Environmental Assessment of the Alaskan Continental Shelf

Annual Reports of Principal Investigators for the year ending March 1978

Volume IV. Receptors — Fish, Littoral, Benthos

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration

U.S. DEPARTMENT OF INTERIOR
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Outer Continental Shelf Environmental Assessment Program
Boulder, Colorado

October 1978

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National Oceanic and Atmospheric Administration

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ACKNOWLEDGMENT

These annual reports were submitted as part of contracts with the Outer Continental Shelf Environmental Assessment Program under major funding from the Bureau of Land Management.

RECEPTORS -- FISH

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FINAL REPORT

CONTRACT: #03-5-022-56
TASK ORDER: #15
RESEARCH UNIT: #5
REPORTING PERIOD: 04/75-09/77
NUMBER OF PAGES: 126

SURVEY OF THE EPIFAUNAL INVERTEBRATES OF THE SOUTHEASTERN BERING SEA

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May 1978

ACKNOWLEDGEMENTS

We would like to thank Bill Kopplin, Robert Roark, and Karl Haflinger for assistance onboard ship. Thanks go to the officers and crew of the following vessels involved in sampling: R/V *Acona* and the NOAA Ship *Miller Freeman*. The assistance of the Marine Sorting Center, University of Alaska is acknowledged; we especially thank Nora Foster for aid with molluscan taxonomic problems. The assistance of Dave Nebert in the initial phases of coding and preparation of the species listings for computer analysis is appreciated. The able assistance of Rosemary Hobson, Data Processing, University of Alaska, with coding problems and ultimate resolution of those problems is acknowledged. The assistance of Cydney Hansen, Data Processing, University of Alaska, with programming problems is appreciated. We would like to especially thank James Dryden, Data Processing, University of Alaska, for his initial, thorough, rapid and satisfactory development of computer programs.

The skills of Ana Lea Vincent (Publications, Institute of Marine Science, University of Alaska) are responsible for the food webs in this report. We thank the Publication Department, Institute of Marine Science, University of Alaska for assistance in all phases of preparation of this report.

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

The objectives of this study are: 1) a qualitative and quantitative inventory of dominant epibenthic species within and near identified oil-lease sites in the Bering Sea, 2) a description of spatial distribution patterns of selected species in the designated study areas, 3) preliminary observations of biological interrelationships, specifically trophic interactions, between selected segments of the benthic biota in the designated study area.

One hundred and eighty-three stations (207 tows) were successfully sampled in 1975 with a 400-mesh Eastern otter trawl in the southeastern Bering Sea. The majority of the 1975 stations were within the 80-m contour. Total epifaunal invertebrate biomass averaged 3.34 g/m^2. Ninety-five percent (95%) of the biomass consisted of Arthropoda (58.0%), Echinodermata (22.0%), Chordata (Ascidiacea) (8.5%), and Mollusca (6.5%). Red king crabs (*Paralithodes camtschatica*) (21.1%), snow crabs (*Chionoecetes opilio* [19.9%] and *C. bairdi* [10.8%]), and the sea star (*Asterias amurensis*) (17.9%) contributed 69.7% of the total epifaunal biomass. King crabs were mainly restricted to stations in Bristol Bay. *Chionoecetes opilio* was mainly caught at depths between 40 and 80 m. Stations in Bristol Bay were essentially void of *C. opilio* while moderate concentrations were found at stations north of Unimak Pass. *Chionoecetes bairdi* was found mainly at stations in Bristol Bay and north of Unimak Pass. The distribution of *C. bairdi* was limited to stations south of 58°30'N. *Asterias amurensis* was the most ubiquitous epibenthic species, although it was absent from stations immediately north of Unimak Pass.

