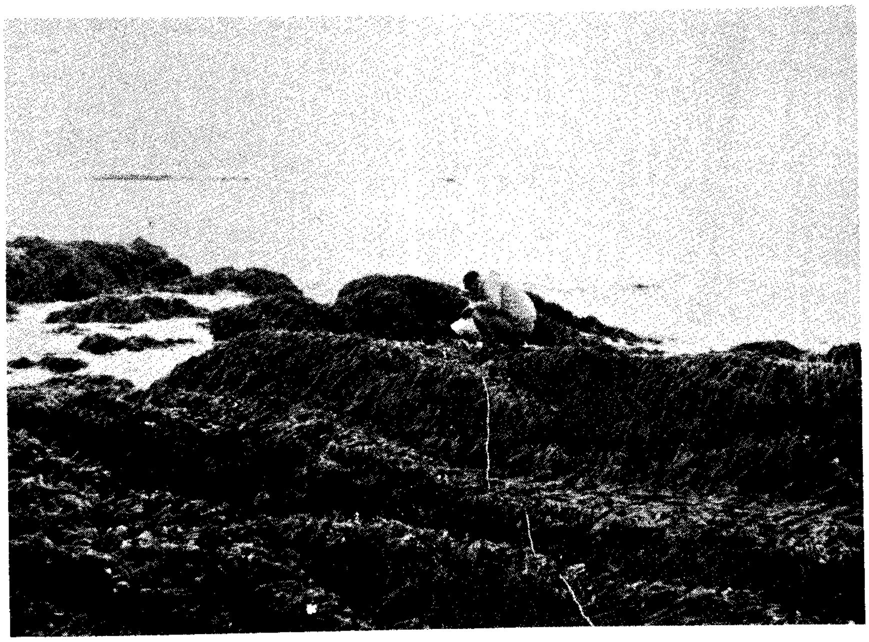
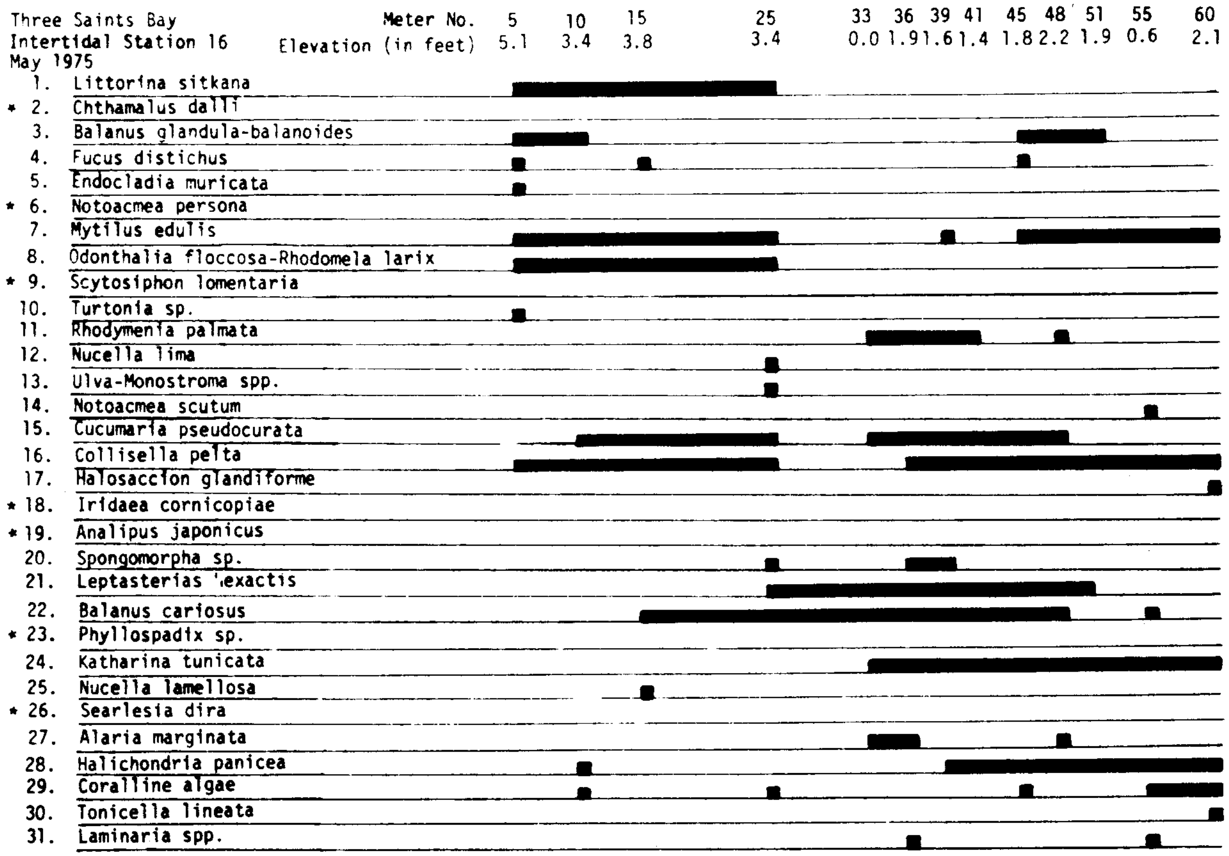


Figure 54. Three Saints Bay, May 1975. Lower end of transect line showing heavy *Alaria* cover.



* Species not present in quadrat collections on this transect line.

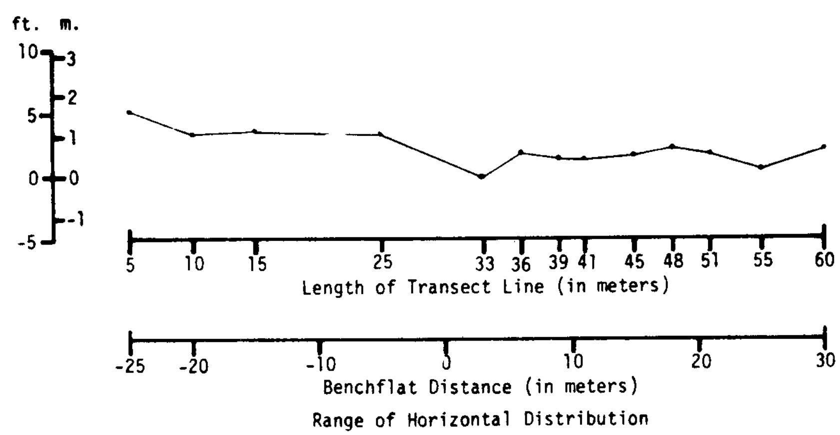
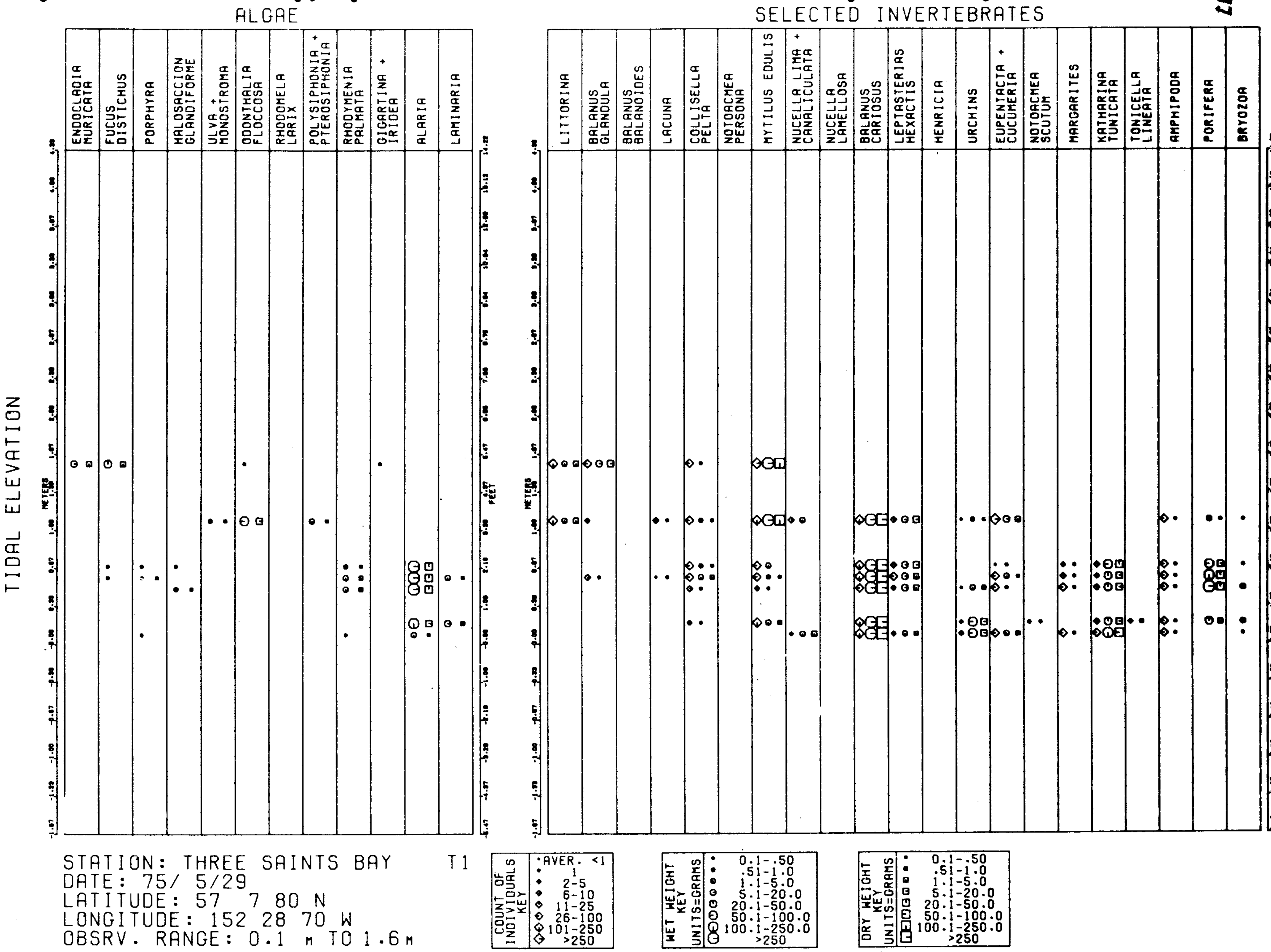
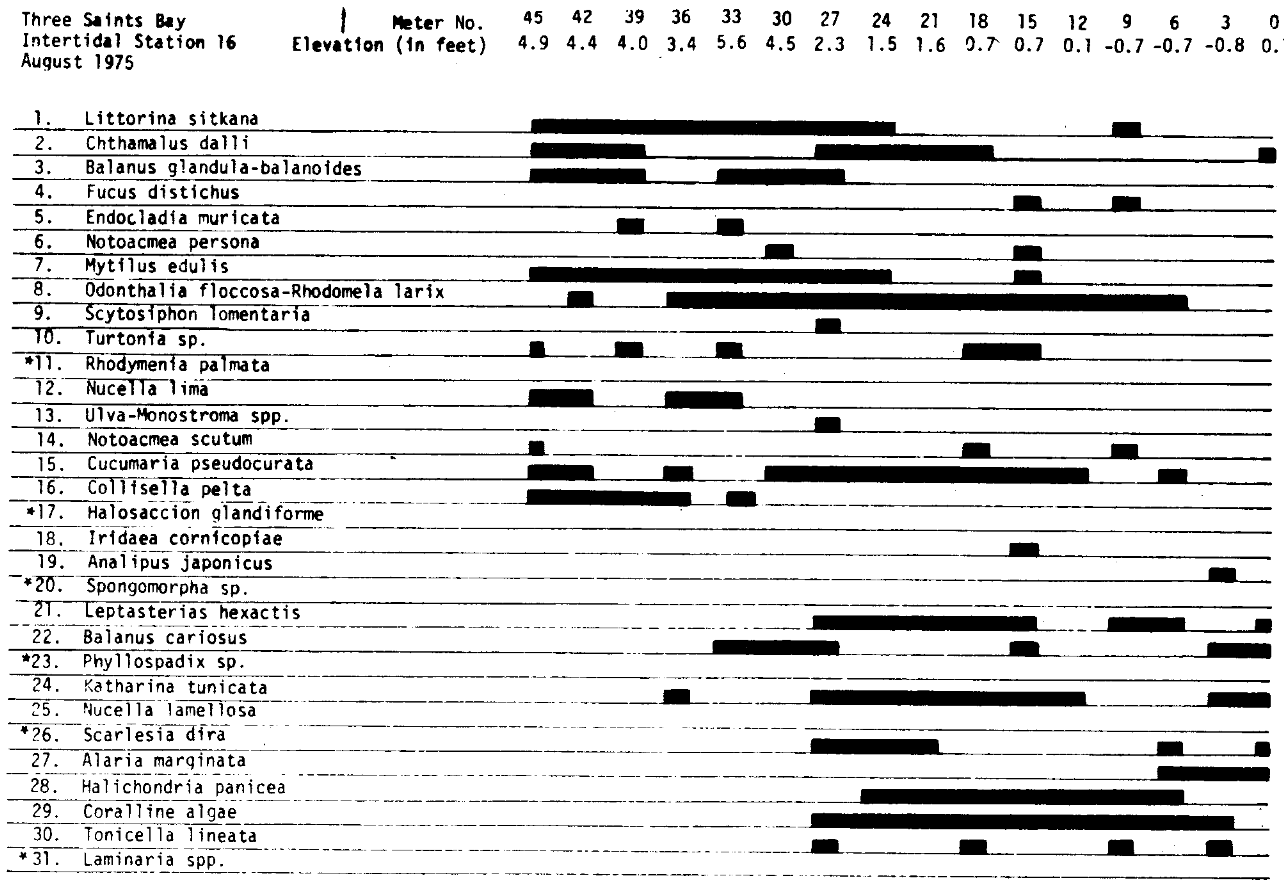


Fig. 55. Horizontal and vertical distribution of selected algae and invertebrates from 1/16 m^2 quadrats along transect line 1.

Fig. 56. Three Saints Bay, May 1975. Densities of selected intertidal organisms along transect line 1.





* Species not present in quadrat collections on this transect line.

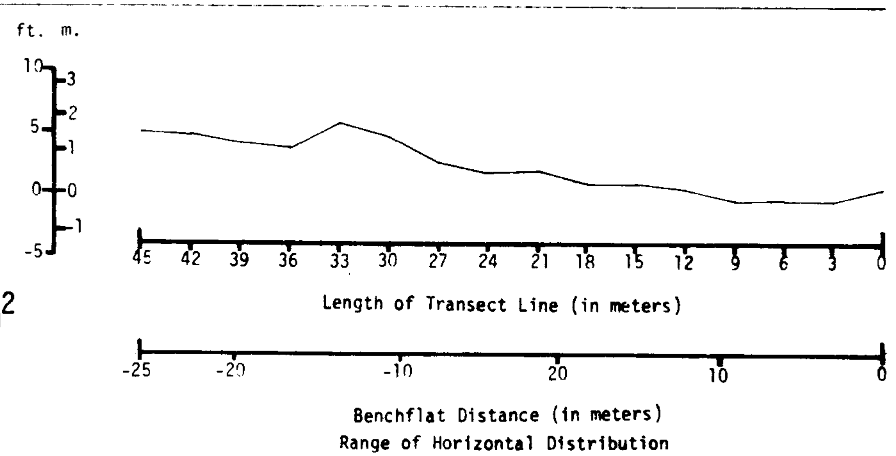
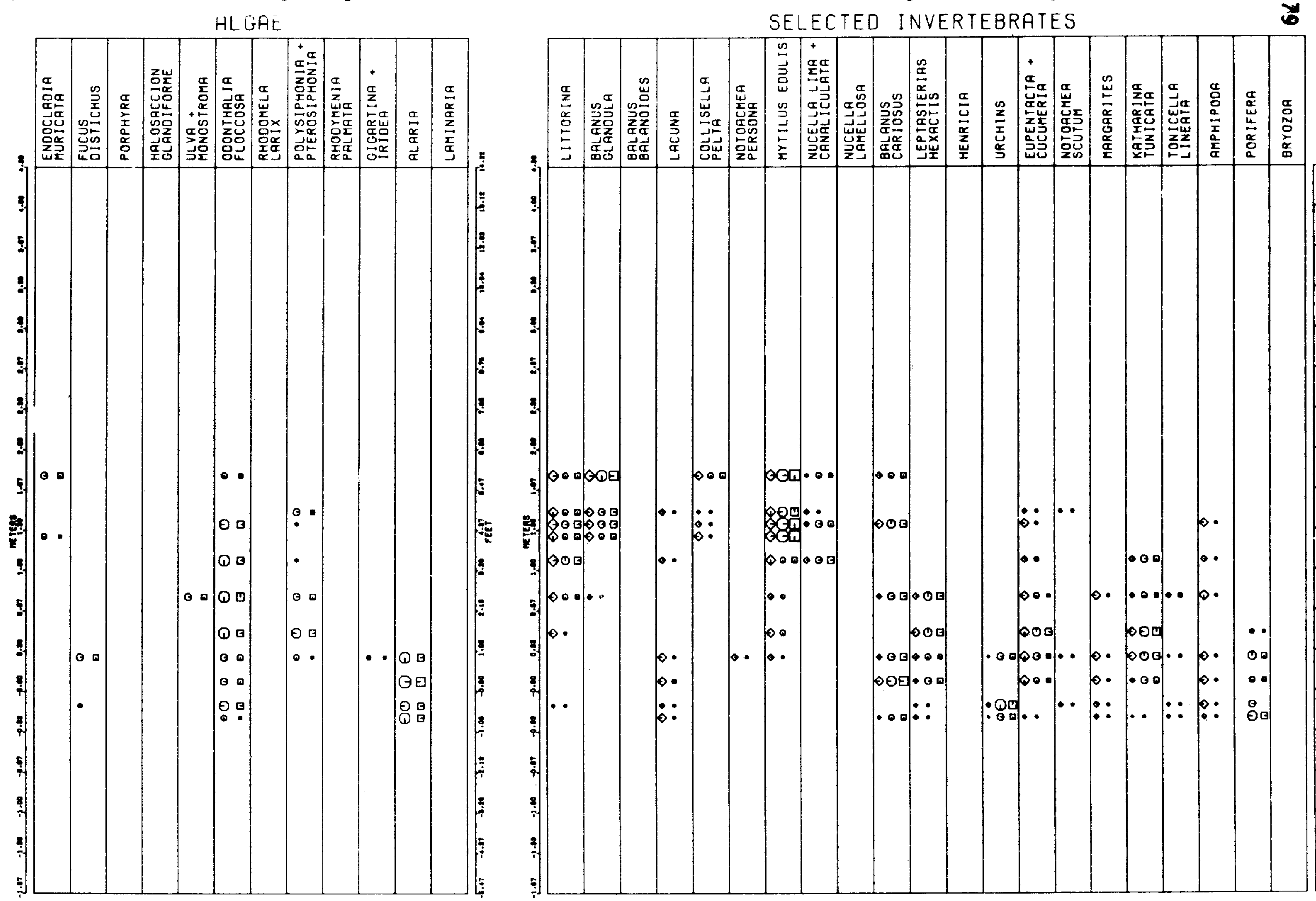


Fig. 57. Horizontal and vertical distribution of selected algae and invertebrates from 1/16 m^2 quadrats along transect line 1.

Fig. 58. Three Saints Bay. August 1975. Densities of selected intertidal organisms along transect line 1.



STATION: THREE SAINTS BAY T1
DATE: 75/ 8/ 7
LATITUDE: 57 7 80 N
LONGITUDE: 152 28 70 W
OBSRV. RANGE: -0.2M TO 1.8M

COUNT OF INDIVIDUALS KEY
AVER. <1
1
2-5
6-10
11-25
26-100
101-250
>250

WET WEIGHT KEY UNITS=GRAMS
0.1-.50
.51-1.0
1.1-5.0
5.1-20.0
20.1-50.0
50.1-100.0
100.1-250.0
>250

DRY WEIGHT KEY UNITS=GRAMS
0.1-.50
.51-1.0
1.1-5.0
5.1-20.0
20.1-50.0
50.1-100.0
100.1-250.0
>250

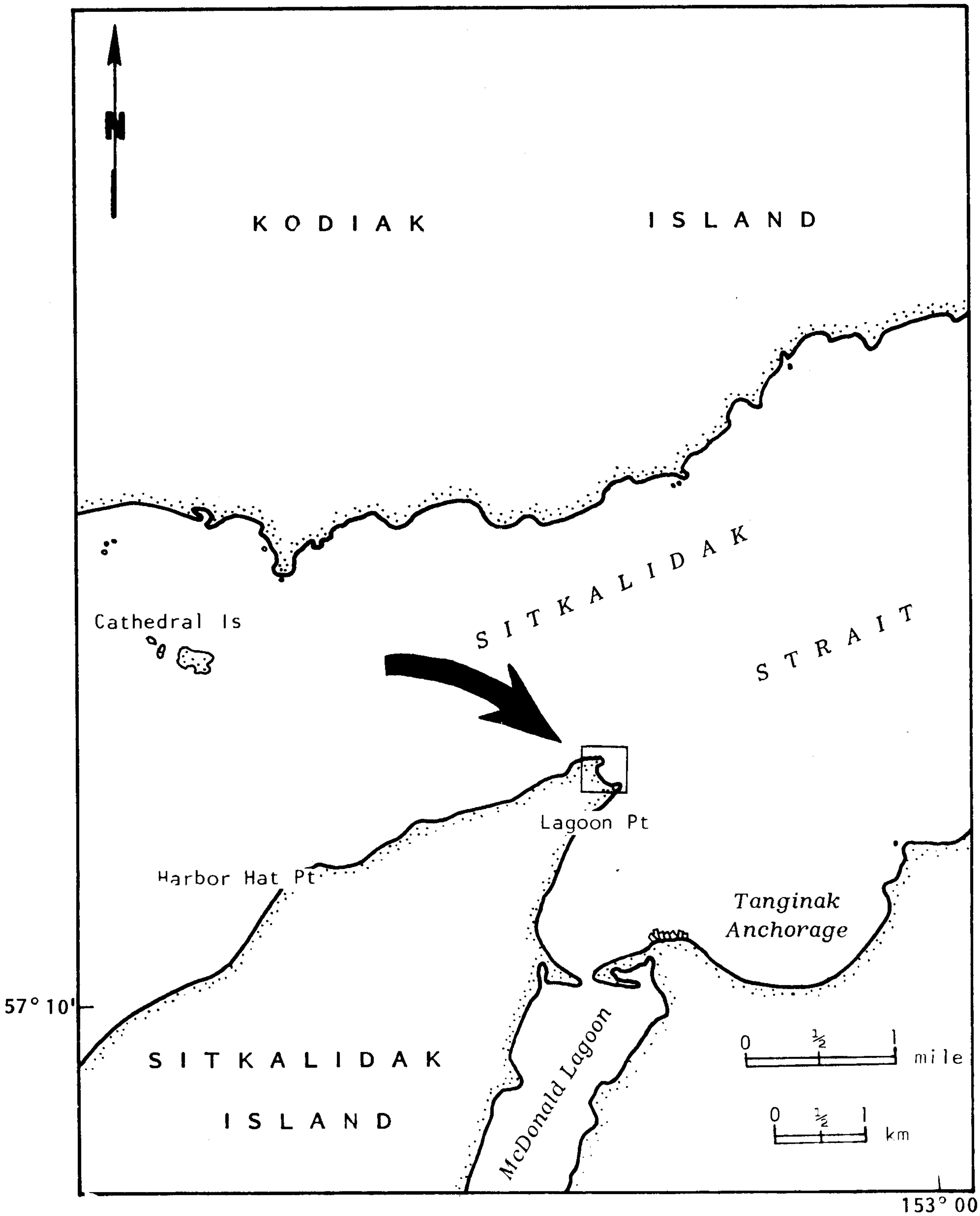
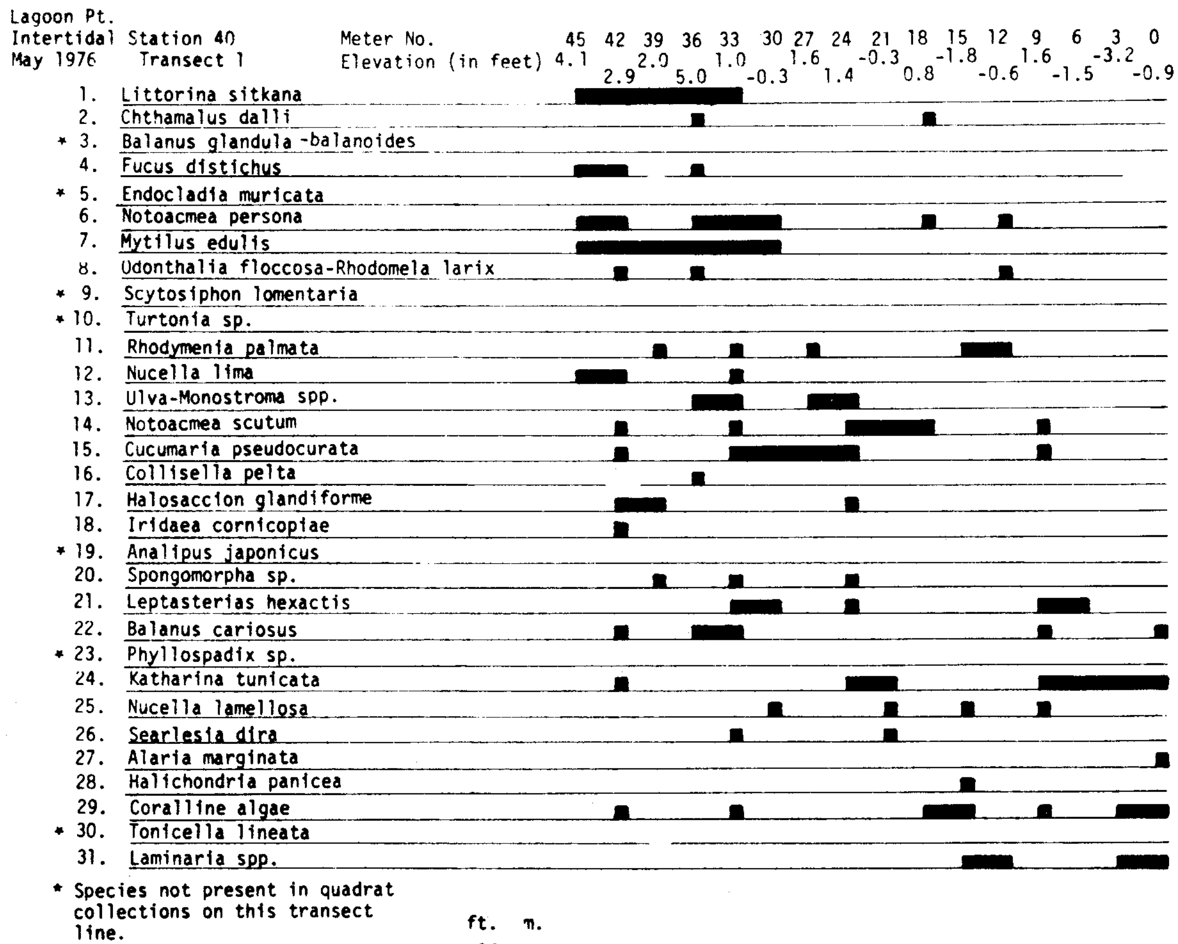


Figure 59. Lagoon Point site.

Figure 60. Lagoon Point, Sitkalidak Island. Mussel zone along transect line 1 in area of large boulders.

Figure 61. Lagoon Point, Sitkalidak Island. Transect line 2. Boulders are considerably smaller than in transect line 1 area.

Figure 62. Lagoon Point, Sitkalidak Island. Area southeast of transect lines. Size of boulders and width of beach are less than in sampling area.



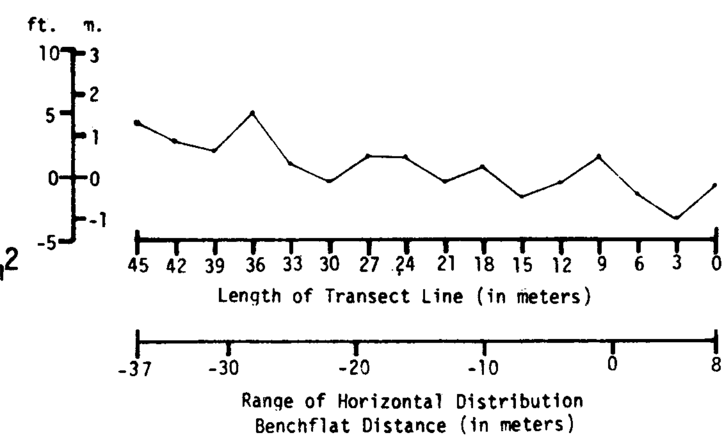
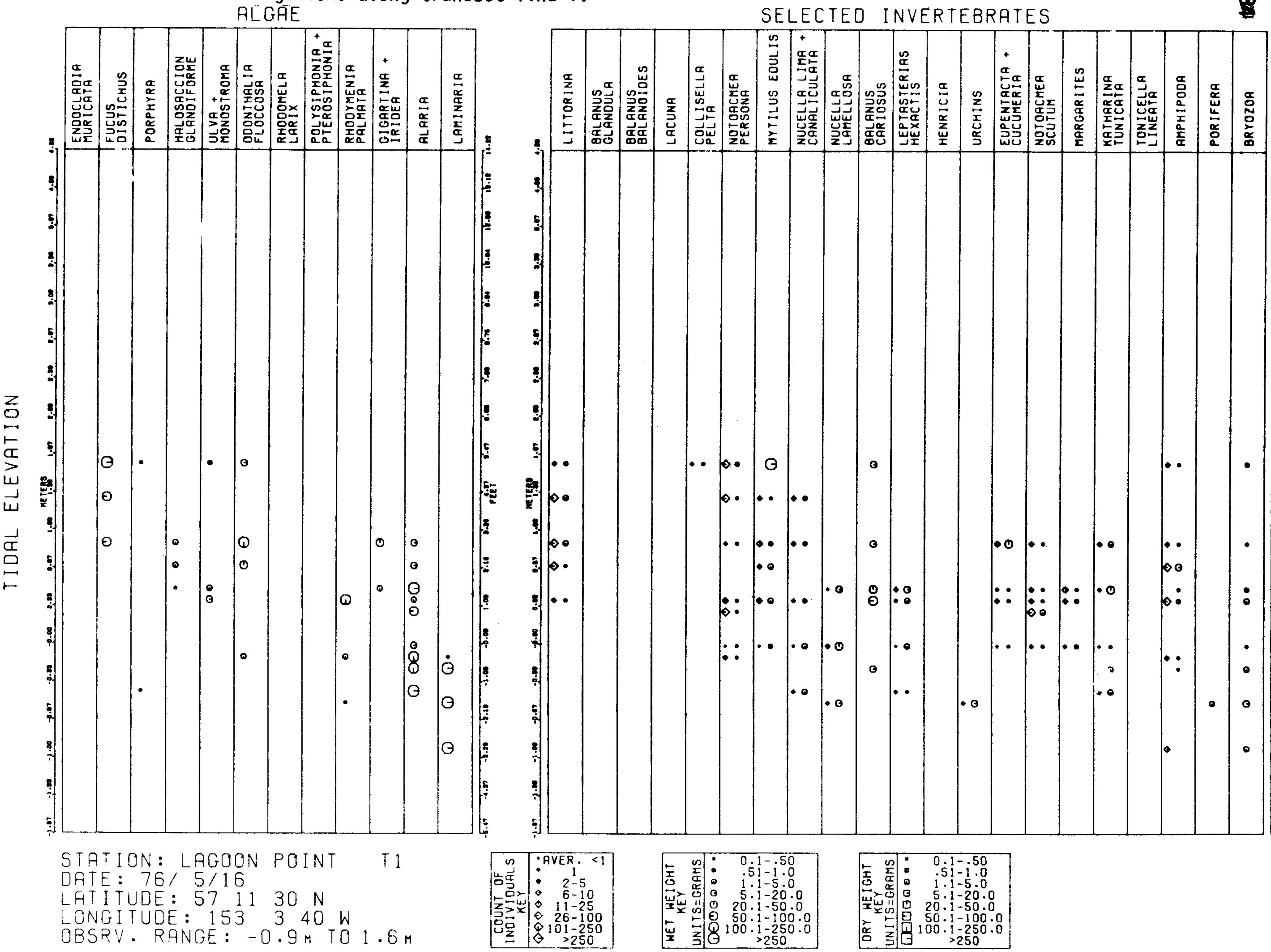
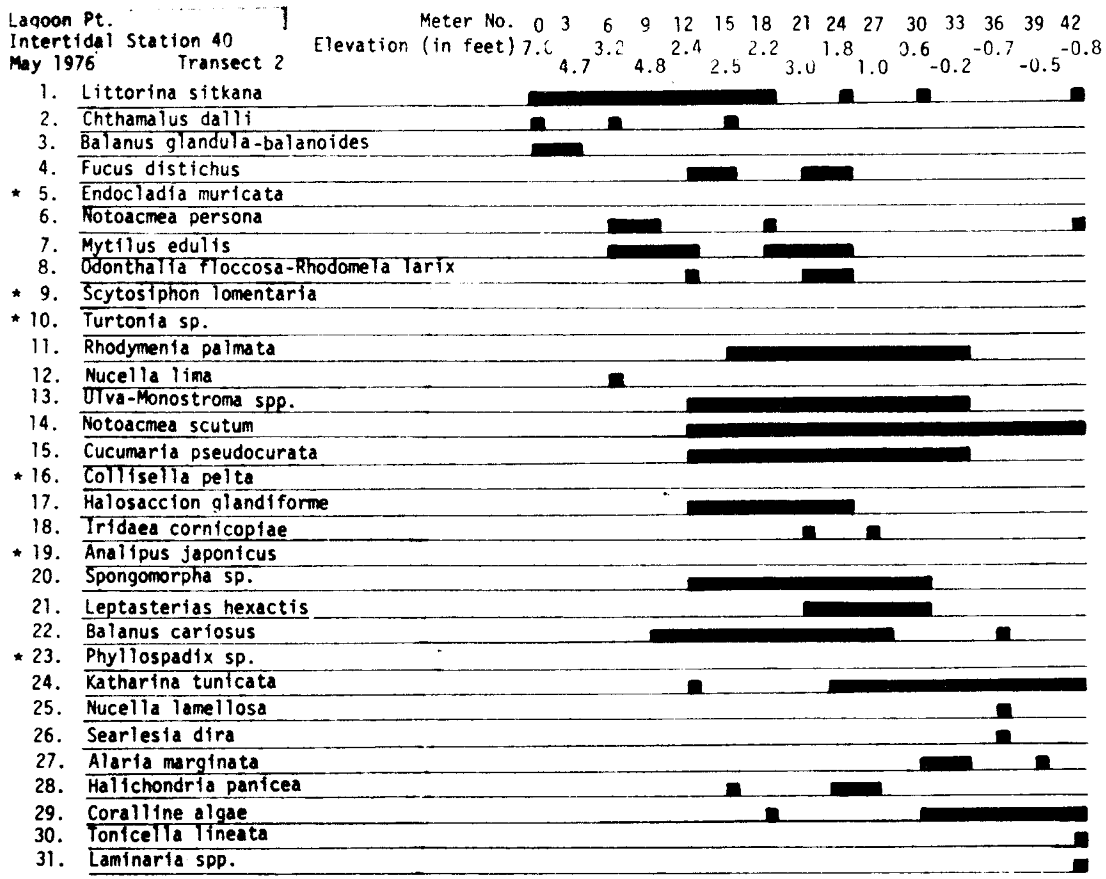


Fig. 63. Horizontal and vertical distribution of selected algae and invertebrates from 1/16 m^2 quadrats along transect line 1.

Figure 64. Lagoon Point, May 1976. Densities of selected intertidal organisms along transect line 1.





* Species not present in quadrat collections on this transect line.

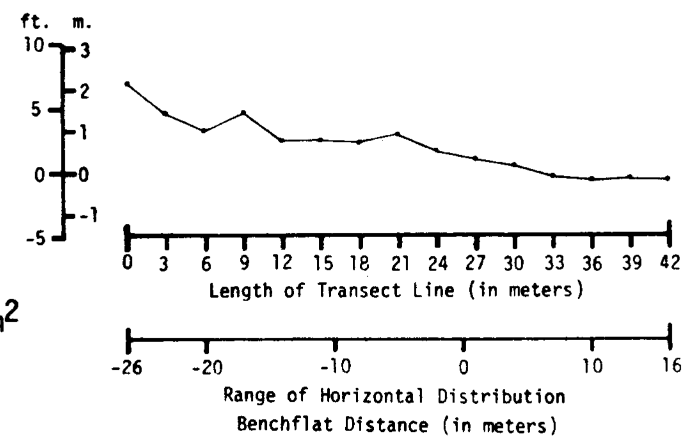
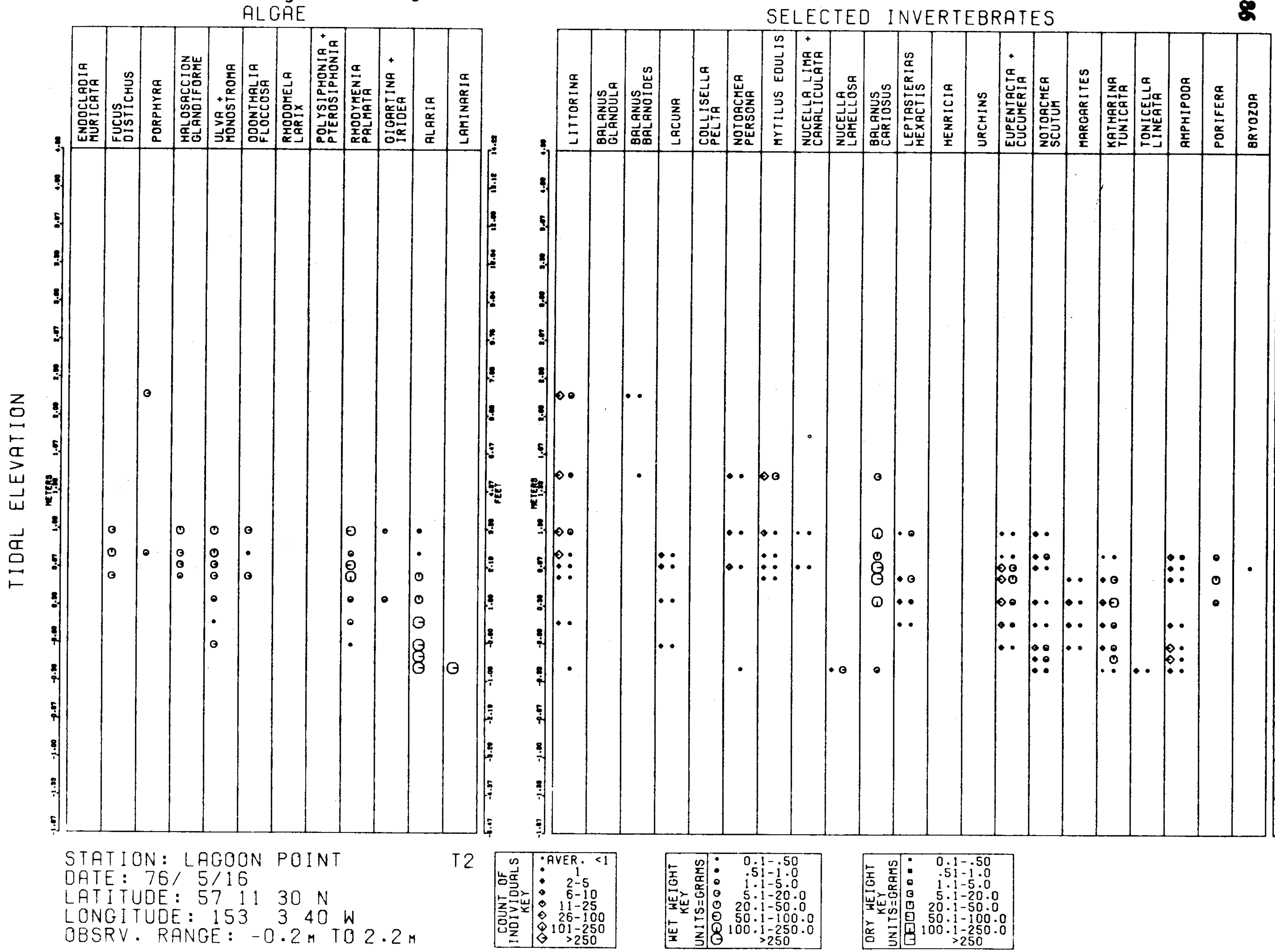
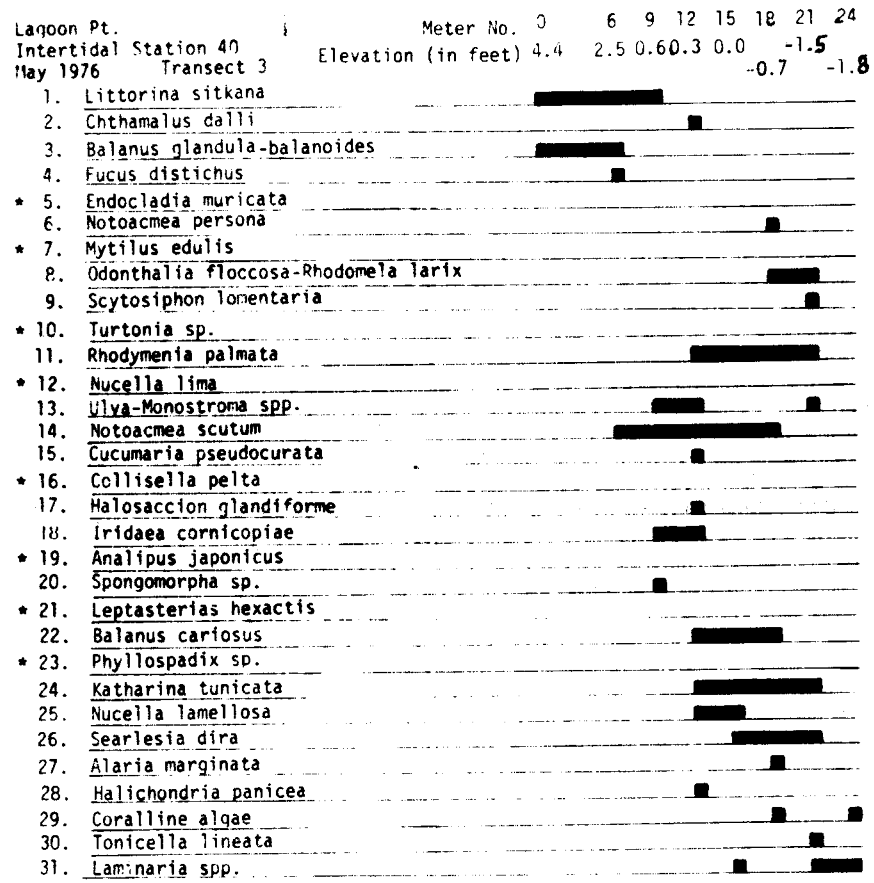


Fig. 65. Horizontal and vertical distribution of selected algae and invertebrates from 1/16 m^2 quadrats along transect line 2.

Figure 66. Lagoon Point, May 1976. Densities of selected intertidal organisms along transect line 2.





* Species not present in quadrat collections on this transect line.

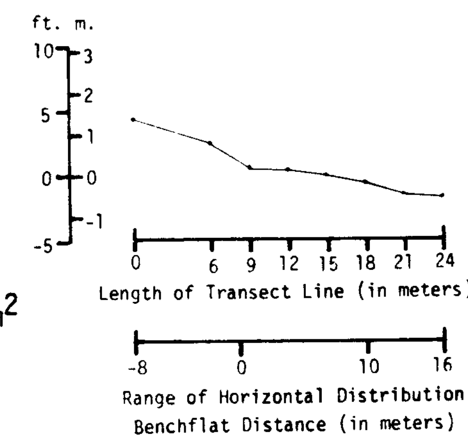
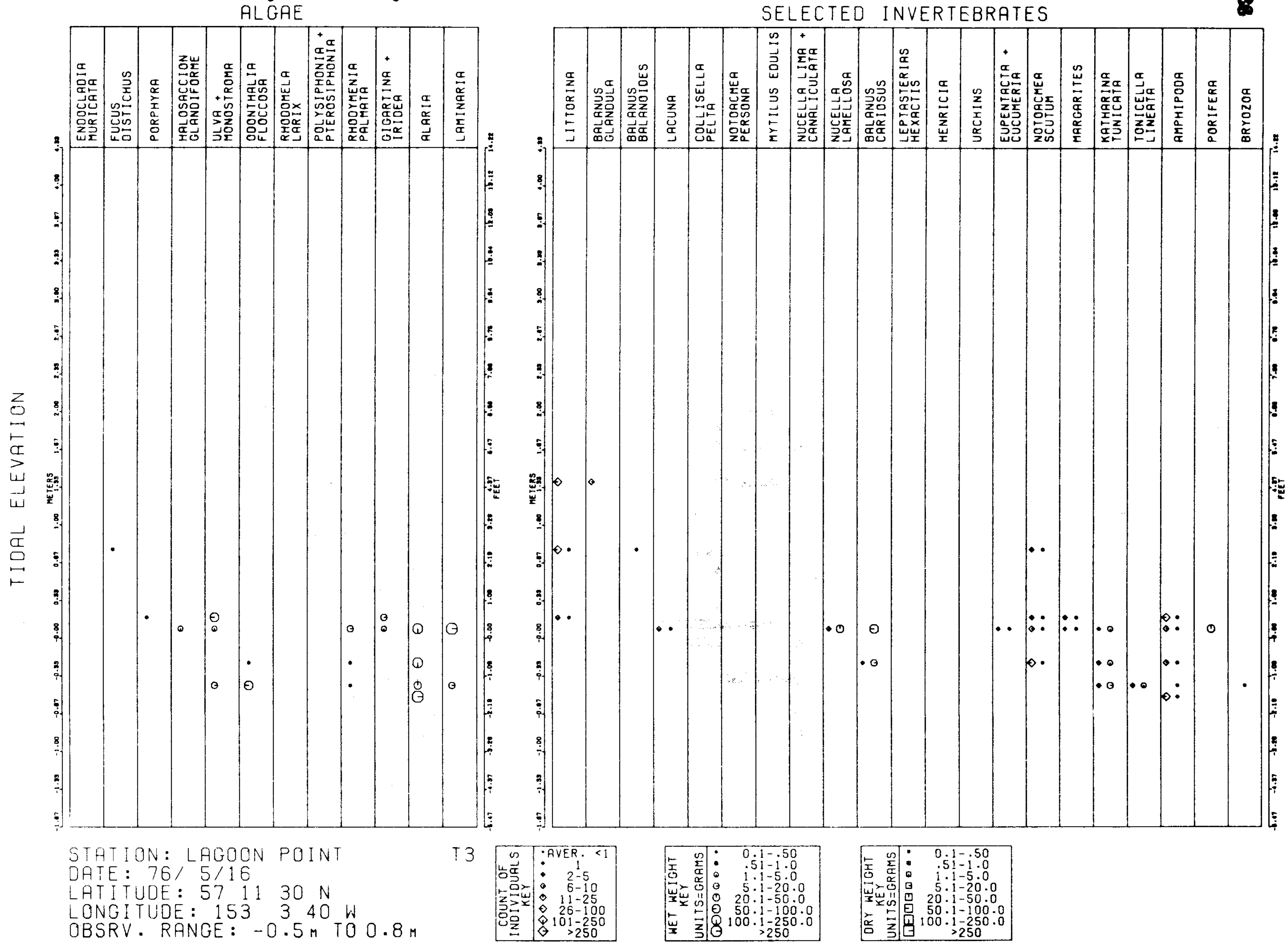


Fig. 67. Horizontal and vertical distribution of selected algae and invertebrates from 1/16 m^2 quadrats along transect line 3.

Figure 68. Lagoon Point, May 1976. Densities of selected intertidal organisms along transect line 3.



reflect this. Sea urchins (Strongylocentrotus droebachiensis) were common, and a small octopus was observed, as well as many large sea anemones. Some species of sea stars (Dermasterias, Pisaster) were not found in the samples but were observed in the immediate area.

Transect 2 (42 m long, sampled at 3-m intervals) was laid in an area with a few large boulders and many small boulders and lacked the varied habitat and invertebrate populations characterizing transect 1 (Figures 65 and 66). Approximately the upper third of the transect lacked algal cover except for a few sprigs of Porphyra. In terms of percent cover, Alaria and the coralline algae were most abundant. Laminaria were abundant in the lowest quadrat and continued into the subtidal range. Rhodymenia were more abundant than in transect 1; often they were found covering boulder tops in an assemblage with bladed green algae and several red algae. Invertebrates were less varied and abundant than in transect 1. In the low zone Balanus cariosus were spatially dominant, chitons and limpets were common, and predatory snails were present. We found littorine snails, limpets, and Balanus balanoides to be spatially dominant along the upper third of the transect.

Transect 3 (24 m long, sampled at 3-m intervals) was approximately 100 m west of transect 2 in an area of even smaller rocks and no large boulders. The distribution of plants and animals in transect 3 (Figures 67 and 68) was similar to transect 2. There were fewer invertebrate species, and density of all species decreased. The sample quadrats missed the Fucus patches in the Fucus zone, so quadrat collection data do not indicate the presence of this zone.

Low Cape (Kodiak Islands)

Low Cape is a flat, small boulder and cobble beach lying on the west shore of Kodiak Island and is exposed from the south and west (Figures 69 and 70). Surf action probably moves the boulders, and vegetation was sparse along the transect (Figures 71 and 72). Rhodomela larix and Odonthalia floccosa, lying in small discrete clumps, were the most visible algae (Figures 73 and 74). Fucus distichus were sparse and Rhodymenia palmata and Alaria sp. were absent in quadrat collections, although small amounts of bleached Rhodymenia were noted in the vicinity of the transect line. Littorina sitkana and polychaete worms were the only organisms which were found in all 11 samples, while very small Mytilus edulis were found in 10 of 11 samples. The seaward samples had more unique species (occurring in only one sample) and also contained more species.

We also made qualitative observations in an area lying beyond the transect line. Aerial reconnaissance showed that the flat slope of the beach continued for some distance into the subtidal zone, and much of the area we looked at was covered with very large, shallow tide pools. Throughout the area there were a few large and apparently immovable boulders which had different assemblages of organisms than those seen on the transect line. For instance, we saw small- to medium-sized Balanus cariosus on the boulders, often covered with aggregations of the predatory snail Nucella lamellosa. The chiton Katharina tunicata was also observed in this area. Neither Nucella nor Katharina were found in the transect line collections. Many species of red algae were found in the tide pools; these algae were often bleached. Most of the tide pool bottom was covered with coralline algae species, and

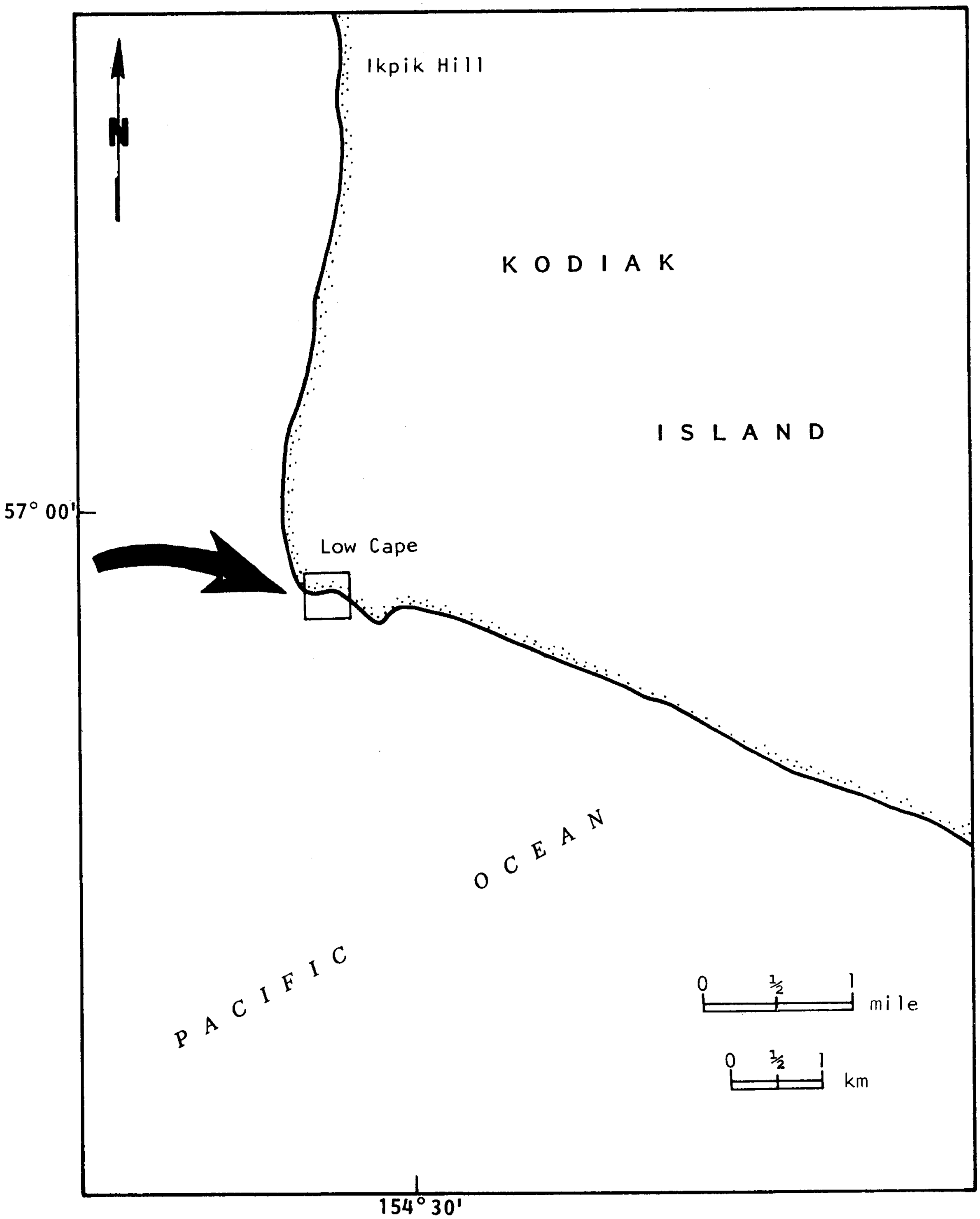


Figure 69. Low Cape site.

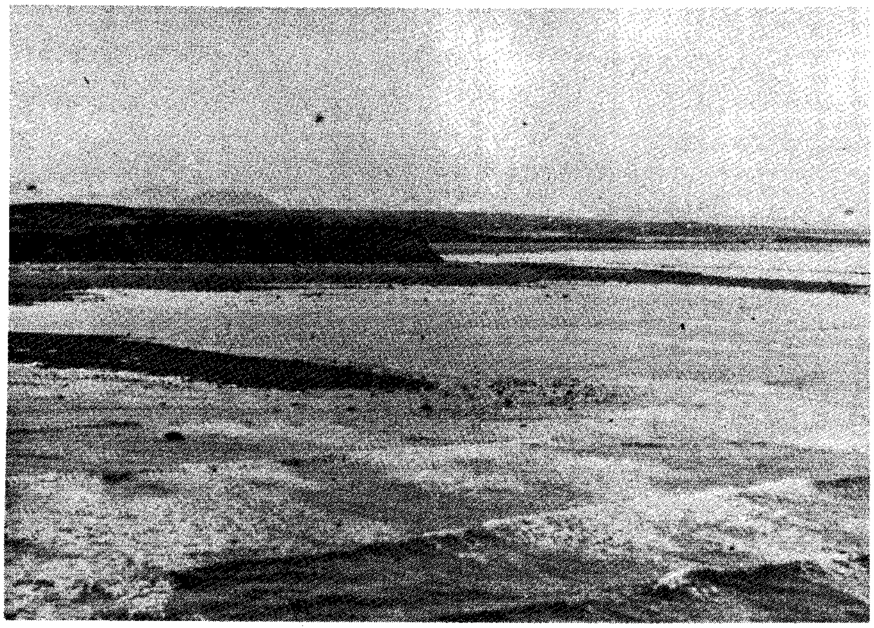


Figure 70. Low Cape, Kodiak Island. General view of sampling area looking north.

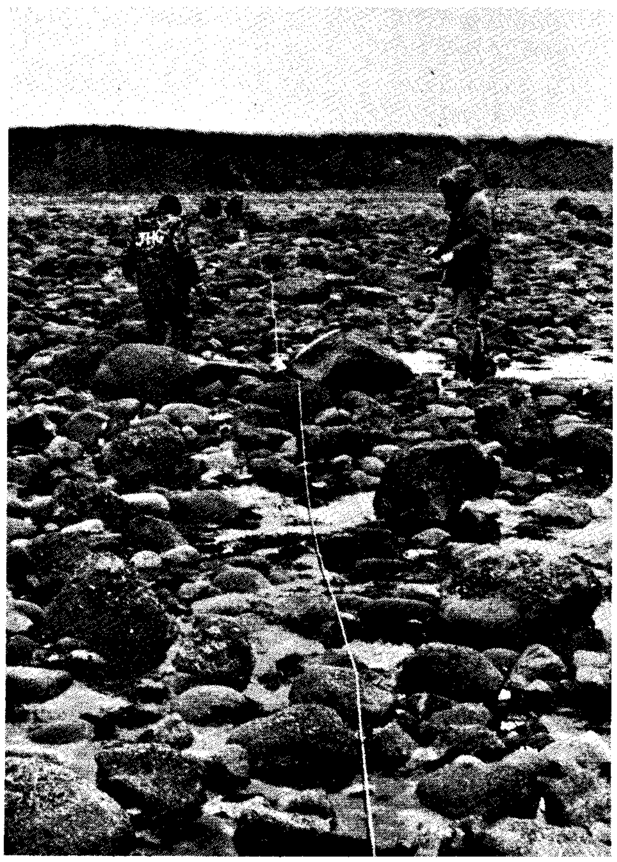


Figure 71. Low Cape.
Upper end of transect line.

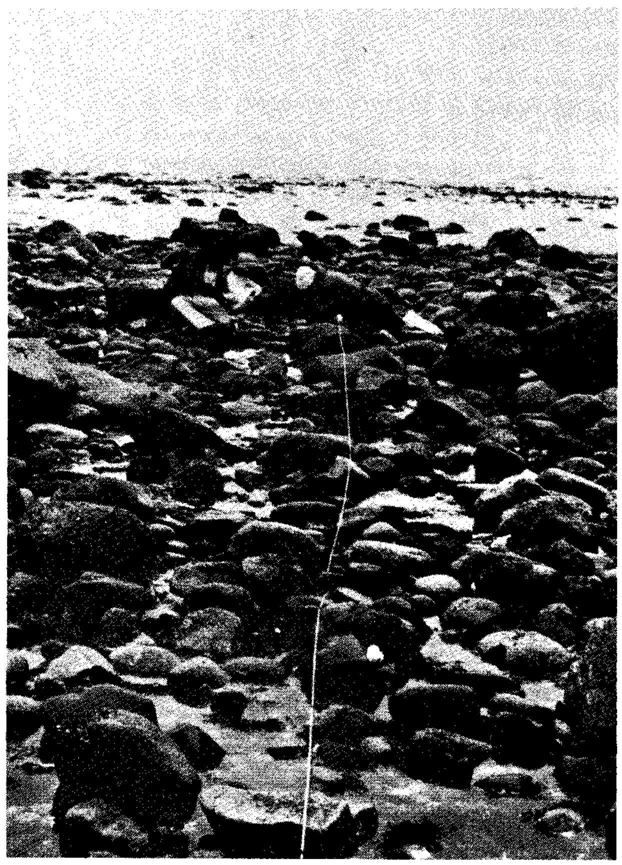


Figure 72. Low Cape.
Lower end of transect line.

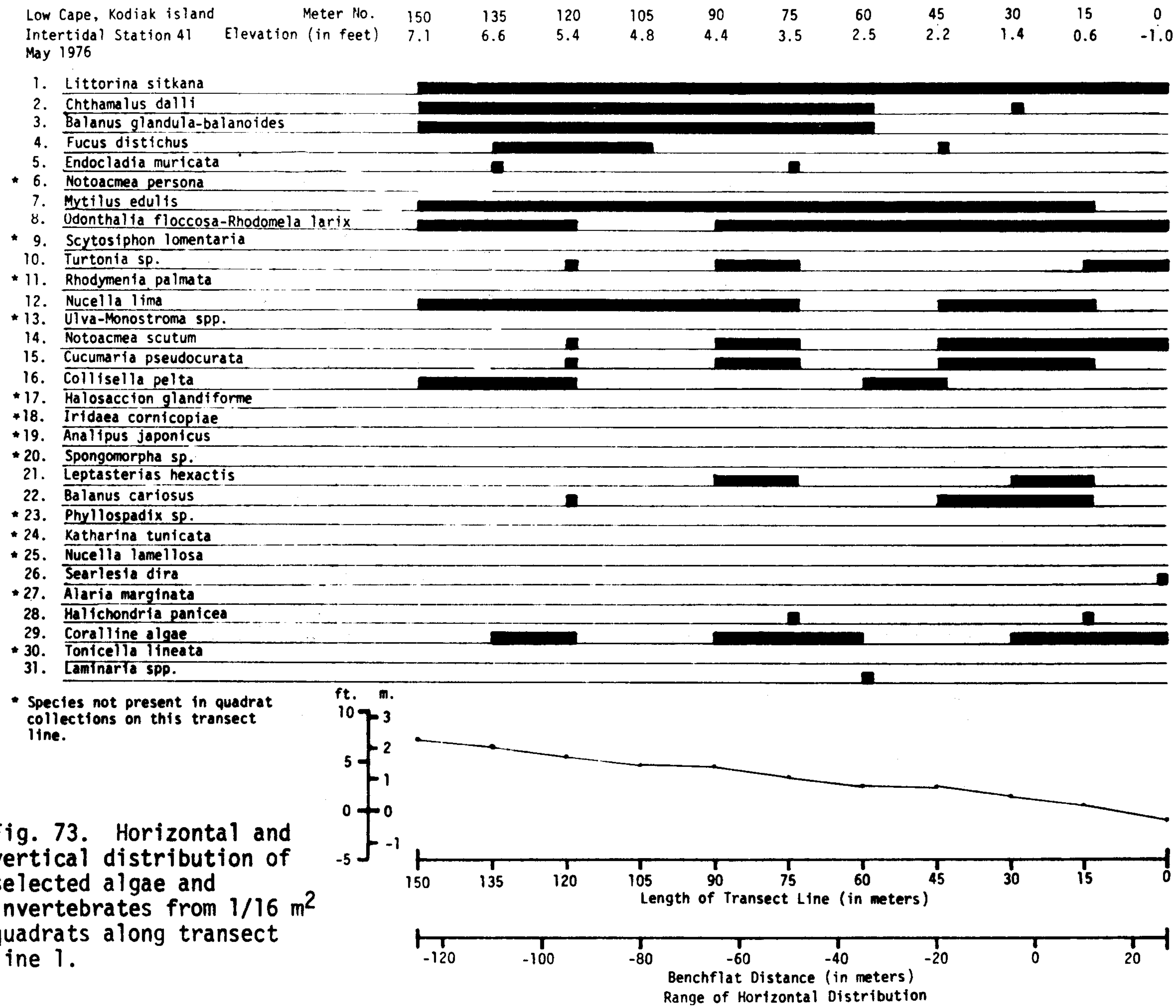
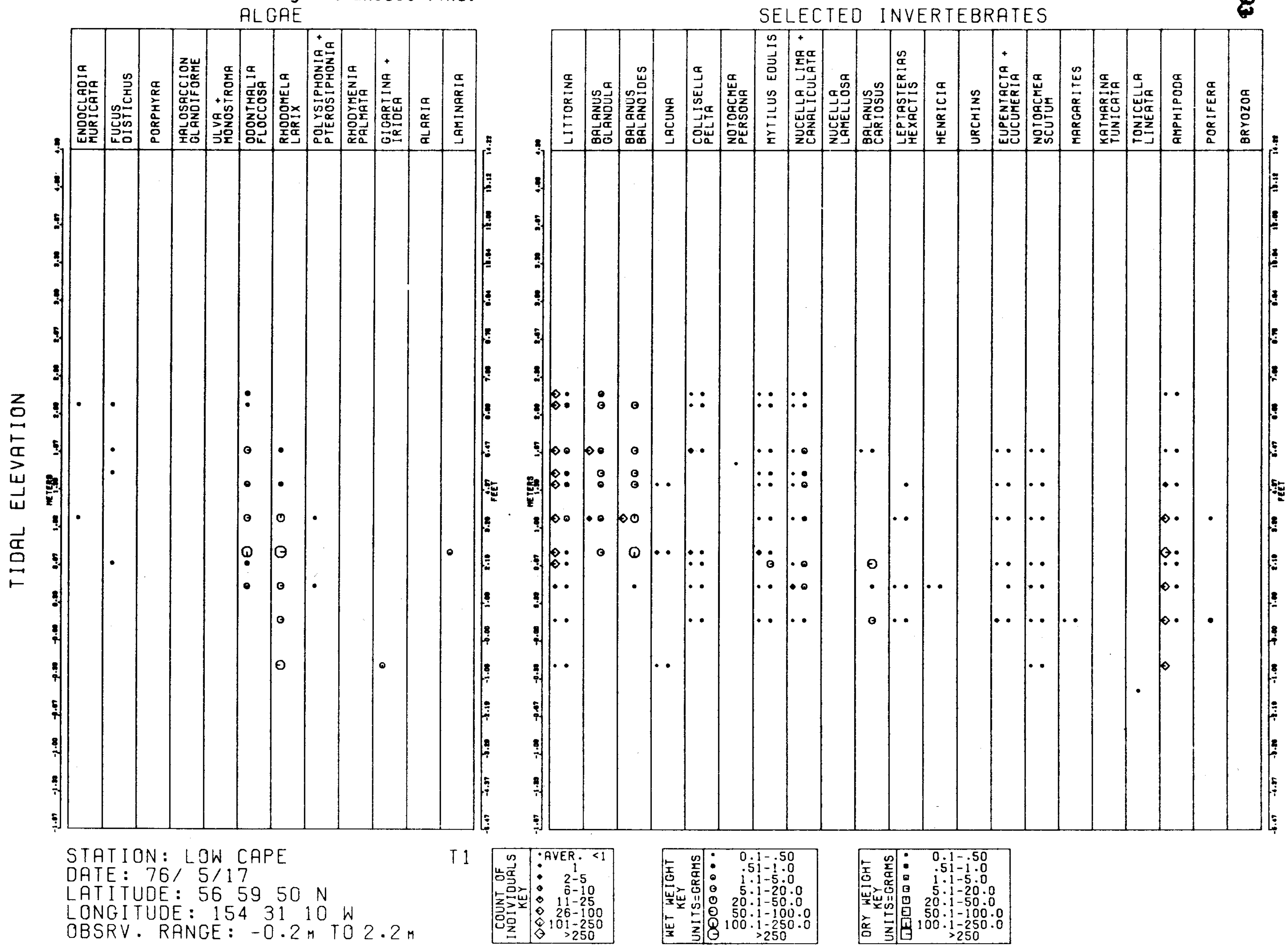


Fig. 73. Horizontal and vertical distribution of selected algae and invertebrates from 1/16 m^2 quadrats along transect line 1.

Fig. 74. Low Cape, May 1976. Densities of selected intertidal organisms along transect line 1. along a transect line.



Constantinea rosa-marina, which generally occur subtidally, were abundant in tide pools. Clumps of Ptilota sp. were also common. Other species included Desmarestia sp., Laminaria yezoensis, and Alaria sp.

The low beach between the tide pools and the end of the transect line was similar to the terrain along the transect line. Sponges and bleached Lithothamnion covered much of the rock surfaces. Other algae in the area were Laminaria sp., Halosaccion glandiforme, Bangia sp., Ulva sp., and Fucus.

Dolina Point (Sitkinak Island, Trinity Islands)

Dolina Point is a flat bedrock point lying along gravelly and sandy beaches on the north coast of Sitkinak Island, Trinity Islands (Figure 75). The point is separated from the beach by a small boulder and cobble bar of lower elevation than the top of the bench. The transect line extended 190 m shoreward from the center of the bench across the bar (Figures 76 and 77).

The distribution and density of selected species are shown in Figures 78 and 79. The outer portion of the transect line crossed rough bedrock covered mainly with Balanus cariosus. Vegetation was light, most commonly Alaria and Odonthalia. The middle portion of the line ran through a mixed area of bedrock, gravel, sand, and standing water. Phyllospadix serrulatus* was growing in small patches in this area. The shoreward portion of the line was cobble beach. Vegetation was small, dense, discrete clumps of Fucus distichus, Rhodomela larix, and Odonthalia floccosa. One-meter-square sample quadrats were used for sampling algae in this section.

Both quadrat collections and visual enumerations showed the dominance of Fucus, Odonthalia, and Rhodomela, as well as the presence of Endocladia muricata, Phyllospadix, and bladed green algae. Alaria sp. were dominant in the quadrats lying in the bedrock portion of the transect line. The distribution of invertebrates was fairly homogeneous along the transect. The most common inhabitants of the cobble area in the upper intertidal zone were limpets, snails, amphipods, and the small sea cucumber Cucumaria. Species of Balanus were not found in the cobble area except for a few Balanus cariosus. The species composition of the bedrock portion of the transect was similar to the cobble portion, but B. cariosus were common in the low area, and chitons, Katharina tunicata, were found in the quadrat collection nearest the water.

Qualitative Surveys: Description of Sites and Biota

On qualitative surveys, two biologists recorded what they observed but made no collections. It is inevitable that some species, particularly motile invertebrates, may have been overlooked on these brief surveys, but the site descriptions provide a general idea of the habitat types and most conspicuous plants and animals present. A map and photographs accompany the

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* Identification by Ronald C. Phillips, Seattle Pacific University, Seattle, Wa., personal communication.

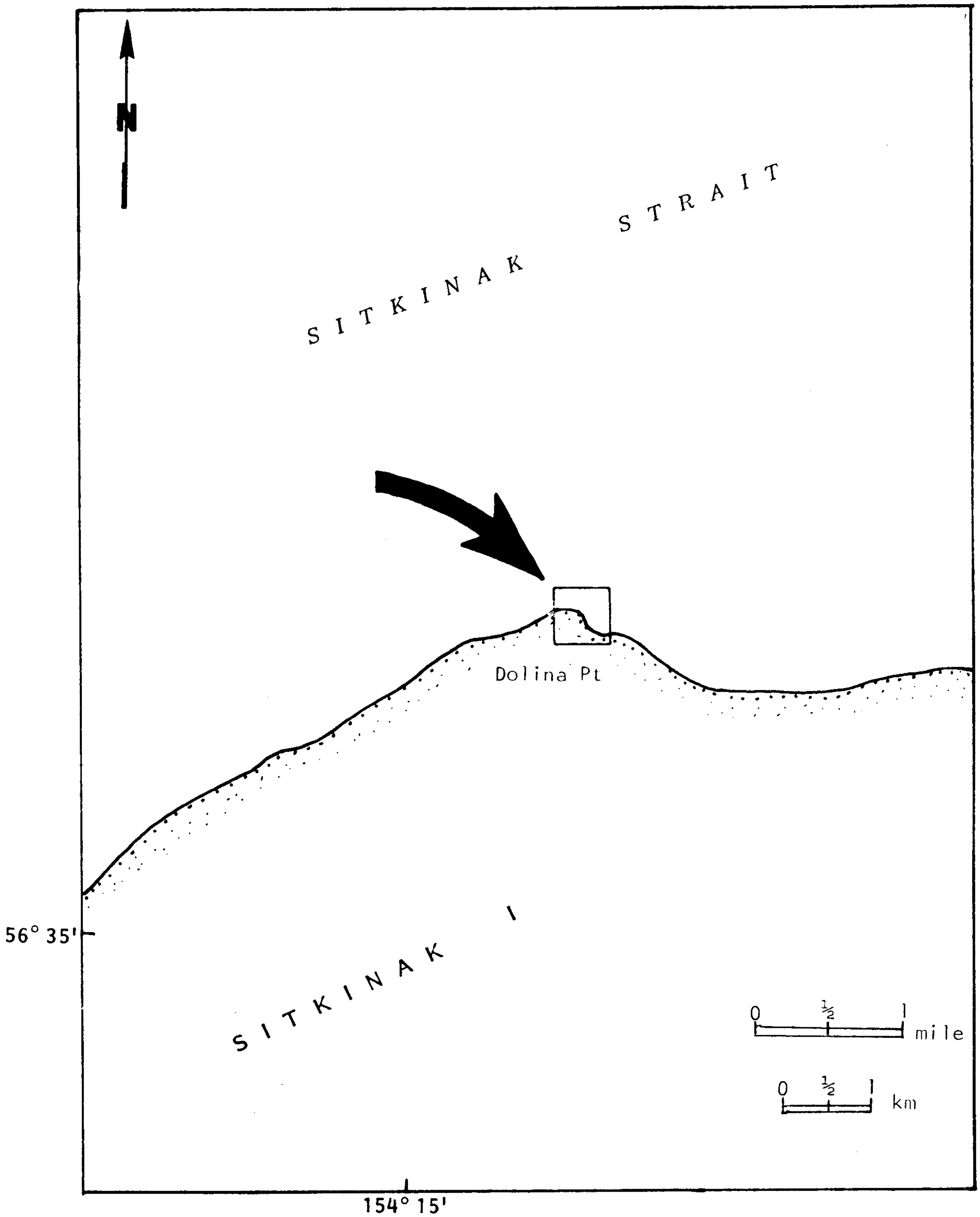


Figure 75. Dolina Point site.

Figure 76.
Dolina Point, Sitkinak Island.
Upper end of transect line.
Quadrats along this portion
of the line were 1/16 m^2.

Figure 77. Dolina Point, Sitkinak Island. Lower end of transect line.
Quadrats along this portion of the line were 1/16 m^2.

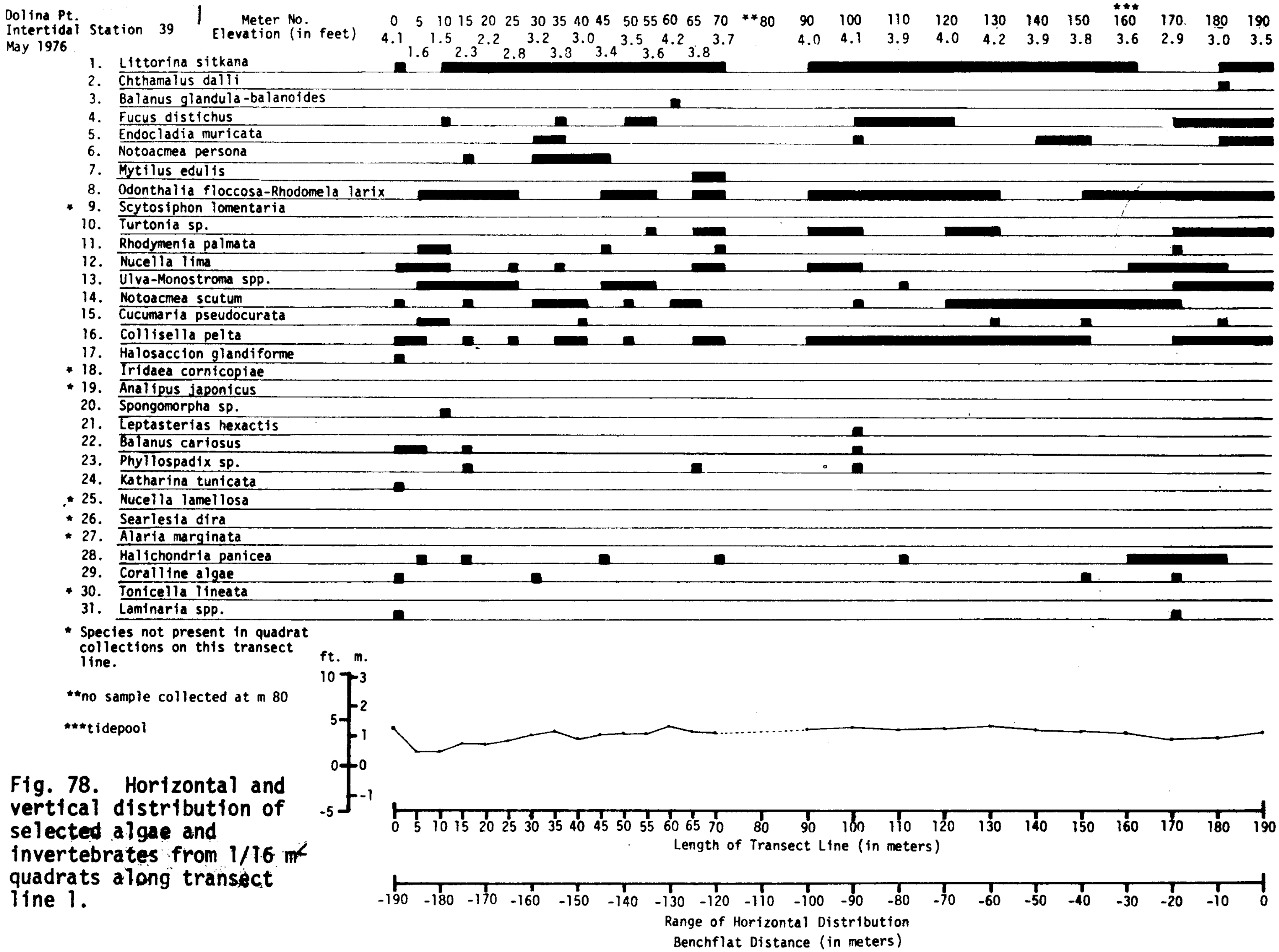
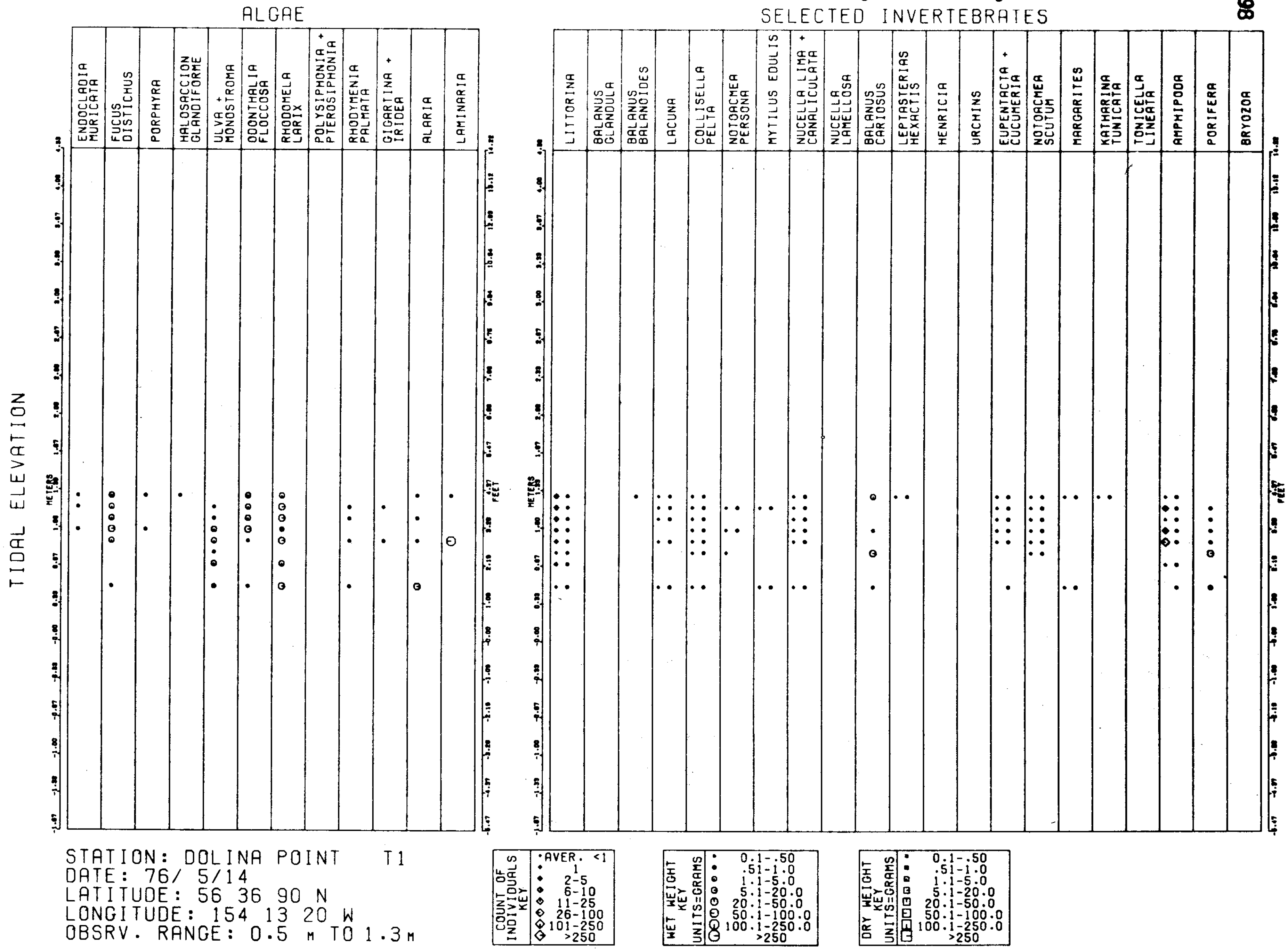


Fig. 78. Horizontal and vertical distribution of selected algae and invertebrates from 1/16 m² quadrats along transect line 1.

Fig. 79. Dolina Point, May 1976. Densities of selected intertidal organisms along transect line 1.



description of each site we surveyed qualitatively. Summary descriptions of the sites we sampled qualitatively are in Table 6.

Table 6.--Description of intertidal sites in the Kodiak Island area, 1975-76: sites sampled qualitatively.

Location	Exposure	Substrate	Date Sampled
Middle Geese Is.	Exposed	Flat bedrock	7-12-76
Narrow Cape	Exposed	Flat bedrock	7-11-76
St. Paul Harbor	Protected	Flat bedrock	7-11-76
Sea Otter Is.	Exposed	Hummocky bedrock or boulder	7-13-76
Pillar Cape	Exposed	Hummocky bedrock or boulder	7-14-76
Spruce Island	Exposed	Hummocky bedrock or boulder	7 -9-76
Tonki Bay	Protected	Hummocky bedrock or boulder	7-14-76
North Shuyak Is.	Protected	Hummocky bedrock or boulder	7-13-76
Whale Island			
Site 1	Protected	Small boulder	7-10-76
Site 2	Exposed	Small boulder	7-10-76

Middle Geese Island (Geese Islands)

The three Geese Islands lie near the southeast tip of Kodiak Island. All three islands are small, the largest approximately 2.5-km long. Between and around this island group is an area of shoal water and reefs. From the air the shoals appear to be profusely covered with kelp and surf grass. In 1913 Rigg described the area as having the second largest kelp concentration in the Kodiak Island area.

We qualitatively sampled three sites on Middle Geese Island in July 1976 (Figure 80). All were topographically similar, being long, flat bedrock areas backed by sandy or cobble beaches and high (30 m) grassy bluffs (Figure 81) above the low tide line. They differed slightly in exposure, and one site had a few vertical outcroppings approximately 3 m high.

At all three sites large tide pools were not common, but drainage across the extensive flat benches appeared to be slow and the entire area remained wet when the tide was out. Intertidal areas had a lush cover of algae and zonation was not apparent. Several large areas were completely covered with surf grass (Phyllospadix) (Figure 82)

Some parts of the uppermost intertidal area were covered with extremely high numbers of littorine snails, especially in exposed areas, but most organisms characteristic of upper intertidal zones (Fucus distichus, Porphyra, Balanus glandula, Collisella pelta) were generally limited to the few rock tops which occurred on the low-relief bench.

In the upper intertidal zone at all three sites we found assemblages consisting primarily of Gigartina sp. and Ulva sp. with localized high densities of Ptilota sp., Seytosiphon sp., Odonthalia floccosa, and Halichondria panicea. Species such as Mytilus edulis and Balanus cariosus, which are usually common at this tide level, were low in abundance. Algae in the lower intertidal zone were Alaria sp. and Hedophyllum sessile. There was an understory of coralline algae, the alga Rhodymenia palmata, and the sponge Halichondria. Large numbers of Fusitriton oregonensis were found laying or guarding eggs. A few Katharina tunicata, Tonicella lineata, Strongylocentrotus droebachiensis, Leptasterias hexactis, and Henricia leviuscula were also encountered. Large beds of Phyllospadix also occurred in the area but were most abundant in proximity to kelp (Laminaria) beds.

Within this general pattern, some differences were evident between sites. At the first site, on the exposed south side of the island, there were large drift accumulations of rotting algae which were absent at the second site on the more protected north shore, and the intertidal zone was much wider than on the more protected northern site, which had larger numbers of starfishes and Margarites, and a wider, more prominent Fucus zone that was not limited to rock tops.

At the third site, on the eastern tip of the island, the same general assemblages occurred on the flats but there were also several large (3-m high) hummocks (Figure 83). On the protected side of the hummocks we found dense bands of mussels and Balanus cariosus. These were being preyed upon by the starfish Evasterias. Other common invertebrates included Henricia, Katharina, and Notoacmea scutum. Abundant algae included Fucus, Odonthalia, Porphyra, Rhodymenia, and Endocladia muricata. On the exposed faces, Mytilus and Evasterias were uncommon.

Narrow Cape (Kodiak Island)

Narrow Cape (Figure 84) on the northeastern side of Ugak Bay, approximately 35 km southeast of the city of Kodiak, is exposed to the full force of the ocean. The sampling area was backed by high (50 m) bluffs which brake abruptly into a nearly flat beach extending several hundred feet seaward. Our sampling area was in the Twin Lake area. Two sites within walking distance of each other were qualitatively examined in July 1976.

The first site was a bedrock shelf of very low gradient and low relief (Figure 85). As on many other exposed flat bedrock beaches with standing water around Kodiak, surf grass (Phyllospadix sp.) was a prominent member of the

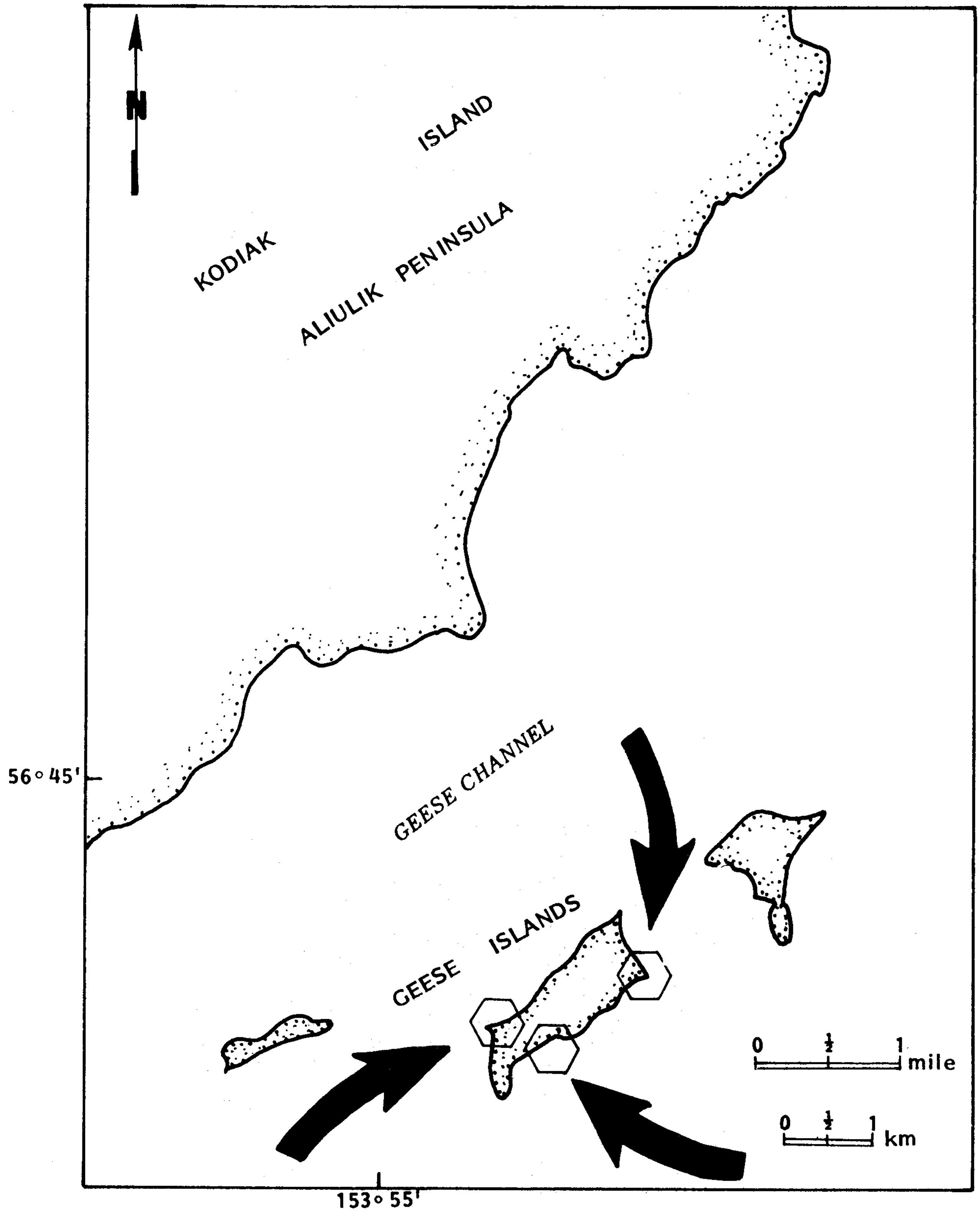


Figure 80. Middle Geese Island site.

Fig. 81. Middle Geese Island.
General view of study area.

Figure 82. Middle Geese Island. Phyllospadix sp., an abundant surf grass.

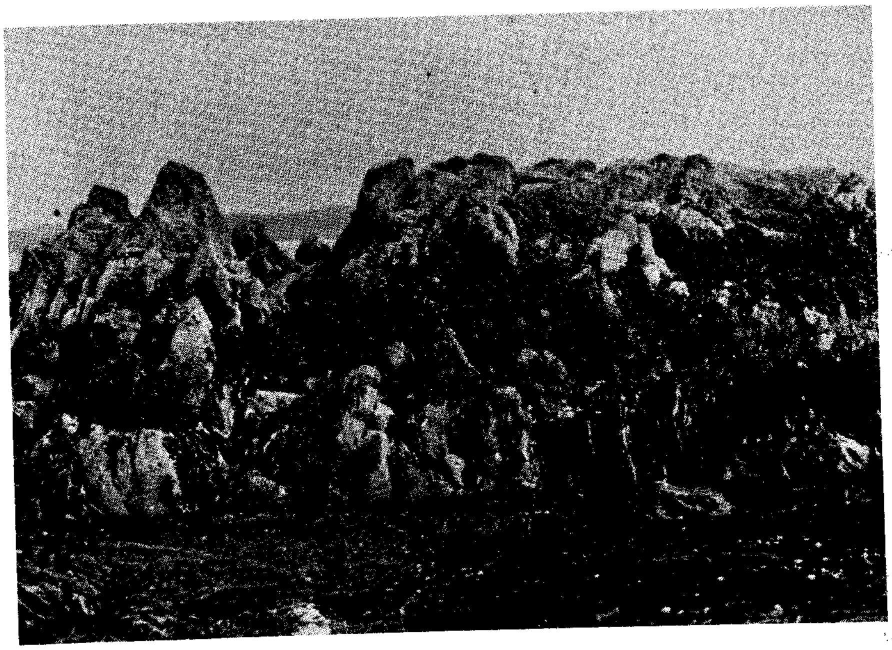


Figure 83. Middle Geese Island. General view of third study area; this area included several large hummocks.