In 1976, 81 stations (104 tows) were successfully sampled. Most of the stations were at depths greater than 80 m. Epifaunal biomass averaged 4.88 g/m^2, and was dominated by Arthropoda (66.9%) and Echinodermata (11.1%), Porifera (sponges) (8.8%) and Cnidaria (anemones) (5.2%) were of lesser importance. *Chionoecetes opilio* (28.8%), *C. bairdi* (16.7%), *Paralithodes camtschatica* (10.8%), and *Asterias amurensis* (4.7%) were the dominant individual species. Both *C. opilio* and *C. bairdi* were found at most stations in 1976. The major concentration of *P. camtschatica* was near

A major portion of the *Paralithodes camtschatica* and *Chionoecetes bairdi* populations occurred immediately north of the Alaska Peninsula. This area is also where the major fishery for these species takes place. The area is also located in a portion of Bristol Bay under consideration for petroleum exploration.

Of the 264 stations sampled, 19 were successfully occupied from two to nine times within the same year. At stations where two or more tows were taken, the first tow of a series included species that were most abundant in number and biomass. Subsequent tows yielded those species which were less important in number and biomass.

Five 30-minute tows and four 60-minute tows were made in 1975 at Station D7. A total of 44 taxa was collected from the combined tows. No significant difference in number of species and biomass (g/m^2) of the two tow durations was noted.

Stomach contents were recorded for one invertebrate species in 1975. Stomachs of six species of invertebrates and more than 13 species of fishes were examined in 1976. *Paralithodes camtschatica* fed primarily on the cockle *Clinocardium ciliatum*, the small snail *Solariella* sp., the nut shell *Nuculana fossa*, the polychaete *Cistenides* sp. and brittle stars of the family Amphiuridae. Polychaetes and ophiuroids were the dominant food items in *Chionoecetes opilio* stomachs. Clams and brittle stars were the only two food items found to be very important in both crabs. Among the sea stars, *Asterias amurensis* fed on *Pandalus goniurus* (humpy shrimp), Ectoprocta (bryozoans) and cockles (Cardiidae, presumably *Clinocardium* sp.) while *Leptasterias polaris acervata* fed exclusively on cockles. The fishes showed a variety of food preferences. *Gadus macrocephalus* (Pacific cod) fed mainly on *Pandalus borealis* (pink shrimp) while *Hemilepidotus papilio* (Irish lord) consumed polychaetes, gammarid and caprellid amphipods, *Theragra chalcogramma* (pollock), and miscellaneous fishes with about equal frequency. *Reinhardtius hippoglossoides* (Greenland halibut) consumed mainly fishes.

It is suggested in this report that comprehension of the relationship between oil, sediment, deposit-feeding clams, king and snow crabs is essential to an understanding of the potential impact of oil on the latter two commercially important species.

In 1975, man-made debris was recorded for 12 tows; in 1976, 43 of the 104 tows contained debris. Of the total number of debris-containing tows, 90% were in the most intensively fished region of the southern Bering Sea.

Initial assessment of all data suggests that: 1) sufficient station uniqueness exists to permit development of monitoring programs based on species composition at selected stations utilizing trawl techniques, and 2) adequate numbers of biologically well-known, unique, and/or large species are available to permit nomination of likely monitoring candidates once industrial activity is initiated.

II. INTRODUCTION

General Nature and Scope of Study

The operations connected with oil exploration, production, and transportation in the Bering Sea will present a wide spectrum of potential dangers to the marine environment (see Olson and Burgess, 1967, 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 (see Baker, 1976; Nelson-Smith, 1973; Pearson, 1971, 1972; 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 communication), but such fluctuations are typically unexplainable because of absence of long-term data (Lewis, 1970).

Benthic invertebrates (primarily the infauna, and sessile and slow-moving epifauna) are particularly 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; and Rosenberg, 1973, for discussion on long-term usage of benthic organisms for monitoring pollution in fjords). The presence of large numbers of benthic epifaunal species of actual or potential commercial importance (crabs, shrimps, snails, fin fishes) in the Bering Sea 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, 1977 and 1978, for a discussion 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 (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 should make it possible to differentiate between normal ecosystem variation and pollutant-induced alteration. Intensive investigations of the benthos of the Bering Sea are also essential in order to understand the trophic interactions there and to predict the changes that might take place once oil-related activities are initiated.