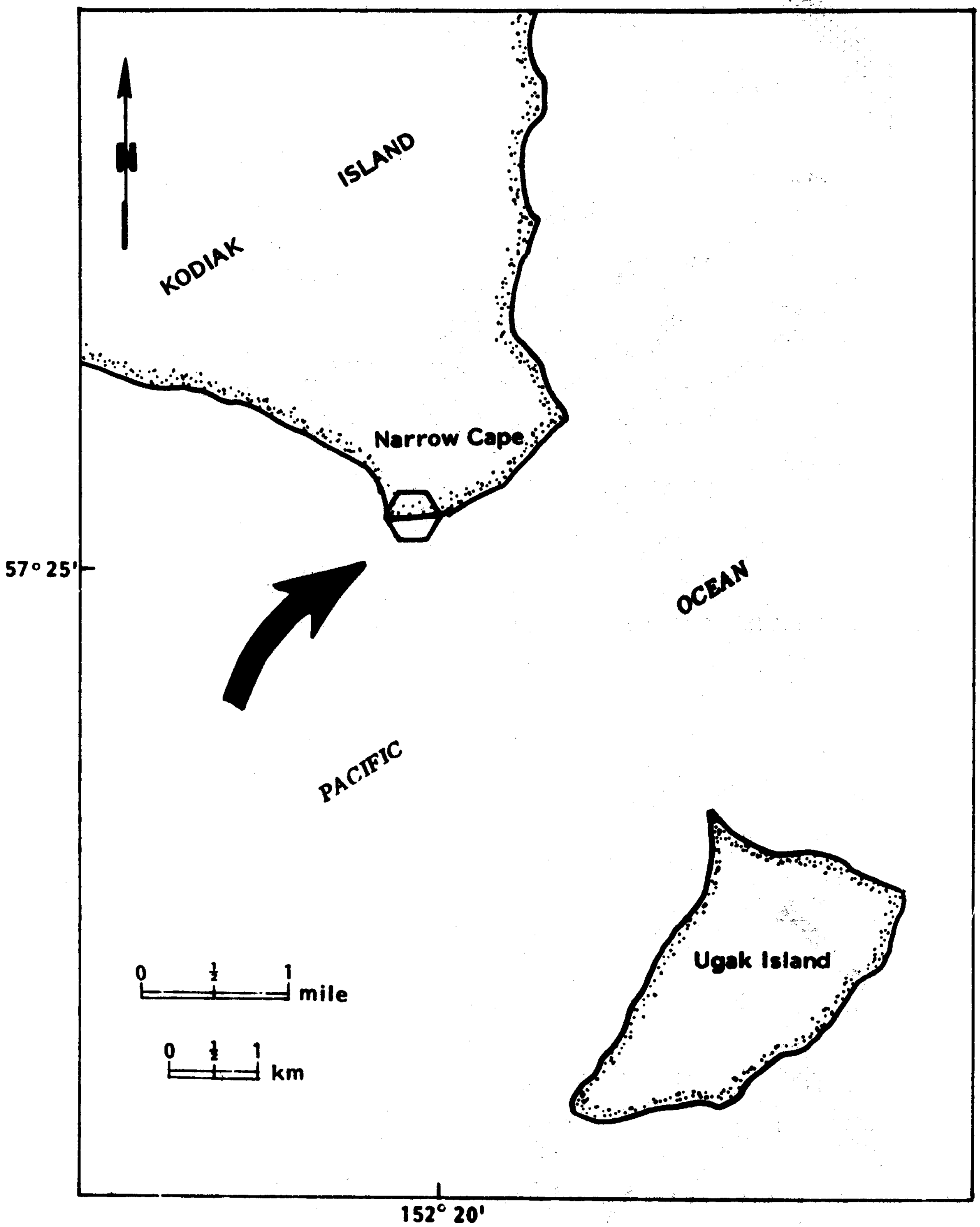


Figure 34. Narrow Cape site.

Figure 85. General view of the Narrow Cape study area.

community, and predatory invertebrate species such as starfishes and Nucella lamellosa were not apparent. Unlike many other exposed sites, however, mussels (Mytilus edulis) were common in some local areas.

Although zonation was obscured due to the flatness of the beach and the presence of Phyllospadix, certain trends were apparent. The intertidal areas farthest from the water contained patchy growths of Fucus distichus, Endocladia muricata, Ralfsia sp., and Balanus glandula. Small limpets (probably Acmaea strigatella or Collisella pelta) grew in profusion. Littorine snails were also quite common.

Closer to the water were areas covered with Odonthalia floccosa and Balanus cariosus. A few Nucella lima were also found. The limpet Collisella was common here and was being harvested by people from Kodiak. Tide pools in this area contained dense growths of Phyllospadix along with Odonthalia floccosa and Alaria sp.

Near the water was a wide zone covered with lush growths of Alaria sp. The understory consisted of patches of Rhodymenia palmata, Balanus cariosus, and Halichondria panicea. Katharina tunicata and one Leptasterias hexactis were also collected at this level.

The second sampling site had large numbers of boulders lying on the bedrock substrate. The biota were similar to the first site except that sessile invertebrate populations (Mytilus, Balanus) were more evident as they had heavily colonized the rock faces.

St. Paul Harbor (Chiniak Bay, Kodiak Island)

St. Paul Harbor lies in Chiniak Bay between the city of Kodiak and the airport (Figure 86). Because of its proximity to industrial development, we would normally not have chosen such an area. However, poor flying conditions in July 1976 forced us to set down soon after the helicopter took off, and we investigated this site while waiting for better weather.

The area is heavily impacted by human activity. A recreational road and trail system ends approximately 400 m from the beach and the intertidal zone is backed by a high berm composed of military junk. The waters seaward of the site are heavily traveled by fishing boats. The intertidal substrate itself is composed of a shale-like bedrock bench which is broad, flat, and contains many tide pools.

Perhaps because of the close proximity to many large fish-processing plants, the filter-feeding invertebrate life here was among the richest seen anywhere in the Kodiak Island area. An extremely heavy cover of barnacles, mussels, sponges, bryozoa, and sabellid worms occurred throughout the area. These invertebrates seemed to be crowding out the algal flora. Algae which had been able to establish themselves seemed in poor condition, possibly due to grazing herbivores such as sea urchins, which were common. The Alaria population seemed particularly impacted by herbivores and, in many areas, rows of bare stipes were all that remained. Although the urchins may have been the main grazer on mature macrophytes, limpets and chitons were also found in profusion and may have been limiting the development of earlier stages of macroalgae.

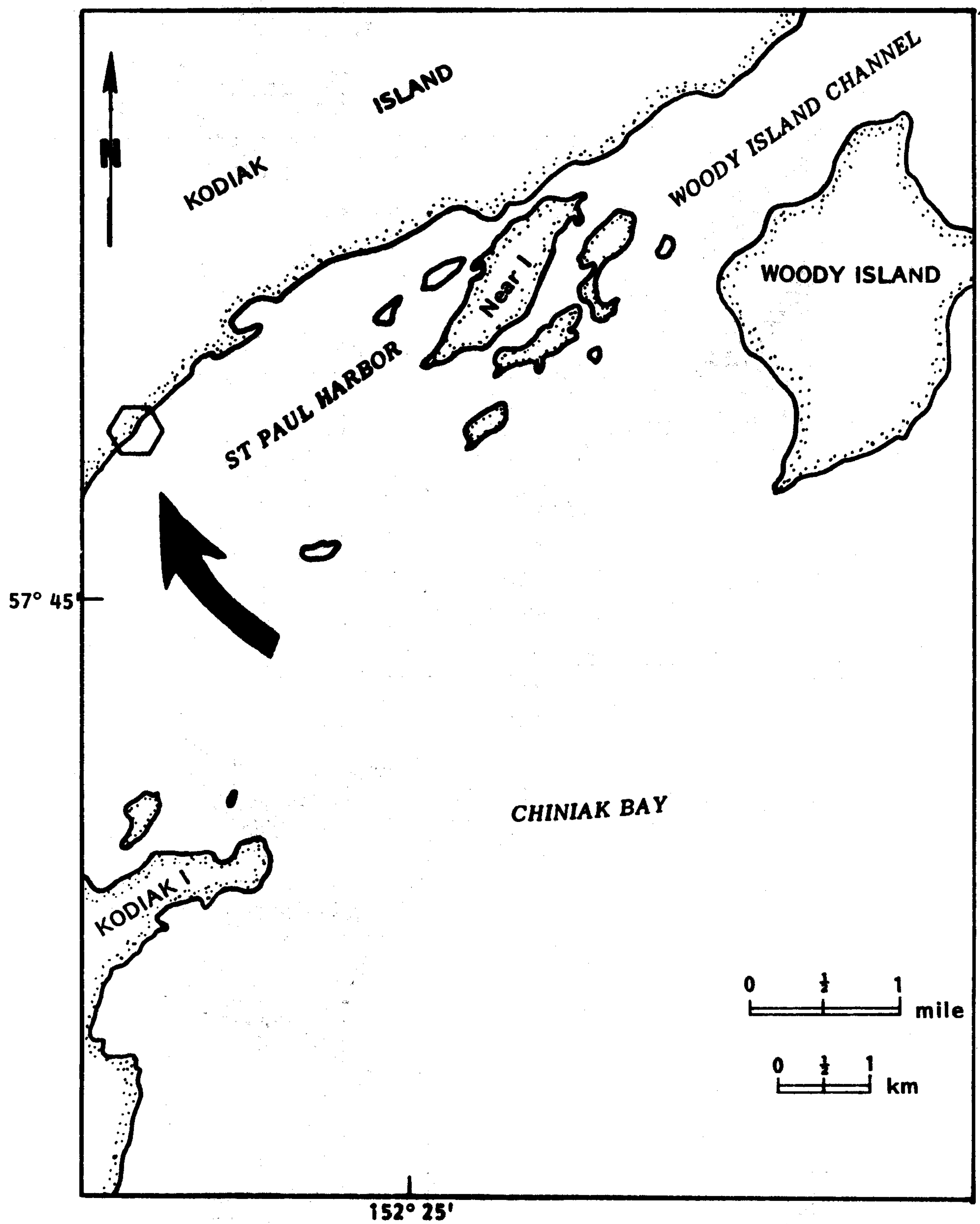


Figure 86. St. Paul Harbor site.

Possibly because of the rich invertebrate fauna and the general protection from wave action, there were also large numbers of carnivores, mainly starfishes (Evasterias) and gastropods (Nucella lamellosa).

The distribution of invertebrates was homogenous due to the flatness of the beach and the presence of tidepools (Figure 87). Generally, the higher levels contained large populations of Littorina sitkana, Balanus glandula, and Collisella digitalis. Common algae included Porphyra sp. and Endocladia muricata. Nucella lamellosa was a common predator at this level.

Below this area was a zone heavily covered with Balanus cariosus and Mytilus edulis. Competition for space was apparent; in many areas the mussels had almost completely overwhelmed populations of large B. cariosus and a recent set of Balanus sp. had almost completely covered the surfaces of the mussel shells.

Close to the water was a zone of fertile Fucus distichus and Odonthalia floccosa which graded into an area of heavily-grazed Alaria sp. The understory in the Alaria-covered area consisted of very heavy growths of B. cariosus, Halichondria panicea, and sabellid worms (Figure 88).

Several tide pools were also investigated. Pools farthest from the water in areas corresponding to the level of the Mytilus zone contained the algae Rhodomela larix, Odonthalia sp., Microcladia sp., and Rhodymenia palmata; coralline algae; and the sponge Halichondria. Mid-level pools had similar algae and also included Alaria sp. and Hedophyllum sessile, as well as the chiton Katharina tunicata. Pools closest to the water were quite full of Alaria sp. along with occasional large populations of tube worms or urchins. Surf grass (Phyllospadix) was found growing in tide pool depressions at several tidal levels.

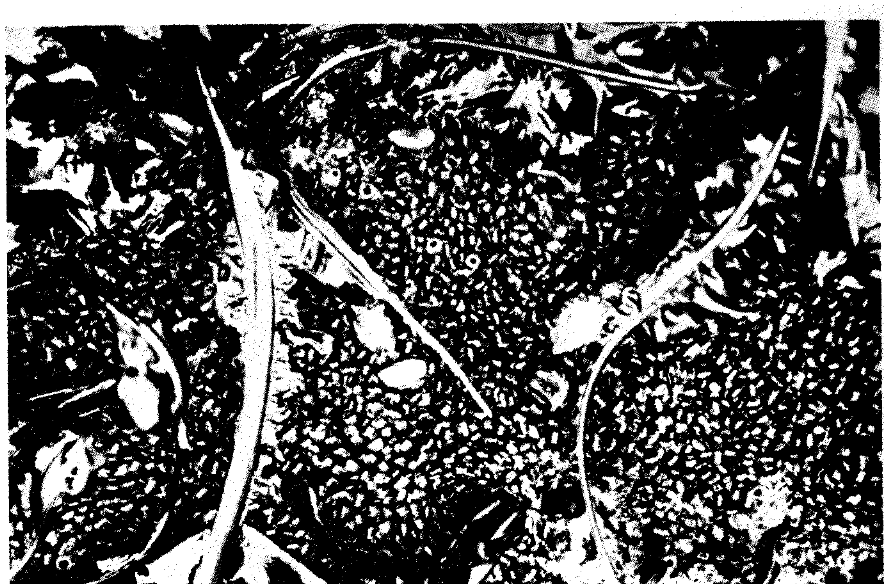
Sea Otter Island

Sea Otter Island (Figure 89) is a small (0.6 km long), highly-exposed island lying approximately 5 km off the coasts of Afognak and Shuyak Islands. The beach is moderately sloping and composed of tilted and fractured bedrock (Figure 90). The island is low (30 m) and grassy, and has large concentrations of sea birds including puffins and gulls. Birds had apparently been feeding on intertidal invertebrates, as indicated by the many empty chiton and limpet shells strewn over the island. Another evidence of utilization of this area by birds was the large amount of Prasiola meridionalis which was growing very high in the intertidal zone. This species of algae usually only occurs in areas of high guano concentration.

When we qualitatively investigated this island in July 1976, it appeared that several generally common invertebrate species were only present in small numbers. Balanus glandula and Mytilus edulis were uncommon, being mainly confined to cracks or crevices in the bedrock. Littorine snails were not common. Predators such as sea stars or carnivorous gastropods (Nucella, Searlesia) were generally absent unless they were small enough to hide in crevices. Although limpets and chitons were also uncommon, concentrations of shells were found in areas utilized by birds.

Figure 87. General view of St. Paul Harbor study area.

Figure 88. Large colonies of sabellid worms which were common at St. Paul Harbor. Note predation by Nucella sp.



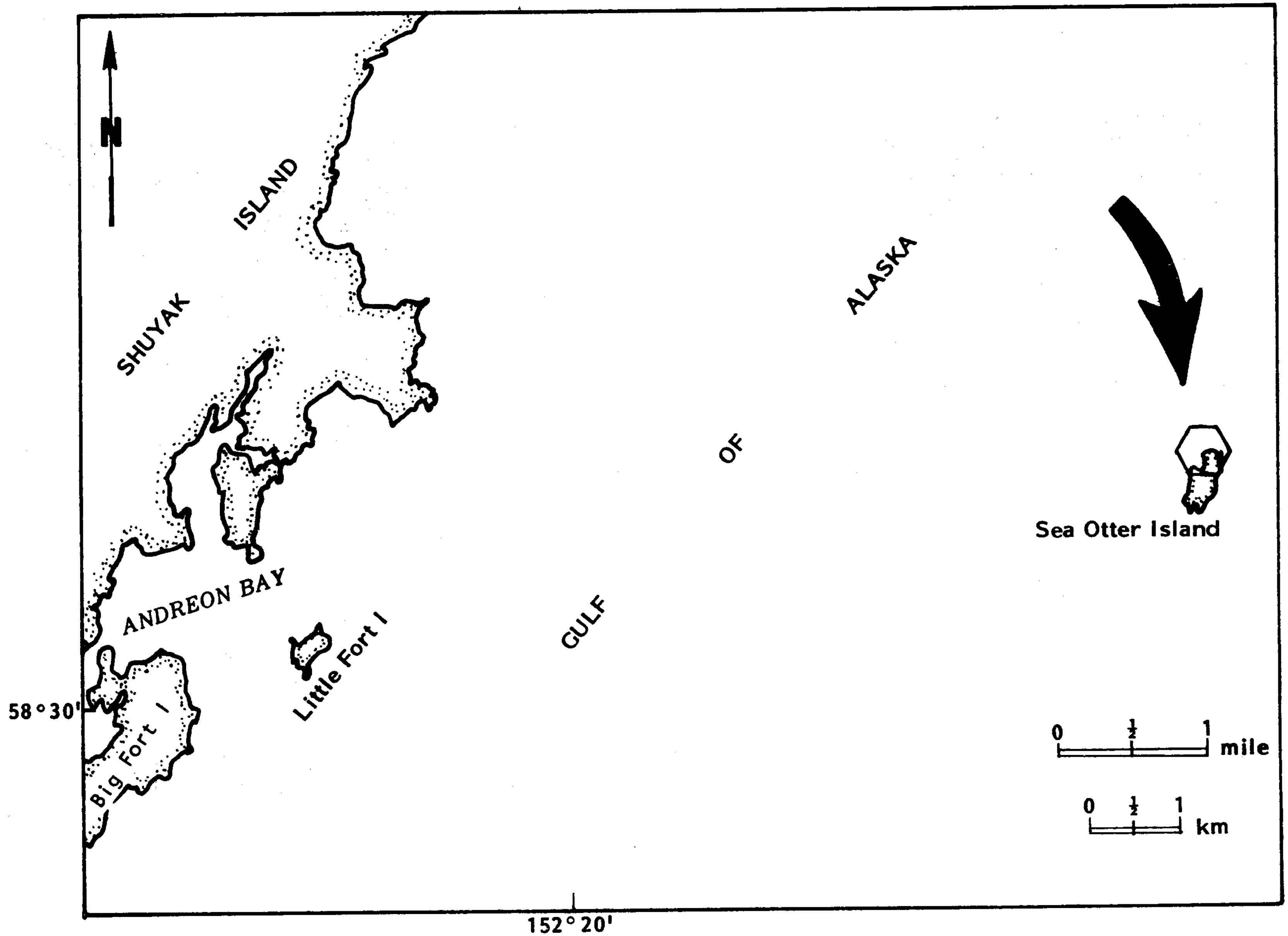


Figure 89. Sea Otter Island site.

Figure 90. Sea Otter Island. General view of bedrock intertidal area.

Figure 91. Sea Otter Island. General view of sampling area showing heavy _Alaria_ cover.

The area was heavily covered by algae (Figure 91). At the highest intertidal levels we found Prasiola and Porphyra sp. A band of Halosaccion glandiforme grew below this and graded into a belt dominated by Rhodymenia palmata f. sarniensis. Both the Halosaccion and Rhodymenia bands were almost monoalgal in nature. Even Fucus distichus and Odonthalia floccosa did not occur in these zones.

At the lower intertidal level Alaria sp. and Laminaria longipes were dominant. They were growing over an understory of Gigartina sp., Balanus cariosus, Halichondria panicea, and coralline algae. Farther out, in the area not exposed by the tides, large beds of Laminaria sp. were observed.

Pillar Cape (Afognak Island)

Pillar Cape lies in a highly exposed location on the eastern side of Afognak Island (Figure 92). Surf in the area is high and the spray zone extends a long distance from the edge of the water.

We qualitatively studied two sites in July 1976. The first was a hummocky bedrock beach (Figure 93) and the second was covered with very large boulders. Both were surrounded by sandy and gravelly beaches (Figure 94). The large amount of bare rock surface seen at all levels at both sites may be indicative of the effect of high wave force combined with the scouring effect of sand and gravel in suspension. Many of the smaller rocks were completely bare of attached organisms.

Biota and zonation were similar at both sites, and generally common forms such as starfishes, sea urchins, and predatory snails (Searlesia, Nucella) were apparently absent. Mussel and barnacle populations were small relative to populations in more protected locations.

The upper area had patchy growths of Porphyra sp. and Halosaccion glandiforme. Littorine snails were common. The middle zones had patchy growths of Rhodymenia palmata, with occasional large populations of Collisella pelta or patches of Balanus cariosus. A few small Mytilus edulis were found growing in cracks and crevices. The lowest zone had sparse to occasionally heavy cover of Alaria sp. with an understory of Rhodymenia, filamentous green algae, and a few Tonicella lineata, B. cariosus, and Mytilus growing in crevices.

Spruce Island

Spruce Island (Figure 95) lies near the northeastern tip of Kodiak Island approximately 13 km from the city of Kodiak. It forms part of the land mass which borders the southern side of Marmot Bay. The coastal substrate generally consists of deeply cleaved bedrock but small sandy beaches are not uncommon.

Our sampling area was on the southeastern tip of Spruce Island and was exposed to storms and surge from the northeast and east. Five sites were qualitatively examined in July 1976 and the presence or absence of common species was noted. Sites one and two were tall rock faces (Figure 96), sites three and four were moderately sloping hummocky bedrock, and site five had a very low-relief, almost flat, bedrock substrate with small pools of standing water.

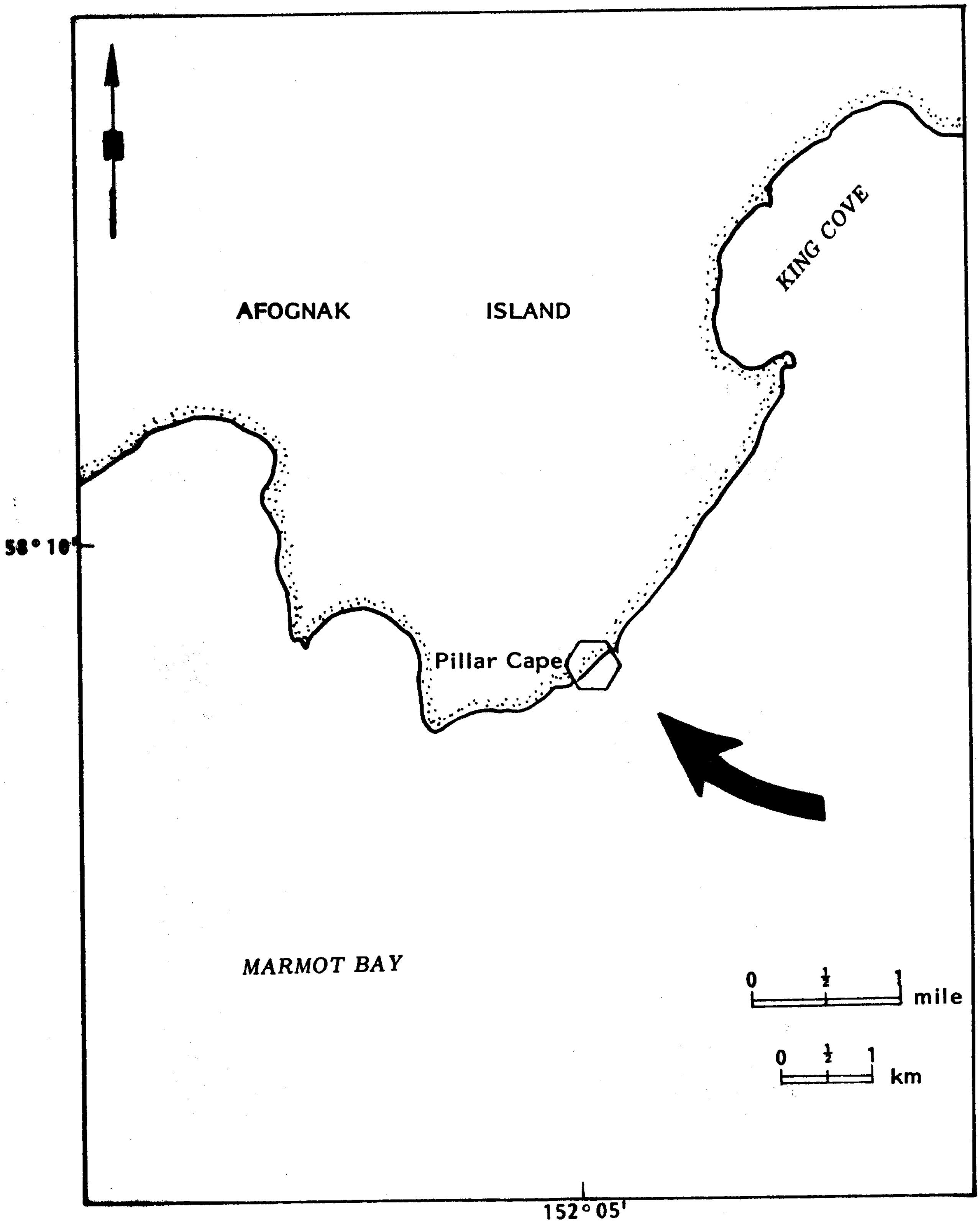


Figure 92. Pillar Cape site.

Figure 93. View of Pillar Cape site showing extensive bare rock.

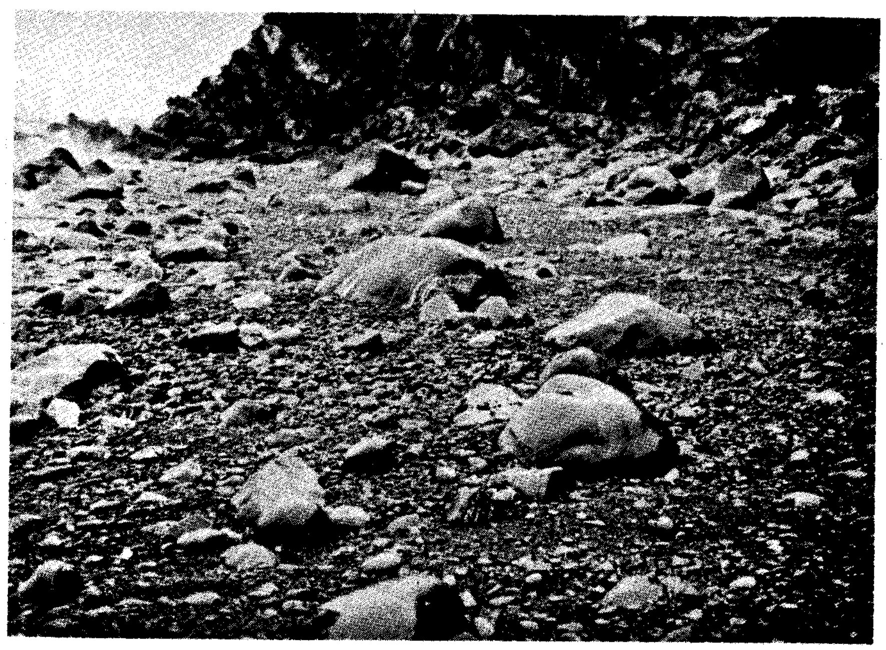


Figure 94. View of Pillar Cape site showing paucity of attached biota on unconsolidated beach material.

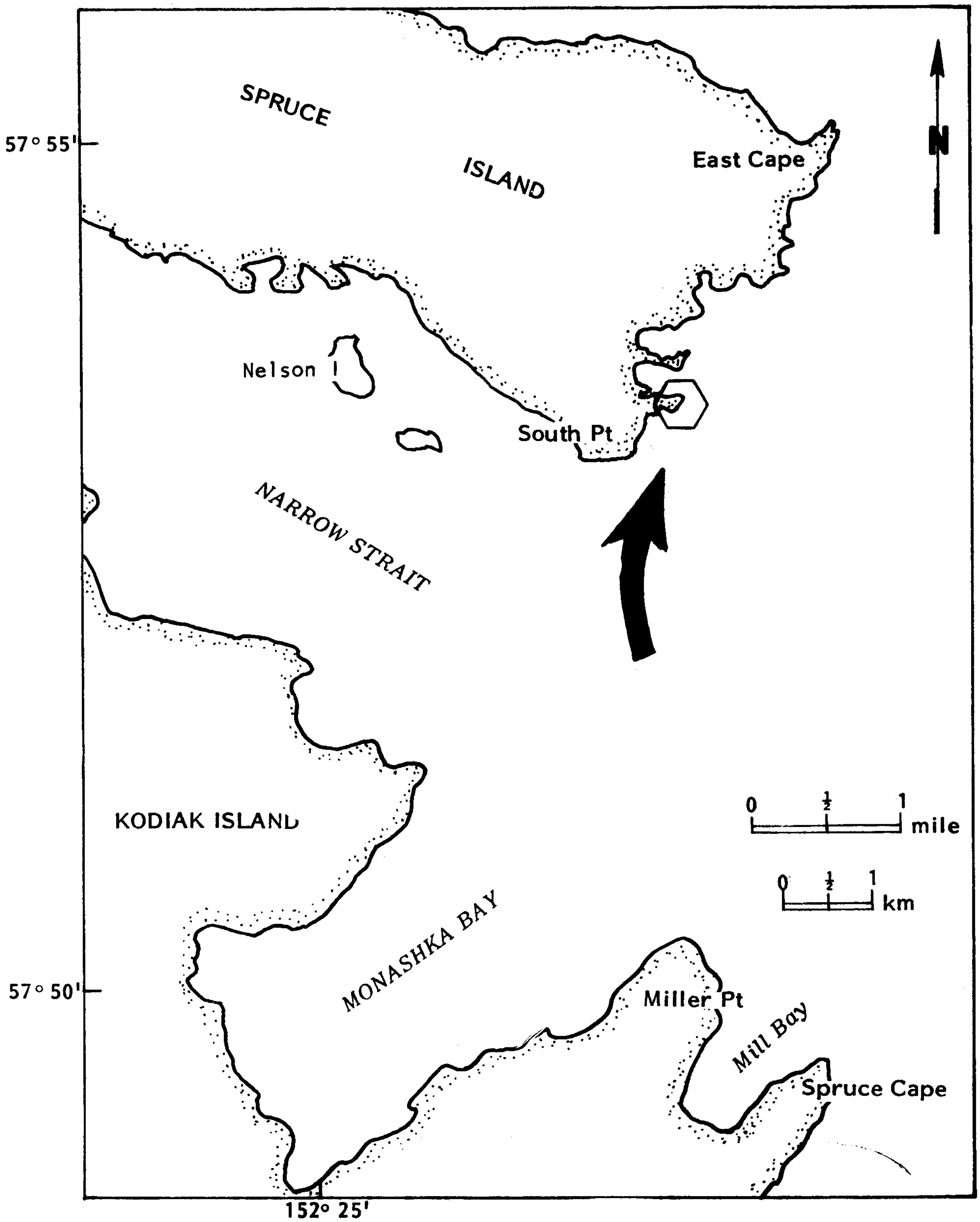


Figure 95. Spruce Island site.

Figure 96. Vertical zonation of intertidal biota on Spruce Island site.
Zone 1 = Balanus glandula, Endocladia muricata
Zone 2 = Fucus distichus
Zone 3 = Odonthalia floccosa, Balanus cariosus
Zone 4 = Alaria spp.

The rock faces exhibited strong zonation (Figure 96) which seemed relatively consistent throughout the area. The highest intertidal levels contained patchy growths of Endocladia muricata, sterile Fucus distichus, and occasionally very dense Porphyra sp. Balanus glandula were also common in the high areas. The next lower zone contained heavy growths of fertile Fucus and mussels (Mytilus edulis) in addition to B. glandula. Below this was a strong band of Odonthalia floccosa which often overlaid heavy growths of B. cariosus. Finally, the lowest exposed zone was strongly dominated by Alaria sp. whose large blades generally covered a fairly rich collection of encrusting forms such as coralline algae and Halichondria panicea. Katharina tunicata and large B. cariosus were also abundant here.

Zonation and species abundances were similar in the areas of moderately sloping bedrock, although Mytilus appeared to be less common and the alga Rhodymenia palmata appeared to be more abundant. Numbers of large herbivores (urchins) and predators (starfishes, snails) were low throughout the area.

The presence of small tide pools at the fifth site tended to make distribution of biota patchy. Several species such as Odonthalia and Mytilus were generally absent although Odonthalia were common in the pools themselves. On exposed surfaces the fertile Fucus zone appeared to merge directly, without any intermediate zonation, into the area dominated by Alaria. Among the tidepools, pools in the upper intertidal area were generally dominated by Scytosiphon lomentaria; middle-zone pools by Odonthalia, Soranthera sp., and coralline algae; and lower-zone pools by Hedophyllum sessile.

Tonki Bay (Afognak Island)

Tonki Bay is a long (approximately 16 km), narrow bay on the eastern side of Afognak Island (Figure 97). The site we qualitatively sampled in July 1976 lies about halfway down the west side of the bay in an area well protected from waves. The substrate was composed of large boulders overlying a bedrock pavement.

The biota were diverse and dominated by invertebrates. Balanus cariosus was the most common species, and most available space in the intertidal zone seemed to be covered with different age groups of this barnacle. B. cariosus were being heavily preyed upon by Nucella lamellosa and Pisaster ochraceus which were relatively very abundant.

Algae were often patchy and in relatively poor condition. Much of the cover consisted of bladed green algae. Species such as Odonthalia floccosa and Alaria sp. seemed to be competing for space with barnacles and mussels. Often the algae grew on Mytilus edulis and barnacles which covered rock surfaces. In this situation the carnivorous starfishes and drills appeared to have a strong effect as they ate and eroded the invertebrate substrate.

Several zones were evident at Tonki Bay. The highest was dominated by Fucus distichus, Halosaccion glandiforme, Balanus glandula, and Littorina sitkana. A band of mussels was often found just below this, and Nucella lamellosa and polysiphonous red algae were associated with it. There was a zone of red algae below the mussels; this was dominated by Rhodymenia palmata and Odonthalia, and small sea cucumbers and snails (Margarites) were

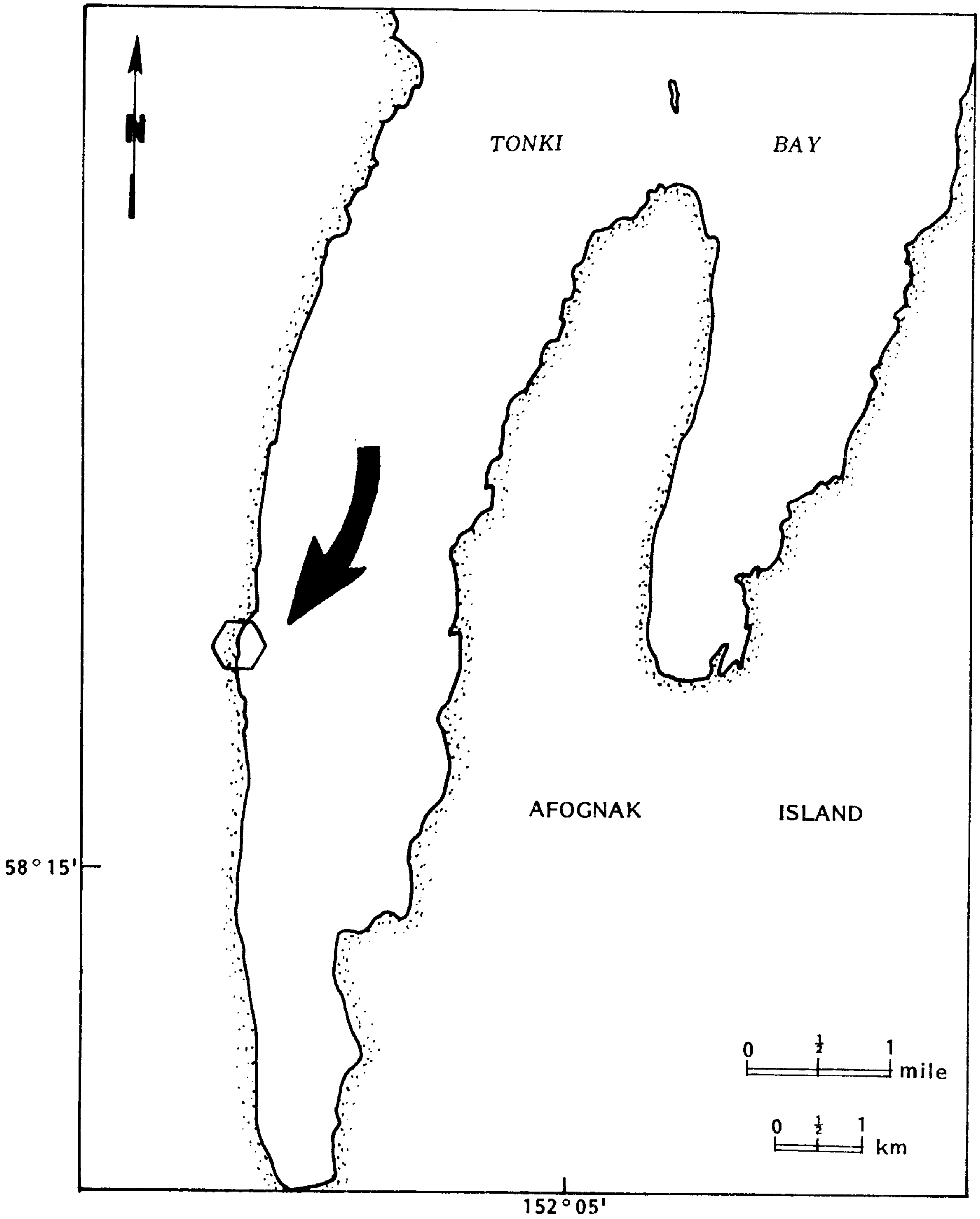


Figure 97. Tonki Bay site.

common invertebrates. The lowest intertidal zone was heavily covered with invertebrates and some Alaria. Common species included bryozoa, Halichondria panicea, B. cariosus, Nucella, and Pisaster. Other species of algae included Gigartina sp. and Iridaea sp.; invertebrates included Fusitriton oregonensis, Pycnopodia helianthoides, Henricia leviuscula, tunicates, and the remains of several urchin tests.

North Shuyak Island

A composite boulder beach in a semiprotected location on North Shuyak Island (Figures 98 and 99) was qualitatively sampled in July 1976. Because of topographic changes which had apparently occurred after the 1964 earthquake, it was not possible to pinpoint our location on charts. Thus the location shown in Figure 98 is approximate.

In the lower zones most of the rock surfaces were covered with heavy growths of Alaria sp. whose blades were often covered with Musculus sp. The Alaria occurred over a substory assemblage of bryozoa, Halichondria panicea, Notoacmea scutum, and algae such as Ptilota sp., Gigartina sp., and coralline red forms. Grazing or predatory invertebrates were not immediately apparent. However, when rocks were turned or the many crevices between boulders examined, many Katharina tunicata, Tonicella lineata, and Strongylocentrotus droebachiensis were discovered. Pisaster ochraceus and Pycnopodia helianthoides were discovered in this manner, and two octopuses were also observed under large rocks.

The middle zone was covered with Fucus distichus, Odonthalia floccosa, Balanus cariosus, and Rhodymenia palmata, with numbers of Leptasterias hexactis, limpets, isopods, and amphipods under and between rocks.

In the upper areas small B. glandula and B. cariosus were common along with Littorina sp. Mytilus edulis were found growing among the rocks at some locations.

Whale Island

Whale Island (Figure 100) lies in the eastern end of Kupreanof Strait between Kodiak and Afognak islands. It is approximately 24 km northwest of the city of Kodiak.

We qualitatively sampled two areas on Whale Island during July 1976. Both were small rock (<2 ft^2) and boulder beaches. The first appeared to be located in a highly protected area (although the Coast Pilot reports currents of 4.5 kn in the area). The second appeared to lie in a much more exposed position. Both had a gentle slope without much relief.

In the first area, which lies in Whale Passage on the southwestern shore of the island, we investigated three sites. The first two had large quantities of fresh water running across the beach while the third did not. The presence of fresh water appeared to affect the types of algae present--diatom species and Enteromorpha intestinalis were quite common at sites one and two but less so at site three. Mytilus edulis appeared to be a much more dominant member of the community in areas of freshwater runoff.

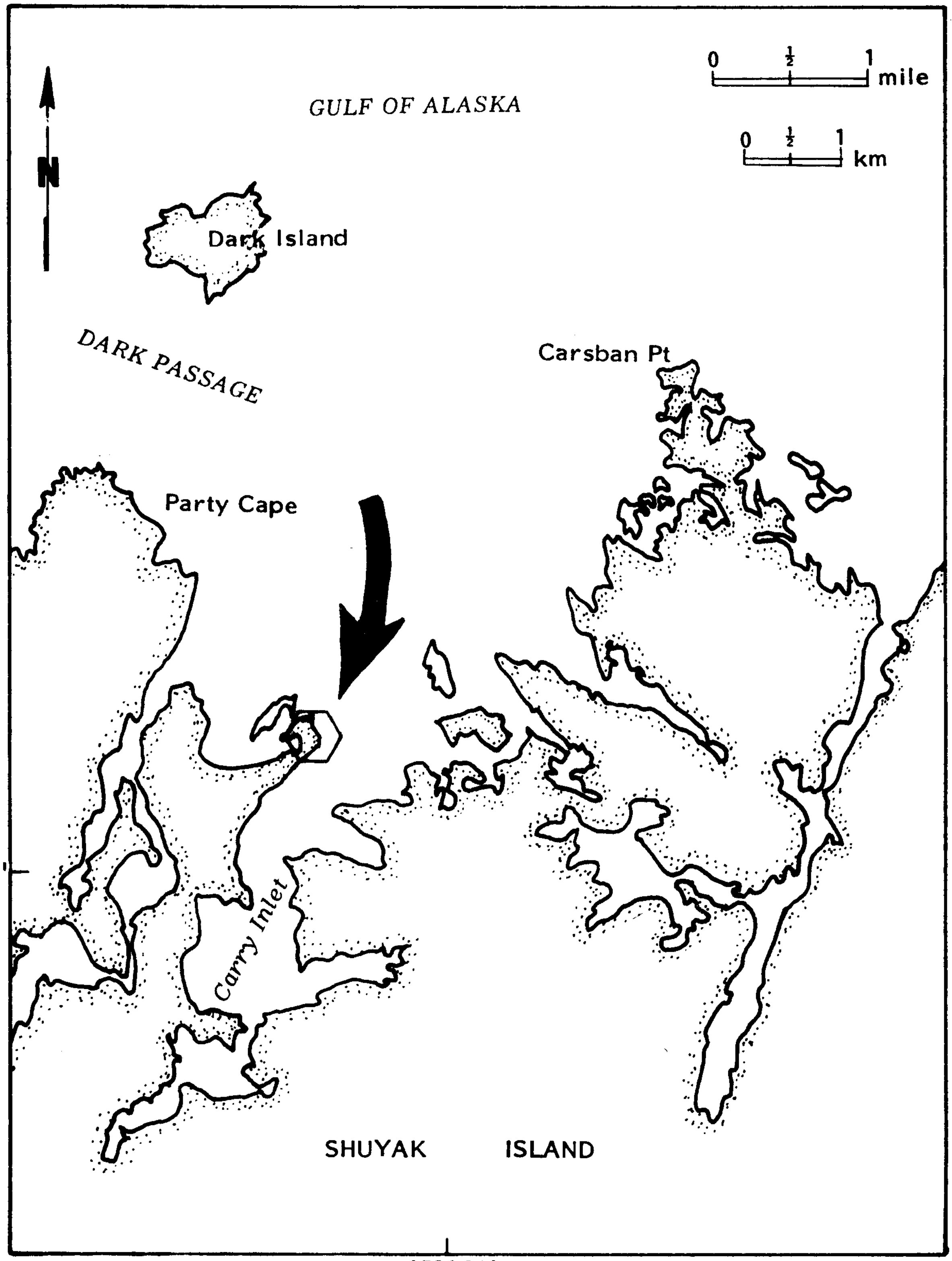


Figure 98. North Shuyak Island site.

Figure 99. North Shuyak Island, July 1976. General view of the sampling area

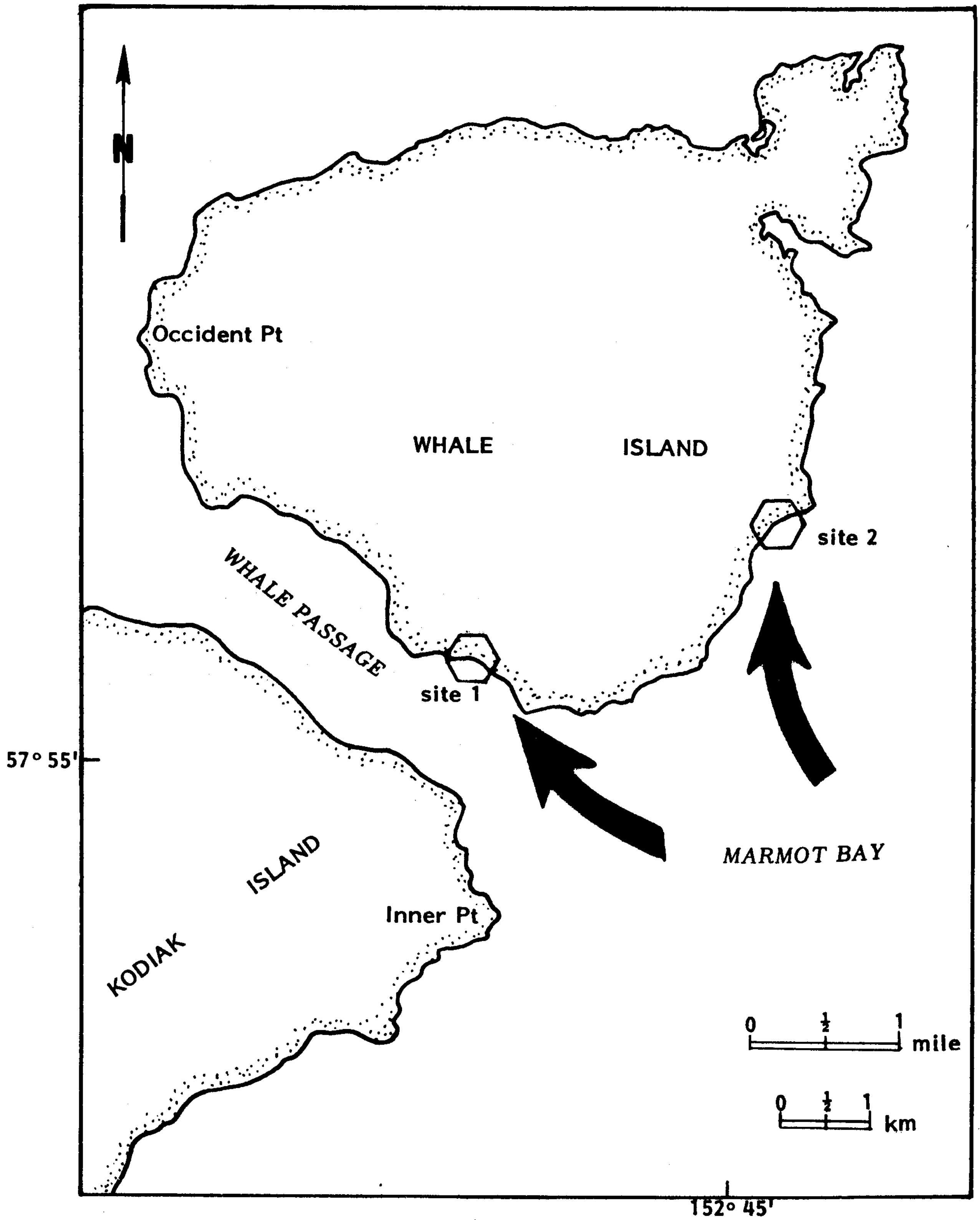


Figure 100. Whale Island sites.

Figure 101. Whale Island, site 1. General view of the area showing heavy intertidal cover attached to small boulders.

Figure 102. Whale Island, site 1. Alaria holdfasts attached to small boulders.

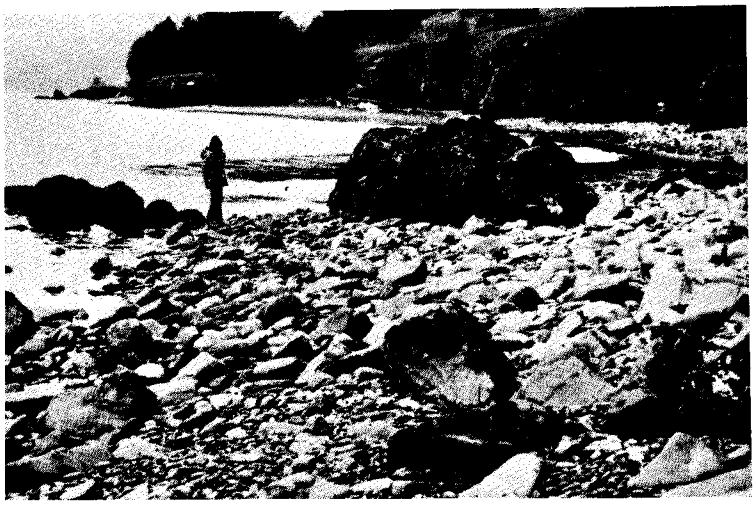


Figure 103.
Whale Island, site 2.
General view of the area showing paucity of intertidal organisms attached to small boulders.

Figure 104.
Whale Island, site 2.
Barnacles growing in protected crevices.

Figure 105.
Whale Island, site 2.
Attached biota was sparse on abraded lower surfaces of large boulders.

In spite of these differences, all three sites had a moderate to heavy cover (Figure 101) of attached biota. The upper areas were dominated by Littorina sitkana and Balanus balanoides. The next lower zone consisted of large clumps of Mytilus which were associated with Odonthalia floccosa and polysiphonous red algae. Predatory snails (Nucella) were active in this zone. Below this was an area dominated by Fucus distichus and Halosaccion glandiforme with associated limpets and small sea cucumbers. These last two zones tended to undulated in relative position--often the Fucus-dominated zone occurred quite high on the beach and extended downward into what was usually the Mytilus-dominated area, while a short distance down the beach Mytilus extended higher than usual.

The lowest exposed area was dominated by the algae Alaria sp. (probably A. marginata), Ulva sp., Rhodymenia palmata, and Hedophyllum sessile. This was a protected habitat as evidenced by large Alaria plants attached to very small rocks (Figure 102). Often two to five plants were attached to a rock only a few inches in diameter. Alaria densities were very high and were associated with a diverse invertebrate community. Common invertebrates, especially in the lowest areas, included Margarites, Pisaster, and an unidentified sedentary polychaete worm which formed large colonies in tide pools. Other species encountered included Pycnopodia helianthoides, Dermasterias sp., Orthasterias sp., Strongylocentrotus droebachiensis, Acmaea mitra, and Tonicella lineata. The starfishes appeared to be feeding on the polychaete colonies. Forms which were rare by comparison with other beaches of the Kodiak Island area included Katharina tunicata and Balanus cariosus.

Seaward of the intertidal area in very shallow water was a large bed of Alaria fistulosa associated with luxuriant growths of Desmarestia sp. and coralline algae.

The second area we explored lies on the more exposed southeastern side of Whale Island. Biota here were much sparser (Figure 103). Almost nothing was attached to the small rock and boulder substrate, possibly because waves had moved the rocks and abraded the attached biota. New sets of barnacles had begun to colonize the area and diatom colonies coated the surfaces of small rocks. On larger boulders, bladed and filamentous green algae grew sparsely. Barnacles and mussels were found in crevices (Figure 104) on the protected areas of very large boulders. The lower exposed surfaces of these large boulders, however, appeared to have been abraded and the rock was bare to a height of about 18 in above the substrate (Figure 105).

Vertical Zonation Patterns of Kodiak Island Area

Two algal species were dominant at almost all intertidal sites. In the middle intertidal area (2-8 ft)*, Fucus distichus were often the most conspicuous organisms. In the lower areas (-2 to +2 ft) at least one species of Alaria was often dominant and several invertebrate species occurred commonly; the barnacle Balanus cariosus was probably the most abundant invertebrate, and its greatest biomass usually occurred at 0 to 4-ft elevations.

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* The heights used in this section are generalized in order to indicate areas of relative dominance. Fucus, for instance, was collected from -1.3 ft to +10 ft but tends to produce its greatest biomass in the 2- to 8-ft range.

Several other species also occurred frequently and made major contributions. Those which were found in bands at different elevations have often been separated into descriptive biotic zones. Appropriate reviews of littoral zonation schemes, with emphasis on Alaska, are in Weinmann (1969) and Nybakken (1969).

After comparing our data on vertical distributions with classical concepts of intertidal zonation, it appeared that the Stephenson type system (Stephenson and Stephenson 1972) applies best to the zonation patterns in the Kodiak Island area. This system recognizes three littoral zones: the supralittoral or splash zone; the littoral zone; and the infralittoral fringe or upper sublittoral zone. The three zones are not further subdivided in the Stephenson system because this system is meant to be "universal". Within any littoral area, however, several subzones are usually evident. Some authors elevate these to full zonal status, with the decision usually based on the spatial extent of each subzonal unit.

In the Kodiak Island area we found several subzones at each site. Some of these were dominant at one site and absent at others. The mussel Mytilus edulis, for instance, often formed a dominant band on large rocks in protected areas. In exposed locations, however, it was often either a small part of the Fucus zone or absent entirely.

Based on the most common occurrences at all sites in the Kodiak Island area we have divided the Stephenson littoral zone into several subzones. It should be emphasized, however, that this is done for general descriptive purposes and, as seen in previous sections, not all of these subzones were found at all of the sites. This scheme (Table 7) represents a generalized picture of the vertical distributions of the most dominant organisms we encountered. In addition to this general observational scheme, we also used transect line data to interpret zonation. Quantitative data on the occurrence of each of several common species were grouped by 2-ft tidal elevations* (Table 8). Both presence-absence data and data on the presence of each species in quantities of greater than 20 g wet weight per sample were listed. The latter was done because presence-absence data are often confounded by incidental collections of very small amounts of material outside the normal range of occurrence. The data in Table 8 indicate the general vertical range of occurrence, and possibly of dominance, for several species which were abundant.

Spatial and Temporal Variability in Species Composition

Marine biological communities are complex and variable. The distribution and abundance of species vary in time and space and are influenced by many environmental factors. To describe a community completely or to predict its occurrence requires an understanding of the dynamic interactions of the components and a knowledge of temporal and spatial variability.

Most of our knowledge of the intertidal communities in the vicinity of Kodiak Island comes from data collected at a few geographic locations which were often sampled only once or twice. This approach is adequate to describe gross characteristics of communities and has been used in this and other surveys.

* Data from all large boulder and bedrock sites were used. Dolina Point and Low Cape data were not included because 1/16-m^2 quadrats were not used.

Table 7.--Generalized zonation of rocky intertidal areas of the Kodiak Island area.

Zone	Approximate tidal range	Biological name	Characteristic organisms
Zone 1-Supralittoral Fringe	Highest reach of spray to mean higher high water	Porphyra-Prasiola zone = Littorina zone (Stephenson and Stephenson 1972, p 20) = Littorina-Verrucaria zone (Lewis 1964, p 82)	Prasiola meridionalis, Porphyra sp., Littorina sitkana
Zone 2--Littoral Zone	Mean higher high water to low water of spring tides		
Subzone 2A		Barnacle-Endocladia zone = Barnacle zone (Nybakken 1969, p 75) = Upper Barnacle zone (Lewis 1964)	Littorina sitkana, Chthamalus dalli, Balanus glandula, Acmaea digitalis, Diatom colonies, Collisella pelta, Endocladia muricata, sterile Fucus distichus
Subzone 2B		Fucus zone=Fucus zone (Nybakken 1969, p 123) = Fucus zone (Stephenson & Stephenson 1972) = Balanus, Patella, Fucus zone (Lewis 1964, p 82)=upper mid-littoral zone (Kozloff 1973, p 124)	Fertile Fucus distichus, Mytilus edulis, Nucella lima, N. lamellosa, Odonthalia floccosa
Subzone 2C		Rhodymenia zone = red algae belt (Lewis 1964, p 82) = Rhodyphyceae zone (Lewis 1964, p 78)	Rhodymenia palmata, Ulva-Monostroma, Balanus cariosus, Cucumaria pseudocurata
Subzone 2D		Alaria zone = Alaria zone (Weinmann 1969, p 29)	Alaria spp., Lithothamnion sp., Ptilota filicina, Crisia, Halichondria panicea, Katharina tunicata
Zone 3-Infralittoral Fringe	Low waters of spring tides to true subtidal (below lowest low water)	Laminaria zone	Laminaria longipes, Laminaria dentigera, Lithothamnion sp., Corallina sp., Acmaea mitra

Table 8.--Percent of samples in which common species occurred and percent of samples with more than 20 g wet weight of each species in 1/16 m^2 quadrat samples collected at different tidal elevations on boulder and bedrock in intertidal sites in the Kodiak Island area.

Species		Elevation (ft) and number of samples collected								
		<-2 (2)	-2-0 (47)	0-2 (122)	2-4 (115)	4-6 (64)	6-8 (39)	8-10 (11)	10-12 (4)	12-14 (1)
Littorina sitkana	% of samples	0	23	51	60	84	97	100	100	0
	% with more than 20 g	0	0	0	2	13	36	0	25	0
Balanus glandula	% of samples	0	0	3	15	28	46	27	75	0
	% with more than 20 g	0	0	0	7	11	8	9	25	0
Fucus distichus	% of samples	0	17	34	47	63	82	45	25	0
	% with more than 20 g	0	2	12	30	31	56	27	0	0
Collisella pelta	% of samples	0	6	20	36	41	46	0	25	0
	% with more than 20 g	0	0	0	0	0	0	0	0	0
Mytilus edulis	% of samples	0	9	16	27	41	31	9	0	0
	% with more than 20 g	0	0	0	4	14	10	0	0	0
Nucella lima	% of samples	0	4	5	10	19	5	0	0	0
	% with more than 20 g	0	0	1	1	6	0	0	0	0
Rhodymenia palmata	% of samples	50	40	39	31	23	15	9	0	0
	% with more than 20 g	0	2	11	20	13	0	0	0	0
Polysiphonous red algae	% of samples	0	9	15	10	15	9	9	0	0
	% with more than 20 g	0	4	2	7	0	0	0	0	0
Odonthalia floccosa	% of samples	0	45	54	28	34	44	0	0	0
	% with more than 20 g	0	13	27	16	17	18	0	0	0
Balanus cariosus	% of samples	0	23	26	21	28	15	9	0	0
	% with more than 20 g	0	9	17	15	11	8	0	0	0

Table 8.--Continued.

Species		Elevation (ft) and number of samples collected								
		<-2 (2)	-2-0 (47)	0-2 (122)	2-4 (115)	4-6 (64)	6-8 (39)	8-10 (11)	10-12 (4)	12-14 (1)
Holothurians	% of samples	0	51	77	32	23	13	6	0	0
	% with more than 20 g	0	0	2	2	0	0	0	0	0
Halosaccion glandiforme	% of samples	0	9	34	21	27	8	0	0	0
	% with more than 20 g	0	0	16	4	6	0	0	0	0
Margarites sp.	% of samples	0	53	62	12	11	10	0	0	0
	% with more than 20 g	0	0	0	0	2	0	0	0	0
Ulvales	% of samples	0	21	42	32	20	3	9	0	0
	% with more than 20 g	0	0	8	9	0	0	0	0	0
Halichondria panicea	% of samples	50	30	33	19	8	5	0	0	0
	% with more than 20 g	0	13	16	3	0	0	0	0	0
Rhodomela larix	% of samples	0	17	9	13	8	5	0	0	0
	% with more than 20 g	0	11	9	10	5	0	0	0	0
Gigartina sp.	% of samples	0	9	21	8	8	8	0	0	0
	% with more than 20 g	0	4	1	2	3	0	0	0	0
Katharina tunicata	% of samples	50	32	17	10	2	0	0	0	0
	% with more than 20 g	0	11	11	6	0	0	0	0	0
Alaria sp.	% of samples	50	64	61	20	6	8	9	0	0
	% with more than 20 g	50	33	47	9	2	0	0	0	0

However, because communities exhibit spatial and temporal differences in numbers and abundance of species (Krebs 1972, Pianka 1974), it is impossible to describe a community completely by sampling it only once. There is also no information on feeding, growth, movement, fecundity, and mortality of organisms present.

To gain information on the spatial and seasonal variability that may exist in our study locations, we compared data collected for this purpose from sites visited more than once and from sites where replicate transect lines were used. To determine whether the degree of exposure and type of substrate are correlated with specific biological communities in the Kodiak Island area, we compared data between several study sites.

Spatial Variability

To learn of spatial variability in the Kodiak Island area, we compared replicate data from Cape Kaguyak and Sud Island. At both sites we collected samples simultaneously along two adjacent transect lines.

The two adjacent transect lines sampled in May 1976 at Cape Kaguyak contained a total of 74 species, 42 of which were common to both lines (Table 9). Transect line 1 contained 64 species (86% of the total) while transect line 2 contained 52 species (only 70% of the total). Some common rocky intertidal species present in transect line 1 but missing from transect line 2 were *Katharina tunicata*, *Halosaccion glandiforme*, and *Laminaria* spp.; species present in transect line 2 but missing from transect line 1 were *Balanus glandula* and *Iridaea cornucopia*. None of the species missing from one line were dominant in the other.

The two adjacent transect lines sampled in August 1975 at Sud Island contained a total of 211 species, 116 of which were common to both lines (Table 9). Transect line 2 contained 171 species (81% of the total), while transect line 1 contained 156 species (only 74% of the total). Some common rocky intertidal species present in transect line 2 but missing from transect line 1 were *Balanus glandula*, *Mytilus edulis*, *Rhodomela larix*, and *Alaria* sp.; species present in transect line 1 but missing from transect line 2 were *Chthamalus dalli* and *Laminaria yezoensis*. With the possible exception of *B. glandula*, no dominant species was missed by either transect line. Depending on which line and location were chosen, 14% to 30% of the species known to be present were missed when only one line was considered at each location sampled. Thus, it is apparent that a significant number of species present can remain undetected when an area is sampled by only one transect line. It is also apparent that of the possible habitats present, i.e., outer surfaces of rocks, cracks, crevices, channels and tide pools, and under surfaces of rock, the outer rock surfaces were sampled most often by our transect sampling techniques. Therefore, sessile species characteristic of outer rock surfaces were well represented in our transect line samples, while motile and more hidden species (cryptofauna of Lewis [1964]) characteristic of the other habitat types mentioned were found seldom or not at all.

As could reasonably be expected, differences were also observed in biomass (mean wet weight per square meter) between adjacent transect lines for the 16 most dominant species (Table 10). A marked difference in mean biomass between the two transect lines occurred for 10 of the 16 dominant species at Cape Kaguyak and 12 of the 16 species at Sud Island.

Table 9. Spatial and temporal variability in total numbers of species* from transect lines sampled at Cape Kaguyak and Sud Island.

	Spatial variability Cape Kaguyak, two adjacent transect lines, 1976		
	Line 1	Line 2	Lines 1 and 2
Total species	64	52	74
Common species	42	42	42
% Missing	14	30	--

	Spatial variability Sud Island, two adjacent transect lines, 1975		
	Line 1	Line 2	Lines 1 and 2
Total species	156	171	211
Common species	116	116	116
% Missing	26	19	---

	Temporal variability Sud Island, transect line 1, May and August 1975		
	May	August	May and August
Total species	133	156	208
Common species	87	87	87
% Missing	36	25	---

* Includes marine algae, sea grasses, invertebrates (including insects), fishes, and fish eggs.

Temporal Variability

Seasonal differences in species composition and abundance have been difficult to document. One of the major problems is that data from different seasons were collected along different transect lines and therefore we are unable to differentiate between seasonal effects and differences in species composition between lines. For example, at Sud Island in August there were 84 species which were not found in May. The total for both dates was 208 species, 87 of which were common to both months (Table 9). The August sample contained 156 species (75% of the total) while the May sample had 133 species (64% of the total). Some common rocky intertidal species present in August but missing in May were Katharina tunicata, Chthamalus dalli, Mytilus edulis, and Leptasterias hexactis. Some common rocky intertidal species present in May but missing on at least one of the August transects were Balanus glandula, Spongomorpha spp., and Nucella sp. Some of these differences are shown in Table 10. None of the species missing from the one month's sample were dominant in the other. The large size of individuals of additional species present in the August samples indicates that they were present in May but not along the transect line sampled. Therefore the differences in species composition reflect spatial rather than seasonal variability.

Differences were also observed between May and August samples in biomass for the 16 most dominant organisms (Table 10). For example, at Sud Island seven species had lower biomass in August, four species had higher biomass in August, and five showed no major differences in biomass between May and August. Because most species showed a decrease in biomass during this time, rather than an increase due to seasonal growth, these differences also probably reflect spatial rather than seasonal variability.

Relation of Species Composition and Abundance to Habitat

Although exposure to waves is difficult to quantify (Bascom 1964), it and substrate type are often used to characterize intertidal communities (Lewis 1964, Rickets and Calvin 1968, Dayton 1973) because they are easily described and because organisms have tolerances or preferences for both factors. However, other factors such as predation, competition, tidal exposure, temperature, light, salinity, turbidity, and humidity also greatly influence community composition (Paine 1966, Paine and Vadas 1969, Connell 1970, Dayton 1971, Estes and Palmisano 1974). Because we did not measure these factors, our analysis of relationships between community distribution and habitat types depends on correlating the habitat factors of substrate type, vertical relief, and wave exposure. It should be emphasized, therefore, that the results of this analysis are preliminary, simplistic, and probably incomplete. This is especially true because correlation is not proof of cause and may even be misleading in areas of limited data.

Data Based on Quantitative Collections

To make the comparison between species occurrences and habitat, we ranked (from most to least dense) the biomass along transect lines of 16 dominant organisms from nine rocky beach sites and tested them against gradients of wave exposure and topography (Table 11). Exposure and topography ranged from sheltered, sloping areas which usually had much relief in the form of

Table 10.--Mean biomass (wet weight in grams per square meter) of 16 dominant organisms from 1/16m^2 quadrats along transect lines sampled at Sud Island and Cape Kaguyak.

Dominant organism	Sud Island 1975 May Transect 1	Sud Island 1975 August Transect 1	Sud Island 1975 August Transect 2	Cape Kaguyak 1976 May Transect 1	Cape Kaguyak 1976 May Transect 2
Littorina	505.4	286.1	184.2	25	147
Mytilus	0	0	55.5	0	0.2
Fucus	1375.7*	1098.6†	816.9§	917¶	594**
Odonthalia	0.5	3.8	23.1	0	0.5
Rhodymenia	642.9	501.1	703.1	77	170
Alaria	1842.1	598.2	96.0	1272	2271
Porifera	115.3	177.3	25.6	3.2	332
Rhodomela	0	0	0.1	0	0
Laminaria	124.4	0	379	112	0
Katharina	0	4.1	24.8	37	0
Ulvales	11.4	1.5	0.0	70.6	62.4
Spongomorpha	62.4	0	3.6	6	112
Balanus cariosus	177.4	5.5	382.5	69	2.9
Collisella pelta	14.1	2.9	4.5	0.8	0
Phyllospadix	0	0	0	0	0
Halosaccion	1.1	0.4	65.2	8	0

* from 9 of 15 quadrats † from 8 of 15 quadrats
§ from 12 of 27 quadrats ¶ from 4 of 8 quadrats
** from 3 of 7 quadrats

Table 11.--Ranked order (from 1, most dense, to 10, least dense) of biomass (mean wet weight in grams per square meter) for 16 dominant organisms along transect lines at nine rocky beach sites in the Kodiak Island area, 1975 and 1976. Sites are arranged, left to right, from partly protected, nonflat sites to exposed, flat sites.

	Partly Protected				Exposed					
	Nonflat				Nonflat		Flat			
Organism	Bedrock Three St. Bay	Small boulders Lagoon Point #3	Large boulders Lagoon Point #1,2	Large boulders Cape Kaguyak	Bedrock Sundstrom Island	Large boulders Sud Island	Bedrock Chirikof Island	Small boulders Dolina Point	Bedrock Cape Sitkinak	Small boulders Low Cape
Spongomorpha	3	4	1	2	6	5	9	7	9	9
Rhodymenia	6	5	3	4	2	1	8	7	9	10
Katharina	1	4	3	5	2	6	9	7	8	10
Alaria	3	1	2	4	7	6	5	8	9.5	9.5
Laminaria	8	1	3	6	2	4	7	5	10	9
Balanus cariosus	1	6	2	8	3	5	10	4	9	7
Porifera	1	6	8	3	2	7	5	4	10	9
Mytilus	1	10	2	-	3	5	9	6	8	4
Halosaccion	7	5	2	6	4	3	1	9.5	8	9.5
Ulvales	8	1	3	4	5	7	6	2	9.5	9.5
Fucus	7	10	5	2	4	1	3	6	8	9

Table 11.--Continued.

	Partly Protected				Exposed					
	Nonflat				Nonflat		Flat			
Organism	Bedrock Three St. Bay	Small boulders Lagoon Point #3	Large boulders Lagoon Point #1,2	Large boulders Cape Kaguyak	Bedrock Sundstrom Island	Large boulders Sud Island	Bedrock Chirikof Island	Small boulders Dolina Point	Bedrock Cape Sitkinak	Small boulders Low Cape
Littorina	5	10	9	3	2	1	4	8	6	7
Odonthalia	3	6	5	10	2	9	1	4	7	8
Collisella pelta	2	9	10	7	4	5	6	1	3	8
Rhodomela	8.5	8.5	8.5	8.5	5	6	4	2	1	3
Phyllospadix	7.5	7.5	7.5	7.5	1	7.5	4	2	3	7.5
All species*	4	5	†	6	2	1	3	7	9	8
All plant species*	4	5	†	7	3	1	2	6	8	9
All invertebrate species*	3	5	†	6	1	2	4	8	9	7

* Includes all species sampled and not only those listed above.
† Lagoon Point data were pooled

hummocks, surge channels, or large boulders, to exposed, flat areas which usually had little relief and were often covered with tide pools and standing water. Although no significant relationships were noted between biomass and habitat type for algal or invertebrate groups, biomass did tend to vary along these gradients for many individual species (Table 11). A Mann-Whitney test (Conover 1971) showed these trends to be significant ($p<0.05$) for five genera. The biomass of Spongomorpha and Alaria was greater per square meter along transect lines in partly protected and nonflat areas than in exposed and flat areas, the biomass of Rhodymenia and Katharina was also greater in nonflat areas than in flat areas, and the biomass of Rhodomela was greater in exposed and flat areas than in partly protected and nonflat areas. No significant differences ($p>0.05$) were noted in biomass between boulder areas and nonflat bedrock areas for any species or group of species.

Similar analyses between species richness (number of species) and habitat type (Tables 12 and 13) showed no significant relationships ($p>0.05$). However, the highest species richness for both algae and invertebrates occurred along transect lines at exposed, nonflat, bedrock and boulder sites while the lowest species richness for these groups occurred at exposed, flat, bedrock sites.

Finally, the nine rocky sites were categorized according to habitat--exposure (partly protected, exposed), vertical relief (flat, non-flat), and substrate (boulders, bedrock)--and the habitat categories were tested against the average biomass per sample (wet weight in grams per square meter) of the same 16 organisms at each site (Table 14). Four of the organisms showed consistent relationships to habitat: Katharina, Rhodomela, Rhodymenia, and Spongomorpha. In each case, the most definite relationship was to vertical relief (flat vs. nonflat), with Rhodomela being found in exposed, flat habitats while the other three were more common in nonflat habitats.

Cover Estimates

Because the transect line collection method was not always representative of all habitats present, we also estimated the percent of cover of dominant species, usually macrophytes, in quadrats along several additional transect lines. Earlier studies (Zimmerman 1975) had indicated that, for most species, percent cover is highly correlated with biomass.

Data from these estimates (Table 15) are similar to the quantitative sampling data. Again, Rhodomela was most common at flat, exposed sites. Gigartina, a species not found in quantitative collections, was also dominant at flat, exposed sites. Alaria and Rhodymenia were most common on the nonflat beaches.

Qualitative Observations with Emphasis on the July 1976 Survey

The purpose of qualitatively observing several different habitats was to discern general trends which might have been overlooked due to the inherent limitations of transect lines and to provide additional observations to verify trends observed during previous work. Some of the major trends are discussed below.

Table 12.--Number of species identified in each major taxonomic group from transect lines sampled at nine rocky beach sites in the Kodiak Island area, 1975 and 1976.

	Partly Protected				Exposed					
	Nonflat				Nonflat		Flat			
Taxonomic group	Bedrock Three St. Bay	Small boulders Lagoon Point #3	Large boulders Lagoon Point #1,2	Large boulders Cape Kaguyak	Bedrock Sundstrom Island	Large boulders Sud Island	Bedrock Chirikof Island	Small boulders Dolina Point	Bedrock Cape Sitkinak	Small boulders Low Cape
Chlorophyta	9	7	*	3	9	9	9	2	1	0
Phaeophyta	7	10	*	6	15	18	23	5	3	2
Rhodophyta	25	18	*	14	34	41	33	22	17	12
Porifera†	1	1	*	1	1	1	1	1	1	1
Cnidaria†	3	2	*	1	1	2	1	1	1	1
Turbellaria†	1	1	*	1	1	1	1	1	1	1
Rhynchocoela†	1	1	*	1	1	1	1	1	1	1
Nematoda†	1	1	*	1	1	1	1	0	0	1
Annelida§	44	4†	*	1†	57	56	43	1†	1†	1†
Polyplacophora	5	3	*	2	7	3	2	1	0	1
Pelecypoda	6	6	*	5	9	7	7	6	1	5
Gastropoda	22	30	*	16	29	22	18	14	11	14
Arachnida†	1	1	*	1	1	1	1	0	0	0

Table 12.--Continued.

Taxonomic group	Partly Protected				Exposed					
	Nonflat				Nonflat		Flat			
	Bedrock Three St. Bay	Small boulders Lagoon Point #3	Large boulders Lagoon Point #1,2	Large boulders Cape Kaguyak	Bedrock Sundstrom Island	Large boulders Sud Island	Bedrock Chirikof Island	Small boulders Dolina Point	Bedrock Cape Sitkinak	Small boulders Low Cape
Pycnogonida†	1	0	*	2	2	2	2	1	3	2
Crustacea§	23	15†	*	10†	20	26	23	9†	9†	14†
Bryozoa†	1	1	*	1	3	3	1	0	0	0
Asteroidea	1	1	*	2	3	1	2	1	1	2
Ophiuroidea	1	1	*	1	2	1	1	0	0	0
Holothuroidea	1	2	*	1	0	2	1	1	1	1
Echinoidea	1	1	*	0	0	0	0	0	0	0
Total species¶	155	106	*	70	196	198	171	66	52	59
Plant species¶	41	35	*	23	58	68	65	29	21	14
Invertebrate species¶	114	71	*	47	138	130	106	37	31	45

* All Lagoon Point data were pooled.
† Organisms not identified to species level at all sites.
§ Most organisms not identified to species.
¶ Includes all species collected, not only those in the above groups.

Table 13.--Ranked order (from 1, most dense, to 9, least dense) of species richness (numbers of species) in selected taxonomic groups (those with the "easiest" species to identify) from transect lines at nine rocky beach sites in the Kodiak Island area, 1975 and 1976. Sites are arranged, left to right, from partly protected, nonflat sites to exposed, flat sites.

Taxonomic group	Partly Protected				Exposed					
	Nonflat				Nonflat		Flat			
	Bedrock Three St. Bay	Small boulders Lagoon Point #3	Large boulders Lagoon Point #1,2	Large boulders Cape Kaguyak	Bedrock Sundstrom Island	Large boulders Sud Island	Bedrock Chirikof Island	Small boulders Dolina Point	Bedrock Cape Sitkinak	Small boulders Low Cape
Chlorophyta	2.5	5	*	6	2.5	2.5	2.5	7	8	9
Phaeophyta	5	4	*	6	3	2	1	7	8	9
Rhodophyta	4	6	*	8	2	1	3	5	7	9
Annelida†	3	5§	*	7.5§	1	2	4	7.5§	7.5§	7.5§
Polyplacophora	2	3.5	*	5.5	1	3.5	5.5	7.5	9	7.5
Pelecypoda	5	5	*	7.5	1	2.5	2.5	5	9	7.5
Gastropoda	3.5	1	*	6	2	3.5	5	7.5	9	7.5
Crustacea†	2.5	5§	*	7§	4	1	2.5	8.5§	8.5§	6§
Total species¶	4	5	*	6	2	1	3	7	9	8
Plant species¶	4	5	*	7	3	1	2	6	8	9
Invertebrate species¶	3	5	*	6	1	2	4	8	9	7

* Lagoon Point data were pooled.
† Organisms not identified to species at all sites.
§ Most organisms not identified to species.
¶ Includes all species collected, not only those in the above groups.

Table 14.--Average biomass (wet weight in grams per square meter) of 16 organisms along transect lines at nine rocky beach sites in the Kodiak Island area, 1975 and 1976.

	Partly Protected				Exposed					
	Nonflat				Nonflat		Flat			
Taxonomic group	Bedrock Three St. Bay	boulders Lagoon Point #3	boulders Lagoon Point #1,2	boulders Cape Kaguyak	Bedrock Sundstrom Island	boulders Sud Island	Bedrock Chirikof Island	boulders Dolina Point	Bedrock Cape Sitkinak	Small boulders Low Cape
Spongomorpha	46.67	23.11	119.65	55.57	9.52	17.06	0.00	1.13	0.00	0.00
Rhodymenia	26.91	69.89	297.02	120.53	409.41	634.78	2.30	7.03	0.80	0.00
Katharina	714.45	27.02	88.75	19.95	249.43	13.24	0.00	0.00	0.00	0.00
Alaria	2,977.60	4,801.42	3,016.55	1,738.24	578.90	656.85	1,209.68	200.00	0.00	0.00
Laminaria	6.91	1,820.62	1,123.80	59.73	1,253.52	216.11	11.85	72.97	0.00	0.21
Balanus cariosus	12,210.70	189.51	1,036.30	38.51	898.88	232.25	0.12	321.72	1.75	105.34
Porifera	1,536.34	97.78	28.20	157.01	511.04	87.84	149.12	152.20	0.00	1.54
Mytilus	1,299.76	0.00	1,007.35	0.11	33.21	27.20	0.00	0.71	0.00	28.15
Halosaccion	2.11	50.22	16.68	10.13	23.78	32.30	56.02	0.00	1.82	0.00
Ulvales	1.72	156.80	77.60	66.78	57.34	3.20	32.47	133.40	0.00	0.00
Fucus	30.06	0.00	278.85	766.93	588.17	1,028.45	671.19	184.84	11.71	0.39
Littorina	15.26	0.53	6.45	82.56	11.20	7.16	147.73	68.45	11.20	10.66
Odonthalia	182.79	124.09	138.45	0.21	917.24	12.43	1,023.71	178.19	86.62	56.61
Collisella pelta	11.61	0.00	0.00	0.43	10.88	6.45	4.06	13.46	11.56	0.18
Rhodomela	0.00	0.00	0.00	0.00	43.88	0.07	113.87	289.30	782.33	197.07
Phyllospadix	0.00	0.00	0.00	0.00	512.06	0.00	0.00	65.56	21.24	0.00

Table 15.--Plants and Bryozoa ranked by estimates of percent cover at rocky beach sites in the Kodiak Island area, May 1976. Asterisk indicates dominance and/or consistency.

Tidal elevation (ft)	Nonflat					
	Boulders (Cape Kaguyak)			Boulders (Lagoon Point)		
	Transect 1	Transect 2	Transect 3	Transect 1	Transect 2	Transect 3
-2.0 to 0.0	*Alaria Ulva-Monostroma Laminaria Coralline algae	*Iridea Alaria Coralline algae	no observation	*Alaria Bryozoa Laminaria Lithothamnion	*Alaria Lithothamnion Bryozoa	*Alaria Ondonthalia Lithothamnion Bryozoa
0.1 to 2.0	*Alaria *Rhodymenia Iridea Spongomorpha	*Alaria *Rhodymenia Spongomorpha Ulva-Monostroma	Fucus (1 observation)	*Alaria Rhodymenia Ulva-Monostroma Spongomorpha	*Alaria Rhodymenia Ulva-Monostroma Spongomorpha	*Rhodymenia Bryozoa Alaria Ulva-Monostroma
2.1 to 4.0	*Porphyra Fucus Rhodymenia Enteromorpha	*Fucus *Porphyra *Ulva-Monostroma Rhodymenia	*Fucus (patchy) Gloiopeltis	Odonthalia Fucus Iridea (1 observation)	*Halosaccion *Rhodymenia Fucus Ulva-Monostroma	Fucus (sparse)
4.1 to 6.0	no algae	Porphyra Fucus (both sparse) (1 observation)	no algae	*Fucus	no algae	no algae
6.1 +	no algae (1 observation)	no observation	no algae	no observation	Porphyra (sparse) (1 observation)	no algae

Table 15.--Continued.

Tidal elevation (ft)	Flat: Bedrock (Cape Sitkinak) Transect 1	Flat: Bedrock (Cape Sitkinak) Transect 2	Flat: Cobble (Low Cape) Transect 1	Flat: Cobble (Dolina Point) Transect 1
-2.0 to 0.0	*Odonthalia *Rhodomela *Gigartina *Iridea	*Odonthalia Rhodymenia Gigartina	*Rhodomela *Rhodymenia Lithothamnion Bossiella	no observation
0.1 to 2.0	*Odonthalia Gigartina Iridea Fucus	*Gigartina *Iridea Rhodymenia	*Odonthalia Bossiella Rhodymenia	*Alaria Odonthalia *Rhodomela Ulva-Monostroma
2.1 to 4.0	no algae	Halosaccion Endocladia (sparse)	*Odonthalia Bossiella Lithothamnion Rhodymenia	*Odonthalia Rhodomela Fucus Ulva-Monostroma
4.1 to 6.0	no algae	no algae	*Odonthalia Fucus	*Odonthalia (sparse)
6.1 to 8.0	no algae	no algae	Odonthalia (sparse)	no observation

Invertebrates

Populations of attached intertidal invertebrates were reduced at exposed outer coast locations. This situation agrees with other intertidal areas of the west coast of North America. Dayton (1973) states that along the open coast of Washington, algae are competitive dominants over invertebrates; Rickets and Calvin (1968) noted that animals are most abundant along partially protected shores and least abundant along entirely unprotected or completely sheltered shores. Some examples follow.

Mytilus edulis.--This mussel is called a "quiet-water animal" by Rickets and Calvin (1968). Although it is very abundant at many locations in the Kodiak Island area, it was not collected, or occurred in very low densities, at most exposed sites such as Chirikof Island, Sud Island, Sundstrom Island, Otter Island, and Narrow Cape. In more protected locations such as Three Saints Bay, Lagoon Point, Tonki Bay, and St. Paul Harbor, this species was quite common and formed dense bands in the middle intertidal zone. It is not entirely limited to these circumstances, however, as we found it growing on flat, exposed bedrock at Narrow Cape and it was almost absent at the partly protected site at Cape Kaguyak.

Balanus cariosus.--This barnacle occurred at almost all of our sites. It appeared, however, that there was a tendency for the species to be less common at exposed bedrock (especially flat bedrock) sites such as Chirikof Island, Cape Sitkinak, Pillar Cape, and Sea Otter Island, and more common at protected sites such as Thre Saints Bay, Lagoon Point, Tonki Bay, and St. Paul Harbor. Individuals at the latter sites often were relatively quite large.

Katharina tunicata.--This chiton was also a ubiquitous species but it was not very common on exposed, flat, bedrock beaches or small boulder beaches such as the Geese Islands, Chirikof Island, Cape Sitkinak, Low Cape, and Dolina Point. The preferred habitat was immovable substrate with vertical relief.

Predatory snails and sea stars.--Several predatory invertebrates commonly were found in the intertidal zone. Although some species such as *Nucella lima* and *Leptasterias hexactis* were ubiquitous, other common forms such as *N. lamellosa*, *Evasterias troschelii*, and *Pisaster ochraceus* were most abundant in protected habitats. Thus, we found large numbers of *N. lamellosa* and *E. troschelii* at Tonki Bay and St. Paul Harbor while no individuals were seen at Chirikof Island, Cape Sitkinak, and Sud Island.

Plants

Qualitative observations at several sites indicated predictable occurrences for two plant species, the red alga *Rhodomela larix* and the surf grass *Phyllospadix* sp. These plants occurred most commonly and in highest densities on flat, bedrock beaches. *Rhodomela larix* were seldom encountered except in this type of habitat. *Phyllospadix* were occasionally found growing in small patches in other habitats, but it formed extensive beds only on flat, bedrock beaches like Chirikof Island, Geese Islands, and Cape Sitkinak. While the occurrence of *Phyllospadix* on flat, bedrock sites was dramatic, most of our quantitative collections were not made in the extensive *Phyllospadix* beds. Thus, the relative dominance of this species is not apparent from transect line data.

Substrate stability

Most intertidal organisms require a stable substrate for survival. Unstable substrates (sand, gravel, cobble, boulder) usually support fewer and different organisms than do stable substrates (bedrock or large boulders). Small boulders at exposed sites such as Low Cape are tumbled by heavy wave action, so neither plants nor animals survive. We found very low densities of biota at exposed, small boulder sites like Low Cape and the southeastern side of Whale Island. Densities were much higher on similar-sized boulders in more protected locations like the southwestern side of Whale Island and North Shuyak Island.

It also appeared that scouring by sand or gravel was responsible for preventing colonization of adjacent bare rock surfaces.

Primary Productivity in the Kodiak Island Area

Marine phytoplankton productivity is generally assumed to exceed marine macrophyte productivity on a world-wide basis (Ryther 1969). It is apparent, however, that the productivity of coastal systems may be greatly enhanced by macrophyte production. In St. Margaret's Bay, Nova Scotia, an area with a high ratio of shoreline to water area, macrophyte production has been estimated to be three times that of phytoplankton (Mann 1972).

In the Kodiak Island area, a luxurient growth of macrophytes occurs in a band from approximately the 20 m curve to mean high water of the intertidal zone. This band varies from about 400 m to 10,000 m in width. The intricate coastline of the Kodiak Island area, with its many bays, straits, islands, and reefs, results in a high ratio of shoreline (3,540 km) to water area.

The importance of kelp productivity in maintaining populations of crustaceans has been shown by Miller et al. (1971) for lobsters in eastern Canada. In this case the lobsters do not feed directly on the algae, but on herbivores such as urchins and on other animals higher up the food chain.

Kelps and other algae have been shown to have a direct relationship to king crab in Alaska. Bright et al. (1959) analyzed stomach contents of Cook Inlet king crab and commonly found several species of algae, including *Laminaria* and *Agarum*. The herbivorous green urchin, *Strongylocentrotus droebachiensis*, which feeds primarily on the kelps, was abundant in crab stomachs and was the most abundant food in the stomachs of small (30 to 50 mm) crabs.

Benthic (Non-Floating) Kelps

As part of our study, divers sampled subtidal kelps quantitatively at nine sites in the Kodiak Island area. Results of this study are being published separately (Calvin and Ellis 1978). Unless otherwise noted, the following information is from this study.

The biomass (mean wet weight) of benthic kelps at the sites, sampled over a depth range of 1.3 to 10 m, ranged from 4.8 to 18.3 kg/m^2. This range compares favorably with biomass in other parts of the world (Table 16). The most abundant species in the quadrats were *Laminaria dentigera*, *L. yezoensis*,

Table 16.--Summary of standing crop of benthic kelps from Kodiak Island and other areas. (All sampling was by hand collecting with scuba excepting MacFarlane who used grab sampling and cutting by hand).

Source	Location	Species	Season of sampling	Number of sites	No. of quadrats collected	Depths sampled (m)	Biomass (mean wet weight*)
Luning 1969	Helgoland, Germany	*Laminaria hyperborea*	Aug. to Nov.	--	61	0-5.5	0.1-11.1 kg/m^2
Mann 1972	Nova Scotia	*L. longicruris* and *L. digitata*	Summer	24	--	--	5.0-16 kg/m^2 (estimates)
MacFarlane 1952	Nova Scotia	*L. longicruris*	Summer	--	--	--	6.0-29 kg/m^2
Jupp and Drew 1974	Scotland	*L. hyperborea*	Dec., Jan., Mar., June	1	22	3 and 9	7.7 and 20.4 kg/m^2
John 1971	Spain	*L. ochroleuca* and *Saccorhiza polychides*	Sept.	7	--	1.6-18.6	0.26-17.9 kg/m^2†
Calvin and Ellis 1978	Kodiak Is., Alaska	*L. dentigera* and other non-floating kelps	May	9	55	1.3-10	4.8-18.3 kg/m^2

* The means are for different depths for some studies and different geographic areas for others.

† Estimated from organic weight figures.

Pleurophycus gardneri, and Agarum cribrosum. L. dentigera was usually dominant, with its greatest development at depths between 3 and 10 m where it reached a maximum size larger than has been reported elsewhere (maximum length 428 cm, maximum width 85 cm).

Canopy (Floating) Kelps

In 1913 a survey was made of floating kelps (Nereocystis luetkeana and Alaria fistulosa) in the Kodiak region (Rigg 1915). The total standing stock weight was estimated to be 2,588,106 tons (2.3×10^9 kg). Aerial surveys (Sears and Zimmerman 1977) confirmed that in 1976 the location of the beds was much the same as it was in 1915. We collected two representative specimens of N. luetkeana to determine their size as an aid in evaluating the role of kelps in the Kodiak Island area. The net weight of one specimen was 39.5 kg and of the other, 40.4 kg. Judging from the immense size of these N. luetkeana, the large size of Laminaria dentigera (see above), and the wide distribution and density of these plants around Kodiak Island, it seems ideal kelp habitat.

Productivity of Phytoplankton

Using coastal charts we determined that the Kodiak Island area's outer continental shelf occupies 3.57×10^{10} m^2. This includes all of the marine areas within the 100-fathom line from southwest of the Trinity Islands (56° 35'N, 155° 05'W) to the western side of Portlock Banks (58° 35'N, 152° 00'W).

Although no direct measurements are available, primary production by phytoplankton in the Kodiak Island area is thought to exceed 200 g/C/m^2/yr (U.S. Department of the Interior 1977). Assuming a uniform phytoplankton productivity of 0.2 kg/m^2/yr throughout the shelf area,the total value would be 7.14×10^9 g/C/m^2/yr.

Estimates of Biomass

One of the purposes in taking quantitative samples was to estimate the biomass of particular organisms present on certain stretches of coastline. The biomass estimate represents the amount of a resource at stake in a certain area and can be one of the many parameters weighed in assessing potential environmental impact in different areas. For example, relative biomass values for several species in an area are used by Isakson et al. (1975) in comparing postulated oil impacts. Also, biomass information may someday be useful in evaluating the roles of intertidal organisms in the total ecosystem. In this section a simple approach for making the biomass estimates is used.

As described in a previous section, sampling was done along transect lines laid perpendicular to the shoreline and quadrat samples were taken at regular intervals along the lines. (Transect lines laid parallel to the shoreline and/or laid all in one zone or at one elevation are ignored in this analysis.) The lines extended from above the highest level at which significant amounts of intertidal organisms were found to as low a level as possible depending on the state of the tide. This was at least the 0-ft tide level in most cases. Data were analyzed from 12 sites with one to three transect lines sampled per site.

For each species an estimate was obtained for each transect line j of the biomass $\hat{B}_{ij}$ lying along a 1-m-wide section of beach under the transect line at site i:

$$B_{ij} = \sum_{k=1}^{l} B_{ijk} P_{ij}$$

where B_{ijk} = biomass (wet weight in grams) in sample k of line j of site i,
P_{ij} = sampling interval (meters) ÷ quadrat size (square meters) used at transect line j of site i, and
l = number of samples in line j at site i.

Whenever a site was sampled by more than one transect line or one visit to the same transect line, the lines or visits were assumed to be random in time and space within the site. All lines for that site were averaged to an unweighted estimate,

$$B_{i\cdot} = \sum_{j=1}^{n} B_{ij}/n$$

for that site i, where n = number of transects.

If it can be assumed that the sites are chosen randomly from among all rocky beaches and the transect lines are random within sites, then an estimate of the average biomass of a particular species per unit length (meter) of rocky shoreline can be obtained,

$$\hat{B}_{\cdot\cdot} = \sum_{i=1}^{n'} B_i/n'$$

where n' = number of sites.

An estimate of the amount of rocky shoreline was obtained from the aerial surveys (Zimmerman et al. 1977a). An estimate of total biomass of particular species on rocky beaches (species may not be exclusive to rocky beaches) in the Kodiak Island area equals the total length (meters) of rocky beaches multiplied by biomass per unit length, $\hat{B}$... The confidence interval for such an estimate, assuming length of rocky beach is a known constant, is proportional to the confidence interval of the $\hat{B}_{\cdot\cdot}$, which can be calculated assuming $\hat{B}_{\cdot\cdot}$ is normally distributed and its variance is estimated by $S^2_{B_i}/n$.

Estimates for total biomass of different intervals within the Kodiak Island area were made by knowing the lengths of rocky shoreline within the area and making the appropriate multiplication. This assumes either that the rocky beach types are proportioned equally among the intervals or there is no difference in B_i's between the beach types and also that there are no geographically correlated differences in B_i's within beach types.

$B_{\cdot\cdot}$ as estimated from the 12 B_i's and the sample standard deviation B_i were calculated for _Fucus_, where $B_{\cdot\cdot}$ = 38,265.85 g/m and S_{B_i} = 37,853.71.

Combining this with information from Table 1 results in an estimate of (38,265.85 g/m x 1,609 m/mile x [1,160 + 304.5] miles of rocky beach) = 9.02 x 10^7 kg of _Fucus_ on rocky beaches of the Kodiak Island region. A 95%

confidence interval is calculated to be:

$$\{38.26585 \pm t_{.05} \frac{(37.854)}{\sqrt{12}} (1{,}609 \times [1{,}160 + 304.5])\} = 3.35 \times 10^7 \text{ kg}$$

$\leq$ total biomass $\leq 1.47 \times 10^8$ kg.

One of the precautions that should be taken when making comparisons within the whole area is to check the assumption that there is no significant difference between the B_i's on different types of rocky beaches. This is important if we know the beach types are not proportioned equally among all areas. In the case of Fucus, no significant differences between bedrock vs. boulder beaches, flat vs. nonflat beaches, or exposed vs. protected beaches were detected. However, because of large within-beach-type variability and small number of samples, the power of our tests was quite low and large differences could go undetected.

There are several other factors which could tend to limit the applicability of our data to this type of analysis:

1) Sites were not chosen entirely randomly. Biomass estimates are biased in favor of gently sloping beaches (with spatially wide zonation) since vertical beaches (with spatially narrow zonation) are more difficult or impossible to sample. We also attempted to sample examples of as many types of beaches as possible. Some of these may have been geographically rare and therefore could have received disproportionate emphasis.

2) Sampling at each site was not entirely random. Transect lines were chosen for representativeness of biological cover. Though no conscious attempt was made to choose areas of high biotic abundance, those were often the areas of greatest biological interest or were representative of most of the beach.