The 1975-76 trawl study considered in this report delineates the major epifaunal species on the eastern Bering Sea shelf in regions of offshore oil and gas concentrations. Data were obtained on faunal composition and abundance which now are baselines to which future changes can be compared. Long-term studies on life histories and trophic interactions should define functional aspects of communities and ecosystems that are vulnerable to environmental damage, and should help determine the rates at which damaged environments can recover.

Relevance to Problems of Petroleum Development

Lack of an adequate data base makes it difficult to predict the effects of oil-related activity on the subtidal benthos of the Bering Sea. However, the rapid expansion of research activities in the Bering Sea should ultimately enable us to point with some confidence to certain species or areas that might bear closer scrutiny once industrial activity is initiated. It must be emphasized that a considerable time frame is needed to comprehend long-term fluctuations in density of marine benthic species; thus, it cannot be expected that short-term research programs will result in adequate predictive capabilities. Assessment of the environment must be conducted on a continuing basis.

As indicated previously, infaunal benthic organisms tend to remain in place and consequently have been useful as an indicator species for disturbed areas. Thus, close examination of stations with substantial complements of infaunal species is warranted (see Feder, 1977, and National Oceanographic Data Center (NODC) data on file for examples of such stations). 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, station with substantial numbers of epifaunal species should be assessed on a continuing basis (see Feder, 1977, for references to relevant stations). The effect of loss of species to the overall trophic structure in the Bering Sea can be conjectured on the basis of available, limited food studies (Feder, 1977; Smith, 1978; Tsalkina, 1969; Mineva, 1964; Shubnikov, 1963; Shubnikov and Lisovenko, 1964).

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, asteroids, and holothuroids) are conspicuous members of the benthos of the Bering Sea and could be affected by oil activities there. Two echinoderm groups, asteroids (sea stars) and ophiuroids (brittle stars), are often components of the diet of large crabs (Cunningham, 1969; Feder, 1977; G. Powell, ADF&G, personal communication) and a few species of demersal fishes (Smith, 1978; Wigley and Theroux, 1965). Snow crabs (*Chionoecetes bairdi* and *C. opilio*) are conspicuous members of the shallow shelf of the Bering Sea, and support commercial fisheries of considerable importance there. Laboratory experiments with *C. bairdi* have shown that postmolt individuals lose most of their legs after exposure to Prudhoe Bay crude oil (Karinen and Rice, 1974); obviously the effect of oil on postmolt snow crabs must be considered in the continuing assessment of this species. Little other direct data based on laboratory experiments are available for subtidal benthic species (Nelson-Smith, 1973). Thus, experimentation on toxic effects of oil on other common members of the subtidal benthos should be strongly encouraged for the future in 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 Bering Sea 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 Bering Sea outer continental shelf.

III. CURRENT STATE OF KNOWLEDGE

The macrofauna of the Bering Sea is relatively well known, and data on distribution, abundance, and feeding mechanisms for infaunal species are reported in the literature (Feder *et al.*, 1976; Filatova and Barsanova, 1964; Kuznetsov, 1964; Lowry *et al.*, 1977, McLaughlin, 1963; Tsalkina, 1969; Pereyra *et al.*, 1976; Feder, 1977; Neyman, 1960, Stoker, 1973). The relationship of infaunal feeding types to the overlying winter ice cover and to primary and secondary productivity in the water column is not known. Also, data on temporal and spatial variability of the benthic fauna are sparse.

Epifauna of the eastern Bering Sea was first examined by the Harriman Alaska Expedition (Merriam, 1904). Additional, but limited, information is found in the reports of the pre-World War II king crab investigations (Fishery Market News, 1942) and from the report on the fishing and processing operations of the *Pacific Explorer* in 1948 (Wigutoff and Carlson, 1950). Some information on species found in the northern Bering Sea is included in the reports of the U.S. Fish and Wildlife Service (Ellson *et al.*, 1949, 1950). Neyman (1960) published a quantitative report, in Russian, on benthic communities in the eastern Bering Sea. A phase of the research program conducted by the king crab investigation of the Bureau of Commercial Fisheries for the International North Pacific Fisheries Commission during the summers of 1958 and 1959 included an ecological study of the eastern Bering Sea (McLaughlin, 1963). Sparks and Pereyra (1966) presented a partial checklist and general discussion of the benthic fauna of the southeastern Chukchi Sea for the summer of 1959. Their marine survey was carried out in the southeastern Chukchi Sea from the Bering Strait to just north of Cape Lisburne and west to 169°W. Some species described by them in the Chukchi Sea extend into the Bering Sea and are important there.

The distribution, biomass and turnover rates of sediment-dwelling microflora, diatoms, microfauna, and meiofauna have not been determined; it is essential that the roles of these organisms be clarified if the Bering Sea benthic system is to be comprehended. It is probable that some of these organisms are vital biological agents for recycling nutrients and carbon from sediment to the overlying water mass (see Fenchel, 1969; and Fenchel and Jørgensen, 1977, for reviews). Of unique interest in the Bering Sea is the potential relationship of the ice edge and under-ice primary productivity blooms to the underlying benthic-biotic-chemical system (V. Alexander, IMS., Univ. of Alaska, personal communication).

Crabs and bottom-feeding fishes of the Bering Sea exploit a variety of food types, benthic invertebrates being most important (Feniuk, 1945; McLaughlin and Hebard, 1961; Takeuchi, 1959, 1967; Mineva, 1964; Shubnikov and Lisovenko, 1964; Cunningham, 1969). Most of these predators feed on the nutrient-enriched upper slope during the winter, but move into the shallower and warmer waters of the shelf of the southeastern Bering Sea for intensive feeding and spawning during the summer. Occasionally they exploit the colder northern portions of the Bering Sea shelf. This differential distribution is reflected by catch statistics which demonstrate that the southeastern shelf area is a major fishing area for crabs and bottom fishes. The effect of intensive predatory activity in the southern vs.

the northern part of the shelf may be partially responsible for the lower standing stock of the food benthos in the southeastern Bering Sea (Neyman, 1960, 1963). It is apparent that bottom-feeding species of fisheries importance are intensively exploiting the southeastern Bering Sea shelf, and are often cropping what appear to be slow-growing species such as polychaetous annelids, snails and clams (Feder, unpublished observations). However, nektobenthic and pelagic crustacea such as amphipods and euphausiids may grow more rapidly in the nutrient-rich water at the shelf edge, and may provide additional important food resources there.

Some marine mammals of the Bering Sea feed on benthic species (see Lowry *et al.*, 1977). Walrus feed predominantly on what appear to be slow-growing species of molluscs, but seals prefer the more rapidly growing crustaceans and fishes in their diets (Fay *et al.*, 1977; Lowry *et al.*, 1977). Although marine mammals show food preferences, they are opportunistic feeders. As a consequence of the broad spectrum of food utilized and the exploitation of secondary and tertiary consumers, marine mammals are difficult to place in a food web and to assess in terms of energy cycling. Intensive trawling, hydraulic dredging, and oil-related activities on the Bering Sea shelf may adversely affect benthic organisms used as food by marine mammals. If benthic trophic relationships are altered by the latter activities, marine mammals may have their food regimes altered.

IV. STUDY AREA

Stations were occupied in conjunction with the National Marine Fisheries Service Resource Assessment trawl survey (Pereyra *et al.*, 1976) which sampled an area encompassed by an outer boundary extending along the shelf edge from Unimak Pass to the vicinity of St. Matthew Island, from St. Matthew Island to the coast, and along the coast to Bristol Bay (Figs. 1 and 2; Table I).

V. SOURCES, METHODS AND RATIONALE OF DATA COLLECTION

Specimens were collected onboard the NOAA Ship *Miller Freeman*. One-half-hour and one-hour tows were made at predetermined stations using a