3) Time of visits may influence some of the biomass estimates. For instance, motile invertebrate species such as Nucella or ephemeral algae such as Porphyra may occur during certain seasons but not others.

4) Estimates for some species, especially Alaria, are known to be incorrect due to incomplete sampling of their entire vertical range and wide seasonal variation of biomass.

Estimates of Species Diversity

Measures of diversity were calculated for most transect line samples from rocky beaches, but the usefulness of these calculations is very limited. A serious problem which was not resolved, particularly for animals, was that the number of species found depends on how exhaustively the collections were made. Many of the smaller animals hide under rocks and in crevices where they could not be recovered. Therefore, it should be emphasized that the species diversity calculations apply to the samples as collected and not necessarily to the intertidal population as a whole. We undoubtedly missed some species which were present. Brillouin's formula for measuring information content per symbol in a finite message as recommended by Pielou (1969) for completely censused collections was used. The formula is:

$$H = \frac{1}{N} \sum_{1}^{s} \ln \frac{N!}{N_1!N_2!\ldots N_s!},$$

where N is the total number of individuals, s is the number of exclusive taxa (species), and N_i is the number of individuals in the ith taxa, so that $\Sigma N_i = N$.

The wet-weight units of plant-type* species were treated as individuals to be compatible in the factorial functions of the formula (Pielou 1969). Diversities of plant-type (weights) and animal-type† (numbers) species were calculated separately.

Animal Species Diversity

Animal species diversity was divided into three components:

1) H(C) is the "class diversity" of the taxa listed in Table 17. Some of the taxa are classes and others are orders or phyla, but each is exclusive of all the others. Collections can be consistently and confidently identified to these taxa, so this component will be consistent and comparable between collections.

When an attempt was made to identify organisms to a taxonomic level beyond those used in H(C), i.e., family, genus, or species, two categories exist.

2) $H_C(S)_A$ is the weighted average of the "within-class" diversity of the "classes" in group A of Table 17. "Classes" in group A are moderately consistent in their identification to the species level and tend to be diverse in our samples.

3) $H_C(S)_B$ is the weighted average of the measurable "within-class" diversity of the "classes" in group B of Table 17. Identification to the more specific levels is not consistent in group B "classes". The measurable diversity of these "classes" also tends to be low in our collections, either because of lack of specific identification capabilities as in Oligochaeta or actual low diversity as in Asteroidea.

Thus, $H_C(S)_A$ is moderately consistent between collections and may be compared as a measure of diversity, while $H_C(S)_B$ cannot be used as a consistent measure of diversity but will hopefully be near-zero much of the time.

It can be shown that summing the three components will equal the simple "species" diversity index H calculated from the most specific level of identification (Pielou 1969). H(C) is by far the largest component of H, so a large portion of the diversity is measured in the most comparable component.

Plant Species Diversity

Plant species diversity is divided into H(C) and $H_C(S)$. The plant "classes" are listed in Table 18. $H_C(S)$ is the weighted average of the "within-class"

* Plant-types are those species where morphometry makes it impossible to count individuals, e.g., sponges and some algal species.

† Animal-types are those species which can be individually counted, e.g., mussels and barnacles.

Table 17.--Animal taxa that were identified consistently and confidently in intertidal collections.

Group A Taxa: Identification to species level moderately consistent	Group B Taxa: Organisms not always identified to species level or groups are of low diversity
Polychaeta	Hydroidea
Polyplacophora	Turbellaria
Pelecypoda	Rhyncocoela
Gastropoda	Oligochaeta
Thoracica	Pycnogonida
Cumacea	Asteroidea
Isopoda	Echinoidea
Amphipoda	Holothuroidea
Decapoda	Sipunculida
	Echiuroidea
	Brachiopoda
	Teleostei
	Harpactacoida
	Acarina

Table 18.--Taxa used to calculate measures of diversity for plants.

Taxa
Ulotrichales
Cladophorales
Codiales
Ectocarpales
Spacelariales
Chordariales
Desmarestiales
Dictyosiphonales
Bangiales
Nemalionales
Cryptonemiales
Gigartinales
Rhodymeniales
Ceramiales
Bacillariophyceae
Phycomycetes
Lichens
Anthophyta
Porifera
Bryozoa
Urochordata

species diversity of all taxa. Our analysis shows that H(C) measures the major portion of the diversity in plant species also.

In making calculations it was assumed that organisms not identified to species are distinct from other organisms of the same taxa that have been identified to species and that the unspecified organism represents only one species unless otherwise noted.

Results

After measures of diversity were calculated for most transect line samples from rocky beaches, class diversity [H(C)] for animal-type organisms and species diversity [H(C) + H_C(S)] for plant-type organisms were plotted versus sample elevation (Figures 106-109). Very little of interpretable significance was readily apparent. It does appear, however, that samples from Three Saints Bay had significantly higher animal diversity measures, and that Lagoon Point and Cape Sitkinak had a greater than average proportion of samples with zero plant diversity. Comparisons between stations are confounded by elevation effects, although relationships between elevation and diversity measure are not obvious in the data.

Within-site analyses also indicated that little was gained by calculating diversity data. For instance, at Sud Island (Table 19), as would be expected, plant diversity and number of species were low above the zone of *Fucus* dominance (greater than 2.1 m). Below the 2.1-m level the number of species and the diversity values were relatively the same although two of the lines showed slightly higher values in the zones dominated by red algae.

Correlation Analysis

Transect line data from the 1976 *Surveyor* cruise (Lagoon Point, Cape Kaguyak, Dolina Point, Low Cape, Cape Sitkinak) were pooled and correlation coefficients (*r*) were calculated for 1,196 pairs of organism variables. Correlations included plant weight with plant weight (Table 20), plant weight with animal number (Table 21), plant weight with animal weight (Table 22), animal number with animal number (Table 23), and animal weight with animal weight (Table 23).

Although *r* exceeded the table values for significance for several pairs*, none was greater than 0.6. Several suspected associations were indicated but many unexplained correlations were also found. Because of the low values, it was felt that these results should not be used, by themselves, to indicate organism associations.

INTERTIDAL SURVEY--SANDY AND GRAVELLY BEACHES

The Kodiak Island area has approximately 776 miles of gravelly beaches and 192 miles of sandy beaches (Table 1). These gravelly and sandy beaches occur predominantly near river mouths or on the southeast and northwest sides of Kodiak Island and on Chirikof Island and the Trinity Islands. They

* Normality assumptions of the *r* statistic are severely violated so statistical significance is misleading.

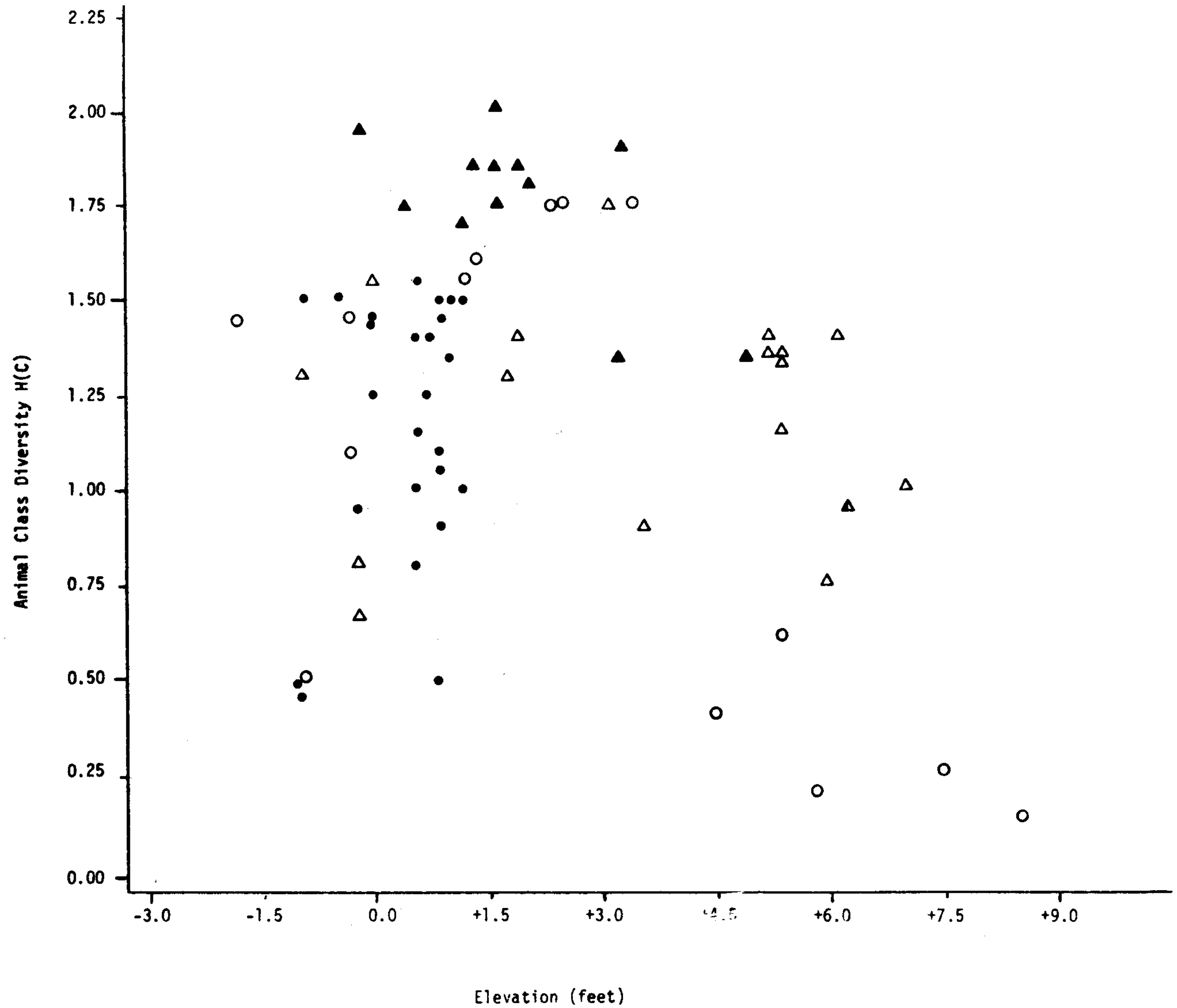

Figure 106. Class diversity, H(C), per quadrat of animals sampled at Sud Island ○, Chirikof Island ●, Sundstrom Island △, and Three Saints Bay ▲ during May 1975.

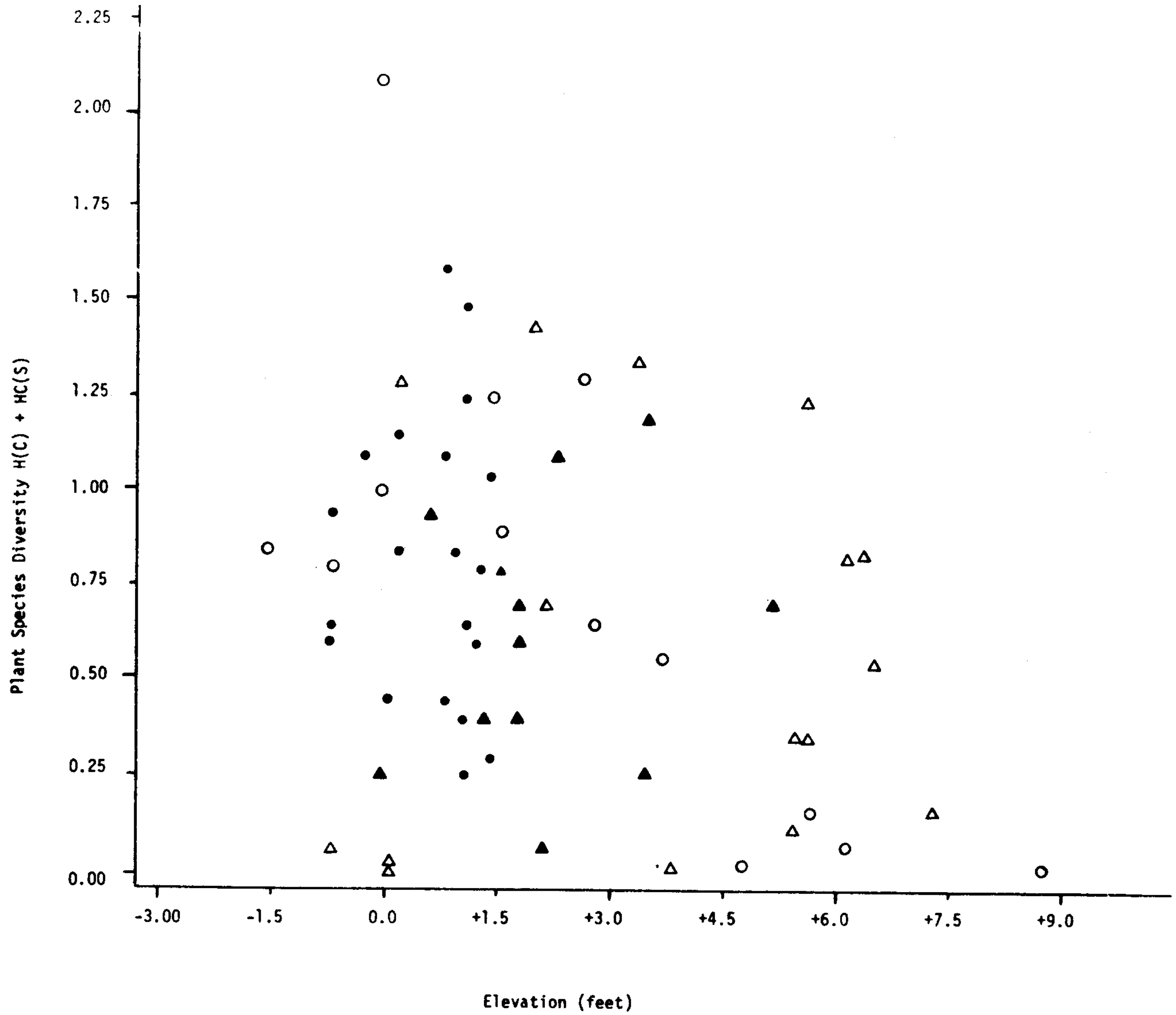

Figure 107. Species diversity, H(C)+HC(S), per quadrat of plant-type organisms sampled at Sud Island O, Chirikof Island ●, Sundstrom Island △, and Three Saints Bay ▲ during May 1975.

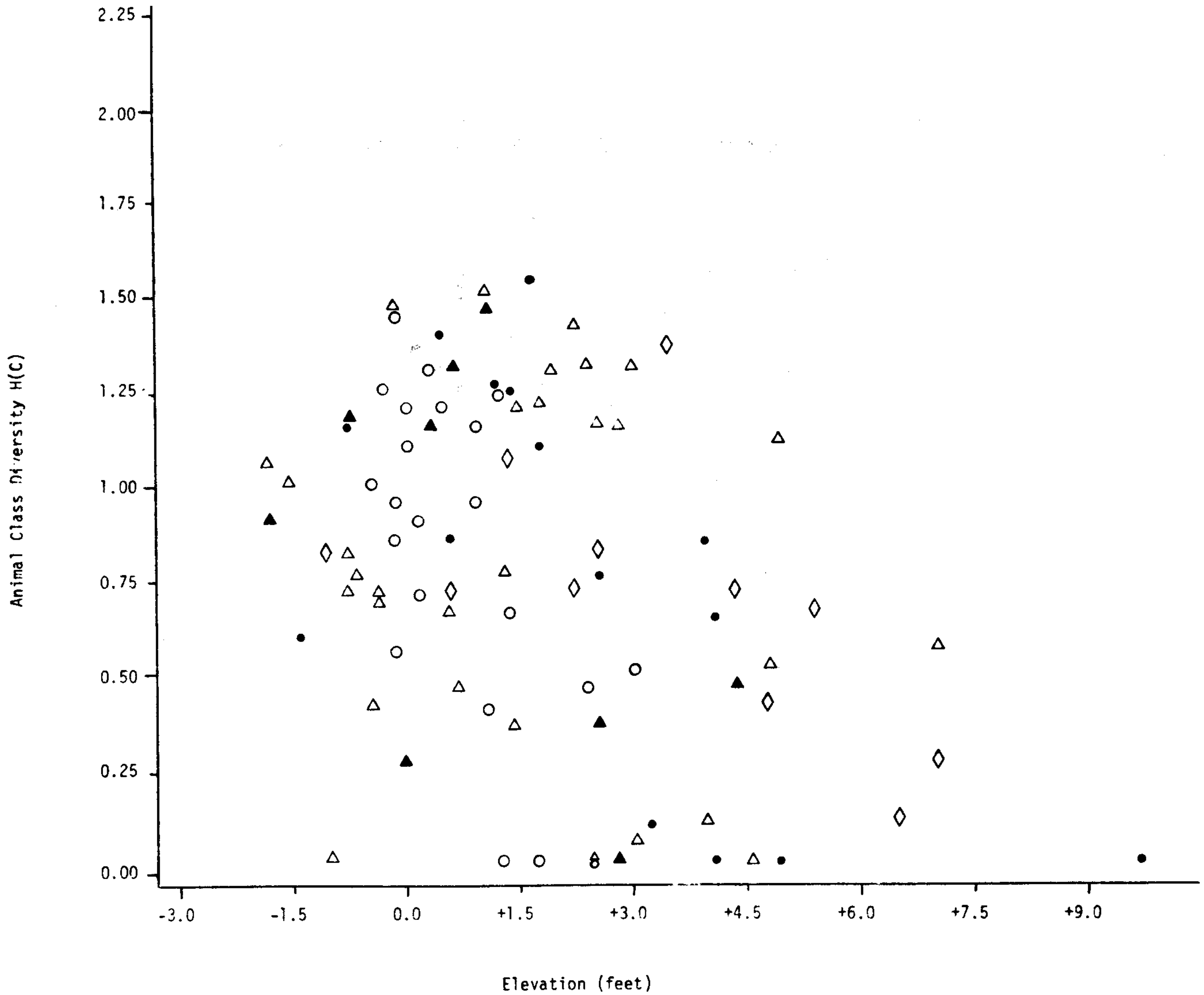

Figure 108. Class diversity, H(C), per quadrat of animals sampled at Cape Sitkinak ○, Cape Kaguyak ●, Lagoon point (transects 1 and 2) △, Lagoon Point (transect 3) ▲, and Low Cape ◊ during May 1976.

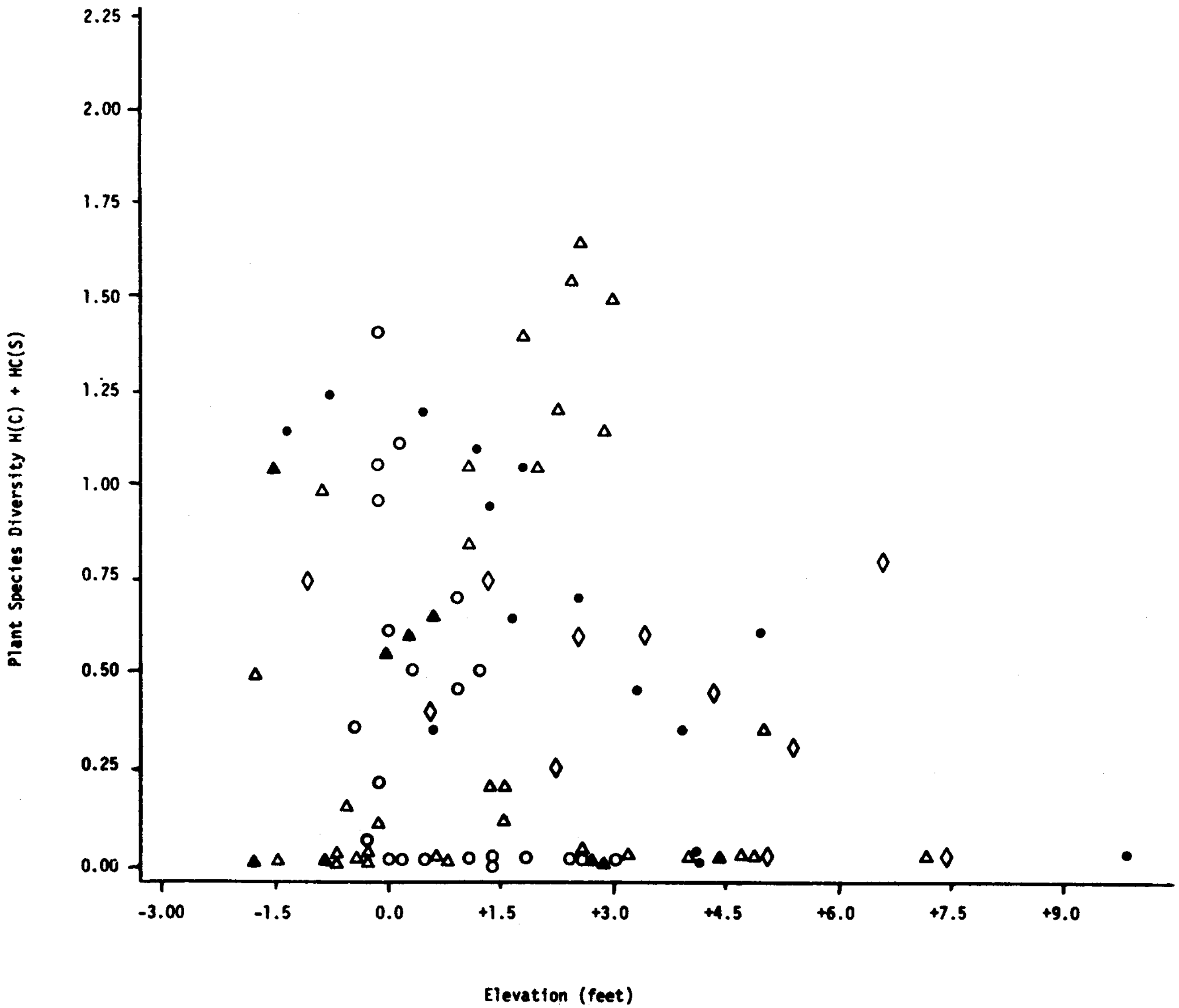

Figure 109. Species diversity, H(C) + HC(S), per quadrat of plant-type organisms sampled at Cape Sitkinak ○, Cape Kaguyak ●, Lagoon Point (transects 1 and 2) △, Lagoon Point (transect 3) ▲, and Low Cape ◊ during May 1976.

Table 19.--Plant [H(C)] and animal [H(C)] diversity values for samples at different tidal elevations at Sud Island, May and August 1976. Pooled values for all samples collected during both trips are also given. Dominant algae at 1.01-2.10 m = Fucales; at 0.00-1.00 m = Rhodophyceae; at 0.00 m = Laminariales.

Date and transect	Height (m)	Plant diversity	No. of plant species	Animal diversity	No. of animal species	No. of samples
May 1976	2.10	0.04	---	0.26	---	(1)
	1.01-2.10	0.19	8	0.82	11.4	(5)
	0.00-1.00	1.03	11.4	1.59	27.0	(6)
	0.00	0.54	9	1.0	3.3	(2)
August 1976 Transect 1	2.10	0.40	4.5	0.24	6	(2)
	1.01-2.10	0.31	4.0	0.86	8.3	(4)
	0.00-1.00	1.11	7.0	1.20	32	(5)
	0.00	0.59	8.8	1.32	50	(4)
August 1976 Transect 2	2.10	0.13	2.5	0.54	8.9	(11)
	1.01-2.10	0.94	8.0	1.29	22.7	(10)
	0.00-1.00	0.60	8.6	1.49	29.6	(5)
	0.00	0.04	7.0	1.58	78	(1)
Pooled Values	2.10	0.16	2.7	0.44	8.5	(14)
	1.01-2.10	0.61	7.2	1.08	16.7	(19)
	0.00-1.00	0.92	9.0	1.44	29.5	(16)
	0.00	0.50	8.6	1.27	49.1	(7)

Table 20.--Correlation matrix between plant weight and plant weight for several of the more abundant species of algae collected in quantitative 1/16 m^2 transect line samples. Only significant values are shown.

	Endocladia muricata	Fucus distichus	Porphyra sp.	Halosaccion glandiforme	Odonthalia floccosa	Ulvales	Spongomorpha sp.	Rhodomela larix	Rhodymenia palmata	Polysiphonous red algae	Alaria sp.	Laminaria sp.	Corallines
Endocladia muricata													
Fucus distichus			.574										
Porphyra sp.													
Halosaccion glandiforme													
Odonthalia floccosa								.146	-.130				.315
Ulvales							.128	.160					.143
Spongomorpha sp.													
Rhodomela larix												.137	.158
Rhodymenia palmata													
Polysiphonous red algae											.350		
Alaria sp.													
Laminaria sp.													

Table 21.--Correlation matrix between plant weight and animal number for several of the more abundant species collected in quantitative 1/16 m^2 transect line samples. Only significant values are shown.

	Endocladia	*Fucus*	*Porphyra*	*Halosaccion*	*Odonthalia*	*Ulvoids*	*Spongomorpha*	*Rhodomela*	*Rhodymenia*	Algal association	Polysiphonous red algae	*Alaria*	*Laminaria*	*Phyllospadix*	Corallines
Littorina sitkana		.119			.220							-.140			
Balanus glandula															
Mytilus edulis	.231														
Collisella pelta															
Notoacmea persona	.472									.150					
Nucella lima					.143			.113							.181
Balanus cariosus												.183			
Leptasterias hexactis							.114					.203			
Notoacmea scutum										.189					
Katharina tunicata					.144	.257						.187			.489
Tonicella lineata															
Sponge [?]												.210			.296
Polychaetes									.202			.128		.279	.207
Amphipods					.145			.189							
Margarites sp.					.138										
Sea cucumbers															
Hiatella arctica												.222			

Table 22.--Correlation matrix between plant weight and animal weight for several of the more abundant species collected in quantitative 1/16 m^2 transect line samples. Only significant values are shown.

	Endocladia muricata	Fucus distichus	Porphyra sp.	Halosaccion glandiforme	Odonthalia floccosa	Ulvoids	Spongomorpha sp.	Rhodomela larix	Rhodymenia palmata	Algal association	Polysiphonous red algae	Alaria sp.	Laminaria sp.	Phyllospadix sp.	Corallines
Littorina sitkana		.395	.235									-.115			
Balanus glandula							.141								
Mytilus edulis															
Collisella pelta															
Notoacmea persona	.386	.118				.218				.404	.186	.288			
Nucella lima								.129							.129
Balanus cariosus							.332								
Leptasterias hexactis							.171								
Notoacmea scutum						.181					.186	.288			
Katharina tunicata															.339
Tonicella lineata					.168										
Halichondria panicea												.210			.296
Polychaetes									.207			.205			.338
Amphipods															
Margarites sp.					.169		.189								.253
Sea cucumbers							.117					.252			
Hiatella arctica							.130					.199			

Table 23.--Correlation matrix between animal number and animal number and between animal weight and animal weight for several of the more abundant species collected in quantitative 1/16 m^2 transect line samples. Only significant values are shown.

	Littorina sitkana	*Balanus glandula*	*Mytilus edulis*	*Collisella pelta*	*Notacmea persona*	*Nucella lima*	*Balanus cariosus*	*Leptasterias hexactis*	*Notoacmea scutum*	*Katharina tunicata*	*Tonicella lineata*	*Halichondria panicea*	Polychaetes	Amphipods	*Margarites*	Sea cucumbers	*Hiatella artica*
								Weight x Weight									
Littorina sitkana				.172													
Balanus glandula			.371	.301		.288											
Mytilus edulis											.420		.160				
Collisella pelta			.598							.162	.465		.133				
Notoacmea persona									.335				-.122				
Nucella lima		.166															
Balanus cariosus																.137	.158
Leptasterias hexactis		.221	.137	.427						.114							
Notacmea scutum					.154								-.119				
Katharina tunicata			.129				.174				.246		.201		.251		
Tonicella lineata													.154				
Halichondria panicea							.147			.166			.334			.301	.347
Polychaetes	-.116		.145	-.111			.175			.463					.271		
Amphipods															.240		
Margarites sp.													.119				
Sea cucumbers		.357	.250										.199				
Hiatella arctica																	

range in length from small pockets isolated between rocky shores to 40-km stretches of beach and lagoon systems.

To verify the accuracy of the aerial survey, we investigated several representative gravelly and sandy beaches on foot. Generally, we found the gravelly beaches were composed of an aggregate of coarse sand and pebble-sized (up to 60 mm) gravel (Figure 110). Sandy beaches were usually composed of well-graded, sand-sized particles (Figure 111).

Because of their unconsolidated nature, both of these beach types are subject to particle movement and morphological changes from surf resulting in an almost complete absence of sessile benthic organisms. Sandy and gravelly beaches do contain infaunal organisms, however. Characteristic sandy beach organisms, for instance, consist of highly motile epifauna (e.g., amphipods such as *Euhaustorius* and the sand lance *Ammodytes hexapterus*), rapidly-burrowing infauna (e.g., the razor clams *Siliqua patula* and *S. alta* and polychaetes such as *Nephtys* sp.), and slow-burrowing but strong-shelled species (e.g., the surf clam *Spisula polynyma*).

Gravelly Beaches

We sampled gravelly beaches at Whirlpool Point and Lagoon Point with a 1-liter corer and examined a gravelly beach at Pasagshak Bay.

Both general observations and analysis of the core samples indicated that biota were scarce at these sites. Neither surface dwellers nor infauna were evident. Analysis of the core samples indicated that amphipods were the most common organisms at Whirlpool Point (Table 24), and nematodes at Lagoon Point (Table 25). Amphipod numbers were quite high in some of the Whirlpool Point samples (maximum 43,100/m^2).

Sandy Beaches

Fourteen sandy beaches were sampled in conjunction with the ADF&G Razor Clam Study (Table 26); for descriptions of sites, see Kaiser and Konigsberg (1976). Razor clams (*Siliqua patula* and *S. alta*) were the most common molluscs encountered in the study (Table 27). Polychaete worms, especially *Scolelepis squamatus* and *Haploscoloplos elongatus*, were also quite common (Table 28). More complete data showing the number and distribution of organisms with respect to tidal height are contained in appendix 3 of Kaiser and Konigsberg (1976).

INTERTIDAL SURVEY--MUDDY BEACHES

Muddy beaches are relatively rare in the Kodiak Island area, comprising only 0.2% of the coastline (Table 1). While verifying the accuracy of the aerial survey, however, it was apparent that the gravelly areas at the upper ends of bays often contain large amounts of silt and mud. Many of the infauna in these areas are also found in muddy strata. On a mixed aggregate beach in Izhut Bay, for example, we found clam populations composed of *Mya arenaria*, *Protothaca staminea*, and *Clinocardium nuttalli*, and several species of polychaete worms.

Figure 110. Surface view of gravel beach.

Figure 111. Surface view of sandy beach. Note razor clam hole.

Table 24.--Organisms in 1-liter gravel cores at Whirlpool Point, 14 May 1976.

Elevation (m)	Core depth(cm) 0-10	10-20	Organism	No. of organisms
4.63	X		---	
3.87	X		Oligochaeta	1
3.23	X		Oligochaeta	1
			Polychaeta	1
2.80	X		Amphipoda-Gammaridae	9
2.80	X		" "	19
2.44	X		" "	65
2.44		X	" "	9
2.44	X		" "	13
2.01	X		" "	11
2.01		X	" "	7
2.01	X		" "	68
			Nemertea	1
1.65			Amphipoda-Gammaridae	431
			<u>Turtonia</u> <u>occidentalis</u>	1
1.65		X	Amphipoda-Gammaridae	430
1.65	X		" "	300
1.19	X		" "	61
1.19		X	" "	200
1.19	X		" "	61
0.49	X		Nemertea (Amphiporidea)	1
0.40	X		---	
0.40		X	Amphipoda-Gammaridae	103
0.40	X		" "	14

Table 25.--Organisms in 1-liter gravel cores at Lagoon Point, 16 May 1976.*

Transect meter number	Core depth(cm) 0-10	10-20	Organism	No. of Organisms
0	x		---	--
5	x		Nematoda	39
			Mytilus edulis	1
10	x		Nematoda	4
15A	x		Oligochaeta	3
			Fabricia sabella	2
15B	x		Nematoda	3
20A	x		Nematoda	15
20A		x	Nematoda	22
20B	x		Nematoda	26
25A	x		Polychaeta	1
25A		x	Archiannelida	1
			Amphipoda-Gammaridae	1
25B	x		Archiannelida	6
			Polychaeta	1
30A	x		Amphipoda-Gammaridae	7
			Polychaeta	1
30A		x	Polychaeta	2
			Nematoda	1
30B	x		Polychaeta	2

* Elevations were not measured for this site. The transect line ran from the water's edge (approximately MLLW) to approximately 3 m above MLLW.

Table 26.--Location of stations and some physical characteristics of 14 Alaska Peninsula and Kodiak Island sandy beaches studied 13 May - 30 August 1976. (Kaiser and Konigsberg 1976)

Beach	Station	Approximate Lat. & Long.	Exposure direction of beach (magnetic degrees)	Estimated length of beach *Siliqua* habitat (km)	Width of beach at station (m)*	Slope distance from +1 to -1 ft tide level (m)
Ocean Bay	B1	57°06'40" N 153°10'00" W	148°	7.08	91.20 (-1)	23.79
Tanner Head	B2	56°52'50" N 154°13'20" W	114°	3.70	155.55 (-3)	22.88
Halibut Bay	B3	57°21'35" N 154°45'40" W	32°	7.61	114.38 (-1.7)	28.98
Swikshak†	B4	58°36'35" N 153°43'10" W	181°	7.24 (-2)	201.91 (-2)	62.83
Village§	B5	58°34'10" N 153°50'30" W	102°	6.92 (-4)	383.39 (-4)	234.24
Big River	B6	58°35'40" N 153°52'10" W	76°	3.22	900 (-4)	131.83
Hallo Bay¶	B7	58°20'10" N 154°04'15" W	64°	6.84	676.66 (-3)	172.52
Kukak**	B8	58°21'20" N 154°06'10" W	90°	1.28	598.93 (-2)	51.82
Bumble Bay	B9	57°16'50" N 154°40'30" W	201°	1.61	108.97 (-1)	26.67

Table 26.--Continued.

Beach	Station	Approximate Lat. & Long.	Exposure direction of beach (magnetic degrees)	Estimated length of beach *Siliqua* habitat (km)	Width of beach at station (m)*	Slope distance from +1 to -1 ft tide level (m)
Tugidak	B10	56°30'40" N 154°28'40" W	153°	?††	73.15 (-1)	23.62
Dakavak§§	B11	58°03'40" N 154°41'10" W	150°	2.4	179.07 (-2)	20.57
Katmai¶¶	B12	58°01'10" N 154°54'58" W	146°	4.02	-	-
Kashvik	B13	57°56'40" N 155°05'35" W	108°	2.01	1,798.92 (-1)	917.75
Alinchak***	B14	57°49'50" N 155°20'10" W	106°	1.61	735.79 (-1)	156.06

* Beach width measured from high tide to low tide indicated in feet within parenthesis.
† Measurements refer to that area of Swikshak beach from the mouth of the Swikshak River northeast to the first prominent rocky bluff.
§ Steep embankment and rock cobble begins just above the zero (0.00 ft) mean low water level.
¶ The beach studied and measured is that beach area between Hallo Creek and Hook Creek.
** Only one beach within an un-named bay within the Kukak Bay system was investigated.
†† Extent of razor clam habitat is unknown.
§§ Measurements refer to the beach west of the major river in Dakavak Bay.
¶¶ No transect was established at Katmai Bay. Measurements refer to beach east of the Katmai River.
***Measurements refer to the northernmost beach within Alinchak Bay.

Table 27.--Numbers of bivalve molluscs in plots on 12 Alaska Peninsula and Kodiak Island sandy beaches, 13 May - 30 August 1976. (Kaiser and Konigsberg 1976)

Beach	No. of tide level stations examined*	*Siliqua patula*	*Siliqua alta*	*Siliqua polynyma*	*Clinocardium nuttallii*	*Macoma lama*	*Macoma balthica*	*Macoma calcarea*	*Macoma loveni*	*Macoma nasuta*	*Macoma yoldiformis*	*Littorina sitkana*	*Mya arenaria*	*Protothaca staminea*	*Tellina lutea alternidenta*	*Tellina nucleoides*	*Tressus capax*
Tanner Head	7	25	0	10	4	0	0	0	0	1	0	1	0	0	0	0	0
Halibut Bay	10	268	3	7	3	1	0	0	0	0	0	0	0	0	1	0	1
Swikshak	6	121	3	17	0	11	0	0	0	1	0	0	0	0	0	1	0
Village	5	208	26	9	0	0	0	0	0	0	0	0	0	0	0	0	0
Big River	5	211	2	11	2	11	0	0	0	0	0	0	0	0	3	0	0
Hallo Bay	8	63	3	21	5	64	16	1	2	0	0	0	20	0	2	0	0
Kukak Bay	10	123	28	37	16	150	3	0	0	0	3	0	0	1	2	0	0
Bumble Bay	6	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tugidak	5	57	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dakavak	7	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Kashvik	7	120	0	4	0	19	11	0	0	0	0	0	0	0	0	0	0
Alinchak	4	85	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0

* Plots at each station were 21 x 3 m.

Table 28.--Numbers of invertebrates (polychaetes and nemerteans) in volumetric samples of sand from 12 Alaska Peninsula and Kodiak Island beaches 13 May - 30 August 1976. (Ka[illegible]r and Konigsberg 1976)

Beach	Volume of sand sieved, in thousands of liters	*Scolelepis squamatus*	*Haploscoloplos elongatus*	*Ophelia assimilis*	*Anaites groenlandica*	*Eteone longa*	*Glycinde picta*	*Cistenides brevicoma*	*Nepthys caeca*	*Nepthys californiensis*	*Nepthys ciliata*	Nemertea	*Cerebratulus californiensis*
Tanner Head	2.1	137	0	14	0	0	0	0	20	0	0	0	0
Halibut Bay	2.1	231	29	13	0	2	4	0	11	0	0	5	0
Swikshak	1.8	359	18	0	0	7	0	0	20	13	3	0	1
Village	1.2	248	30	1	0	0	0	2	28	19	0	0	3
Big River	1.5	157	44	9	0	0	0	0	7	2	0	0	1
Hallo Bay	1.8	264	14	0	6	0	0	2	57	0	0	1	4
Kukak	3.0	912	16	0	4	1	1	0	80	1	0	5	3
Bumble Bay	0.2	3	0	4	0	0	0	0	1	0	0	0	0
Tugidak	1.4	0	9	4	0	2	7	0	0	7	0	0	0
Dakavak	1.5	24	1	111	2	1	0	0	0	104	0	3	1
Kashvik	1.7	270	24	9	0	5	2	0	23	21	0	0	0
Alinchak	1.1	496	0	0	0	0	0	0	13	9	0	0	0

The only area we sampled which had a substrate of soft mud was at South Sitkalidak Lagoon (Figure 112). The entrance to the lagoon is a narrow neck which opens into a large (about 2 km^2) bay with a mud bottom. At high tide the lagoon is filled with water and even at low tide some areas are covered by tidal run-off or brackish streams (Figures 113 and 114).

We sampled an area of soft mud near the entrance of the lagoon using a transect line and a 1-liter corer. Samples were characterized by large numbers of a few species. The most numerous organism was an oligochaete worm. Other organisms included three species of polychaete worms three species of clams, nemertean worms, and amphipods (Table 29).

We made qualitative observations by walking over the area and digging in the mud with a shovel. The distribution of organisms appeared to be patchy, with species aggregated according to microhabitat. For this reason our transect line sampling was an inadequate representation of the extensive and varied area. During our qualitative sampling we found aggregations of several species of polychaete worms and clams (for instance Mya arenaria), many of which could not have been adequately sampled using our standard corer because of their large size or because they occurred deeper in the substrate than we normally sampled. Juvenile starry flounder, small adult shrimp, and larval shrimp were found in the tidal streams. Sandy areas along the edges of tidal streams were often populated with sand lances. Algal species in the mud-sand-gravel area were Fucus distichus, Scytosiphon lomentaria, Desmarestia sp., Polysiphonia sp., and Monostroma sp. The seagrass Zostera marina also occurred in small patches in the mud habitat.

On a rock berm at the head of the lagoon we observed littorine snails, Mytilus edulis, Balanus sp., and the algae Odonthalia floccosa and Monostroma sp.

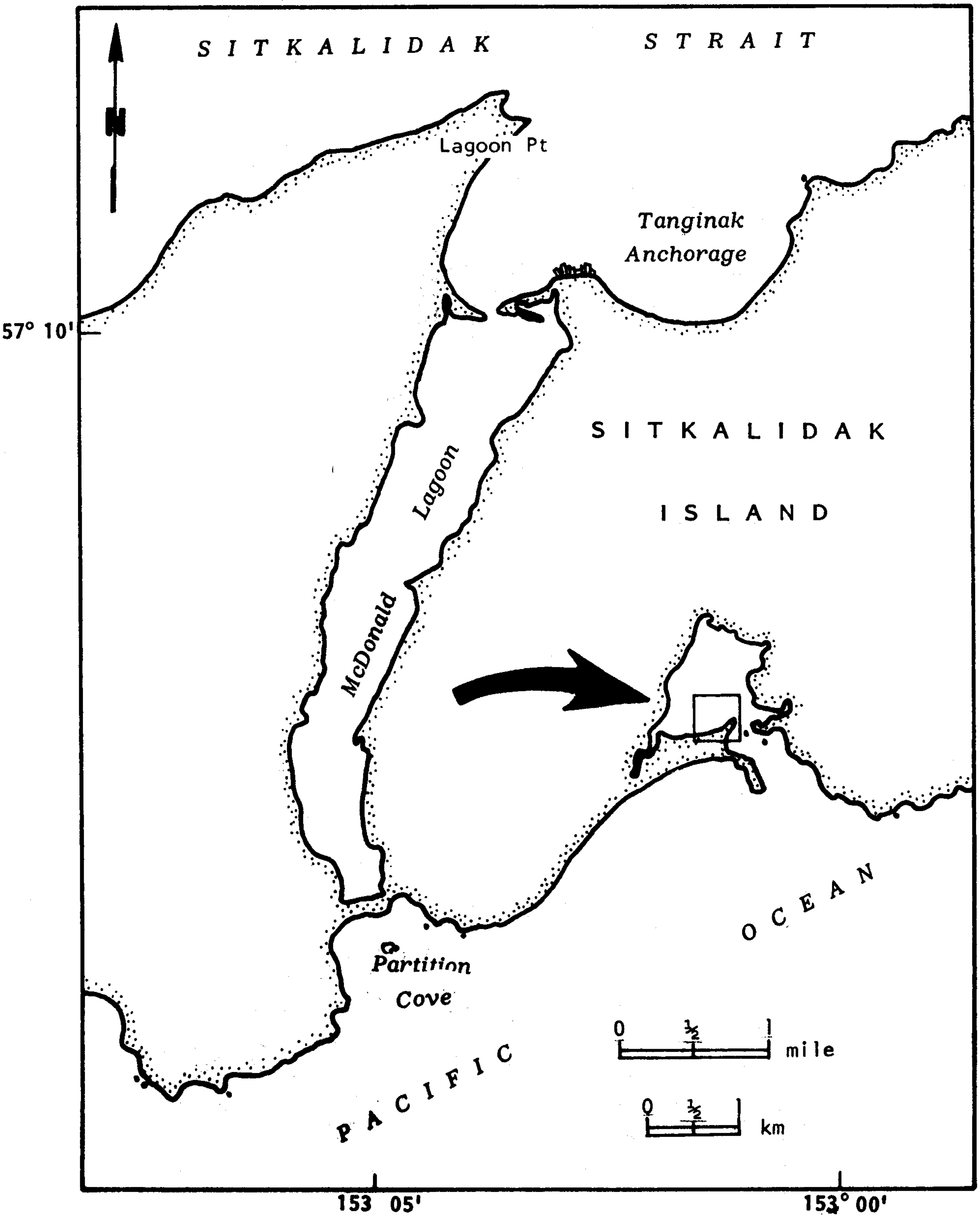

Figure 112. South Sitkalidak Lagoon site.

Figure 113. South Sitkalidak Lagoon. General view of sampling area showing mud flats.

Figure 114. South Sitkalidak Lagoon. General view of sampling area showing algal cover and flowing brackish water at low tide.

Table 29.--Number of organisms collected in 1-liter cores (10 cm x 10 cm) at South Sitkalidak Lagoon on 19 May 1976.

Transect meter number	Elevation (m)	Replicate	Depth of core	Organism	No. of organisms
80	1.00		0-10 cm	Oligochaeta	184
				Eteone longa	8
				Turtonia occidentalis	96
				Fabricia sabella	96
				Polychaeta	8
				Nemertea	8
95	0.98		0-10 cm	Oligochaeta	22
				Oligochaeta	2
				Turtonia occidentalis	3
				Fabricia sabella	19
				Amphipoda	1
65A1	0.98	1	0-10 cm	Oligochaeta	688
				Turtonia occidentalis	32
				Fabricia sabella	288
				Nephtys caeca	1
65A2	0.98		10-20 cm	Oligochaeta	68
				Turtonia occidentalis	4
				Fabricia sabella	12
65B	0.98	2	0-10 cm	Oligochaeta	248
				Oligochaeta	56
				Turtonia occidentalis	24
				Fabricia sabella	376
				Macoma balthica	1
110	0.95		0-10 cm	Oligochaeta	304
				Turtonia occidentalis	48
				Fabricia sabella	168
				Nephtys caeca	1
				Macoma balthica	1
				Archiannelida	8
125A1	0.88	1	0-10 cm	Oligochaeta	864
				Turtonia occidentalis	8
				Fabricia sabella	60
				Amphipoda	8
				Archiannelida	16
125A2	0.88		10-20 cm	Oligochaeta	26
				Fabricia sabella	3

Table 29.--Continued.

Transect meter number	Elevation (m)	Replicate	Depth of core	Organisms	No. of Organisms
125B	0.88	2	0-10 cm	Oligochaeta	280
				Fabricia sabella	28
				Polychaeta	24
				Archiannelida	16
5A	0.88	1	0-10 cm	Oligochaeta	848
				Oligochaeta	48
				Turtonia occidentalis	48
				Fabricia sabella	48
				Polychaeta	48
				Macoma balthica	1
				Nemertea	16
5B	0.88	2	0-10 cm	Oligochaeta	184
				Oligochaeta	528
				Fabricia sabella	136
50A1	0.85	1	0-10 cm	Oligochaeta	1,680
				Oligochaeta	48
				Turtonia occidentalis	32
				Fabricia sabella	656
				Nephtys caeca	1
50A2	0.85		10-20 cm	Oligochaeta	176
				Fabricia sabella	32
50B	0.85	2	0-10 cm	Oligochaeta	64
				Turtonia occidentalis	12
				Fabricia sabella	136
				Nemertea	4
35A1	0.70	1	0-10 cm	Oligochaeta	1,008
				Turtonia occidentalis	48
				Fabricia sabella	143
				Nephtys caeca	1
35A2	0.70		10-20 cm	Oligochaeta	24
				Turtonia occidentalis	16
				Fabricia sabella	8
				Polychaeta	8
35B	0.70	2	10-20 cm	Oligochaeta	496
				Turtonia occidentalis	96
				Fabricia sabella	48
				Nephtys caeca	1

Table 29.--Continued

Transect meter number	Elevation (m)	Replicate	Depth of Core	Organism	No. of Organisms
140	0.67		0-10 cm	Oligochaeta	96
19A	0.67	1	0-10 cm	Oligochaeta	2,608
				Fabricia sabella	368
				Nemertea	16
19B1	0.67	2	0-10 cm	Oligochaeta	1,056
				Oligochaeta	112
				Fabricia sabella	208
19B2	0.67		10-20 cm	Oligochaeta	5
				Oligochaeta	1
				Polychaeta	1
				Nemertea	1
25	0.49		0-10 cm	Oligochaeta	736
				Oligochaeta	96
				Turtonia occidentalis	32
				Amphipoda	32
				Macoma calcera	1
155	0.18		0-10 cm	Oligochaeta	376
				Turtonia occidentalis	40
				Fabricia sabella	56
				Etone longa	40
				Nemertea	8
				Mytilus edulis	1

SUMMARY

An aerial survey indicated that intertidal biological cover is heaviest in the northeastern and southern sections of the region around Kodiak Island. Therefore, special care should be taken to protect these areas from oil pollution.

Bedrock substrate characterizes 48% of Kodiak's intertidal area.

The distributions and abundances of principal intertidal plants and invertebrates are described at about 40 sites in the Kodiak Island region. Littoral zonation in the region is compared with published descriptions of areas elsewhere in the north Pacific and with Stephenson and Stephenson's universal scheme.

Comparison of species composition and biomass on adjacent transects at two sites indicated that spatial variability within sites was high, obscuring seasonal patterns and confounding between-site comparisons. Nevertheless, when sites were classed accoring to exposure, topography, and substrate, exposed flat bedrock beaches appeared to have lower species number and biomass than other stable bedrock beaches. *Rhodomela larix*, *Phyllospadix serrulatus*, and *Gigartina* sp. were found on exposed flat bedrock habitats while *Rhodymenia palmata*, *Spongomorpha* sp., and *Katharina tunicata* were more common in nonflat habitats. *Mytilus edulis* appeared to reach highest densities in protected or partly protected areas and were uncommon at exposed locations.

Densities of biota were lower at sites affected by frequent physical disturbance such as scouring by sand or gravel and unstable substrates (cobble and boulders) at exposed sites.

Benthic kelps were widely distributed and high in biomass in the region of Kodiak Island. Very large individuals of *Nereocystis luetkeana* and *Laminaria dentigera* were recorded. The total biomass of *Fucus* spp. on rocky beaches in the Kodiak Island region was estimated to be 3×10^7 to 1×10^8 kg.

Diversity indices did not reveal any clear patterns in species diversity of plants or animals within or between sites.

Correlation analysis was of limited use in detecting species associations.

Biomass on gravel and sand beaches was relatively small, with pelecypod molluscs, polychaete worms, and amphipods the most common organisms. On mud flats the distribution of organisms was patchy. Polychaete and oligochaete worms were the most common species at the single muddy quantitative study area.

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Howard Sears made the aerial survey of habitat distribution.

Alexander Hoke developed the computer format and programs. The analyses were completed by Jean Grimm; card punching was done by Alice Tipton and Terry Slavin. Ted Merrell helped to direct and develop the overall program in his capacity as co-principal investigator.

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REFERENCES CITED

Arctic Environmental Information and Data Center (AEIDC).
1974. The western Gulf of Alaska. A summary of available knowledge prepared under Contract No. 08550-CT3-9 for Bureau of Land Management, Washington, D.C. AEIDC, 599 p.

Bascom, W.
1964. Waves and beaches, the dynamics of the ocean surface. Doubleday and Co., Garden City, N.Y. 267 p.

Bousefield, E. L., and D. E. McAllister.
1962. Station lists of the National Museum Marine Biological Expedition to Southeastern Alaska and Prince William Sound. Natl. Mus. Can. Bull. 183:76-103.

Bright, D. B., J. W. Knudsen, and F. E. Durham.
1959. Preliminary results of the Cook Inlet king crab, Paralithodes camtschatica (Tilesius) investigations. Dept. Biology, Alan Hancock Foundation, Univ. Southern California, Los Angeles. 88 p.

Calvin, N. I.
1977. A qualitative description of the intertidal plants and animals of Berners Bay, southeastern Alaska. Syesis 10:11-24.

Calvin, N. I., and R. J. Ellis.
1978. Quantitative and qualitative observations on Laminaria dentigera and other subtidal kelps of southern Kodiak Island, Alaska. Mar. Biol. (in press).

Capps, S. R.
1937. Kodiak and adjacent islands, Alaska. U.S. Geol. Survey Bull. 880-C. 184 p.

Connell, J. H.
1970. A predator-prey system in the marine intertidal region. 1. Balanus glandula and several predatory species of Thais. Ecol. Monogr. 40:49-78.

Conover, W. J.
1971. Practical nonparametric statistics. Wiley, New York. 462 p.

Dayton, P. K.
1971. Competition, disturbance and community organization: the provision and subsequent utilization of space in a rocky intertidal community. Ecol. Monogr. 41:351-389.

1973. Dispersion, dispersal and persistence of the annual intertidal algae Postelsia palmaeformis Ruprecht. Ecology 54:433-438.

Druehl, L. D.
1970. The pattern of Laminariales distribution in the northeast Pacific. Phycologia 9:237-47.

Estes, J. A., and J. F. Palmisano.
1974. Sea otters: their role in structuring nearshore communities. Science 185:1058-1060.

Feder, H. M., and G. Mueller.
1972. The intertidal region of the Gulf of Alaska, Section 4. In D. H. Rosenberg (editor), A review of the oceanography and renewable resources of the northern Gulf of Alaska, p. 75-130. Inst. Mar. Sci., Univ. Alaska, Fairbanks. Report R72-23.

Harriman Alaska Expedition.
1899. C. Hart Merriam (editor), Doubleday, Page and Company, New York. 14 Vols.

Hubbard, J. D.
1971. Distribution and abundance of intertidal invertebrates at Olsen Bay in Prince William Sound, Alaska, one year after the 1964 earthquake. In The great Alaska earthquake of 1964: Biology. Natl. Acad. Sci., Washington, D.C., p. 137-157.

Isakson, J. S., J. M. Storie, J. Vagners, G. A. Erickson, J. F. Kruger, and R. F. Corlett.
1975. Comparison of ecological impacts of postulated oil spills at selected Alaskan locations. Final Report. 3 vols. Prepared by Mathematical Sciences Northwest, Inc., for U.S. Coast Guard. Rep. CG-D-155-75 National Technical Information Service. Springfield, Virginia.

John, D. M.
1971. The distribution and net productivity of sublittoral populations of attached macrophytic algae in an estuary on the Atlantic coast of Spain. Mar. Biol. 11:90-97.

Jupp, B. P., and E. A. Drew.
1974. Studies on the growth of Laminaria hyperborea (Gunn.) Fosl. I. Biomass and productivity. J. Exp. Mar. Biol. Ecol. 15:185-196.

Kaiser, R. J., and D. Konigsberg.
1976. Razor clam (Siliqua patula Dixon) distribution and population assessment study. Principal investigators' reports July-September, 1976. In Vol. 2 Environmental Assessment of the Alaskan Continental Shelf, p. 115-162. U.S. Dept. Commerce, NOAA, Environmental Research Laboratory, Boulder, Colorado.

Kozloff, E. N.
1973. Seashore life of Puget Sound, the Strait of Georgia and the San Juan Archipelago. University of Washington Press, Seattle. 282 p.

Krebs, C. J.
1972. Ecology: the experimental analysis of distribution and abundance. Harper and Row, New York. 694 p.

Lebednik, P. A., F. C. Weinmann, and R. E. Norris.
1971. Spatial and seasonal distributions of marine algal communities at Amchitka Island, Alaska. BioScience 21:656-660.

Lewis, J. R.
1964. The ecology of rocky shores. English University Press, Ltd., London. 323 p.

Lindstrom, S. C., and N. I. Calvin.
1975. New records of marine red algae from the Gulf of Alaska. Syesis 8:405-406.

Lüning, K.
1969. Standing crop and leaf area index of the sublittoral Laminaria species near Helgoland. Mar. Biol. 3:282-286.

MacFarlane, C.
1952. A survey of certain seaweeds of commercial importance in southwest Nova Scotia. Can. J. Bot. 30:78-97.

Mann, K. H.
1972. Ecological energetics of the seaweed zone in a marine bay on the Atlantic Coast of Canada. I. Zonation and biomass of seaweeds. Mar. Biol. 12:1-10.

Miller, R. J., K. H. Mann, and D. J. Scarrsatt.
1971. Production potential of a seaweed-lobster community in eastern Canada. J. Fish. Res. Board Can. 28:1733-1738.

Nickerson, R. V.
1975. A critical analysis of some razor clam (Siliqua patula, Dixon) populations in Alaska. Alaska Dep. Fish Game Pub., Div. Fisheries Rehabilitation, Enhancement, and Development. July 1975, 294 p.

Nybakken, J. W.
1969. Pre-earthquake intertidal ecology of Three Saints Bay, Kodiak Island, Alaska. Biol. Pap. Univ. Alaska 9:117.

O'Clair, C. E., and K. K. Chew.
1971. Transect studies of littoral macrofauna, Amchitka Island, Alaska. BioScience 21:661-665.

Paine, R. T.
1966. Food web complexity and species diversity. Am. Nat. 100:65-75.

Paine, R. T., and R. L. Vadas.
1969. The effect of grazing by sea urchins, Strongylocentrotus spp., on benthic algal populations. Limnology and Oceanography 14:710-719.

Pianka, E. R.
1974. Evolutionary ecology. Harper and Row, New York. 356 p.

Pielou, E. C.
1969. An introduction to mathematical ecology. Wiley-Interscience, New York. 286 p.

Ricketts, E. F., and J. Calvin. (revised by J. W. Hedgpeth.)
1968. Between Pacific tides, 4th ed. Stanford Univ. Press, California. 614 p.

Rigg, G. B.
1915. Potash from kelp. V. The kelp beds of western Alaska. U.S. Dep. Agric. Rep. 100:105-122.

Rosenthal, R. J., and D. C. Lees.
1977. Marine plant community studies Kachemak Bay, Alaska. Final Report on Job No. 6791-003-20 for Alaska Dep. Fish Game. 288 p.

Ryther, John H.
1969. Photosynthesis and fish production in the sea. Sci. 166:72-74.

Scagel, R. F.
1971. Guide to the common seaweeds of British Columbia. Handbook 27. British Columbia Provincial Museum. 330 p.

Sears, H. S., and S. T. Zimmerman.
1977. Alaska intertidal survey atlas. U.S. Dep. Commerce, Natl. Mar. Fish. Serv., Northwest and Alaska Fisheries Center, Auke Bay Laboratory, P.O. Box 155, Auke Bay, Alaska 99821.

Stephenson, T. A., and A. Stephenson.
1972. Life between tidemarks in rocky shores. W. W. Freeman Co., San Francisco. 425 p.

U.S. Department of the Interior, Bureau of Land Management, Alaska Outer Continental Shelf Office.
1977. Draft Environmental Impact Statement: Western Gulf-Kodiak. 2 Vols.

Weinmann, F. C.
1969. Amchitka Bioenvironmental Program. Aspects of benthic marine algal ecology at Amchitka Island, Alaska. BM1-171-115. Battelle Memorial Institute Columbus Laboratories, 53 p. (Also M.S. thesis, 1968, same title, Univ. Washington, Seattle, 74 p.)

Zimmerman, S. T.
1975. Baseline characterization, littoral biota, Gulf of Alaska and Bering Sea. Principal Investigators' Reports, July-September 1975. In Vol. 1 Environmental Assessment of the Alaskan Continental Shelf, p. 511-603. U.S. Dep. Commerce, NOAA, Environmental Research Laboratories, Boulder, Colorado.

Zimmerman, S. T., J. H. Gnagy, N. I. Calvin, J. S. MacKinnon, L. Barr, J. Fujioka, and T. R. Merrell.
1977b. Baseline/reconnaissance characterization, littoral biota, Gulf of Alaska and Bering Sea. Principal Investigators' Reports for the year ending March 1977. In Vol. 8 Environmental Assessment of the Alaskan Continental Shelf, p. 1-92. U.S. Dep. Commerce, NOAA, Environmental Research Laboratories, Boulder, Colorado.

FINAL REPORT

FOR

SORTING AND IDENTIFICATION OF INTERTIDAL SAMPLES

Contract # 03-7-208-35135

Research Unit 79

Work Accomplished and Report Prepared by

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August 30, 1978

PART I - INTRODUCTION

This report summarizes the stations and taxonomic problems encountered in this service contract. It is divided into three parts: Introduction, Station List and Taxonomic Section. The taxonomic section is further divided in a discussion of significant taxonomic problems, a species list, and the major references used for determination of the group. The taxonomic order is of convenience and not strictly hierarchical.

Within the past three years well over 2,000 samples from approximately 80 localities were analyzed. The species composition, numbers of individuals, and in many cases wet and dry weights were determined. Recognizing the constraints of collecting, two groups in particular, Algae and Annelids, did not survive the preservation and shipping. The Algae was often fragmented and generally in poor condition. The other groups were found in good condition in most instances.

The systematic quality of the entire study is excellent. Those groups that posed taxonomic problems and were in sufficient abundance were either sent out for examination by recognized authorities or compared by staff members with well identified material in other museums. It should be recognized, however, that in a study of this magnitude some misidentifications will inevitably occur. In house spot checks on identifications indicate that errors in identification and in quantitative analysis were less than one half of one (1%) percent.

All of the sample analyzes have been completed and submitted. The vouchers will be shipped in the near future. The submission of this final report should complete the contract.

PART II - LISTING OF SAMPLES PROCESSED BY SORTING CENTER

Localities of Samples Processed by Sorting Center - 1974

Locality	Collection Date	No. of Stations
Dayville (Port Valdez)	28 April - 31 July	3
Anchor Cove	8 September	8
Anchor Bay	September	17
Squirrel Bay (nested quad.)	13 September	13
Ocean Cape site	October	1
Boswell Bay	September	46
Katalla	October	15
McLeod Harbor	September	27
Middleton Mud	October	10
Squirrel Bay	September	32
Yakutat, Yakataga	October	42
Zaikof	September	10
Port Valdez	September	20

PART II (Cont'd.)

Localities of Samples Processed by Sorting Center - 1975

Locality	Collection Date	No. of Stations
Akun	18 July	27
Amak	19 July	19
Anchor Cove	21 April	20
Day Harbor	3 September	41
Boswell Bay	1 May	22
Boswell Bay	9 September	33
Cape Pierce	21 July	17
Chirikof	27 May	38
Chirikof	10 August	30
Crooked Island	20 July	16
Walrus Island	20 July	1
Katalla	28 April	34
Katalla	9 September	36
Kayak	9 September	19
Latouche	29 April	24
Latouche	4 September	44
Makushin	25 July	23
Makushin	13 August	21
McLeod Harbor	17 April	17
McLeod Harbor	5 September	31
Middleton mud	28 April	10
	6 September	9
Mordvinoff	24 July	8

PART II (Cont'd.)

Urilia Bay	24 July	3
Nukshak	24 May	24
	8 August	31
Otter Island	16 August	39
Port Dick	21 May	36
	6 August	22
Port Edward	22 July	38
Port Moller	23 July	7
Port Etches	27 April	15
Constantine	27 April	1
Port Valdez	24 July	40
Port Valdez	May	40
Spectacle	25 May	34
	11 August	25
Sud Island	23 May	24
Barren Island	23 May	1
Sud	8 August	50
Sundstrom	17-28 May	33
	August	47
Three Saints Bay	29 May	32
	7 August	16
Yakutat	10 June	15
Yakutaga	11 June	41
Ocean Cape (Yakutaga)	4 September	21

PART II (Cont'd.)

Yakutaga	5 September	42
Zaikof	25 August	44
Zaikof	26 September	40
St. George	July - August	10
Bristol Bay	July - August	1
Walrus Island	July - August	2
Sud Island	July - August	2
Makushin Bay	July - August	2
Captain's Bay	July - August	2
Zaikof Bay (nested quad.)	September	6
McLeod (nested quad.)	September	4
Zapadni	15 August	41

PART II (Cont'd.)

Localities of Samples Processed by Sorting Center - 1976

Locality	Collection Date	No. of Stations
Woody Point	9 August	29
Stuart Island	8 August	15
Cape Lupin	17 June	21
Cape Glazenak	16 June	15
Eider Point	14 June	30
Otter Island	12 June	22
Dolina Point	14 May	18
Cape Kaguyak	12 May	11
Kayak	19 April	17
Egg Island	15 April	27
Golovin	11 August	13
Hook Point	13 April	18
Sledge	7 August	6
Boswell Bay	14 April	32
Bluff site 2	12 August	8
Rocky Point	11 August	6
Cape Denbigh	10 August	12
Cape Wooley	13 August	10
Cape Sitkinak	13 May	16
Low Cape	17 May	11
Lagoon Point	15 May	41
Izembeck #1	15 June	41
Izembeck #2	15 June	12
Izembeck #3	16 June	14

PART II (Cont'd.)

Cape Nome	14 August	7
Tolstoi Point	9 June	2
Kanak Island	17 April	23
Softuk spit	18 April	14
Zapadni	10 June	8

1974 Samples	244
1975 Samples	1,371
1976 Samples	499
Total	2,114

PART III - TAXONOMIC SECTION

PORIFERA

Taxonomic Problems:

The species *Halichondria panicea*, as currently understood, is an extremely plastic species occurring from the intertidal through shelf depths. This species may eventually be separated into several species.

Species List:

Halichondria panicea

Leucandra heathi

References:

Bakus, G.J. 1966. Marine poecilosceridan sponges of the San Juan Archipelago, Washington. J. Zool. Lond. 149, 415-531.

Burton, M. 1963. A Revision of the Classification of the Calcereous Sponges. British Mus. Nat. His. London.

Koltun, V.M. 1959. Silicospongin sponges of the Northern and Far Eastern Seas of the USSR - Keys to the fauna of the USSR. (In Russian). Opred. Faune SSSR 67: 1-227.

Lambe, Lawrence M. 1892. On some sponges from the Pacific Coast of Canada and Behring Sea. Trans. Roy. Soc. Canada. Sect. IV.

Lambe, Lawrence M. 1894. Sponges from the Western Coast of North America. Trans. Roy. Soc. Canada. Sect. IV.

Laubenfels, M.W. de. 1961. Porifera of Friday Harbor and Vicinity. Pacific Science, Vol. XV.

Laubenfels, M.W. 1932. The Marine and Fresh-Water Sponges of California. Proceedings U.S. National Museum, Vol. 81, Art. 4, No. 2927.

CNIDARIA - HYDROZOA

Taxonomic Problems:

Hydrozoa were identified in all cases where the material was in adequate condition and amount.

Species List:

Halecium sp.

Bougainvilliidea

Clava cf. multiformis

Endendrium rameum

Endendrium annulatum

Sertularella tricuspidata

Sertularella rugosa

Sertularia albimaris

Abietinaria felicula

Abietinaria variabilis

Tubularia simplex

Obelia longissima

Obelia geniculata

Thuiaria sp.

Clava multiformis

References:

Fraser, C.M. 1937. Hydroids of the Pacific Coast of Canada and the United States. Univ. of Toronto Press. Toronto. 207 p.

Naumov, D.V. 1969. Hydroids and Hydromedusae of the USSR. U.S. Dept. of Commerce, Springfield, Va. 22151.

Torrey, H.B. 1902. The Hydroids of the Pacific Coast of North America. Univ. Calif. Press in Zool. 1:104.

CNIDARIA - SCYPHOZOA

Taxonomic Problems:

The few scyphozoa presented no difficulty in determination as presented.

Species List:

Haliclystus auricula

Haliclystus sp.

Cyanea capillata

Paloclistus sp.

References:

Naumov, S.V. 1961. Scyphomedusae of the Seas of the USSR (In Russian). IZD. Akad. Nuak. SSSR 75: 1-98.

Kramp, P.L. 1961. Synopsis of the Medusae of the World. Syndics of the Cambridge University Press, London.

Mayer, A.G. 1910. Medusae of the World. Vol. III. The Scyphomedusae. Carneg. Inst. Wash. Publ. 109.

Stiasny, G. and H. van der Maaden. 1943. On Sycphomedusae from the Okhotsk and Kamchatka Seas with some criticism of the general *Cyanea* and *Desmonema* (In German). Zool. Jahr. ABT, Fur Syst. Geog. and Biol. Bd.76/3:227-266.

CNIDARIA - ANTHOZOA

Taxonomic Problems:

Actinarians were not determined in this study. Identification of material in Alaska requires examination of internal structures, from material relaxed and carefully preserved. Identification from external features is not possible in view of the lack of knowledge of Alaskan fauna.

Species List:

Eunephthya rubiformis

References:

Gaevskaia, N.S. ed. 1948. Keys to the Fauna and Flora of the Northern Seas of the USSR. Governmental Publications of Socialist Science. Vol. 74:1-667.

PLATYHELMINTHES

Taxonomic Problems:

Platyhelminthes were not determined in this study. Approximately two hundred individuals from 1974-1976 were examined and in all cases were juveniles or the reproductive apparatus was insufficiently developed to determine genera.

RHYNCHOCOELA

Taxonomic Problems:

Nemerteans were not determined except in a few cases where fragmentation had not occurred.

Species List:

Cerebratulus sp.

Emplectonema gracile

References:

Coe, W.R. 1940. Revision of the Nemertean Fauna of the Pacific Coasts of North, Central and Northern South America. Allan Hancock Pac. Expedition. 2(13):247-323.

PRIAPULIDA

Taxonomic Problems:

None

Species List:

Priapulus caudatus

References:

Gaevskaia, N.S. ed. 1948. Keys to the Fauna and Flora of the Northern Seas of the USSR. Governmental Publications of Socialist Science. Vol. 74:1-667.

SIPUNCULA and ECHIURA

Taxonomic Problems:

None.

Species List:

Sipuncula

Phascolosoma agassizii

Echiura

Bonelliopsis alaskana

Echiurus echiurus alaskana

References:

Stephen, A.C. and S.J. Edmonds. 1972. The Phyla Sipuncula and Echiura. Trustees of the British Museum (Natural History), London. pg. 1-732.

MOLLUSCA

Taxonomic Problems:

Mollusca are for the most part well described. The Alaskan fauna is perhaps the best known of any phylum. Those species that presented taxonomic problems for the most part have been resolved by Nora Foster through comparison with material at the U. S. National Museum of Natural History, Los Angeles County Museum and at the California Academy of Sciences. In those groups where resolution of the species has not been possible the specimens have not been identified to species.

Species List:

Aplacophora

Chaetoderma robusta

Polyplacophora

Cyanoplax dentiens

Ischnochiton albus

Dendrochiton thamnoporus

Katharina tunicata

Lepidochitona sharpei

Mopalia ciliata

Mopalia cirrata

Mopalia laevior

Mopalia lignosa

Mopalia mucosa

Placiphorella rufa

Schizoplax brandtii

Tonicella lineata

Tonicella marmorea

Tonicella rubra

Spongioradsia aleutica

Pelecepoda

Astarte alaskensis

Axinopsida serricata

Clinocardium californiensis

Clinocardium ciliatum

Clinocardium nuttallii

Cyrtodaria kurriana

Dacrydium sp.

Entodesma saxicolum

Hiatella arctica

Kellia laperousi

Macoma balthica

Macoma brota

Macoma lama

Macoma moesta

Macoma obliqua

Megacrenella columbiana

Modiolus modiolus

Musculus discors

Musculus niger

Musculus olivaceous

Musculus vernicosus

Mya arenaria

Mya elegans

Mysella planata

Mysella tumida

Mytilus edulis

Nucula tenuis

Neaeromya compressa

Nuculana pernula

Pododesmus machrochisma

Protothaca staminea

Saxidomus gigantea

Serripes groenlandica

Siliqua alta

Spisula polynyma

Telina leutea

Thracia sp.

Turtonia occidentalis

Gastropoda

Acanthodoris sp.

Acmaea mitra

Acmaea rosacea

Acmaea sybaritica

Admete couthouyi

Alvinia aurivilli

Alvinia compacta

Amauropsis islandicus

Amphissa columbiana

Aquilonaria turneri

Balcis columbiana

Balcis micrans

Balcis randolfi

Barleeia haliotiphila

Barleeia subtenuis

Bittium munitum

Buccinum baeri

Bulbus fragilis

Calliostoma ligatum

Cerithiopsis stejnegeri

Cerithiopsis stephansae

Cingula aleutica

Cingula katharinae

Collisella digitalis

Collisella fenestrata

Collisella ochracea

Collisella pelta

Collisella persona

Collisella scutum

Collisella cf. strigiatella

Crepidula nummaria

Crepipatella lingulata

Cylinchn alba

Cylinchna occulta

Cryptobranchia alba

Cryptobranchia concentrica

Diaphana brunnea

Diaphana minuta

Fusitriton oregonensis

Granulina margaritula

Haloconcha reflexa

Homalopoma engbergi

Lacuna carininata

Lacuna marmorata

Lacuna variagata

Lacuna vincta

Lepeta caeca

Lirularia succintus

Littorina aleutica

Littorina scutulata

Littorina squalida

Margarities beringensis

Margarities helicinus

Margarities pupillus

Mitrella gouldi

Mitrella rosacea

Mitrella tuberosa

Moellaria costulata

Moellaria drusiana

Moellaria quadrae

Nassarius mendicus

Natica clausa

Neptunea heros

Neptunea lyrata

Nucella canaliculata

Nucella lamellosa

Nucella lima

Ocenebra interfossa

Odostomia sp.

Onchidella borealis

Oneopota tabulata

Polinices pallida

Puncturella cucullata

Puncturella noachina

Retusa sp.

Searlesia dira

Siphonaria thersities

Solariella sp.

Trichotropsis cancel ata

Trichotropsis i ignis

Trophanopsis multicostatus

Turbonilla sp.

Urosalpinx lurida (*ocenebra*)

Velutina velutina

Volutharpa ampulacea

References:

Abbott, R.T. 1974. American Seashells. 2nd. Ed. Van Nostrand Reinhold Co. New York. 663 p.

Bernard, Frank R. 1970. A distributional checklist of the marine molluscs of British Columbia, based on faunistic surveys since 1950. Syesis, vol. 3, 75-94, 1 pl.

Berry, S.S. 1917. Notes on West American Chitons. 1. Proc. Cal. Acad. Sci., Ser. 4. 7:229-248.

Berry, S.S. 1919. Notes on West American Chitons. II. Proc. Cal. Acad. Sci., Ser. 4. 9:1-36.

Berry, S.S. 1927. Some Notes on British Columbian Chitons. Proc. Malac. Soc. London. 17:159-164.

Berry, S.S. 1951. Notes on Some British Columbian Chitons. II. Proc. Malac. Soc. London. 28:213-229.

Bertsch, Hans, T. Gosliner, R. Wharton, and G. Williams. 1972. Natural history and occurrence of opisthobranch gastropods from the open coast of San Mateo County, California. Veliger, vol. 14, no. 3, pp. 302-14.

References (Cont'd.)

Coan, E.V. 1971. The Northwest American Tellinidae. Veliger, vol. 14 (suppl.), 63 pp., 12 pls., 30 figs.

Curtiss, R.M. 1941. An ecological and taxonomic survey of the Acmaeidae of the northwest Pacific area. M.S. Thesis. Univ. Wash. 121 p. 37 plates.

Dall, W.H. 1921. Summary of the marine shellbearing mollusks of the northwest coast of America. Bull. U.S. Nat. Mus., no. 112, 217 pp., 22 pls.

Dall, W.H., and Paul Bartsch. 1909. A monograph of West American pyramidellid mollusks. Bull. U.S. Nat. Mus., no. 68, 258 pp., 30 pls.

Grant, U.S., IV, and H. R. Gale. 1931. Catalogue of the marine Pliocene and Pleistocene Mollusca of California. Mem. San Diego Soc. Nat. Hist., vol. 1, 1036 pp., 32 pls., 15 figs.

Grau, Gilbert. 1959. Pectinidae of the eastern Pacific. Univ. So. Calif. Publ. (Allan Hancock Pacific Expeditions), no. 23, 308 pp., 57 pls.

Habe, T. and K. Ito. 1974. Shells of the World in Colour. Vol. 1. The Northern Pacific. Hoikusha Publ. Co., Ltd. Osaka, Japan. 176 p. (text in Japanese).

Heath, Harold. 1911. The solenogastres. Mem. Harvard Mus. Comp. Zool., vol. 45, no. 1, pp. 1-182, 40 pls.

Hertlein, L.G. 1961. A new species of Siliqua (Pelecypoda) from western North America. Bull. So. Calif. Acad. Sci., vol. 60, no. 1, pp. 12-19, 2 pls.

Keen, A.M. and E. Coan. 1974. Marine molluscan genera of western North America: an illustrated key. 2nd Ed. Stanford University Press. Stanford. 208 p.

MacGinitie, Nettie. 1959. Marine Mollusca of Point Barrow, Alaska. Proc. U.S. Nat. Mus., vol. 109, no. 3412, pp. 59-208, 27 pls.

MacNeil, F.S. 1965. Evolution and distribution of the genus Mya and Tertiary migrations of Mollusca. U.S. Geol. Survey Prof. Paper 483-G, iv + 51 pp.

Macpherson, Elizabeth. 1971. The Marine Molluscs of Arctic Canada. National Museums of Canada, Publications in Biological Oceanography, No. 3. 74p.

McLean, J.H. 1971. A revised classification of the family Turridae. Veliger, vol. 14, no. 1, pp. 114-30, 4 pls.

Oldroyd, I.S. 1925-27. The marine shells of the West Coast of North America (Stanford Univ. Pub. Geol.). Vol. 1, Pelecypoda (dated 1924, publ. 1925), 248 pp., 57 pls. Vol. 2, Gastropoda, Scaphopoda, and Amphineura: pt. 1, 298 pp., pls. 1-29; pt. 2, 304 pp., pls. 30-72; pt. 3, 340 pp., pls. 73-108.†

References (Cont'd.)

Palmer, K. van W. 1958. Type specimens of marine Mollusca described by P.P. Carpenter from the West Coast (San Diego to British Columbia). Mem. Geol. Soc. Amer., no. 76, 376 pp., 35 pls.

Rice, Tom. 1972. Marine shells of the Pacific Northwest. Port Gamble, Wash.: Sea & Shore. 102 pp., 40 col. pls., 3 figs.

Soot-Ryen, Tron. 1955. A report on the family Mytilidae (Pelecypoda). Univ. So. Calif. Publ. (Allan Hancock Pacific Expeditions), vol. 20, no. 1, 175 pp., 10 pls., 78 figs. (Nov. 10).

ANNELIDA - POLYCHAETA

Taxonomic Problems:

In general all polychaetes are correctly identified to genera; because of the problem of fragmentation there may be errors in some of the specific determinations. Representatives of 28 problem species were confirmed by George Mueller by comparison at the Allan Hancock Foundation, Los Angeles, California. Additional problems are detailed below:

Family Phyllodocidae

Anaitides mucosa and *A. maculata* are determined by color patterns. These patterns do not appear to be consistent in intertidal specimens. *A. mucosa* as collected from subtidal grab samples is clearly separable from *A. macula*. The intertidal specimens are closer to *A. maculala* and as a consequence are called *Anaitides maculata*. A similar problem in intergradation occurs between *Eulalia viridis* and *E. quadrioculata*. The decision was to report all of the specimens as *Eulalia quadrioculata*.

Family Syllidae

All species' determinations of *Autolytus* are questionable. Neither the review of the Genus by Imajima nor the revision by Gidholm appears adequate for Alaskan material.

The genus *Typosyllis* is not well understood. Of the species reported *T. pulchra*, *T. alternata* and *T. adamantea* fit their descriptions and were confirmed at the Allan Hancock Foundation with no problems. The other species reported either do not fit their descriptions well or are insufficiently described for positive determination.

Syllid epitokes are not described for Alaskan waters.

Taxonomic Problems (Cont'd.)

Family Nereidae

There is a problem with *Nereis pelagica* and *Nereis zonata* determinations. It appears that a third species falling between the above is present and currently is undescribed. This species may have been assigned to either of the above species as well as being reported as *Nereis* sp. Sexually mature forms, heteroneried, are not described for Alaska.

Family Spionidae

The species of *Polydora* and *Boccardia* in the 1974 samples were poorly identified.

Family Cirratulidae

The species *Chaetozone setosa* and *Cirratulus cirrata* are are correct. The species of *Tharyx* cannot be determined.

Family Capitellidae

The determinations of *Capitella capitata* may contain other species. When capitellids were determined to be *Heteromastus* they are correct.

Family Terebellidae

This family preserves very poorly. As a consequence specific determinations may not always be correct.

Family Maldanidae

Specimens of this family generally fragment while identification requires whole specimens. The determinations are generally correct but may contain fragments of additional unreported species.

Family Ophelidae

Ammotrypane is no longer correct and should be changed to *Ophelina*. The trivial name remains the same.

Family Sabellidae

Species determinations of *Chone* and *Fabricia* are questionable. Available literature is inadequate for the positive determination of Alaskan material.

Species List:

Polynoidae

Arctonoe pulchra

Arctonoe vittata

Gattyana ciliata

Gattyana treadwelli

Halosynda brevisetosa

Harmathoe extenuata

Harmathoe imbricata

Hesperone sp.

Lepidonatus squamatus

Peicidice aspera

Pholoe minuta

Chrysopetalidae

Dysponetus pygamaeus

Paleanotus bellis

Phyllodocidae

Anaitides groenlandica

Anaitides maculata

Anaitides mucosa

Eteone longa

Eulalia bilineata

Eulalia quadrioculata

Eulalia viridis

Genetyllis castanea

Species List (Cont'd.)

Mysta barbata

Notophyllum tectum

Syllidea

Autolytus cornutus

Autolytus prismaticus

Autolytus trilineatus

Brania brevipharyngea

Eusyllis assimilis

Eusyllis bloomstrandi

Exogone gemmifera

Exogone lourei

Exogone molesta

Exogone verrugera

Parasphaerosyllis sp.

Sphaerosyllis brandhorsti

Sphaerosyllis hystrix

Sphaerosyllis pirifera

Syllides japonica

Typosyillis a. adamantea

Typosyillis alternata

Typosyillis armillaris

Typosyillis elongata

Typosyillis harti

Typosyillis hyalina

Typosyillis pulchra

Typosyillis stewarti

Typosyillis variegata

Neriedae

Neries grubei

Neries pelagica

Neries procera

Neries vexillosa

Neries zonata

Platyneries bicanaliculata

Nephtyidae

Nepthys caeca

Nepthys ciliata

Nepthys cornuta

Nepthys longosetosa

Sphaerodoridae

Sphaerodorum gracilis

Sphaerodropsis minuta

Sphaerodropsis sphaerulifer

Glyceridae

Glycera capitata

Goniadae

Goniada annulata

Glycinde armigera

Glycinde picta

Onuphidae

Onuphis geophiliformis

Onuphis iridescens

Onuphis stigmatis

Species List (Cont'd.)

Eunicidae

Eunice kobiensis

Eunice valens

Lumbrineridae

Lumbrinaries inflata

Lumbrinaries similabris

Lumbrinaries zonata

Dorvilleidae

Protodorvillea sp.

Orbinidae

Haploscoloplos elongatus

Haploscoloplos panamensis

Naineries laevigata

Naineries quadricuspida

Scoloplos armiger

Paraonidae

Aricidea suecica

Paraonis gracilis

Spionidae

Boccardia columbiana

Boccardia natrix

Boccardia proboscidea

Laonice cirrata

Nerine cirratulus

Polydora caulleryi

Polydora ciliata

Polydora quadrilobata

Polydora socialis

Prionospio cirrifera

Prionospio malmgreni

Pygospio californica

Pygospio elegans

Rhynchospio sp.

Spiophanes bombyx

Spiophanes cirrata

Megelonidae

Magelona sp.

Chaetopteridae

Chaetopterus variopedatus

Cirratulidae

Chaetozone setosa

Cirratulus cirratus

Tharyx sp.

Flabelligeridae

Brada villosa

Flabelligera affinis

Pherusa papillata

Scalibregmidae

Scalibregma inflatum

Species List (Cont'd.)

Ophelidae

Ammotrypane aulogaster

Armandia brevis

Ophelia limacina

Thoracophelia micronata

Capitellidae

Capitella capitata

Heteromastus filiformis

Arenicolidae

Abarenicola pacifica

Arenicola glacialis

Sabellariidae

Idanthyrsus armatus

Oweniidae

Myriochele heeri

Owenia fusiformis

Maldanidae

Axiothella rubrocincta

Maldane sarsi

Maldanella robusta

Nichomanche personata

Praxillella affinis

Pectinariidae

Cistenides brevicoma

Cistenides granulata

Ampharetidae

Ampharete arctica

Asabellides sibirica

Glyphanostomun pallescens

Terebellidae

Nicolea zostericola

Polycirrus caliendrum

Polycirrus medusa

Thelepus hematus

Trichobranchidae

Terebellides stroemii

Sabellidae

Amphiglena pacifica

Chone cincta

Chone gracilis

Fabricia crenicolis

Fabricia minuta

Fabricia pacifica

Fabricia sabella

Laonome sp.

Potamilla neglecta

Pseudopotamillia reniformis

Schizobranchia insignis

Species List (Cont'd.)

Serpulidae

Crucugera zygophora

Dexiospira spirillum

Serpula vermicularis

Spirorbis granulatus

References

Banse, K. and K. D. Hobson. 1974. Benthic errantiate polychaetes from British Columbia and Washington. Fish. Res. Bd. Canada, Bull. 185:1-111.

Berkeley, E. and C. Berkeley. 1948. Annelida, Polychaeta errantia. Canadian Pacific Fauna, Fish. Res. Bd, Canada 9b(1):1-100.

Berkeley, E. and C. Berkeley. 1952. Annelida, Polychaeta sedentaria. Canadian Pacific Fauna, Fish. Res. Bd, Canada 9b(2):1-139.

Blake, J.A. 1971. Revision of the genus *Polydora* from the east coast of North America (Polychaeta, Spionidae). Smithsonian Contr. Zool. 75:1-32.

Bush, K.J. 1904a. Tubicolous annelids of the tribes Sabellides and Serpulides from the Pacific Ocean. Harriman Alaska Exped. 12:169-355.

Day, J.H. 1964. A review of the family Ampharetidae (Polychaeta). Ann. South African Mus. 48:97-121.

Day, J.H. 1967. A monograph on the Polychaeta of Southern Africa. British Museum Nat. Hist. Publ. 656:38 and 878 pp.

Fauchald, K. 1968b. Onuphidae (Polychaeta) from western Mexico. Allan Hancock Monogr. mar. biol. 3:1-82.

Fauchald, K. 1969. A revision of six species of the flavusbidentatus group of Eunice (Eunicidae: Polychaeta). Smithsonian Contr. Zool. 6:1-15.

Fauchald, K. 1970. Polychaetous annelids of the families Eunicidae, Lumbrineridae, Iphitimidae, Arabellidae, Lysaretidae and Dorvilleidae from western Mexico. Allan Hancock Monogr. mar. biol. 5:1-335.

Fauchald, K. 1974b. Sphaerodoridae (Polychaeta: Errantia) from world-wide areas. J. Nat. Hist. 8:257-289.

Fauchald, K. 1977. The Polychaete Worms Definitions and Keys to the Orders, Families and Genera. Nat. Hist. Mus. of Los Angeles County. S.S. 28:1-188.

Fauvel, P. 1923a. Polychetes errantes. Faune de France, Paris :1-488.

Fauvel, P. 1927. Polychetes sedentaires. Addenda aux Errantes, Archiannelides, Myzostomaires. Faune de France, Paris, 16:1-494.

Fauvel, P. 1953. The Fauna of India including Pakistan, Ceylon, Burma and Malaya. Annelida Polychaeta. Allahabad, XII and 507 pp.

Gidholm, L. 1967. A revision of Autolytinae (Syllidae, Polychaeta) with special reference to Sandinavian species, and with notes on external and internal morphology, reproduction and ... logy. Ark. Zool. Stockholm (2)19:157-213.

Hartman, O. 1947. Polychaeteous annelids. Pt. 7. Capitellidae. Allan Hancock Pacific Exped. 10:391-481.

Hartman, O. 1950. Polychaetous annelids. Goniadidae, Glyceridae, Nephtyidae. Allan Hancock Pacific Exped. 15:1-181.

Hartman, O. 1957. Orbiniidae, Apistobranchidae, Paraonidae and Longosomidae. Allan Hancock Pacific Exped. 15:211-393.

Hartman, O. 1959. 1965. Catalogue of the Polychaetous annelids of the world. Allan Hancock Foundation Occasional Paper 23:628 pp. Supplement and index (1965). 197 pp.

Hartman, O. 1968. Atlas of errantiate polychaetous annelids from California. Allan Hancock Foundation, University of Southern California, Los Angeles, 828 pp.

Hartman, O. 1969. Atlas of sedentariate polychaetous annelids from California. Allan Hancock Foundation, University of Southern California, Los Angeles, 812 pp.

Imajima, M. 1966a. The Syllidae (Polychaetous annelids) from Japan.I. Exogoninae. Publ. Seto Mar. Biol. Lab. 13:385-404.

Imajima, M. 1966b. The Syllidae (Polychaetous annelids) from Japan. II. Autolytinae. Publ. Seto Mar. Biol. Lab. 14:27-83.

Imajima, M. 1966c. The Syllidae (Polychaetous annelids) from Japan. III. Eusyllinae. Publ. Seto Mar. Biol. Lab. 14:85-111.

References (Cont'd.)

Imajima, M. 1966d. The Syllidae (Polychaetous annelids) from Japan IV. Syllidae 1. Publ. Seto Mar. Biol. Lab. 14:219-252.

Imajima, M. L966e. The Syllidae (Polychaetous annelids) from Japan V. Syllidae 2. Publ. Seto Mar. Biol. Lab. 14:253-294.

Imajima, M. 1967. The Syllidae (Polychaetous annelids) from Japan VI. Distribution and Literature. Publ. Seto Mar. Biol. Lab. 14-351-368.

Imajima, M. 1972. Review of the annelid worms of the family Nereidae of Japan, with description of five new species or subspecies. Bull. Natl. Sci. Mus. Tokyo 15:37-153.

Imajima, M. and O. Hartman. 1964. The polychaetous annelids of Japan. Allan Hancock Foundation Occasional Paper 26:1-452.

Johnson, H.P. 1901. The Polychaeta of the Puget Sound region. Proc. Boston Soc. Nat. Hist. 29:381-437.

Jumars, P.A. 1974. A generic revision of the Dorvilleidae (Polychaeta) with six new species from the deep North Pacific. Jour. Linn. Soc. London, Zool. 54:101-135.

McIntosh, W.C. 1900. A monograph of British Annelids. 1(2):Polychaeta, Amphinomidae to Sigalionidae: 215-442. Ray Society, London.

McIntosh, W.C. 1914b. A monograph of the British Annelids. 3(1) Polychaeta, Opheliidae to Amphictenidae: VIII and 368 pp. Ray Society, London.

McIntosh, W.C. 1923. A monograph of the British Marine Annelids 4(2) Polychaeta: Sabellidae to Serpulidae. With additions to the British marine Polychaeta during the publication of the monograph: XII and 251-538. Ray Society, London.

Pettibone, Marian H. 1953. Some scale-bearing polycheates of Puget Sound and adjacent waters. Univ. of Wash. press, Seattle. Library of Congress catalogue card #53-6933.

Pettibone, M.H. 1963. Marine Polychaete worms of the New England Region 1. Aphroditidae through Trochochaetidae. U.S. Nat. Mus., Bull. 227:1-356.

Pettibone, M.H. 1966b. Revision of the Pilargiidae (Annelida: Polychaeta), including descriptions of new species, and redescription of the pelagic Podarmus ploa Chamberlin (Polynoidae). U.S. Nat. Mus., Proc. 118(3525):155-208.

Pîltz, Fred. 1977. A key to the species of Typosyllis reported or described from the Pacific Coast of the United States and Canada. Proc. of the Taxonomic Standardization Program. 5/3:25-38.

Uschakov, P. 1955a. (Polychaetous annelids of the Far Eastern Seas of the USSR). (In Russian). Akad. Nauk SSSR, Keys to the Fauna of the SSSR 56:1-433 (translated, 1965 by Israel Program Scientific Translating, Jerusalem).

References (Cont'd.)

McIntosh, W.C. 1923. A monograph of the British Marine Annelids 4(2) Polychaeta: Sabellidae to Serpulidae. With additions to the British marine Polychaeta during the publication of the monograph: XII and 251-538. Ray Society, London.

Pettibone, Marian H. 1953. Some scale-bearing polycheates of Puget Sound and adjacent waters. Univ. of Wash. press, Seattle. Library of Congress catalogue card #53-6933.

Pettibone, M.H. 1963. Marine Polychaete worms of the New England Region 1. Aphroditidae through Trochochaetidae. U.S. Nat. Mus., Bull. 227:1-356.

Pettibone, M.H. 1966b. Revision of the Pilargiidae (Annelida: Polychaeta), including descriptions of new species, and redescription of the pelagic *Podarmus ploa* Chamberlin (Polynoidae). U.S. Nat. Mus., Proc. 118(3525):155-208.

Piltz, Fred. 1977. A key to the species of *Typosyllis* reported or described from the Pacific Coast of the United States and Canada. Proc. of the Taxonomic Standardization Program. 5/3:25-38.

Uschakov, P. 1955a. (Polychaetous annelids of the Far Eastern Seas of the USSR). (In Russian). Akad. Nauk SSSR, Keys to the Fauna of the SSSR 56:1-433 (translated, 1965 by Israel Program Scientific Translating, Jerusalem).

References (Cont'd.)

Uschakov, P. 1972. (Polychaeta 1. Polychaetes of the suborder Phyllodociformia of the Polar Basin and the northwestern part of the Pacific). (In Russian). Akad. Nauk SSSR. Zool. Inst. Fauna of the SSSR, n.s. 102, 271 pp. (translated 1974 by the Israel Program for Scientific Translation, Jerusalem).

Wells, G.P. 1959. The genera of Arenicolidae (Polychaeta). Proc. Zool. Soc. London 133:301-314.

ANNELIDA - ARCHIANNELIDA

Taxonomic Problems

None.