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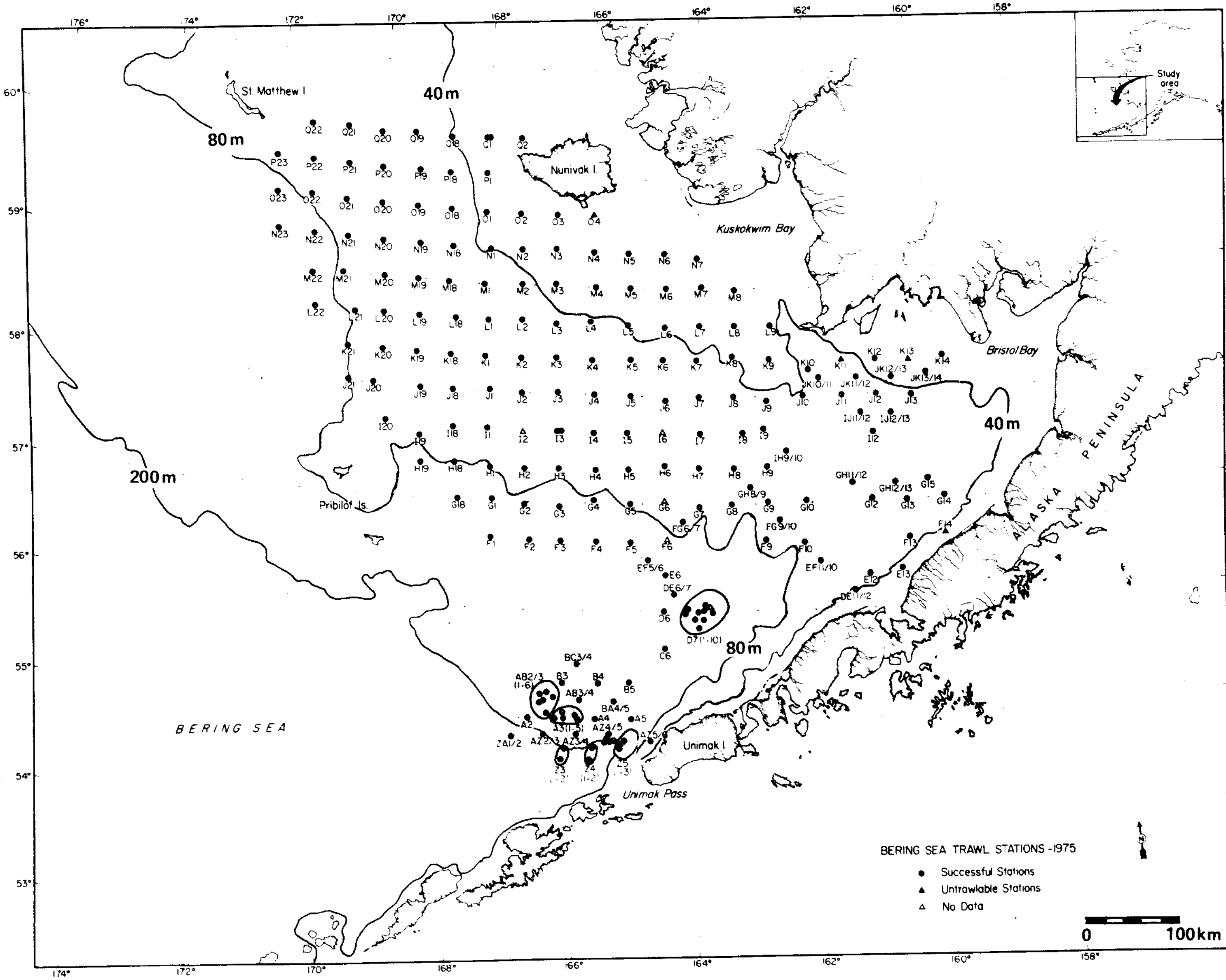

Figure 1. Benthic trawl stations occupied by NOAA Ship *Miller Freeman*, 15 August-20 October, 1975 Multiple tows are typically enclosed within a circle to separate them from neighboring stations. Shaded areas represent potential petroleum lease sites.

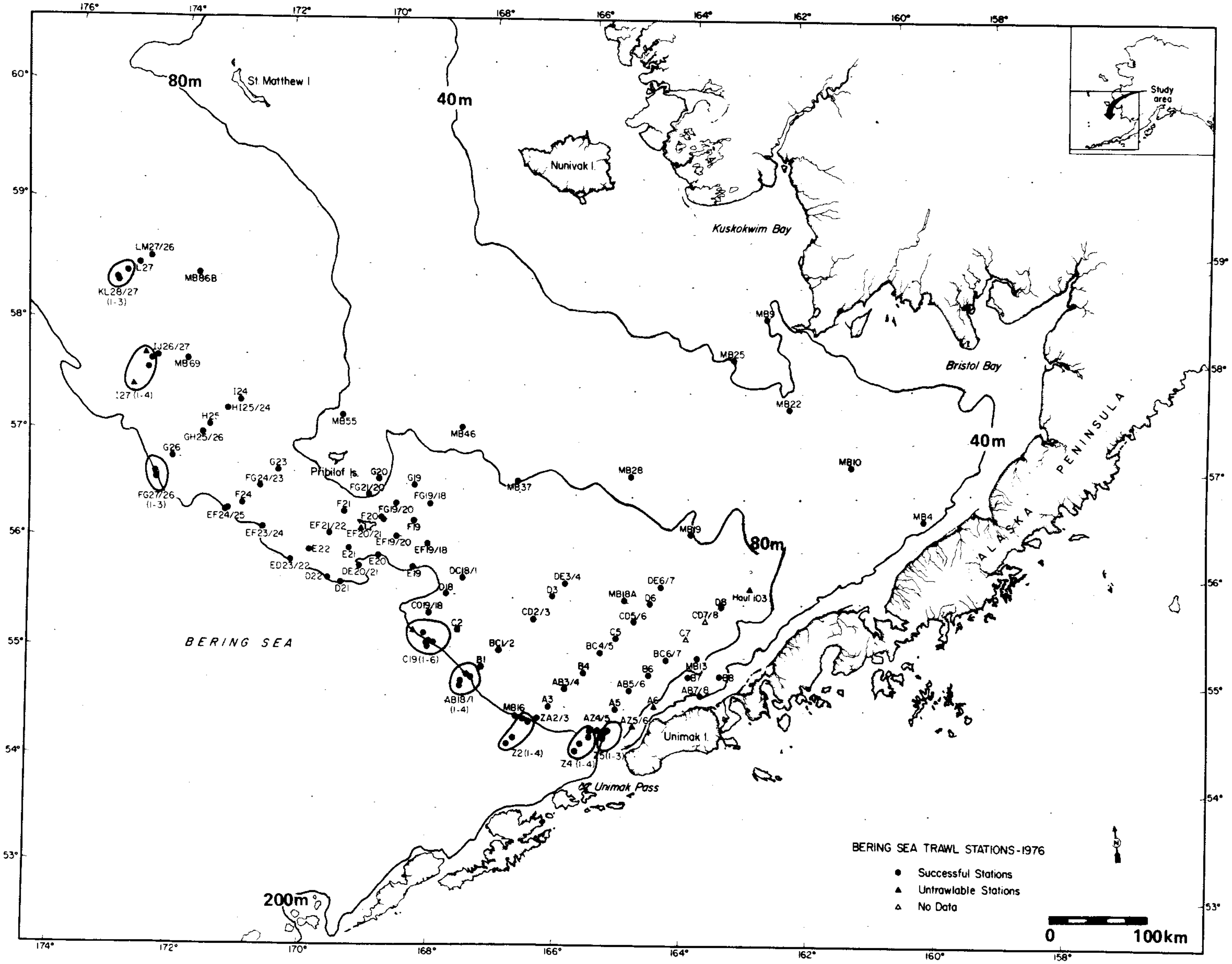

Figure 2. Benthic trawl stations occupied by NOAA Ship *Miller Freeman*, 28 March-4 June, 1976. Multiple tows are typically enclosed within a circle to separate them from neighboring stations. Shaded areas represent potential petroleum lease sites.