Species List:

Saccocirrus sp.

References:

Fauchald, K. 1977. The Polychaete Worms Definitions and Keys to the Orders, Families and Genera. Natural History Museum of Los Angeles County. S.S. 28:1-188.

ANNELIDA - OLIGOCHAETA

Taxonomic Problems:

The majority of Oligochaetes found were not sexually mature and could not be identified to genus. Additionally, most specimens are in the family Enchytraeidae, the marine representatives of which are simply not known anywhere.

References:

Brinkhurst, R.O. and B.G.M. Jamieson. 1971. Aquatic Oligochaeta of the World. Oliver & Boyd. Edinburgh. University of Toronto Press. 860 p.

ARTHROPODA - PYCNOGONIDA

Taxonomic Problems:

Pycnogonids were identified from original sources including those listed below until mid-1975 when an in-house key was constructed. Juvenile pycnogonida are undescribed for Alaska.

Species List:

Achelia spinosa

Achelia chelata

Ammothea alaskensis

Ammothea gracilipes

Ammothea latifrons

Ammothea pribilofensis

Nyphon grossipes

Phoxichilidim femoratum

References:

Cole, L.J. 1904. Pycnogonida of the West Coast of North America. Harriman Alaska Exped. 10:249-298.

Hedgpeth, J.W. 1941. A Key to the Pycnogonida of the Pacific Coast of North America. Trans. San Diego Soc. Nat. Hist. 9:253-264.

Hedgpeth, Joel W. 1949. Report on the Pycnogonida Collected by the ALBATROSS in Japanese Waters in 1900 and 1906. Proc. of the U.S. Nat. Mus., Vol. 98, No. 3231.

Hilton, W.A. 1942. Pycnogonids from Allan Hancock Exped. Allan Hancock Pacific Expeditions, 5(9):277-339.

References (Cont'd.)

Lozina-Lozinskii, L.K. 1933. Pantopoda of the Eastern Seas of the USSR (In Russian). Issled. Mor. SSSR. 17:43-80.

Sars, G.O. 1891. Zoology-Pycnogonidea. The Norwegian North-Atlantic Expeditions 1876-1878. Grondahl & Son, London.

Shimkevich, V.M. 1929-30. Mnogokolenchatye (Pantopoda). IZD-VO. Akad Nauk SSSR. 555 p.

ARTHROPODA - CRUSTACEA - COPEPODA

Taxonomic Problems:

Marine Harpacticoida are not described for Alaskan waters. Calanoida presented no problems in determination.

Species List:

Calanus cristatus

Calanus plumchrus

Metridia lucens

References:

Brodkii, K.A. 1950. Calanoida of the Far Eastern Seas and Polar Basin of the USSR. Izdatel'stvo Akademii Nauk SSSR, Moskva Leningrad. pp. 1-440.

ARTHROPODA - CIRRIPEDIA

Taxonomic Problems:

A reported undescribed *Chthamalus* from the Bering Sea was not found in the material from this study. All of the *Chthamalus* found appeared to be only *C. dalli*. The genus *Balanus* presented no problems.

Species List:

- *Chthamalus dalli*
- *Balanus balanoides*
- *Balanus balanus*
- *Balanus cariosus*
- *Balanus crenatus*
- *Balanus glandula*
- *Balanus nubilis*
- *Balanus rostratus*

References:

Pilsbry, H.A. 1916. The Sessile Barnacles (Cirripedia) contained in the Collections of the U.S. National Museum. Bull. U.S. Nat'l. Mus. 93:1-366.

ARTHROPODA - CRUSTACEA - ISOPODA

Taxonomic Problems:

The Asellota is not a well known group in the North Pacific. The genera *Ianiropsis* and *Munna* are correct. The determined species are the "best fit" to those described in the literature. *Synidotea ritteri* may represent an undescribed species or variation.

Species List:

Anthuridae

Cryptothir balani

Dynamenella glabra

Dynamenella sheareri

Exosphaeroma amplicauda

Exosphaeroma media

Gnorimosphaeroma oregonensis

Idotea fewkesi

Ianiropsos k. kincaida

Ligia pallasi

Munna chromatocephala

Munna stephensensi

Bopyridae

Pentidotea wosensenskii

Synidotea pettiboneae

Synidotea picta

Synidotea ritteri

Saduria entomon

Sphaeromatidae

References:

George, R.Y. and J.-O. Stromberg. 1968. Some New Species and New Records of Marine Isopods from San Juan Archipelago, Washington, U.S.A. Crustaceana. 14:225-254.

Gurjanova, E. 1933. Contributions to the Isopoda Fauna of the Pacific Ocean. I. New Species of Valifera and Flabellifera. Explor. of the Seas of the U.S.S.R., Institut Hydrobiologi. Leningrad. no. 17:87-106. II. New Species of Gnathiidea and Asellota. Ibid. no. 19:79-91. (Russian and English texts.)

Hatch, M.H. 1947. The Chelifera and Isopoda of Washington and adjacent regions. Univ. of Wash. Publ. in Biol. 10(5):155-274.

Menzies, R.J. 1950. The Taxonomy, Ecology, and Distribution of Northern California Isopods of the Genus Idothea with the Description of a New Species. Wasmann Journ. Biol. 8:155-195.

Menzies, R.L. and M.A. Miller. 1972. Systematics and zoogeography of the genus Synidotea (Crustacea: Isopoda) with an account of Californian species. Smithsonian Contributions to Zoology. No. 102. Washington, D.C.

Richardson, H. 1905. Monograph on the isopods of North America. Bull. U.S. Nat'l. Mus. 54:1-727.

Schultz, G.A. 1969. The marine isopod crustaceans. Wm. C. Brown Co. Dubuque, Iowa. 359 p.

Wolff, T. 1962. The systematics and biology of Bathyal and abyssal Isopoda Asellota. Galathea Report. 6:7-320.

ARTHROPODA - CRUSTACEA AMPHIPODA

Taxonomic Problems:

The monographs of Barnard and Gurianova are quite complete for the North Pacific and Bering Sea. The taxonomic problems involving species commonly encountered in this study were examined by J. L. Barnard and resolved. Those not resolvable were reported to the lowest possible taxon determinable with accuracy.

Species List:

Caprellidea

Caprella christibranchium

Caprella sp.

Gammaridea

Accedomoera sp.

Allorchestes anceps

Allorchestes angustus

Allorchestes angustus carinatus

Allorchestes moleolus

Amphithoe brevipes

Amphithoe delli

Amphithoe lindbergi

Amphithoe rubricata

Amphithoe rubricatoides

Anisogammarus locustoides

Anisogammarus subcarinatus

Anonyx sp.

Aoroides columbiae

Calliopiella pratti

Corophium sp.

Eonaustorious washingtonianus

Ericthonius sp.

Heterophoxus oculatus

Hyale grandicornis

Ischyrocerus anguipes

Ischyrocerus kraschenínikovi

Jassa pulcella

Melita sp.

Metopella nasuta

Metopelliodes sp.

Najna conciliorum

Odius carinatus

Oligochinus lighti

Orchomene lepidula

Orchomene minuta

Onisimus (Ps.) littoralis

Species List (Cont'd.)

Parallorchestes ochtensis

Paramoera carlottensis

Paramoera columbiana

Paraphoxus sp.

Paraphoxus spinosus

Parapleustes johanseni

Parapleustes nautilus

Parapleustes pugettensis

Photis brevipes

Photis reinhardi

Photis spasskii

Pleustes panopia

Pleustes panoplus

Pleusymptes sp.

Polycheria osbornzi

Pontogeneia kondakoui

Stenopleustes glaber

Stenopleustes siberotobois

Stenopleustes suberitobius

Stenopleustes uncigera

Sympleustes suberitobius

References:

Barnard, J.L. 1954. Marine Amphipoda of Oregon. Oregon State Monog. Zool. No. 8, 103 p.

Barnard, J.L. 1969. Gammaridean Amphipoda of the Rocky Intertidal of California: Monterey Bay to La Jolla. Bull. U.S. Nat. Mus. 258:230 p.

Barnard, J.L. 1969. The families and genera of marine gammaridean amphipods. U.S. Nat'l. Mus. Smithsonian Inst. Bull. 27:1-535.

Gurianova, E.F. 1951. (Amphipods of the Seas of the USSR and Adjacent Waters (Amphipoda: Gammaridae)). Opredeliteli po-Faune SSSR. 41. 1029 p. (in Russian)

References (Cont'd.)

Gurianova, E.F. 1962. (Amphipods of the Northern Part of the Pacific Ocean. Part I) Opredeliteli po Faune SSSR. 74. 440 p. (in Russian).

Laubitz, D.R. 1970. Studies on the Caprellidae (Crustacea, Amphipoda) of the American North Pacific. Can. Nat'l. Mus. Sci. Publ. Biol. Ocean. 1: 1-89.

Vasilenko, S.V. 1974. Caprellids (sea goats) of the seas of the USSR and nearby waters. (in Russian). Akademiia Nauk SSSR. Zoologicheskim Institut. Opredeliteli po faune SSSR. No. 107. 287 p.

ARTHROPODA - OTHER PERACARIDA

Taxonomic Problems:

None to the level in which the data is presented.

Species List:

Mysidacea

Archaeomysis grebnitzkii

Neomysis czerniawskii

Mysis sp.

Cumacea

Lamprops quadriplicata

Endorella emarginata

Diastylis sulcata

Campylapsis affinis

Cumella sp.

Tanaidacea

Tanais sp.

References:

Banner, A.H. 1947. A Taxonomic Study of the Mysidacea and Euphausiacea (Crustacea) of the Northeastern Pacific. I. Mysidacea: Family Lophogastridae Through Tribe Erythropini. Trans. Roy. Can. Inst. 27(57): 347-399.

Banner, A.H. 1948. A Taxonomic Study of the Mysidacea and the Euphausiacea (Crustacea) of the Northeastern Pacific. II. Mysidacea: Tribe Mysini Through Subfamily Mysidellinae. Trans. Roy. Can. Inst. 27(57): 65-125.

References (Cont'd.)

Lang, K.F. 1957. Tanaidacea from Canada and Alaska. Contr. Depart. Pech. Quebec. 52:1-54.

Lomakina, N.B. 1958. (Cumacean Crustaceans (Cumacea) of the Seas of the U.S.S.R.). Opredeliteli po Faune SSSR. 66. 301 p. (in Russian).

Richardson, H. 1905. A Monograph of the Isopods of North America. Bull. U.S. Nat. Mus. 54:727p.

ARTHROPODA - CRUSTACEA - DECAPODA

Taxonomic Problems:

None

Species List:

Caridea

Crangon sp.

Heptacarpus brevirostris

Heptacarpus camtschatica

Anomura

Dermaturus mandtii

Pagurus beringanus

Pagurus hirsutinsculus

Brachyura

Cancer oregonensis

Chionoecetes sp. (Megalops)

Pugettia gracilis

Telmessus cheiragonus

References:

McLaughlin, P.A. 1974. The Hermit Crabs (Crustacea Decopoda, Paguridea) of the Northwestern North America. Zool. Verhandel. Leiden. Pg. 396.

Makarov, J.J. 1938. Fauna of the USSR. V. X, No. 3. Crustacea: Anomura. Zool. Institut. Akademii. Nauk. SSSR. Moskva. pg. 283.

Rathbun, M.J., H. Richardson, S.J. Holmes, and L. J. Cole. 1910. H.A.E. Vol. Crustacea. Smithsonian Institution. Wash., D.C. Publ. 1997. Pg. 337.

ARTHROPODA - INSECTA

Taxonomic Problems:

Marine Insecta of Alaska for the most part are unknown. It was not possible to determine most of the material below family.

Species List:

Staphylinidae

Cicadellidae

Chironomidae

Dolichopodidae

Psyllidae

References:

Usinger, R.L. 1956. Aquatic Insects of Calif. with Keys to North American Genera and Calif. Species. Un. of Calif. Berkeley Press. Pg. 508.

ECTOPROCTA

Taxonomic Problems:

The bryozoans encountered in this set of samples generally posed no taxonomic problems to the level reported. *Flustra securifrons* has not been reported south of the Bering Str. The other species reported below are relatively well known and described.

Species List:

Alcyonidium disciforme

Alcyonidium polyoum

Bugula sp.

Clavipora occidentalis

Costazia sercularis

Crisia occidentalis

Dendrobeania murrayana

Encrata loricata

Filicrisia sp.

Flustra securifrons

Flustrella sp.

Flustrella gigantea

Hippodiplosia insulpta

Hippothoa hyalina

Microporella sp.

Microporina borealis

Myriozoum coarctatum

Tricellaria occidentalis

Tricellaria ternata

References:

Luge, G.A. 1975. Bryozoa of the Northern Seas of the U.S.S.R. Zool. Inst., Acad. of Sci. USSR No. 76. pg. 711.

Osburn, R.C. 1950. Bryozoa of the Pacific Coast of America. Pt. I Cheilostomata-Anasca. Allan Hancock Pacific Exped. XIV. Un. of So. Calif. Press. Pg. 1-269.

Osburn, R.C. 1952. Bryozoa of the Pacific Coast of America. Pt. II. Cheilostomata-Ascophora. Allan Hancock Pacific Exped. XIV. Un. of So. Calif Press. Pg. 271-611.

Osburn, R.C. 1953. Bryozoa of the Pacific Coast of America. Pt. III. Cyclostomata, Ctenostomata, Entoprocta and addenda, Allan Hancock Pacific Exped. XIV. Un. of So. Calif. Press. Pg. 614-841.

Ross, J.R.P. 1970. Keys to the Recent Cyclostome Ectoprocta of the Marine Waters of Northwest Washington State. Northwest Science. Vol. 44 No. 3. Pg. 154-169.

BRACHIOPODA

Taxonomic Problems:

None.

Species List:

Terebratalia transversa

References:

Bernard, F.R. 1972. The Living Brachiopoda of British Columbia. Syesis 5:73-82.

ECHINODERMATA

Taxonomic Problems:

Species of the Asteroid Genera, Henricia and Leptasterias are poorly defined. Some mature and most immature individuals intergrade between the various species within each genera making identification difficult at best. Holothuroidians with two exceptions were not identified due to general poor preservation and lack of knowledge of Alaskan material.

Species List:

Asteriodea

Asterias amurensis

Evasterias troschelli

Evasterias sp.

Henricia sanguinolenta

Henricia sp.

Henricia leviscula

Leptasterias alaskensis

Leptasterias groenlandica

Leptasterias hexactis

Leptasterias leptodoma

Leptasterias camtschatica

Pisaster ochraceous

Pycnopodia helianthoides

Ophuroidea

Ophiophalis aculeata

Species List (cont'd.)

Echinoidea

Strongylocentrotus droebachiensis

Strongylocentrotus pallidus

Strongylocentrotus purpuratus

Holothuroidea

Cucumaria pseudocurata

Thyonidium pellucidus

References:

Clark, H.L. 1901. The Holothurians of the Pacific Coast of North America. Zool. Anz. 24:162-171.

Clark, H.L. 1911. North Pacific Ophiurans in the collection of the U.S. Nat'l. Mus. Bull. U.S. Nat'l. Museum No. 75. pg. 1-302.

Deichmann, E. 1930. The Holothurians of the Western Part of the Atlantic Coast. Bull. Mus. Com. Zool. Vol. LXXI No. 3, pg. 43-226.

Deichmann, E. 1938. New Holothurians of the Western Coast of North America and Some Remarks on the Genus *Caudina*. Proc. New Eng. Zool. Club. Vol. XVI. Pg. 103-115.

D'yakonov, A.M. 1950. Sea Stars (asteroids) of the U.S.S.R. Seas. Acad. of Sci. of U.S.S.R. (Trans. from Russian. Israel Prog. for Sci.). Trans. 1968. pg. 1-183.

References (Cont'd.)

D'yakonov, A.M. 1954. Ophiuroids of the U.S.S.R. Seas. Acad. of Sci. of USSR (Trans. from Russian, Israel Prog. for Sci.). Trans. 1967. pg. 123.

Edwards, C.L. 1908. The Holothurians of the North Pacific Coast of North America, collected by the Albatross in 1903. Proc. U.S. Nat'l. Mus. 33:49-68.

Fell, H.B. 1960. Synoptic key to the Genera of Ophiuroidea. Zool. Publ. Victoria Un. Wellington. 26:3-34.

Fisher, W.K. 1911-1930. Asteroidea of the North Pacific and adjacent waters. Pt. 1 Phanerozonia and Spinulosa. 1911. Pg. 419. Pt. 2 Forcipulata. 1928. Pt. 3 Forcipulata (concluded) 1930. U.S. Nat'l. Mus. Bull. 76. P. 356.

Ohshima, H. 1915. Report on the Holothurians collected by the U.S. Fisheries Steamer "Albatross" in the Northwestern Pacific during the summer of 1906. Proc. U.S. Nat'l. Mus. 48:213-291.

CHORDATA - TUNICATA

Taxonomic Problems:

The tunicates represent a little known segment of the Alaskan fauna. Consequently, the tunicates were only occasionally identified. Those that are identified are correct to the level reported.

Species List:

Amaroncium glabrum

Molgula oregonia

Pelonaia corrugata

Sigillinaria sp.

Styela sp.

Synoicum sp.

References:

Berrill, N.J. 1950. The Tunicata, with an account of the British Species. Ray Society, pg. 1-354.

Millar, R.H. 1970. British Ascidians. Academic Press, New York, pg. 1-92.

Van Name, Willard G. 1945. The North and South American Ascidians. Bull. Amer. Mus. Nat. History. 84:1-476.

CHORDATA - PISCES

Taxonomic Problems:

No taxonomic problem to the level reported.

Species List:

Clinocottus acuticeps

Clinocottus embryum

Gymnocanthus pistilligea

Liparis callyodon

Liparis sp.

Lumpenus sagitta

Oligocottus maculosus

Pholis sp.

Phytichthys chirus

Xiphister mucosus

References:

Hart, J.L. 1973. Pacific Fishes of Canada. Fisheries Research Board of Canada. Bull. 180, pg. 1-740.

Wilimovsky, N.J. 1958. Provisional keys to the Fishes of Alaska. Fisheries Res. Lab. U.S. Fish and Wildlife Service, Juneau, Alaska, pg. 113.

CHRYSOPHYTA

Taxonomic Problems:

None.

Species List:

Licmophora sp.

References:

Cupp, E.E. 1943. Marine Plankton Diatoms of the West Coast of North America. Bull. Scripps Inst. Oceanogr. 5(1):1-238.

CYANOPHYTA

Taxonomic Problems:

The blue green algae are not authoritatively identified. The names submitted can only be considered provisional.

Species List:

Rivularia sp.

Microcoleus sp.

Lyngbya sp.

References:

Smith, G.M. 1950. The Freshwater Algae of the United States. McGraw-Hill Book Co., Inc., pg. 719.

CHLOROPHYTA

Taxonomic Problems:

The genera *Spongomorpha* and *Cladophora* in some instances were not separable in the material as submitted. These two genera are in addition not well understood in Alaska. Formalin preserved *Ulva lactuca* and *U. fenestrata* were difficult to separate and may be confused in the data.

Species List:

Cladophora sp.

Enteromorpha sp.

Enteromorpha clathrata

Lola sp./*Rhizoclonium* sp.

Monostroma cf. *arcticum*

Monostroma cf. *zostericola*

Prasiola sp.

Prasiola meridionalis

Rhizoclonium sp./*Lola* sp.

Rhizoclonium implexum

Rosenviengiella sp.

Rosenvingiella cf. *polyrhiza*

Schizogonium murale

Spongomorpha mertensii

Spongomorpha sp.

Spongomorpha cf. *saxatilis*

Spongomorpha spinescens

Species List (Cont'd.)

Ulothrix cf. *flacca*

Ulva fenestrata

Ulva lactuca

Urospora sp.

Urospora mirabilis

Urospora wormsjkoldii

References:

Abbott, I.A. and G. Hollenberg. 1976. The Marine Algae of California. Stanford Univ. Press, pg. 827.

Scagel, R.F. 1966. Marine Algae of British Columbia and Northern Washington, Part I. Chlorophyta. Bull. Nat. Mus. Can. 207:1-257.

Hoek, C. van den. 1963. Revision of the European species of *Cladophora*. Leiden, pg. 1-248.

PHAEOPHYTA

Taxonomic Problems:

The major taxonomic problem in this group is the genus *Alaria*. Material was submitted to Widdowson for identification. The resulting comments of Widdowson indicate that most of our identifications are probably correct but without large amounts of fertile material positive identification is impossible.

Species List:

Alaria sp.
Alaria cf. *angusta*
Alaria cf. *crispa*
Alaria fistulosa
Alaria glandifolia
Alaria marginata
Alaria taeniata
Analipus filiformis
Analipus japonicus
Chordaria flagelliformis
Coilodesme polygnampta
Colpomenia bullosa
Cystoseira geminata
Desmarestia aculeata
Desmarestia viridis
Dictyosiphon sp.
Dictyosiphon sinicola
Dictyosiphonales
Ectocarpus sp.
Ectocarpus cf. *parvus*
Elachistea fucicola
cf. *Feldmannia*
Fucus sp.
Fucus distichus
Fucus spiralis
Hedophyllum sessile
Laminaria sp.
Laminaria cf. *ephemera*
Laminaria groenlandica
Laminaria longipes
Laminaria saccharina
cf. *Melanosiphon*
Melanosiphon intestinale
Petalonia fascia

Species List (Cont'd.)

Phaeostrophion irregulare

Pilayella littoralis

Ralfsia fungiformis

Ralfsiaceae

Saundersella simplex

Scytosiphon lomentaria

Soranthera ulvoidea

Sphacelaria racemosa

Thallasiophyllum clathrus

References:

Abbott, I.A. and G. Hollenberg. 1976. The Marine Algae of California. Standord Univ. Press, pg. 1-827.

Druehl, L.D. 1968. Taxonomy and distribution of NE Pacific species of *Laminaria*. Can. Jour. Bot. 46:539-47.

Setchell, W. and Gardner. 1925. The Marine Algae of the Pacific Coast of North America. Part III. Melanophyceae. Univ. Calif. Publ. Bot. 13:1-13.

Widdowson, T. 1972. A taxonomic revision of the genus *Alaria* (Greville) Phaeophyta. Syesis 4:11-49.

Widdowson, T. 1973. The Marine Algae of B.C. and Northern Washington: Revised list and key. Part I. Phaeophyceae. Syesis 5:81-96.

Wynne, M. 1969. Life History and Systematic Studies of some Pacific N.A. Phaeophyceae. Univ. Calif. Publ. Bot. 50:1-88.

RHODOPHYTA

Taxonomic Problems:

Determinations of Porphyra moculosa and P. smithii should be changed to Porphyra sp. The material simply was not in good enough condition to make these determinations. Early determinations of Iridaea cornucopiae are probably not correct. This species is regarded by many phycologists to be quite rare. M. Guiry is reviewing several Halosaccion/Rhodymenia - which have not been returned at this time. Antithamnion is poorly identified in this material.

Species List:

- Acrochaetium sp.
- Ahnfeltia plicata
- Bangia fusco-purpurea
- Bossiella sp.
- Bossiella chiloensis
- Bossiella cretacea
- Bossiella plumosa
- Callithamnion pikeanum
- Callophyllis cristata
- Callophyllis flabelluta
- Ceramiaceae
- Ceramium pacificum
- Chondrus cf. pinnulatus
- Clathromorphum compactum
- Clathromorphum reclinatum
- Constantinea sp.
- Constantinea subulifera
- Corallina sp.
- Corallina vancouvierensis
- Cryptonemiaceae
- Cryptonemiales
- Cryptosiphonia woodii
- Delesseriaceae
- Dilsea californica
- Dumontia incrossata
- Endocladia muricata

Species List (Cont'd.)

Farlowia mollis

Gigartina pacific

Gigartina papillata (stellata) complex

Halosaccion sp.

Halosaccion glandiforme

Hypophyllum cf. dentatum

Iridaea sp.

Iridaea cordata

Iridaea cornucopiae

Iridaea heterocordata

Lithothamnaceae

Melobesioideae

Microcladia borealis

cf. Neopolyporolithon

Neoptilota sp.

Neoptilota aspleniodes

Nienburgia sp.

Odonthalia floccosa

Odonthalia kamtschatica

Odonthalia washingtoniensis

Palmaria sp.

Palmaria palmata

Petrocelis sp.

Petrocelis franscicana

cf. Peyssonnellia sp.

Phycodrys riggii

Pleonosporium sp.

Polysiphonia cf. broderi

Polysiphonia hendryi

Polysiphonia pacifica

Porphyra sp.

Porphyra perforata

Pterosiphonia bipinnata

Pterosiphonia bipinnata f. robusta

Ptilota sp.

Ptilota filicina

Rhodomela larix

Rhodomelaceae

Rhodymenia sp.

Rhodymenia palmata f. sobolifera

Rhodymeniaceae

Tokitodendron bullata

References:

Abbott, I.A. 1967. Studies in some foliose red algae of the Pacific Coast. I. Cryptonemiaceae. Journ. Phycol. 3:139-49.

Abbott, I.A. 1967. Studies in the foliose red algae of the Pacific Coast. II. Schizymenia. Bull. So. Calif. Acad. Sci. 66:167-74.

References (Cont'd.)

Abbot, I.A. 1968. Studies in some foliose red algae of the Pacific Coast. III. Dumontiaceae, Weeksiaceae, Kallymeniaceae. Journ. Phycol. 4:180-98.

Abbot, I.A. and G. Hollenberg. 1976. The Marine Algae of California. Stanford Univ. Press, pg. 1-827.

Adey, W. and Johansen. 1972. Morphology and taxonomy of Corallinaceae with special reference to Clathromorphum, Mesophyllum and Neopolyporolithon. Phycologia 11:159-80.

Conway, Mumford and Scagel. 1975. The genus Porphyra in B.C. and Washington.

Johansen, H.W. 1969. Morphology and systematics of Coralline algae with special reference to Calliarthron. Un. of Calif. Publ. Bot. 49:1-78.

Johansen, H.W. 1971. Bossiella, a genus of articulated corallines in the Eastern Pacific. Phycologia 10:381-96.

Kylin, H. 1925. The marine red algae in the vicinity of the Biological Station at Friday Harbor, Washington. Lunds Univ. Arsskr. 21(9):1-87.

Kylin, H. 1956. Die Gattungen der Rhodophyceen. Lund. pg. 1-673.

Segawa, S. 1977. Coloured illustrations of the Seaweeds of Japan. Hoikusha, Osaka, Japan, pg. 1-175.

Setchell and Gardner. 1903. Algae of Northwestern America. Univ. of Calif. Publ. Bot. 1:165-419.

References (Cont'd.)

Wollaston, E.M. 1971. *Antithamnion* and related genera occurring on the Pacific Coast of North America. Syesis 4:73-92.

Wynne, M. 1970. Marine Algae of Amchitka Island (Aleutian Island). I. Delesseriaceae. Syesis 3:95-144.

FINAL REPORT

BASELINE STUDIES OF THE DEMERSAL RESOURCES OF THE EASTERN AND WESTERN GULF OF ALASKA SHELF AND SLOPE: A HISTORICAL REVIEW

Research Unit 174

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NOTE: We are sorry that the following errata sheets were not received in time to be included in OCSEAP's Final Reports, Vol. 2 (June 1978).

Demersal Fish and Shellfish Resources of the Gulf of Alaska from
Cape Spencer to Unimak Pass, 1948- 1976

Volume 3 --Errata

Page 701, Paragraph 2

1. 2 Change 1,922 to 1,871
1. 3 Change 24% to 25%
1. 3 Change 57% to 59%
1. 4 Change 19% to 16%
1. 5 Change 64% to 67%
1. 6 Change 24% to 25%
1. 7 Change 16% to 17%

Page 701, Paragraph 3

1. 1 Change 10.9 to 10.6
1. 5 Change while to and
1. 5 Change 28.3 to 28.6
1. 6 Change Prince William to Sanak

Page 701, Paragraph 4

1. 1 Change 86% to 85%
1. 3 Change 86% to 84%
1. 6 Change 49% to 51%
1. 6 Change 33% to 32%

Page 706, Table XI-103

REGION	DEPTH ZONE	CHANGE
Fairweather	201-400	4.7 to 5.5
	0-400	4.6 to 4.7
Yakutat	201-400	11.7 to 13.7
	0-400	7.7 to 7.9

Volume 3 -- Errata

Page 706, Table XI-103

REGION	DEPTH ZONE	CHANGE
Prince William	0-100	29.2 to 39.2
	101-200	34.7 to 46.5
	201-400	73.5 to 21.6
		28.3 to 8.3
		20.6 to 7.1
		36.1 to 14.2
	0-400	203.6 to 151.7
		10.5 to 7.8
		10.6 to 8.1
Kenai	201-400	6.7 to 7.9
	0-400	9.5 to 9.7
Kodiak	201-400	24.3 to 28.5
	0-400	23.8 to 24.5
Shelikof	201-400	10.6 to 12.4
	0-400	3.4 to 3.5
Chirikof	201-400	14.3 to 16.7
	0-400	16.2 to 16.7
Sanak	201-400	7.1 to 8.3
	0-400	24.3 to 24.9
Total	0-100	24.2 to 24.8
	101-200	57.2 to 58.8
	201-400	358.2 to 306.3
		8.7 to 7.4
		18.7 to 16.4
	0-400	1,922.4 to 1,870.5
		10.9 to 10.6

Volume 3 -- Errata

Page 710, Paragraph 1

1. 6 Change 23% to 27%

Page 710, Paragraph 2

1. 1 Change 641 to 589

1. 2 Change 38% to 41%

1. 2 Change 32% to 26%

1. 2 Change 30% to 33%

1. 4 Change 57% to 50%

Page 710, Paragraph 3

1. 5 Change 14% to 16%

Page 711, Table XI-104

SPECIES	DEPTH ZONE	CHANGE
Roundfish	201-400	22.8 to 26.7
	0-400	49.2 to 50.6
Flatfish	0-100	30.2 to 32.9
	101-200	37.7 to 41.0
	201-400	205.7 to 153.8
		5.0 to 3.7
		57.5 to 50.3
		32.1 to 26.1
	0-400	640.7 to 588.8
		3.6 to 3.3
		33.3 to 31.5
Invertebrates	201-400	13.8 to 16.2
	0-400	14.5 to 14.9
Rockfish	201-400	4.1 to 4.8
	0-400	1.5 to 1.6

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Volume 3 -- Errata

Page 711, Table XI-104

SPECIES	DEPTH ZONE	CHANGE
Elasmobranchs	201-400	1.8 to 2.1
Total	0-100	24.2 to 24.8
	101-200	57.2 to 58.8
	201-400	357.6 to 305.7
		8.8 to 7.4
		18.6 to 16.4
	0-400	1,922.0 to 1,870.
	0-400	10.9 to 10.6

Page 717, Table XI-106

REGION	COLUMN	CHANGE
Fairweather	4	6.2 to 6.8
Yakutat	4	13.1 to 14.3
Prince William	3	57,637.7 to 5,763.8
	3	89,048.3 to 37,174.4
	4	15.4 to 36.8
	4	19.9 to 47.7
	4	65.7 to 15.5
	4	13.9 to 6.3
Kenai	4	11.5 to 12.5
Kodiak	4	23.0 to 25.1
Shelikof	4	3.7 to 4.0
Chirikof	4	9.0 to 9.8
Sanak	4	19.4 to 21.2
Total	3	205,687.2 to 153,813.3
	3	640,677.4 to 588,803.5
	4	30.2 to 32.9

November 15, 1978 5/5

Volume 3 -- Errata

Page 717, Table XI-106

REGION	COLUMN	CHANGE
Total	4	37.7 to 41.0
	4	32.1 to 26.1

Research Unit 174

Demersal Fish and Shellfish Resources of the Gulf of Alaska from Cape Spencer to Unimak Pass 1948 - 1976

A Historical Review

by

Lael L. Ronholt, Herbert.H. Shippen,

and Eric S. Brown

August 1978

Volume 4

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SECTION

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XII

DECADE COMPARISON

INTRODUCTION

To examine long-term trends in the relative magnitude of fisheries resources within the Survey Area, a comparison was made between the catch per unit of effort (kg/hr) for the "1960" (actually 1961) survey by the IPHC and the BCF and the "1970" (actually 1973-1976) surveys by the NMFS.

Mean CPUEs (geometric) were calculated for each survey period, for each species or group, and for each region-depth zone. Where the various region-depth zones were combined, each mean CPUE was weighted in proportion to that part of the total area it represented.

Standard deviations were calculated for each region and depth zone, and a 2-standard deviation factor was used as a divisor and multiplier, respectively, to determine a confidence interval for the mean CPUE. If the mean CPUE index for either survey period fell within the 2-standard deviation confidence interval around the mean for the other period, no statistically-significant change in CPUE is presumed to have occurred. Where the geometric mean CPUE for the 1960's fell outside the 2-standard deviation confidence interval for the 1970's, and vice versa, a statistically-significant change is presumed to be evident.

Because of the relatively broad confidence intervals associated with the mean CPUE indices, few statistically-significant changes from the 1960's to the 1970's can be identified. Comparison between the mean CPUEs of the two periods, however, suggests that in many cases a large change occurred although statistical significance cannot be asserted.

To describe the nature of the changes that have occurred from 1960 until 1970 in the respective indices of density, the 1970 CPUE was divided by the 1960 CPUE and the resulting ratio coded and described as follows:

1970 ÷ 1960 CPUE	CODE	DESCRIPTION
0.51 to 2.00	0	No marked change
0.26 to 0.50	-	Moderate decrease
0.13 to 0.25	--	Large decrease
Less than 0.13	---	Very large decrease
2.01 to 4.00	+	Moderate increase
4.01 to 8.00	++	Large increase
Greater than 8.00	+++	Very large increase

DECADE COMPARISON BY SPECIES AND GROUP (GULF OF ALASKA)

For the Study Area as a whole, there were few statistically significant changes from 1960 to 1970 as determined by the comparison of the mean CPUEs (geometric) and confidence intervals. Statistically-significant increases were indicated for the roundfish group, Dover sole, and walleye pollock, while a statistically-significant decrease was indicated for Pacific ocean perch. Moderate increases in the CPUE index between 1960 and 1970 were determined for the invertebrate species group and rex sole (Table XII-1).

Table XII-1.--Decade comparison by species and species group (all regions and depth zones combined).

Species or Group	"1960s" Mean CPUE1/	"1960s" Confidence Interval2/	"1970s" Mean CPUE1/	"1970s" Confidence Interval2/	Confidence Interval Comparison3/	CPUE Ratio 1970÷1960
Group						
Elasmobranchs	4.50	2.16- 9.36	5.39	2.62- 11.10	N.C.	1.20 (0)
Flatfish	82.99	42.13-163.49	147.25	90.90-238.55	N.C.	1.77 (0)
Roundfish	27.70	12.15- 63.16	94.49	47.25-188.98	C.	3.41 (+)
Rockfish	4.22	1.98- 8.99	2.65	1.47- 4.77	N.C.	0.63 (0)
Invertebrates	19.37	6.22- 60.43	47.60	21.83-103.77	N.C.	2.46 (+)
Species						
Skates	3.49	1.73- 7.05	5.24	2.54- 10.79	N.C.	1.50 (0)
Turbot	23.05	10.48- 50.71	44.85	23.12- 87.01	N.C.	1.95 (0)
Halibut	5.45	2.53- 11.72	4.69	2.19- 10.04	N.C.	0.86 (0)
Flathead sole	6.49	2.80- 15.06	7.96	2.97- 21.33	N.C.	1.23 (0)
Dover sole	1.36	0.94- 1.97	2.28	1.37- 3.78	C.	1.68 (0)
Rex sole	1.81	1.10- 2.99	4.26	1.72- 10.52	N.C.	2.35 (+)
Rock sole	2.74	1.41- 5.34	3.35	1.62- 6.93	N.C.	1.22 (0)
Sablefish	2.28	1.26- 4.13	1.69	1.02- 2.81	N.C.	0.74 (0)
Cottids	4.50	2.74- 7.38	4.37	2.13- 8.96	N.C.	0.97 (0)
Pacific cod	4.71	1.96- 11.30	8.78	3.77- 20.46	N.C.	1.87 (0)
Walleye pollock	2.86	1.44- 5.66	17.57	5.09- 60.62	C.	6.14 (++)
Pac. o. perch	3.57	1.66- 7.68	1.38	0.84- 2.28	C.	0.39 (-)
Tanner crab	5.66	1.79- 17.94	5.78	2.28- 14.68	N.C.	1.02 (0)
King crab	1.69	0.86- 3.31	2.22	1.14- 4.25	N.C.	1.31 (0)

1/ Weighted geometric mean catch per unit of effort (kg/hour).

2/ Mean CPUE ± 2 standard deviations.

3/ C. = "Change" (both means outside the confidence limits); N.C. = "No Change" (one or both means within the confidence limits).

DECADE COMPARISON BY REGIONS OF THE GULF OF ALAS

The Survey Area was divided into 9 regions of which 7 provided sufficient information in both the 1960 and 1970 surveys to permit comparison. Comparisons are made for Fairweather, Yakutat, Prince William, Kenai, Kodiak, Chirikof, and Sanak. The regions for which no comparisons are made include Shelikof and Shumagin (Figure XII-1).

1. Fairweather Region

In the Fairweather Region there were no statistically-significant changes in CPUE for any of the species groups; however, the CPUEs for all groups except elasmobranchs declined from 1960 to 1970 with moderate decreases indicated for flatfish and invertebrates. For the 14 species compared, only Tanner crab indicated a statistically-significant decrease while no statistically-significant increases were indicated. The CPUE ratio showed a moderate increase for 1 species, skates, while moderate decreases were indicated for turbot, halibut, Pacific cod, and Pacific ocean perch, and large decreases for sablefish and Tanner crab (Table XII-2).

Charts showing the distribution of Tanner crab in 1961 (Figure XI-177) and in 1976 (Figure XI-477) in the Fairweather Region indicate that greater densities of this species occurred between Cape Spencer and Yakutat Bay during the earlier survey than in the later.

2. Yakutat Region

In the Yakutat Region there were no statistically-significant changes in either the species groups or species, although 3 groups (elasmobranchs, flatfish, and roundfish) and 5 species (skates, turbot, Dover sole, rex sole, and pollock) showed moderate increases, and 1 species, Pacific ocean perch, showed a moderate decrease (Table XII-3).

3. Prince William Region

For the Prince William Region statistically-significant increases were shown in the roundfish group and the invertebrate group from 1960 to 1970, and a moderate increase was suggested for the flatfish group. Much of the roundfish increase was probably because of an increase in walleye pollock; no other species increased significantly. Moderate increases in the CPUE index did occur for turbot, flathead sole, Dover sole, rex sole, cottids, and Pacific cod, and a very large increase occurred for Tanner crab. The only marked decrease in the CPUE index from 1960 to 1970 was for Pacific ocean perch (Table XII-4). The increase in the density of walleye pollock from 1961 (Figure XI-217) to 1975 (Figure XI-432) as reflected by CPUE appeared to be general throughout the entire Prince William Region. The 18-fold increase in the mean CPUE for pollock, together with lesser increases in the densities of Pacific cod, cottids, and sablefish, accounted for the large increase in the CPUE for roundfish. The more than 20-fold increase in the CPUE for invertebrates from 1960 (Figure XI-136) to 1970 (Figure XI-411) occurred principally among the Tanner crab in a broad arc from Kayak Island to Cape Cleare at the southwest end of Montague Island.

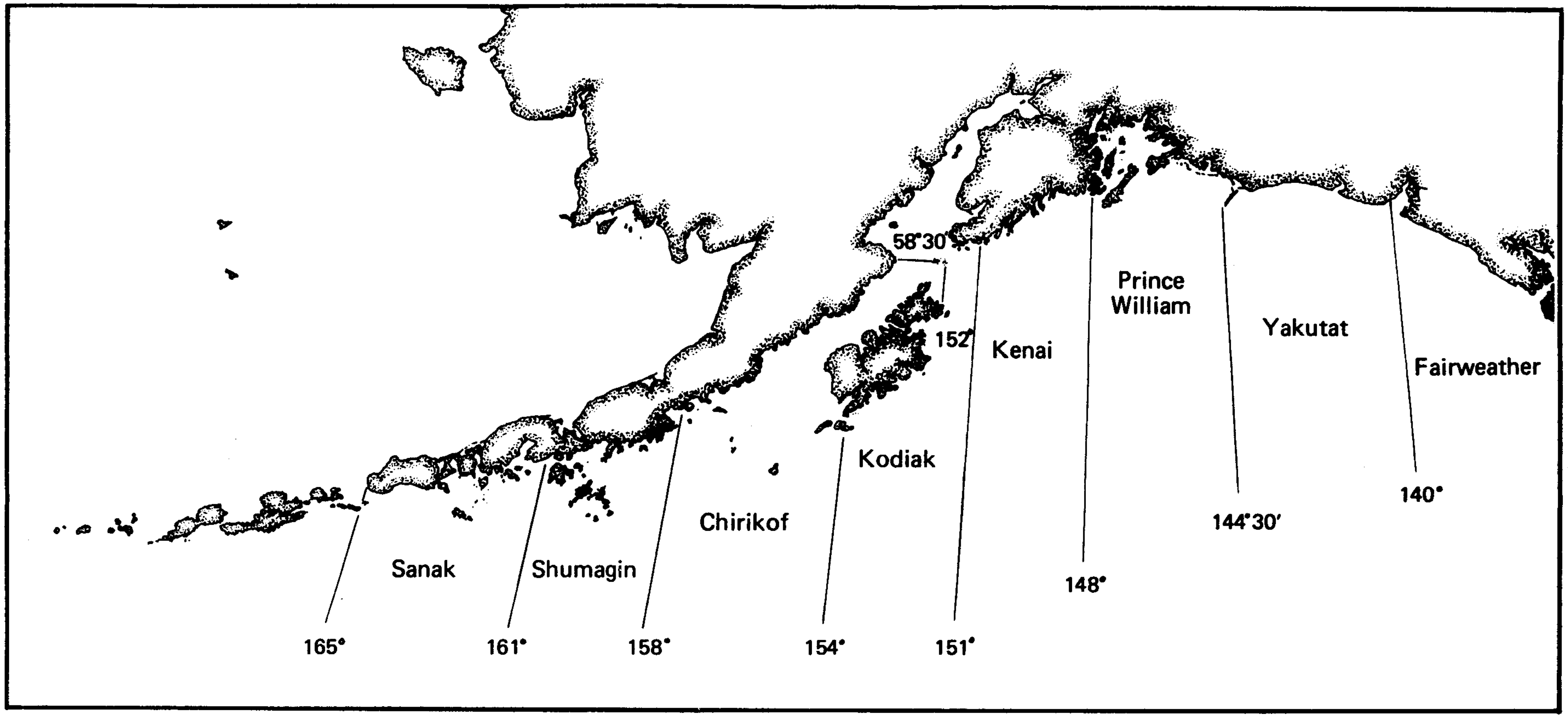

Figure XII-1.--Regions of the northern Gulf of Alaska Survey Area.

NOTE: Draw a line across the top of the Chirikof Region at 57°00'N from the south end of Kodiak I. to the Alaska Peninsula. The area to the north of this line between Kodiak I. and the Alaska Peninsula should be labeled SHELIKOF.

Table XII-2.--Decade comparison by species and species groups for the Fairweather Region (depth zones combined).

Species or Groups	"1960s" Mean CPUE 1/	"1960s" Confidence Interval 2/	"1970s" Mean CPUE 1/	"1970s" Confidence Interval 2/	Confidence Interval Comparison 3/	CPUE Ratio 1970÷1960
Group						
Elasmobranchs	11.99	1.16- 124.46	14.02	1.80-180.94	N.C.	1.17 (0)
Flatfish	191.01	20.54-1776.39	83.02	12.05-572.15	N.C.	0.43 (-)
Roundfish	16.16	1.26- 207.01	14.80	2.76- 79.48	N.C.	0.92 (0)
Rockfish	4.93	0.59- 41.07	2.86	0.38- 21.34	N.C.	0.58 (0)
Invertebrates	73.47	6.22- 868.42	36.88	4.43-307.21	N.C.	0.50 (-)
Species						
Skates	6.67	0.56- 78.84	13.53	1.89- 97.01	N.C.	2.03 (+)
Turbot	94.26	6.33-1402.59	31.21	3.42-284.64	N.C.	0.33 (-)
Halibut	5.20	0.76- 36.19	2.47	0.39- 15.71	N.C.	0.48 (-)
Flathead sole	7.11	0.42- 119.31	5.55	0.30-101.90	N.C.	0.78 (0)
Dover sole	2.06	0.46- 9.15	1.58	0.99- 2.53	N.C.	0.77 (0)
Rex sole	2.87	0.43- 19.00	4.84	0.54- 43.66	N.C.	1.69 (0)
Rock sole	1.39	0.37- 5.20	1.13	0.73- 1.75	N.C.	0.81 (0)
Sablefish	4.92	0.38- 63.03	1.09	0.71- 1.68	N.C.	0.22 (--)
Cottids	1.19	0.37- 3.80	1.30	0.56- 3.04	N.C.	1.09 (0)
Pacific cod	4.05	0.39- 42.48	1.97	0.34- 11.33	N.C.	0.49 (-)
Walleye pollock	1.69	0.54- 5.29	2.28	0.42- 12.47	N.C.	1.35 (0)
Pac. o. perch	3.40	0.46- 25.36	1.20	0.31- 4.63	N.C.	0.35 (-)
Tanner crab	10.03	2.89- 34.80	1.68	0.29- 9.66	C.	0.17 (--)
King crab	1.09	0.43- 2.79	1.14	0.41- 3.14	N.C.	1.05 (0)

1/ Weighted geometric mean catch per unit of effort (kg/hour).

2/ Mean CPUE ± 2 standard deviations.

3/ C. = "Change" (both means outside the confidence limits); N.C. = "No Change"(one or both means within the confidence limits).

Table XII-3.--Decade comparison by species and species group for the Yakutat Region (depth zones combined).

Species or Group	"1960s" Mean CPUE 1/	"1960s" Confidence Interval 2/	"1970s" Mean CPUE 1/	"1970s" Confidence Interval 2/	Confidence Interval Comparison 3/	CPUE Ratio 1970÷1960
Group						
Elasmobranchs	9.06	0.98- 83.44	21.80	5.44- 87.42	N.C.	2.41 (+)
Flatfish	76.16	10.83-535.40	166.20	40.54-681.42	N.C.	2.18 (+)
Roundfish	17.69	1.98-158.15	45.83	7.89-266.27	N.C.	2.59 (+)
Rockfish	9.60	1.04- 88.42	8.74	1.77- 43.26	N.C.	0.91 (0)
Invertebrates	43.22	4.42-422.69	43.90	7.56-255.06	N.C.	1.02 (0)
Species						
Skates	6.45	1.13- 36.77	20.34	4.87- 85.02	N.C.	3.15 (+)
Turbot	30.05	3.54-255.45	74.59	15.22-365.49	N.C.	2.48 (+)
Halibut	4.51	0.78- 26.20	3.60	0.63- 20.70	N.C.	0.80 (0)
Flathead sole	5.02	0.56- 45.28	4.74	0.44- 51.19	N.C.	0.94 (0)
Dover sole	1.89	0.47- 7.52	3.81	0.31- 46.86	N.C.	2.02 (+)
Rex sole	2.81	0.56- 14.19	6.66	0.47- 94.24	N.C.	2.37 (+)
Rock sole	1.14	0.59- 2.19	1.14	0.70- 1.85	N.C.	1.00 (0)
Sablefish	4.16	0.61- 28.37	2.85	0.32- 25.48	N.C.	0.69 (0)
Cottids	1.06	0.61- 1.67	1.60	0.37- 6.90	N.C.	1.00 (0)
Pacific cod	4.46	0.63- 31.35	4.83	0.70- 33.28	N.C.	1.08 (0)
Walleye pollock	4.05	0.53- 30.82	8.74	1.06- 72.11	N.C.	2.16 (+)
Pac. o. perch	6.34	0.59- 68.47	2.02	0.31- 13.11	N.C.	0.32 (-)
Tanner crab	3.34	0.58- 19.21	2.80	0.53- 14.73	N.C.	0.84 (0)
King crab	1.03	0.47- 2.25	--	--	--	--

1/ Weighted geometric mean catch per unit of effort (kg/hour).

2/ Mean CPUE ± standard deviations.

3/ C. = "Change" (both means outside the confidence limits); N.C. = "No Change" (one or both means within the confidence limits).

Table XII-4.--Decade comparison by species and species group for the Prince William Region (depth zones combined).

Species or Group	"1960s" Mean CPUE1/	"1960s" Confidence Interval2/	"1970s" Mean CPUE1/	"1970s" Confidence Interval2/	Confidence Interval Comparison3/	CPUE Ratio 1970÷1960
Group						
Elasmobranchs	5.20	0.73- 37.28	7.94	0.95- 66.14	N.C.	1.53 (0)
Flatfish	32.12	8.09-127.52	107.09	25.38-451.92	N.C.	3.33 (+)
Roundfish	6.66	0.93- 47.75	100.65	24.55-412.67	C.	15.11 (+++)
Rockfish	3.99	0.61- 26.13	2.34	0.38- 14.30	N.C.	0.59 (0)
Invertebrates	5.30	1.02- 27.61	119.14	30.24-469.41	C.	22.48 (+++)
Species						
Skates	3.97	0.50- 31.76	7.61	0.90- 64.69	N.C.	1.92 (0)
Turbot	11.89	2.57- 54.93	41.59	13.86-124.77	N.C.	3.50 (+)
Halibut	3.37	0.72- 15.87	6.50	1.05- 40.11	N.C.	1.93 (0)
Flathead sole	4.32	1.37- 13.65	14.09	2.70- 73.41	N.C.	3.26 (+)
Dover sole	1.12	0.77- 1.62	2.59	0.68- 9.89	N.C.	2.31 (+)
Rex sole	1.48	0.69- 3.17	5.34	1.19- 23.92	N.C.	3.61 (+)
Rock sole	1.30	0.52- 3.22	1.17	0.50- 2.76	N.C.	0.90 (0)
Sablefish	1.58	0.80- 3.11	1.99	0.69- 5.75	N.C.	1.26 (0)
Cottids	1.03	0.84- 1.26	2.67	0.74- 9.69	N.C.	2.59 (+)
Pacific cod	2.09	0.36- 12.27	6.64	0.99- 44.42	N.C.	3.18 (+)
Walleye pollock	2.36	0.62- 8.92	41.66	4.48-387.44	C.	17.65 (+++)
Pac. o. perch	3.75	0.56- 25.09	1.29	0.39- 4.24	N.C.	0.34 (-)
Tanner crab	3.82	0.76- 19.10	45.36	3.76-547.04	N.C.	11.87 (+++)
King crab	--	--	--	--	--	--

1/ Weighted geometric mean catch per unit of effort (kg/hour).

2/ Mean CPUE ± 2 standard deviations.

3/ C. = "Change" (both means outside the confidence limits); N.C. = "No Change"(one or both means within the confidence limits).

4. The Kenai Region

In the Kenai Region there was a statistically-significant decrease in the elasmobranch group's CPUE from 1960 to 1970, a large decrease in the rockfish group, and a moderate increase in the roundfish group. Among the 14 species, a statistically-significant decrease in CPUE occurred only for skates, a substantial part of the elasmobranch group. A moderate decrease took place in flathead sole, and very large decreases occurred in Pacific ocean perch and Tanner crab. The CPUE showed a very large increase from 1960 through 1970 for Dover sole, a large increase for rex sole, and a moderate increase for walleye pollock (Table XII-5).

The occurrence of moderate numbers of skates (elasmobranchs) in the Blying Sound area in 1961 (Figure XI-154) and their apparent lack in 1975 (Figure XI-425) accounts in large measure for the decline in the elasmobranch and skate CPUE indices over the decade. The apparent availability of pollock in the Kenai Region increased by a factor of more than 3 from 1961 (Figure XI-217) to 1975 (Figure XI-432).

5. The Kodiak Region

In the Kodiak Region no statistically-significant changes occurred in any of the species groups; however, 1 species, walleye pollock, showed a statistically-significant increase. A moderate increase also occurred in the roundfish and flatfish species groups. Among the species, moderate increases were found in Pacific cod, rock sole, Dover sole, and turbot, and a moderate decrease occurred for king crab (Table XII-6).

The increases in walleye pollock density from 1961 (Figure XI-218) to 1973 (Figure XI-433) largely occurred on Albatross Bank, Portlock Bank, and in the basin north of Portlock Bank.

6. The Chirikof Region

For the Chirikof Region, no statistically-significant changes were found in any of the species groups, and only 1 species, walleye pollock, had a statistically-significant increase. A moderate increase in the CPUE was found for the roundfish group, and moderate decreases occurred for flatfish and rockfish. Among the 14 species considered, a moderate increase was shown in the CPUE for Pacific cod and moderate decreases for the cottids, Pacific ocean perch, and king crab (Table XII-7).

The increase in the density of walleye pollock from 1960 to 1970 was widespread throughout the Chirikof Region (Figure XI-218 and Figure XI-433).

7. The Sanak Region

For the species groups and individual species in the Sanak Region, statistically-significant increases in CPUE occurred for the flatfish group, turbot, and sablefish, and no significant decreases were indicated. Large increases were noted for the roundfish and invertebrate groups, as well as for the king crab. Rex sole, rock sole, sablefish, and Pacific cod showed moderate increases and walleye pollock a very large increase. A moderate decrease was indicated for the cottids (Table XII-8).

Table XII-5.--Decade comparison by species and species group for the Kenai Region (depth zones combined).

Species or Group	"1960s" Mean CPUE[1/]	"1960s" Confidence Interval[2/]	"1970s" Mean CPUE[1/]	"1970s" Confidence Interval[2/]	Confidence Interval Comparison[3/]	CPUE Ratio 1970÷1960
Group						
Elasmobranchs	19.91	2.75- 144.15	1.73	0.61- 4.90	C.	0.09 (---)
Flatfish	118.21	14.93- 936.22	103.96	11.07-976.18	N.C.	0.88 (0)
Roundfish	55.82	2.72-1143.75	112.43	18.05-700.44	N.C.	2.01 (+)
Rockfish	21.12	1.22- 365.16	4.40	0.51- 31.71	N.C.	0.21 (--)
Invertebrates	26.67	3.33- 213.36	14.66	1.09-197.32	N.C.	0.55 (0)
Species						
Skates	16.03	1.92- 133.53	1.73	0.61- 4.90	C.	0.11 (---)
Turbot	71.34	11.22- 453.72	50.26	5.46-462.89	N.C.	0.70 (0)
Halibut	2.40	0.32- 17.74	2.59	0.26- 25.23	N.C.	1.08 (0)
Flathead sole	36.32	4.06- 324.70	11.91	0.54-261.78	N.C.	0.33 (-)
Dover sole	1.03	0.89- 1.19	9.33	0.69-125.58	N.C.	9.06 (+++)
Rex sole	1.04	0.89- 1.22	7.03	0.90- 54.62	N.C.	6.76 (++)
Rock sole	--	--	--	--	--	--
Sablefish	4.07	1.29- 12.86	3.16	0.47- 21.14	N.C.	0.78 (0)
Cottids	1.51	0.44- 5.22	2.29	0.44- 11.93	N.C.	1.52 (0)
Pacific cod	11.19	0.50- 248.42	18.54	3.10-111.05	N.C.	1.65 (0)
Walleye pollock	14.56	0.73- 289.60	50.86	3.45-749.17	N.C.	3.49 (+)
Pac. o. perch	19.22	0.93- 397.85	1.79	0.33- 9.70	N.C.	0.09 (---)
Tanner crab	24.96	1.22- 511.43	1.54	0.28- 8.59	N.C.	0.06 (---)
King crab	--	--	1.47	0.20- 10.97	--	--

1/ Weighted geometric mean catch per unit of effort (kg/hour).

2/ Mean CPUE ± 2 standard deviations.

3/ C. = "Change" (both means outside the confidence limits); N.C. - "No Change (one or both means within the confidence limits).

Table XII-6.--Decade comparison by species and species group for the Kodiak Region (depth zones combined).

Species or Group	"1960s" Mean CPUE[1/]	"1960s" Confidence Interval[2/]	"1970s" Mean CPUE[1/]	"1970s" Confidence Interval[2/]	Confidence Interval Comparison[3/]	CPUE Ratio 1970÷1960
Group						
Elasmobranchs	1.52	0.47- 4.89	1.11	0.65- 1.89	N.C.	0.73 (0)
Flatfish	134.76	36.72- 494.57	363.40	158.69- 832.19	N.C.	2.70 (+)
Roundfish	76.40	22.54- 259.00	233.18	20.95-2595.29	N.C.	3.05 (+)
Rockfish	2.46	0.42- 14.44	1.53	0.76- 3.07	N.C.	0.62 (0)
Invertebrates	45.75	1.85-1133.69	74.94	7.66- 732.91	N.C.	1.64 (0)
Species						
Skates	1.48	0.46- 4.72	1.11	0.65- 1.89	N.C.	0.68 (0)
Turbot	13.42	1.93- 93.40	33.12	5.21- 210.64	N.C.	2.47 (+)
Halibut	12.26	1.09- 137.93	13.10	2.62- 65.50	N.C.	1.07 (0)
Flathead sole	5.53	0.76- 40.04	8.79	0.69- 111.46	N.C.	1.59 (0)
Dover sole	1.01	0.90- 1.13	2.21	0.58- 8.35	N.C.	2.19 (+)
Rex sole	1.34	0.54- 3.32	1.70	0.35- 8.18	N.C.	1.27 (0)
Rock sole	16.94	1.65- 174.14	55.48	0.94-3281.64	N.C.	3.28 (+)
Sablefish	1.20	0.67- 2.16	1.40	0.60- 3.28	N.C.	1.17 (0)
Cottids	39.65	9.40- 167.32	39.96	6.28- 254.15	N.C.	1.01 (0)
Pacific cod	5.97	0.73- 48.77	23.06	1.01- 527.38	N.C.	3.86 (+)
Walleye pollock	1.60	0.24- 10.48	25.77	0.47-1421.22	C.	17.36 (+++)
Pac. o. perch	2.26	0.39- 13.13	1.35	0.67- 2.69	N.C.	0.60 (0)
Tanner crab	13.72	0.97- 194.14	11.86	1.41- 99.86	N.C.	0.86 (0)
King crab	13.52	0.51- 359.36	6.62	0.40- 108.83	N.C.	0.49 (-)

1/ Weighted geometric mean catch per unit of effort (kg/hour).

2/ Mean CPUE ± 2 standard deviations.

3/ C. = "Change" (both means outside the confidence limits); N.C. = "No Change" (one or both means within the confidence limits).

Table XII-7.--Decade comparison by species and species group for the Chirikof Region (depth zones combined).

Species or Group	"1960s" Mean CPUE 1/	"1960s" Confidence Interval 2/	"1970s" Mean CPUE 1/	"1970s" Confidence Interval 2/	Confidence Interval Comparison 3/	CPUE Ratio 1970÷1960
Group						
Elasmobranchs	2.49	0.96- 6.45	1.46	0.61- 3.49	N.C.	0.59 (0)
Flatfish	158.14	57.51-434.89	68.60	16.26-289.49	N.C.	0.43 (-)
Roundfish	59.47	19.00-186.14	125.10	33.72-464.12	N.C.	2.10 (+)
Rockfish	4.66	0.70- 31.18	2.23	0.64- 7.72	N.C.	0.48 (-)
Invertebrates	19.48	1.70-223.44	20.28	3.42-120.26	N.C.	1.04 (0)
Species						
Skates	2.42	0.92- 6.39	1.46	0.61- 3.49	N.C.	0.60 (0)
Turbot	28.20	8.25- 96.44	22.23	5.64- 87.59	N.C.	0.79 (0)
Halibut	10.05	1.91- 52.86	5.32	1.20- 23.62	N.C.	0.53 (0)
Flathead sole	7.90	2.03- 15.80	10.65	1.89- 60.07	N.C.	1.35 (0)
Dover sole	1.53	0.71- 3.27	1.79	0.71- 4.49	N.C.	1.17 (0)
Rex sole	2.67	0.67- 10.71	2.48	0.71- 8.66	N.C.	0.93 (0)
Rock sole	5.01	2.98- 8.42	2.78	0.77- 10.01	N.C.	0.55 (0)
Sablefish	2.27	0.92- 5.58	1.58	0.75- 2.50	N.C.	0.70 (0)
Cottids	20.11	4.62- 87.48	5.61	1.38- 22.78	N.C.	0.28 (-)
Pacific cod	3.77	1.06- 13.42	8.08	1.50- 43.39	N.C.	2.14 (+)
Walleye pollock	3.43	0.83- 14.20	29.22	3.92-217.98	C.	8.52 (+++)
Pac. o. perch	4.42	0.67- 28.95	1.40	0.54- 3.65	N.C.	0.32 (-)
Tanner crab	4.06	0.03-493.33	5.16	1.03- 25.80	N.C.	1.27 (0)
King crab	8.07	0.84- 77.31	2.27	0.39- 13.32	N.C.	0.28 (-)

1/ Weighted geometric mean catch per unit of effort (kg/hour).

2/ Mean CPUE ± 2 standard deviations.

3/ C. = "Change" (both means outside the confidence limits); N.C. = "No Change" (one or both means within the confidence limits).

Table XII-8.--Decade comparison by species and species group for the Sanak Region (depth zones combined).

Species or Group	"1960s" Mean CPUE 1/	"1960s" Confidence Interval 2/	"1970s" Mean CPUE 1/	"1970s" Confidence Interval 2/	Confidence Interval Comparison 3/	CPUE Ratio 1970÷1960
Group						
Elasmobranchs	1.31	0.56- 3.04	2.26	0.42- 12.14	N.C.	1.73 (0)
Flatfish	69.42	20.72-232.56	282.99	106.39- 752.75	C.	4.08 (++)
Roundfish	82.45	18.20-373.50	361.30	66.05-1976.31	N.C.	4.38 (++)
Rockfish	1.49	0.52- 4.26	1.11	1.09- 1.13	N.C.	0.74 (0)
Invertebrates	8.70	0.26-288.14	48.07	6.57- 351.87	N.C.	5.53 (++)
Species						
Skates	1.28	0.56- 2.93	2.26	0.42- 12.14	N.C.	1.77 (0)
Turbot	9.83	2.11- 45.81	53.11	12.21- 231.03	C.	5.40 (++)
Halibut	7.87	1.14- 54.22	5.90	0.90- 38.65	N.C.	0.75 (0)
Flathead sole	6.22	0.89- 43.29	7.67	0.67- 87.97	N.C.	1.23 (0)
Dover sole	1.03	0.82- 1.29	1.30	0.46- 3.68	N.C.	1.26 (0)
Rex sole	1.24	0.66- 2.33	3.04	0.31- 29.73	N.C.	2.45 (+)
Rock sole	10.21	1.04- 99.85	25.80	1.90- 350.88	N.C.	2.53 (+)
Sablefish	1.15	0.63- 2.12	2.81	1.98- 4.19	C.	2.44 (+)
Cottids	48.68	9.17-258.49	19.19	1.94- 189.41	N.C.	0.39 (-)
Pacific cod	8.08	0.87- 75.14	29.95	3.25- 275.84	N.C.	3.71 (+)
Walleye pollock	2.47	0.52- 11.76	33.26	0.59-1890.17	N.C.	13.47 (+++)
Pac. o. perch	1.49	0.53- 4.22	1.10	1.09- 1.11	N.C.	0.74 (0)
Tanner crab	4.74	0.21-108.40	5.46	0.40- 75.02	N.C.	1.15 (0)
King crab	1.99	0.18- 22.39	9.98	0.94- 105.69	N.C.	5.02 (++)

1/ Weighted geometric mean catch per unit of effort (kg/hour).

2/ Mean CPUE ± 2 standard deviations.

3/ C. = "Change" (both means outside the confidence limits); N.C. = "No Change" (one or both means within the confidence limits).

The increase in the CPUE for the roundfish group from 1960 to 1970 stems largely from the increase in walleye pollock (Figure XI-218 and Figure XI-433).

DECADE COMPARISON BY DEPTH ZONE

On the inner shelf, 0-100 m, a comparison of geometric mean CPUEs for the 5 species groups indicates that all increased from the 1960's, and for the species, all but 2 also increased. On the outer shelf, 101-200 m, CPUEs for 4 of the species groups increased from 1960 to 1970; among the 14 species considered, CPUEs for 8 increased and those for 6 decreased. With the species groups in the upper slope zone, 2 increased and 3 declined; there were increases in CPUEs for 7 species, decreases in 6, and no change in 1.

1. The 0-100 m Depth Zone

For the 0-100 m depth zone, the inner shelf, there were statistically-significant increases in CPUE from 1960 to 1970 in the flatfish and roundfish groups and for turbot; there were no statistically-significant decreases in any group or species (Table XII-9).

In the ratios of the 1970 mean CPUE divided by that for 1960, there were moderate increases in Pacific cod and Tanner crab and large increases for invertebrates and walleye pollock.

2. The 101-200 m Depth Zone

For the 101-200 m depth zone, the outer shelf, there was a statistically-significant increase from 1960 to 1970 for only a single species, the walleye pollock, and there were no significant decreases. Moderate increases in the mean CPUE occurred with the roundfish and invertebrate species groups and with rex sole; a moderate decrease occurred with Pacific ocean perch (Table XII-10).

3. The 201-400 m Depth Zone

For the 201-400 m depth zone, the upper slope, there were no statistically-significant changes from 1960 to 1970 in species group CPUEs, but a significant decrease did occur for Pacific ocean perch. A moderate increase was indicated in the roundfish group and large increases occurred in Dover sole and rex sole, while moderate decreases occurred in the rockfish group and Tanner crab (Table XII-11).

DECADE COMPARISON BY REGION-DEPTH ZONE

The changes in each region-depth zone from 1960 to 1970 based upon comparisons of mean CPUEs (geometric) are listed below:

1. The Inner Shelf (0-100 m) Depth Zone (Table XII-12).

a. Fairweather Region

No marked changes: Elasmobranchs, rockfish, and invertebrates.
Moderate decreases: Halibut, rex sole, rock sole, walleye pollock, and Tanner crab.
Large decreases: Roundfish.
Very large decreases: Flatfish, turbot, flathead sole, and Pacific cod.

Table XII-9.--Decade comparison by species and species group for the 0-100 m depth zone (all regions combined).

Species or Group	"1960s" Mean CPUE 1/	"1960s" Confidence Interval 2/	"1970s" Mean CPUE 1/	"1970s" Confidence Interval 2/	Confidence Interval Comparison 3/	CPUE Ratio 1970÷1960
Group						
Elasmobranchs	2.19	0.93- 5.17	2.83	1.05- 7.64	N.C.	1.30 (0)
Flatfish	63.93	22.91-178.36	178.98	86.88-369.70	C.	2.80 (+)
Roundfish	29.73	7.56-116.84	126.12	41.22-385.93	C.	4.24 (++)
Rockfish	1.08	0.79- 1.47	1.09	0.69- 1.73	N.C.	1.00 (0)
Invertebrates	9.87	0.99- 98.01	57.18	13.76-237.30	N.C.	5.79 (++)
Species						
Skates	1.82	0.77- 4.30	2.76	1.03- 7.37	N.C.	1.52 (0)
Turbot	6.49	2.02- 20.83	29.70	11.08- 79.60	C.	4.58 (++)
Halibut	9.13	2.13- 39.17	12.22	3.13- 47.66	N.C.	1.34 (0)
Flathead sole	3.02	0.87- 10.51	5.04	1.20- 21.22	N.C.	1.67 (0)
Dover sole	1.03	0.87- 1.23	1.20	0.80- 1.80	N.C.	1.17 (0)
Rex sole	1.49	0.82- 2.70	2.28	0.91- 5.68	N.C.	1.53 (0)
Rock sole	8.72	1.96- 38.99	16.51	3.60- 75.62	N.C.	1.89 (0)
Sablefish	1.30	0.86- 1.98	1.13	0.80- 1.59	N.C.	0.87 (0)
Cottids	7.99	2.54- 25.09	14.33	3.62- 56.75	N.C.	1.79 (0)
Pacific cod	5.40	1.13- 25.92	12.31	1.91- 79.40	N.C.	2.28 (+)
Walleye pollock	1.71	0.66- 4.45	11.65	0.84-162.05	N.C.	6.83 (++)
Pac. o. perch	1.07	0.81- 1.41	1.00	0.99- 1.01	N.C.	0.93 (0)
Tanner crab	2.85	0.45- 17.84	7.93	1.42- 44.25	N.C.	2.78 (+)
King crab	2.51	0.40- 15.76	3.57	1.01- 12.60	N.C.	1.42 (0)

1/ Weighted geometric mean catch per unit of effort (kg/hour).

2/ Mean CPUE ± 2 standard deviations.

3/ C. = "Change" (both means outside the confidence limits); N.C. = "No Change" (one or both means within the confidence limits).

Table XII-10.--Decade comparison by species and species group for the 101-200 m depth zone (all regions combined).

Species or Group	"1960s" Mean CPUE 1/	"1960s" Confidence Interval 2/	"1970s" Mean CPUE 1/	"1970s" Confidence Interval 2/	Confidence Interval Comparison 3/	CPUE Ratio 1970÷1960
Group						
Elasmobranchs	5.59	1.76- 17.77	6.82	2.05- 22.64	N.C.	1.22 (0)
Flatfish	92.10	31.33-270.77	116.50	48.54-279.60	N.C.	1.26 (0)
Roundfish	28.10	7.81-101.16	92.23	32.36-262.86	N.C.	3.28 (+)
Rockfish	4.90	1.18- 20.43	2.78	0.96- 8.03	N.C.	0.57 (0)
Invertebrates	20.46	4.18-100.25	45.47	15.68-131.86	N.C.	2.22 (+)
Species						
Skates	4.17	1.27- 13.72	6.59	1.98- 21.88	N.C.	1.58 (0)
Turbot	38.10	10.61-136.78	47.77	16.76-136.14	N.C.	1.25 (0)
Halibut	6.31	2.07- 19.25	3.14	0.98- 10.05	N.C.	0.50 (-)
Flathead sole	9.35	2.40- 36.47	11.57	2.31- 57.85	N.C.	1.24 (0)
Dover sole	1.20	0.70- 2.06	1.98	0.83- 4.75	N.C.	1.65 (0)
Rex sole	1.67	0.76 - 3.69	4.71	1.15- 19.22	N.C.	2.83 (+)
Rock sole	1.72	0.72- 4.09	1.68	0.61- 4.65	N.C.	0.97 (0)
Sablefish	2.23	0.78- 6.40	1.43	0.81- 2.53	N.C.	0.64 (0)
Cottids	4.34	2.38- 7.90	3.08	1.21- 7.85	N.C.	0.71 (0)
Pacific cod	5.42	1.41- 20.81	9.36	3.27- 26.77	N.C.	1.73 (0)
Walleye pollock	3.45	1.10- 10.87	30.58	5.80-161.16	C.	8.87 (+++)
Pac. o. perch	4.18	1.02- 17.18	1.55	0.69- 3.49	N.C.	0.37 (-)
Tanner crab	7.85	1.13- 54.48	5.48	1.37- 21.87	N.C.	0.70 (0)
King crab	1.33	0.78- 2.27	1.98	0.75- 5.25	N.C.	1.49 (0)

1/ Weighted geometric mean catch per unit of effort (kg/hour).

2/ Mean CPUE ± 2 standard deviations.

3/ C. = "Change" (both means outside the confidence limits); N.C. = "No Change" (one or both means within the confidence limits).

Table XII-11.--Decade comparison by species and species group for the 201-400 m depth zone (all regions combined).

Species or Group	"1960s" Mean CPUE 1/	"1960s" Confidence Interval 2/	"1970s" Mean CPUE 1/	"1970s" Confidence Interval 2/	Confidence Interval Comparison 3/	CPUE Ratio 1970÷1960
Group						
Elasmobranchs	10.43	1.30- 83.88	9.89	3.13- 31.25	N.C.	0.95 (0)
Flatfish	131.34	39.92-432.11	211.28	37.80-1181.06	N.C.	1.61 (0)
Roundfish	22.46	6.38- 79.06	53.85	10.97- 264.40	N.C.	2.40 (+)
Rockfish	51.01	15.65-166.29	16.38	4.93- 54.38	N.C.	0.32 (-)
Invertebrates	52.18	13.66-198.93	36.92	5.20- 262.13	N.C.	0.71 (0)
Species						
Skates	9.06	2.46- 33.34	9.82	2.98- 32.41	N.C.	1.08 (0)
Turbot	67.69	17.77-257.90	89.23	21.50- 370.30	N.C.	1.32 (0)
Halibut	2.05	0.77- 5.43	1.65	0.69- 3.96	N.C.	0.80 (0)
Flathead sole	10.10	2.14- 47.57	6.07	1.19- 31.02	N.C.	0.60 (0)
Dover sole	3.77	0.77- 18.55	15.17	0.69- 333.28	N.C.	4.02 (++)
Rex sole	3.74	0.89- 15.63	15.46	0.77- 310.44	N.C.	4.14 (++)
Rock sole	1.04	0.84- 1.29	1.04	0.87- 1.24	N.C.	1.00 (0)
Sablefish	8.58	2.28- 32.26	7.30	0.47- 112.42	N.C.	0.85 (0)
Cottids	1.43	0.92- 2.22	2.56	0.41- 16.00	N.C.	1.79 (0)
Pacific cod	2.18	0.97- 4.91	3.35	0.89- 12.63	N.C.	1.54 (0)
Walleye pollock	4.74	1.86- 12.09	6.53	1.50- 28.34	N.C.	1.38 (0)
Pac. o. perch	29.69	11.64- 75.71	1.90	0.30- 11.89	C.	0.06 (---)
Tanner crab	8.46	1.96- 36.55	3.90	1.05- 14.43	N.C.	0.46 (-)
King crab	1.52	0.83- 2.80	1.29	0.70- 2.37	N.C.	0.85 (0)

1/ Weighted geometric mean catch per unit of effort (kg/hour).

2/ Mean CPUE ± 2 standard deviations.

3/ C. = "Change" (both means outside the confidence limits); N.C. = "No Change" (one or both means within the confidence limits).

Table XII-12--Ratio of the 1970÷1960 geometric mean CPUE index (kg/hr) for the 0-100 m depth zone by region of the Gulf of Alaska.

Species or Group	REGION						
	Fairweather	Yakutat	Prince William	Kenai	Kodiak	Chirikof	Sanak
Group							
Elasmobranchs	1.88	2.25	2.02	--	--	--	--
Flatfish	0.09	1.85	11.29	--	2.86	0.46	3.90
Roundfish	0.17	11.31	18.87	--	2.12	1.47	3.55
Rockfish	0.98	0.99	--	--	--	--	--
Invertebrates	1.83	2.48	87.05	--	4.99	0.52	3.18
Species							
Skates	3.13	3.37	2.64	--	--	--	--
Turbot	0.10	1.55	18.66	--	3.35	2.90	7.35
Halibut	0.38	3.06	3.64	--	2.26	0.21	0.88
Flathead sole	0.07	2.35	8.79	--	1.66	2.03	0.98
Dover sole	--	1.57	--	--	--	--	--
Rex sole	0.40	1.88	2.72	--	1.73	1.61	1.26
Rock sole	0.33	1.32	0.76	--	5.15	0.46	5.32
Sablefish	--	0.59	--	--	--	--	--
Cottids	--	0.82	--	--	1.22	0.50	0.96
Pacific cod	0.11	7.05	2.41	--	5.12	0.93	2.65
Walleye pollock	0.50	12.50	--	--	10.01	2.98	4.29
Pac. o. perch	--	0.99	--	--	--	--	--
Tanner crab	0.41	3.26	42.23	--	1.85	1.39	0.95
King crab	--	--	--	--	0.66	0.11	4.66

Moderate increases: Skates.
Large increases: None.
Very large increases: None.

b. Yakutat Region

No marked changes: Flatfish, rockfish, turbot, Dover sole, rex sole, rock sole, sablefish, cottids, and Pacific ocean perch.
Moderate decreases: None.
Large decreases: None.
Very large decreases: None.
Moderate increases: Elasmobranchs, invertebrates, skates, halibut, flathead sole, and Tanner crab.
Large increases: Pacific cod.
Very large increases: Roundfish and walleye pollock.

c. Prince William Region

No marked changes: Rock sole.
Moderate decreases: None.
Large decreases: None.
Very large decreases: None.
Moderate increases: Elasmobranchs, skates, halibut, rex sole, and Pacific cod.
Large increases: None.
Very large increases: Flatfish, roundfish, invertebrates, turbot, flathead sole, and Tanner crab.

d. Kenai Region

No comparative information in the 0-100 m depth zone.

e. Kodiak Region

No marked changes: Flathead sole, rex sole, cottids, Tanner crab, and king crab.
Moderate decreases: None.
Large decreases: None.
Very large decreases: None.
Moderate increases: Flatfish, roundfish, turbot, and halibut.
Large increases: Invertebrates, rock sole, and Pacific cod.
Very large increases: Walleye pollock.

f. Chirikof Region

No marked changes: Roundfish, invertebrates, rex sole, Pacific cod, and Tanner crab
Moderate decreases: Flatfish, rock sole, and cottids.
Large decreases: Halibut.
Very large decreases: King crab.
Moderate increases: Turbot, flathead sole, and walleye pollock.
Large increases: None.
Very large increases: None.

g. Sanak Region

No marked changes: Halibut, flathead sole, rex sole, cottids, and Tanner crab.
Moderate decreases: None.
Large decreases: None.
Very large decreases: None.
Moderate increases: Flatfish, roundfish, invertebrates, and Pacific cod.
Large increases: Turbot, rock sole, walleye pollock, and king crab.
Very large increases: None.

2. The Outer Shelf (101-200 m) Depth Zone (Table XII-13)

a. Fairweather Region

No marked changes: Elasmobranchs, roundfish, rockfish, invertebrates, flathead sole, Dover sole, rock sole, cottids, Pacific cod, walleye pollock, and king crab.
Moderate decreases: Flatfish, turbot, halibut, sablefish, and Pacific ocean perch.
Large decreases: Tanner crab.
Moderate increases: Skates and rex sole.
Large increases: None.
Very large increases: None.

b. Yakutat Region

No marked changes: Elasmobranchs, roundfish, rockfish, invertebrates, halibut, flathead sole, Dover sole, rex sole, Pacific cod, walleye pollock, and Tanner crab.
Moderate decreases: Sablefish and Pacific ocean perch.
Large decreases: None.
Very large decreases: None.
Moderate increases: Flatfish, skates, and turbot.
Large increases: None.
Very large increases: None.

c. Prince William Region

No marked changes: Elasmobranchs, flatfish, skates, turbot, halibut, and sablefish.
Moderate decreases: Rockfish and Pacific ocean perch.
Large decreases: None.
Very large decreases: None.
Moderate increases: Flathead sole, Dover sole, rex sole, and cottids.
Large increases: Pacific cod and Tanner crab.
Very large increases: Roundfish, invertebrates, and walleye pollock.

d. Kenai Region

No marked changes: Flatfish, invertebrates, turbot, halibut, sablefish, cottids, and Pacific cod.
Moderate decreases: Rockfish and flathead sole.
Large decreases: Skates and Pacific ocean perch.
Very large decreases: Elasmobranchs and Tanner crab.
Moderate increases: Roundfish.
Large increases: None.
Very large increases: Dover sole, rex sole, and walleye pollock.

Table XII-13.--Ratio of the 1970÷1960 geometric mean CPUE index (kg/hr) for the 101-200 m depth zone by region of the Gulf of Alaska.

Species or Group	REGION						
	Fairweather	Yakutat	Prince William	Kenai	Kodiak	Chirikof	Sanak
Group							
Elasmobranchs	1.17	1.91	1.11	0.10	0.65	0.66	3.47
Flatfish	0.30	2.29	1.41	1.23	2.07	0.35	3.90
Roundfish	1.40	1.14	18.28	3.01	4.27	3.32	5.22
Rockfish	0.52	1.12	0.41	0.28	0.31	0.50	--
Invertebrates	0.51	1.21	9.30	0.79	0.37	1.30	9.14
Species							
Skates	2.09	2.57	1.40	0.13	0.65	0.60	3.61
Turbot	0.26	2.87	1.53	1.05	1.53	0.43	3.47
Halibut	0.43	0.51	0.57	0.91	0.38	0.12	0.63
Flathead sole	1.17	1.24	2.35	0.31	2.61	0.75	1.45
Dover sole	0.68	1.50	2.34	9.50	3.73	1.16	1.54
Rex sole	2.21	1.83	3.51	7.37	1.99	0.78	4.70
Rock sole	0.95	--	--	--	1.62	0.45	1.20
Sablefish	0.33	0.36	1.07	1.16	1.08	0.62	1.03
Cottids	0.93	--	2.03	1.54	0.43	0.14	0.15
Pacific cod	0.64	0.51	4.83	1.58	4.59	1.70	5.61
Walleye pollock	1.59	1.78	24.80	8.02	32.10	68.49	43.85
Pac. o. perch	0.47	0.34	0.29	0.15	0.36	0.30	--
Tanner crab	0.13	0.90	4.91	0.10	0.46	0.97	1.44
King crab	1.14	--	--	--	0.43	0.49	6.17

e. Kodiak Region

No marked changes: Elasmobranchs, skates, turbot, rex sole, rock sole, and sablefish.
Moderate decreases: Invertebrates, halibut, cottids, Tanner crab, king crab, rockfish, and Pacific ocean perch.
Large decreases: None.
Very large decreases: None.
Moderate increases: Flatfish, flathead sole, and Dover sole.
Large increases: Roundfish and Pacific cod.
Very large increases: Walleye pollock..

f. Chirikof Region

No marked changes: Elasmobranchs, invertebrates, skates, flathead sole, Dover sole, rex sole, sablefish, Pacific cod, and Tanner crab.
Moderate decreases: Flatfish, rockfish, turbot, rock sole, Pacific ocean perch, and king crab.
Large decreases: Cottids.
Very large decreases: Halibut.
Moderate increases: Roundfish.
Large increases: None.
Very large increases: Walleye pollock.

g. Sanak Region

No marked changes; Halibut, flathead sole, Dover sole, rock sole, sablefish, and Tanner crab.
Moderate decreases: None.
Large decreases: Cottids.
Very large decreases: None.
Moderate increases: Elasmobranchs, flatfish, skates, and turbot.
Large increases: Roundfish, rex sole, Pacific cod, and king crab.
Very large increases: Invertebrates and walleye pollock.

3. The Upper Slope (201-400 m) Depth Zone (Table XII-14)

a. Fairweather Region

No marked changes: Elasmobranchs, roundfish, rockfish, skates, flathead sole, Dover sole, and walleye pollock.
Moderate decreases: None.
Large decreases: None.
Very large decreases: Invertebrates and sablefish.
Moderate increases: Flatfish, rex sole, and cottids.
Large increases: Turbot.
Very large increase: None.

b. Yakutat Region

No marked changes: Rockfish, halibut, Pacific cod, and walleye pollock.
Moderate decreases: Invertebrates.
Large decreases: Flathead sole and Tanner crab.
Very large decreases: Pacific ocean perch.
Moderate increases: Flatfish, roundfish, turbot, and sablefish.
Large increases: Elasmobranchs, skates, Dover sole, and rex sole.
Very large increases: None.

Table XII-14.--Ratio of 1970÷1960 geometric mean CPUE index (kg/hr) for the 201-400 m depth zone by region of the Gulf of Alaska.

Species or Group	REGION						
	Fairweather	Yakutat	Prince William	Kenai	Kodiak	Chirikof	Sanak
Group							
Elasmobranchs	0.67	4.37	1.94	0.06	--	0.30	1.15
Flatfish	3.05	2.29	1.52	0.40	4.92	0.55	13.76
Roundfish	0.72	3.94	3.98	0.80	13.71	1.63	9.14
Rockfish	0.54	0.55	0.14	0.06	12.24	0.19	0.78
Invertebrates	0.10	0.31	7.80	0.24	0.11	1.66	--
Species							
Skates	1.02	4.60	2.14	0.07	--	0.31	1.15
Turbot	4.95	2.79	0.39	0.28	1.58	0.44	20.51
Halibut	--	.63	--	1.59	0.19	1.93	0.81
Flathead sole	1.68	0.23	0.51	0.37	0.15	1.99	--
Dover sole	1.18	4.82	6.08	--	--	1.32	4.75
Rex sole	2.16	5.09	9.46	--	--	0.65	7.73
Rock sole	--	--	--	--	1.61	0.92	--
Sablefish	0.06	3.03	1.32	0.30	--	0.50	2.12
Cottids	2.95	--	--	--	7.10	0.39	0.36
Pacific cod	--	1.00	1.74	1.84	0.22	7.65	2.13
Walleye pollock	1.88	0.67	1.51	0.52	--	1.47	35.22
Pac. o. perch	--	0.10	0.03	--	2.79	0.09	0.24
Tanner crab	--	0.21	5.35	0.05	0.05	1.69	--
King crab	--	--	--	--	0.08	0.37	--

c. Prince William Region

No marked changes: Elasmobranchs, flatfish, flathead sole, sablefish, Pacific cod, and walleye pollock.
Moderate decreases: Turbot.
Large decreases: Rockfish
Very large decreases: Pacific ocean perch.
Moderate increases: Roundfish and skates.
Large increases: Invertebrates, Dover sole, and Tanner crab.
Very large increases: Rex sole.

d. Kenai Region

No marked changes: Roundfish, halibut, Pacific cod, and walleye pollock.
Moderate decreases: Flatfish, turbot, flathead sole, and sablefish.
Large decreases: Invertebrates.
Very large decreases: Elasmobranchs, rockfish, skates, and Tanner crab.
Moderate increases: None.
Large increases: None.
Very large increases: None.

e. Kodiak Region

No marked changes: Turbot and rock sole.
Moderate decreases: None.
Large decreases: Halibut, flathead sole, and Pacific cod.
Very large decreases: Invertebrates, and Tanner and king crab.
Moderate increases: Pacific ocean perch.
Large increases: Flatfish and cottids.
Very large increases: Roundfish and rockfish.

f. Chirikof Region

No marked changes: Flatfish, roundfish, invertebrates, halibut, flathead sole, Dover sole, rex sole, rock sole, walleye pollock, and Tanner crab.
Moderate decreases: Elasmobranchs, skates, turbot, sablefish, cottids, and king crab.
Large decreases: Rockfish.
Very large decreases: Pacific ocean perch.
Moderate increases: None.
Large increases: Pacific cod.
Very large increases: None.

g. Sanak Region

No marked changes: Elasmobranchs, rockfish, skates, and halibut.
Moderate decreases: Cottids.
Large decreases: Pacific ocean perch.
Very large decreases: None.
Moderate increases: Sablefish and Pacific cod.
Large increases: Dover sole and rex sole.
Very large increases: Flatfish, roundfish, turbot, and walleye pollock.

DECADE COMPARISON BY SPECIES GROUP AND SPECIES

1. Species Groups

a. Elasmobranchs (Table XII-15)

The overall CPUE for elasmobranchs showed no marked change from 1960 to 1970 within the Gulf of Alaska. Within the regions, a moderate increase in CPUE occurred in Yakutat and a very large (statistically-significant) decrease in Kenai. No marked changes occurred in any other region or depth zone. A large increase in the CPUE for elasmobranchs occurred in the Yakutat-upper slope. Very large decreases occurred in the Kenai-outer shelf and Kenai-upper slope. Thus, the Kenai region saw a large decline in elasmobranchs from 1960 to 1970.

b. Flatfish (Table XII-16)

No marked change occurred in the overall density of flatfish in the Gulf of Alaska from 1960 to 1970. Within the regions, there were moderate increases in Yakutat, Prince William, and Kodiak; a large (statistically-significant) increase in Sanak; and moderate decreases in Fairweather and Chirikof. A moderate (statistically-significant) increase occurred in the CPUE for flatfish within the inner shelf depth zone, but no marked changes were indicated in the other depth zones. Individual region-depth zones with large or very large increases in the flatfish group from 1960 to 1970 were the Prince William-inner shelf, Kodiak-upper slope, and the Sanak upper slope. The Fairweather-inner shelf had a very large decrease in the flatfish CPUE in the decade from 1960 to 1970.

c. Roundfish (Table XII-17)

The CPUE for the roundfish group within the Gulf of Alaska showed a moderate (statistically-significant) increase from 1960 to 1970. The CPUE increased moderately in the Yakutat, Kenai, Kodiak, and Chirikof Regions; a large increase occurred in Sanak; and a very large (statistically-significant) increase occurred in Prince William. Among the depth zones, a large (statistically-significant) increase occurred in the inner shelf and moderate increases occurred in the outer shelf and upper slope zones. No decreases were indicated in any region or depth zone. The individual region-depth zones with marked increases were the Kodiak-outer shelf and the Sanak-outer shelf with large increases, and the Yakutat-inner shelf, the Prince William-inner shelf, the Prince William-outer shelf, the Kodiak-upper slope, and the Sanak-upper slope with very large increases. A large decrease in CPUE occurred in the Fairweather-inner shelf. Thus, the roundfish group apparently increased throughout much of the Gulf of Alaska from 1960 to 1970 in all regions except the extreme eastern part of the Survey Area.

d. Rockfish (Table XII-18)

The rockfish was the only species group to show a decline in CPUE from 1960 to 1970 in the Gulf of Alaska as a whole (Table XII-1). Within the various regions of the Gulf of Alaska, the CPUE for rockfish did not show a marked

Table XII-15.--Ratio of 1970÷1960 geometric mean CPUE index (kg/hr)1/ for elasmobranchs.

Species or Species Group	Depth Zone (m)	REGION: Fairweather	Yakutat	Prince William	Kenai	Kodiak	Chirikof	Sanak	Total
Elasmobranchs	0-100	0	+	+	2/	2/	2/	2/	0
	101-200	0	0	0	---	0	0	+	0
	201-400	0	++	0	---	2/	-	0	0
	Total	0	+	0	---4/	0	0	0	0

Table XII-16.--Ratio of 1970÷1960 geometric mean CPUE index (kg/hr)1/ for flatfish.

Species or Species Group	Depth Zone (m)	REGION: Fairweather	Yakutat	Prince William	Kenai	Kodiak	Chirikof	Sanak	Total
Flatfish	0-100	---	0	+++	2/	+	-	+	+3/
	101-200	-	+	0	0	+	-	+	0
	201-400	+	+	0	-	++	0	+++	0
	Total	-	+	+	0	+	-	++3/	0

1/

Code	Ratio	Description
0	0.51-2.00	No marked change, 1960-1970
-	0.26-0.50	Moderate decrease, 1960-1970
--	0.13-0.25	Large decrease, 1960-1970
---	Less than 0.13	Very large decrease, 1960-1970
+	2.01-4.00	Moderate increase, 1960-1970
++	4.01-8.00	Large increase, 1960-1970
+++	Greater than 8.00	Very large increase, 1960-1970

2/ Insufficient data.

3/ Significant increase indicated by confidence interval.

4/ Significant decrease indicated by confidence interval.

Table XII-17.--Ratio of 1970÷1960 geometric mean CPUE index (kg/hr)[1/] for roundfish.

Species or Species Group	Depth Zone (m)	REGION							
		Fairweather	Yakutat	Prince William	Kenai	Kodiak	Chirikof	Sanak	Total
Roundfish	0-100	--	+++	+++	2/	+	0	+	++3/
	101-200	0	0	+++	+	++	+	++	+
	201-400	0	+	+	0	+++	0	+++	+
	Total	0	+	+++3/	+	+	+	++	+3/

Table XII-18.--Ratio of 1970÷1960 geometric mean CPUE index (kg/hr)[1/] for rockfish.

Species or Species Group	Depth Zone (m)	REGION							
		Fairweather	Yakutat	Prince William	Kenai	Kodiak	Chirikof	Sanak	Total
Rockfish	0-100	0	0	2/	2/	2/	2/	2/	0
	101-200	0	0	-	-	0	-	2/	0
	201-400	0	0	--	---	+++	--	0	-
	Total	0	0	0	--	0	-	0	0

1/

Code	Ratio	Description
0	0.51-2.00	No marked change, 1960-1970
-	0.26-0.50	Moderate decrease, 1960-1970
--	0.13-0.25	Large decrease, 1960-1970
---	Less than 0.13	Very large decrease, 1960-1970
+	2.01-4.00	Moderate increase, 1960-1970
++	4.01-8.00	Large increase, 1960-1970
+++	Greater than 8.00	Very large increase, 1960-1970

2/ Insufficient data.

3/ Significant increase indicated by confidence interval.

Table XII-19.--Ratio of 1970÷1960 geometric mean CPUE index (kg/hr)1/ for invertebrates.

Species or Species Group	Depth Zone (m)	REGION							
		Fairweather	Yakutat	Prince William	Kenai	Kodiak	Chirikof	Sanak	Total
Invertebrates	0-100	0	+	+++	2/	++	0	+	++
	101-200	0	0	+++	0	-	0	+++	+
	201-400	---	-	++	--	---	0	2/	0
	Total	-	0	+++3/	0	0	0	++	+

Table XII-20.--Ratio of 1970÷1960 geometric mean CPUE index (kg/hr)1/ for skates.

Species or Species Group	Depth Zone (m)	REGION							
		Fairweather	Yakutat	Prince William	Kenai	Kodiak	Chirikof	Sanak	Total
Skates	0-100	+	+	+	2/	2/	2/	2/	0
	101-200	+	+	0	--	0	0	+	0
	201-400	0	++	+	---	2/	-	0	0
	Total	+	+	0	---3/	0	0	0	0

1/

Code	Ratio	Description
0	0.50-2.00	No marked change, 1960-1970
-	0.26-0.50	Moderate decrease, 1960-1970
--	0.13-0.25	Large decrease, 1960-1970
---	Less than 0.13	Very large decrease, 1960-1970
+	2.01-4.00	Moderate increase, 1960-1970
++	4.01-8.00	Large increase, 1960-1970
+++	Greater than 8.00	Very large increase, 1960-1970

2/ Insufficient data.

3/ Significant increase indicated by confidence interval.

Table XII-21.--Ratio of 1970÷1960 geometric mean CPUE index (kg/hr)1/ for turbot.

Species or Species Group	Depth Zone (m)	REGION Fairweather	Yakutat	Prince William	Kenai	Kodiak	Chirikof	Sanak	Total
Turbot	0-100	---	0	+++	2/	+	+	++	++3/
	101-200	-	+	0	0	0	-	+	0
	201-400	++	+	-	-	0	-	+++	0
	Total	-	+	+	0	+	0	++3/	0

Table XII-22.--Ratio of 1970÷1960 geometric mean CPUE index (kg/hr)1/ for halibut.

Species or Species Group	Depth Zone (m)	REGION Fairweather	Yakutat	Prince William	Kenai	Kodiak	Chirikof	Sanak	Total
Halibut	0-100	-	+	+	2/	+	--	0	0
	101-200	-	0	0	0	-	---	0	-
	201-400	2/	0	2/	0	--	0	0	0
	Total	-	0	0	0	0	0	0	0

1/

Code	Ratio	Description
0	0.51-2.00	No marked change, 1960-1970
-	0.26-0.50	Moderate decrease, 1960-1970
--	0.13-0.25	Large decrease, 1960-1970
---	Less than 0.13	Very large decrease, 1960-1970
+	2.01-4.00	Moderate increase, 1960-1970
++	4.01-8.00	Large increase, 1960-1970
+++	Greater than 8.00	Very large increase, 1960-1970

2/ Insufficient data.

3/ Significant increase indicated by confidence interval.

change except in Chirikof with a moderate decrease and Kenai with a large decrease. Among the depth zones, there were no marked changes in CPUE in the inner and outer shelf zones and a moderate decrease in the upper slope. Individual region-depth zones with large or very large increases in the rockfish included only the Kodiak-upper slope with a very large increase. Decreases in CPUE occurred in the Prince William-upper slope and Chirikof-upper slope which had large decreases, and a very large decresed occurred in the Kenai-upper slope. Thus, the more dramatic changes in CPUE for rockfish occurred during the decade from 1960 to 1970 in the upper slope depth zone with the Kodiak-upper slope showing sharp increases and adjacent regions showing decreases.

e. Invertebrates (Table XII-19)

A moderate increase occurred in the CPUE index for the invertebrate group from 1960 to 1970 in the Gulf of Alaska. Within the regions, no marked changes were found in the Yakutat, Kenai, Kodiak, and Chirikof Regions, while a moderate decrease occurred in Fairweather, a large increase in Sanak, and a very large (statistically-significant) increase in Prince William. Within the 3 depth zones of the Gulf of Alaska, there was no marked change in the upper slope, a moderate increase in the outer shelf, and a large increase in the inner shelf. Region-depth zones with large or very large changes included a large decrease in the Kenai-upper slope and very large decreases in the Fairweather-upper slope and the Kodiak-upper slope; a large increase in CPUE took place in the Kodiak-inner shelf and the Prince William-upper slope. Very large increases occurred in the 2 shelf zones of the Prince William Region and in the Sanak-outer shelf. Thus, the decade saw dramatic increases in the CPUE indicies for invertebrates in the Prince William and Sannk Regions, and either little change or marked decreases occurred in much of the remainder of the Survey Area.

2. Species

a. Skates (Table XII-20)

No marked change occurred in the CPUE for skates from the 1960 survey to that of 1970 in the Gulf of Alaska, nor were there marked changes in any of the depth zones. In the various regions, a very large (statistically-significant) decrease was found in the CPUE in the Kenai Region and moderate increases in the Fairweather and Yakutat Regions; the other regions saw no marked changes. Individual region-depth zones with large or very large changes were the Kenai-outer shelf and Kenai-upper slope with decreases and the Yakutat-upper slope with a large increase. Thus, in comparison with 1960, the 1970 distribution of skates appears to have shifted eastward from the Kenai Region toward Yakutat and Fairweather.

b. Turbot (Table XII-21)

No marked change occurred in the CPUE for turbot from 1960 to 1970 in the Gulf of Alaska, and while the upper slope and outer shelf depth zones also saw no marked changes, there was a large (statistically-significant) increase in CPUE in the inner shelf. Among the various regions, a moderate decrease in CPUE occurred in the Fairweather Region; moderate increases in the Yakutat, Prince William, and Kodiak Regions; and a large (statistically-significant) increase in the Sanak Region. Within the region-depth zones a very large decrease was found in the Fairweather-inner shelf, and large or very large increases occurred in the Fairweather-upper slope, Prince William-inner shelf, Sanak-inner shelf, and in the Sanak-upper slope.

c. Halibut (Table XII-22)

Length-frequency information collected from catches of halibut made by otter trawls fished at the relatively slow speeds used during these surveys indicate that the trawl does not proportionally sample the large specimens. The comparison of mean CPUEs from the surveys in 1960 and 1970, therefore, must be made with reservations.

No marked change in the CPUE for halibut was indicated from 1960 to 1970 in the Gulf of Alaska, and two of the depth zones, the inner shelf and upper slope, also saw no marked changes. On the outer shelf, however, there was a moderate decrease in CPUE. Fairweather, with a moderate decrease, was the only region with a marked change in CPUE from 1960 to 1970. Among the region-depth zones with large or very large changes, were the Kodiak-upper slope, the Chirikof-inner shelf, and the Chirikof-outer shelf with marked decreases.

d. Flathead sole (Table XII-23)

The CPUE for flathead sole did not change markedly within the Gulf of Alaska from the 1960 to the 1970 survey, nor did it change in any of the depth zones. Within the various regions, there were no marked changes except for a moderate decrease in Kenai and a moderate increase in Prince William. Among the region-depth zones with large or very large changes in CPUE were the Fairweather-inner shelf, the Yakutat-upper slope, and the Kodiak-upper slope with decreases, and the Prince William-inner shelf with a very large increase.

e. Dover sole (Table XII-24)

During these resource assessment surveys the depth ranges sampled with respect to Dover sole included only the upper part of the normal distribution of the species. Some reservations, therefore, should be attached to conclusions drawn from comparisons of CPUE between survey periods as reflecting real changes in the entire Dover sole population.

A statistically-significant increase in the CPUE index for Dover sole occurred within the Gulf of Alaska from the 1960 to the 1970 survey, and among the depth zones only the upper slope saw a marked change, a large increase. Within the various regions, moderate increases occurred in Yakutat, Prince William, and Kodiak; and a very large increase took place in the Kenai Region. Among region-depth zones with either large or very large changes, increases occurred in the Yakutat-upper slope, the Prince William-upper slope, the Kenai-outer shelf, the Kenai-upper slope, the Kodiak-upper slope, and the Sanak-upper slope. There appeared to be a widespread increase in CPUE for Dover sole throughout most of the Gulf of Alaska from 1960 to 1970.

f. Rex sole (Table XII-25)

A moderate increase occurred in the CPUE for rex sole in the Gulf of Alaska during the decade from the 1960's to the 1970's. Within the three depth zones, the CPUEs for rex sole indicated no marked change in the inner shelf, a moderate increase in the outer shelf, and a large increase in the upper slope. In the regions of the Survey Area, moderate increases occurred in Yakutat, Prince William, and Sanak, and a large increase in Kenai.

Table XII-23.--Ratio of 1970÷1960 geometric mean CPUE index (kg/hr)1/ for flathead sole.

Species or Species Group	Depth Zone (m)	REGION Fairweather	Yakutat	Prince William	Kenai	Kodiak	Chirikof	Sanak	Total
Flathead sole	0-100	---	+	+++	2/	0	+	0	0
	101-200	0	0	+	-	+	0	0	0
	201-400	0	--	0	-	--	0	2/	0
	Total	0	0	+	-	0	0	0	0

Table XII-24.--Ratio of 1970÷1960 geometric mean CPUE index (kg/hr)1/ for Dover sole.

Species or Species Group	Depth Zone (m)	REGION Fairweather	Yakutat	Prince William	Kenai	Kodiak	Chirikof	Sanak	Total
Dover sole	0-100	2/	0	2/	2/	2/	2/	2/	0
	101-200	0	0	+	+++	+	0	0	0
	201-400	0	++	++	+++	+++	0	++	++
	Total	0	+	+	+++	+	0	0	0 3/

1/

Code	Ratio	Description
0	0.51-2.00	No marked change, 1960-1970
-	0.26-0.50	Moderate decrease, 1960-1970
--	0.13-0.25	Large decrease, 1960-1970
---	Less than 0.13	Very large decrease, 1960-1970
+	2.01-4.00	Moderate increase, 1960-1970
++	4.01-8.00	Large increase, 1960-1970
+++	Greater than 8.00	Very large increase, 1960-1970

2/ Insufficient data.

3/ Significant increase indicated by confidence interval.

Table XII-25.--Ratio of 1970÷1960 geometric mean CPUE index (kg/hr)1/ for rex sole.

Species or Species Group	Depth Zone (m)	REGION							
		Fairweather	Yakutat	Prince William	Kenai	Kodiak	Chirikof	Sanak	Total
Rex sole	0-100	-	0	+	2/	0	0	0	0
	101-200	+	0	+	++	0	0	++	+
	201-400	+	++	+++	2/	+++	0	++	++
	Total	0	+	+	++	0	0	+	+

Table XII-26.--Ratio of 1970÷1960 geometric mean CPUE index (kg/hr)1/ for rock sole.

Species or Species Group	Depth Zone (m)	REGION							
		Fairweather	Yakutat	Prince William	Kenai	Kodiak	Chirikof	Sanak	Total
Rock sole	0-100	-	0	0	2/	++	-	++	0
	101-200	0	2/	2/	2/	0	-	0	0
	201-400	2/	2/	2/	2/	0	0	2/	0
	Total	0	0	0	2/	+	0	+	0

1/

Code	Ratio	Description
0	0.51-2.00	No marked change, 1960-1970
-	0.26-0.50	Moderate decrease, 1960-1970
--	0.13-0.25	Large decrease, 1960-1970
---	Less than 0.13	Very large decrease, 1960-1970
+	2.01-4.00	Moderate increase, 1960-1970
++	4.01-8.00	Large increase, 1960-1970
+++	Greater than 8.00	Very large increase, 1960-1970

2/ Insufficient data.

Within the region-depth zones with large and very large changes in CPUE, there were no decreases, but increases occurred in the Kenai-outer shelf and in the upper slopes in Yakutat, Prince William, Kodiak, and Sanak. Thus, during the decade, there was a general increase in the density of rex sole throughout most of the Survey Area, especially in the upper slope depth zone.

g. Rock sole (Table XII-26)

No marked change was found in the CPUE for rock sole in the Gulf of Alaska from 1960 to 1970, nor was there a marked change in any of the depth zones. Only two of the regions, Kodiak and Sanak, with moderate increases in CPUE, saw any marked changes from 1960 to 1970. Only 2 region-depth zones had large or very large changes, the Kodiak-inner shelf and Sanak-inner shelf, both with large increases. Thus, with the exception of the inner shelf zones of Kodiak and Sanak, there was little change in rock sole over the decade from 1960 to 1970.

h. Sablefish (Table XII-27)

The otter trawl surveys of the 1960's and 1970's covered only the upper portion of the bathymetric distribution of sablefish in the Gulf of Alaska; additionally, an unknown part of the population may be found off bottom above the headrope height of the trawl, and the larger fish may be able to avoid the trawl when it is towed at the speeds used during these surveys. Therefore, any changes in the catch rates of sablefish between 1960 and 1970 should be viewed with reservations because availability rather than abundance may be a factor in the difference.

The CPUE for sablefish in the Gulf of Alaska did not show a marked change from 1960 to 1970, nor did the CPUE in any of the 3 depth zones. Only 2 of the 7 regions saw any marked changes in sablefish CPUE during the decade; a large decrease in Fairweather and a moderate (statistically-significant) increase in Sanak. Within the region-depth zones with either large or very large changes, there were very large decreases in the Fairweather-inner shelf and in the Fairweather-upper slope along with a large increase in the Kodiak-upper slope. Thus, there appears to have been a general decline in the density of sablefish in the easterm part of the Survey Area from 1960 to 1970.

i. Cottids (Table XII-28)

No marked change in the CPUE for cottids was found from 1960 to 1970 within the Gulf of Alaska, in the 3 depth zones, or in 4 of the 7 regions. Two of the regions, Chirikof and Sanak, showed moderate decreases, and in 1 region, Prince William, there was a moderate increase. Among the region-depth zones with either large or very large changes in the CPUE for cottids were the outer shelf zones of Chirikof and Sanak which had large decreases and the upper slopes of Prince William and Kodiak with large increases. Thus, there were general decreases in CPUE for cottids in the western extreme of the Survey Area and some increases in the central part.

Table XII-27.--Ratio of 1970÷1960 geometric mean CPUE index (kg/hr)1/ for sablefish.

Species or Species Group	Depth Zone (m)	REGION							
		Fairweather	Yakutat	Prince William	Kenai	Kodiak	Chirikof	Sanak	Total
Sablefish	0-100	---	0	2/	2/	2/	2/	2/	0
	101-200	-	-	0	0	0	0	0	0
	201-400	---	+	0	-	2/	-	+	0
	Total	--	0	0	0	0	0	+3/	0

Table XII-28.--Ratio of 1970÷1960 geometric mean CPUE index (kg/hr)1/ for cottids.

Species or Species Group	Depth Zone (m)	REGION							
		Fairweather	Yakutat	Prince William	Kenai	Kodiak	Chirikof	Sanak	Total
Cottids	0-100	2/	0	2/	2/	0	-	0	0
	101-200	0	2/	+	0	-	--	--	0
	201-400	+	2/	++	2/	++	-	-	0
	Total	0	0	+	0	0	-	-	0

1/

Code		Description
0	0.51-2.00	No marked change, 1960-1970
-	0.26-0.50	Moderate decrease, 1960-1970
--	0.13-0.25	Large decrease, 1960-1970
---	Less than 0.13	Very large decrease, 1960-1970
+	2.01-4.00	Moderate increase, 1960-1970
++	4.01-8.00	Large increase, 1960-1970
+++	Greater than 8.00	Very large increase, 1960-1970

2/ Insufficient data.

3/ Significant increase indicated by confidence interval.

j. Pacific cod (Table XII-29)

Since the Pacific cod is known to be semi-pelagic, a portion of the population may occur off bottom and be unavailable to the otter trawls employed in the 1960 and 1970 surveys. Therefore, some of the differences in CPUE noted between the results of the surveys may be because of changes in availability rather than because of changes in abundance, and these data should be viewed with that reservation.

The CPUE for Pacific cod showed no marked change from the 1960's to the 1970's in the Gulf of Alaska but did indicate a moderate increase in the inner shelf depth zone. Within the regions there was a moderate decrease in CPUE in Fairweather; and moderate increases occurred in Prince William, Kodiak, Chirikof, and Sanak. The region-depth zones with large or very large changes in the CPUE for Pacific cod were as follows: decreases occurred in the Fairweather-inner shelf and the Kodiak-upper slope, and increases occurred in the Yakutat-inner shelf, the Prince William-outer shelf, the Kodiak-inner shelf, the Kodiak outer shelf, the Chirikof-upper slope, and the Sanak-outer shelf.

k. Walleye pollock (Table XII-30)

Walleye pollock are known to be semi-pelagic, and an unknown portion of the population may have been off bottom and unavailable to the otter trawls during the 1960 and 1970 surveys. The differences in mean CPUE between surveys, therefore, may be due in part to differences in availability rather than a reflection of actual differences in relative abundance.

There was a large (statistically-significant) increase in the density index for pollock between the 1960 and 1970 surveys in the Gulf of Alaska. In the depth zones there was a large increase in the CPUE for pollock in the inner shelf, a very large (statistically-significant) increase in the outer shelf, and no marked change in the upper slope. Within the various regions, there were decreases in the CPUE in none; no marked change in Fairweather, moderate increases in Yakutat and Kenai; and very large (statistically-significant) increases in Prince William, Kodiak, and Chirikof. In the Sanak Region the very large increase was not statistically-significant. Among the region-depth zones with large or very large changes, all such changes were increases and occurred in the inner shelf depth zones of Yakutat, Prince William, Kodiak, and Sanak; in the outer shelf depth zones of Prince William, Kenai, Kodiak, Chirikof, and Sanak; and in the upper slope zones of Kodiak and Sanak. Thus, there was a general increase in pollock throughout most of the Gulf of Alaska in the inner and outer shelf depth zones except in the eastern extreme.

l. Pacific ocean perch (Table XII-31)

The Pacific ocean perch is known to be semi-pelagic, and therefore a portion of the population may have been distributed in the water above the headrope of the otter trawl. This species is also known to occur over rough, rocky substrata unsampleable by otter trawls as rigged during these surveys. Therefore, the CPUE estimates made may be minimal and possibly biased so they should be viewed with caution.

Table XII-29.--Ratio of 1970÷1960 geometric mean CPUE index (kg/hr)1/ for Pacific cod.

Species or Species Group	Depth Zone (m)	REGION							
		Fairweather	Yakutat	Prince William	Kenai	Kodiak	Chirikof	Sanak	Total
Pacific cod	0-100	---	++	+	2/	++	0	+	+
	101-200	0	0	++	0	++	0	++	0
	201-400	2/	0	0	0	--	++	+	0
	Total	-	0	+	0	+	+	+	0

Table XII-30.--Ratio of 1970÷1960 geometric mean CPUE index (kg/hr)1/ for walleye pollock.

Species or Species Group	Depth Zone (m)	REGION							
		Fairweather	Yakutat	Prince William	Kenai	Kodiak	Chirikof	Sanak	Total
Walleye pollock	0-100	-	+++	+++	2/	+++	+	++	++
	101-200	0	0	+++	+++	+++	+++	+++	+++3/
	201-400	0	0	0	0	+++	0	+++	0
	Total	0	+	+++3/	+	+++3/	+++3/	+++	++3/

1/

Code	Ratio	Description
0	0.51-2.00	No marked change, 1960-1970
-	0.26-0.50	Moderate decrease, 1960-1970
--	0.13-0.25	Large decrease, 1960-1970
---	Less than 0.13	Very large decrease, 1960-1970
+	2.01-4.00	Moderate increase, 1960-1970
++	4.01-8.00	Large increase, 1960-1970
+++	Greater than 8.00	Very large increase, 1960-1970

2/ Insufficient data.

3/ Significant increase indicated by confidence interval.

Table XII-31.--Ratio of 1970÷1960 geometric mean CPUE index (kg/hr)1/ for Pacific ocean perch.

Species or Species Group	Depth Zone (m)	REGION Fairweather	Yakutat	Prince William	Kenai	Kodiak	Chirikof	Sanak	Total
Pacific ocean perch	0-100	2/	0	2/	2/	2/	2/	2/	0
	101-200	-	-	-	--	-	-	2/	-
	201-400	---	---	---	---	+	---	--	---
	Total	-	-	-	---	0	-	0	-4/

Table XII-32.--Ratio of 1970÷1960 geometric mean CPUE index (kg/hr)1/ for Tanner crab.

Species or Species Group	Depth Zone (m)	REGION Fairweather	Yakutat	Prince William	Kenai	Kodiak	Chirikof	Sanak	Total
Tanner crab	0-100	-	+	+++	2/	0	0	0	+
	101-200	--	0	++	---	-	0	0	0
	201-400	2/	--	++	---	---	0	2/	-
	Total	--	0	+++	---	-	0	0	0

1/

Code	Ratio	Description
0	0.51-2.00	No marked change, 1960-1970
-	0.26-0.50	Moderate decrease, 1960-1970
--	0.13-0.25	Large decrease, 1960-1970
---	Less than 0.13	Very large decrease, 1960-1970
+	2.01-4.00	Moderate increase, 1960-1970
++	4.01-8.00	Large increase, 1960-1970
+++	Greater than 8.00	Very large increase, 1960-1970

2/ Insufficient data.

4/ Significant decrease indicated by confidence interval.

There was a moderate (statistically-significant) decrease in CPUE for Pacific ocean perch within the Gulf of Alaska as a whole. Among the depth zones there was no marked change in the inner shelf, a moderate decrease in the outer shelf, and a very large (statistically-significant) decrease in the upper slope. Within the regions, there were no marked changes in CPUE for Pacific ocean perch in Sanak and Kodiak; moderate decreases occurred in Fairweather, Yakutat, Prince William, and Chirikof; and a very large decrease occurred in Kenai. Among the region-depth zones with large or very large changes there were decreases in the Kenai-outer shelf and in the upper slope zones of Fairweather, Yakutat, Prince William, Kenai, Chirikof, and Sanak. Thus, the CPUE for Pacific ocean perch generally declined within the Gulf of Alaska from 1960 to 1970.

m. Tanner crab (Table XII-32)

Otter trawls towed at the 2½ - 3 knots speeds utilized during these surveys are apparently more effective at capturing female and small male Tanner crab than at catching large males. Therefore, the comparisons of mean CPUEs for the 1960's and 1970's may be biased with reference to those parts of the stocks which are harvested commercially.

There was no marked change in the CPUE for Tanner crab within the Gulf of Alaska during the decade from 1960 to 1970. Within the three depth zones there was a moderate increase in the inner shelf, and a moderate decrease occurred in the upper slope. Among the 7 regions there were no marked changes in CPUE in Yakutat, Chirikof, and Sanak; a moderate decrease in Kodiak; a large decrease in Fairweather, a very large decrease in Kenai; and a very large increase in Prince William. Region-depth zones with either large or very large changes in the CPUE for Tanner crab are as follows: decreases occurred in the Fairweather-outer shelf, the Yakutat-upper slope, the Kenai-outer shelf, the Kenai-upper slope, and the Kodiak upper slope; increases occurred in all 3 of the Prince William depth zones. Thus, only in the Prince William region were there marked inccreases in the CPUE for Tanner crab from 1960 to 1970.

n. King crab (Table XII-33)

Otter trawls towed at the 2½ - 3 knots speeds utilized during these surveys are apparently more effective at the capture of female and small male king crab than at catching large males. Therefore, the comparisons of mean CPUEs for the for the 1960's and 1970's may be biased in estimating catch rates for that part of the population which is fished commercially.

There was no marked change in CPUE for king crab in the decade from 1960 to 1970 in the Gulf of Alaska as a whole. Within the 3 depth zones there were also no marked changes. Among the various regions, there was no marked change from 1960 to 1970 in Fairweather; moderate decreases occurred in Kodiak and Chirikof; and a large increase took place in Sanak. The region-depth zones with large or very large changes in CPUE from 1960 to 1970 were the Kodiak-upper slope and the Chirikof-inner shelf with decreases and the Sanak-inner shelf and the Sanak-outer shelf with increases. A general increase in king crab appears to have occurred in the 2 Sanak shelf zones while all depth zones in the Chirikof Region and the two deeper zones in Kodiak indicated decreases.

Table XII-33.--Ratio of 1970÷1960 geometric mean CPUE index (kg/hr)1/ for king crab.

Species or Species Group	Depth Zone (m)	REGION							
		Fairweather	Yakutat	Prince William	Kenai	Kodiak	Chirikof	Sanak	Total
King crab	0-100	2/	2/	2/	2/	0	---	++	0
	101-200	0	2/	2/	2/	-	-	++	0
	201-400	---	2/	2/	2/	---	-	2/	0
	Total	2/	2/	2/	2/	-	-	++	0

1/ Code

Code		
0	0.51-2.00	No marked change, 1960-1970
-	0.26-0.50	Moderate decrease, 1960-1970
--	0.13-0.25	Large decrease, 1960-1970
---	Less than 0.13	Very large decrease, 1960-1970
+	2.01-4.00	Moderate increase, 1960-1970
++	4.01-8.00	Large increase, 1960-1970
+++	Greater than 8.00	Very large increase, 1960-1970

2/ Insufficient data.

4/ Significant decrease indicated by confidence interval.

DISTRIBUTION OF BIOMASS BY DEPTH ZONE IN 1960 AND 1970

Within the Survey Area, the mean biomass in the 1960 survey was 8.9 mt/km^2 (Table XI-9) as compared with 10.6 mt/km^2 (Table XI-104) in the 1970 survey, an increase of 19.1 percent. By depth zone the greatest biomass density occurred in the 1960 survey in the upper slope (9.9 mt/km^2) followed by the outer shelf (9.2 mt/km^2) and the inner shelf (8.1 mt/km^2); in the 1970 surveys the outer shelf had the greatest density (12.7 mt/km^2) followed by the inner shelf (9.6 mt/km^2), and the upper slope (7.4 mt/km^2). Thus, the upper slope mean density declined by 25 percent from 1960 to 1970 and changed that zone's ranking from first in 1960 to last in 1970.

DISTRIBUTION OF BIOMASS BY REGION IN 1960 AND 1970

The distribution of biomass in the regions of the Gulf of Alaska varied considerably between the 1960 and 1970 surveys (Table XII-34). The Fairweather Region had the greatest density of any in 1960 (20.4 mt/km^2) and the least in 1970 (5.4 mt/km^2). The biomass density in the Prince William Region increased 3-fold from 2.5 mt/km^2 in 1960 to 7.8 mt/km^2 in 1970. In the Sanak Region the density increased from 6.7 mt/km^2 in 1960 to 18.4 mt/km^2 in 1970--nearly 3-fold. In the Kodiak Region the biomass nearly doubled from 1960 (9.7 mt/km^2) to 1970 (18.6 mt/km^2).

RANKING OF PROMINENT SPECIES WITHIN THE GULF OF ALASKA ON THE BASIS OF CATCH PER UNIT EFFORT IN 1960 AND 1970

In the Survey Area as a whole the rank order of species by CPUE in the 1960 survey and again in 1970 is listed in Table XII-35. The more dramatic changes from 1960 to 1970 include the declines in king crab (72.3 to 18.9 kg/hr), cottids (40.3 to 21.6 kg/hr), Pacific ocean perch (36.8 to 3.9 kg/hr), and sablefish (7.9to 4.2 kg/hr) and the increases in flathead sole (31.0 to 43.7 kg/hr), rock sole (29.2 to 46.9 kg/hr), walleye pollock (15.9 to 320.5 kg/hr), rex sole (4.1 to 19.7 kg/hr), and Dover sole (2.9 to 19.3 kg/hr). Thus, there were general increases in most of the flatfish from 1960 to 1970 accompanied by a 20-fold increase in the walleye pollock, a roundfish. During the same period another roundfish, the sablefish, and a prominent rockfish, the Pacific ocean perch, decreased.

In the 0-100 m depth zone the rankings of species by CPUE in the 1960 survey and in the 1970 survey are shown in Table XII-36. A sharp decrease occurred in the CPUE for king crab (179.6 to 23.3 kg/hr), but there were moderate increases in rock sole (73.0 to 147.2 kg/hr), Pacific cod (30.3 to 81.7 kg/hr), and turbot (21.7 to 43.4 kg/hr), and large increases in walleye pollock (3.0 to 108.9 kg/hr), and skates (1.8 to 10.5 kg/hr).

In the 101-200 m depth zo , the CPUE rankings of the prominent species in 1960 and 1970 are listed in Tab XII-37. The decade between the surveys saw decreases in the stock of Tanner crab (64.5 to 35.6 kg/hr), Pacific ocean perch (50.1 to 6.1 kg/hr), cottids (48.1 to 14.0 kg/hr), sablefish (7.3 to 2.1 kg/hr), and shortspine thornyhead (3.2 to 1.1 kg/hr). During this same period the CPUEs for other species were increasing: walleye pollock (23.9 to 528.7 kg/hr), Dover sole (0.8 to 14.2 kg/hr), king crab (14.7 to 23.6 kg/hr), and rex sole (3.4 to 18.7 kg/hr).

Table XII-34.--Estimated biomass in metric tons per square kilometer during the 1960 and 1970 resource assessment surveys in the Gulf of Alaska.

Region	1960		1970	
	mt/km^2	Rank	mt/km^2	Rank
Fairweather	20.4	1	5.4	8
Yakutat	9.0	5	7.5	5
Prince William	2.5	9	7.8	4
Kenai	9.2	4	6.7	6
Kodiak	9.7	3	18.6	1
Shelikof	6.3	7	5.7	7
Chirikof	11.4	2	9.5	3
Shumagin	5.8	8	--	--
Sanak	6.7	6	18.4	2
Total	8.9		10.9	

Table XII-35.--Fifteen most prominent species in the 1960 and 1970 resource assessment surveys in the Gulf of Alaska (all depth zones and regions combined).

1960 (kg/hr)	1970 (kg/hr)
Turbot (91.0)	Walleye pollock (320.5)
King crab (72.3)	Turbot (82.8)
Tanner crab (47.9)	Pacific cod (47.6)
Pacific cod (43.6)	Rock sole (46.9)
Cottids (40.3)	Flathead sole (43.7)
Pacific ocean perch (36.8)	Tanner crab (36.9)
Flathead sole (31.0)	Cottids (21.6)
Rock sole (29.2)	Rex sole (19.7)
Halibut (20.7)	Dover sole (19.3)
Walleye pollock (15.9)	King crab (18.9)
Skates (9.5)	Halibut (18.0)
Sablefish (7.9)	Skates (11.2)
Rex sole (4.1)	Shortspine thornyhead (4.9)
Shortspine thornyhead (3.2)	Sablefish (4.2)
Dover sole (2.9)	Pacific ocean perch (3.9)

Table XII-36.--Fifteen most prominent species in the 0-100 m depth zone in the 1960 and 1970 resource assessment surveys in the Gulf of Alaska (all regions combined).

1960 (kg/hr)	1970 (kg/hr)
King crab (179.6)	Rock sole (147.2)
Rock sole (73.0)	Walleye pollock (108.9)
Cottids (46.4)	Pacific cod (81.7)
Halibut (35.1)	Cottids (49.0)
Tanner crab (32.6)	Turbot (43.4)
Pacific cod (30.3)	Tanner crab (34.1)
Turbot (21.7)	Halibut (28.6)
Flathead sole (10.4)	King crab (23.3)
Walleye pollock (3.0)	Flathead sole (15.4)
Skates (1.8)	Skates (10.5)
Rex sole (1.5)	Rex sole (4.0)
Pacific ocean perch (1.1)	Smelts (0.8)
Sablefish (0.9)	Dover sole (0.5)
Dover sole (0.1)	Shortspine thornyhead (0.5)
Shortspine thornyhead (0.0)	Sablefish (0.4)

Table XII-37.--Fifteen most prominent species in the 101-200 m depth zone in the 1960 and 1970 resource assessment surveys in the Gulf of Alaska (all regions combined).

1960 (kg/hr)	1970 (kg/hr)
Turbot (103.3)	Walleye pollock (528.7)
Pacific cod (65.6)	Turbot (90.9)
Tanner crab (64.5)	Flathead sole (61.2)
Pacific ocean perch (50.1)	Pacific cod (41.2)
Cottids (48.1)	Tanner crab (35.6)
Flathead sole (43.6)	King crab (23.6)
Walleye pollock (23.9)	Rex sole (18.7)
Halibut (15.0)	Dover sole (14.2)
King crab (14.7)	Cottids (14.0)
Skates (11.7)	Skates (12.3)
Sablefish (7.3)	Rock sole (10.8)
Rock sole (6.4)	Halibut (9.9)
Rex sole (3.4)	Pacific ocean perch (6.1)
Dover sole (0.8)	Smelts (2.9)
Shortspine thornyhead (0.8)	Sablefish (2.1)

In the 201-400 m depth zone the most prominent species in terms of catch per unit of effort in 1960 and 1970 are listed in Table XII-38. Between the 2 surveys there were sharp decreases in turbot (206.8 to 119.1 kg/hr), Pacific ocean perch (76.5 to 3.4 kg/hr), sablefish (26.5 to 13.4 kg/hr), and king crab (7.1 to 3.6 kg/hr). Increases occurred in walleye pollock (20.3 to 103.4 kg/hr), Pacific cod (7.4 to 22.4 kg/hr), halibut (6.2 to 23.1 kg/hr), and rock sole (0.4 to 5.1 kg/hr).

XIII

SUMMARY

Included in this report is a description of the Survey Area, a 2,200 kilometer long arc in the Gulf of Alaska from Cape Spencer to Unimak Pass. The area contains 220,000 km^2 of which 36% is in the 0-100 m depth zone, 48% in the 101-200 m depth zone, and 16% in the 201-400 m depth zone.

The fish and invertebrate fauna are described. The fishes include 287 species belonging to 55 families. The invertebrate fauna is less well defined than the fish fauna, but 13 commercially-valuable species from 5 families are included.

Informational sources that have been analyzed for the report include both research reports and the commercial fisheries data. Research sources include exploratory fishing cruises and resource assessment surveys. Commercial fisheries sources include both domestic and foreign catch statistics.

Commercial exploitation of demersal resources in the Gulf of Alaska has been carried out by nationals of the United States, Canada, Japan, the Soviet Union, South Korea, Poland, and Taiwan. The more important fisheries for the Americans have been those for king crab, Tanner (snow) crab, Pandalid shrimp, and scallops. A joint fishery by American and Canadian fishermen for halibut has endured for many years. Japanese and Soviet fishermen have generally pursued fin fishes other than halibut as well as shrimp. Fishing by the Koreans, Poles, and Taiwanese has been relatively minor thus far.

Exploratory fishing cruises were conducted in the Survey Area from 1948 through 1970. Pandalid shrimp surveys to determine their distribution and to estimate stock magnitude took place from 1971 through 1976. Demersal fish resource assessment surveys were made from 1961 to 1962 and from 1973 to 1976. These surveys differed from exploratory fishing operations in that the surveys were designed to provide estimates of the magnitude, distribution, and composition of resources whereas exploratory fishing had as its objective the discovery of locales of favorable fishing conditions.

Comparisons between the results of resource abundance surveys in the Gulf of Alaska during 1961 and those in 1973-1976, indicate a statistically-significant increase in walleye pollock and Dover sole, and a decrease in Pacific ocean perch. Changes in CPUE from the 1960's to the 1970's were noted in each of 7 regions of the Survey Area, 3 depth zones, and 21 region-depth zones. Comparison between the 1960 and 1970 surveys was also made with reference to the distribution of biomass and rank order of prominent species in catch per km^2, both of which varied widely and suggested that dramatic changes have occurred over the years.

Table XII-38.--Fifteen most prominent species in the 201-400 m depth zone in the 1960 and 1970 resource assessment surveys in the Gulf of Alaska (all regions combined).

1960 (kg/hr)	1970 (kg/hr)
Turbot (206.8)	Turbot (119.1)
Pacific ocean perch (75.6)	Walleye pollock (103.4)
Flathead sole (38.9)	Dover sole (52.1)
Tanner crab (32.5)	Tanner crab (42.4)
Sablefish (26.5)	Flathead sole (40.7)
Walleye pollock (20.3)	Rex sole (40.3)
Skates (19.9)	Halibut (23.1)
Shortspine thornyhead (17.5)	Pacific cod (22.4)
Dover sole (15.6)	Shortspine thornyhead (17.8)
Rex sole (13.1)	Sablefish (13.4)
Pacific cod (7.4)	Skates (11.5)
King crab (7.1)	Rock sole (5.1)
Halibut (6.2)	Cottids (4.9)
Cottids (4.0)	King crab (3.6)
Rock sole (0.4)	Pacific ocean perch (3.4)

XIV

LITERATURE CITED

ANONYMOUS

1970. A list of Common and Scientific Names of Fishes, Amer. Fish. Soc., Special Publication #6. 150 p.

BELL, F. HEWARD

1967. Eastern Pacific halibut fishery, 1888-1965. U.S. Fish Wildl. Serv., Fish. Leafl. 602, 8 p.

BUTLER, T. H.

1950. The commercial shrimps of British Columbia. Fish. Res. Bd. Canada, Pacific Coast Sta., Prog. Rept. 83: 30-34.

CHITWOOD, PHILIP E.

1969. Japanese, Soviet and South Korean Fisheries off Alaska. Development and history through 1966, U.S. Fish Wildl. Serv., Circular 310., Jan. 1969.

CLEMENS, W. A. and G. V. WILBY

1961. Fishes of the Pacific Coast of Canada. Bull. Fish. Res. Bd. Can., 68: 443 p.

HART, J. L.

1973. Pacific Fishes of Canada. Bull. Fish. Res. Bd. Can., 180: 740 p.

INTERNATIONAL NORTH PACIFIC FISHERIES COMMISSION

1975. Proceedings of the 22nd annual meeting. Int. N. Pac. Fish. Comm., 342 p.

QUAST, JAY C. and ELIZABETH L. HALL

1972. List of fishes of Alaska and adjacent waters with a guide to some of their literature. U.S. Dept. Commerce, Natl. Oceanic and Atmos. Admin., Natl. Mar. Fish. Serv., NOAA Technical Rep. NMFS SSRF-658. 47 p.

SCHMITT, W. L.

1921. The marine decapod crustacea of California. Univ. Calif. Publ. Zool., No. 23, 470 pp.

TANONAKA, GEORGE K. and JIRO NISHIMOTO

1965. A Japanese gill-net fishery for bottomfish in the Gulf of Alaska Comm. Fish. Rev. 27 (12): 1-12.

WIESE, JOHN

1971. Alaska's Shrimp Industry. Univ. Alaska, Institute of Social, Economic and Government Research, Vol VIII (2), July 1971., 24 p.

XV

APPENDICES

APPENDIX A

GAZETTEER

Table 1.--Latitudes, longitudes and brief descriptions of geographic features mentioned in the text.

Aialik Bay — 59°50'N - 149°43'W

An inlet along the south coast of Kenai peninsula

Aliulik Peninsula — 56°49'N - 154°00'W

The peninsula which forms the southwest corner of Kodiak Island

Afognak Island — 59°13'N - 152°35'W

A large island immediately northeast of Kodiak Island

Albatross Bank — north: 57°15'N - 151°45'W

middle: 56°40'N - 152°05'W

south: 56°20'N - 153°05'W

A series of three banks south of Kodiak Island

Alitak Bay — 56°55'N - 154°00'W

A bay in southwest Kodiak Island

Amatuli Island — 58°55'N - 152°00'W

One of the Barren Islands at the mouth of Cook Inlet

Beaver Bay — 55°30'N - 160°55'W

An inlet in southern Alaska Peninsula inside of Unga Island

Belkofski Bay — 55°05'N - 162°10'W

A bay in the south coast of southern Alaska Peninsula

Blying Bank — 59°30'N - 148°45'W

A bank south of Kenai peninsula 25 miles southwest of Cape Cleare

Cape Cleare $59^{\circ}45'N - 147^{\circ}53'W$

The southwest tip of Montague Island

Cape Douglas $58^{\circ}50'N - 153^{\circ}15'N$

The easternmost point of Alaska Peninsula, mouth of Cook Inlet

Cape Elizabeth $59^{\circ}10'N - 151^{\circ}53'W$

The southwest tip of Kenai Peninsula, mouth of Cook Inlet

Cape Hinchinbrook $60^{\circ}14'N - 146^{\circ}37'W$

The southwest tip of Hinchinbrook Island

Cape Kiavak $57^{\circ}00'N - 153^{\circ}33'W$

A cape on the western shore of Aliulik Peninsula, south Kodiak

Cape Saint Elias $59^{\circ}88'N - 144^{\circ}25'W$

The southwestern point of Kayak Island, 60 miles southeast of Prince William Sound

Cape Spencer $58^{\circ}12'N - 136^{\circ}38'W$

A point at the northern entrance to the inside waters of southeast Alaska

Cape Suckling $59^{\circ}59'N - 143^{\circ}55'W$

A point in the south Alaska coast between Icy Bay and Prince William Sound

Castle Bay $56^{\circ}10'N - 158^{\circ}15'W$

An inlet in the south coast of Alaska Peinisula

Chignik Bay $56^{\circ}20'N - 158^{\circ}20'W$

A bay in the south coast of Alaska Peninsula

Chignik Gully $57^{\circ}30'N - 151^{\circ}30'W$

A depression running southwest from Chiniak Bay, Kodiak Island

Chirikof Island $55^{\circ}50'N - 155^{\circ}40'W$

An island 70 miles southwest of Kodiak Island

Cook Inlet $60^{\circ}00'N - 152^{\circ}00'W$

A large inlet in south Alaska between Kenai and Alaska Peninsulas

Day Harbor $59^{\circ}57'N - 149^{\circ}10'W$

An inlet in the south coast of Kenai Peninsula

Dry Bay $57^{\circ}38'N - 155^{\circ}42'W$

A bay in the south coast of Alaska Peninsula at the mouth of Shelikof Straits

Hinchinbrook Entrance $60^{\circ}19'N - 146^{\circ}50'W$

The passage between Hinchinbrook and Montague Islands

Hinchinbrook Gully $59^{\circ}55'N - 147^{\circ}05'W$

A depression running south from Hinchinbrook Entrance

Hinchinbrook Island $60^{\circ}25'N - 146^{\circ}25'W$

An island in the mouth of Prince William Sound

Icy Bay $59^{\circ}55'N - 141^{\circ}25'W$

A bay in the south Alaska coast between Yakutat Bay and Cape Suckling

Ikatan Bay $54^{\circ}48'N - 163^{\circ}16'W$

A bay between Alaska Peninsula and Unimak Island

Jack Bay $60^{\circ}02'N - 146^{\circ}37'W$

A thin arm of northeast Prince William Sound

Kachemak Bay $59^{\circ}35'N - 151^{\circ}25'W$

An arm of lower Cook Inlet in the west shore of Kenai Peninsula

Kayak Island $59^{\circ}54'N - 144^{\circ}25'W$

A long island offshore of Cape Suckling

Kenai Peninsula $60^{\circ}00'N - 150^{\circ}00'W$

The major peninsula between Cook Inlet and Prince William Sound

Kiluda Bay $57^{\circ}19'N - 153^{\circ}00'W$

A bay on the south coast of Kodiak Island

Kodiak Island $57^{\circ}25'N - 154^{\circ}15'W$

A large island south of Upper Alaska Peninsula

Kuiukta Bay $56^{\circ}06'N - 158^{\circ}38'W$

A bay in the south coast of Alaska Peninsula

Kujalik Bay $56^{\circ}37'N - 157^{\circ}49'W$

A bay in the south coast of Alaska Peninsula

Kukak Bay $58^{\circ}19'N - 154^{\circ}15'W$

An arm of Shelikof Strait extending into Alaska Peninsula

Lituya Bay $58^{\circ}38'N - 137^{\circ}34'W$

An inlet in the Alaska coast about 45 miles northwest of Cape Spencer

Marmot Bay $58^{\circ}00'N - 152^{\circ}20'W$

A bay between Kodiak and Afognak Islands

Marmot Gully $58^{\circ}11'N - 151^{\circ}20'W$

A depression extending east from Marmot Bay

Middleton Island $59^{\circ}26'N - 146^{\circ}19'W$

An island 60 miles south of Prince William Sound

Mitrofania Bay $55^{\circ}54'N - 158^{\circ}58'W$

A bay in the south shore of Alaska Peninsula

Mitrofania Gully $55^{\circ}37'N - 158^{\circ}55'W$

A depression running south from between Mitrofania and Chiach Islands (South Alaska Peninsula)

Mitrofania Island $55^{\circ}52'N - 158^{\circ}48'W$

A small island off the south coast of Alaska Peninsula

Montague Gully $59^{\circ}30'N - 148^{\circ}12'W$

A depression extending south from the Montague Straits

Montague Island $60^{\circ}00'N - 147^{\circ}26'W$

A long island in the mouth of Prince William Sound

Montague Straits $60^{\circ}07'N - 147^{\circ}38'W$

The waters between Montague Island and Letouche and Knight Islands

Morzhovoi Bay $55^{\circ}02'N - 163^{\circ}05'W$

A bay in the southern tip of Alaska Peninsula

Nagai Island 55°08'N - 159°58'W

One of the Shumagin Islands, south of Alaska Peninsula

Nagai Straits 55°22'N - 159°44'W

The straits between Nagai, Andronica and Big Koniuji Islands (Shumagin Islands)

Nuka Bay 59°27'N - 150°30'W

A bay in the south coast of Kenai Peninsula

Nuka Passage 59°22'N - 150°45'W

The strait on the west side of Nuka Island (south Kenai)

Ocean Cape 59°32'N - 139°53'W

A point at the mouth of Yakutat Bay

Orca Bay 60°35'N - 146°05'W

An arm of the east side of Prince William Sound

Otter Cove 54°48'N - 163°22'W

A small embayment in the southeast corner of Unimak Island

Pavlof Bay 55°30'N - 161°35'W

A bay in the south end of Alaska Peninsula

Pernosa Bay 58°24'N - 152°15'W

A bay in the northeast corner of Afognak Island

Port Bainbridge 60°05'N - 148°25'W

A bay in the Kenai Peninsula next to the mouth of Prince William Sound

Port Dick — 59°16'N - 151°04'W

An inlet in the south coast of Kenai Peninsula

Port Fidalgo — 60°48'N - 146°20'W

An arm of eastern Prince William Sound

Port Gravina — 60°42'N -146°20'W

An arm of eastern Prince William Sound

Portlock Bank — 58°21'N - 150°30'W

A large bank south of Kenai Peninsula and west of Kodiak Island

Port Valdez — 61°05'N - 146°39'W

An arm of northeastern Prince William Sound

Prince William Sound — 60°38'N - 147°23'W

A large embayment in the south coast of Alaska, east of Kenai Peninsula

Pye Islands — 59°26'N - 150°25'W

Three small islands south of Kenai Peninsula

Raspberry Straits — 58°05'N - 153°05'W

A narrow channel along the southwest side of Afognak Island

Sanak Gully — 54°20'N - 162°24'W

A depression running between Deer and Sanak Islands

Sanak Island — 54°25'N - 162°40'W

An island 40 miles south of the tip of Alaska Peninsula

Scotch Cap — 54°24'N - 164°44'W

The southwest corner of Unimak Island

Semidi Islands 56°05'N - 156°45'W

A group of islands between Chirikof Island and Alaska Peninsula

Seward Gully 59°25'N - 149°07'W

A depression running southward from Kenai Peninsula

Shelikof Strait 58°00'N - 154°00'W

A group of islands south of Alaska Peninsula

Shumagin Islands 55°10'N - 160°00'W

A group of islands south of Alaska Peninsula

Shuyak Island 58°32'N - 152°30'W

An island northeast of Afognak Island

Sitkalidak Island 57°06'N - 153°10'W

An island off the south coast of Kodiak Island

Sitkinak Island 56°34'N - 154°09'W

An island off the southwest corner of Kodiak Island

Stepovak Bay 55°42'N - 159°45'W

A bay in the south coast of Alaska Peninsula

Tonki Bay 58°19'N - 152°04'W

A bay in the west shore of A[illegible]nak Island

Tonki Cape 58°21'N - 151°59'W

A point on the northeast corner of Afognak Island

Trinity Islands $56^{\circ}33'N - 154^{\circ}24'W$

Two islands off the southwest corner of Kodiak Island

Uganik Bay $57^{\circ}52'N - 153^{\circ}34'W$

A bay in the north coast of Kodiak Island

Unga Island $55^{\circ}20'N - 160^{\circ}44'W$

The most westerly of the Shumagin Islands

Unga Strait $55^{\circ}25'N - 160^{\circ}34'W$

The most westerly of the Shumagin Islands

Unimak Bight $54^{\circ}34'N - 164^{\circ}00'W$

The wide bay formed by the south coast of Unimak Island

Unimak Pass $54^{\circ}25'N - 165^{\circ}15'W$

The pass between Unimak Island and the Krenitzen Island group

Ushagat Island $59^{\circ}07'N - 152^{\circ}18'W$

One of the Barren Islands at the mouth of Cook Inlet

Uyak Bay $57^{\circ}39'N - 153^{\circ}56'W$

A bay in the north coast of Kodiak Island

Viekoda Bay $57^{\circ}55'N - 153^{\circ}20'W$

A bay in the north coast of Kodiak Island

Yakutat Bay $59^{\circ}45'N - 140^{\circ}00'W$

A large bay on the south coast of Alaska between Cape Spencer and Icy Bay

Yakutat Gully $59^{\circ}30'N - 141^{\circ}00'W$

A depression extending southwest from Yakutat Bay

APPENDIX B

Variances of the biomass estimates by regions, depth zones, and surveys

Table 1.--Variances of the Biomass estimates for the Fairweather region for May-October 1961, Cr 611.

Species	Depth Zones (m) 0-100	101-200	201-400	Total
Elasmobranchs	$.354253 \times 10^{11}$	$.874543 \times 10^{12}$	$.294161 \times 10^{12}$	$.120412 \times 10^{13}$
Flatfishes	$.293278 \times 10^{14}$	$.276017 \times 10^{16}$	$.160562 \times 10^{14}$	$.280556 \times 10^{16}$
Roundfishes	$.163348 \times 10^{15}$	$.478686 \times 10^{13}$	$.903261 \times 10^{13}$	$.177168 \times 10^{15}$
Rockfishes	$.116858 \times 10^{9}$	$.293174 \times 10^{12}$	$.984767 \times 10^{13}$	$.101409 \times 10^{14}$
Invertebrates	$.549537 \times 10^{12}$	$.318586 \times 10^{16}$	$.649536 \times 10^{14}$	$.325136 \times 10^{16}$
Skates	$.320733 \times 10^{11}$	$.824144 \times 10^{12}$	$.312766 \times 10^{12}$	$.116898 \times 10^{13}$
Turbot	$.334772 \times 10^{14}$	$.250713 \times 10^{15}$	$.150718 \times 10^{13}$	$.285697 \times 10^{15}$
Halibut	$.178589 \times 10^{12}$	$.269128 \times 10^{12}$	0.	$.447718 \times 10^{12}$
Flathead sole	$.222059 \times 10^{14}$	$.282509 \times 10^{14}$	$.123307 \times 10^{14}$	$.516899 \times 10^{14}$
Dover sole	$.386309 \times 10^{9}$	$.100143 \times 10^{12}$	$.382202 \times 10^{13}$	$.392255 \times 10^{13}$
Rex sole	$.845666 \times 10^{11}$	$.916256 \times 10^{11}$	$.102687 \times 10^{13}$	$.120306 \times 10^{13}$
Rock sole	$.110493 \times 10^{12}$	$.666601 \times 10^{11}$	0.	$.177153 \times 10^{12}$
Sablefish	$.737995 \times 10^{11}$	$.275271 \times 10^{13}$	$.860100 \times 10^{13}$	$.114275 \times 10^{14}$
Cottidae	0.	$.731725 \times 10^{11}$	$.177013 \times 10^{9}$	$.733495 \times 10^{11}$
Pacific cod	$.160125 \times 10^{15}$	$.926796 \times 10^{12}$	$.163737 \times 10^{10}$	$.161053 \times 10^{15}$
Walleye pollock	$.742377 \times 10^{10}$	$.123713 \times 10^{11}$	$.158503 \times 10^{11}$	$.356455 \times 10^{11}$
Thornyheads	0.	$.498617 \times 10^{10}$	$.175160 \times 10^{13}$	$.175659 \times 10^{13}$
Pacific ocean perch	0.	$.261071 \times 10^{12}$	$.820791 \times 10^{13}$	$.846898 \times 10^{13}$
Tanner crab	$.566596 \times 10^{11}$	$.472501 \times 10^{14}$	$.610642 \times 10^{11}$	$.473678 \times 10^{14}$
King crab	0.	$.359027 \times 10^{9}$	$.101558 \times 10^{11}$	$.105148 \times 10^{11}$

Table 2.--Variances of the biomass estimates for the Yakutat region for May-October 1961, Cr 611.

Species	Depth Zones (m) 0-100	101-200	201-400	Total
Elasmobranchs	$.239225 \times 10^{12}$	$.839940 \times 10^{12}$	$.260847 \times 10^{12}$	$.134001 \times 10^{13}$
Flatfishes	$.225766 \times 10^{14}$	$.309605 \times 10^{14}$	$.310893 \times 10^{14}$	$.846265 \times 10^{14}$
Roundfishes	$.242177 \times 10^{13}$	$.391241 \times 10^{13}$	$.536025 \times 10^{12}$	$.687021 \times 10^{13}$
Rockfishes	$.591767 \times 10^{8}$	$.454031 \times 10^{14}$	$.875550 \times 10^{13}$	$.541586 \times 10^{14}$
Invertebrates	$.246621 \times 10^{14}$	$.454019 \times 10^{14}$	$.119348 \times 10^{15}$	$.189412 \times 10^{15}$
Skates	$.357628 \times 10^{11}$	$.171013 \times 10^{12}$	$.265499 \times 10^{12}$	$.472275 \times 10^{12}$
Turbot	$.524319 \times 10^{13}$	$.157634 \times 10^{14}$	$.152100 \times 10^{14}$	$.362167 \times 10^{14}$
Halibut	$.184870 \times 10^{12}$	$.226678 \times 10^{12}$	$.134470 \times 10^{12}$	$.546019 \times 10^{12}$
Flathead sole	$.165360 \times 10^{12}$	$.204696 \times 10^{13}$	$.429999 \times 10^{12}$	$.264232 \times 10^{13}$
Dover sole	$.515490 \times 10^{8}$	$.334524 \times 10^{11}$	$.296193 \times 10^{13}$	$.299543 \times 10^{13}$
Rex sole	$.778910 \times 10^{11}$	$.131029 \times 10^{12}$	$.152655 \times 10^{13}$	$.173547 \times 10^{13}$
Rock sole	$.711872 \times 10^{10}$	$.752981 \times 10^{10}$	0.	$.146485 \times 10^{11}$
Sablefish	$.615759 \times 10^{11}$	$.132435 \times 10^{13}$	$.214482 \times 10^{12}$	$.160041 \times 10^{13}$
Cottidae	$.584279 \times 10^{11}$	0.	$.612446 \times 10^{7}$	$.584341 \times 10^{11}$
Pacific cod	$.138132 \times 10^{13}$	$.739439 \times 10^{12}$	$.610941 \times 10^{11}$	$.218185 \times 10^{13}$
Walleye pollock	$.140297 \times 10^{12}$	$.736373 \times 10^{12}$	$.495125 \times 10^{11}$	$.926183 \times 10^{12}$
Thornyheads	0.	$.347203 \times 10^{12}$	$.159276 \times 10^{13}$	$.193996 \times 10^{13}$
Pacific ocean perch	$.591767 \times 10^{8}$	$.451256 \times 10^{14}$	$.499724 \times 10^{13}$	$.501229 \times 10^{14}$
Tanner crab	$.954359 \times 10^{11}$	$.458255 \times 10^{12}$	$.577467 \times 10^{12}$	$.113115 \times 10^{13}$
King crab	0.	0.	$.137800 \times 10^{10}$	$.137800 \times 10^{10}$

Table 3.--Variances of the biomass estimates for Prince William region for May-October 1961, Cr 052.

Species	Depth Zones (m) 0-100	101-200	201-400	Total
Elasmobranchs	$.802363 \times 10^{12}$	$.165234 \times 10^{13}$	$.544770 \times 10^{11}$	$.250918 \times 10^{13}$
Flatfishes	$.723787 \times 10^{12}$	$.939985 \times 10^{13}$	$.691968 \times 10^{12}$	$.108156 \times 10^{14}$
Roundfishes	$.175517 \times 10^{13}$	$.110291 \times 10^{13}$	$.444983 \times 10^{10}$	$.286253 \times 10^{13}$
Rockfishes	0.	$.275920 \times 10^{14}$	$.267922 \times 10^{13}$	$.302713 \times 10^{14}$
Invertebrates	$.634283 \times 10^{10}$	$.126447 \times 10^{13}$	$.987757 \times 10^{12}$	$.225857 \times 10^{13}$
Skates				
Turbot	$.783312 \times 10^{10}$	$.738109 \times 10^{13}$	$.937473 \times 10^{12}$	$.832640 \times 10^{13}$
Halibut	$.319206 \times 10^{12}$	$.425383 \times 10^{12}$	$.432014 \times 10^{10}$	$.748910 \times 10^{12}$
Flathead sole	$.708116 \times 10^{10}$	$.301509 \times 10^{12}$	$.334811 \times 10^{11}$	$.342072 \times 10^{12}$
Dover sole	$.729935 \times 10^{8}$	$.117688 \times 10^{10}$	$.432014 \times 10^{10}$	$.557002 \times 10^{10}$
Rex sole	$.212289 \times 10^{10}$	$.905496 \times 10^{10}$	$.415425 \times 10^{10}$	$.153321 \times 10^{11}$
Rock sole	$.598775 \times 10^{11}$	$.826445 \times 10^{8}$	0.	$.599601 \times 10^{11}$
Sablefish	0.	$.153172 \times 10^{11}$	$.254456 \times 10^{11}$	$.407629 \times 10^{11}$
Cottidae	$.437201 \times 10^{8}$	$.520217 \times 10^{9}$	0.	$.563937 \times 10^{9}$
Pacific cod	$.186863 \times 10^{13}$	$.150218 \times 10^{12}$	$.185766 \times 10^{10}$	$.202071 \times 10^{13}$
Walleye pollock	$.316305 \times 10^{9}$	$.588516 \times 10^{12}$	$.140404 \times 10^{11}$	$.602873 \times 10^{12}$
Thornyheads	0.	$.184031 \times 10^{11}$	$.276489 \times 10^{10}$	$.211680 \times 10^{11}$
Pacific ocean perch	0.	$.274896 \times 10^{14}$	$.246356 \times 10^{13}$	$.299532 \times 10^{14}$
Tanner crab	$.129563 \times 10^{10}$	$.996240 \times 10^{12}$	$.998774 \times 10^{12}$	$.199631 \times 10^{13}$
King crab				

Table 4.--Variances of the biomass estimates for the Kenai region for May-October 1961, Cr 052.

Species	Depth Zones (m) 0-100	101-200	201-400	Total
Elasmobranchs	0.	$.973626x10^{13}$	0.	$.973626x10^{13}$
Flatfishes	0.	$.108349x10^{15}$	0.	$.108349x10^{15}$
Roundfishes	0.	$.742632x10^{16}$	0.	$.742632x10^{16}$
Rockfishes	0.	$.357276x10^{15}$	0.	$.357276x10^{15}$
Invertebrates	0.	$.115678x10^{14}$	0.	$.115678x10^{14}$
Skates	0.	$.916046x10^{13}$	0.	$.916048x10^{14}$
Turbot	0.	$.319648x10^{14}$	0.	$.319647x10^{14}$
Halibut	0.	$.279657x10^{13}$	0.	$.279657x10^{13}$
Flathead sole	0.	$.243525x10^{14}$	0.	$.243525x10^{14}$
Dover sole	0.	$.350971x10^{10}$	0.	$.350971x10^{10}$
Rex sole	0.	$.511136x10^{10}$	0.	$.511136x10^{10}$
Sablefish	0.	$.102895x10^{12}$	0.	$.102895x10^{12}$
Cottidae	0.	$.149469x10^{12}$	0.	$.149469x10^{12}$
Pacific cod	0.	$.778664x10^{16}$	0.	$.778664x10^{16}$
Walleye pollock	0.	$872290x10^{14}$	0.	$.872290x10^{14}$
Pacific ocean perch	0.	$.357958x10^{15}$	0.	$.35798x10^{15}$
Tanner crab	0.	$.115522x10^{14}$	0.	$.115522x10^{14}$

Table 5.--Variances of the biomass estimates for the Kodiak region for May-October 1961, Cr 618.

Species	Depth Zones (m) 0-100	101-200	201-400	Total
Elasmobranchs	$.853233 \times 10^{11}$	$.114351 \times 10^{12}$	$.205532 \times 10^{7}$	$.199677 \times 10^{12}$
Flatfishes	$.185743 \times 10^{15}$	$.248489 \times 10^{15}$	$.751296 \times 10^{13}$	$.441745 \times 10^{15}$
Roundfishes	$.340374 \times 10^{14}$	$.289124 \times 10^{14}$	$.730083 \times 10^{10}$	$.629572 \times 10^{14}$
Rockfishes	$.901600 \times 10^{12}$	$.25400 \times 10^{13}$	$.127462 \times 10^{11}$	$.345437 \times 10^{13}$
Invertebrates	$.438258 \times 10^{15}$	$.50060 \times 10^{14}$	$.194084 \times 10^{13}$	$.490204 \times 10^{15}$
Skates	$.854365 \times 10^{11}$	$.110925 \times 10^{12}$	$.205532 \times 10^{7}$	$.196364 \times 10^{12}$
Turbot	$.122228 \times 10^{13}$	$.235860 \times 10^{15}$	$.694754 \times 10^{12}$	$.237777 \times 10^{15}$
Halibut	$.633176 \times 10^{13}$	$.118405 \times 10^{13}$	$.114827 \times 10^{13}$	$.866408 \times 10^{13}$
Flathead sole	$.190371 \times 10^{13}$	$.252926 \times 10^{13}$	$.761156 \times 10^{12}$	$.519449 \times 10^{13}$
Dover sole	$.266974 \times 10^{6}$	$.109929 \times 10^{11}$	0.	$.109931 \times 10^{11}$
Rex sole	$.136124 \times 10^{11}$	$.201886 \times 10^{8}$	$.416203 \times 10^{8}$	$.338426 \times 10^{11}$
Rock sole	$.157706 \times 10^{15}$	$.332541 \times 10^{12}$	$.184979 \times 10^{10}$	$.158040 \times 10^{15}$
Sablefish	$.365488 \times 10^{9}$	$.256568 \times 10^{13}$	$.328852 \times 10^{8}$	$.256608 \times 10^{13}$
Cottidae	$.609448 \times 10^{13}$	$.120554 \times 10^{14}$	$.174047 \times 10^{10}$	$.181516 \times 10^{14}$
Pacific cod	$.951930 \times 10^{13}$	$.280698 \times 10^{13}$	$.249146 \times 10^{11}$	$.123512 \times 10^{14}$
Walleye pollock	$.223089 \times 10^{13}$	$.304224 \times 10^{13}$	$.223824 \times 10^{8}$	$.527316 \times 10^{13}$
Thornyheads	0.	0.	0.	0.
Pacific ocean perch	$.863220 \times 10^{12}$	$.254457 \times 10^{13}$	$.703384 \times 10^{10}$	$.341482 \times 10^{13}$
Tanner crab	$.593875 \times 10^{13}$	$.254789 \times 10^{14}$	$.139044 \times 10^{13}$	$.3280814 \times 10^{14}$
King crab	$.439450 \times 10^{15}$	$.240826 \times 10^{14}$	$.357398 \times 10^{12}$	$.463890 \times 10^{15}$

Table 6.--Variances of the biomass estimates for the Shelikof region for May-October, 1961 Cruise 618.

Species	Depth Zones (m) 0-100	101-200	201-400	Total
Elasmobranchs	0.	$.980368 \times 10^{11}$	$.973404 \times 10^{10}$	$.107770 \times 10^{12}$
Flatfishes	0.	$.207888 \times 10^{14}$	$.386901 \times 10^{13}$	$.246578 \times 10^{14}$
Roundfishes	0.	$.337207 \times 10^{13}$	$.812938 \times 10^{12}$	$.418500 \times 10^{13}$
Rockfishes	0.	$.832804 \times 10^{10}$	$.219543 \times 10^{12}$	$.227871 \times 10^{12}$
Invertebrates	0.	$.641507 \times 10^{13}$	$.119758 \times 10^{13}$	$.761265 \times 10^{13}$
Skates	0.	$.980368 \times 10^{11}$	$.757673 \times 10^{8}$	$.981126 \times 10^{11}$
Turbot	0.	$.100807 \times 10^{13}$	$.341266 \times 10^{11}$	$.104220 \times 10^{13}$
Halibut	0.	$.597788 \times 10^{11}$	$.454427 \times 10^{9}$	$.602322 \times 10^{11}$
Flathead sole	0.	$.204082 \times 10^{14}$	$.766527 \times 10^{10}$	$.204159 \times 10^{14}$
Dover sole	0.	$.103812 \times 10^{10}$	$.387317 \times 10^{7}$	$.104199 \times 10^{10}$
Rex sole	0.	$.190581 \times 10^{10}$	$.635169 \times 10^{6}$	$.190644 \times 10^{10}$
Rock sole	0.	$.152788 \times 10^{8}$	$.716885 \times 10^{5}$	$.151094 \times 10^{8}$
Sablefish	0.	$.516209 \times 10^{11}$	$.357904 \times 10^{8}$	$.516567 \times 10^{11}$
Cottidae	0.	$.122771 \times 10^{12}$	$.295559 \times 10^{9}$	$.123066 \times 10^{12}$
Pacific cod	0.	$.183426 \times 10^{13}$	$.352077 \times 10^{10}$	$.183778 \times 10^{13}$
Walleye pollock	0.	$.112505 \times 10^{13}$	$.769104 \times 10^{9}$	$.112582 \times 10^{13}$
Thornyheads	-	-	-	-
Pacific ocean perch	0.	$.787761 \times 10^{10}$	$.217440 \times 10^{10}$	$.100520 \times 10^{11}$
Tanner crab	0.	$.554971 \times 10^{13}$	$.123555 \times 10^{11}$	$.556206 \times 10^{13}$
King crab	0.	$.254353 \times 10^{12}$	$.336286 \times 10^{9}$	$.254689 \times 10^{12}$
Scallop	0.	0.	0.	0.

Table 7.--Variances of the biomass estimates for the Chirikof region for May-October 1961, Cr 618.

Species	Depth Zones (m) 0-100	101-200	201-400	Total
Elasmobranchs	$.191753\text{x}10^{10}$	$.404363\text{x}10^{11}$	$.141707\text{x}10^{13}$	$.145942\text{x}10^{13}$
Flatfishes	$.554530\text{x}10^{14}$	$.247482\text{x}10^{14}$	$.307677\text{x}10^{14}$	$.110968\text{x}10^{15}$
Roundfishes	$.851685\text{x}10^{13}$	$.109182\text{x}10^{15}$	$.171168\text{x}10^{13}$	$.119410\text{x}10^{15}$
Rockfishes	$.182101\text{x}10^{7}$	$.217922\text{x}10^{15}$	$.890534\text{x}10^{13}$	$.226828\text{x}10^{15}$
Invertebrates	$.598479\text{x}10^{16}$	$.226720\text{x}10^{14}$	$.149139\text{x}10^{13}$	$.600895\text{x}10^{16}$
Skates	$.191753\text{x}10^{10}$	$.407874\text{x}10^{11}$	$.142201\text{x}10^{13}$	$.146472\text{x}10^{13}$
Turbot	$.738327\text{x}10^{12}$	$.531872\text{x}10^{13}$	$.364037\text{x}10^{14}$	$.424607\text{x}10^{14}$
Halibut	$.118633\text{x}10^{14}$	$.298503\text{x}10^{13}$	$.105658\text{x}10^{12}$	$.149540\text{x}10^{14}$
Flathead sole	$.989245\text{x}10^{11}$	$.315174\text{x}10^{13}$	$.872503\text{x}10^{12}$	$.412316\text{x}10^{13}$
Dover sole	$.408468\text{x}10^{7}$	$.617563\text{x}10^{10}$	$.220576\text{x}10^{12}$	$.226755\text{x}10^{12}$
Rex sole	$.164266\text{x}10^{10}$	$.101957\text{x}10^{13}$	$.103582\text{x}10^{13}$	$.205703\text{x}10^{13}$
Rock sole	$.342815\text{x}10^{14}$	$.301705\text{x}10^{13}$	$.396987\text{x}10^{11}$	$.373383\text{x}10^{14}$
Sablefish	$.102117\text{x}10^{7}$	$.191243\text{x}10^{12}$	$.810374\text{x}10^{11}$	$.272281\text{x}10^{12}$
Cottidae	$.709719\text{x}10^{13}$	$.110334\text{x}10^{15}$	$.824606\text{x}10^{11}$	$.117513\text{x}10^{15}$
Pacific cod	$.606314\text{x}10^{12}$	$.135927\text{x}10^{12}$	$.206356\text{x}10^{11}$	$.762877\text{x}10^{12}$
Walleye pollock	$.161436\text{x}10^{9}$	$.706053\text{x}10^{13}$	$.129718\text{x}10^{13}$	$.835787\text{x}10^{13}$
Thornyheads	0.	0.	$.126317\text{x}10^{13}$	$.126317\text{x}10^{13}$
Pacific ocean perch	$.196064\text{x}10^{7}$	$.218035\text{x}10^{15}$	$.601344\text{x}10^{13}$	$.224049\text{x}10^{15}$
Tanner crab	$.546354\text{x}10^{14}$	$.135043\text{x}10^{14}$	$.106097\text{x}10^{13}$	$.692007\text{x}10^{14}$
King crab	$.647729\text{x}10^{16}$	$.320151\text{x}10^{13}$	$.112326\text{x}10^{12}$	$.648060\text{x}10^{16}$

Table 8.--Variances of the biomass estimates for the Shumagin region for May-October 1961, Cr 618.

Species	Depth Zones (m)			Total
	0-100	101-200	201-400	
Elasmobranchs	0.	$.277124 \times 10^{11}$	$.113566 \times 10^{11}$	$.390691 \times 10^{11}$
Flatfishes	$.178117 \times 10^{14}$	$.165222 \times 10^{14}$	$.137570 \times 10^{15}$	$.171904 \times 10^{15}$
Roundfishes	$.485914 \times 10^{13}$	$.151871 \times 10^{14}$	$.276322 \times 10^{14}$	$.476785 \times 10^{14}$
Rockfishes	0.	$.304454 \times 10^{14}$	$.321507 \times 10^{14}$	$.625962 \times 10^{14}$
Invertebrates	$.284507 \times 10^{14}$	$.144385 \times 10^{14}$	$.745583 \times 10^{11}$	$.429638 \times 10^{14}$
Skates	0.	$.268042 \times 10^{11}$	$.113566 \times 10^{11}$	$.381609 \times 10^{11}$
Turbot	$.334555 \times 10^{12}$	$.928011 \times 10^{13}$	$.137950 \times 10^{15}$	$.147565 \times 10^{15}$
Halibut	$.717522 \times 10^{12}$	$.184944 \times 10^{12}$	$.191952 \times 10^{10}$	$.904386 \times 10^{12}$
Flathead sole	$.537587 \times 10^{12}$	$.176692 \times 10^{13}$	$.308050 \times 10^{13}$	$.538501 \times 10^{13}$
Dover sole	$.600366 \times 10^{9}$	$.932577 \times 10^{8}$	$.290941 \times 10^{10}$	$.360303 \times 10^{10}$
Rex sole	$.502386 \times 10^{8}$	$.966891 \times 10^{10}$	$.172533 \times 10^{11}$	$.269725 \times 10^{11}$
Rock sole	$.399426 \times 10^{13}$	$.713983 \times 10^{11}$	0.	$.406566 \times 10^{13}$
Sablefish	$.345811 \times 10^{8}$	$.148320 \times 10^{11}$	$.196440 \times 10^{14}$	$.196589 \times 10^{14}$
Cottidae	$.351392 \times 10^{13}$	$.515840 \times 10^{13}$	$.695787 \times 10^{10}$	$.867928 \times 10^{13}$
Pacific cod	$.793900 \times 10^{12}$	$.581662 \times 10^{11}$	$.422927 \times 10^{12}$	$.120499 \times 10^{13}$
Walleye pollock	$.473228 \times 10^{10}$	$.409146 \times 10^{13}$	$.199810 \times 10^{13}$	$.609429 \times 10^{13}$
Thornyheads	0.	$.465145 \times 10^{9}$	$.545732 \times 10^{11}$	$.550383 \times 10^{11}$
Pacific ocean perch	0.	$.302385 \times 10^{14}$	$.334149 \times 10^{14}$	$.636534 \times 10^{14}$
Tanner crab	$.119771 \times 10^{14}$	$.991640 \times 10^{13}$	$.754882 \times 10^{11}$	$.219690 \times 10^{14}$
King crab	$.950756 \times 10^{13}$	$.313285 \times 10^{13}$	0.	$.126404 \times 10^{14}$
Scallop	$.240146 \times 10^{10}$	0.	0.	$.240146 \times 10^{10}$

Table 9.--Variances of the biomass estimates for the Sanak region for May-October 1961, Cr 618.

Species	Depth Zones (m) 0-100	101-200	201-400	Total
Elasmobranchs	$.154241x10^{10}$	$.225950x10^{11}$	$.109903x10^{11}$	$.351278x10^{11}$
Flatfishes	$.890591x10^{13}$	$.552864x10^{13}$	$.360072x10^{12}$	$.147946x10^{14}$
Roundfishes	$.353098x10^{14}$	$.176505x10^{14}$	$.496258x10^{12}$	$.534566x10^{14}$
Rockfishes	$.286774x10^{9}$	$.127938x10^{13}$	$.449795x10^{13}$	$.577763x10^{13}$
Invertebrates	$.572513x10^{15}$	$.177618x10^{14}$	0.	$.590275x10^{15}$
Skates	$.154241x10^{10}$	$.226213x10^{11}$	$.109903x10^{11}$	$.351541x10^{11}$
Turbot	$.139849x10^{12}$	$.411894x10^{12}$	$.721256x10^{11}$	$.623869x10^{12}$
Halibut	$.806370x10^{12}$	$.283555x10^{12}$	$.302940x10^{9}$	$.109022x10^{13}$
Flathead sole	$.189532x10^{12}$	$.817655x10^{12}$	0.	$.100718x10^{13}$
Dover sole	$.438731x10^{9}$	$.675307x10^{8}$	$.298167x10^{8}$	$.536078x10^{9}$
Rex sole	$.512597x10^{10}$	$.154919x10^{10}$	$.343511x10^{12}$	$.350186x10^{12}$
Rock sole	$.548184x10^{13}$	$.381601x10^{13}$	0.	$.929786x10^{13}$
Sablefish	$.109682x10^{7}$	$.134017x10^{11}$	$.724608x10^{10}$	$.206489x10^{11}$
Cottidae	$.268335x10^{14}$	$.111036x10^{14}$	$.610369x10^{10}$	$.379432x10^{14}$
Pacific cod	$.110381x10^{13}$	$.286920x10^{13}$	$.354248x10^{11}$	$.400844x10^{13}$
Walleye pollock	$.686819x10^{11}$	$.141165x10^{13}$	$.448861x10^{11}$	$.152522x10^{13}$
Thornyheads	0.	0.	$.153816x10^{11}$	$.153816x10^{11}$
Pacific ocean perch	$.286774x10^{9}$	$.127809x10^{13}$	$.460891x10^{13}$	$.588729x10^{13}$
Tanner crab	$.350745x10^{14}$	$.174116x10^{14}$	0.	$.524862x10^{14}$
King crab	$.554638x10^{15}$	$.243505x10^{11}$	0.	$.554662x10^{15}$

Table 10.--Variance of the biomass estimates for the Kodiak region for September-November 1961, Cr 619.

Species	Depth Zones (m)			Total
	0-100	101-200	201-400	
Elasmobranchs	$.142397 \times 10^{13}$	$.472186 \times 10^{10}$	$.957384 \times 10^{10}$	$.143827 \times 10^{13}$
Flatfish	$.186883 \times 10^{15}$	$.964336 \times 10^{14}$	$.801065 \times 10^{12}$	$.284118 \times 10^{15}$
Roundfish	$.169634 \times 10^{15}$	$.106654 \times 10^{15}$	$.819259 \times 10^{12}$	$.277107 \times 10^{15}$
Rockfish	$.122080 \times 10^{10}$	$.298898 \times 10^{13}$	$.154869 \times 10^{10}$	$.299175 \times 10^{13}$
Invertebrates	$.322376 \times 10^{15}$	$.155850 \times 10^{16}$	$.158769 \times 10^{14}$	$.189676 \times 10^{16}$
Skates	$.142397 \times 10^{13}$	$.433657 \times 10^{10}$	$.957384 \times 10^{10}$	$.143788 \times 10^{13}$
Turbot	$.917099 \times 10^{12}$	$.397070 \times 10^{14}$	$.559562 \times 10^{11}$	$.406800 \times 10^{14}$
Halibut	$.309415 \times 10^{13}$	$.475428 \times 10^{13}$	$.607341 \times 10^{11}$	$.790916 \times 10^{13}$
Flathead	$.166883 \times 10^{12}$	$.170675 \times 10^{14}$	$.175846 \times 10^{12}$	$.174103 \times 10^{14}$
Dover	$.706121 \times 10^{9}$	$.467827 \times 10^{9}$	$.374583 \times 10^{7}$	$.117769 \times 10^{10}$
Rex	$.851216 \times 10^{10}$	$.200865 \times 10^{13}$	$.739916 \times 10^{6}$	$.201717 \times 10^{13}$
Rock	$.1708515 \times 10^{15}$	$.151903 \times 10^{13}$	$.566499 \times 10^{8}$	$.172370 \times 10^{15}$
Sablefish	0.	$.137006 \times 10^{12}$	$.104050 \times 10^{12}$	$.241057 \times 10^{12}$
Cottidae	$.109530 \times 10^{15}$	$.374881 \times 10^{14}$	$.206668 \times 10^{12}$	$.147225 \times 10^{15}$
Pacific cod	$.513903 \times 10^{13}$	$.109223 \times 10^{14}$	$.266370 \times 10^{10}$	$.160640 \times 10^{14}$
Walleye pollock	$.764389 \times 10^{10}$	$.439062 \times 10^{14}$	$.145023 \times 10^{9}$	$.439140 \times 10^{14}$
Thornyhead	-	-	-	-
Pacific ocean perch	$.125532 \times 10^{10}$	$.300074 \times 10^{13}$	$.240399 \times 10^{10}$	$.300440 \times 10^{13}$
Dungeness crab	$.837543 \times 10^{13}$	$.154577 \times 10^{13}$	0.	$.992121 \times 10^{13}$
Tanner crab	$.268759 \times 10^{15}$	$.140487 \times 10^{15}$	$.873046 \times 10^{13}$	$.417977 \times 10^{15}$
King crab	$.166531 \times 10^{15}$	$.159133 \times 10^{16}$	$.752922 \times 10^{12}$	$.175861 \times 10^{16}$

Table 11.--Variances of the biomass estimates for the Shelikof region for September-November 1961, Cr 619.

Species	Depth Zones (m) 0-100	101-200	201-400	Total
Elasmobranchs	0.	$.457885 \times 10^{12}$	$.193906 \times 10^{11}$	$.477276 \times 10^{12}$
Flatfish	0.	$.201293 \times 10^{14}$	$.116848 \times 10^{14}$	$.318141 \times 10^{14}$
Roundfish	0.	$.198077 \times 10^{13}$	$.120425 \times 10^{13}$	$.318503 \times 10^{13}$
Rockfish	0.	$.160827 \times 10^{11}$	$.486642 \times 10^{12}$	$.502725 \times 10^{12}$
Invertebrates	0.	$.299158 \times 10^{13}$	$.830563 \times 10^{13}$	$.112972 \times 10^{14}$
Skates	0.	$.884043 \times 10^{11}$	$.189976 \times 10^{11}$	$.107401 \times 10^{12}$
Turbot	0.	$.454572 \times 10^{13}$	$.424937 \times 10^{13}$	$.879510 \times 10^{13}$
Halibut	0.	$.672813 \times 10^{12}$	$.183782 \times 10^{11}$	$.691191 \times 10^{12}$
Flathead	0.	$.606940 \times 10^{13}$	$.351662 \times 10^{13}$	$.958603 \times 10^{13}$
Dover	0.	$.150021 \times 10^{9}$	$.166529 \times 10^{10}$	$.181531 \times 10^{10}$
Rex	0.	$.283513 \times 10^{9}$	$.782450 \times 10^{6}$	$.284295 \times 10^{9}$
Rock	0.	$.121420 \times 10^{9}$	$.612320 \times 10^{7}$	$.127543 \times 10^{9}$
Sablefish	0.	$.134193 \times 10^{12}$	$.157899 \times 10^{11}$	$.149983 \times 10^{12}$
Cottidae	0.	$.182669 \times 10^{12}$	$.756741 \times 10^{10}$	$.190236 \times 10^{12}$
Pacific cod	0.	$.286137 \times 10^{11}$	$.176379 \times 10^{12}$	$.204992 \times 10^{12}$
Walleye pollock	0.	$.927527 \times 10^{12}$	$.776923 \times 10^{12}$	$.170445 \times 10^{13}$
Thornyhead		-	-	-
Pacific ocean perch	0.	$.121966 \times 10^{11}$	$.486036 \times 10^{12}$	$.498232 \times 10^{12}$
Dungeness crab	0.	$.300023 \times 10^{12}$	0.	$.300023 \times 10^{12}$
Tanner crab	0.	$.295854 \times 10^{13}$	$.930997 \times 10^{12}$	$.388954 \times 10^{13}$
King crab	0.	$.164250 \times 10^{12}$	$.503192 \times 10^{13}$	$.519617 \times 10^{13}$

Table 12.--Variances of the biomass estimates for the Chirikof region for May-October 1961, Cr 619.

Species	Depth Zones (m) 0-100	101-200	201-400	Total
Elasmobranchs	$.260173 \times 10^{12}$	$.333889 \times 10^{10}$	$.904359 \times 10^{11}$	$.353948 \times 10^{12}$
Flatfishes	$.761557 \times 10^{14}$	$.383442 \times 10^{15}$	$.516942 \times 10^{14}$	$.511292 \times 10^{15}$
Roundfishes	$.158822 \times 10^{14}$	$.803867 \times 10^{14}$	$.745720 \times 10^{14}$	$.170840 \times 10^{15}$
Rockfishes	0.	$.314818 \times 10^{14}$	$.146948 \times 10^{14}$	$.461767 \times 10^{14}$
Invertebrates	$.668480 \times 10^{16}$	$.121439 \times 10^{16}$	$.796366 \times 10^{14}$	$.797884 \times 10^{16}$
Skates	$.176719 \times 10^{12}$	$.333889 \times 10^{10}$	$.904359 \times 10^{11}$	$.270494 \times 10^{12}$
Turbot	$.876166 \times 10^{12}$	$.181794 \times 10^{15}$	$.268424 \times 10^{14}$	$.209513 \times 10^{15}$
Halibut	$.755218 \times 10^{14}$	$.184229 \times 10^{13}$	$.443744 \times 10^{12}$	$.778078 \times 10^{14}$
Flathead Sole	$.126877 \times 10^{13}$	$.658588 \times 10^{14}$	$.601849 \times 10^{13}$	$.731461 \times 10^{14}$
Dover sole	0.	$.455551 \times 10^{11}$	$.342993 \times 10^{12}$	$.388548 \times 10^{12}$
Rex sole	$.480150 \times 10^{9}$	$.138778 \times 10^{13}$	$.441850 \times 10^{12}$	$.183011 \times 10^{13}$
Rock sole	$.373660 \times 10^{13}$	$.357487 \times 10^{14}$	$.556286 \times 10^{7}$	$.394853 \times 10^{14}$
Sablefish	$.175203 \times 10^{11}$	$.105187 \times 10^{13}$	$.436159 \times 10^{12}$	$.150555 \times 10^{13}$
Cottidae	$.160787 \times 10^{14}$	$.167763 \times 10^{14}$	$.113645 \times 10^{11}$	$.328664 \times 10^{14}$
Pacific cod	$.682833 \times 10^{9}$	$.250143 \times 10^{13}$	$.852199 \times 10^{11}$	$.258733 \times 10^{13}$
Walleye pollock	$.603809 \times 10^{11}$	$.815023 \times 10^{14}$	$.707497 \times 10^{14}$	$.152312 \times 10^{15}$
Thornyheads	0.	0.	$.129883 \times 10^{12}$	$.129883 \times 10^{12}$
Pacific ocean perch	0.	$.315046 \times 10^{14}$	$.126493 \times 10^{14}$	$.441540 \times 10^{14}$
Dungeness crab	$.532614 \times 10^{10}$	$.325408 \times 10^{12}$	0.	$.330734 \times 10^{12}$
Tanner crab	$.835222 \times 10^{14}$	$.333873 \times 10^{15}$	$.130612 \times 10^{14}$	$.430457 \times 10^{15}$
King crab	$.653028 \times 10^{16}$	$.102460 \times 10^{16}$	$.413749 \times 10^{14}$	$.759626 \times 10^{16}$

Table 13.--Varinaces of the biomass estimates for the Shumagin region for September-November 1961, Cr 619.

Species	Depth Zones (m)			Total
	0-100	101-200	201-400	
Elasmobranchs	0.	$.273902 \times 10^{11}$	$.826448 \times 10^{8}$	$.274728 \times 10^{11}$
Flatfish	$.134995 \times 10^{14}$	$.221405 \times 10^{14}$	$.251028 \times 10^{13}$	$.381503 \times 10^{14}$
Roundfish	$.132063 \times 10^{13}$	$.255286 \times 10^{14}$	$.547212 \times 10^{13}$	$.323214 \times 10^{14}$
Rockfish	$.165476 \times 10^{7}$	$.649259 \times 10^{11}$	$.405190 \times 10^{14}$	$.405840 \times 10^{14}$
Invertebrates	$.152639 \times 10^{15}$	$.457400 \times 10^{14}$	$.248565 \times 10^{11}$	$.198404 \times 10^{15}$
Skates	0.	$.273902 \times 10^{11}$	$.826448 \times 10^{8}$	$.274728 \times 10^{11}$
Turbot	$.111490 \times 10^{12}$	$.121949 \times 10^{14}$	$.139693 \times 10^{13}$	$.137033 \times 10^{14}$
Halibut	$.468917 \times 10^{13}$	$.318108 \times 10^{12}$	$.587933 \times 10^{10}$	$.501316 \times 10^{13}$
Flathead	$.156480 \times 10^{8}$	$.177881 \times 10^{13}$	$.314918 \times 10^{12}$	$.209375 \times 10^{13}$
Dover	$.184650 \times 10^{8}$	$.571932 \times 10^{8}$	$.435118 \times 10^{8}$	$.119170 \times 10^{9}$
Rex	$.212869 \times 10^{8}$	$.259980 \times 10^{10}$	$.116087 \times 10^{10}$	$.378196 \times 10^{10}$
Rock	$.117238 \times 10^{14}$	$.115985 \times 10^{12}$	$.681408 \times 10^{8}$	$.118399 \times 10^{14}$
Sablefish	0.	$.195032 \times 10^{11}$	$.485092 \times 10^{11}$	$.680124 \times 10^{11}$
Cottidae	$.129466 \times 10^{13}$	$.132507 \times 10^{14}$	$.237475 \times 10^{11}$	$.145691 \times 10^{14}$
Pacific cod	$.933051 \times 10^{10}$	$.210540 \times 10^{12}$	$.195209 \times 10^{13}$	$.217196 \times 10^{13}$
Walleye pollock	$.661904 \times 10^{7}$	$.975512 \times 10^{13}$	$.820188 \times 10^{13}$	$.179570 \times 10^{14}$
Thornyhead	0.	$.312478 \times 10^{10}$	0.	$.312478 \times 10^{10}$
Pacific ocean perch	$.165476 \times 10^{7}$	$.355050 \times 10^{10}$	$.405190 \times 10^{14}$	$.405226 \times 10^{14}$
Dungeness crab	$.132557 \times 10^{14}$	$.741987 \times 10^{11}$	0.	$.133299 \times 10^{14}$
Tanner crab	$.114114 \times 10^{15}$	$.342685 \times 10^{14}$	$.257314 \times 10^{11}$	$.148408 \times 10^{15}$
King crab	$.264761 \times 10^{12}$	$.275004 \times 10^{13}$	0.	$.301480 \times 10^{13}$

Table 14.--Variances of the biomass estimates for the Sanak region for September-November 1961, Cr 619.

Species	Depth Zones (m) 0-100	101-200	201-400	Total
Elasmobranchs	$.188769\times10^{11}$	$.372751\times10^{11}$	0.	$.561521\times10^{11}$
Flatfish	$.392575\times10^{14}$	$.114657\times10^{14}$	0.	$.507232\times10^{14}$
Roundfish	$.102598\times10^{15}$	$.144943\times10^{14}$	0.	$.117092\times10^{15}$
Rockfish	$.202591\times10^{8}$	$.156035\times10^{12}$	0.	$.156044\times10^{12}$
Invertebrates	$.915436\times10^{15}$	$.711604\times10^{15}$	0.	$.162704\times10^{16}$
Skates	$.184571\times10^{11}$	$.372751\times10^{11}$	0.	$.557323\times10^{11}$
Turbot	$.225402\times10^{13}$	$.303822\times10^{13}$	0.	$.529225\times10^{13}$
Halibut	$.688612\times10^{12}$	$.734582\times10^{11}$	0.	$.762071\times10^{12}$
Flathead	$.179334\times10^{12}$	$.188886\times10^{13}$	0.	$.206820\times10^{13}$
Dover	0.	$.342461\times10^{11}$	0.	$.342460\times10^{11}$
Rex	$.180746\times10^{11}$	$.144907\times10^{12}$	0.	$.162971\times10^{12}$
Rock	$.231546\times10^{14}$	$.388017\times10^{13}$	0.	$.270348\times10^{14}$
Sablefish	$.342218\times10^{10}$	$.104934\times10^{10}$	0.	$.446996\times10^{10}$
Cottidae	$.658412\times10^{14}$	$.103284\times10^{14}$	0.	$.761697\times10^{14}$
Pacific cod	$.495430\times10^{13}$	$.230510\times10^{13}$	0.	$.725941\times10^{13}$
Walleye pollock	$.147462\times10^{11}$	$.828684\times10^{11}$	0.	$.976130\times10^{11}$
Thornyhead	0.	$.772784\times10^{11}$	0.	$.772784\times10^{11}$
Pacific ocean perch	$.667359\times10^{7}$	$.356602\times10^{11}$	0.	$.356560\times10^{11}$
Dungeness crab	$.416458\times10^{13}$	$.145111\times10^{11}$	0.	$.417909\times10^{13}$
Tanner crab	$.868630\times10^{15}$	$.632831\times10^{15}$	0.	$.150146\times10^{16}$
King crab	$.142755\times10^{14}$	$.177240\times10^{14}$	0.	$.319995\times10^{14}$

Table 16.--Variances of the biomass estimates for the Yakutat region for June-August 1962, Cr 628.

Species	Depth Zones (m) 0-100	101-200	201-400	Total
Elasmobranchs	$.115873\times10^{12}$	$.334935\times10^{12}$	$.870225\times10^{11}$	$.537831\times10^{12}$
Flatfish	$.131605\times10^{14}$	$.233193\times10^{14}$	$.233193\times10^{14}$	$.898771\times10^{14}$
Roundfish	$.127682\times10^{13}$	$.404385\times10^{12}$	$.197217\times10^{13}$	$.365338\times10^{13}$
Rockfish	0.	$.613854\times10^{14}$	$.241949\times10^{13}$	$.638049\times10^{14}$
Invertebrates	$.101669\times10^{14}$	$.946594\times10^{13}$	$.135273\times10^{13}$	$.209856\times10^{13}$
Skates	$.240915\times10^{11}$	$.302509\times10^{12}$	$.925100\times10^{11}$	$.419111\times10^{12}$
Turbot	$.359974\times10^{13}$	$.350571\times10^{14}$	$.939179\times10^{13}$	$.480486\times10^{14}$
Halibut	$.181133\times10^{12}$	$.266450\times10^{12}$	$.111618\times10^{10}$	$.448699\times10^{12}$
Flathead	$.220415\times10^{12}$	$.366898\times10^{13}$	$.168939\times10^{13}$	$.557879\times10^{13}$
Dover	$.139205\times10^{8}$	$.539367\times10^{11}$	$.989892\times10^{12}$	$.104384\times10^{13}$
Rex	$.511467\times10^{11}$	$.395837\times10^{11}$	$.597012\times10^{12}$	$.687743\times10^{12}$
Rock	$.780647\times10^{9}$	$.525845\times10^{8}$	0.	$.833232\times10^{9}$
Sablefish	$.141899\times10^{10}$	$.616723\times10^{11}$	$.362338\times10^{11}$	$.993252\times10^{11}$
Cottidae	0.	$.191690\times10^{10}$	$.430894\times10^{1}$[illegible]	$.622584\times10^{10}$
Pacific cod	$.698289\times10^{11}$	$.173109\times10^{11}$	$.275635\times10^{11}$	$.114703\times10^{12}$
Walleye pollock	$.691862\times10^{12}$	$.161336\times10^{12}$	$.127485\times10^{13}$	$.212805\times10^{13}$
Thornyhead	0.	$.883358\times10^{10}$	$.665143\times10^{12}$	$.673977\times10^{12}$
Pacific ocean perch	0.	$.614729\times10^{14}$	$.329419\times10^{13}$	$.647671\times10^{14}$
Tanner crab	$.214015\times10^{12}$	$.500971\times10^{12}$	$.135273\times10^{13}$	$.206771\times10^{13}$
Scallop	$.122593\times10^{14}$	$.757709\times10^{13}$	0.	$.198364\times10^{14}$

Table 17.--Varinaces of the biomass estimates for the Prince William region for June-August 1962, Cr 628.