TABLE I

SOUTHEASTERN BERING SEA BENTHIC TRAWL STATIONS OCCUPIED BY THE NOAA SHIP *MILLER FREEMAN*, 1975 AND 1976

1975 Stations	Latitude	Longitude	Depth m
F2	56°37'	166°59'	93.0
G2	56°59'	167°03'	72.8
G1	57°01'	167°37'	75.7
G18	57°01'	168°14'	80.1
H18	57°21'	168°18'	71.0
H19	57°20'	168°53'	70.0
I19	57°39'	168°59'	68.3
I20	57°41'	169°35'	68.0
J20	57°59'	169°36'	69.2
J21	58°01'	170°16'	72.8
K21	58°19'	170°20'	72.8
L21	58°39'	170°15'	70.0
L22	58°40'	170°59'	80.5
M22	58°58'	171°05'	75.6
N22	59°20'	171°07'	73.1
N23	59°20'	171°47'	80.1
O23	59°40'	171°51'	75.7
P23	60°00'	171°56'	65.0
Q22	60°20'	171°21'	66.0
Q21	60°21'	170°40'	66.0
Q20	60°20'	170°02'	50.0
Q19	60°21'	169°24'	43.0
Q18	60°20'	168°42'	32.0
Q1	60°22'	168°02'	28.2
Q2	60°22'	167°22'	26.2
P1	60°01'	168°00'	24.0
P18	60°00'	168°42'	36.4
P19	60°00'	169°16'	44.0
P20	60°00'	169°58'	52.0
P21	60°00'	170°36'	59.2
P22	60°00'	171°16'	68.3
O22	59°41'	171°14'	71.0
O21	59°40'	170°35'	66.0
O20	59°40'	169°56'	55.0
O19	59°40'	169°16'	46.0
O18	59°40'	168°38'	36.4
O1	59°40'	167°59'	33.5
O2	59°40'	167°20'	32.0
O3	59°40'	166°39'	25.0
O4	59°40'	165°58'	21.5
N4	59°20'	165°56'	20.5
N5	59°20'	165°19'	22.0
N6	59°20'	164°38'	24.0
N7	59°17'	164°02'	24.0

TABLE I

CONTINUED

1975 Stations	Latitude	Longitude	Depth m
M8	59°59'	163°22'	24.0
M7	59°01'	163°59'	28.2
M6	59°00'	164°37'	28.2
M5	59°00'	165°16'	29.0
M4	59°00'	165°54'	32.0
M3	59°01'	166°37'	35.7
N3	59°21'	166°38'	30.0
N2	59°20'	167°16'	35.0
N1	59°20'	167°52'	38.2
N18	59°20'	168°32'	40.0
N19	59°20'	169°10'	52.0
N20	59°20'	169°51'	63.0
N21	59°20'	170°30'	71.5
M21	59°00'	170°28'	74.0
M20	59°01'	169°45'	65.0
M19	59°00'	169°09'	58.0
M18	59°00'	168°33'	48.0
M1	59°00'	167°54'	44.0
M2	59°01'	167°13'	42.0
L1	58°40'	167°48'	48.0
L18	58°40'	168°24'	55.0
L19	58°40'	169°05'	66.0
L20	58°40'	169°42'	71.0
K20	58°20'	169°41'	73.0
K19	58°20'	169°05'	71.0
K18	58°20'	168°27'	72.0
K1	58°20'	167°50'	66.6
J1	58°01'	167°43'	70.0
J19	58°00'	168°58'	74.0
J18	58°00'	168°23'	74.0
I18	57°41'	168°22'	74.0
I1	57°41'	167°45'	73.0
H1	57°20'	167°41'	76.4
D7	56°00'	164°01'	92.8
C6	55°40'	164°34'	115.0
B5	55°21'	165°10'	98.6
A4	55°00'	165°44'	134.0
BC3/4	55°30'	166°04'	126.7
B3	55°20'	166°18'	132.0
AB2/3	55°09'	166°39'	146.0
ZA1/2	54°49'	167°06'	355.0
A2	55°00'	166°51'	159.5
F1	56°40'	167°38'	103.5
H2	57°19'	167°04'	74.6
I2	57°39'	167°09'	71.0
I3	57°40'	166°30'	69.1