Species	Depth Zones (m) 0-100	101-200	201-400	Total
Elasmobranchs	$.194404x10^{13}$	$.289738x10^{12}$	$.148075x10^{11}$	$.224858x10^{13}$
Flatfish	$.136759x10^{14}$	$.741606x10^{14}$	$.430371x10^{13}$	$.921403x10^{14}$
Roundfish	$.293107x10^{12}$	$.482412x10^{13}$	$.122206x10^{12}$	$.523943x10^{13}$
Rockfish	$.121387x10^{10}$	$.929667x10^{13}$	$.416388x10^{13}$	$.134617x10^{14}$
Invertebrates	$.313617x10^{14}$	$.114084x10^{13}$	$.125407x10^{12}$	$.326279x10^{14}$
Skates	$.162987x10^{13}$	$.282015x10^{12}$	$.118333x10^{11}$	$.192372x10^{13}$
Turbot	$.250197x10^{13}$	$.313702x10^{14}$	$.285135x10^{13}$	$.367236x10^{14}$
Halibut	$.394024x10^{12}$	$.204704x10^{12}$	$.225488x10^{9}$	$.598955x10^{12}$
Flathead	$.452828x10^{12}$	$.131737x10^{14}$	$.394659x10^{12}$	$.140212x10^{14}$
Dover	$.163366x10^{10}$	$.135199x10^{12}$	$.900943x10^{11}$	$.226927x10^{12}$
Rex	$.101754x10^{12}$	$.729798x10^{11}$	$.625899x10^{11}$	$.237324x10^{12}$
Rock	$.520156x10^{11}$	$.163432x10^{7}$	0.	$.520172x10^{11}$
Sablefish	$.114868x10^{11}$	$.498541x10^{11}$	$.184301x10^{11}$	$.797712x10^{11}$
Cottidae	$.189963x10^{9}$	$.344263x10^{11}$	$.193461x10^{10}$	$.365509x10^{11}$
Pacific cod	$.353767x10^{11}$	$.455175x10^{11}$	$.104680x10^{11}$	$.913624x10^{11}$
Walleye pollock	$.717889x10^{10}$	$.418807x10^{13}$	$.139031x10^{12}$	$.433428x10^{13}$
Thornyhead	0.	$.344861x10^{11}$	$.725416x10^{11}$	$.107027x10^{12}$
Pacific ocean perch	$.122051x10^{10}$	$.892822x10^{13}$	$.398842x10^{13}$	$.129178x10^{14}$
Tanner crab	$.219095x10^{12}$	$.104395x10^{13}$	$.125470x10^{12}$	$.138851x10^{13}$
Scallop	$.993523x10^{8}$	$.136548x10^{12}$	0.	$.136648x10^{12}$

Table 19.--Varinaces of the biomass estimates for the Fairweather region for May-October 1962, Cr 629.

Species	Depth Zones (m) 0-100	101-200	201-400	Total
Elasmobranchs	$.612021 \times 10^{12}$	$.113970 \times 10^{13}$	$.163204 \times 10^{13}$	$.338376 \times 10^{13}$
Flatfish	$.242970 \times 10^{14}$	$.156153 \times 10^{15}$	$.623247 \times 10^{13}$	$.186682 \times 10^{15}$
Roundfish	$.107701 \times 10^{11}$	$.831458 \times 10^{13}$	$.241084 \times 10^{13}$	$.107361 \times 10^{14}$
Rockfish	0.	$.408196 \times 10^{12}$	$.396999 \times 10^{13}$	$.437818 \times 10^{13}$
Invertebrates	$.176630 \times 10^{13}$	$.58703 \times 10^{13}$	$.133228 \times 10^{12}$	$.777036 \times 10^{13}$
Skates	$.472105 \times 10^{11}$	$.994228 \times 10^{12}$	$.661511 \times 10^{12}$	$.170294 \times 10^{13}$
Turbot	$.289699 \times 10^{12}$	$.781212 \times 10^{14}$	$.125056 \times 10^{12}$	$.785359 \times 10^{14}$
Halibut	$.947467 \times 10^{11}$	$.129230 \times 10^{13}$	0.	$.138704 \times 10^{13}$
Flathead	$.290806 \times 10^{11}$	$.627567 \times 10^{13}$	$.446734 \times 10^{13}$	$.107720 \times 10^{14}$
Dover	$.423511 \times 10^{10}$	$.932059 \times 10^{12}$	$.331260 \times 10^{12}$	$.126755 \times 10^{13}$
Rex	$.383866 \times 10^{12}$	$.245166 \times 10^{13}$	$.305477 \times 10^{11}$	$.286607 \times 10^{13}$
Rock	$.207333 \times 10^{9}$	$.342350 \times 10^{9}$	0.	$.549684 \times 10^{9}$
Sablefish	$.147662 \times 10^{9}$	$.576687 \times 10^{13}$	$.447613 \times 10^{12}$	$.621463 \times 10^{13}$
Cottidae	$.742099 \times 10^{7}$	$.108355 \times 10^{10}$	0.	$.109097 \times 10^{10}$
Pacific cod	$.667889 \times 10^{10}$	$.799801 \times 10^{11}$	0.	$.866590 \times 10^{11}$
Walleye pollock	$.250799 \times 10^{9}$	$.288982 \times 10^{13}$	$.358953 \times 10^{12}$	$.324903 \times 10^{13}$
Thornyhead	0.	$.173626 \times 10^{12}$	$.370737 \times 10^{12}$	$.544364 \times 10^{12}$
Pacific ocean perch	0.	$.265708 \times 10^{12}$	$.495777 \times 10^{13}$	$.522347 \times 10^{13}$
Tanner crab	$.514926 \times 10^{9}$	$.553613 \times 10^{13}$	$.133228 \times 10^{12}$	$.566988 \times 10^{13}$
Scallop	$.140540 \times 10^{13}$	$.116402 \times 10^{13}$	0.	$.256942 \times 10^{13}$

Table 20.--Varinaces of the biomass estimates for the Yakutat region for May-October 1962, Cr 629.

Species	Depth Zones (m)			Total
	0-100	101-200	201-400	
Elasmobranchs	$.599104 \times 10^{12}$	$.114166 \times 10^{13}$	$.468772 \times 10^{12}$	$.220953 \times 10^{13}$
Flatfish	$.125631 \times 10^{12}$	$.125631 \times 10^{14}$	$.515395 \times 10^{11}$	$.133939 \times 10^{14}$
Roundfish	$.142001 \times 10^{11}$	$.184630 \times 10^{13}$	$.161842 \times 10^{12}$	$.202234 \times 10^{13}$
Rockfish	$.394165 \times 10^{9}$	$.628028 \times 10^{13}$	$.234546 \times 10^{13}$	$.862614 \times 10^{13}$
Invertebrates	$.680391 \times 10^{11}$	$.151146 \times 10^{13}$	$.401375 \times 10^{12}$	$.198088 \times 10^{13}$
Skates	$.863282 \times 10^{12}$	$.994448 \times 10^{12}$	$.434645 \times 10^{12}$	$.229237 \times 10^{13}$
Turbot	$.134714 \times 10^{11}$	$.383561 \times 10^{13}$	$.221859 \times 10^{12}$	$.407094 \times 10^{13}$
Halibut	$.419986 \times 10^{12}$	$.560669 \times 10^{12}$	$.361453 \times 10^{12}$	$.638813 \times 10^{13}$
Flathead	$.798310 \times 10^{8}$	$.965004 \times 10^{11}$	$.452556 \times 10^{11}$	$.141833 \times 10^{12}$
Dover	0.	0.	$.172689 \times 10^{9}$	$.172689 \times 10^{9}$
Rex	$.536364 \times 10^{10}$	$.187235 \times 10^{11}$	$.180516 \times 10^{11}$	$.421388 \times 10^{11}$
Sablefish	0.	$.994434 \times 10^{9}$	0.	$.994434 \times 10^{9}$
Cottidae	$.162156 \times 10^{8}$	$.257740 \times 10^{11}$	0.	$.257902 \times 10^{11}$
Pacific cod	$.179619 \times 10^{11}$	$.139769 \times 10^{13}$	$.420777 \times 10^{11}$	$.145773 \times 10^{13}$
Walleye pollock	0.	$.805532 \times 10^{11}$	$.134960 \times 10^{12}$	$.215513 \times 10^{12}$
Thornyhead	$.611206 \times 10^{8}$	$.284509 \times 10^{13}$	$.328735 \times 10^{12}$	$.137389 \times 10^{13}$
Pacific ocean perch	$.210803 \times 10^{9}$	$.809638 \times 10^{11}$	$.269684 \times 10^{13}$	$.277801 \times 10^{13}$
Dungeness crab	$.916427 \times 10^{10}$	0.	0.	$.916427 \times 10^{10}$
Tanner crab	$.587512 \times 10^{9}$	$.245272 \times 10^{12}$	$.387470 \times 10^{12}$	$.633329 \times 10^{12}$
Scallop	$.779600 \times 10^{11}$	$.997811 \times 10^{10}$	$.137800 \times 10^{10}$	$.891160 \times 10^{11}$

Table 21.--Variances of the biomass estimates for the Prince William region for May-October 1962, Cr 629.

Species	Depth Zones (m) 0-100	101-200	201-400	Total
Elasmobranchs	$.116894 \times 10^{14}$	$.388744 \times 10^{12}$	$.111560 \times 10^{12}$	$.121897 \times 10^{14}$
Flatfish	$.658560 \times 10^{13}$	$.611509 \times 10^{13}$	$.350976 \times 10^{13}$	$.162104 \times 10^{14}$
Roundfish	$.132960 \times 10^{11}$	$.390956 \times 10^{12}$	$.807056 \times 10^{13}$	$.847481 \times 10^{13}$
Rockfish	$.597102 \times 10^{10}$	$.561879 \times 10^{12}$	$.244236 \times 10^{12}$	$.812086 \times 10^{12}$
Invertebrates	$.951309 \times 10^{13}$	$.154593 \times 10^{13}$	$.138168 \times 10^{12}$	$.111971 \times 10^{14}$
Skates	$.978347 \times 10^{13}$	$.293034 \times 10^{12}$	$.569374 \times 10^{11}$	$.101334 \times 10^{14}$
Turbot	$.243570 \times 10^{13}$	$.215814 \times 10^{13}$	$.178611 \times 10^{13}$	$.637997 \times 10^{13}$
Halibut	$.279191 \times 10^{12}$	$.728913 \times 10^{11}$	$.130335 \times 10^{11}$	$.365116 \times 10^{12}$
Flathead	$.222688 \times 10^{12}$	$.140691 \times 10^{13}$	$.120916 \times 10^{12}$	$.175051 \times 10^{13}$
Dover	$.128071 \times 10^{9}$	$.126897 \times 10^{10}$	$.204457 \times 10^{12}$	$.205854 \times 10^{12}$
Rex	$.805824 \times 10^{11}$	$.152045 \times 10^{11}$	$.151304 \times 10^{11}$	$.110917 \times 10^{12}$
Sablefish	$.119809 \times 10^{11}$	$.447797 \times 10^{10}$	$.968006 \times 10^{11}$	$.113259 \times 10^{12}$
Cottidae	$.619215 \times 10^{9}$	$.144026 \times 10^{11}$	$.736245 \times 10^{10}$	$.223843 \times 10^{11}$
Pacific cod	$.743950 \times 10^{10}$	$.236157 \times 10^{12}$	$.264498 \times 10^{11}$	$.246241 \times 10^{12}$
Walleye pollock	$.877246 \times 10^{9}$	$.110871 \times 10^{12}$	$.584023 \times 10^{13}$	$.595198 \times 10^{13}$
Thorynheads	0.	$.120420 \times 10^{10}$	$.158254 \times 10^{11}$	$.170296 \times 10^{11}$
Pacific ocean perch	$.597102 \times 10^{10}$	$.519510 \times 10^{12}$	$.110626 \times 10^{12}$	$.636108 \times 10^{12}$
Dungeness crab	$.676940 \times 10^{13}$	0.	0.	$.676940 \times 10^{13}$
Tanner crab	$.245773 \times 10^{13}$	$.155866 \times 10^{13}$	$.135517 \times 10^{12}$	$.415191 \times 10^{13}$
Scallop	$.639491 \times 10^{9}$	$.652066 \times 10^{11}$	0.	$.658461 \times 10^{11}$

Table 22.--Variances of the biomass estimates for the Fairweather region for April-October 1976, Cr 762.

Species	Depth Zones (m) 0-100	101-200	201-400	Total
Elasmobranchs				
Flatfishes	$.185809x10^{14}$	$.157430x10^{14}$	$.299974x10^{14}$	$.106521x10^{15}$
Roundfishes	$.145938x10^{12}$	$.105203x10^{13}$	$.391656x10^{12}$	$.158962x10^{13}$
Rockfishes	$.149777x10^{9}$	$.545059x10^{12}$	$.542085x10^{12}$	$.108729x10^{13}$
Invertebrates	$.146832x10^{13}$	$.347985x10^{15}$	$.272176x10^{11}$	$.349481x10^{15}$
Skates	$.676770x10^{11}$	$.197853x10^{13}$	$.140587x10^{12}$	$.218679x10^{13}$
Turbot	$.332172x10^{11}$	$.993813x10^{13}$	$.717802x10^{13}$	$.171493x10^{14}$
Halibut	$.102336x10^{12}$	$.246800x10^{12}$	0.	$.349137x10^{12}$
Flathead sole	$.199703x10^{9}$	$.260944x10^{14}$	$.177499x10^{14}$	$.438446x10^{14}$
Dover sole	$.599108x10^{7}$	$.817498x10^{9}$	$.428314x10^{12}$	$.429137x10^{12}$
Rex sole	$.393459x10^{10}$	$.983563x10^{12}$	$.446347x10^{12}$	$.143384x10^{13}$
Rock sole	$.576919x10^{9}$	$.104497x10^{10}$	0.	$.162189x10^{10}$
Sablefish	0.	$.104497x10^{10}$	$.743601x10^{9}$	$.178857x10^{10}$
Cottidae	0.	$.537842x10^{10}$	$.390855x10^{11}$	$.444639x10^{11}$
Pacific cod	$.128209x10^{12}$	$.211054x10^{12}$	0.	$.339263x10^{12}$
Walleye pollock	$.405619x10^{9}$	$.953059x10^{11}$	$.281306x10^{12}$	$.377017x10^{12}$
Smelt	$.416047x10^{9}$	$.576057x10^{12}$	$.562348x10^{10}$	$.582097x10^{12}$
Thornyhead	0.	$.128610x10^{12}$	$.582983x10^{12}$	$.711593x10^{12}$
Pacific ocean perch	0.	$.212599x10^{12}$	0.	$.212599x10^{12}$
Tanner crab	$.909757x10^{9}$	$.447624x10^{12}$	0.	$.448534x10^{12}$
King Crab	0.	$.307948x10^{11}$	0.	$.307948x10^{11}$
Scallop	$.156092x10^{13}$	$.340079x10^{9}$	0.	$.156126x10^{13}$

Table 23.--Variances of the biomass estimates for the Yakutat region for April-October 1975, Cr 751.

Species	Depth Zones (m)			Total
	0-100	101-200	201-400	
Elasmobranchs	$.561359 \times 10^{12}$	$.180138 \times 10^{12}$	$.172185 \times 10^{12}$	$.913684 \times 10^{12}$
Flatfishes	$.207721 \times 10^{15}$	$.398728 \times 10^{14}$	$.328370 \times 10^{14}$	$.280430 \times 10^{15}$
Roundfishes	$.486011 \times 10^{13}$	$.339674 \times 10^{13}$	$.946315 \times 10^{12}$	$.920318 \times 10^{13}$
Rockfishes	$.201795 \times 10^{8}$	$.263311 \times 10^{12}$	$.365432 \times 10^{12}$	$.628764 \times 10^{12}$
Invertebrates	$.989152 \times 10^{12}$	$.120873 \times 10^{13}$	$.105632 \times 10^{14}$	$.127611 \times 10^{14}$
Skates	0.	0.	0.	0.
Turbot	$.10257 \times 10^{13}$	$.205291 \times 10^{14}$	$.870712 \times 10^{13}$	$.302619 \times 10^{14}$
Halibut	$.321934 \times 10^{12}$	$.294272 \times 10^{12}$	$.203578 \times 10^{9}$	$.616410 \times 10^{12}$
Flathead sole	$.288359 \times 10^{12}$	$.407353 \times 10^{13}$	$.372564 \times 10^{9}$	$.436226 \times 10^{13}$
Dover sole	$.112132 \times 10^{10}$	$.970744 \times 10^{10}$	$.825569 \times 10^{13}$	$.826652 \times 10^{13}$
Rex sole	$.141153 \times 10^{12}$	$.683446 \times 10^{11}$	$.171484 \times 10^{13}$	$.192434 \times 10^{13}$
Rock sole	$.883190 \times 10^{10}$	0.	0.	$.883190 \times 10^{10}$
Sablefish	$.339286 \times 10^{9}$	$.342228 \times 10^{10}$	$.103675 \times 10^{13}$	$.104051 \times 10^{13}$
Cottidae	$.958701 \times 10^{8}$	$.288144 \times 10^{10}$	$.919050 \times 10^{10}$	$.121678 \times 10^{11}$
Pacific cod	$.106054 \times 10^{13}$	$.114916 \times 10^{13}$	$.126322 \times 10^{10}$	$.221097 \times 10^{13}$
Walleye pollock	$.583911 \times 10^{13}$	$.127594 \times 10^{13}$	$.939732 \times 10^{9}$	$.711600 \times 10^{13}$
Smelt	$.448236 \times 10^{9}$	$.118766 \times 10^{11}$	$.445247 \times 10^{9}$	$.127701 \times 10^{11}$
Thornyhead	$.151115 \times 10^{7}$	$.568935 \times 10^{11}$	$.338163 \times 10^{12}$	$.395059 \times 10^{12}$
Pacific ocean perch	$.192748 \times 10^{8}$	$.451822 \times 10^{11}$	$.537817 \times 10^{11}$	$.989833 \times 10^{11}$
Tanner crab	$.376603 \times 10^{12}$	$.260483 \times 10^{11}$	$.592752 \times 10^{10}$	$.408579 \times 10^{12}$
King crab	0.	0.	0.	0.
Scallop	$.104483 \times 10^{12}$	$.728068 \times 10^{11}$	$.168246 \times 10^{7}$	$.177292 \times 10^{12}$

Table 24.--Variances of the biomass estimates for the Prince William region for April-October 1975, Cr 751.

Species	Depth Zones (m) 0-100	101-200	201-400	Total
Elasmobranchs	$.257134 \times 10^{13}$	$.147940 \times 10^{12}$	$.442941 \times 10^{11}$	$.276357 \times 10^{13}$
Flatfishes	$.598772 \times 10^{13}$	$.322910 \times 10^{13}$	$.241521 \times 10^{13}$	$.116320 \times 10^{14}$
Roundfishes	$.126374 \times 10^{14}$	$.341623 \times 10^{14}$	$.300159 \times 10^{13}$	$.488013 \times 10^{14}$
Rockfishes	$.870550 \times 10^{11}$	$.857077 \times 10^{12}$	$.481841 \times 10^{12}$	$.142597 \times 10^{13}$
Invertebrates	$.216665 \times 10^{14}$	$.623150 \times 10^{13}$	$.616628 \times 10^{13}$	$.340643 \times 10^{14}$
Skates	$.257246 \times 10^{13}$	$.144033 \times 10^{12}$	$.421121 \times 10^{11}$	$.275860 \times 10^{13}$
Turbot	$.154851 \times 10^{13}$	$.128420 \times 10^{13}$	$.237860 \times 10^{12}$	$.307057 \times 10^{13}$
Halibut	$.290441 \times 10^{12}$	$.144620 \times 10^{12}$	0.	$.435061 \times 10^{12}$
Flathead sole	$.107711 \times 10^{13}$	$.464005 \times 10^{13}$	$.330475 \times 10^{13}$	$.484587 \times 10^{13}$
Dover sole	$.744365 \times 10^{10}$	$.139773 \times 10^{12}$	$.533023 \times 10^{12}$	$.680241 \times 10^{12}$
Rex sole	$.522793 \times 10^{11}$	$.950094 \times 10^{11}$	$.284215 \times 10^{12}$	$.431504 \times 10^{12}$
Rock sole	$.389153 \times 10^{11}$	$.256887 \times 10^{8}$	0.	$.389410 \times 10^{11}$
Sablefish	$.541492 \times 10^{10}$	$.464443 \times 10^{10}$	$.700793 \times 10^{11}$	$.801387 \times 10^{11}$
Cottidae	$.222495 \times 10^{11}$	$.571009 \times 10^{10}$	$.355506 \times 10^{11}$	$.635102 \times 10^{11}$
Pacific cod	$.275425 \times 10^{12}$	$.495514 \times 10^{12}$	$.147043 \times 10^{12}$	$.917983 \times 10^{12}$
Walleye pollock	$.115916 \times 10^{14}$	$.320574 \times 10^{14}$	$.254875 \times 10^{13}$	$.461979 \times 10^{14}$
Smelt	$.212185 \times 10^{11}$	$.585966 \times 10^{9}$	$.238715 \times 10^{12}$	$.260519 \times 10^{12}$
Thornyhead	$.868187 \times 10^{11}$	$.597248 \times 10^{11}$	$.386586 \times 10^{12}$	$.533130 \times 10^{12}$
Pacific ocean perch	0.	$.748742 \times 10^{12}$	$.201250 \times 10^{12}$	$.750755 \times 10^{12}$
Tanner crab	$.856260 \times 10^{13}$	$.561713 \times 10^{13}$	$.653283 \times 10^{13}$	$.207125 \times 10^{14}$
Scallop	$.289677 \times 10^{11}$	$.276885 \times 10^{9}$	$.164062 \times 10^{8}$	$.292610 \times 10^{10}$

Table 25.--Variances of the biomass estimates for the Kenai region for April - October, 1976 Cruise 762.

Species	Depth Zones (m)			Total
	0-100	101-200	201-400	
Elasmobranchs	0.	$.950106 \times 10^{10}$	$.149052 \times 10^{11}$	$.244063 \times 10^{11}$
Flatfishes	0.	$.273772 \times 10^{15}$	$.100768 \times 10^{14}$	$.283849 \times 10^{15}$
Roundfishes	0.	$.311069 \times 10^{15}$	$.155790 \times 10^{14}$	$.326648 \times 10^{15}$
Rockfishes	0.	$.847467 \times 10^{12}$	$.320720 \times 10^{11}$	$.879539 \times 10^{12}$
Invertebrates	0.	$.568068 \times 10^{14}$	$.162612 \times 10^{13}$	$.584329 \times 10^{14}$
Skates	0.	$.940983 \times 10^{10}$	$.140255 \times 10^{11}$	$.234353 \times 10^{11}$
Turbot	0.	$.928049 \times 10^{14}$	$.374973 \times 10^{13}$	$.965547 \times 10^{14}$
Halibut	0.	$.144763 \times 10^{13}$	$.181551 \times 10^{13}$	$.326314 \times 10^{13}$
Flathead sole	0.	$.150026 \times 10^{14}$	$.126628 \times 10^{13}$	$.162725 \times 10^{14}$
Dover sole	0.	$.212255 \times 10^{14}$	$.633208 \times 10^{11}$	$.212888 \times 10^{14}$
Rex sole	0.	$.104686 \times 10^{13}$	$.492619 \times 10^{11}$	$.109613 \times 10^{13}$
Rock sole	0.	$.310661 \times 10^{9}$	0.	$.310661 \times 10^{9}$
Sablefish	0.	$.102906 \times 10^{12}$	$.183488 \times 10^{12}$	$.286394 \times 10^{12}$
Cottidae	0.	$.234735 \times 10^{12}$	$.332087 \times 10^{10}$	$.238056 \times 10^{12}$
Pacific cod	0.	$.266\ 41 \times 10^{13}$	$.150675 \times 10^{13}$	$.417116 \times 10^{13}$
Walleye pollock	0.	$.282708 \times 10^{15}$	$.822004 \times 10^{13}$	$.290928 \times 10^{15}$
Smelt	0.	$.333247 \times 10^{11}$	$.556254 \times 10^{9}$	$.338809 \times 10^{11}$
Thornyhead	0.	$.192434 \times 10^{11}$	$.357948 \times 10^{11}$	$.550382 \times 10^{11}$
Pacific ocean perch	0.	$.178902 \times 10^{12}$	0.	$.178902 \times 10^{12}$
Tanner crab	0.	$.463897 \times 10^{12}$	$.807488 \times 10^{11}$	$.544645 \times 10^{12}$
King crab	0.	$.180890 \times 10^{13}$	$.137376 \times 10^{13}$	$.318267 \times 10^{13}$

Table 26.--Variances of the biomass estimates for the Kodiak region for April-October 1973, Cr 734.

Species	Depth Zones (m) 0-100	101-200	201-400	Total
Elasmobranchs	0.	$.135880 \times 10^{11}$	$.34140 \times 10^{8}$	$.136222 \times 10^{11}$
Flatfishes	$.208195 \times 10^{15}$	$.860323 \times 10^{14}$	$.491708 \times 10^{14}$	$.343398 \times 10^{15}$
Roundfishes	$.107199 \times 10^{16}$	$.168042 \times 10^{16}$	$.231432 \times 10^{15}$	$.298384 \times 10^{16}$
Rockfishes	$.468853 \times 10^{9}$	$.361801 \times 10^{11}$	$.111764 \times 10^{14}$	$.112130 \times 10^{14}$
Invertebrates	$.290709 \times 10^{15}$	$.194703 \times 10^{15}$	$.956232 \times 10^{13}$	$.494974 \times 10^{15}$
Skates	0.	$.135880 \times 10^{11}$	$.341401 \times 10^{8}$	$.136222 \times 10^{11}$
Turbot	$.250352 \times 10^{12}$	$.358737 \times 10^{13}$	$.381263 \times 10^{13}$	$.765036 \times 10^{13}$
Halibut	$.643642 \times 10^{13}$	$.173811 \times 10^{12}$	$.425940 \times 10^{11}$	$.665282 \times 10^{13}$
Flathead sole	$.194864 \times 10^{13}$	$.179000 \times 10^{14}$	$.182089 \times 10^{13}$	$.216696 \times 10^{14}$
Dover sole	$.468853 \times 10^{7}$	$.573317 \times 10^{13}$	$.372869 \times 10^{14}$	$.430201 \times 10^{14}$
Rex sole	$.382584 \times 10^{11}$	$.171761 \times 10^{14}$	$.137376 \times 10^{14}$	$.154935 \times 10^{14}$
Rock sole	$.189442 \times 10^{15}$	$.362160 \times 10^{13}$	$.729535 \times 10^{13}$	$.200359 \times 10^{15}$
Sablefish	0.	$.166551 \times 10^{12}$	$.354764 \times 10^{12}$	$.521315 \times 10^{12}$
Cottidae	$.422254 \times 10^{14}$	$.212313 \times 10^{13}$	$.152126 \times 10^{12}$	$.445006 \times 10^{14}$
Pacific cod	$.523537 \times 10^{15}$	$.435510 \times 10^{14}$	$.572535 \times 10^{11}$	$.567145 \times 10^{15}$
Walleye pollock	$.456427 \times 10^{14}$	$.144797 \times 10^{16}$	$.244770 \times 10^{15}$	$.173838 \times 10^{16}$
Smelt	0.	$.578708 \times 10^{8}$	0.	$.578708 \times 10^{8}$
Thornyhead	0.	0.	$.342208 \times 10^{12}$	$.342208 \times 10^{12}$
Pacific ocean perch	$.468853 \times 10^{9}$	$.369752 \times 10^{11}$	$.130730 \times 10^{12}$	$.168174 \times 10^{12}$
Tanner crab	$.977559 \times 10^{12}$	$.186201 \times 10^{14}$	$.848482 \times 10^{13}$	$.280825 \times 10^{14}$
King crab	$.823540 \times 10^{13}$	$.122720 \times 10^{15}$	$.665433 \times 10^{11}$	$.131022 \times 10^{15}$
Scallop	$.144461 \times 10^{13}$	0.	0.	$.144461 \times 10^{13}$

Table 27.--Variances of the biomass estimates for the Shelikof region for April-October 1973, Cr 733.

Species	Depth Zones (m)			Total
	0-100	101-200	201-400	
Elasmobranchs	$.614624 \times 10^{8}$	$.423051 \times 10^{9}$	$.408186 \times 10^{11}$	$.413031 \times 10^{11}$
Flatfishes	$.546531 \times 10^{11}$	$.478030 \times 10^{13}$	$.475071 \times 10^{13}$	$.958567 \times 10^{13}$
Roundfishes	$.211419 \times 10^{11}$	$.165747 \times 10^{14}$	$.844474 \times 10^{13}$	$.250406 \times 10^{14}$
Rockfishes	0.	$.121944 \times 10^{10}$	$.656991 \times 10^{10}$	$.778936 \times 10^{10}$
Invertebrates	$.914371 \times 10^{11}$	$.248319 \times 10^{13}$	$.212474 \times 10^{14}$	$.238220 \times 10^{14}$
Skates	0.	$.423051 \times 10^{9}$	$.408186 \times 10^{11}$	$.412416 \times 10^{11}$
Turbot	$.345726 \times 10^{6}$	$.337415 \times 10^{11}$	$.131337 \times 10^{12}$	$.165078 \times 10^{12}$
Halibut	$.266478 \times 10^{11}$	$.539432 \times 10^{12}$	$.230154 \times 10^{13}$	$.286762 \times 10^{13}$
Flathead sole	$.153656 \times 10^{8}$	$.369163 \times 10^{13}$	$.339840 \times 10^{13}$	$.709005 \times 10^{13}$
Dover sole	0.	$.296136 \times 10^{8}$	$.191014 \times 10^{11}$	$.191310 \times 10^{11}$
Rex sole	0.	$.281752 \times 10^{8}$	$.456244 \times 10^{8}$	$.737996 \times 10^{8}$
Rock sole	$.499382 \times 10^{8}$	$.423051 \times 10^{7}$	$.712958 \times 10^{9}$	$.767126 \times 10^{9}$
Sablefish	-	-	-	-
Cottidae	$.349567 \times 10^{9}$	$.537339 \times 10^{11}$	$.644934 \times 10^{11}$	$.118576 \times 10^{12}$
Pacific cod	$.960351 \times 10^{6}$	$.253707 \times 10^{12}$	$.619945 \times 10^{12}$	$.873653 \times 10^{12}$
Walleye pollock	$.297593 \times 10^{11}$	$.179953 \times 10^{14}$	$.441407 \times 10^{13}$	$.224391 \times 10^{14}$
Smelt	$.147957 \times 10^{11}$	$.170079 \times 10^{10}$	$.238037 \times 10^{10}$	$.188768 \times 10^{11}$
Thornyhead	-	-	-	-
Pacific ocean perch	0.	$.337383 \times 10^{9}$	$.656991 \times 10^{10}$	$.690730 \times 10^{10}$
Tanner crab	$.743351 \times 10^{11}$	$.234810 \times 10^{12}$	$.131613 \times 10^{14}$	$.134705 \times 10^{14}$
King crab	$.256901 \times 10^{12}$	$.700573 \times 10^{10}$	0.	$.263907 \times 10^{12}$

Table 28.--Variances of the biomass estimates for the Chirikof region for April-October 1975, Cr 753.

Species	Depth Zones (m) 0-100	101-200	201-400	Total
Elasmobranchs	0.	$.633658\times10^{11}$	$.279793\times10^{12}$	$.343159\times10^{12}$
Flatfishes	$.636401\times10^{13}$	$.967328\times10^{13}$	$.276740\times10^{14}$	$.437113\times10^{14}$
Roundfishes	$.224924\times10^{14}$	$.100949\times10^{17}$	$.110185\times10^{14}$	$.101284\times10^{17}$
Rockfishes	$.165263\times10^{8}$	$.303525\times10^{13}$	$.172313\times10^{11}$	$.305249\times10^{13}$
Invertebrates	$.266577\times10^{14}$	$.356429\times10^{13}$	$.191469\times10^{13}$	$.321377\times10^{14}$
Skates	0.	$.633658\times10^{11}$	$.279793\times10^{12}$	$.343159\times10^{12}$
Turbot	$.225781\times10^{12}$	$.287602\times10^{13}$	$.152952\times10^{14}$	$.183970\times10^{14}$
Halibut	$.232164\times10^{13}$	$.490772\times10^{10}$	$.254544\times10^{13}$	$.487199\times10^{13}$
Flathead sole	$.181231\times10^{13}$	$.210940\times10^{13}$	$.204643\times10^{13}$	$.596814\times10^{13}$
Dover sole	$.734505\times10^{9}$	$.170885\times10^{11}$	$.180971\times10^{12}$	$.198794\times10^{12}$
Rex sole	$.712863\times10^{10}$	$.136831\times10^{12}$	$.129051\times10^{12}$	$.273010\times10^{12}$
Rock sole	$.624014\times10^{12}$	$.887214\times10^{12}$	$.222144\times10^{9}$	$.151145\times10^{13}$
Sablefish	$.734505\times10^{9}$	$.574080\times10^{9}$	$.763269\times10^{11}$	$.776355\times10^{11}$
Cottidae	$.927338\times10^{12}$	$.998009\times10^{12}$	$.302735\times10^{11}$	$.195562\times10^{13}$
Pacific cod	$.555862\times10^{11}$	$.132034\times10^{13}$	$.516274\times10^{13}$	$.653867\times10^{13}$
Walleye pollock	$.194309\times10^{14}$	$.116507\times10^{17}$	$.793793\times10^{12}$	$.116710\times10^{17}$
Smelt	0.	$.103167\times10^{9}$	$.921251\times10^{9}$	$.102441\times10^{10}$
Thornyhead	0.	0.	$.409357\times10^{8}$	$.409357\times10^{8}$
Pacific ocean perch	0.	$.335215\times10^{13}$	$.459390\times10^{9}$	$.335261\times10^{13}$
Tanner crab	$.483514\times10^{12}$	$.147442\times10^{13}$	$.609987\times10^{11}$	$.201893\times10^{13}$
King crab	$.182125\times10^{14}$	$.300593\times10^{12}$	$.785193\times10^{11}$	$.185916\times10^{14}$
Scallop	$.459066\times10^{8}$	0.	0.	$.459066\times10^{8}$

Table 29.--Variances of the biomass estimates for the Sanak region for April-October 1974, Cr 744.

Species	Depth Zones (m)			Total
	0-100	101-200	201-400	
Elasmobranchs	0.	$.211434\times10^{13}$	$.108611\times10^{11}$	$.212520\times10^{13}$
Flatfishes	$.183311\times10^{15}$	$.669666\times10^{14}$	$.108633\times10^{14}$	$.261141\times10^{15}$
Roundfishes	$.449676\times10^{15}$	$.827767\times10^{16}$	$.171556\times10^{14}$	$.874450\times10^{16}$
Rockfishes	0.	0.	$.106859\times10^{13}$	$.106859\times10^{13}$
Invertebrates	$.269603\times10^{14}$	$.150797\times10^{14}$	$.109866\times10^{14}$	$.530268\times10^{14}$
Skates	0.	$.211434\times10^{13}$	$.108611\times10^{11}$	$.212520\times10^{13}$
Turbot	$.195209\times10^{14}$	$.233838\times10^{14}$	$.115626\times10^{14}$	$.544674\times10^{14}$
Halibut	$.599668\times10^{12}$	$.289815\times10^{12}$	$.356968\times10^{9}$	$.889840\times10^{12}$
Flathead sole	$.509291\times10^{12}$	$.297302\times10^{14}$	$.413776\times10^{11}$	$.302809\times10^{14}$
Dover sole	0.	$.147159\times10^{12}$	$.110541\times10^{12}$	$.257700\times10^{12}$
Rex sole	$.386653\times10^{11}$	$.320905\times10^{14}$	$.750892\times10^{11}$	$.322043\times10^{14}$
Rock sole	$.120489\times10^{15}$	$.198191\times10^{14}$	$.356968\times10^{7}$	$.140308\times10^{15}$
Sablefish	0.	$.279819\times10^{10}$	$.520239\times10^{11}$	$.548221\times10^{11}$
Cottidae	$.171498\times10^{14}$	$.279836\times10^{13}$	$.514035\times10^{8}$	$.199482\times10^{14}$
Pacific cod	$.151804\times10^{15}$	$.273378\times10^{14}$	$.539772\times10^{11}$	$.179195\times10^{15}$
Walleye pollock	$.499554\times10^{15}$	$.855920\times10^{16}$	$.165474\times10^{14}$	$.907530\times10^{16}$
Smelt	$.415118\times10^{7}$	$.168660\times10^{12}$	0.	$.168664\times10^{12}$
Thornyhead	0.	0.	$.353421\times10^{12}$	$.353421\times10^{12}$
Pacific ocean perch	0.	0.	$.273706\times10^{12}$	$.273706\times10^{12}$
Tanner crab	$.580597\times10^{13}$	$.314039\times10^{13}$	0.	$.894636\times10^{13}$
King crab	$.116574\times10^{14}$	$.815599\times10^{13}$	0.	$.198134\times10^{14}$
Scallop	0.	$.188318\times10^{11}$	0.	$.188318\times10^{11}$

FINAL REPORT

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Beaufort Sea Estuarine Fishery Study

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31 October 1977

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Beaufort Sea Estuarine Fisheries Study

This report presents data collected between 1975 and 1977. The report is divided into three parts. Part one covers field work conducted during 1975 and 1976 on the major objectives of this study. The second part is a supplemental report for 1977 presenting additional data on the timing and movements of anadromous fish near Prudhoe Bay. Part three lists overall conclusions of the three year study. Michael R. Doxey, Alaska Department of Fish and Game, authored the 1977 segment of this report.

SUMMARY

Fisheries surveys were conducted along 102 miles (163 km) of Beaufort Sea coastline between the Colville and Canning rivers over a two year period beginning in 1975. An attempt was made to sample all of the principal habitats within this study area. A total of 28,369 fish representing seven familes and 15 species was captured. During the open water season freshwater and anadromous species dominated the near shore fish fauna and accounted for 52% of the entire catch. Arctic char, *Salvelinus alpinus*, Arctic cisco, *Coregonus autumnalis*, and least cisco, *C. sardinella*, were the most widespread and abundant anadromous fishes. The two most abundant marine species are fourhorn sculpin, *Myoxocephalus quadricornis* and Arctic cod, *Boreogadus saida*.

During 1976, 4,962 anadromous fish were tagged with Floy FD-67 anchor tags. Eight percent (384) were recaptured within the study area and in the Colville River. Anadromous fish enter the Beaufort Sea at breakup and forage for variable distances along the coastline. Adults reenter freshwater systems to spawn and overwinter earlier than juveniles and nonspawning members of the same species. The movements of juvenile fish along the coastline are restricted to less saline, protected waters of major river deltas and lagoons. Anadromous whitefish and char spawn during the fall in a variety of river habitats ranging from perennial groundwater springs in headwater tributaries to isolated pockets of under-ice water in river deltas. Overwintering habitat has not been identified in the fast ice zone of the Beaufort Sea. Tag recoveries indicate that the Colville River is the major spawning and overwintering drainage for whitefish captured within the study area. The destruction or disturbance of overwintering and spawning habitat appears to present the greatest threat to survival of near shore anadromous fish populations along the Beaufort Sea.

In the final segment of the three year study in 1977 emphasis was placed on further defining migration patterns and timing of anadromous fishes in Prudhoe Bay.

During the period from mid-July to mid-August 5,160 fish of eleven species were captured with fyke nets. A total of 2,324 anadromous fish were captured and 941 were tagged.

Movement patterns were similar to those noted in 1976, but numbers captured were down considerably from the 6,354 anadromous fish captured during the same period in 1976 with approximately the same effort.

Much higher salinities in the bay ($\bar{x}$ of 17.0 ppt) in 1977 than those recorded in 1976 ($\bar{x}$ of 7.5 ppt) were given as a probable cause for the decrease in fish numbers and it was suggested that many fish may have remained in less saline environments, e.g. river mouths during the study period. Tag returns for the least cisco, *Coregonus sardinella*, indicated a strong schooling behavior.

INTRODUCTION

Petroleum exploration and development is rapidly increasing throughout the near shore areas of the Beaufort Sea. The demands by industry for construction material, gravel sources, fresh water and transportation avenues are substantial. Alterations of the physical environment resulting from water and gravel removal or the construction of roads, pads and causeways are imminent. Information on the biology of fish inhabiting these waters is necessary prior to evaluating the ultimate effects these activities have on the resource.

The objectives of this study are to determine the distribution and relative abundance of the various species of fish inhabiting the near shore environs of the Beaufort Sea. By correlating important life history data with the knowledge of habitat needs, we hope to obtain base line information that can be used to direct the activities of people and industry in the proposed lease area. Specifically, the objectives of the study are:

1. To determine the seasonal distribution, relative abundance, size and species composition, growth rates, feeding habits and reproductive capabilities of Beaufort Sea near shore fishes in the area from the Colville to the Canning rivers and between shore and the barrier islands, including river deltas.

2. To determine migration patterns and timing of these fishes.

3. To identify critical habitats including spawning, overwintering, feeding, rearing and migration areas.

4. To determine the interrelationship of Arctic fishes to lower food-web organisms.

5. To determine the present rate of exploitation of the anadromous fishes of the area and to monitor changes in this usage as development of the area's petroleum resource progresses.

CURRENT STATE OF KNOWLEDGE

Prior to the accelerated interest and development in the Arctic by major oil companies, there have been few investigations of the fishes in the Beaufort Sea. The Alaska Department of Fish and Game (Roguski and Komarek, 1971) initiated a study to assess the environmental characteristics and fish species in coastal waters of the Arctic National Wildlife Range. The following year, a four year investigation of the waters draining into Prudhoe Bay was initiated (Yoshihara, 1972, 1973 and Furniss 1974, 1975). These investigations emphasized the life histories and distributions of anadromous species with special emphasis on Arctic char. Other fisheries studies on North Slope drainages were conducted by McCart, Craig and Bain (1972) and Johnson (1973). With the advent of designing and proposing utility corridors to transport natural gas south from the Arctic, several more investigations were initiated, many of which stressed the life history and biology of fish in their freshwater habitats of North Slope drainages. More recently, fisheries investigations have been centered along the northern coastlines of Alaska and Canada. Furniss (1975) investigated the age, growth, fecundity, species composition and distribution of fishes in Prudhoe Bay. Doxey (1977) conducted a study under contract to the Atlantic Richfield Company to determine the effects of a newly completed Prudhoe Bay causeway on fish movements and timing. Griffiths and Craig et al. (1975) conducted a site specific study of the fishes in the Nunaluk Lagoon, along the Arctic coast of the Yukon Territory. Griffiths et al. (1976) conducted a similar study at Barter Island, and other investigators have conducted studies aimed at evaluating the importance of the Mackenzie (Percy, Eddy and Munro, 1974) and Colville (Kogl and Schell, 1975) river deltas to Arctic Ocean fish. Studies of overwintering fish in the Arctic have been directed towards the larger bodies of fresh water, including river deltas (Mann, 1975; Kogl and Schell, 1975) and spring areas or unfrozen pockets of river water under thick ice (Craig and McCart, 1974; Alt and Furniss, 1976). These studies have led to a much greater understanding of the habitat requirements and life histories of Arctic fishes; however, much remains to be understood of these fishes during their seasonal occupation of the shallow near shore environments along the Beaufort Sea coast.

STUDY AREA

The OCS Beaufort Sea studies encompass an area between the eastern margin of Harrison Bay and Flaxman Island, a linear distance of approximately 102 miles (163 km) (Fig. 1). Centrally located along this stretch of coastline is Prudhoe Bay, the development and staging area for North Slope oil fields and the beginning of the Trans-Alaska oil pipeline. A barrier island system consisting of raised pebble reefs extends intermittently along the entire length of the study area. These islands, lying from 1/2 to 12 miles (1-16 km) offshore, tend to prevent large quantities of fresh water and nutrients entering the Beaufort Sea from readily mixing with the cooler, more saline waters of the Arctic Ocean. They also shelter the mainland coastline from pack ice during the summer months, thus providing a low salinity, relatively ice-free lagoon system inhabited by several species of anadromous, freshwater or marine fish throughout much of the year. Physical features of the mainland coastline include river deltas, spits, shallow bays, and narrow pebble or fine sediment beaches. Direct wave action and thermal erosion of permanently frozen shore banks produce local beaches composed of humus and decayed vegetation. Sharp variations in water temperatures and salinities were noted, both between short distances and with time, during the open water season (Fig. 2). Physiographic and environmental characteristics of the Beaufort Sea and coast are described by Namtvedt, et al. (1974) and State of Alaska, Division of Policy Development and Planning (1975).

Figure 1. Map of Alaska showing North Slope Study Area.

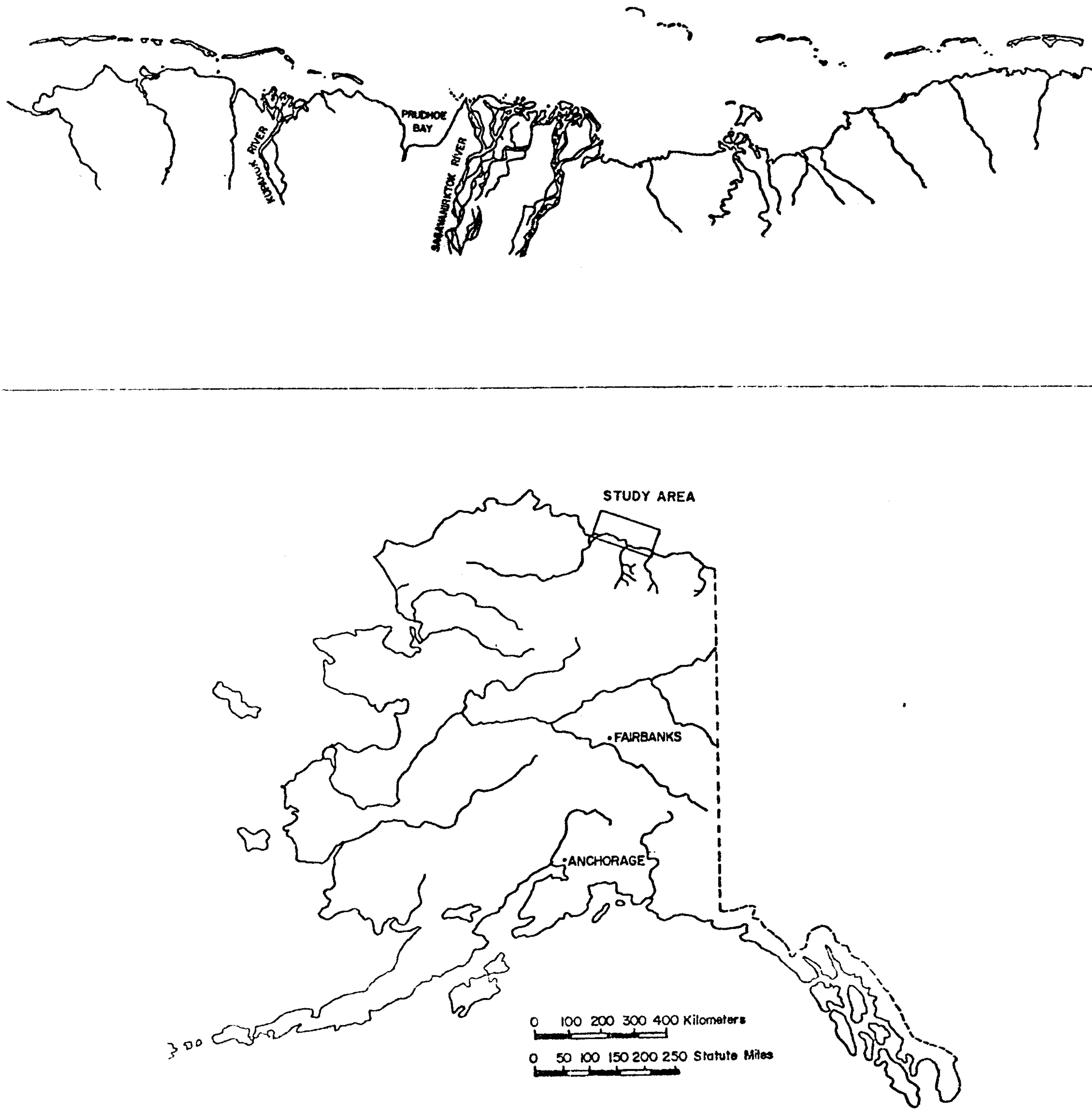
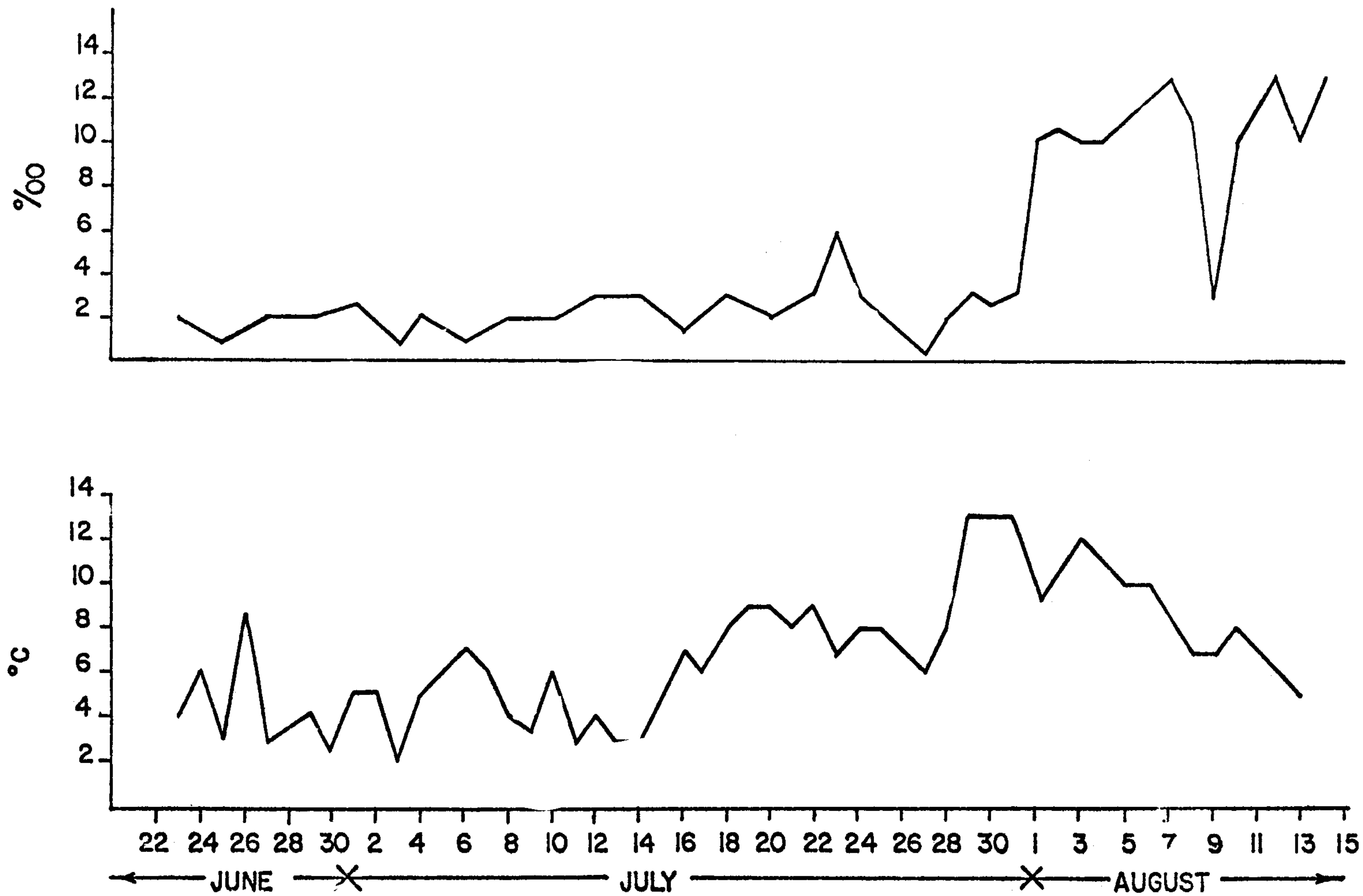


Figure 2. Seasonal variation in salinity and temperature at Prudhoe Bay, 1976.



SOURCES, METHODS AND RATIONALE OF DATA COLLECTION

Methods of Capture and Observations

Multifilament graduated mesh sinking gill nets measuring 125' x 6' and consisting of five 25' panels of 1/2' through 2 1/2" mesh were used for capturing and sampling fish. Multifilament gill nets measuring 25' x 3' and consisting of single mesh sized from 1/2" to 1 1/2" were used for capturing fish during under-ice surveys.

Beach seines measuring 100' x 4' were used to sample fish in confined locations within small bays and lagoons, and along exposed beaches where water was sufficiently shallow to allow the seaward end of the seine to be maneuvered on foot.

Fyke traps were operated at several locations within Prudhoe Bay. Traps were 20' in length overall and were supported by five "D" shaped, 3/4" aluminum tube frames. Two throats measuring 10" in diameter were located at the first and third frames. Netting was 1/2" square mesh knotless nylon. The fyke traps were anchored in approximately 4' of water and were attached to shore by 50', 100' or 150' center leads. Two 25' x 4' wings funneled fish into the trap.

A try trawl measuring 12' in width and constructed with 3/4" square measure knotted nylon mesh was used to sample fish offshore.

Hook and line sampling was employed to capture fish in river deltas and under the ice.

An underwater closed circuit television system was used under the ice in the Sagavanirktok and Kuparuk river deltas to detect and observe over-wintering fish occupying isolated pockets of unfrozen water. The system is sold by Hydro Products, Box 2528, San Diego, California. Its operation employed the use of the following five components:

- Underwater television camera with 12.5 mm optics
- High resolution 9" monitor
- Gas discharge lamp ballast
- 250 watt Thallium iodide lamp
- Portable 115 V power source

A Yellow Springs Instrument Co. salinity meter was used to determine water temperature, salinity and conductivity. Wind force and direction, current force and direction, sea state, cloud amount, present weather and air temperature were observed and recorded daily throughout most 1976 open water season.

Anadromous fish over 200 mm in fork length that were not sampled were tagged with numbered Floy FD-67 internal anchor tags. All other fish, including those below the "minimum" tagging size that were not sampled, were noted on daily catch forms and released.

A 21' Boston whaler and a 12' Zodiac inflatable boat were used for trawling and setting nets offshore near Prudhoe Bay.

Rotary wing aircraft were used for transporting field personnel and gear for monitoring movements of fish along the coastline and into river deltas.

Processing of Fish

Fish samples were preserved in 10% Formalin or frozen and sent to Fairbanks via commercial airlines for further laboratory analysis. All samples were grouped by date and location. Fish were weighed to the nearest gram on a triple-beam balance. Fork lengths were measured to the nearest millimeter. Sex and stage of maturity were determined by examining gonads.

Fecundity counts were determined by displacing a volume of water with a known quantity of eggs. The total number of eggs was then calculated using the quantity of water displaced by the entire ova mass.

Arctic char, cod, flounder, sculpins and liparids were aged by reading otoliths wetted in zylene under a binocular dissecting scope. Scales were used to age all other species. Scales used for age determination were cleaned and impressed on 20 mil acetate sheets. A Bruning 200 microprojector was used to read the scales. Lengths at the end of each year of life for several species were back calculated using the direct proportion formula.

Selected fish stomachs were slit and preserved in 10% Formalin. The gut contents were later examined, sorted and identified.

Data Management

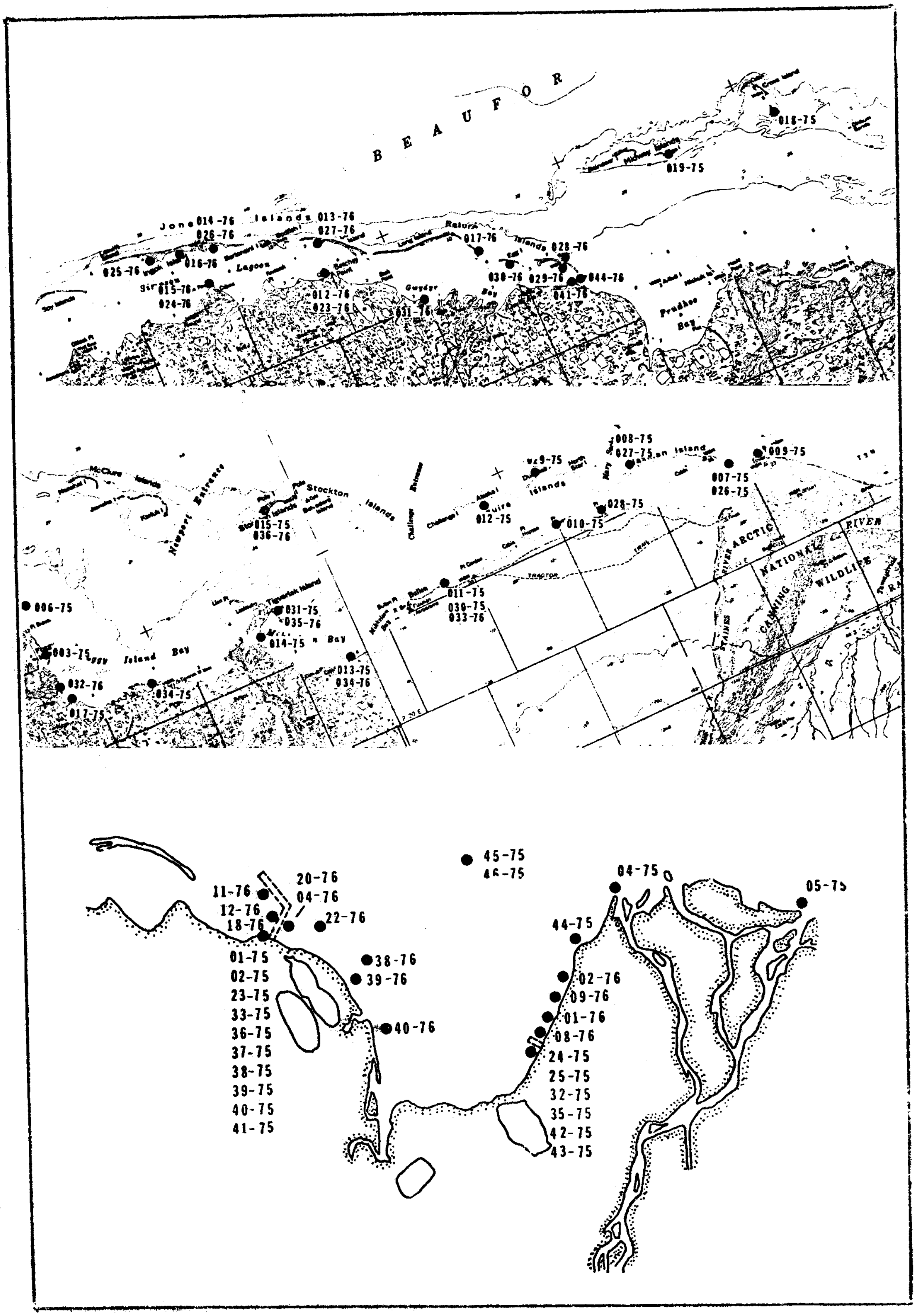
Raw data collected for this study have been prepared within the design of the OCSEAP data management format and stored on magnetic tape. Voucher specimens of the fish, invertebrates and food items collected during this study are in storage at the Fairbanks office of the Department of Fish and Game.

FINDINGS - 1975 to 1976

Species Composition and Relative Abundance

Seventy-six sampling sites were established between the eastern margins of Harrison Bay (70°33' N, 149°38' W) and Brownlow Point (70°10' N, 145°53' W) (Fig. 3). An attempt was made to sample all of the dominant habitat types within this area. These include outer islands, near shore islands, spits, points, bays, lagoons and river deltas. Salinity, water and air temperature, conductivity and depth of water were recorded at each station. During the summer of 1976 the following additional parameters were recorded at each site: bottom type, present weather,

Figure 3. Seventy-six sampling sites established between the eastern margins of Harrison Bay and Brownlow Point.



cloud amount, sea state, wind direction, wind force, current direction and current force. These additional parameters were observed rather than measured and were recorded as prescribed by the fish resource assessment format designed and provided by OCS.

A total of 28,369 fish representing seven families and 15 species has been captured. Fish species captured between Harrison Bay and Brownlow Point are listed in Table 1.

During 1975, graduated mesh gill nets were the most extensively used method of capture; however it became obvious late in the season that the use of gill nets was not conducive to the capture of gadids, liparids and the early life stages of salmonids. Fyke traps were subsequently stationed at several locations in Prudhoe Bay and proved more effective at catching the above mentioned fishes. During 1976, an attempt was made to maintain several fyke trap stations throughout the open water season in Prudhoe Bay while graduated mesh gill nets were used for 24 hour sets at more remote stations requiring helicopter transportation. Fyke traps also proved to be the least harmful method of capturing fish for tagging studies.

Beach seines effectively captured fish in shallow waters; however, adverse weather conditions and wave activity frequently prohibited their use. A shrimp try trawl was used in Prudhoe Bay. Transects were run for 20 minutes with the lead line of the trawl riding on the bottom. Larval and early life stages of Arctic cod, capelin and liparids dominated the offshore trawl catches.

The most widespread group of fishes captured along the coast were salmonids; Arctic char were captured at 75% of the gill net stations. Arctic cisco and least cisco were captured at 59% and 44% of the stations respectively. Least cisco were captured in the greatest abundance however, followed by Arctic char and Arctic cisco. Figure 4 shows the seasonal abundance of Arctic char, least cisco and Arctic cisco captured in Prudhoe Bay.

Catch data show a more widespread distribution for adult Arctic char and Arctic cisco than for other anadromous species. Arctic char and Arctic cisco were captured at nearly all of the barrier island stations as well as along mainland beaches. Least cisco, however, showed a greater affinity for near shore areas throughout the study area. Broad whitefish were rarely captured in waters east of Bullen Point (70°10' N, 146°45' W) and were found in the greatest abundance near the Sagavanirktok and Colville river deltas. Adult humpback whitefish were likewise distributed along mainland beaches between the Sagavanirktok and Colville rivers.

Figure 5 shows the relative abundance of all species captured within the study area. The majority of fish were captured in fyke traps set in locations adjacent to the mainland. The two most abundant marine species (Arctic cod and fourhorn sculpin) accounted for 48% of the entire catch. Figure 6 shows the seasonal distribution of all species captured in Prudhoe Bay.

Table 1. List of near shore species captured between Harrison Bay and Brownlow Point.

Scientific Name	Common Name	Species Abbreviation	OCS Species Code
Salmonidae			
Salvelinus alpinus	Arctic char	AC	7904010402
Coregonus sardinella	Least cisco	LCI	7904010105
C. autumnalis	Arctic cisco	ACI	7904010101
C. nasus	Broad whitefish	BWF	7904010103
C. pidschian	Humpback whitefish	HWF	7904010104
Prosopium cylindraceum	Round whitefish	RWF	7904010601
Thymallus arcticus	Arctic grayling	GR	7904010701
Osmeridae			
Osmerus mordax	Boreal smelt	BSM	7904020302
Mallotus villosus	Capelin	CAP	7904020201
Gadidae			
Boreogadus saida	Arctic cod	ACD	7909020201
Eleginus gracilis	Saffron cod	SCD	7909020301
Cottidae			
Myoxocephalus quadricornis	Fourhorn sculpin	FSC	7915042206
Pleuronectidae			
Liopsetta glacialis	Arctic flounder	AFL	7917021101
Gasterosteidae			
Pungitius pungitius	Ninespine stickleback	NSB	7914010201
Liparidae			
Liparus sp.	Snailfish	Lip	791506

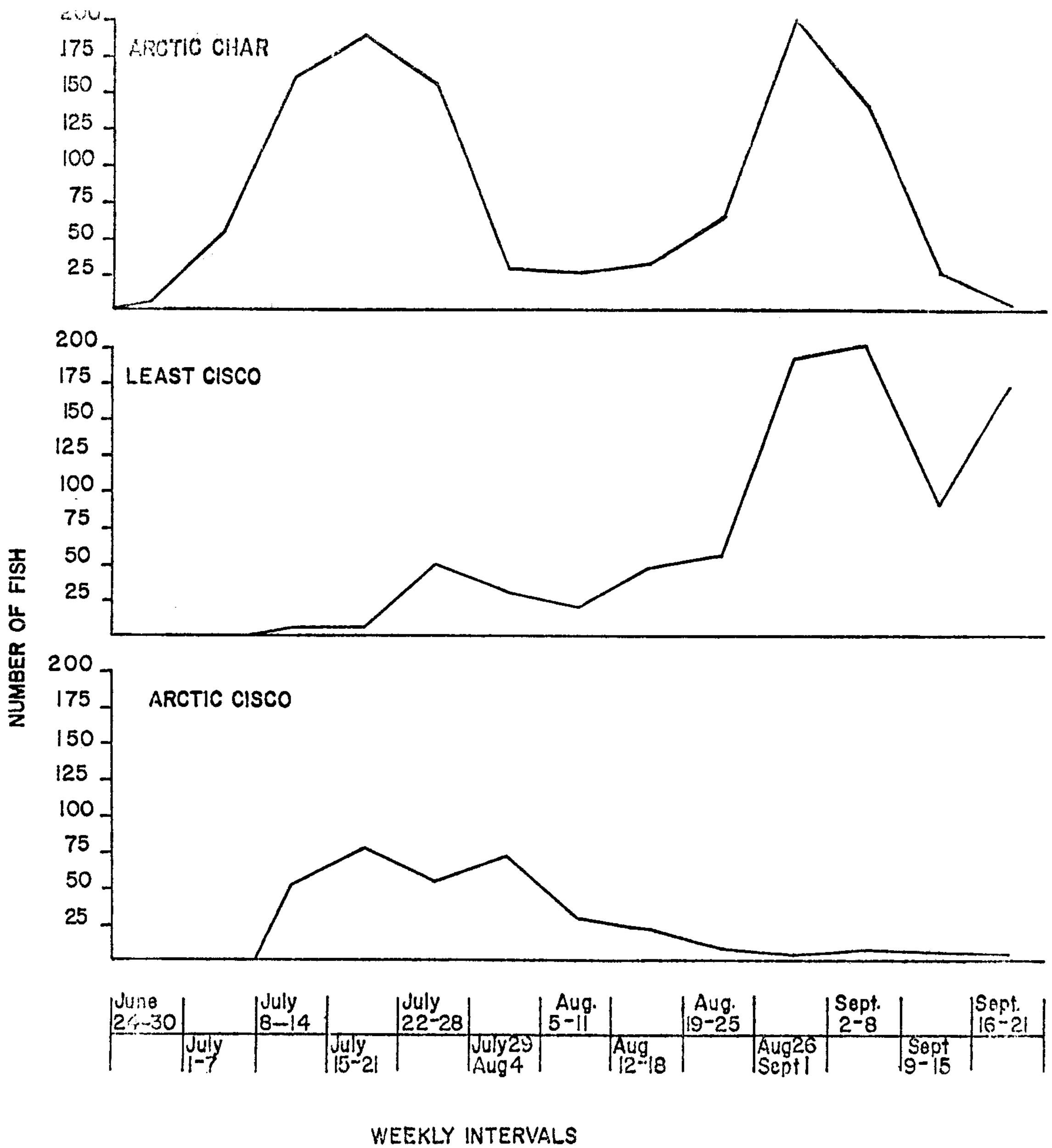


Figure 4. Seasonal abundance of three anadromous fish species in Prudhoe Bay.

Figure 5. Relative abundance of freshwater, anadromous and marine fish found in Prudhoe Bay.

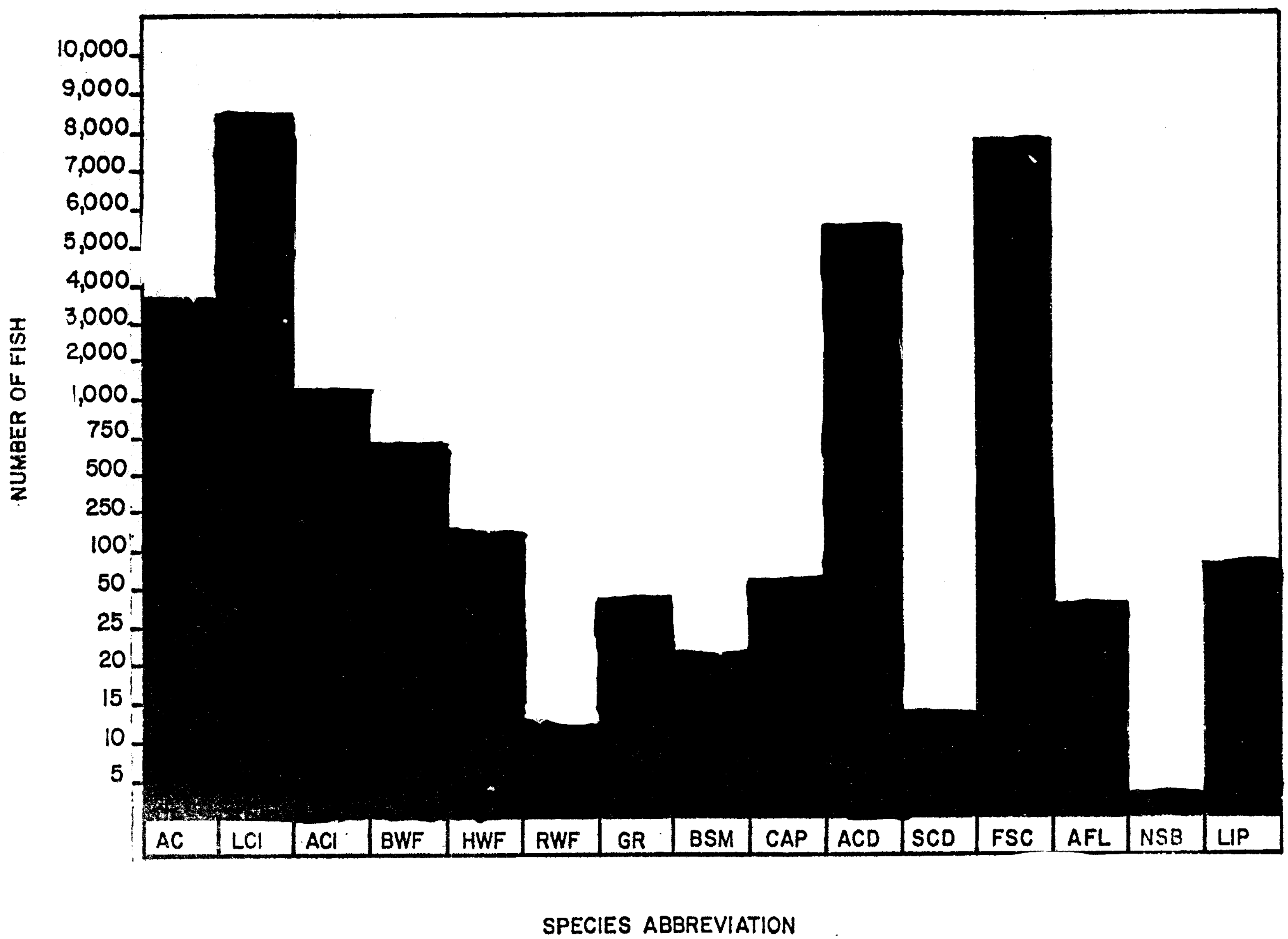
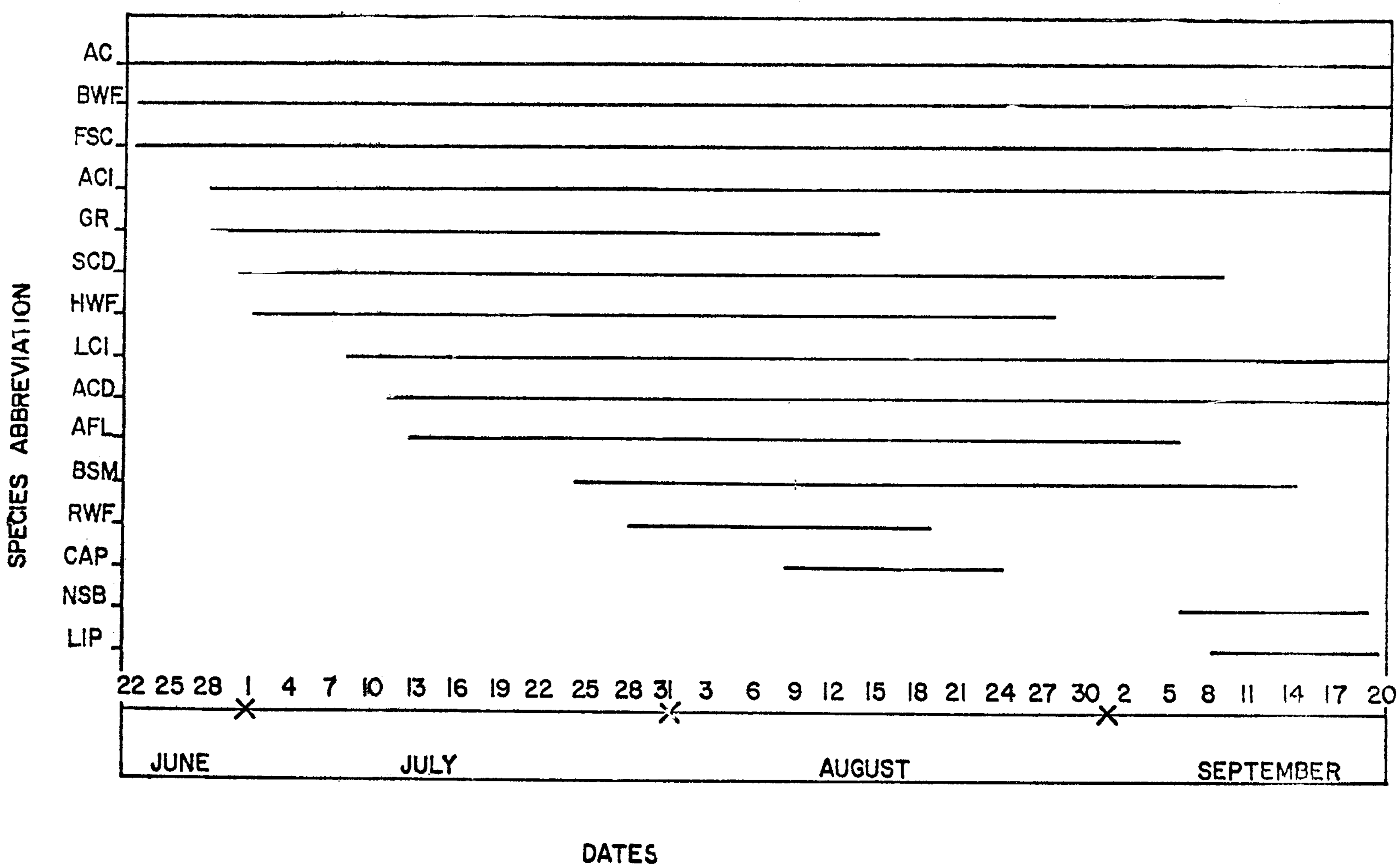


Figure 6. Seasonal distribution of fish species captured in Prudhoe Bay, 1976.



Migration Patterns and Timing 1975-1976

The presence of bottom-fast ice during winter months over much of the near shore waters between the mainland and the barrier islands precludes the presence of fish near shore until after breakup. During both years of this study, sea ice began lifting during the early weeks of June. During 1976, breakup occurred several weeks earlier in the rivers than in Prudhoe Bay. Fresh turbid water from the Sagavanirktok River flooded bottom-fast sea ice in the vicinity of the delta beginning approximately the first of June. Shortly thereafter, gill nets and fyke traps were set in open water leads as they appeared near shore in Prudhoe Bay. By June 21, the open water along the western margin of Prudhoe Bay (vicinity of ARCO causeway) was 1°C and the salinity was less than 1 ppt, indicating that the sea ice had not yet lifted and that fresh, river water was not mixing with the more saline waters of the ocean. The first fish captured in Prudhoe Bay were Arctic char and broad whitefish on June 22. By June 24, salinity increased to 2.5 ppt along the eastern margin of Prudhoe Bay and the first marine species (fourhorn sculpin) was captured. Throughout the remainder of June, Prudhoe Bay catches consisted of Arctic char, grayling, broad whitefish and fourhorn sculpin. Catches of Arctic cisco, humpback whitefish and saffron cod began in the first week of July. Least cisco, Arctic cod and Arctic flounder appeared in Prudhoe Bay during the second week of July. Both species of smelt found in the study were initially captured near shore in late July and early August, and the liparids were captured near shore for the first time on September 8. Throughout the open water season, short term variations in temperature and salinity did not affect the distribution or abundance of fish captured in Prudhoe Bay.

During 1976, 4,962 anadromous fish were tagged in Prudhoe Bay and 384 (8%) were recaptured within the study area and in the Colville River. The total number of fish captured at the permanent stations in Prudhoe Bay increased slowly throughout the 1976 open water season, reaching a peak during the first week of August. The length frequency distribution of the five anadromous species (Arctic char, least cisco, Arctic cisco, broad whitefish and humpback whitefish) found in Prudhoe Bay varied throughout the open water season. All of the above species that were greater than 200 mm in fork length that were captured in fyke traps were tagged with FD-67 Floy tags. Thus, we could segregate the number of each species captured into two rough size groupings; those greater than 200 mm which were subsequently tagged and those less than 200 mm which were accounted for and released. During the month of June, 24% of the above species combined were greater than 200 mm. In July, August and September, 41%, 74%, and .08% of the anadromous fish captured were greater than 200 mm in fork length. Thus the percentage of larger and older fish of each species increased throughout the summer to a peak in early August, then decreased very rapidly and remained low until the time the traps were removed (September 22). The decrease in the percentage of larger fish corresponds with the timing of mature individuals movement back into fresh water spawning and overwintering habitats. In both years of this study, immature Arctic char and least and Arctic cisco remained in the salt water until freezeup. Of the marine species captured, only fourhorn sculpin, Arctic cod and liparids were taken after September 1. More detailed information on distribution and movements follows in the discussion of individual species.

Overwintering Habitats

Very little information is available concerning overwintering fish and their habitat in Arctic and subArctic waters. The two major rivers within the study area (Sagavanirktok and Kuparuk) attain maximum rates of discharge during spring breakup. Thereafter, the flow decreases throughout the remainder of the year. Freezeup usually occurs in September. As the river ice increases in thickness, it freezes into the substrate in shallow areas and riffles. By mid winter, this process has effectively created a series of discontinuous pools of water under the ice which constitute the only overwinter habitat for fish occupying the lower reaches of these rivers. Late winter flows in the Sagavanirktok and Kuparuk deltas are poorly defined, but near zero.

Ten locations were examined for overwintering fish between March 18 and April 10, 1976 (Fig. 7). The following parameters were recorded at each site: ice depth, water depth, bottom type, approximate dimensions of under-ice pool, air temperature, water temperature, salinity and dissolved oxygen. Observations of fish under the ice were made with the underwater closed circuit television system. Fish were captured by hook and line and with gill nets. The use of minnow traps to capture juvenile fish was tried unsuccessfully at several locations. Up to 28 man hours of effort were required to set a single 25' net under the ice.

Our initial investigation indicates that the amount of under-ice habitat is extremely limited during late winter and every location thoroughly examined was found to contain fish. Table 2 summarizes the data collected at each site. Dissolved oxygen readings varied between 7 ppm and saturation (in excess of 15 ppm at 0°C). Station 03 on the Sagavanirktok River was anaerobic in April. This may have resulted from industrial dewatering of this site in earlier winter. Salinity was zero at all river locations. Water depths varied between 7" (dewatered by industry) and 66". The maximum ice thickness was 89". Bottom types varied from sand to coarse gravel up to 3" in diameter.

Following is a list of the fish either observed, or captured during March and April, 1976.

Sagavanirktok River	Kuparuk River
Grayling	Grayling
Round whitefish	Round whitefish
Broad whitefish	...
Humpback whitefish	...
Burbot	Burbot
Slimy sculpin	Slimy sculpin
...	Ninespine stickleback

Figure 7. Winter sampling sites, 1976.

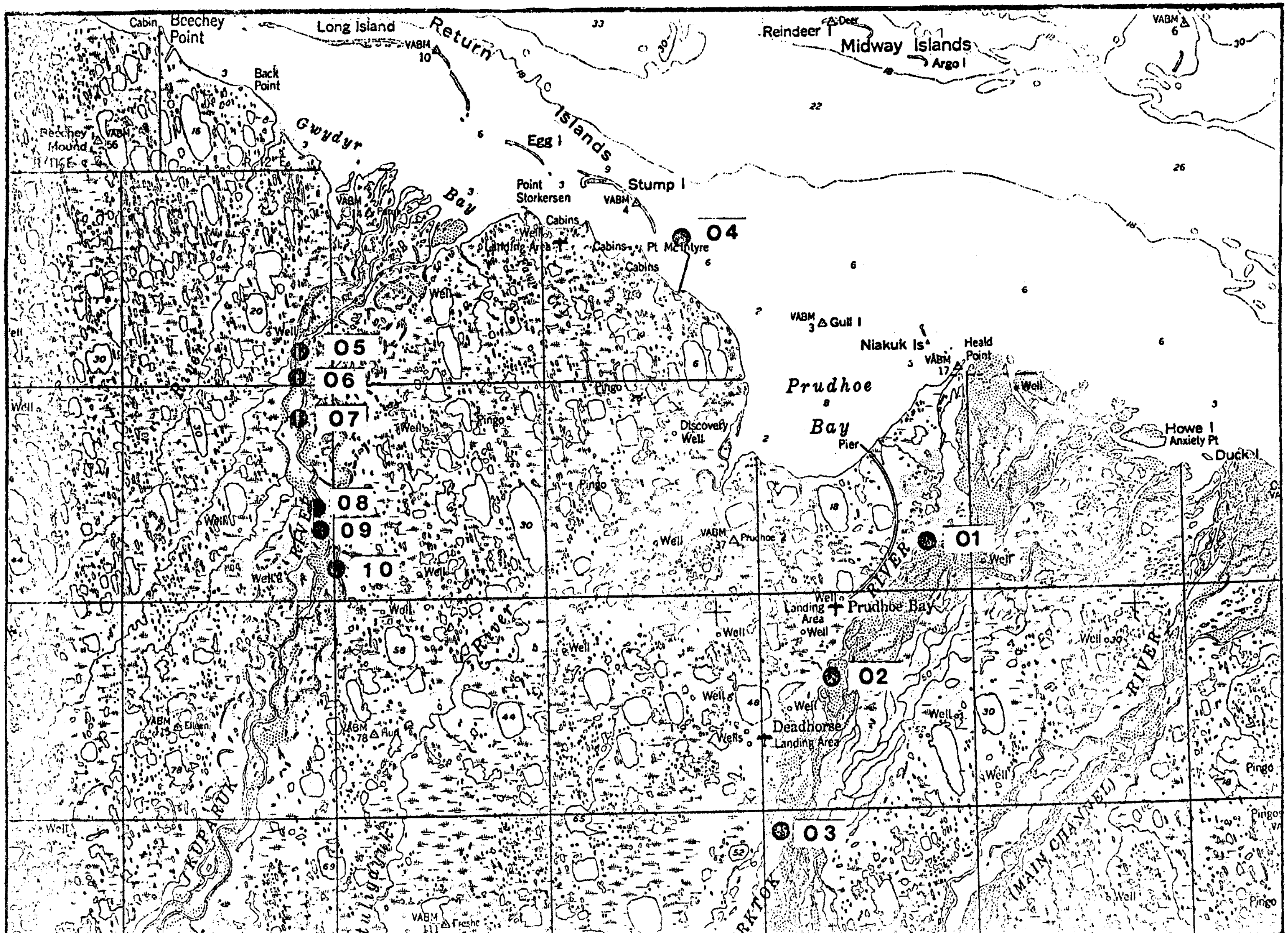


Table 2. Physical parameters recorded at overwintering sites 1976.

Station Number	Date	Location	Under-ice Water Depth (inches)	Ice Thickness (inches)	Water Temp. (°C)	Salinity (ppt)	DO (% saturation)	Species Present
01	3-19	Sagavanirktok R.	20	60	0	0	55	GR, RWF, BB, BWF, *HWF, SC
02	4-10	Sagavanirktok R.	41	89	0	0	100	GR, RWF, SC, BB
03	4-19	Sagavanirktok R.	27	65	0	0	0	GR
04	3-21	Prudhoe Bay	36	72	-1	30	N/A**	...
05	4-3	Kuparuk R.	62	66	0	0	>100	GR, BB, SC, NSB
06	4-3	Kuparuk R.	48	72	1.5	0	90	N/A*
07	4-5	Kuparuk R.	64	69	0	0	49	GR, BB, RWF
08	3-20	Kuparuk R.	20	84	0	0	>100	GR, BB, RWF, SC
09	3-20	Kuparuk R.	16	80	0	0	>100	N/A*
10	4-5	Kuparuk R.	46	66	0	0	>100	N/A*

* No attempt was made to observe with the camera or set a net.
** Dissolved oxygen values were not taken at this site.

Grayling captured under the ice averaged 279 mm in fork length and ranged from 35 mm (young-of-year) to 377 mm (X years). Females over 250 mm were gravid. All grayling had empty stomachs at the time of capture.

Round whitefish ranged from 217 mm to 284 mm in fork length with an average of 244 mm. Round whitefish ranged from IV through VI years in age and all had empty stomachs at the time of capture.

Broad whitefish ranged from 239 mm to 445 mm in fork length and averaged 380 mm. Ages ranged from V through XIII years. Broad whitefish from 370 mm to 445 mm had spawned the previous fall probably at or near the same location as captured under the ice. All of the broad whitefish had empty stomachs.

Burbot captured under the ice averaged 493 mm in fork length and ranged from 255 mm to 702 mm. Ages varied from V through XII years and mature individuals, upon examination, showed evidence of having recently spawned. Burbot were feeding on grayling, slimy sculpin, and ninespine stickleback as well as larval insects.

Several age groups of a species, and in some cases all species, were captured at the same site. The only species tentatively identified with an underwater camera but not captured was the humpback whitefish. Arctic char, an important species in the Sagavanirktok River, was neither observed nor captured under the ice in the lower river.

These preliminary results stress the importance of the limited overwintering habitat for fish in North Slope rivers. Under-ice pools of water serve as winter refuge for all age classes of the species present and provide spawning and incubation habitat for fall and winter spawners such as whitefish and burbot. Thus, overwintering habitat in North Slope river deltas is clearly susceptible to the deleterious effects of seismic activity, dewatering to meet domestic and industrial water needs, or chemical pollution.

A single under-ice location was examined in Prudhoe Bay on March 21 and 22, 1976. The substrate at this location was composed of mud and fine grained sediments. The underwater television camera showed a slight water current when the bottom sediments were disturbed. No fish were observed at this location. Isopods and several species of amphipods were moving within the water column throughout the duration of our underwater observation. Sufficient effort has not yet been made to determine the significance of near shore waters as overwintering habitat, however enclosed pockets of hyper-saline water within the fast ice zone appear to be the least suitable habitat for overwintering marine species.

INDIVIDUAL SPECIES DISCUSSION

Arctic Char

Arctic char have a circumpolar distribution. Morphological forms are varied and many distinct life history types occur within the range of this species.

Arctic char, found along the entire northern coast of Alaska, are the object of a traditional subsistence and expanding sport fishery. Several recent investigations have been conducted on the life history of the Arctic char in major North Slope drainages (Yosihara, 1973, 1974; Furniss, 1974, 1975; and Griffiths and Craig et al. 1975).

A total of 3,739 Arctic char was captured during 1975 and 1976. Fork lengths ranged from 154 mm through 685 mm with a mean of 427 mm. A length mode occurred between 520 and 529 mm. Length frequency distribution is shown in Fig. 8.

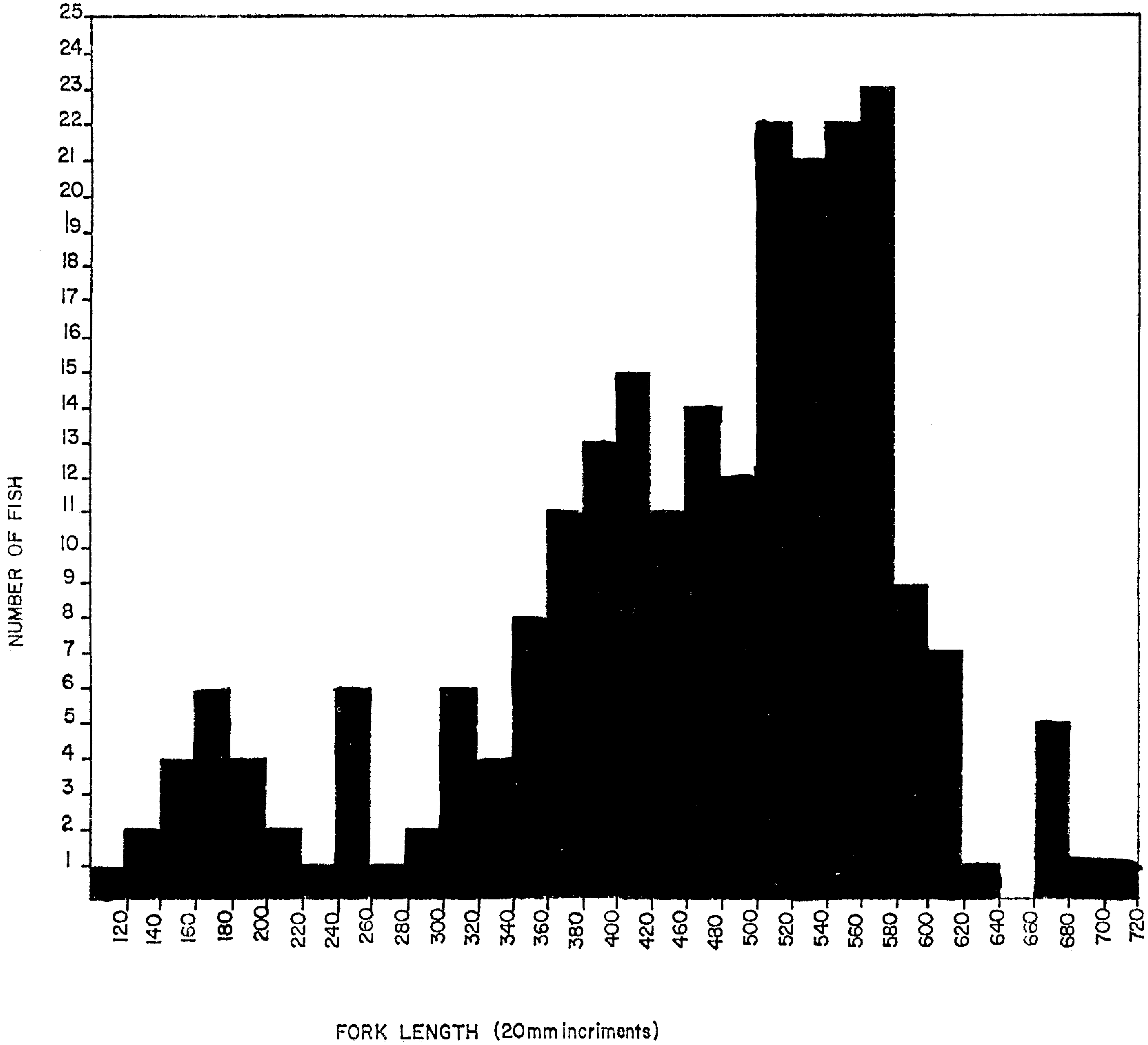
Arctic char ranged from Age III through Age XII, with the majority of fish between VII and IX. Juveniles less than 200 mm were abundant in the near shore waters between the Colville and Sagavanirktok rivers during the open water season.

Sexual maturity is reached from Ages VI to VIII for most anadromous char. Upon reaching maturity, most char spawn in alternate years (Yoshihara, 1973). The sex ratio of Arctic char captured within the study area was biased in favor of females. The female to male ratio of 235 Arctic char was 2:1. Similar disproportions in sex ratios of char were observed by Furniss (1975), Glova and McCart (1974) and others. Of 75 female anadromous char captured in the Beaufort Sea that were judged to be mature, 75% were prespawners (individuals that would spawn in the coming fall).

A total of 808 Arctic char was tagged in Prudhoe Bay during 1976 and 30 of these individuals were recaptured. Arctic char enter the Beaufort Sea at breakup and spread out along the coast in plumes of fresh river water that flood the fast ice. Char were first captured in Prudhoe Bay on June 22, 1976. The greatest number of char was captured during the month of July, and adults began entering the Sagavanirktok River to spawn and overwinter during the first week of August. Juvenile char (less than 200 mm) are present in the Beaufort Sea until freezeup and enter the Sagavanirktok River during September. Adult Arctic char forage widely during summer and were captured at the most remote barrier island stations. Previous studies (Furniss, 1975) indicate that char may travel as far as 300 km (from the Sagavanirktok River to Pt. Barrow) during the open water season. A limited amount of sport fishing effort by oil company employees primarily during July and August, was observed in Prudhoe Bay and the Sagavanirktok Delta.

Arctic char are opportunistic feeders and prey on a variety of epibenthic organisms as well as insect larvae and fish. Of 210 guts collected, 44%

Figure 8. Length frequency of Arctic char captured during 1975 and 1976.



were empty. Following is a list of food items from Prudhoe Bay char, omitting empty stomachs:

Amphipods	95%
Cod, B. saida	42%
Mysids	32%
Isopods	11%

Griffiths et al. (1975) working in Nunaluk Lagoon found char feeding on five species of fish (mostly fourhorn sculpin) as well as chironomid larvae, dipteran pupae and copepods.

Least Cisco

The least cisco is distributed throughout western North America and Siberia. It is a resident of many inland waters of Alaska and is anadromous in streams draining into the Bering, Chukchi and Beaufort seas.

The least cisco was the most frequently captured coregonid within our study area. The absence of least cisco in catches along the outer barrier islands suggests that this species has a strong affinity for brackish waters of the mainland coastline. Life history details of this species residing in northern waters are described by Mann, 1974; Kendel et al., 1974; Percy et al., 1974; and others.

A total of 8,545 least cisco was captured during 1975 and 1976. Fork lengths ranged from 82 mm through 364 mm with a mean of 272 mm (n=271). Figure 9 shows the length frequency of least cisco captured during this investigation. Females (n=216) were larger than males (n=66). The maximum lengths correspond well with least cisco captured in the Colville River (Kogl, 1971) and are lower than those described by McPhail and Lindsey, 1970.

Least cisco ages ranged from I through XII with VII through X individuals most frequently captured (Table 3). The growth rates of least cisco were lower than those reported from the MacKenzie River (Hatfield et al., 1972) and Interior Alaska (Alt, 1971). Figure 10 compares mean back calculated lengths for least cisco taken in Interior Alaska (Chatanika River) and the Beaufort Sea.

Sexual maturity begins at Age VII and 57% of the Age VIII least cisco were mature. Of those that were mature, 20% had redeveloping gonads and would not spawn in the year of capture, indicating that upon reaching maturity, a portion of the population will not spawn every year. The age of maturity of least cisco from the Beaufort Sea is from 1 to 2 years greater than reported from Siberia (Berg, 1948-49). Spawning is reported to take place during fall in the lower reaches of major rivers. There were no spawning or overwintering areas located within the study area. Tag returns and movement patterns obtained during 1976 indicate that the majority of the least cisco captured along the coast move out of, and return to the Colville River.

Figure 9. Length frequency of least cisco captured during 1975 and 1976.

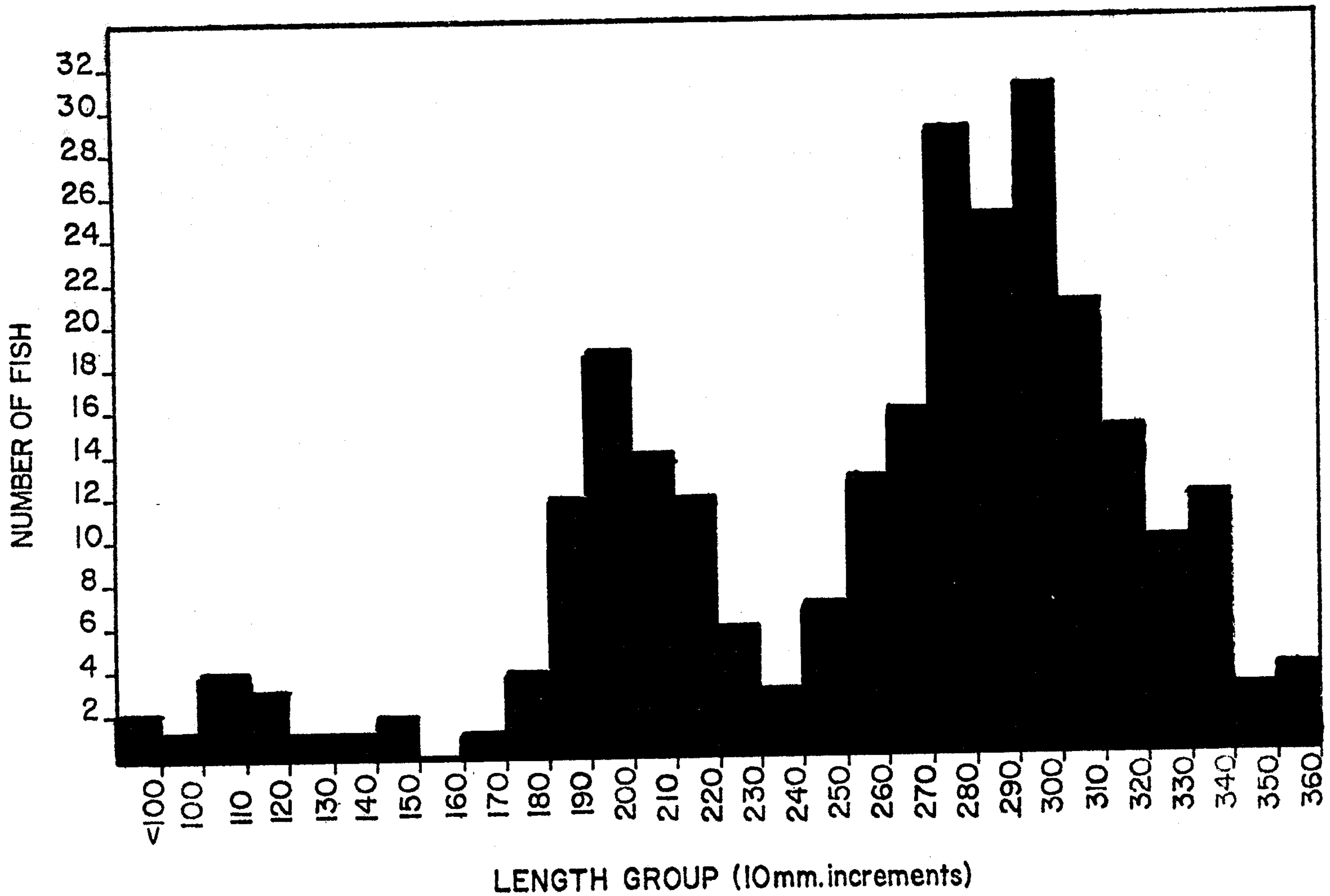
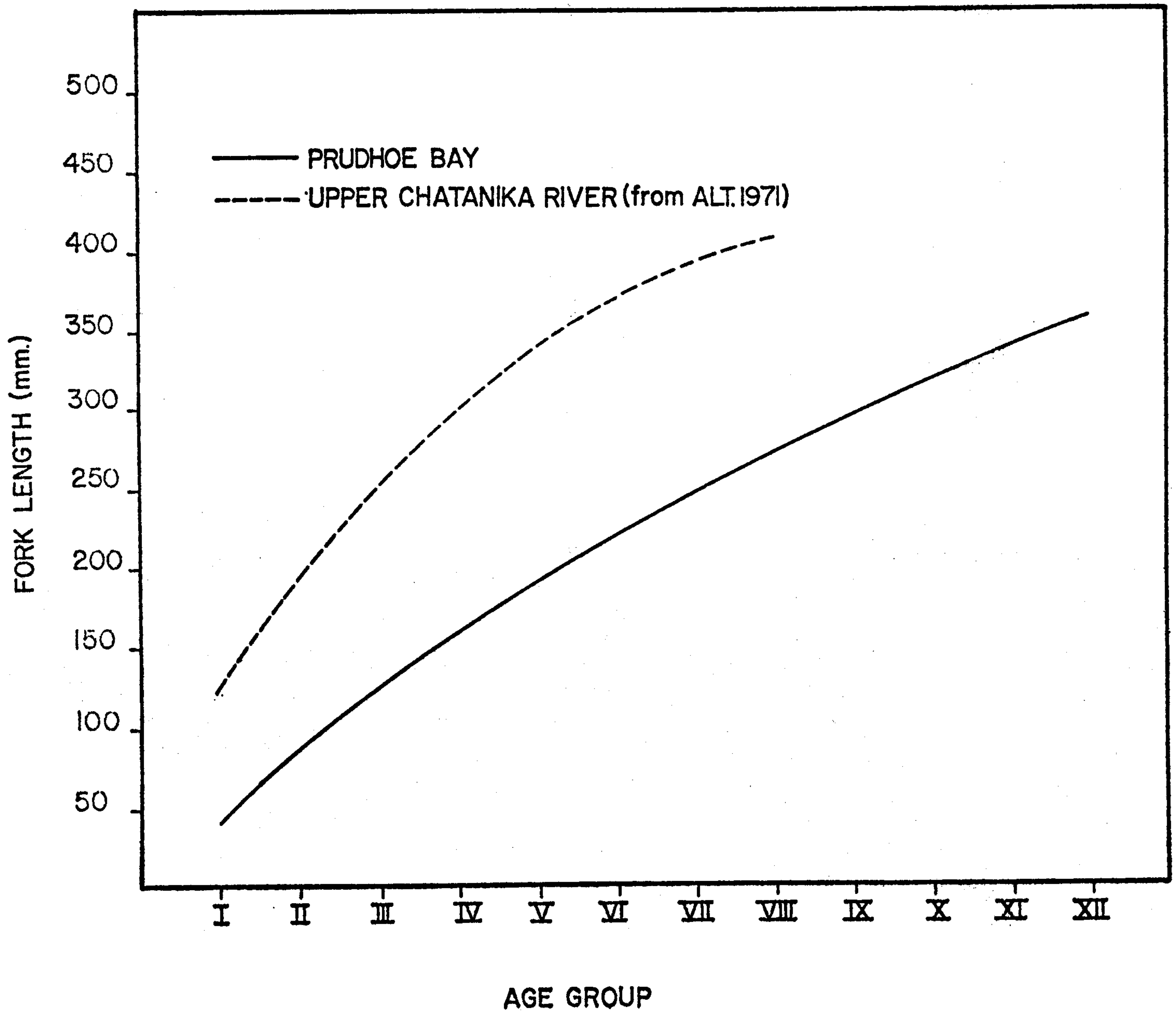


Figure 10. Back calculated fork lengths of least cisco taken in Prudhoe Bay and the Chatanika River (Interior Alaska).



In 1976, a total of 3,185 least cisco was tagged in Prudhoe Bay and 328 were recaptured within the study area and in the Colville River. Least cisco first appeared in Prudhoe Bay during the first week of July 1976. Their abundance increased to a peak during early September, however the greatest number of large fish (over 200 mm) was captured during the month of August. Although Age I and II least cisco were captured in Prudhoe Bay, it appears that most enter the brackish waters of the Beaufort Sea during their third year. Tagged individuals showed an eastward movement through Prudhoe Bay from breakup through mid-August and then generally westward movement until freeze-up. Several individuals were recaptured at various sites within Prudhoe Bay throughout July and August, indicating random movement within the same general area for an extended period of time. One least cisco was recaptured at Barter Island (250 km east of Prudhoe Bay). The migration of adults to the Colville River was first recorded in mid August when a least cisco tagged in Prudhoe Bay was captured in the Colville River seven days after being tagged. Eighty-two percent of the recaptured least cisco were taken during fall in the lower Colville River. Wohlschlag (1954), in comparing migratory and non-migratory least cisco, suggests that the former migrates over distances of at least 100 miles (161 km) but returns to fresh water during winter.

Seventy-five percent of the least cisco stomachs examined (n=201) contained food. Twelve least cisco stomachs were examined from fish taken during 1975. Of the twelve, one was empty. Following is a list of the gut contents, omitting the empty stomach:

Mysids	91%
Amphipods	45%
Dipterans (adult)	27%
Isopods	9%
Vegetation/detritus	9%

Arctic Cisco

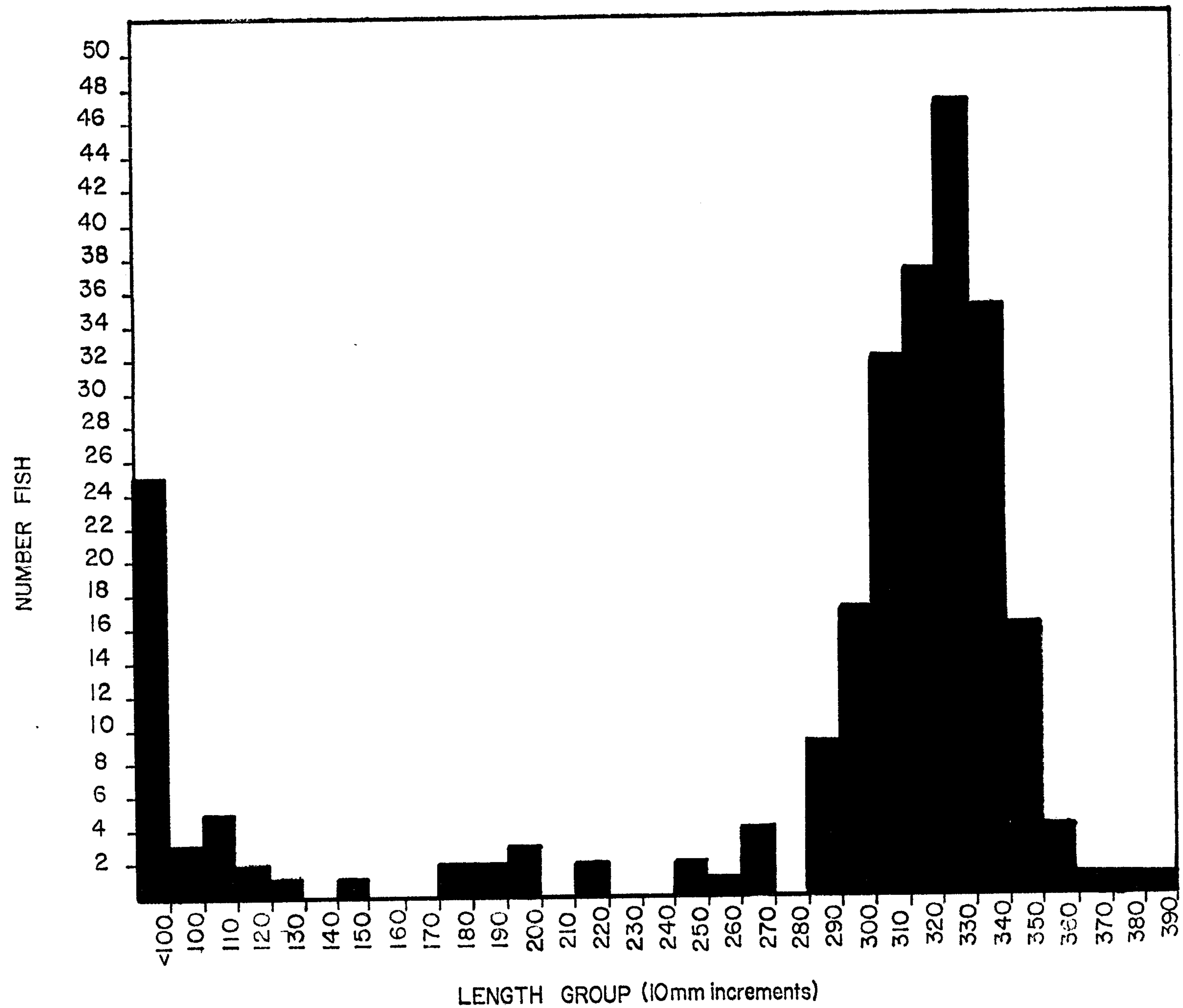
The Arctic cisco is distributed throughout northern Europe, Siberia and western Arctic North America. From the Gulf of Alaska north to the western Beaufort Sea, the Arctic cisco is replaced by the Bering cisco, *C. laurettae*, as described by McPhail (1966). In Alaskan waters, the Arctic cisco ranges from Point Barrow east to Demarcation Point. They are one of the most common and widely distributed fish found with our study area and are used by local residents in coastal subsistence fisheries as well as in small commercial fisheries at the mouth of the Colville River and near Point Barrow. Arctic cisco life history data are discussed by Craig and McCart (1976) and Hatfield, Stein et al. (1972).

A total of 1,361 Arctic cisco was captured during 1975 and 1976. Fork lengths ranged from 62 mm to 390 mm with a mean of 285 mm (n=253). Figure 11 shows the length frequency of Arctic cisco captured during this study. Few individuals in the sample were greater than 350 mm. Maximum lengths are less than those reported by Berg (1948-49) for

Table 3. Age length frequency of least cisco captured during 1975 and 1976.

Length Group	Age Classes I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
< 100	1	1											2
100-109	1												1
110-119	4												4
120-129	2	1											3
130-139		1											1
140-149			1										1
150-159		1	1										2
160-169													0
170-179			1										1
180-189			4										4
190-199			9	3									12
200-209			11	7	1								19
210-219			3	10			1						14
220-229				6	1	1	4						12
230-239				1	4		1						6
240-249				1	1	1							3
250-259					1	3	3						7
260-269						4	4	2	3				13
270-279						3	10	2	1				16
280-289						2	17	4	5	1			29
290-299						1	4	7	5	6	2		25
300-309							1	7	15	5	3		31
310-319								3	5	11	2		21
320-329									7	4	4		15
330-339								1	4	3	1	1	10
340-349									1	7	2	2	12
350-359										2		1	3
360-369										1	1	2	4
n	8	4	30	28	8	15	45	26	46	40	15	6	271
$\bar{x}$	110	127	197	212	231	264	272	296	309	319	320	350	272
Range	82-125	92-150	139-210	190-240	202-250	225-290	219-285	260-345	278-340	290-353	297-360	331-364	84-364

Figure 11. Length frequency of Arctic cisco captured during 1975 and 1976.



Siberian forms, McPhail (1966) for Point Barrow and Hatfield, Stein et al. (1972) for MacKenzie River forms.

Although Arctic cisco reach a maximum age of at least XI (Hatfield, Stein et al., 1972), cisco within the study area ranged from Age I through Age IX. Immature fish of Age VI comprised 46% of the sample. An age-length frequency is presented in Table 4. As with least cisco the growth rate of Arctic cisco captured in the Beaufort Sea is lower than reported for the MacKenzie River (Hatfield, 1972) and Siberia (Berg, 1948-1949). Figure 12 shows the mean back calculated lengths of Arctic cisco from the Beaufort Sea. Arctic cisco enter the Beaufort Sea at Age I.

The female to male sex ratio of 198 Arctic cisco was 9:1. There were no sexually mature individuals in our sample. Berg (1948, 1949) states that Siberian Arctic cisco mature at Age V, however the age at maturity varied between river systems. Craig and McCart (1976) suggest that Arctic cisco from the Beaufort Sea reach maturity between ages of VII and IX. Craig and McCart (1976) further postulate that Arctic cisco only use the two largest drainages in the region, the Colville and MacKenzie rivers, as spawning areas. Arctic cisco spawn in the fall. The spawning periods and locations for the Colville River have not been identified. Either mature Arctic cisco do not range in the area of our study or they do not range as far from natal streams as do the younger age classes.

Six hundred twenty-eight Arctic cisco were tagged in Prudhoe Bay during 1976 and 21 of those were recaptured throughout the season. The first Arctic cisco was captured on June 28, and their seasonal abundance was similar to that of least cisco; the greatest number being captured during the month of August. A single individual tagged in Prudhoe Bay was recaptured at Griffin Point near Barter Island, 19 days after being tagged. Movement trends of Arctic cisco in Prudhoe Bay require further investigation. Nineteen of the 21 recaptured Arctic cisco were taken during the fall run in the Colville River.

Sixty-five percent of the Arctic cisco stomachs examined (n=153) contained food. Following is a list of the gut contents of stomachs:

Mysids	60%
Amphipods	53%
Vegetation/detritus	40%

Broad Whitefish

Broad whitefish are distributed throughout Eurasia and drainages of the Arctic Ocean. In North America, broad whitefish inhabit drainages of the Bering, Chukchi and Beaufort seas ranging as far east as Perry River. Berg (1948-49), Nikolsky (1961), Alt (1972) and Hatfield, Stein et al. (1972) have investigated the life histories of northern populations of broad whitefish. Broad whitefish in Alaskan waters support valuable commercial and subsistence fisheries.

Table 4. Age length frequency of Arctic cisco captured during 1975 and 1976.

Length Group	Age Classes									
	I	II	III	IV	V	VI	VII	VIII	IX	total
< 100	25									25
100-109		3								3
110-119	3	2								5
120-129		2								2
130-139		1								1
140-149										
150-159			1							1
160-169										
170-179										
180-189			2							2
190-199			2							2
200-209			3							3
210-219										
220-229			1	1						2
230-239										
240-249										
250-259				2						2
260-269				1						1
270-279				1	3					4
280-289										
290-299				1		6	2			9
300-309					1	10	3	2	1	17
310-319					5	16	4	7		32
320-329					1	28	3	3	2	37
330-339					1	30	9	5	2	47
340-349						16	8	11		35

Table 4. (Cont.) Age length frequency of Arctic cisco captured during 1975 and 1976.

Length Group	Age Classes I	II	III	IV	V	VI	VII	VIII	IX	total
350-359						7	5	4		16
360-369						3		1		4
370-379								1		1
380-389								1		1
390-399								1		1
n	28	8	9	6	11	116	34	36	5	253
$\bar{x}$	82	116	199	259	303	327	331	339	323	283
Range	62-115	104-131	156-220	222-290	270-335	290-365	298-355	305-390	306-331	62-390

Figure 12. Back calculated fork lengths of Arctic cisco captured in Prudhoe Bay.

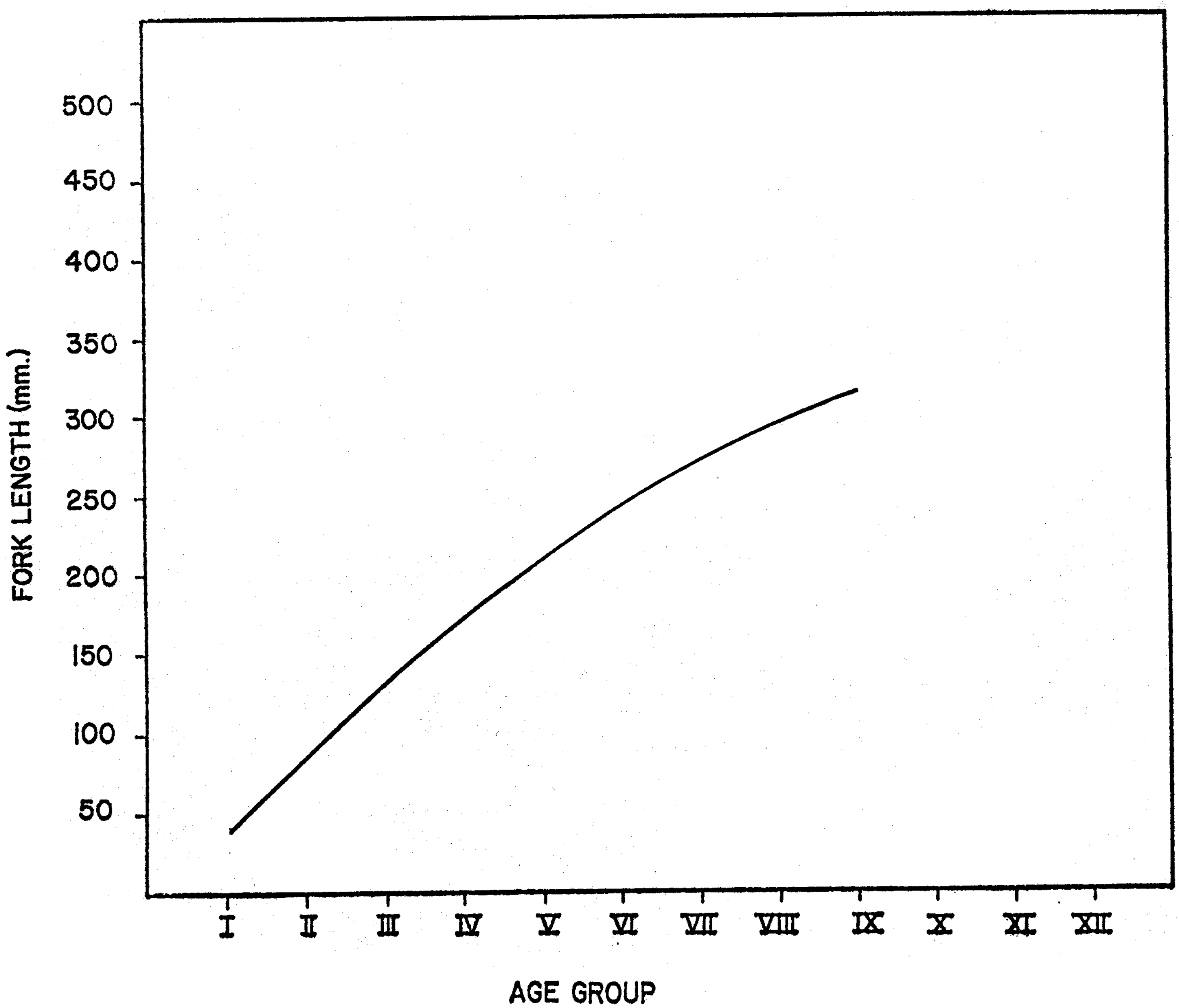


Figure 13. Back calculated fork lengths of broad whitefish taken in Prudhoe Bay and Minto Flats (Interior Alaska).

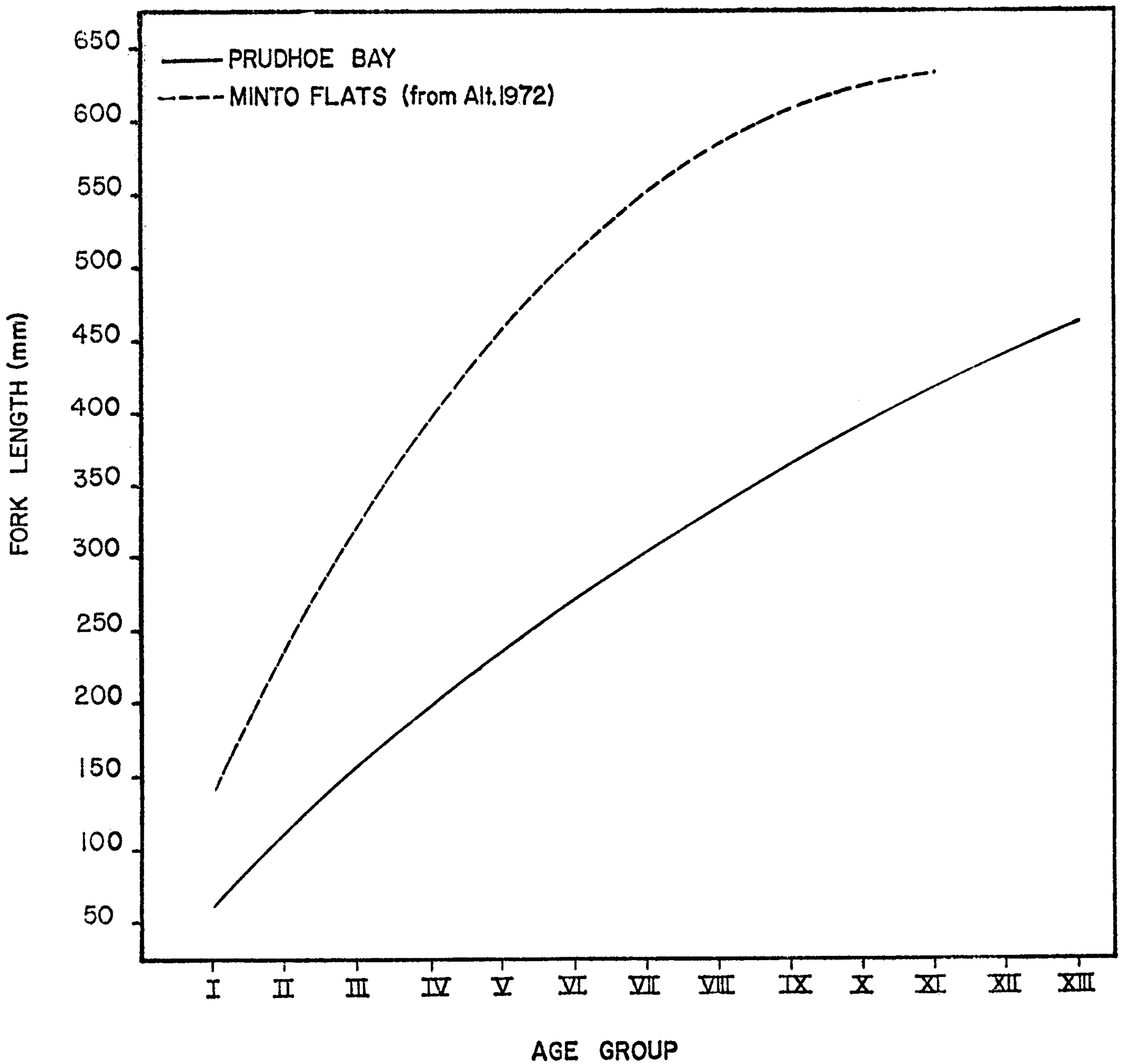
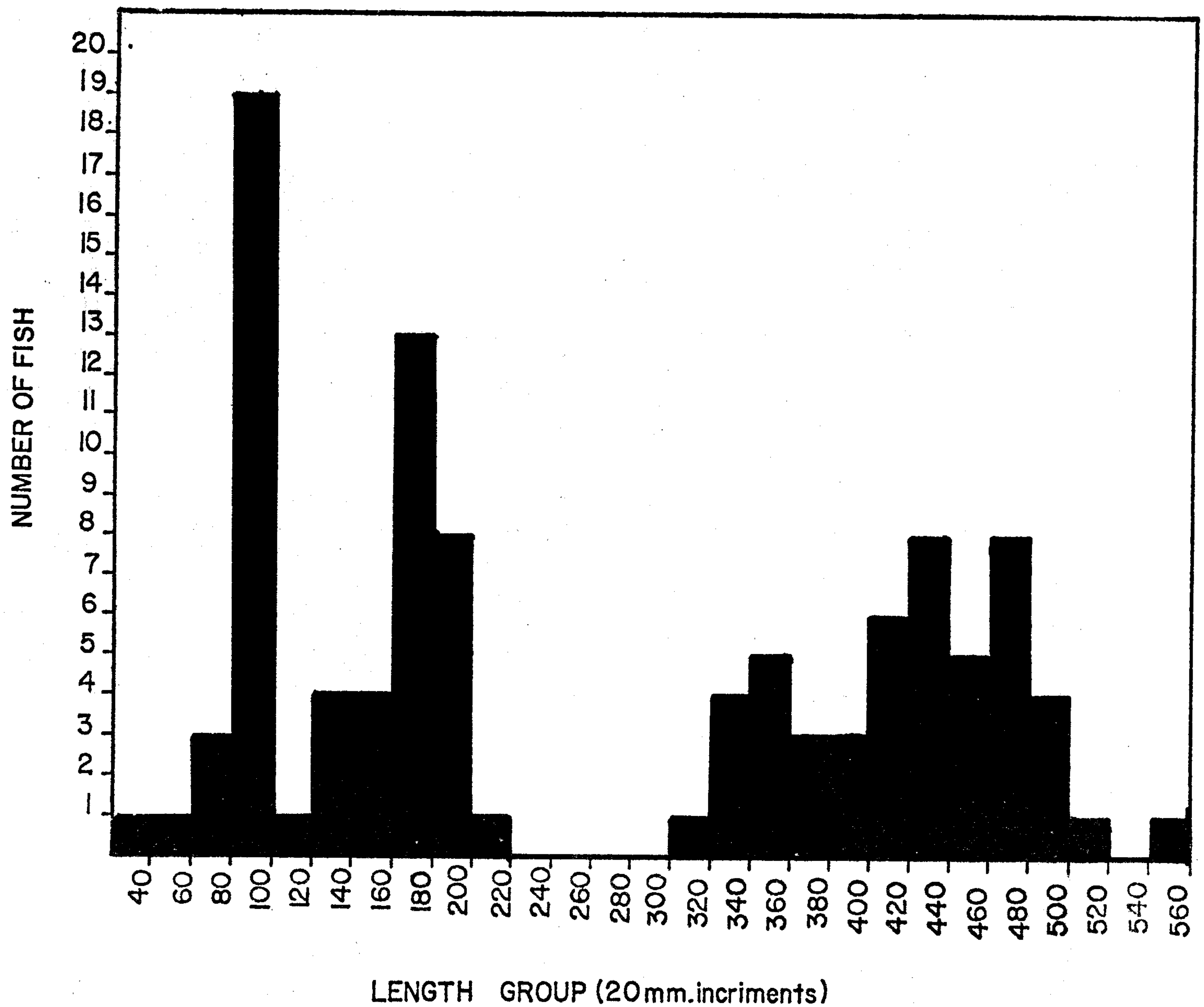


Figure 14. Length frequency of broad whitefish taken in Prudhoe Bay during 1975 and 1976.



A total of 741 broad whitefish was captured between the Colville River and the eastern margin of Foggy Bay during 1975 and 1976. Fork lengths ranged from 58 mm to 555 mm with a mean of 287 mm (n=113). Maximum lengths are considerably smaller than those reported for the MacKenzie River (Hatfield, Stein et al., 1972) and Siberia (Berg, 1948). Figure 13 compares back calculated fork lengths of broad whitefish in Prudhoe Bay and Minto Flats (Interior Alaska). The length frequency for broad whitefish is presented in Fig. 14.

Ages ranged from young-of-the-year through Age XV, however Ages IV-VII were not represented in the sample. The ratio of females to males was 0.52:1. Fifty percent of the Age IX broad whitefish were mature. Twenty-three of those fish between Ages XI and XIII had redeveloping gonads and would not spawn in the year of capture.

One hundred ninety-seven broad whitefish were tagged in Prudhoe Bay during 1976. Only one of these individuals was recaptured. Broad whitefish enter the Beaufort Sea when the larger rivers break up in early June. Broad whitefish were captured off the Sagavanirktok River delta on June 11 and were found in Prudhoe Bay on June 23. Upon entering the Beaufort Sea, broad whitefish forage along the mainland coastline, inhabiting shallow bays and lagoons. Young-of-the-year and Age I broad whitefish seldom traveled beyond the waters adjacent to the Sagavanirktok and Colville river deltas. Tagging conducted by Furniss (1975) suggests that both Colville and Sagavanirktok river stocks of broad whitefish inhabit Prudhoe Bay and other near shore waters between these two rivers during the summer months. Broad whitefish were absent from all but the western barrier islands within the study area. Adult broad whitefish re-enter the Sagavanirktok River in late August and spawn in deep pools throughout the lower reaches of the delta. In 1976, ripe broad whitefish were captured in the Sagavanirktok River during the last week of September. Large numbers of broad whitefish overwinter in deep pools within the river delta.

Forty percent of the broad whitefish stomachs contained food. The predominant food organisms were chironomid larva and amphipods. All of the spawning broad whitefish captured in the Sagavanirktok River had empty stomachs.

Humpback Whitefish

Humpback whitefish are distributed across northern North America and Arctic Siberia. It is the most widely distributed of any whitefish in Alaska. They generally range throughout mainland drainages and are less frequently found at sea. McPhail and Lindsey (1970), Hatfield, Stein et al. (1972); and Alt (1973, 1974) present life history data on northern populations of humpback whitefish. Alt (1974) considers all Alaskan humpback whitefish to be the species *C. pidschian* and that the allied species *C. clupeaformis* of the Great Lakes extends west only to British Columbia and the Yukon Territory.

A total of 170 humpback whitefish was captured during 1975 and 1976. Fork lengths range from 61 mm to 475 mm and averaged 410 mm. The length frequency of 170 humpback whitefish is presented in Fig. 15.

Ages ranged from I to XIII. Figure 16 presents mean back calculated fork lengths for humpback whitefish and compares growth between Prudhoe Bay and the Chatanika River (Interior Alaska).

The greatest abundance of humpback whitefish was near the western border of the study area in the vicinity of the Colville River delta. One hundred forty-six humpback whitefish were tagged in Prudhoe Bay during 1976. Only two individuals were recaptured, moving westward approximately 6 miles in early August. Humpback whitefish were only sparsely distributed between the Colville and Sagavanirktok deltas.

The Colville River is undoubtedly the major contributor of humpback whitefish to the Beaufort Sea on the Alaskan Arctic Slope. Humpback whitefish spawn during the fall in the lower reaches of the Colville River and probably overwinter near the river delta.

Arctic Cod

Arctic cod are circumpolar in distribution. They are widespread throughout the Arctic Ocean and are usually associated with sea ice. Quast (1974) reported that densities of juvenile Arctic cod in the Chukchi Sea increased with depth but they are also known to inhabit freshened surface sea waters (salinity 10-15 ppt) and brackish coastal waters of the Beaufort Sea. Arctic cod occupy an important trophic position in the Arctic food web. They are considered the main consumer of plankton in Arctic seas (excluding coastal regions) and serve as a major food item in the diets of many species of marine mammals, birds and fish. They are sought for both human consumption and for animal food by coastal residents in northern Alaska. Various life history aspects of Arctic cod are discussed by Andriyashev (1964).

Arctic cod were the second most abundant marine species found in near shore waters of our study area. A total of 5,659 Arctic cod was captured during 1975 and 1976. Total lengths of Arctic cod ranged from 20 mm through 193 mm and averaged 120 mm. A length mode was observed between 110 and 129 mm corresponding to Age II individuals. The length frequency of Arctic cod captured in Prudhoe Bay is shown in Fig. 17.

Ages of Arctic cod ranged from young-of-the-year through Age III. Age II individuals comprised 52% of the sample. According to Andriyashev (1964) Arctic cod mature at Age IV (greater than 200 mm total length) however no mature specimens were taken in our sample. The female to male sex ratio of 89 Arctic cod was 1.7:1.

Growth of Arctic cod captured near shore in the Beaufort Sea was slower than reported in Andriyashev (1964) for the Bering Sea and Cheshskaya Bay. The average total length at age for Arctic cod captured near shore during August is as follows: Age 0, 24 mm; Age I, 99 mm; Age II, 131 mm; Age III, 161 mm.

Figure 15. Length frequency of humpback whitefish taken in Prudhoe Bay during 1975 and 1976.

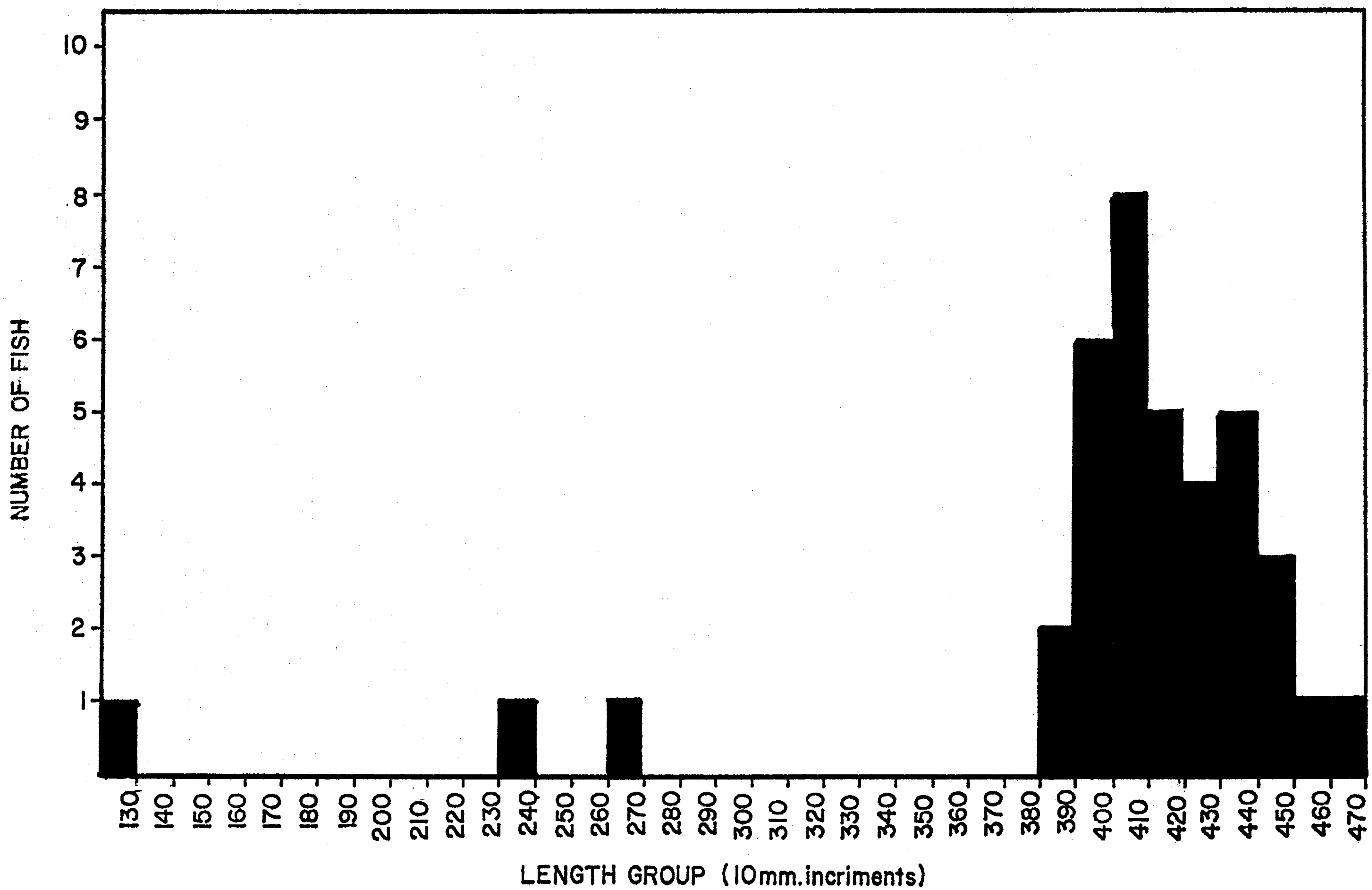


Figure 16. Back calculated fork lengths of humpback whitefish taken in Prudhoe Bay and the Chatanika River (Interior Alaska).

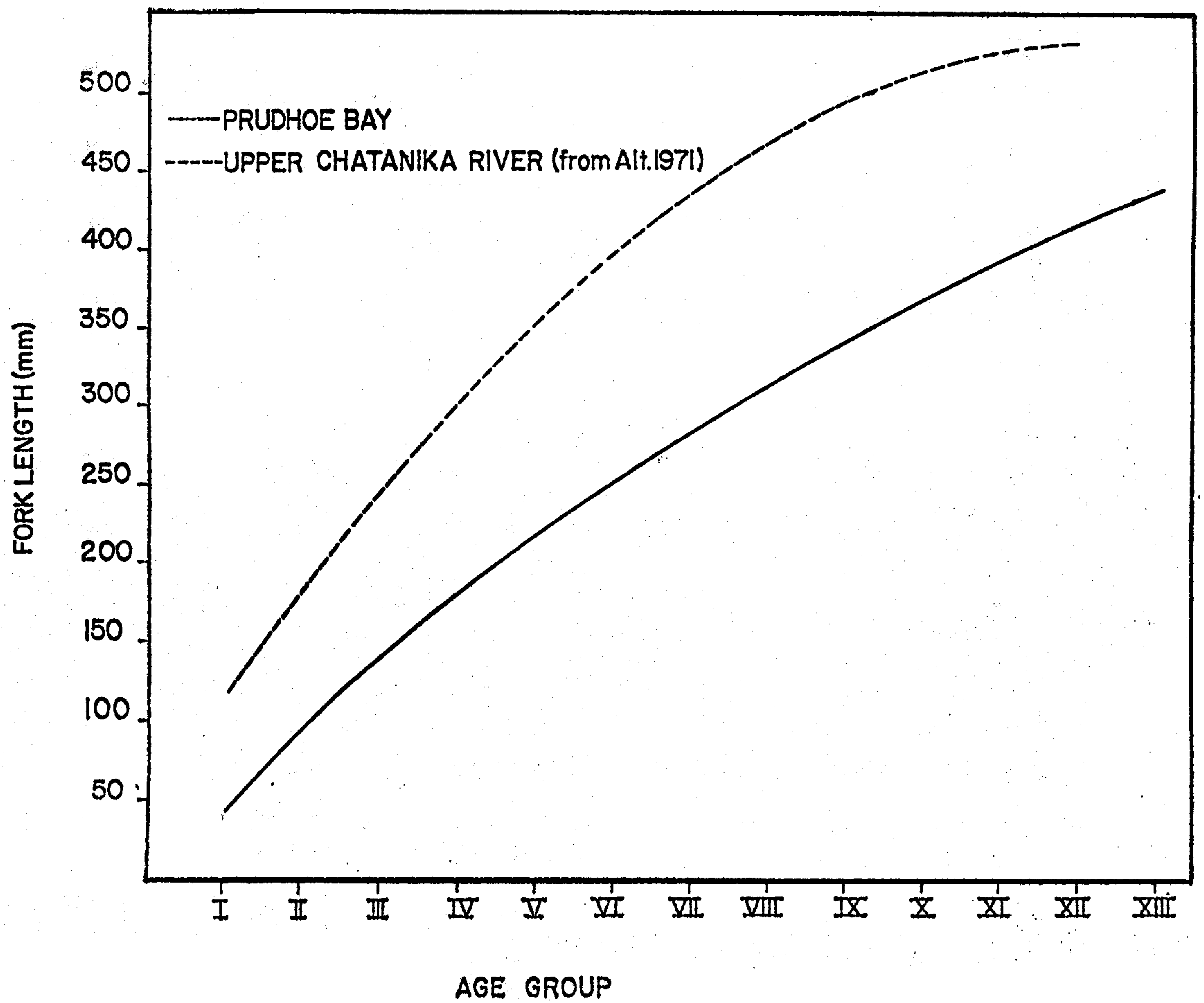
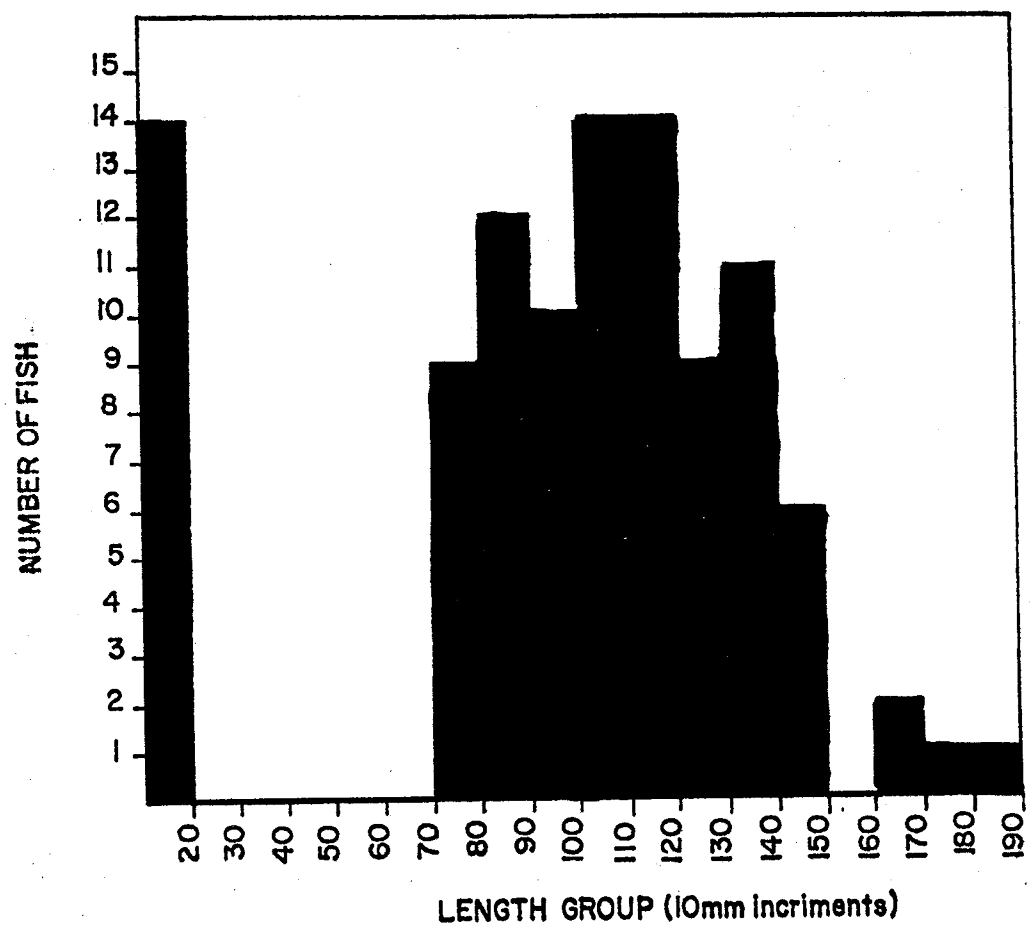


Figure 17. Length frequency of Arctic cod captured in Prudhoe Bay during 1975 and 1976.



Arctic cod were first captured in Prudhoe Bay during the second week of July. Daily catches were low for the remainder of July and first half of August then increased greatly through the second week of September. Large numbers of cod fry (corresponding to Age 0 fish above), were trawled offshore in Prudhoe Bay (2-4 m of water) during the second week of August 1975.

Arctic cod spawn near shore under the ice during January and February, however locations and timing of spawning have not been documented for the Beaufort Sea. Arctic cod eggs are the largest and fewest per female of all Gadidae and fecundity varies from 9,000 to 21,000 eggs (Andriyashev).

Arctic cod reportedly feed on phytoplankton and zooplankton including copepod eggs, nauplii, and copepods.

The examination of 12 stomachs indicated that cod feed primarily on mysids in Prudhoe Bay.

Fourhorn Sculpin

The distribution of the fourhorn sculpin is circumpolar. They are found in marine, brackish, and occasionally fresh water. The fourhorn sculpin is the most abundant marine species in our study area.

It occupies nearly all available habitats and was captured off several of the outer barrier islands, as well as in the low salinity waters of the major river deltas. Some life history aspects of fourhorn sculpin in the Beaufort Sea are discussed by Griffiths et al., (1975).

A total of 7,890 fourhorn sculpin was captured during this investigation. Total lengths ranged from 50 mm to 263 mm with a mean of 125 mm. Figure 18 shows the length frequency of fourhorn sculpin captured during 1975 and 1976.

Ages of fourhorn sculpin varied from I through VII years with the majority of fish captured in Age Classes II and III.

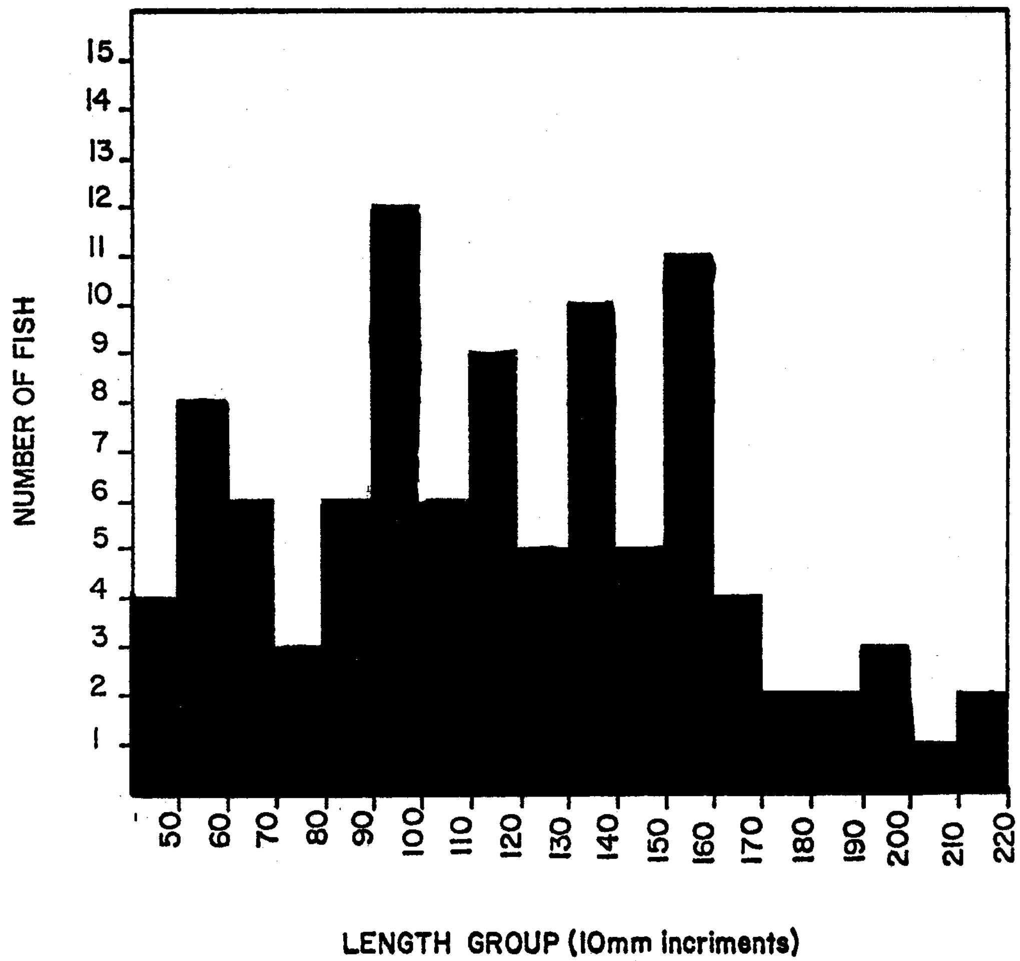
Fourhorn sculpin were the earliest marine species captured in Prudhoe Bay (June 23) and they were captured in abundance throughout the open water season.

Within the study area, fourhorn sculpin fed primarily on immature isopods, amphipods and juvenile Arctic cod.

Arctic Flounder

The Arctic flounder was the only marine flatfish taken near shore during the two years of this study. Little information is available on the life history of Arctic flounder taken in North American Arctic waters. McPhail and Lindsey (1970) delineate the worldwide distribution of Arctic flounder and Griffiths et al. (1975) examined a small sample of Arctic flounder captured in Nunaluk Lagoon, east of Barter Island.

Figure 18. Length frequency of fourhorn sculpin captured during 1975 and 1976.



Andriyashev (1964) provides other life history information for this species.

Arctic flounder were not common within the study area, however small numbers were captured throughout the open water season. Their near shore abundance was greatest near the mouth of the Colville River. Arctic flounder were captured near shore in Prudhoe Bay from the second week of July through the first week of September.

A total of 37 Arctic flounder was captured during the present study. Fork lengths ranged from 60 mm through 254 mm and averaged 191 mm (n=31). Figure 19 shows the length frequency of Arctic flounder captured during this study. The length distribution of Arctic flounder taken in Prudhoe Bay corresponds well with catches reported by Griffiths et al. (1975) and Andriyashev (1964).

Ages of Arctic flounder ranged from I to XII with the greatest number of fish captured at Age X. The growth rate of Arctic flounder is apparently very slow.

Sexual maturity is attained at the fourth or fifth year of life. Fecundity is 50,000-200,000 eggs and spawning takes place under the ice during January and February (Andriyashev). Mature individuals in Prudhoe Bay ranged from Age IV through Age XII. There were no Arctic flounder spawning or overwintering areas located in this study.

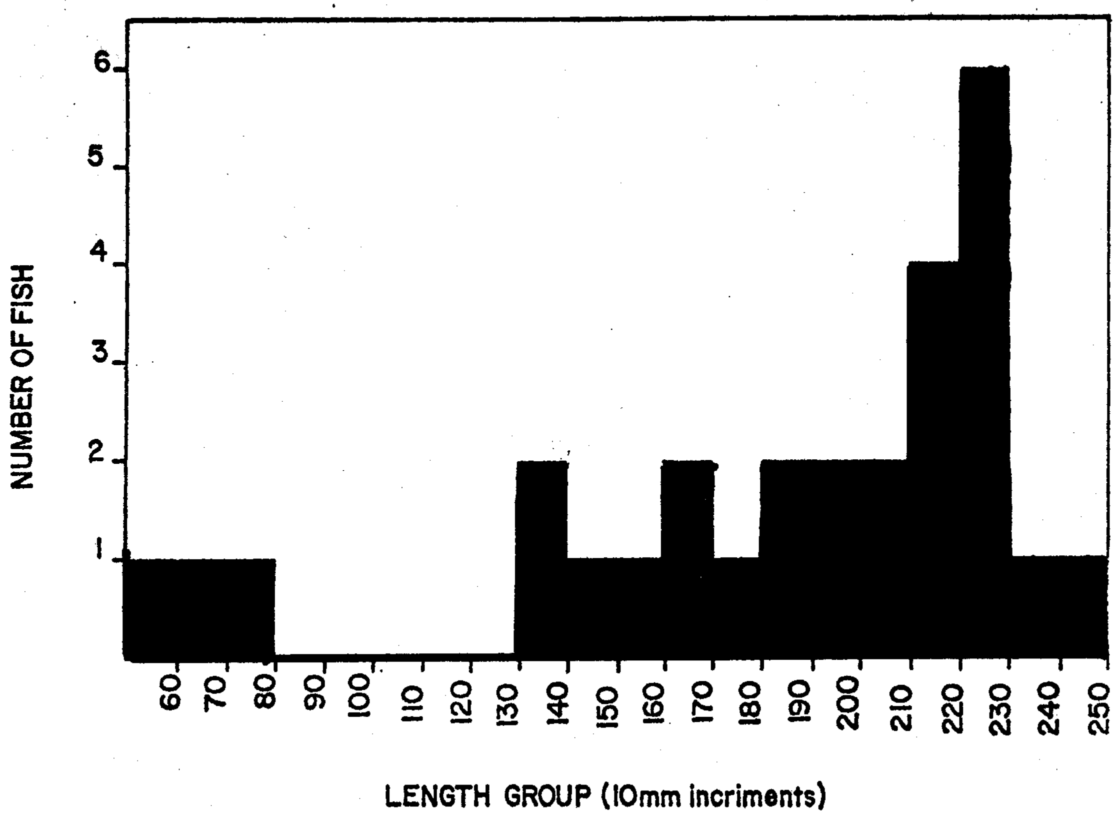
Arctic flounder reportedly feed on small fish, bivalve mollusks and small bottom invertebrates. In Prudhoe Bay, Arctic flounder feed primarily on amphipods and to a lesser extent on mysids and juvenile isopods.

Other Species

Two species of smelt (capelin and boreal smelt) were captured in low numbers throughout the study area. Of the two, capelin were the most abundant, but they were only captured during a two week period in mid-August when spawning took place within the surf along exposed gravel beaches. Young-of-the-year capelin were trawled in Prudhoe Bay during the same time period. A total of 60 capelin was captured during 1975 and 1976. Little information is available on the life history, spawning and overwintering habits of capelin. Andriyashev (1964) describes three spawning runs of capelin in the Barents Sea taking place from March through September. Near Pt. Barrow, capelin spawn in late July and August and are captured with hand nets by local residents for food. The importance of capelin in the marine trophic system is not clearly understood.

Fifty-five boreal smelt were captured during this study. They are distributed across the northern coast of Alaska and Canada and ascend the Mackenzie River as far as the Arctic Red River. During January and February, large numbers of boreal smelt are caught under the ice of the Kuk River Delta (near Wainwright, Alaska) by local residents. Boreal

Figure 19. Length frequency of Arctic flounder captured during 1975 and 1976.



smelt captured within the study area ranged from 92 mm to 251 mm with a mean of 146 mm. Ages varied from II through IX. Age III individuals comprised 64% of the catch and those individuals Aged IV and older were mature.

Saffron cod and an unidentified species of the genus *Liparus* were also captured in low numbers incidental to the other marine species. Fourteen saffron cod were captured between June and September, and 71 liparids were netted during the second and third weeks of September. Young-of-the-year liparids were trawled in Prudhoe Bay during late August.

Grayling, round whitefish and ninespine stickleback were captured sporadically and in low numbers throughout Prudhoe Bay during 1976. Only two ninespine stickleback were captured in September. Fourteen immature round whitefish were captured in July and August. Forty-seven grayling were captured in Prudhoe Bay between the last of June and the middle of August 1976. Grayling in Prudhoe Bay were captured in salinities that ranged from 1 ppt to 13 ppt.

FINDINGS 1977

Fish Migrations and Timing in Prudhoe Bay

The study in 1977 concentrated on anadromous fishes in Prudhoe Bay. The primary objective was to compare the timing and movement data gathered in 1977 with that of the same time period in 1976. A secondary objective was to tag as many of these fish as possible to further identify migration patterns of these fish.

The techniques for capture and tagging were identical to those employed during the 1976 field season in Prudhoe Bay. Data gathered in 1976 indicated that the period from mid-July to mid-August was the most productive time for capturing large numbers of anadromous fish of tagging size (over 200 mm). On July 12, 1977 fyke trap stations were established on both sides of the new Prudhoe Bay causeway on the northwest corner of the bay and on the west side of the old causeway on the eastern shoreline of the bay, approximately 15 km away (Fig. 20).

Stations were checked once or twice daily and all fish captured were enumerated and the numbers recorded on catch forms. All salmonids over 200 mm in length were tagged with orange or red Floy tags and released.

Physical parameters recorded at the stations each day included air temperature, water temperature and salinity.

Ice movement forced occasional removal of traps for short periods of time and storm action occasionally raised the water level so that the traps could not be checked, or lowered the water level so that the traps were not fishing efficiently. Fyke trapping was conducted until August 14.

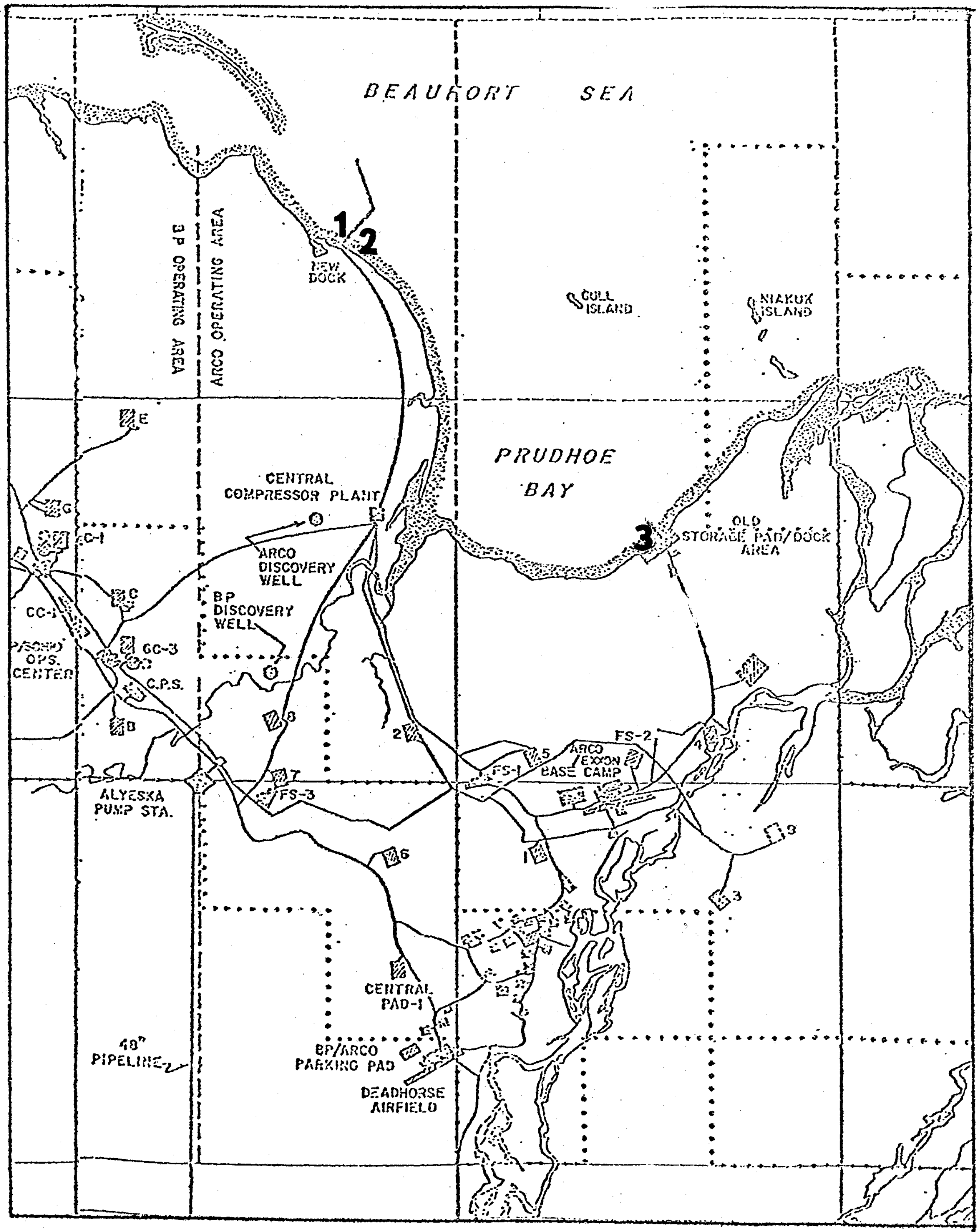


Figure 20. 1977 tagging stations in Prudhoe Bay. 1 - West New Dock, 2 - East New Dock, 3 - West Old Dock.

The numbers of each species captured at each station each day and the surges in numbers of fish caught were compared, where possible, to show the direction of movement.

The number of fish tagged was compared to the number of fish captured to determine the approximate percentage of fish over 200 mm in the catch. This gives us an idea of the percentage of larger, older fish in the bay

A total of 5,160 fish of all species was captured (Table 5), including 2,324 fish of the target species (Arctic char, Arctic cisco, broad whitefish, humpback whitefish, and least cisco). Nine hundred forty-one of these fish were tagged (Table 6). This compares with 6,354 anadromous fish captured during the same time period of 1976, of which 3,943 were tagged.

Water temperatures were slightly higher in 1977 than they were during the same period in 1976.

Salinities were significantly higher in 1977 than in 1976. The average salinity for the areas where capture stations were operated was as high as the highest salinity recorded for those areas during the equivalent period in 1976 (Table 7 and Appendix I).

High salinities in 1977 may have accounted for the lower numbers of all anadromous fish in the bay. Greater numbers of anadromous fish, especially Arctic char and least cisco, appeared to move into or through the bay in response to short term decreases in salinity. This was especially apparent at the West Old Dock and East New Dock capture stations (Appendix I).

This contrasts with results obtained in 1976, when, during periods of moderate or low salinity, no correlation could be made between fish abundance and increases or decreases in salinity. It is probable that the fish were remaining in areas of fresher water, such as river deltas, during the periods of high salinity in 1977.

Four of the fish tagged during the 1977 season were recaptured. Three of these (two least cisco and one char) were cpatured in the same locations where they were tagged from 2 to 8 days later and little could be learned from them. The fourth, a least cisco was recaptured by an Eskimo fisherman at Griffin Point, 241 km (150 mi) to the east, 20 days later.

Four Arctic char tagged in 1976 in Prudhoe Bay were recaptured in Prudhoe Bay in 1977. Their time out ranged from 342 days to 367 days and averaged 357 days.

Ten least cisco tagged in 1976 were recaptured in 1977. Their time out ranged from 364 days to 397 days and averaged 377 days. Two fish that were tagged and released consecutively in July of 1976 were recaptured in the same trap 370 days later. Two other least cisco tagged out of

Table 5. Fish species and number captured during the 1977 summer season at Prudhoe Bay.

Common Name	Scientific Name	OCS Species Code	Number Captured
Arctic char	Salvelinus alpinus	7904010402	903
Grayling	Thymallus arcticus	7904010701	3
Humpback whitefish	Coregonus pidschian	7904010104	16
Broad whitefish	C. nasus	7904010103	89
Least cisco	C. sardinella	7904010105	1,078
Arctic cisco	C. autumnalis	7904010101	238
Arctic cod	Boregadus saida	7909020201	647
Fourhorn sculpin	Myoxocephalus quadricornis	7915042206	2,171
Arctic flounder	Liopsetta glacialis	7917021101	7
Boreal smelt	Osmerus mordax	7904020302	7
Pink salmon	Oncorhynchus gorbuscha	8755010201	1
Total			5,160

Table 6. Comparison of numbers of anadromous fish captured and tagged during the period from July 13 to August 14 in 1976 and 1977. Percentages of total fish captured that were tagged are in parentheses.

Species	Number Captured 1976	Number Captured 1977	Number Tagged* 1976	Number Tagged* 1977
Arctic char	2,103	903	467 (22%)	232 (26%)
Arctic cisco	751	238	461 (61%)	139 (58%)
Broad whitefish	271	89	151 (56%)	34 (38%)
Humpback whitefish	132	16	124 (94%)	15 (94%)
Least cisco	3,097	1,078	2,740 (88%)	521 (48%)
Totals	6,354	2,324	3,943	941

* These numbers correspond to the numbers of fish with a fork length of 200 mm or greater.

Table 7. Average salinity and water temperature of Prudhoe Bay for period of July 13 to August 15, 1976 and 1977.*

Area	Average Temperature, °C 1976	Average Temperature, °C 1977	Average Salinity, PPT 1976	Average Salinity, PPT 1977
West Old Dock	8.0 (n=32)	9.0 (n=29)	5.0 (n=29)	14.0 (n=29)
East New Dock	7.5 (n=19)	8.0 (n=21)	11.0 (n=15)	15.0 (n=21)
West New Dock	5.5 (n=29)	6.0 (n=29)	6.5 (n=24)	22.0 (n=28)
Average all areas	7.0	8.5	7.5	17.0
Range all areas	2 - 14	2 - 17	0 - 17	2 - 32

* Derived from Appendix I.

the same trap the same day in 1976 were recaptured in the same trap in 1977 a day apart.

Movement, direction, and timing were about the same in 1977 for those species for which enough fish were captured to make a determination.

Arctic char, Arctic cisco and least cisco all exhibited approximately the same movement patterns in 1977 that they did during the same time period in 1976.

Arctic char showed eastward movement in late July and early to mid-August, with increasing percentages of larger, older fish in August.

There was a strong eastward movement of least cisco in late July and early August. Over half of these fish were larger, older fish. There was a westward surge of small fish in mid-August.

The only significant tag return, as of October 1977, was the least cisco that swam from Prudhoe Bay to Griffin Point. In 1976 during the same time period a least cisco took 21 days to do the same thing. This indicates that a portion of the least cisco population either ranges far to the east or that some of the Prudhoe Bay fish are of eastern origin. The 1976 results show the majority of least cisco in Prudhoe Bay were of Colville River origin.

The phenomenon of consecutively tagged least cisco being recaptured at the same time at the same location after a long period of time was observed several times and indicates strong schooling behavior among least cisco.

Arctic char and least cisco both started their late summer movement (char to the Sagavanirktok River and least cisco to the Colville River) slightly earlier than in 1976, probably in response to the higher salinity.

As in 1976, Arctic cisco movements were unclear. There were apparently small magnitude eastward movements in mid-July. Fifty-eight percent of the catch was composed of larger, older fish (fork length > 200 mm).

Broad whitefish and humpback whitefish were present in eastern Prudhoe Bay in small numbers in the last part of July and early August. The majority of broad and humpback whitefish may have remained off the river deltas all summer.

CONCLUSIONS

Species diversity of fish inhabiting the nearshore waters of the Beaufort Sea between Harrison Bay and Brownlow Point is low.

Freshwater and anadromous species are more abundant than marine species within the study area during the open water season.

The density of both anadromous and marine species is greatest shoreward of the 2 meter depth during the open water season.

The numbers of anadromous fish present in Prudhoe Bay may vary considerably from year to year.

Arctic fish are slow growing and late maturing and several species may only spawn in alternate years.

Stomach analysis indicates that fish utilizing the nearshore waters of the study area are opportunistic feeders, preying on a variety of marine epibenthic organisms, as well as fresh water invertebrates, aerial insects and other fish. Thus, a large scale reduction in invertebrate fauna may have a profound effect on the fishery.

The larger rivers draining into the study area serve as overwintering and spawning habitat as well as important migration corridors for anadromous fish utilizing the Beaufort Sea for the brief open water season.

Overwintering and fall spawning areas within river deltas are extremely sensitive to disruption due to the concentrated number of fish that are restricted to small pockets of under-ice water.

Large-scale gravel mining in river deltas can disrupt their hydrologic regime, thus affecting the availability of fall spawning and overwintering habitat.

Human use of fish resources within the study area is low, however sport fishing has been steadily increasing since the advent of North Slope oil development.

Data from 1974 through 1977 have shown that timing and patterns of fish movements in the bay are consistent and can probably be expected to occur similarily in future years.

LITERATURE CITED

Alt, K. T. 1971. Sheefish and whitefish investigations in Alaska. Alaska Dept. of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1970-1971.

__________. 1972. Sheefish and whitefish investigations in Alaska. Alaska Dept. of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1971-1972.

__________. 1973. Sheefish and whitefish investigations in Alaska. Alaska Dept. of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1972-1973.

__________. 1974. Sheefish and whitefish investigations in Alaska. Alaska Dept. of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1973-1974.

Alt, K.T. and R. Furniss. 1976. Inventory and cataloging of North Slope waters. Alaska Dept. of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, Project F-9-8, 17(G-I-0): 129-150.

Andriyashev, A. P. 1954. Fishes of the northern seas of the USSR Izdatel'stvo Akad. Nauk. SSR, Moskva-Leningrad. Translation from Russian, Israel Program for Scientific Translations. Jerusalem, 1964. 617 pp.

Berg, L. S. 1949. Freshwater fishes of the USSR and adjacent countries (translation). Zool. Inst. Akad. Nauk. 27, 39, 30.

Craig, P. and P. J. McCart. 1974. Fall spawning and overwintering areas of fish populations along routes of proposed pipeline between Prudhoe Bay and the MacKenzie Delta 1972-1973. Canadian Arctic Gas Study Limited, Biological Report Series 15(3)37.

__________. 1976. Fish use of nearshore coastal waters in the western Arctic: emphasis on anadromous species. IN: Assessment of the Arctic Marine Environment: Selected topics. Institute of Marine Sciences, University of Alaska, Fairbanks. pp 361-388.

Doxey, M. R. 1977. Fishery impact survey of the Atlantic Richfield Company causeway. Contractual investigation for Atlantic Richfield Co. of Alaska. Department of Fish and Game, Fairbanks: 1-36. (unpublished).

Furniss, R. A. 1974. Inventory and cataloging of Arctic area waters. Alaska Dept. of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, Project F-9-6, 15(G-I-I): 1-45.

__________. 1975. Inventory and cataloging of Arctic area waters. Alaska Dept. of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, Project F-9-7, 16(G-I-I): 1-47.

Glova, G., and P. McCart. 1974. Life history of Arctic char, Salvelinus alpinus, in the Firth River, Yukon Territory. Canadian Arctic Gas Study Limited, Biological Report Series 20(3)37.

Griffiths, W., P. C. Craig, G. Walder, and G. Mann. 1975. Fisheries investigations in a coastal region of the Beaufort Sea (Nunaluk Lagoon, Yukon Territory). Canadian Arctic Gas Study Limited, Biological Report Seriecs 34(2)219.

Griffiths, W., P. C. Craig, and J. den Beste. Fisheries investigations in a coastal region of the Beaufort Sea. Part 2 (Kaktovik Lagoon, Alaska). Canadian Arctic Gas Study Limited, Calgary, Alberta, Biological Report Series (in press).

Hatfield, C. T., J. N. Stein, M. R. Falk, and C. S. Jessop. 1972. Fish resources of the MacKenzie River Valley. Fisheries Service, Environment Canada, Interim Report I, Vols, I, II. 274p.

Johnson, R. L., and J. Rockwell, Jr. 1973. List of streams and other water bodies along the proposed Trans-Alaska pipeline route. Pipeline Division, Alaska State Office Bureau of Land Management.

Kendel, R. E., R. A. C. Johnston, M. D. Kozak, and V. Lobsiger. 1974. Movements, distribution, populations and food habits of fish in the western coastal Beaufort Sea. Fisheries and Marine Service, Environment Canada. Interim Report of Beaufort Sea Project Study B1. 64p.

Kogl, D. R., and D. Schell. 1975. Colville River Delta fisheries research. IN: Environmental Studies of an Arctic Estuarine System - Final Report. Institute of Marine Science, University of Alaska. Chapter 10 pp. 483-504.

Mann, G. J. 1974. Life history types of the least cisco, Coregonus sardinella Vallenciennes, in the Yukon Territory, North Slope, and eastern MacKenzie River delta drainages. Canadian Arctic Gas Study Limited, Biological Report Series 18(3). 160p.

__________. 1975. Winter fisheries survey across the MacKenzie Delta. Canadian Arctic Gas Study Limited. Geological Report Series 34(3). 54p.

McCart, P., P. Craig, and H. Bain. 1972. Report on fisheries investigations in the Sagavanirktok River and neighboring drainages. Report to the Alyeska Pipeline Service Company, Bellevue, Washington. 170p.

McPhail, J. D. 1966. The Coregonus autumnalis complex in Alaska and northwestern Canada. J. Fish. Res. Bd. Can. 23:141-148.

McPhail, J. D. and C. C. Lindsey. 1970. The freshwater fishes of northwestern Canada and Alaska. Fish. Res. Bd. Can. Bull. 173: 381p.

Namtvedt, T. (ed.) 1974. The Alaskan Arctic coast, a background study of available knowledge. Department of the Army Alaska District, Corps of Engineers Contract No. DACW85-74-C-0029. 551p.

Nikolsky, G. V. 1961. (special icthyology.) 2nd ed. IN: Russian; English translation by Israel Program for Scientific Translations. Jerusalem, 1961. 538p.

Percy, R., W. Eddy, and D. Munro. 1974. Anadromous and freshwater fish of the outer macKenzie Delta. Fisheries and Marine Service Environment Canada. Interim Report of Beaufort Sea Project Study B2. 51p.

Quast, J. C. 1974. Density distribution of juvenile Arctic cod, *Boreogadus saida*, in the eastern Chukchi Sea in the fall of 1970. Fish. Bull. U.S. 72(4): 1094-1105.

Roguski, E. A., and E. Komarek. 1971. Monitoring and evaluation of Arctic waters with emphasis on the North Slope drainages. Alaska Dept. of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, Project F-9-3, 12(G-III-A): 1-22.

State of Alaska. 1975. Proposed Beaufort Sea nearshore lease. Prepared by: Division of Policy Development and Planning, Office of the Governor. 491p.

Wohlschlag, D. E. 1954. Growth peculiarities of the cisco, *Coregonus sardinella* Vallenciennes, in the vicinity of Point Barrow, Alaska. Stanford Icthyol. Bull. 4:189-209.

Yoshihara, H. T. 1972. Monitoring and evaluation of Arctic waters with emphasis on the North Slope drainages. Alaska Dept. of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, Project F-9-4, 13(G-III-A): 1-49.

__________. 1973. Monitoring and evaluation of Arctic waters with emphasis on the North Slope drainages. Alaska Dept. of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, Project F-9-5, 14(G-III-A): 1-83.

APPENDIX I

Temperature, Salinity and Anadromous Fish Captured
in Prudhoe Bay, 1977

Area: West Old Dock

Period: July, August 1977

Date	Temp. °C	Salinity ppt	Arctic Char	Arctic Cisco	Least Cisco	Broad Whitefish	Humpback Whitefish
7/13	7.0	3.0	9	1	0	0	0
7/14	6.5	3.5	14	1	3	0	1
7/15	7.0	3.0	25	1	19	0	0
7/16	17.0	4.5	32	4	3	0	0
7/17	6.0	6.0	29	0	8	0	0
7/18			43	2	10	6	0
7/19	7.0	5.0	70	10	3	3	1
7/20	10.0	16.0	9	2	5	1	0
7/21	8.0	13.0	20	2	4	2	0
7/22	7.0	19.0	6	0	1	2	0
7/23	7.0	17.5	5	0	0	2	0
7/24	7.0	15.0			DID NOT FISH		
7/25	8.0	8.0	3	0	0	0	0
7/26	6.0	19.0	12	0	7	1	0
7/27	8.0	14.0	4	0	3	1	0
7/28	11.0	15.0	6	0	10	7	0
7/29							
7/30*	11.0	17.0	6	4	28	11	0
7/31	11.0	21.0	3	0	2	0	0
8/1	13.0	19.0	16	0	7	0	0
8/2	12.0	21.0	10	0	3	0	1
8/3	14.0	17.0	12	0	2	10	0
8/4	10.0	22.0	1	0	1	1	0
8/5	11.0	20.0	3	0	0	1	0
8/6	9.0	22.0	1	0	1	2	0
8/7	9.0	22.0	1	0	2	0	0
8/8	6.0	13.0	2	30	0	20	0
8/9**							
8/10							
8/11	6.0	12.0					
8/12	7.0	13.0					
8/13	5.0	13.0					
8/14	8.0	12.0	0	0	7	0	0

* Fish captured on 7/30 are two day totals.
**8/9 through 8/14 trap did not produce due to low water.

Area: East New Dock

Period: July-August, 1977

Date	Temp. °C	Salinity ppt	Arctic Char	Arctic Cisco	Least Cisco	Broad Whitefish	Humpback Whitefish
7/13							
7/14							
7/15	4.0	2.0	5	0	0	0	0
7/16*							
7/17							
7/18	2.0	5.5					
7/19							
7/20							
7/21							
7/22							
7/23							
7/24			0	0	2	0	0
7/25	6.0	5.0	10	4	106	0	0
7/26	6.0	11.0	6	1	26	0	1
7/27	7.0	8.5	8	0	7	2	3
7/28	8.0	19.0	7	2	29	0	1
7/29	11.0	19.0	5	0	2	0	0
7/30	11.0	21.0	5	0	1	1	2
7/31	10.0	14.0	22	0	10	1	0
8/1	10.0	12.0	28	0	12	0	0
8/2	11.0	15.5	24	0	6	0	0
8/3	11.0	24.0	3	0	0	0	0
8/4	11.0	22.0	1	0	1	0	1
8/5	10.0	19.0		0			
8/6	10.0	19.5	0	0		0	0
8/7**	5.0	27.0	19	0	14	1	2
8/8	7.0	19.0	0	0	3	0	0
8/9					DID NOT FISH		
8/10					DID NOT FISH		
8/11	5.0	12.0					
8/12	7.0	12.0	2	2	8	0	0
8/13	6.0	12.0	4	25	57	1	0
8/14	7.0	11.0	2	8	23	1	0

* Did not fish due to ice 7/16 through 7/23.
**Fish captured on 8/7 are totals of 8/5, 8/6 and 8/7.

Station 01 - 100 yards west of West Dock

Area: West New Dock

Period: July-August, 1977

Date	Temp. °C	Salinity ppt	Arctic Char	Arctic Cisco	Least Cisco	Broad Whitefish	Humpback Whitefish
7/13	3.0	2.0					
7/14	5.0	4.0	32	9	4	1	1
7/15	2.5	3.0	1	0	0	0	0
7/16	3.0	7.0		1	11		
7/17*							
7/18							
7/19	2.0	20.0					
7/20	8.0	24.5					
7/21	9.0	28.5					
7/22	6.0	15.5	5	4	27	0	0
7/23**	6.0	23.0	7	3	44	1	
7/24							
7/25	3.0	30.0					
7/26	4.0	32.0					
7/27	6.0	26.0					
7/28	6.0	26.0					
7/29	9.0						
7/30	9.0	26.0					
7/31	8.0	26.5					
8/1	6.0	29.0					
8/2	6.0	18.5					
8/3	9.0	26.5					
8/4	9.0	28.0					
8/5	5.0	30.0					
8/6	5.0	31.0					
8/7	7.0	23.0					
8/8	6.0	27.0					
8/9	5.0	19.0					
8/10	6.0	20.0					
8/11							
8/12	6.0	23.0					
8/13	6.0	26.0					
8/14	5.0	29.0					

* Did not fish 7/17 through 7/21.
**Capture station not operated after 7/23

Station 02 - West New Dock at shoreline

Area: West New Dock

Period: July-August, 1977

Date	Temp. °C	Salinity ppt	Arctic Char	Arctic Cisco	Least Cisco	Broad Whitefish	Humpback Whitefish
7/13	3.0	2.0	2	0	0	1	0
7/14	5.0	4.0	9	1	0	0	0
7/15*	2.5	3.0					
7/16	3.0	7.0					
7/17							
7/18							
7/19	2.0	20.0					
7/20	8.0	24.5	0	0	0	0	0
7/21	9.0	28.5	0	0	4	0	0
7/22	6.0	15.5	5	0	12	1	0
7/23	6.0	23.0	3	2	27	1	1
7/24			2	0	8	0	0
7/25	3.0	30.0	12	0	14	1	0
7/26	4.0	32.0	1	0	1	0	0
7/27	6.0	26.0	1	0	2	0	0
7/28	6.0	26.0	11	1	15	0	0
7/29	9.0		3	10	9	0	0
7/30	9.0	26.0	4	0	5	0	0
7/31	8.0	26.5	2	1	4	0	0
8/1	6.0	29.0	2	0	1	0	0
8/2	6.0	18.5	1	1	0	0	0
8/3	9.0	26.5	1	0	1	0	0
8/4	9.0	28.0	2	0	2	0	0
8/5	5.0	30.0	0	0	0	1	0
8/6	5.0	31.0	0	0	2	0	0
8/7	7.0	23.0	0	1	4	0	0
8/8	6.0	27.0	2	0	0	0	0
8/9	5.0	19.0	2	0	0	0	0
8/10	6.0	20.0	15	0	0	0	0
8/11					DID NOT FISH		
8/12	6.0	23.0	1	1	0	0	0
8/13	6.0	26.0	1	1	1	0	0
8/14	5.0	29.0	6	1	1	0	0

* Did not fish 7/15 through 7/19 due to ice.

Station 03 - 1/4 mile on causeway

Area: West New Dock

Period: July-August, 1977

Date	Temp. °C	Salinity ppt	Arctic Char	Arctic Cisco	Least Cisco	Broad Whitefish	Humpback Whitefish
7/13	3.0	2.0					
7/14	5.0	4.0	3	0	1	0	0
7/15	2.5	3.0			DID NOT FISH		
7/16	3.0	7.0	1	1	0	0	0
7/17*							
7/18							
7/19	2.0	20.0					
7/20	8.0	24.5					
7/21	9.0	28.5					
7/22	6.0	15.5					
7/23	6.0	23.0					
7/24			11	9	119	2	1
7/25	3.0	30.0	16	4	144	0	0
7/26	4.0	32.0	5	2	13	0	0
7/27	6.0	26.0	1	0	14	0	0
7/28	6.0	26.0	98	8	28	0	0
7/29	9.0		18	6	34	0	0
7/30	9.0	26.0	8	1	32	0	0
7/31	8.0	26.5	2	0	4	0	0
8/1	6.0	29.0	4	1	7	0	0
8/2	6.0	18.5	2	1	1	0	0
8/3	9.0	26.5	10	3	5	0	1
8/4	9.0	28.0	11	0	3	1	0
8/5	5.0	30.0	5	6	6	0	0
8/6	5.0	31.0	2	0	2	0	0
8/7	7.0	23.0					
8/8**	6.0	27.0	22	3	10	0	0
8/9	5.0	19.0	13	8	7	0	0
8/10	6.0	20.0			DID NOT FISH		
8/11					DID NOT FISH		
8/12	6.0	23.0	4	1	1	3	
8/13	6.0	26.0	1	4	5		
8/14	5.0	29.0	17	0	4	0	0

* 7/17 through 7/23 did not fish
**Fish captured on 8/8 are two day totals

PRELIMINARY OBSERVATIONS ON THE DISTRIBUTION ABUNDANCE AND FOOD HABITS OF SOME NEARSHORE FISHES IN THE NORTHEASTERN GULF OF ALASKA

Research Unit 542

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ABSTRACT

The marine fishes are an important component of the inshore fauna of the Gulf of Alaska. Direct observations of fishes living in both exposed and protected habitats of the north Gulf Coast/Prince William Sound region were made while diving from 1974-77. A total of 44 species of fish were observed in these shallow water habitats. Six species were previously unreported in these waters, and therefore represent northern range extensions in the Eastern Pacific. One hundred and ninety specimens were collected and examined for food items; the foraging habits varied considerably depending on the habitat and the species of fish. Dietary trends were identified, important prey of the bottom feeders included amphipods, isopods, crabs, snails, mussels and brittle stars. Trophic interaction or links in the food web between the fishes and their prey are also presented.

Numerical data was also collected on relative abundance and occurrence in the nearshore zone during August, 1977. In all, 1410 square meters of sea floor were examined quantitatively at Schooner Rock, Hinchinbrook Entrance and Danger Island, Montague Strait. The numerical dominants in the band transects during daylight hours were black rockfish (Sebastes melanops); china rockfish (Sebastes nebulosus); kelp greenling (Hexagrammos decagrammus); lingcod (Ophiodon elongatus) and alaskan ronquil (Bathymaster caeruleofasciatus). Fishes that were common in more protected locations during summer included the pacific tomcod (Microgodus proximus); pink salmon (Oncorhynchus gorbuscha), whitespotted greenling

(*Hexagrammos stelleri*), and great sculpin (*Myoxocephalus* spp.).

Descriptions of major habitat types, and summer distributions of inshore pelagic and demersal species are presented in relation to substrate type, depth and vegetation. The emphasis was placed on the characteristic or conspicuous fishes that were believed to be either numerical or functional dominants in the nearshore system.

INTRODUCTION

The present report deals with the marine fishes of the northeastern Gulf of Alaska. More specifically, the teleostean fishes that typically inhabit the inshore zone from the intertidal/subtidal fringe out to depths of around -30 meters. The nearshore fish assemblages of southern Alaska are for the most part poorly understood. Most of the information is at best, only fragmentary, or based on studies from other areas of the north Pacific (see Isakson, Simenstad and Burgner 1971; Simenstad and Nakatani 1977, etc.). For example, even though "there are more than 50 scorpaenids (rockfishes) endemic to the Pacific Coast of North America, the food habits of only a few are known" (Prince and Gotshall, 1976). Reproductive and early life history studies of several species of rockfish have been conducted by Westrheim (1975) off British Columbia and southeastern Alaska, however, most of the samples were obtained offshore. Therefore, until more is known about the habits of the inshore fishes of the Pacific rim, these studies will provide only a frame of reference for future work.

Still, the problem remains that the nearshore fishes and their respective habitats are most certainly vulnerable to disturbances and perturbations associated with OCS development in the Gulf of Alaska. It became apparent from the onset that a different kind of sampling program was needed in order to adequately describe these shallow water assemblages. For the most part, the use of conventional biological sampling gear such as grabs, trawls and nets is severely restricted in shoal areas that are dominated by rocky, irregular substrata and dense vegetation. To this end, we relied on another scientific approach - one that involved diving in which direct observations and the acquisition of data is obtained simultaneously. Examples of this *in situ* approach can be obtained by examining the pioneer works of Limbaugh (1955) who studied the fishes of the southern California kelp beds, to more recent studies by Hobson and Chess (1976) who described the interactions of fishes and their major prey species off Santa Catalina Island. The contribution that has been made by these and other diver-biologists over the past 2 decades are broad based, and certainly goes beyond the expectations of most investigators engaged in marine research.

This study was funded by NOAA/OCSEAP under the auspices of the environmental assessment of the Alaska Continental Shelf. The initial intent of this work was to synthesize unpublished field notes on certain fishes of the northeastern Gulf of Alaska (NEGOA), and to augment these data with a summer field survey during 1977. This investigation by design is admittedly limited in scope, and what is needed now is an intense exploration which would go beyond these observations, and adequately describe the nearshore fish assemblages and the role(s) of the key species in the natural system.

SAMPLING METHODS

Direct observations were made while scuba diving at depths from MLLW to 32.0 meters below the sea surface. The diving observations were conducted during daylight hours from 0800 to 1900 hours. Several types of quantitative information were collected about the characteristic or conspicuous fishes that were present in each location. Included were estimates of fish density (number of specimens per meter^2) which were usually obtained from band transects of varying dimension. The transect lines were placed at both predetermined and haphazard (unbiased) locations in the subtidal zone, and were usually run along a specific depth contour. The lines were occasionally left on the sea floor between dives, in order to check sample error, and to recount after an elapsed time interval of 1-2 hours. Replicated 0.25 M^2 quadrats were also placed in a random manner, or stratified in such a way that a particular habitat or microhabitat was sampled in the sublittoral zone.

Samples of inshore fishes were obtained during 1974-77, from the protected waters of Port Valdez to exposed locations in the northeastern Gulf of Alaska. Most of the specimens that were taken for food habits were collected with spears and mesh bags. The remainder were collected with either a variable mesh, monofilament gill net or were taken by hook and line. All specimens were measured to the nearest centimeter, standard length. The sex, gonad condition and weight (grams) was recorded for specimens obtained during August 1977. Stomachs were extracted after capture and either examined fresh under dissecting microscope, or preserved for future identification and analysis. Some of the fishes were sent to Dr. Robert Lavenberg, Curator of Fishes, Los Angeles County Museum of Natural History, for taxonomic verification and were subsequently placed into the LACM fish collection.

In addition to the numerical information, species-specific interactions or natural history phenomena involving feeding, reproduction and/or spatial distribution were recorded in situ. These methods assisted in describing conditions at each study site and permitted examination of the similarities or differences between study locations.

DESCRIPTION OF THE MAJOR STUDY SITES

The summer (1977) field survey was conducted in two key locations: (1) the ocean entrance to Montague Strait off Danger Island, and (2) the west side of Hinchinbrook Entrance at Schooner Rock and Zaikof Point (Figure 1). Both areas are known to be important centers of fish activity, and have been targeted as possible sites of oil and gas impingement because of oceanic circulation patterns and tanker traffic in the northern Gulf of Alaska. The waters of Prince William Sound are for the most part protected from deep sea swells and ocean surf originating in the Gulf. However, the major areas we chose to investigate were more exposed and as such represent fish assemblages that are more typical of the outer coast.

Danger Island

Danger Island is situated on the southwest edge of Prince William Sound. The site is strategically positioned between Latouche Passage on the north and Montague Strait to the south (Figure 2). These waterways are major arteries that connect the Sound to the Gulf of Alaska. An extensive reef extends for approximately 4 km off Latouche Point and eventually merges with Danger Island. The entire reef complex is exposed to westerly ocean swells, and a great deal of drift accumulates along the beachlines, especially during spring and fall. Tidal currents are typically moderate to weak in the lee of Latouche Island, however, further offshore where the water mass is not deflected by land, tidal currents can exceed 3 nautical miles per hour.

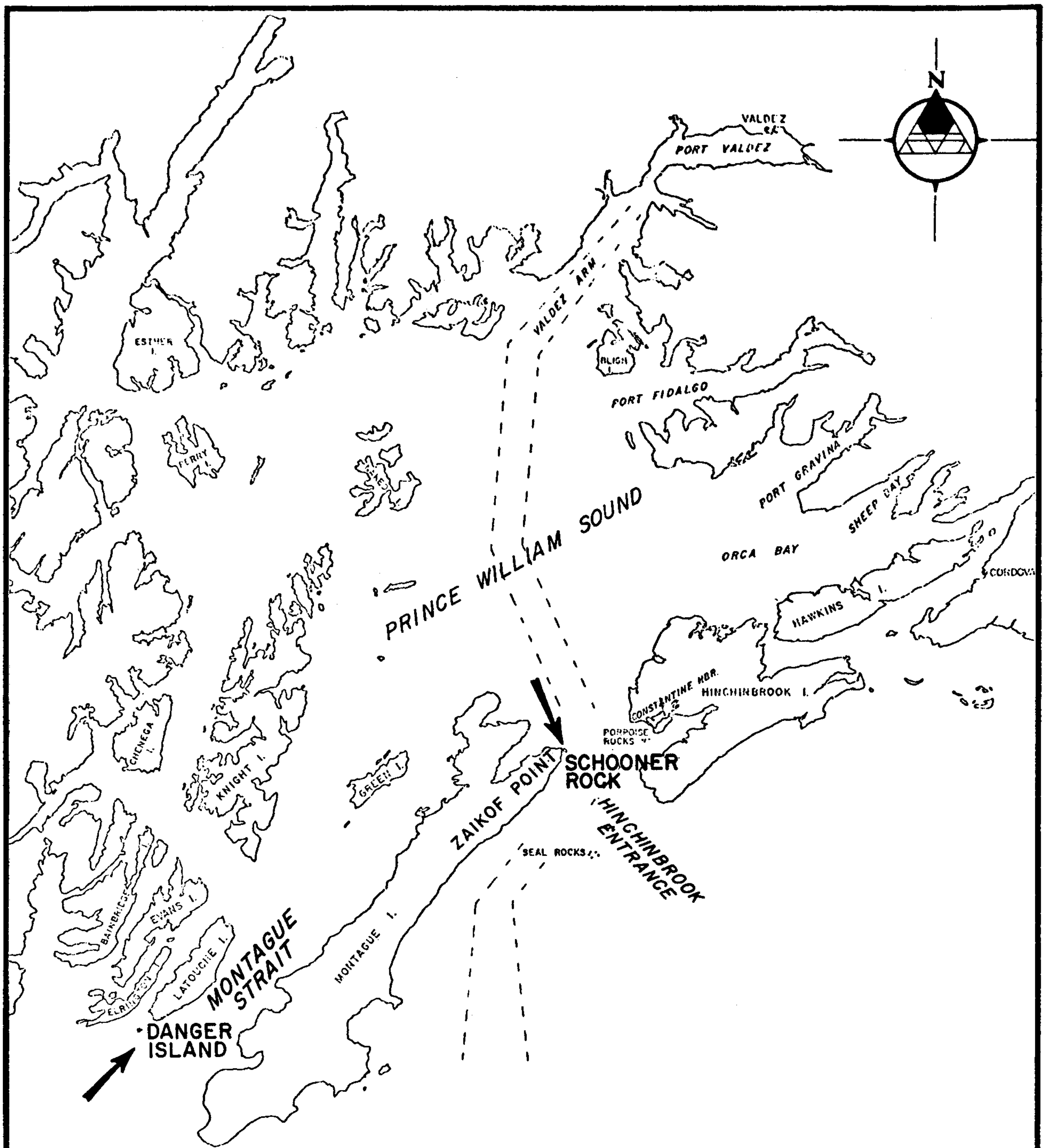

FIGURE 1

SHALLOW WATER STUDY SITES
IN
NORTHEASTERN GULF OF ALASKA

NAUTICAL MILES
0 10 20 30

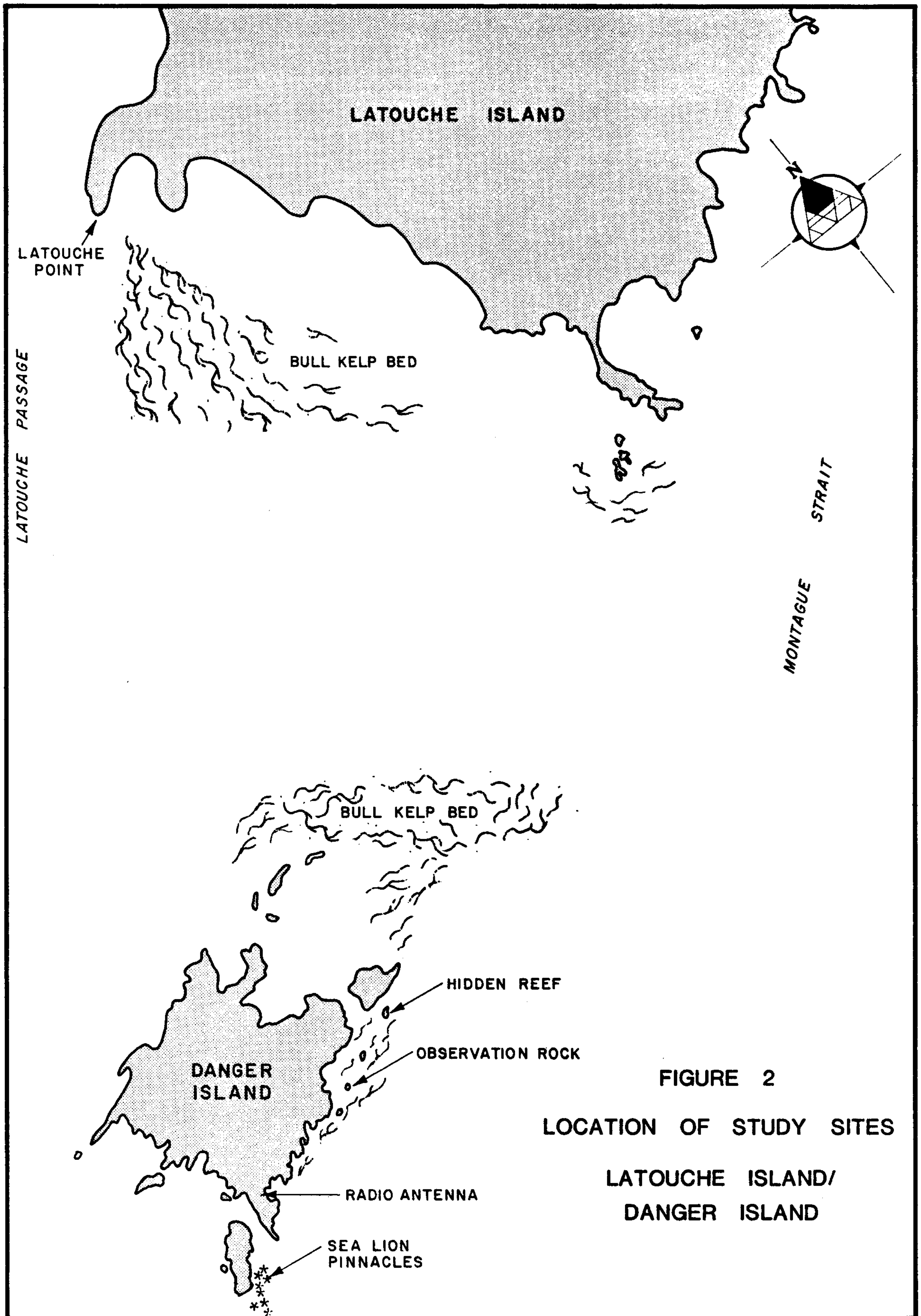

FIGURE 2

LOCATION OF STUDY SITES

LATOUCHE ISLAND/ DANGER ISLAND

The shallow subtidal zone is heterogeneous in relief. The bottom substratum consists primarily of rock pavement overlain by boulders and cobbles. Numerous fractures and surge channels cut through the rock substrate, usually the resulting depressions are collection points for coarse sands, gravel and shell debris. Vertical relief on the southern end of Danger Island is sharp, with recorded depths of 30 fathoms only a few hundred meters off the rocky shoreline. Most of the direct observations were made at "Hidden Reef", "Observation Rock", "Sea Lion Pinnacles" and "Latouche Point" (Figure 2). During summer months a large bed of bull kelp (*Nereocystis luetkeana*) grew on the shoal area between Latouche Point and Danger Island, and smaller patches fringed the steeply sloped shores of Danger Island.

Schooner Island/Zaikof Point

A small rocky islet off the eastern end of Zaikof Point was chosen as the primary sampling station in Hinchinbrook Entrance. Most of the underwater observations were made on the north side of the island, below a light that has been installed as an aid to coastal navigation (Figure 3). The leeward (north) side of Schooner Rock appears to be somewhat protected from wave shock, however tidal currents are intense. For example, on an incoming tide the surface water boiled and eddied around the island with such force that underwater activities were generally confined to the north face of the reef. Conversely on an ebb, the opposite was in affect as the water flowed out of the Sound. The pulse was such that flotsam or debris drifting by on the sea surface usually reappeared on the next phase of the tide. The surface waters around the

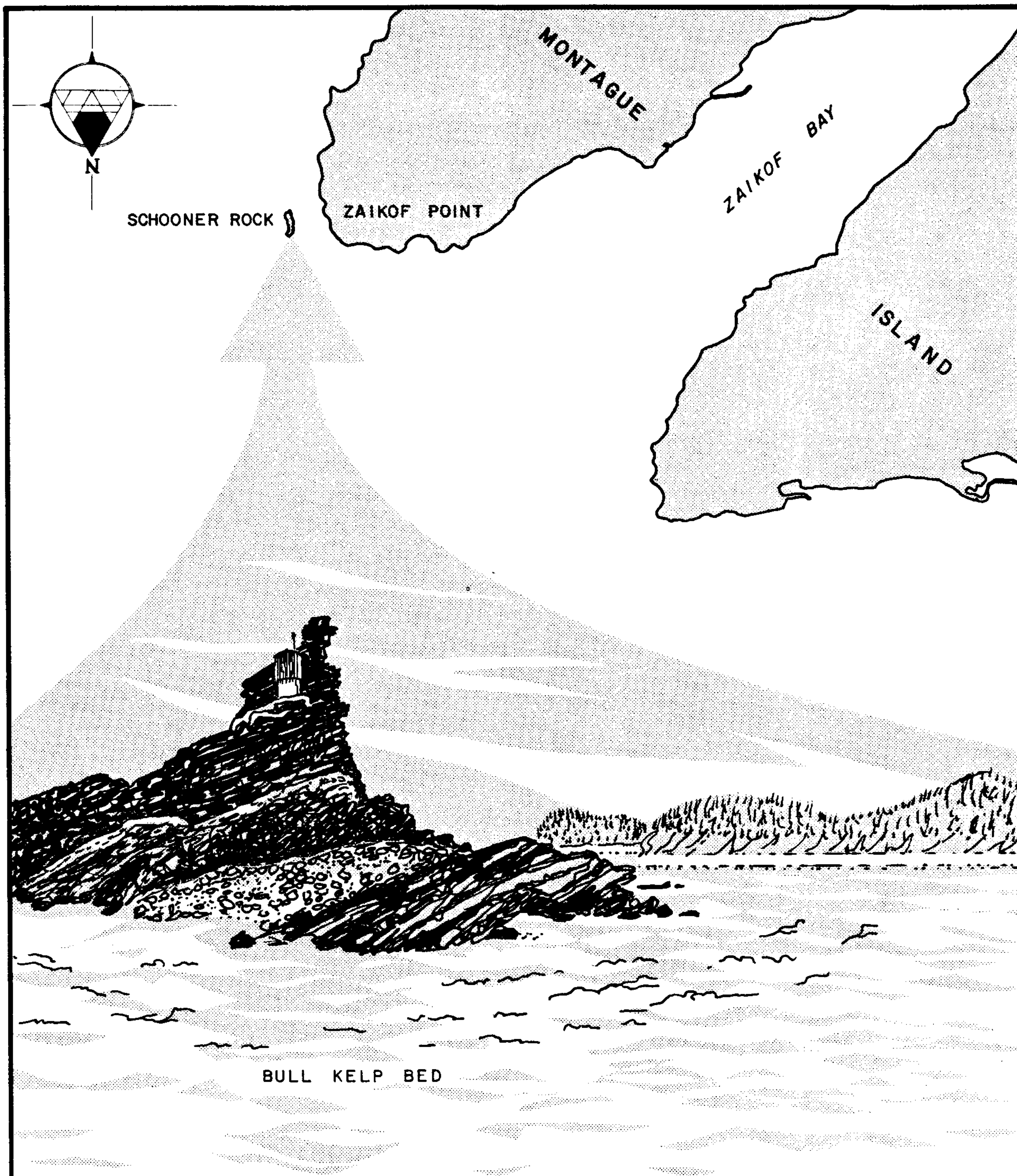

FIGURE 3

NEARSHORE STUDY SITE
SCHOONER ROCK, HINCHINBROOK ENTRANCE

reef are occasionally exposed to storm force winds that generally blow southeasterly from Port Etches in the direction of Zaikof Point.

Small stands of bull kelp grew close to Schooner Rock, and a much larger bed extended seaward off Zaikof Point. The underlying reef below the rocky intertidal zone was composed of pavements, cobbles and boulders. Vertical relief is gradual and then drops off sharply approximately 40 m from the shoreline. A submarine boulder field occurs at this point, around 12.0 meters below the sea surface. North of the boulder field is an expanse of sand interspersed with small rocks and shell debris. Above the boulder field the macrophytic cover was moderate to heavy, however below and out to a depth of 24 meters the benthic vegetation was sparse to absent.

Some physical oceanographic measurements were obtained during this time frame. Sea surface temperatures varied from 13.5 C to 14.0 C during the August (1977) survey. Water transparency was determined by making either visual observations while submerged, or estimating transparency with the aid of a standard white secchi disc. Estimates of downward irradiance averaged 8.0 meters, while corresponding horizontal visibility underwater ranged from 5.0 to 13.0 meters depending on the depth and the stage of the tide.

RESULTS

NEARSHORE FISHES AND THEIR HABITATS

Macrophyte Assemblage (exposed)

The marine macrophytes (seaweeds and seagrasses) formed a conspicuous band along the shores of Danger Island and Schooner Rock. The width of the band varied, however, it usually extended from the intertidal zone down to approximately 30 meters below the sea surface. Bull kelp (*Nereocystis luetkeana*) was the visual dominant in the floating canopy. Individual plants were found from the intertidal - subtidal fringe, out to depths of around 20 m. The average density of bull kelp during all sample periods was 0.35 ind./m^2 at Latouche Point and 1.48/m^2 at Danger Island (Rosenthal, 1977). Relative abundance was similar in Hinchinbrook Entrance; the average plant density in the bull kelp bed at Schooner Rock was 1.75 ind./m^2.

Beneath the floating or surface canopy was a multi-layered undergrowth of brown and red algae. These summer canopies were composed of the annual brown alga *Cymathere triplicata*, which covered substantial portions of the underlying sea floor. Another layer was comprised of *Laminaria groenlandica*, *L. yezoensis*, *L. dentigera*, and *Pleurophycus gardneri*. *Pleurophycus* was the most abundant kelp in the algal understory at Danger Island. The final layer of brown algae was dominated by sieve kelp (*Agarum cribrosum*) and hair-like growth forms of *Desmarestia*.

Below the brown algal guild were foliose reds such as

Callophyllis spp., Ptilota filicina, Opuntiella californica, and Membranoptera spp.. Crustose and articulated corallines formed the final vegetative veneer on the rock surfaces. It is an extrememly robust system; at least 60 species of macroalgae are commonly seen in shallow waters of the northern Gulf, and estimates of seaweed standing crop range as high as 20 kg fresh weight/m^2 during summer.

The seaweed canopies at both Danger Island and Schooner Rock provided food and cover for the animal components of the system. Of the some 44 species of fish collected from the area (Table 1), only about 9 species are listed as characteristic of outer coast or exposed macrophyte assemblages (Table 2). Both demersal and schooling pelagic fishes congregated in these nearshore habitats. For example, during August and early September, juvenile pacific herring (Clupea harengus pallasi) frequently appeared around the seaweed canopies. Juvenile herring also hovered in quite schools along the rocky shoreline, and feeding during daylight hours was directed at plankton drifting in the water column. Adult herring were not seen in these same habitats during summer months, however they did occur in the shallow sublittoral zone during spring.

Another important pelagic species, which occurred in dense schools at both study sites was the pacific sand lance (Ammodytes hexapterus). Sand lance also concentrated around the margins of the bull kelp forest, and these inshore schools frequently formed compact units which directed their feeding near the sea surface.

A third schooling species which occurred in this habitat was the

Table 1

LIST OF FISHES CAPTURED IN THE NEARSHORE WATERS OF THE NORTHEASTERN GULF OF ALASKA

COMMON NAME	SCIENTIFIC NAME	LOCATION
Pink Salmon	Oncorhyncus gorbuscha	D,S
Walleye Pollock	Theragra chalcogramma	S
Pacific Tomcod	Microgadus proximus	D,S
Pacific Cod	Gadus macrocephalus	S
Tube-Snout	Aulorhynchus flavidus*	D,S
Searcher	Bathymaster signatus	Port Valdez
Alaskan Ronquil	B. caeruleofasciatus	D,S
Pacific Sand Lance	Ammodytes hexapterus	D,S
Copper Rockfish	Sebastes caurinus	D
?Dusky Rockfish	S. ciliatus	D
Yellowtail Rockfish	S. flavidus*	D,S
Quillback Rockfish	S. maliger	D,S
Black Rockfish	S. melanops	D,S
China Rockfish	S. nebulosus*	D,S
Tiger Rockfish	S. nigrocinctus	S
Yelloweye Rockfish	S. ruberrimus	D
Kelp Greenling	Hexagrammos decagrammus	D,S
Rock Greenling	H. lagocephalus	D,S
Whitespotted Greenling	H. stelleri	D,S
Lingcod	Ophiodon elongatus*	D,S
Padded Sculpin	Artedius fenestralis	D,S
Sharpnose Sculpin	Clinocottus acuticeps	D
Antlered Sculpin	Enophrys diceraus	D
Red Irish Lord	Hemilepidotus hemilepidotus	D,S
Yellow Irish Lord	H. jordani	D
?Blackfin Sculpin	Malacocottus kincaidi	D
Great Sculpin	Myoxocephalus polyacanthocephalus	D
--------------	Myoxocephalus sp.	D
Sailfin Sculpin	Nautichthys oculofasciatus*	Port Chalmers
Grunt Sculpin	Rhamphocottus richardsoni	D
Crested Sculpin	Blepsias bilobus	D,S
Silverspotted Sculpin	B. cirrhosus	D
Sturgeon Poacher	Agonus acipenserinus	S
Pacific Spiny Lumpsucker	Eumicrotremus orbis	S
Marbled Snailfish	Liparis dennyi	Port Fidelgo
Wolf-Eel	Anarrhichthys ocellatus	D,S
Snake Prickleback	Lumpenus sagitta	S
Arctic Shanny	Stichaeus punctatus*	D,S
Decorated Warbonnet	Chirolophis decoratus	Port Valdez
Crescent Gunnel	Pholis laeta	D
Pacific Herring	Clupea harengus pallasi	D,S
Pacific Halibut	Hippoglossus stenolepis	D,S
Rock Sole	Lepidopsetta bilineata	D,S
Yellowfin Sole	Limanda aspera	S
Starry Flounder	Platichthys stellatus	S

D = Danger Island/Latouche Point
S = Schooner Rock/Zaikof Bay
* = Range Extension

Table 2

CHARACTERISTIC FISHES MOST FREQUENTLY SEEN IN THE FOUR HABITATS DURING SUMMER

Boulder Field	Macrophyte Assemblage (exposed)	Macrophyte Assemblage (protected)	Soft Bottom
Kelp Greenling	Kelp Greenling	Kelp Greenling	Pacific Halibut
Lingcod	Rock Greenling	White-spotted Greenling	Rock Sole
Quillback Rockfish	Pacific Sandlance	Pacific Tomcod	Starry Flounder
China Rockfish	Black Rockfish	Tube-snout	Yellowfin Sole
Yellowtail Rockfish	Rockfish (juveniles)	Pacific Sandlance	Pacific Sandlance
Black Rockfish	Red Irish Lord	Copper Rockfish	
Tiger Rockfish	Pacific Herring (juvenile)	Rockfish (juveniles)	
Yelloweye Rockfish	Pacific Tomcod	Yellow Irish Lord	
Rockfish (juveniles)	Tube-snout	Pacific Herring	
Wolf-eel		Searcher	
Alaskan Ronquil		Arctic Shanny	
Red Irish Lord		Great Sculpin	
		Antlered Sculpin	
		Sturgeon Poacher	
		Rock Sole	
		Starry Flounder	
		Crescent Gunnel	
		Pink Salmon	
		Scalyhead Sculpin	
		Pacific Staghorn Sculpin	

tube-snout (*Aulorhynchus flavidus*). The reported northern range of *Aulorhynchus* was southeast Alaska (Quast and Hall, 1972), however, our observations extend the northern distribution of this species into Prince William Sound. Tube-snout usually concentrated in small schools around beds of seaweeds and seagrasses. Most of their foraging activities seemed to be directed at plankters that occurred on or near the bottom vegetation.

Aggregations of juvenile rockfish (*Sebastes*) appeared inshore during summer months. Sometimes these schools were mixed with different species, e.g. black rockfish (*Sebastes melanops*), yellowtail rockfish (*S. flavidus*) and numerous unidentified *Sebastes*. These rockfish were active during the day, and frequently hovered in small to moderate sized schools along the edges of the kelp forest. Most of the feeding was directed at prey species in the water column. Adult black rockfish also migrated into these shallower zones, however the adults were usually segregated from the juveniles.

The pacific tomcod (*Microgadus proximus*) was also found in these exposed locations. However, most of the individuals appeared to be large juveniles. Since their frequency and abundance was greater in more protected macrophyte assemblages, their biology will be presented in a following section.

Numerous solitary bottom dwellers were also common in these exposed habitats. One of these, the red irish lord (*Hemilepidotus hemilepidotus*) was usually seen on a rocky bottom concealed by the vegetative undergrowth. Estimates of density ranged from 0 to $0.04/m^2$ at Schooner Rock (Tables 3 & 4), however, no _H. hemilepidotus_ occurred in the band transects at Danger Island even though this species was seen on most of the dives. Four specimens were captured in these locations during August , 1977. The diet consisted heavily of a small rock crab, _Cancer oregonensis_; it occurred in 2/4 of the samples and made up 75 percent of the total prey. The other important prey species were a brittle star (_Ophiopholis aculeata_), hermit crabs (_Pagurus_ spp.) and an unidentified cottid.

Table 3

DENSITY ESTIMATES OF SOME CONSPICUOUS FISHES
AT SCHOONER ROCK, HINCHINBROOK ENTRANCE

Species	8/15/77	8/16/77	8/16/77	8/16/77*
Sebastes melanops (Black Rockfish)	0	0	0	28 0.05/m^2
Sebastes nebulosus (China Rockfish)	0	0	0	0
Sebastes nigrocinctus (Tiger Rockfish)	0	0	0	0
Sebastes spp. (Juveniles)	0	0	0	present
Sebastes maliger (Quillback Rockfish)	0	0	0	0
Hexagrammos decagrammus (Kelp Greenling)	2 0.08/m^2	3 0.05/m^2	4 0.07/m^2	2 0.03/m^2
Hexagrammos lagocephalus (Rock Greenling)	1 0.04/m^2	0	0	0
Ophiodon elongatus (Lingcod)	0	1 0.02/m^2	1 0.02/m^2	0
Bathymaster caeruleofasciatus (Alaskan Ronquil)	6 0.24/m^2	0	2 0.03/m^2	4 0.07/m^2
Hemilepidotus hemilepidotus (Red Irish Lord)	0	0	0	0
Anarrhichthys ocellatus (Wolf-Eel)	0	0	0	0
Area Sampled:	25 x 1m	30 x 2m	30 x 2m	30 x 2m
Depth (meters):	7.6-9.0	17.0-18.0	16.5	16.5
Substrate:	Bo & Ledg	Bo & Sa	Bo & Sa	Bo & Sa

* = Repeat of preceding transect (1-2 hrs. later in the day)

Table 4

DENSITY ESTIMATES OF SOME CONSPICUOUS FISHES
AT SCHOONER ROCK, HINCHINBROOK ENTRANCE

Species	8/16/77	8/17/77	8/17/77	8/18/77
Sebastes melanops (Black Rockfish)	0	11 0.12/m^2	31 0.52/m^2	0
Sebastes nebulosus (China Rockfish)	0	1 0.01/m^2	1 0.02/m^2	0
Sebastes nigrocinctus (Tiger Rockfish)	0	1 0.01/m^2	0	0
Sebastes spp. (Juveniles)	10 0.33/m^2	0	0	0
Sebastes maliger (Quillback Rockfish)	0	1 0.01/m^2	2 0.03/m^2	0
Hexagrammos decagrammus (Kelp Greenling)	3 0.10/m^2	4 0.04/m^2	0	0
Hexagrammos lagocephalus (Rock Greenling)	0	0	0	0
Ophiodon elongatus (Lingcod)	0	1 0.01/m^2	0	0
Bathymaster caeruleofasciatus (Alaskan Ronquil)	0	24 0.27/m^2	0	0
Hemilepidotus hemilepidotus (Red Irish Lord)	0	1 0.01/m^2	0	1 0.04/m^2
Anarrhichthys ocellatus (Wolf-Eel)	0	0	0	2 0.08/m^2
Area Sampled:	15 x 2m	30 x 3m	30 x 2m	25 x 1m
Depth (meters):	11.5	13.5	12.5-13.5	16.5-18.0
Substrate:	Bo	Bo	Bo	Bo & Kelp

* = Report of preceding transect (1-2 hrs. later in the day)

Hexagrammos decagrammus (Pallas) - Kelp Greenling

The kelp greenling was the most widely distributed and most numerous hexagrammid in the northern Gulf of Alaska. It was particularly common in exposed or semi-exposed habitats, which were dominated by rocky substratum and macroscopic algae. Kelp greenling were found as far north as Port Valdez, and the reputed southern range is La Jolla, California (Miller and Lea 1972). Density estimates at Danger Island during late August 1977 varied from 0 to $0.10/M^2$ with an average density in all of the band transects (1,008 sq. m) of $0.06/M^2$ (Tables 5-8). Estimates at Schooner Rock were remarkabley similar; the range was 0 to $0.10/M^2$ and the average was $0.05/M^2$ in the 410 sq. m of sea floor that was examined during August 1977 (Tables 3 & 4).

The kelp greenling was commonly seen throughout the subtidal vegetative band; it was also one of the more conspicuous reef fishes in the boulder field habitat below -22 m (Figure 4). The color was highly variable depending on the time of year, reproductive state and habitat where each fish was collected. Generally there were two distinct color phases in mature *H. decagrammus*, the males were green to coppery brown with blue spots, and the females were brown to reddish orange with orange spots.

Twenty-seven specimens were collected for information on food habits and of these all 27 had some identifiable food items in their stomachs. Stomach fullness ranged from 10-100 percent, with an average fullness of 61.0 percent. These specimens ranged in size from 8.8 cm

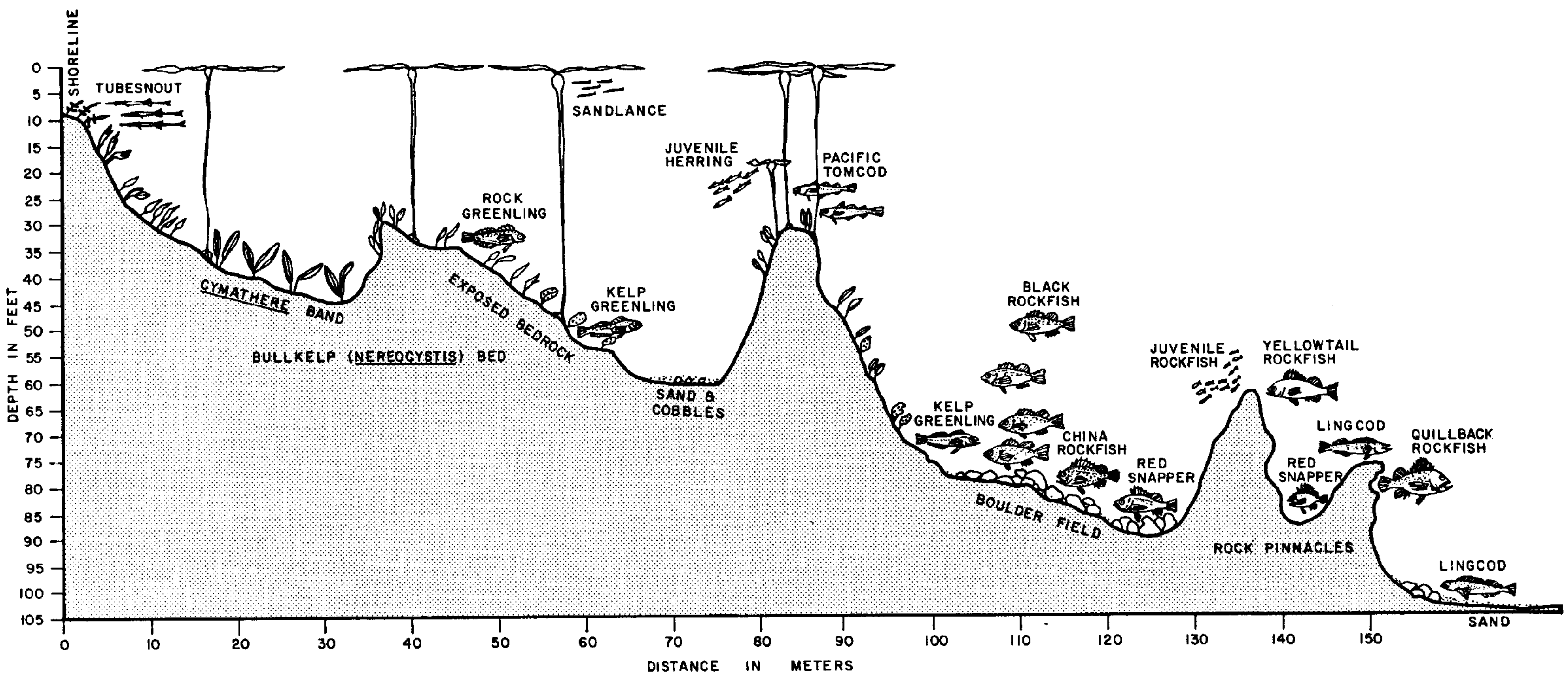

FIGURE 4

DISTRIBUTION OF FISHES IN RELATION TO HABITAT TYPE & DEPTH

DANGER ISLAND, MONTAGUE STRAIT

(SUMMER)

Table 5

DENSITY ESTIMATES OF SOME DOMINANT
FISHES FROM THE S.W. END OF DANGER ISLAND

Species	8/26/77	8/26/77	8/27/77	8/27/77	8/27/77	8/27/77*
Sebastes melanops (Black Rockfish)	2 $0.04/m^2$	10 $0.22/m^2$	0	8 $0.20/m^2$	0	0
Sebastes nebulosus (China Rockfish)	1 $0.02/m^2$	0	0	0	0	0
Sebastes ruberrimus (Red Snapper)	1 $0.02/m^2$	0	0	0	0	0
Sebastes flavidus (Yellowtail Rockfish)	0	0	0	5 $0.13/m^2$	0	0
Sebastes maliger (Quillback Rockfish)	0	0	0	0	0	0
Hexagrammos decagrammus (Kelp Greenling)	2 $0.04/m^2$	3 $0.07/m^2$	3 $0.08/m^2$	3 $0.08/m^2$	4 $0.05/m^2$	6 $0.08/m^2$
Hexagrammos lagocephalus (Rock Greenling)	0	0	1 $0.03/m^2$	0	0	0
Ophiodon elongatus (Lingcod)	0	0	0	0	0	0
Bathymaster caeruleofasciatus (Alaskan Ronquil)	0	1 $0.02/m^2$	0	0	0	0
Area Sampled:	30 x 1.5m	30 x 1.5m	20 x 2m	20 x 2m	25 x 3m	25 x 3m
Depth (meters)	23.0	23.0	19.5	24.0	13.5-16.5	13.5-16.5
Substrate:	Bo & Rk	Bo & Rk	Rk	Bo & Rk	Bo & Rk	Bo & Rk

* = Repeat of preceding transect (1-2 hrs. later in the day)

Table 6

DENSITY ESTIMATES OF SOME CONSPICUOUS FISHES FROM THE S.W. END OF DANGER ISLAND

Species	8/28/77	8/28/77	8/28/77	8/29/77	8/29/77*
Sebastes melanops (Black Rockfish)	8 0.16/m^2	2 0.04/m^2	0	0	0
Sebastes nebulosus (China Rockfish)	1 0.02/m^2	0	0	0	0
Sebastes ruberrimus (Red Snapper)	0	1 0.04/m^2	0	0	0
Sebastes flavidus (Yellowtail Rockfish)	0	0	0	0	0
Sebastes maliger (Quillback Rockfish)	1 0.02/m^2	0	0	0	0
Hexagrammos decagrammus (Kelp Greenling)	3 0.06/m^2	0	4 0.07/m^2	2 0.04/m^2	5 0.10/m^2
Hexagrammos lagocephalus (Rock greenling)	0	0	0	0	0
Ophiodon elongatus (Lingcod)	2 0.04/m^2	2 0.04/m^2	0	0	0
Bathymaster caeruleofasciatus (Alaskan Ronquil)	1 0.02/m^2	0	0	1 0.02/m^2	0
Area Sampled:	25 x 2m	25 x 2m	30 x 2m	25 x 2m	25 x 2m
Depth (meters):	24.0-26.0	30.0	20.0-24.0	18.0	18.0
Substrate:	Rk	Rk & Sa	Bo & Sa	Rk & BO	Rk & Bo

* = Repeat of Preceding Transect (1-2 hrs. later in the day)

Table 7

DENSITY ESTIMATES OF SOME CONSPICUOUS
FISHES FROM THE S.W. END OF DANGER ISLAND

Species	8/29/77	8/29/77*	8/29/77	8/29/77*	8/29/77	8/29/77
Sebastes melanops (Black Rockfish)	0	0	0	0	1 $0.02/m^2$	5 $0.08/m^2$
Sebastes nebulosus (China Rockfish)	0	0	0	0	0	0
Sebastes ruberrimus (Red Snapper)	0	0	0	0	0	0
Sebastes flavidus (Yellowtail Rockfish)	0	0	0	0	0	0
Sebastes maliger (Quillback Rockfish)	0	0	0	0	0	0
Hexagrammos decagrammus (Kelp Greenling)	2 $0.04/m^2$	2 $0.04/m^2$	3 $0.06/m^2$	5 $0.10/m^2$	4 $0.07/m^2$	4 $0.07/m^2$
Hexagrammos lagocephalus (Rock greenling)	0	0	1 $0.02/m^2$	0	0	0
Ophiodon elongatus (Lingcod)	0	0	0	0	0	0
Bathymaster caeruleofasciatus (Alaskan Ronquil)	0	0	0	0	0	0
Area Sampled:	25 x 2m	25 x 2m	25 x 2m	25 x 2m	30 x 2m	30 x 2m
Depth (meters)	14.5-18.0	14.5-18.0	14.0-17.5	14.0-17.5	13.5-15.0	13.5-15.0
Substrate:	Rk & Bo	Rk & Bo	Rk & Bo	Rk & Bo	Rk & Bo	Rk & Bo

* = Repeat of preceding transect (1-2 hrs. later in the day)

Table 8

DENSITY ESTIMATES OF SOME CONSPICUOUS FISHES FROM THE S.W. END OF DANGER ISLAND

Species	8/30/77	8/30/77*
Sebastes melanops (Black Rockfish)	17 0.31/m^2	11 0.20/m^2
Sebastes nebulosus (China Rockfish)	1 0.02/m^2	2 0.04/m^2
Sebastes ruberrimus (Red Snapper)	1 0.02/m^2	0
Sebastes flavidus (Yellowtail Rockfish)	0	0
Sebastes maliger (Quillback Rockfish)	0	0
Hexagrammos decagrammus (Kelp Greenling	1 0.02/m^2	1 0.02/m^2
Hexagrammos lagocephalus (Rock Greenling)	0	0
Ophiodon elongatus (Lingcod)	1 0.02/m^2	1 0.02/m^2
Bathymaster caeruleofasciatus (Alaskan Ronquil)	0	1 0.02/m^2
Area Sampled:	27 x 2m	27 x 2m
Depth (meters):	22.5-24.0	22.5-24.0
Substrate:	Bo	Bo

* = Repeat of preceding transect (1-2 hrs. later in the day)

(10.0 g) to 42.0 cm (1,350 g) and the average _H. decagrammus_ was 29.6 cm. At least 36 different categories of food items are listed in Table 9, and the major ones are crustaceans, mollusks and fish eggs. Gammaridean amphipods were the major prey species of the kelp greenling in these study areas, and this represented 60.0 percent (N=312) of the total identifiable food items. The kelp greenling is a highly opportunistic predator in the inshore zone and it dined on a variety of prey ranging from zooplankters to the eggs of conspecifics. This foraging versatility is expressed by the diet of one individual (31.5 cm) that was collected off the southwest end of Danger Island. The specimen was a female, and it was found to have eaten a cluster of greenling eggs, 1 sand lance (_Ammodytes hexapterus_), 2 decorator crabs (_Pugettia gracilis_), 1 rock crab (_Cancer oregonensis_), 2 gastropods (_Velutina_ sp.), 8 gammarid amphipods and pieces of red and brown algae.

Table 9

FOOD OF KELP GREENLING (*Hexagrammos decagrammus*)
FROM THE NORTHEASTERN GULF OF ALASKA (N=27)

Food Items	Frequency of Occurrence	Number	Percentage of Total
Gammaridean amphipods	19/36	312	60.0
Caprellid amphipods	5/36	28	5.3
Caridean shrimps	4/36	4	0.7
Brachyuran juveniles	6/36	20	3.8
Tanaids	1/36	1	0.1
Pugettia gracilis (crab)	13/36	23	4.4
Cancer oregonensis (crab)	8/36	12	2.3
Idothea sp. (isopod)	1/36	1	0.1
Margarites helicinus (snail)	1/36	2	0.3
Synoicum sp. (ascidian)	6/36	6	1.1
Telmessus cheiragonus (crab)	1/36	1	0.1
Pagurus sp. (hermit crab)	1/36	1	0.1
Velutina spp. (snail)	8/36	15	2.4
Lacuna variegata (snail)	1/36	3	0.5
Opisthobranchs	1/36	2	0.3
Polychaetes	7/36	22	4.2
Rhodophyta (red algae)	6/36	6	1.1
Fish eggs	4/36	4	0.7
Musculus spp. (mussel)	8/36	15	2.8
Eupentacta sp. (sea cucumber)	2/36	5	0.9
Elassochirus gilli (hermit crab)	1/36	1	0.1
Microporina borealis (bryozoan)	1/36	1	0.1
Ophiopholis aculeata (brittle star)	1/36	1	0.1
Mysids	3/36	8	1.5
Hiatella arctica (bivalve)	1/36	1	0.1
Euphrosine sp. (polychaete)	2/36	2	0.3

Table 9 (cont.)

Food Items	Frequency of Occurrence	Number	Percentage of Total
Ammodytes hexapterus (fish)	1/36	1	0.1
Didemnum sp. (ascidian)	2/36	2	0.3
Polyplacophora (chiton)	1/36	1	0.1
Phaeophyta (brown algae)	2/36	2	0.3
Fusitriton operculum (snail)	1/36	8	1.5
Munnidae (isopod)	1/36	1	0.1
Abietinaria sp. (hydroid)	2/36	2	0.3
Gastropoda (snails)	2/36	2	0.3
Crucigera operculum (serpulid)	1/36	1	0.1
Fishes	4/36	4	0.7

Hexagrammos lagocephalus (Pallas) - Rock Greenling

The rock greenling, *Hexagrammos superciliosus* was synonymized with *H. lagocephalus* by Quast (1964). Rock greenling, which can exceed a total length of 38.0 cm, was especially numerous in the shallow portions of the subtidal zone. Frequently it was seen resting on a bottom dominated by macroalgae, at other times it was observed swimming slowly through the vegetative undergrowth. Most were solitary in distribution; estimates of density ranged from 0 to $0.04/M^2$ at Schooner Rock (Tables 3 & 4), to 0 to $0.03/M^2$ off the southwest end of Danger Island (Tables 5-8). During summer months most individuals were observed in the shallow to mid-depth region of the bull kelp beds off Danger Island and Schooner Rock (Figures 4 & 5).

The activity pattern of the rock greenling seemed to change markedly during the year. For example, during the period from late fall to early spring most of the *H. lagocephalus* were cryptic or secretive in habit and hid under formations of rock and seaweed. However, with the onset of the reproductive and spawning season (June - September), the rock greenling assumed a more overt, highly visible posture. Most of these "aggressive" individuals were brightly colored males. Mature males ranged from a reddish-brown to a blood-red body coloration, mottled with green and turquoise blue. The inside of the mouth is frequently blue. Nest guarding males were observed from July through mid-September. The eggs were usually deposited in small clusters attached to kelp holdfasts, articulated corallines and even hair-like branches of *Desmarestia aculeata*. Male rock greenling defend the nests against all intruders - attacking not only conspecifics but also other bottom fishes, crabs and even divers. Mouth fighting by male H. *lagocephalus* has been observed on three different occasions. The females were more subdued in coloration, most were greenish-brown, mottled with yellow and red. The female rock greenling has not been seen in association with a nest that is being guarded by a vigilant male.

All the 16 individuals collected in these areas during daylight hours had food items present in their stomachs. These specimens ranged in size from 14.0 to 38.0 cm, and averaged 25.4 cm. Stomach fullness ranged from 20-90 percent, with the average at 51 percent. The condition of the prey and the degree of stomach fullness suggests that the rock greenling feeds heavily during daylight hours. A total of 28 different categories of food were taken by these rock greenling (Table 10). The numerical dominant was gammaridean amphipods which accounted for 77.1 percent (N=301) of the total food items. Snails, crabs, mussels and fish eggs were also important constituents of the rock greenling diet in this geographical location. These data agree with the findings of Simenstad and Nakatani (1977) who found that gammarids dominated the prey composition of the rock greenling at Attu Island, Alaska. Rock greenling are omnivorous and as such ingest small quantities of algae incidental to the uptake of animal material. Fish eggs were common in the stomachs of male rock greenling, and one individual (29.0 cm) that was collected at Danger Island had a stomach that was 40 percent full of the eggs of a conspecific. Nest-robbery seems to be a common practice in the hexagrammids.

Table 10

FOOD OF ROCK GREENLING (*Hexagrammos lagocephalus*)
FROM THE NORTHEASTERN GULF OF ALASKA (N=16)

Food Items	Frequency of Occurrence	Number	Percentage of Total
Gammaridean amphipods	11/16	301	77.1
Caprellid amphipods	1/16	1	0.2
Caridean shrimps	3/16	3	0.7
Brachyuran juveniles	1/16	1	0.2
Tanaids	3/16	4	1.0
Cummaceans	1/16	1	0.2
Polychaetes	4/16	5	1.2
Musculus vernicosus (mussel)	3/16	6	1.5
Idothea sp. (isopod)	2/16	2	0.5
Gnorimosphaeroma oregonensis (isopod)	2/16	3	0.7
Psolus chitonoides (sea cucumber)	1/16	1	0.2
Margarites helicinus (snail)	1/16	2	0.5
Fish eggs	5/16	5	1.2
Mitrella spp. (snail)	2/16	2	0.5
Velutina sp. (snail)	2/16	7	1.7
Oregonia gracilis (crab)	1/16	1	0.2
Trophon sp. (snail)	1/16	1	0.2
Synoicum sp. (ascidian)	2/16	2	0.5
Pagurus sp. (hermit crab)	1/16	1	0.2
Abietinaria sp. (hydroid)	2/16	2	0.5
Metridium senile (sea anemone)	1/16	1	0.2
Didemnum sp. (ascidian)	1/16	1	0.2
Rhodophyta (red algae)	6/16	6	1.5
Hyas lyrata (crab)	1/16	3	0.7
Ophiopholis aculeata (brittle star)	1/16	1	0.2
Cancer oregonensis (crab)	1/16	1	0.2
Pugettia gracilis (crab)	4/16	5	1.2
Lacuna spp. (snail)	3/16	21	5.3

Subtidal Boulder Field (exposed)

The solid substratum below the macrophyte band covers a wide variety of geological facies, ranging from patches of gravel and cobbles to extensive reefs composed of rock pavement and boulders. Typically, the biota is attached to, or associated with the hard substrate. The boulder field habitat at Danger Island occurs as shallow as -22 m off the south end of the island (Figure 4), whereas the upper portion of the boulder field at Schooner Rock is less than 12 m below MLLW (Figure 5). Despite these obvious differences in bathymetry and distance from shore, the habitats are remarkably similar in appearance. From a distance the boulders have the general appearance of being bare, and yet upon closer inspection the rock surfaces display a wide assortment of epibiota ranging from crustose coralline algae to compound ascidians and bryozoans. Most of the macroscopic plant life was comprised of short statured or decumbent growth forms. This was usually the case with the sessile macro-invertebrates, except on some of the boulders there were large sea anemones such as Metridium senile, Cribrinopsis sp. and Tealia spp..

The submarine boulder fields supported high densities of bottom or demersal fishes during August, 1977. The number of species or species richness was also relatively high during summer, and this might be due in part to the physical stability of the habitat. The boulder formations provide a complexity of shelters and microhabitats, which are apparently needed to support such a high density of fish life. Usually the demersal fishes hovered close to the sea floor, or remained under the cover of the reef complex.

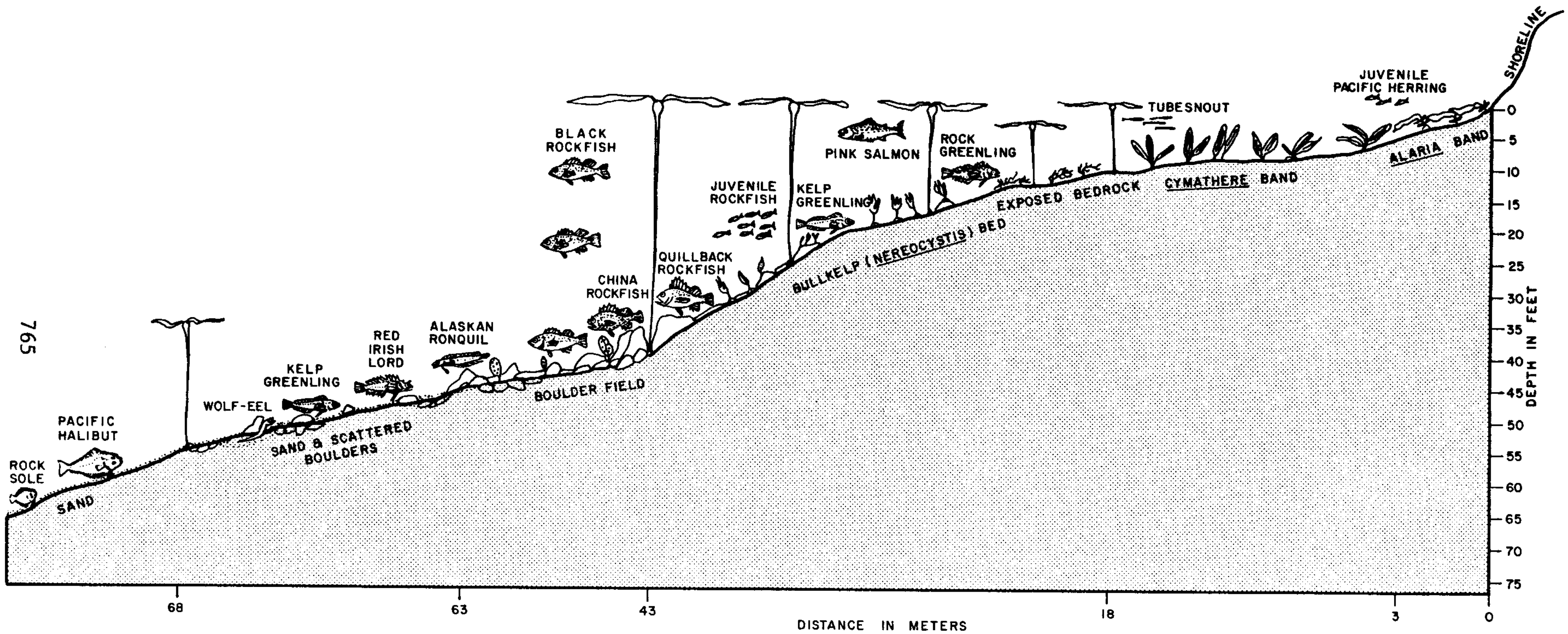

FIGURE 5

DISTRIBUTION OF FISHES IN RELATION TO HABITAT TYPE & DEPTH

SCHOONER ROCK, HINCHINBROOK ENTRANCE

(SUMMER)

The rockfishes were the most conspicuous group of bottom fishes in this assemblage. Six species were commonly seen during daylight hours. One of these, the quillback rockfish (Sebastes maliger), had a maximum recorded density of $0.03/M^2$ at Schooner Rock (Table 4), and $0.02/M^2$ off the southern end of Danger Isalnd (Table 6). Most of the larger quillbacks occurred below -25 m, and were seen either resting on rock walls or hovering around pinnacles and rock piles. Three of the quillback rockfish that were examined for food items had consumed gammaridean amphipods, mysids, cummaceans and caridean shrimp.

One species that was previously unreported in Prince William Sound was the tiger rockfish (Sebastes nigrocinctus). The previous northern range of the tiger rockfish was southeastern Alaska (Hart, 1973), although recently Quast and Hall (1972) extended the range northward to Cape Resurrection on the outer Kenai Peninsula. A large, solitary S. nigrocinctus was observed and subsequently photographed in a small cave at -15.0 m off the north end of Schooner Rock. This was the only tiger rockfish that was seen during August, 1977, however its' abundance could be greater since most probably go unnoticed because of their retiring nature.

Small schools of yellowtail rockfish (Sebastes flavidus) occurred at Danger Island; estimates of density ranged from 0 to $0.13/M^2$ (Tables 5-8). Previous reports list the range of the yellowtail rockfish from San Diego, California to Kodiak Island (Miller and Lea, 1972). Juvenile S. flavidus frequently were seen along the margins of bull kelp forests, whereas larger individuals occurred above the boulder fields. Pereyra, Pearcy and Carvey (1969) examined the stomach contents of yellowtail rockfish collected off the coast of Washington, and found that 90 percent of the food items were mesopelagic organisms such as the northern lampfish (Stenobrachius leucopsarus), crustaceans and squid. Conversely, the bulk of this species diet in the nearshore waters of Washington State was amphipods (Miller, Simenstad and Moulton, 1976). As yet, no information is available on the food habits of S. flavidus from the northeastern Gulf of Alaska.

At these same depths we encountered the wolf-eel (Anarrhichthys ocellatus) hiding in the crevices of the reef. Most are secretive and usually remain under cover, except when feeding or protruding the head from a crevice or rock pile. Numerous small wolf-eels occurred in the boulder field at Schooner Rock; density estimates ranged from 0 to $0.08/M^2$ (Tables 3 & 4). Because of their secretive nature abundance was difficult to assess. However, one clue to their presence is the food debris or middens which frequently collect at the base of their lairs. Pieces of sea urchins, broken clam shells and crab remains were seen in wolf-eel lairs at Danger Island. Also, a direct observation of a large wolf-eel ($>$182 cm) feeding on green sea urchins was made while diving in the entrance channel to Constantine Harbor, Hinchinbrook Island (Rosenthal, 1977).

Two other fishes that were frequently seen in this habitat were the kelp greenling (H. decagrammus) and the red irish lord (H. hemilepidotus). Available information on both species was reported in the preceding section on exposed macrophyte assemblages.

Bathymaster caeruleofasciatus Gilbert & Burke - Alaskan Ronquil

The Alaskan ronquil (Bathymaster caeruleofasciatus) is a common member of the inshore fish assemblages of the Gulf of Alaska. This elongate, slender fish was the most numerous member of the family Bathymasteridae. Captured specimens ranged in length from 11.7 to 24.3 cm, and had an average fresh weight of 116 grams. The color was variable, some were dark olive to bluish green, while others were mottled with saddle markings on the body. Bathymaster caeruleofasciatus characteristically inhabits rocky overhangs, crevices and boulder fields. It was rarely seen to move out of this habitat, except to pursue food items or give chase to conspecifics and/or other members of the benthic community. Territorial behaviour was pronounced. Aggressive defense of a territory or home crevice in the form of mouth fighting was observed at Schooner Rock on two different occasions.

Estimates of B. caeruleofasciatus density ranged from 0 to $.27/M^2$ at Schooner Rock (Tables 3 & 4). The average density was $0.08/M^2$ in the 410 square meters of sea floor that was examined quantitatively during mid-August, 1977. Conversely, this same species was much less abundant at Danger Island where densities ranged from 0 to $0.02/M^2$ and averaged less than $0.01/M^2$ in the 1,008 square meters of sea bottom examined during late August, 1977 (Tables 5 & 8).

The diet was variable and consisted of macroinvertebrates and zooplankters that were often times associated with benthic vegetation (Table 11). Ten specimens were captured during this time period, and of

Table 11

FOOD OF ALASKAN RONQUIL (*Bathymaster caeruleofasciatus*)
FROM THE NORTHEASTERN FULF OF ALASKA (N=10)

Food Items	Frequency of Occurrence	Number	Percentage of Total
Gammaridean amphipods	5/10	25	43.1
Caprellid amphipods	2/10	9	15.5
Caridean shrimps	1/10	1	1.7
Brachyuran Juveniles	1/10	2	3.4
Ophiopholis aculeata (brittle star)	5/10	10	17.2
Velutina spp. (snail)	2/10	2	3.4
Tanaids	1/10	2	3.4
Paralithodes kamtschatica (juvenile king crab)	1/10	2	3.4
Musculus vernicosus (mussel)	1/10	1	1.7
Polychaetes	1/10	2	3.4
Crepipatella sp. (snail)	1/10	1	1.7
Rhodophyta (red algae)	1/10	1	1.7

these, 9 had food items in their stomachs. Gammaridean amphipods comprised 43.1 percent of the total identifiable prey. Another important prey species was the brittle star (Ophiopholis aculeata) which occurred in 17.2 percent of the diets; frequency of occurrence was 5/10 and one specimen had 5 brittle stars in the gut. Other important prey were caprellid amphipods, juvenile brachyuran crabs, juvenile king crab (Paralithodes kamtschatica) unidentified polychaetes and a snail Velutina spp.

Sebastes nebulosus Ayres - China Rockfish

China rockfish were observed in the shallow waters of Montague Strait and Hinchinbrook Entrance. These direct observations extend the northern range of this fish from southeastern Alaska (Quast and Hall, 1972) to the southern reaches of Prince William Sound. This geographical extension is not startling, but what is interesting is the china rockfish is such a common member of the nearshore zone, where previously it was unreported. *Sebastes nebulosus* inhabits subtidal rocky outcrops, pinnacles and boulder fields below about -15 meters. Usually solitary in distribution; the china rockfish was rarely seen more than 1-2 meters off the sea floor. Frequently associated with the yelloweye rockfish (*S. ruberrimus*) and the quillback rockfish (*Sebastes maliger*), which seem to occupy similar types of microhabitats.

Density extimates ranged from 0 to $0.04/M^2$ at Danger Island (Tables 5-8), to between 0 and $0.02/M^2$ for the population at Schooner Rock (Tables 3 & 4). The average density was remarkably similar at both sites, with estimates of less than $0.01/M^2$.

Six individuals ($\overline{x}$ = 29.9 cm) were collected from these two sites during 1977. The stomachs of all six contained food items, and the major food was a brittle star (*Ophiopholis aculeata*); this one item accounted for 74.1 percent of the total prey (Table 12). One china rockfish (37.0 cm) that was collected off Danger Island had 39 fresh *O. aculeata* in it's stomach while another specimen that was taken at Schooner Rock had 13 brittle stars in the gut. The second most important prey

Table 12

FOOD OF CHINA ROCKFISH (*Sebastes nebulosus*)
FROM THE NORTHEASTERN GULF OF ALASKA (N=6)

Food Items	Frequency of Occurrence	Number	Percentage of Total
Ophiopholis aculeata (brittle star)	6/6	63	74.1
Cancer oregonensis (crab)	3/6	5	5.8
Pugettia gracilis (crab)	5/6	11	12.9
Pagurus sp. (hermit crab)	1/6	1	1.1
Cancer branneri (crab)	1/6	1	1.1
Heteropora sp. (bryozoan)	1/6	1	1.1
Sclerocrangon sp. (shrimp)	1/6	1	1.1
Microporina borealis (bryozoan)	1/6	1	1.1
Abietinaria sp. (hydroid)	1/6	1	1.1

species was a decorator crab (*Pugettia gracilis*); frequency of occurrence was 5/6, and this species accounted for 12.9 percent of the total identifiable food items. Another crab that was important in the diet was *Cancer oregonensis*; it was third in importance and accounted for 5.8 percent of the total.

Sebastes melanops Girard - Black Rockfish

The black rockfish was the most commonly observed species of schooling fish in the shallow waters of the Gulf. The northern range of this species was extended to Port Valdez, however the largest concentrations of black rockfish were either seen along the exposed outer coast or in ocean entrances leading into the Gulf. Some of the schools contained hundreds of S. melanops, typically the juvenile or immature fish were segregated from the adults. Black rockfish were most often seen along the outer edges of bull kelp forests, near rock pinnacles or around submarine boulder fields.

Estimates of density ranged from 0 to .52/M^2 at Schooner Rock (Tables 3 & 4). Similar densities were obtained for the S. melanops population at Danger Island, where counts ranged from 0 to .31/M^2 (Tables 5-8). These estimates are extremely conservative, since only those fish that occurred near the bottom were included in the counts. Some of the largest schools extended from the bottom up through the water column to approximately 5 meters from the sea surface. In these instances abundance could not be estimated by the band transect or line intercept method. Schools of juvenile S. melanops frequently aggregated with other juvenile rockfish.

Eighteen specimens were collected from the two major study sites; these individuals ranged from 17.0 to 49.0 cm. Sebastes melanops was collected during daylight hours; the stomachs were empty in 5 specimens, and in 7 of the 18 the food items were unidentifiable. Those prey that were identified were planktonic forms such as jellyfish, ctenophores, juvenile fishes, gammaridean amphipods and swimming polychaetes (Table 13). Unlike some of the other Sebastes which pluck their food items from the bottom, the black rockfish forage in the water column for drifting or pelagic forms.

Table 13

FOOD OF BLACK ROCKFISH (*Sebastes melanops*)
FROM THE NORTHEASTERN GULF OF ALASKA (N=13)

Food Items	Frequency of Occurrence	Number	Percentage of Total
?*Beroe* sp. (ctenophore)	1/13	3	13.0
Polychaetes, swimming	1/13	2	8.6
Fishes, unid.	3/13	3	13.0
Gammaridean amphipods	1/13	4	17.3
Hydromedusae	2/13	2	8.6
Other	9/13	9	39.1

Sebastes ruberrimus Cramer - Yelloweye Rockfish

The yelloweye rockfish or red snapper as it is commonly known occurs from Ensenada, Mexico (Miller and Lea, 1972) to the Gulf of Alaska (Hart, 1973). Recently, juvenile *S. ruberrimus* have been observed as far north as Seal Rocks, Port Valdez, and this observation probably represents the northern range of this species in the eastern Pacific. The extensive distribution and high marketability of the flesh has made *S. ruberrimus* a highly sought after commercial species. It has been rarely seen by divers above a depth of 25 meters. Solitary in distribution, frequently associated with rock crevices, overhanging ledges and caves. Superfically the habitat requirements of this species appears to be similar to the china rockfish (*S. nebulosus*), which was repeatedly seen in close proximity to the red snapper.

Yelloweye rockfish were first observed at Danger Island during August, 1977; the maximum recorded density at this time was $0.04/M^2$ (Table 8). *Sebastes ruberrimus* was not encountered at Schooner Rock, however this was probably due to our oversight rather than the species being absent from Hinchinbrook Entrance. Four *S. ruberrimus* were captured from the subtidal zone at Danger Island; these specimens ranged from 58.5 cm to 66.0 cm. Two of the fishes had identifiable prey in their stomachs, in the others the stomachs were empty. The prey in both cases was a brightly colored lithodid crab, *Placetron wosnesenskii*. One of the rockfish had 2 of these crabs in it's stomach. The stomach was 80 percent full. Little else is known about the diet, except Hart (1973) reported that *Sebastes ruberrimus* eats crustaceans and lingcod spawn in the Pacific northwest.

Ophiodon elongatus Girard - Lingcod

Lingcod are known to range as far north as Port Fidalgo in northeastern Prince William Sound. Generally, they appear to be more abundant along exposed parts of the coastline than in sheltered waters such as Prince William Sound. During summer months the fish were most frequently observed on solid substrata below about -22.0 m. Most of the O. elongatus were seen on a sea floor dominated by boulders, rocky outcrops and high relief pinnacles (Figure 4). Lingcod were rarely seen swimming more than a few meters off the bottom. Large fish were aggressive, and seemed to be territorial.

Known to be voracious feeders on fishes, including herring, sand lance, flounder, hake, walleye pollock, cod and rockfish (Hart, 1973). Only five individuals were collected during the course of this study, and in these, the food items consisted of black rockfish (S. melanops); unidentified Sebastes and Octopus sp.. Direct observations have also been made of their foraging habits. For example, on one occasion our presence frightened a black rockfish that was immediately pursued and captured by a large lingcod that was hiding in a concealed position.

Lingcod grow to a reported length of 152 cm, and weigh up to 47 kg off the coast of British Columbia (Hart, 1973). To date, however, no lingcod have been collected in either Hinchinbrook Entrance or Montague Strait which approach this reported size, although a few large O. elongotus (>20 kg) were seen off Danger Island during August, 1977. Usually the lingcod is solitary in distribution. Density estimates at

Schooner Rock reached a maximum of $0.02/M^2$ (Tables 3 & 4); more were encountered at Danger Island where densities ranged from 0 to $0.04/M^2$ (Tables 5-8). The average density of $0.006/M^2$ was identical in both locations.

Soft Bottom (exposed)

The soft bottom north of Schooner Rock consisted of coarse to finely packed sand. Ripple marks and small sand waves were prominent about 21.0 m below the sea surface. Small rocks were occasionally found in this habitat, especially in close proximity to the rocky reef.

Some of the dominant macroinvertebrates that were observed on the soft bottom in this location were tubicolous polychaetes, a sea pen (Ptilosarcus gurneyi), snails (Olivella baetica and Nassarius mendicus) and a crab (Cancer branneri).

The nearshore fish fauna was also common on the unconsolidated substrates. Most of these species were demersal forms which are adapted for this unique habitat. Among these were righteye flounders or flatfishes such as the yellowfin sole (Limanda aspera), starry flounder (Platichthys stellatus), rock sole (Lepidopsetta bilineata) and pacific halibut (Hippoglossus stenolepis). Pacific sand lance (Ammodytes hexapterus) were also seen on this expanse of sand. Some large schools of A. hexapterus were observed in the water column along the edge of the reef, and other individuals buried themselves in the soft bottom. When frightened or disturbed, the sand lance usually darted out of the soft sediment and fled.

Lepidopsetta bilineata Ayres - Rock Sole

One of the most conspicuous flounders in the nearshore zone is the rock sole (Lepidopsetta bilineata). Rock sole were abundant around Schooner Rock and most were seen on soft or unconsolidated substratum at shallow depths between 18 and 24 m. Frequently, this species was observed with Pacific halibut (Hippoglossus stenolepis) and starry flounder (Platichthys stellatus). Besides their occurrence in the ocean entrances of Prince William Sound, these fish range as far north as Port Valdez and inhabit estuaries, eelgrass meadows and protected embayments or fjords. Hart (1973) reported that rock sole move into shallow water during summer, and this seems to be the case in Prince William Sound.

The stomach contents of 9 L. bilineata, ranging in size from 25 to 40 cm, were examined for food items. Eight of the 9 specimens contained identifiable organisms in their stomachs. Fish eggs occurred in 3 of 8 specimens, and this category accounted for 13.6 percent of the food items (Table 14). Sand lance (Ammodytes hexapterus) were found in the stomachs of 2 rock sole collected at -23.0 m off the north side of Schooner Rock. Another L. bilineata, that was taken in Port Fidalgo when the herring were spawning along the beachlines, had a stomach that was 100 percent full of herring eggs and 6 Aglaja ?ocelligera, a shell-less cephalaspidean. Forrester and Thomson (1969) found that this small flatfish preyed upon shrimps, small crabs, polychaete worms, clam siphons, brittle stars and sand lance in the coastal waters of British Columbia.

Table 14

FOOD OF ROCK SOLE (*Lepidopsetta bilineata*)
FROM THE NORTHEASTERN GULF OF ALASKA (N=8)

Food Items	Frequency of Occurrence	Number	Percentage of Total
Ammodytes hexapterus (fish)	2/8	2	9.0
Gammaridean amphipods	1/8	2	9.0
Olivella baetica (snail)	1/8	1	4.5
Aglaja ocelligera (opisthobranch snail)	1/8	6	27.2
Polychaete (worms)	2/8	2	9.0
Caridean shrimps	1/8	1	4.5
Arenicolidae	2/8	2	9.0
Tellinidae (bivalve)	1/8	1	9.0
Unid. food items	2/8	2	9.0
Fish eggs (herring)	3/8	3	13.6

Hippoglossus stenolepis Schmidt - Pacific Halibut

Mature halibut are found in the shallow waters of Prince William Sound and the northern Gulf of Alaska predominantly during the months of May through September (Cordova fishermen, pers. comm.). This highly sought after species is routinely taken from near surface to depths in excess of 100 fathoms. The inshore fishing grounds are comprised of a variety of habitats ranging from subtidal kelp forests to protected embayments and exposed offshore reefs. Halibut occurred at both study sites during 1977. At Schooner Rock the fish were collected from the base of the reef out to a depth of -24 m. Most of the specimens were taken on a bottom that was composed of coarse sands and small rock (Figure 5). Halibut were also seen along the steeply sloped shores of Danger Island; here the bottom was dominated by boulders, exposed bedrock and deeply cut valleys with sand and shell debris. One large *H. stenolepis* (182 cm) was taken on hook and line while anchored on station above the 19 m depth contour. This huge fish was a female and it weighed in excess of 90 kg.

Food consisted of crabs, snails, octopus and brown algae (Table 15). The major prey species was *Cancer branneri* (crab); it occurred in 3 of 5 specimens, and comprised 53.8 percent of the total. One halibut (62 cm) had 5 *Cancer branneri* in it's stomach. All of the crabs were swallowed whole, thus simplifying the identification process. The second major food item was the decorator crab (*Pugettia gracilis*); frequency of occurrence was 2/5, and this species accounted for 11.5 percent of the total number of food items obtained from these specimens. The occurrence of halibut preying on large crustacea such as dungeness, king and tanner crab was reported by Gray (1964) for samples obtained off Kodiak Island.

Table 15

FOOD OF PACIFIC HALIBUT (*Hippoglossus stenolepis*)
FROM THE NORTHEASTERN GULF OF ALASKA (N=5)

Food Items	Frequency of Occurrence	Number	Percentage of Total
Cancer branneri (crab)	3/5	14	53.8
Pugettia gracilis (crab)	2/5	3	11.5
Oregonia gracilis (crab)	1/5	1	3.8
Neptunea sp. (snail)	1/5	1	3.8
Octopus sp. (octopus)	1/5	1	3.8
Desmarestia aculeata (brown algae)	1/5	1	3.8
Stones	1/5	5	19.2

Platichthys stellatus Pallas - Starry Flounder

Starry flounder are distributed from Santa Barbara, California to arctic Alaska and the Sea of Japan (Miller and Lea, 1972). In the northern Gulf of Alaska, *P. stellatus* has been collected as far north as Port Valdez. Common in the shallow waters of Prince William Sound from April through September; it frequents a variety of habitats ranging from ocean entrances to protected estuaries.

Seven specimens were collected in the nearshore zone during 1976-77; most were taken in northeastern Prince William Sound when the Pacific herring (*Clupea harengus pallasi*) were spawning in the vicinity of Port Fidalgo and Tatitlek Narrows. Six starry flounder ranged in size from 45.5 cm to 59.0 cm; all 6 flatfish had consumed herring eggs that were attached to seaweeds and seagrasses. The stomachs of these specimens were 80-100 percent full of herring eggs. Another starry flounder (52.5 cm) was collected on the soft bottom at the base of Schooner Rock. The diet consisted of clam siphons, brittle stars and a crab *Cancer branneri* (Table 16). Clemens and Wilby (1961) reported that the food of *P. stellatus* consists of crabs, shrimps, worms, clams, clam siphons, small mollusks and fish.

Table 16

FOOD OF STARRY FLOUNDER (*Platichthys stellatus*)
FROM THE NORTHEASTERN GULF OF ALASKA (N=7)

Food Items	Frequency of Occurrence	Number	Percentage of Total
Herring eggs (fish)	6/7	6*	35.2
Clam siphons	1/7	2	11.7
Brittle stars (unidentified)	1/7	3	17.6
Cancer branneri (crab)	1/7	1	5.8
Analipus japonicus (brown algae)	2/7	2	11.7
Zostera marina (eelgrass)	2/7	2	11.7
Desmarestia aculeata (brown algae)	1/7	1	5.8

*hundreds of eggs were ingested by these fish

Macrophyte Assemblage (protected)

Within the protected confines of Prince William Sound there is an undetermined amount of macrophyte biomass. The marine plants form a conspicuous girdle along the beachlines of the Sound. Now and then the belt is broken or interrupted by conditions that are unfavorable or preclude plant colonization and growth. The rocky or solid substratum generally provides most of the suitable habitat for seaweed germination and growth. Conversely, the soft or unconsolidated silty clays and sands, from about -9.0 m to MLLW, seem to offer optimal substrate for eelgrass (Zostera marina). Most of the eelgrass has been found near the mouths of creeks, or in quite estuaries and saltwater lagoons. The eelgrass stands of Prince William Sound vary in areal dimension from small patches to meadows covering several square acres. These protected habitats differ from those on the outer coast in that the sea floor and vegetative undergrowth is usually dusted by a thin layer of silt.

The eelgrass meadows and protected seaweed beds were typically high in the number of fish species. However, maximum species richness and abundance was not sustained on a year-round basis, but was instead highly seasonal, since the highest counts were obtained from about April to October. The influx of fishes into the nearshore zone is usually centered around the activities of commercially valuable species such as the pacific herring, chum salmon, red salmon, pink and silver salmon. The flurry of activity is intense, when these and other pelagic schooling species move into the shallow sublittoral zone. In addition to the adult fishes, newly emergent fry and juvenile stages of an undetermined number of fish species pass their early developmental periods within the protected confines of the macrophyte band. Schools of juvenile herring, tube-snout, sand lance, salmon and walleye pollock, were frequently seen hovering around the meadows of benthic vegetation. Conspicuous bottom fishes of the assemblage consisted of pacific tomcod, white-spotted greenling, flatfishes, great sculpin and arctic shanny. With the approach of winter, the macrophyte canopies begin to deteriorate, water temperatures decline sharply and the transient species migrate out of the shallow water zone. The habitat now has the appearance of being almost devoid of fish life, except for the demersal species that remain under cover.

There is sufficient evidence of trophic interaction between fishes and their prey species in the nearshore zone to present a very qualitative food web (Figure 6). It should be pointed out that all of the habitats and species investigated have been combined in this single diagram.

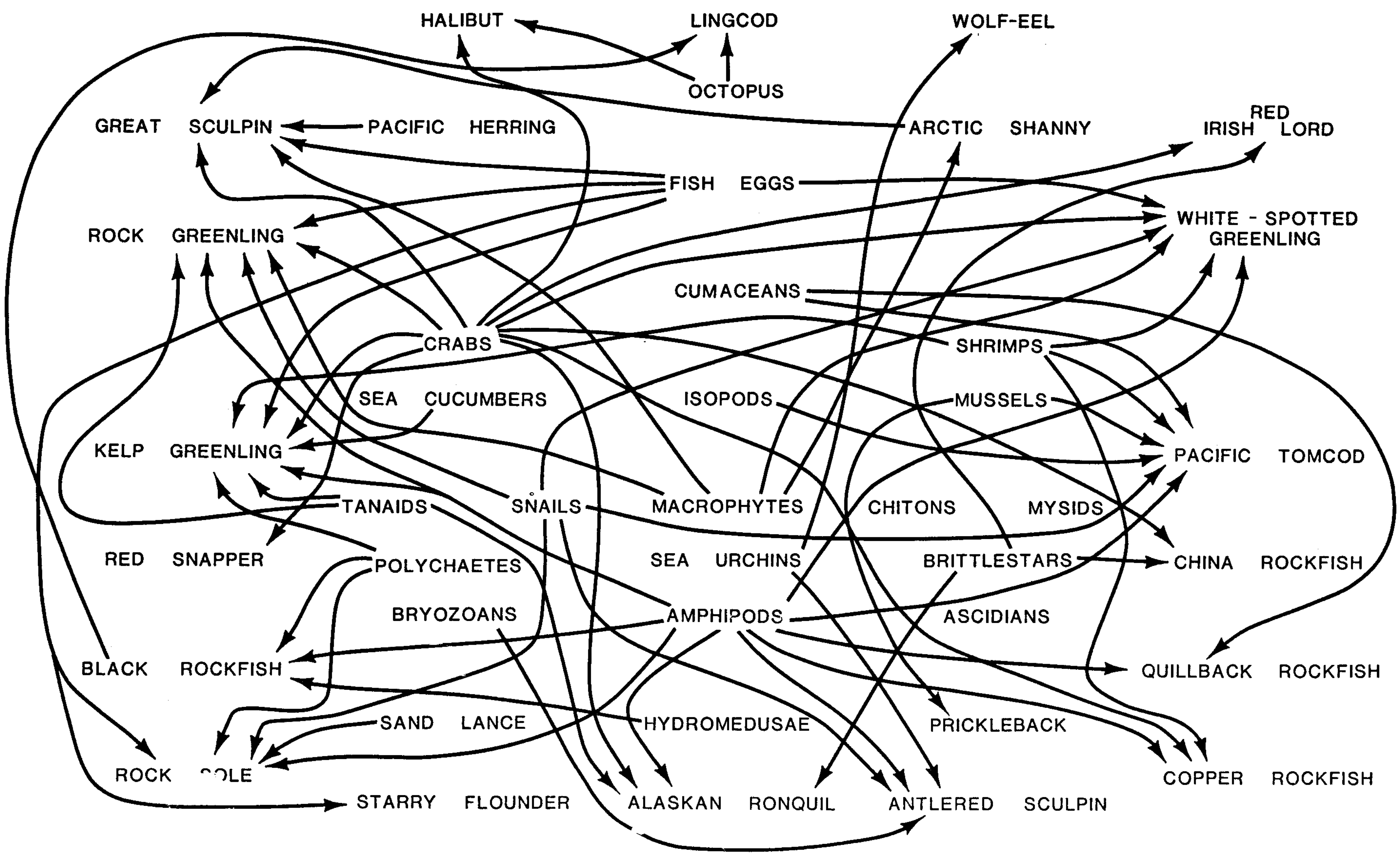

FIGURE 6

TROPHIC INTERACTION AMONG NEARSHORE FISHES AND THEIR PREY SPECIES IN THE NORTHEASTERN GULF OF ALASKA

Microgadus proximus Girard - Pacific Tomcod

The pacific tomcod is one of the most ubiquitous species in the shallow waters of the northeastern Gulf of Alaska. It has been collected in a variety of habitats ranging from boat harbors and protected eelgrass meadows to exposed outer coast kelp beds. Young tomcod were frequently observed hovering in bull kelp forests and seaweed canopies off the southwest end of Latouche Point and Danger Island. Juvenile pollock are known to associate with the jellyfish *Cyanea* (Van Hyning and Cooney, 1974), and young tomcod possibly also accompany these jellyfishes which drift in dense aggregations. During summer months, the *Cyanea* are often accompanied by immature gadids which swim under the bell and among the tentacles. Hart (1973) reports that mature tomcod reach a maximum length of 30.5 cm, however one individual that was collected by us at Zaikof Point was 31.6 cm in total length.

Pacific tomcod occurred in small to moderate size schools of up to around 100 individuals. The densest concentrations were observed along the edges of eelgrass meadows. Active during daylight hours, particularly when they are foraging along the bottom in the shallow subtidal zone. It was the most commonly captured fish in the experimental gillnet sampling at Zaikof Point, and accounted for 46 percent of the total catch (Table 17).

Twenty-seven individuals (9.0 - 31.6 cm) were collected from Prince William Sound, and of these, all 27 contained food items (Table 18). Gammaridean amphipods were the major prey in terms of numerical dominance, and this group accounted for 47.7 percent of the ingested prey. Three of

Table 17

EXPERIMENTAL GILLNET FISHING AT ZAIKOF POINT*
12 HOUR FISHING TIME - 1800 HR. (8/16/77) TO 0600 HR. (8/17/77)

Species	Number	Percentage of Total Catch
Oncorhynchus gorbuscha (Pink Salmon)	9	24.3
Hexagrammos decagrammus (Kelp Greenling)	1	2.7
Hexagrammos stelleri (Whitespotted Greenling)	8	21.6
Hexagrammos lagocephalus Rock Greenling	1	2.7
Sebastes sp. (Juvenile Rockfish)	1	2.7
Microgadus proximus (Pacific Tomcod)	17	45.9
TOTAL	37	100

*Edge of Bull Kelp (*Nereocystis*) bed off north end of Point

Table 18

FOOD OF PACIFIC TOMCOD (*Microgadus proximus*) FROM THE NORTHEASTERN GULF OF ALASKA (N=27)

Food Items	Frequency of Occurrence	Number	Percentage of Total
Gammaridean amphipods	10/27	204	47.7
Caprellid amphipods	1/27	3	0.7
Caridean shrimps	5/27	11	2.5
Brachyuran juveniles	2/27	8	1.8
Tanaids	1/27	1	0.2
Cummaceans	4/27	4	0.9
Polychaetes	3/27	3	0.7
Musculus spp. (mussel)	3/27	91	21.3
Olivella baetica (snail)	3/27	28	6.5
Idothea spp. (isopod)	3/27	6	1.4
Ammodytes hexapterus (fish)	2/27	2	0.4
Gnorimosphaeroma oregonensis (isopod)	9/27	45	10.5
?*Homalopoma* sp. (snail)	1/27	4	0.9
Cucumaria sp. (sea cucumber)	1/27	1	0.2
Telmessus cheiragonus (crab)	1/27	1	0.2
Fishes	3/27	3	0.7
Lacuna spp. (snail)	1/27	4	0.9
Pugettia gracilis (crab)	1/27	1	0.2
Pagurus spp. (hermit crab)	1/27	2	0.4
Zostera marina (eelgrass)	2/27	2	0.4
Phaeophyta (brown algae)	2/27	1	0.2
Other	2/27	2	0.4

the _M. proximus_ that were collected from an eelgrass meadow in Sheep Bay (Figure 1) had a combined total of 91 mussels (_Musculus_ sp.) in their stomachs. These prey accounted for 21.3 percent of the total number of identifiable food items. A small sphaeromatid isopod, _Gnorimosphaeroma oregonensis_ occurred in 9 of the 27 specimens, and this represented 10.5 percent of the prey for those fish collected during 1974-77. Other important food items were snails, caridean shrimps, juvenile brachyuran crabs and small fishes such as _Ammodytes hexapterus_.

Hexagrammos stelleri Tilesius - Whitespotted Greenling

The whitespotted greenling is distributed along the shores of Prince William Sound from Port Valdez to Hinchinbrook Entrance. However, unlike two of its' congeners (*H. lagocephalus* and *H. decagrammus*) which seem to thrive in outer coast or exposed habitats, the whitespotted is more typically found in protected habitats which rarely are influenced by deep sea swells. It was commonly seen in association with eelgrass (*Zostera marina*) meadows and beds of seaweeds. Occassionally it was seen swimming with small schools of pacific tomcod (*Microgadus proximus*), however during daylight hours it was most often solitary in distribution. It reputedly reaches a size of 41 cm, although we have seen some individuals that possibly could have exceeded this total body length.

During most of the calender year, mature *H. stelleri* are light brown to yellowish green in color, with white spots scattered on the head and body. There is also another color pattern in males which identifies a nest-guarding individual from other members of the species. In these individuals the white spots are usually replaced by grey ones, and the body coloration is more of a uniform golden-brown. Nest guarding individuals were collected in northeastern Prince William Sound on September 28, 1977. Seven individuals ($\bar{x}$ = 24.4 cm) were captured from nests, and all of these were males. The eggs were attached to decumbent fleshy seaweeds, hydroids and articulated corallines. Most of the egg clusters were 5.0 to 10.0 cm in diameter and occurred in shallow water above -10 meters.

Hexagrammos stelleri was not encountered in the subtidal band transects at either Schooner Rock or Danger Island, however, individuals were collected off Latouche Point (Figure 2) and along the north side of Zaikof Point (Figure 3). In addition to these direct observations, H. stelleri was the third most abundant species captured by gillnet sampling at Zaikof Point and this represented 21 percent of the total (Table 17).

Twenty specimens (10.5 - 31.0 cm) were collected from the shallow subtidal waters of the Sound, and the stomachs of all of these contained identifiable food items (Table 19). Although these fish contained zooplankters, most of the prey organisms were probably plucked from attached vegetation and solid substrata. Gammaridean amphipods accounted for 70.9 percent of the total food items. Other principal foods were small gastropods such as Margarities spp. and Lacuna variegata, caridean shrimps, brachyuran crabs, isopods, mussels, caprellid amphipods and fish eggs. Most of these prey were associated with macrophytes, which were also ingested along with the animal material. Plant fragments and detritus occurred in 9 of 20 specimens.

Table 19

FOOD OF WHITESPOTTED GREENLING (*Hexagrammos stelleri*) FROM THE NORTHEASTERN GULF OF ALASKA (N=20)

Food Items	Frequency of Occurrence	Number	Percentage of Total
Gammaridean amphipods	14/20	183	70.9
Caprellid amphipods	2/20	2	1.2
Caridean shrimps	5/20	8	3.1
Brachyuran juveniles	2/20	4	1.5
Pugettia gracilis (crab)	4/20	6	2.3
Idothea spp. (isopod)	2/20	3	1.1
Margarites spp. (snail)	3/20	16	6.2
Lacuna variegata (snail)	2/20	5	1.9
Mytilus edulis (mussel)	2/20	6	2.3
Gnorimosphaeroma oregonensis (isopod)	1/20	1	0.3
Polychaetes	1/20	1	0.3
Fish eggs	4/20	4	1.5
Telmessus cheiragonus (crab)	1/20	1	0.3
Pandalus danae (shrimp)	1/20	1	0.3
Nassarius meandicus (snail)	1/20	1	0.3
Cancer oregonensis (crab)	1/20	1	0.3
Ammodytes hexapterus (fish)	1/20	1	0.3
Lophopanopeus bellus (crab)	1/20	1	0.3
Hiatella arctica (bivalve)	1/20	1	0.3
Zostera marina (eelgrass)	3/20	3	1.1
Rhodophyta (red algae)	6/20	6	2.3
Detritus	2/20	2	0.7
Polyplacophora (chiton)	1/20	1	0.3

Enophrys diceraus Pallas - Antlered Sculpin

The genus *Enophrys* is represented by at least 3 possible species in the Gulf of Alaska - *E. bison*, *E. diceraus* and possibly *E. lucasi* (Sandercock and Wilimovsky, 1968). The status of *E. lucasi* is still in doubt since it may be shown to be a deep water sibling of *E. diceraus*.

The antlered sculpin is widely distributed in Prince William Sound, however it's occurrence in the exposed reaches of the northern Gulf is poorly understood. Most of the antlered sculpin were seen in protected embayments and shallow water kelp beds. Four specimens were captured during late spring and summer of 1977. One of the *E. diceraus* (22.0 cm) that was collected in Galena Bay on April 7, 1977 had eaten 4 green sea urchins (*Strongylocentrotus droebachiensis*), 5 limpets (*Notoacmaea* spp.) and 7 hermit crabs (*Pagurus* sp.). Limpets made up 35.4 percent of the diet of these sculpin, other important food items were juvenile brachyuran crabs and gammarid amphipods (Table 20). *Enophrys* is a generalist, and it forages on sedentary or slow moving macroinvertebrates that typically inhabit macrophyte communities.

Table 20

FOOD OF ANTLERED SCULPIN (*Enophrys diceraus*)
FROM THE NORTHEASTERN GULF OF ALASKA (N=4)

Food Items	Frequency of Occurrence	Number	Percentage of Total
Notoacmaea spp. (limpet)	2/4	11	35.4
Strongylocentrotus droebachiensis (sea urchin)	3/4	6	19.3
Pagurus spp. (hermit crab)	2/4	8	25.8
Crepidula sp. (snail)	1/4	1	3.2
Microporina borealis (bryozoan)	1/4	1	3.2
Brachyuran juveniles	1/4	2	6.4
Gammaridean amphipods	1/4	2	6.4

Myoxocephalus - Great Sculpin

The taxonomy and arrangement of the genus *Myoxocephalus* is apparently in need of revision. There are reports of at least 2 species: *M. polyacanthocephalus* and *M. scorpius* from the Gulf of Alaska (Quast and Hall, 1972). Because of these taxonomic problems our observations on foraging behavior are directed at the genus *Myoxocephalus*. This large sculpin has been seen as far north as Port Valdez; it commonly inhabits protected embayments, eelgrass meadows and kelp beds. Vertical distribution is unknown, however, a large aggregation of mature *Myoxocephalus* was observed around the sunken fishing vessel *Saint Peter*, approximately 52 meters below the sea surface.

Ten great sculpin were collected in northeastern Prince William Sound during spring, 1977. These fish ranged in size from 22.5 to 40.0 cm. All of the specimens were taken in the shallow subtidal zone, on a bottom that was dominated by seaweeds and seagrasses. Brachyuran crabs accounted for a combined total of 42.7 percent of the food items (Table 21). The major prey species was the pacific herring (*Clupea harengus pallasi*); it occurred in 5 out of 10 samples and comprised 25.0 percent of the total. One of the *Myoxocephalus* ingested 3 adult herrings (22.0 - 24.0 cm), 1 hermit crab (*Elassochirus gilli*) and eelgrass leaves. Prior to the herring spawning activities the sculpin preyed on adult herring, however after egg deposition the *Myoxocephalus* switched to eating the herrings' eggs that were attached to macrophytes.

Table 21

FOOD OF GREAT SCULPIN (*Myoxocephalus* spp.)
FROM THE NORTHEASTERN GULF OF ALASKA (N=10)

Food Items	Frequency of Occurrence	Number	Percentage of Total
Cancer oregonensis (crab)	1/10	2	7.1
Pugettia gracilis (crab)	2/10	3	10.7
Telmessus cheiragonus (crab)	4/10	6	21.4
Pagurus spp. (hermit crab)	1/10	2	7.1
Elassochirus gilli (hermit crab)	1/10	1	3.5
Chionoecetes bairdi (crab)	1/10	1	3.5
Stichaeus punctatus (fish)	1/10	1	3.5
Clupea harengus pallasi (fish)	5/10	7	25.0
Fish eggs (herring)	1/10	1	3.5
Zostera marina (eelgrass)	2/10	2	7.1
Rhodophyta (red algae)	2/10	2	7.1

SUMMARY

1.) The nearshore fish assemblages of the northern Gulf of Alaska were represented by at least 44 fish species during daylight hours. The shallow water habitats investigated during 1974-77, harbored distinct assemblages despite similarities in depth and distance from the shoreline.

2.) There was a pronounced oscillation in the composition of these fish assemblages from season to season. During summer months the protected habitats were dominated by pelagic schooling species, e.g. herring, salmon and sand lance, whereas the exposed habitats were dominated by demersal reef fishes such as black rockfish, greenling and lingcod. Abundance and species richness remained high into early fall. However, by winter the fishes were a minor component of the inshore system within the protected confines of Prince William Sound. These differences were less noticable on the outer coast, however, some changes in vertical distribution and abundance were apparent in the subtidal kelp forests.

3.) The subtidal boulder fields below the macrophyte belt were key habitats, and characteristically yielded the highest estimates of fish abundance and biomass compared to other areas on the exposed coastline. Preliminary observations indicate that the substrate type, and degree of oceanic circulation are prime factors in determining the structure and appearance of the fish community.

4.) The opportunistic foraging behavior of the bottom fishes was apparent from the wide array of prey that were taken as food. Major prey included gammaridean amphipods, brachyuran crabs, isopods, snails, mussels, caridean shrimps and brittle stars.

5.) These limited observations indicate that the nearshore zone provides refuge and feeding grounds for countless numbers of juvenile fish. It also houses or attracts a number of large predatory reef fishes such as the red snapper, lingcod and halibut, and more transient pelagic species like the pacific salmon. Most certainly these species are functional dominants in these assemblages, and as such play vital roles in the overall ecosystem.

REFERENCES

Clemens, W.A., and G.V. Wilby. 1961. Fishes of the Pacific Coast of Canada. Fish. Res. Board Can., Bull. 68, 443 p.

Farwell, M.K., Green, J.M. and V.A. Pepper. 1976. Distribution and known life history of Stichaeus punctatus in the northwest Atlantic. Copeia (3):598-602.

Forrester, C.R. and J.A. Thomson. 1969. Population studies on the rock-sole Lepidopsetta bilineata of northern Hecate Strait, British Columbia. Fish. Res. Board Can. Tech. Rep. 108: 104 p.

Gray, G.W. 1964. Halibut preying on large crustacea. Copeia (3):590.

Hart, J.L. 1973. Pacific fishes of Canada. Fish Res. Board Can. Bull 180, 740 pp.

Hobson, E.S. and J.R. Chess. 1976. Trophic interactions among fishes and zooplankters near shore at Santa Catalina Island, Calif. Fish Bull., U.S. 74(3):567-598.

Isakson, J.S., Simenstad, C.A. and R.L. Burgner. 1971. Fish communities and food chains in the Amchitka area. Bio Science 21(12):666-670.

Limbaugh, C. 1955. Fish life in the kelp beds and the effects of kelp harvesting. Univ. Calif. Inst. Mar. Resour., IMR Ref. 55-9, 158 p.

Miller, B.S., Simenstad, C.A. and L.R. Moulton. 1976. Puget Sound baseline program: Nearshore fish survey. Annual Rept. Fish. Res. INST., Univ. of Wash. 196 pp.

Miller, D.J. and R.N. Lea. 1972. Guide to the coastal marine fishes of California. Calif. Dept. Fish and Game, Fish Bull. 180, 740 pp.

Pereyra, W.T., Pearcy, W.G. and F.E. Carvey. 1969. Sebastodes flavidus, a shelf rockfish feeding on mesopelagic fauna, with consideration of the ecological implications. J. Fish. Res. Board Can. vol. 26 (8):2211-2215.

Prince, E.D. and D.W. Gotshall. 1976. Food of the copper rockfish, Sebastes caurinus Richardson, associated with an artificial reef in south Humboldt Bay, California. Calif. Fish and Game. 62(4):247-285.

Quast, J.C. 1964. Meristic variation in the hexagrammid fishes. U.S. Fish and Wild. Ser., Fish Bull., 63(3):589-609.

Quast, J.C. and E.L. Hall. 1972. List of fishes of Alaska and adjacent waters with a guide to some of their literature. NOAA Tech. Rept. NMFS SSRF-658:47 pp.

Rosenthal, R.J. 1977. Sea Otters and their subtidal habitats in Prince William Sound, Alaska. Final Report U.S. Fish and Wild. Serv., 127 pp.

Sandercock, F.K. and N.J. Wilimovsky. 1968. Revision of the cottid genus Enophrys. Copeia (4):832-853.

Simenstad, C.A. and R.E. Nakatani. 1977. Nearshore fish communities of Attu Island, Alaska. Annual Report. Fish Res. Inst., Univ. of Wash. 42 pp.

Van Hyning, J.M. and R.T. Cooney. 1974. Association of Walleye Pollock, Theragra chalcogramma, with the jellyfish, Cyanea. Copeia (3):791.

Westrheim, S.J. 1975. Reproduction, maturation, and identification of larvae of some Sebastes (Scorpaenidae) species in the northeastern Pacific Ocean. J. Fish Res. Board Can. 32(12):2399-2411.

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