TABLE I

CONTINUED

1975 Stations	Latitude	Longitude	Depth m
I4	57°40'	165°52'	66.0
H4	57°19'	165°50'	40.0
G5	57°00'	165°13'	74.6
H5	57°20'	165°15'	80.3
I5	57°40'	165°16'	63.7
I6	57°40'	164°38'	55.0
H6	57°22'	164°37'	67.3
G6	57°01'	164°37'	73.0
FG6/7	56°51'	164°18'	74.6
A3	55°00'	166°16'	138.0
F3	56°39'	166°24'	87.3
G3	56°58'	166°27'	72.8
Z3	54°40'	166°16'	322.1
AZ2/3	54°50'	166°34'	188.3
AZ3/4	54°51'	166°01'	156.4
AZ4/5	54°50'	165°25'	148.0
Z5	54°42'	165°05'	88.3
D6	55°59'	164°35'	93.6
DE6/7	56°11'	164°16'	91.0
E6	56°20'	164°35'	89.1
EF5/6	56°29'	164°55'	81.0
F6	56°40'	164°35'	76.8
G7	56°59'	164°00'	69.1
G8	57°00'	163°26'	65.5
GH8/9	57°10'	163°06'	68.2
G9	57°01'	162°48'	61.6
FG9/10	56°51'	162°36'	65.5
F10	56°38'	162°10'	75.4
EF11/10	56°28'	161°52'	82.8
AZ5/6	54°51'	164°53'	75.5
A5	55°00'	165°09'	111.2
BA4/5	55°10'	165°26'	201.1
B4	55°20'	165°44'	123.7
AB3/4	55°09'	166°00'	132.3
Z4	54°40'	165°46'	319.0
H3	57°20'	166°29'	71.0
G4	57°02'	165°52'	73.0
F4	56°39'	165°48'	73.0
F5	56°40'	165°12'	77.3
I7	57°40'	163°59'	52.0
H7	57°20'	164°00'	63.0
H8	57°20'	163°23'	54.0
H9	57°21'	162°48'	50.0
IH9/10	57°29'	162°27'	50.0
I12	57°39'	160°56'	56.4

TABLE I

CONTINUED

1975 Stations	Latitude	Longitude	Depth m
IJ12/13	57°49'	160°36'	52.5
J13	57°59'	160°15'	53.0
JK13/14	58°11'	159°57'	42.0
K14	58°20'	159°37'	27.3
K13	58°18'	160°15'	25.5
JK12/13	58°09'	160°34'	44.0
J12	58°00'	160°51'	46.0
IJ11/12	57°50'	161°08'	47.3
J11	58°00'	161°29'	55.6
JK11/12	58°10'	161°12'	47.3
K12	58°20'	160°51'	48.5
J10	58°00'	162°10'	38.2
JK10/11	58°10'	161°52'	40.0
K11	58°20'	161°29'	39.2
K10	58°15'	162°03'	46.6
K9	58°21'	162°45'	32.0
L9	58°40'	162°43'	24.0
L8	58°40'	163°21'	32.0
L7	58°40'	163°58'	35.0
L6	58°39'	164°37'	38.2
L5	58°40'	165°17'	39.1
L4	58°41'	165°58'	36.4
L2	58°41'	167°12'	45.0
K2	58°20'	167°11'	54.0
J2	58°00'	167°08'	66.0
L3	58°39'	166°34'	44.0
K3	58°21'	166°33'	47.3
J3	58°01'	166°30'	62.0
J4	58°00'	165°51'	55.7
K4	58°19'	165°54'	47.3
J5	58°00'	165°12'	50.0
K5	58°21'	165°13'	46.0
K6	58°21'	164°39'	45.0
K7	58°20'	164°01'	42.0
K8	58°22'	163°24'	37.2
J6	57°57'	164°35'	47.3
J7	58°00'	164°00'	47.3
J8	58°00'	163°23'	45.0
J9	57°58'	162°49'	45.0
I9	57°42'	162°52'	46.0
I8	57°40'	163°12'	49.8
DE11/12	56°11'	161°18'	43.0
E12	56°20'	161°02'	55.0
G12	57°01'	160°58'	65.6

TABLE I

CONTINUED

1975 Stations	Latitude	Longitude	Depth m
GH12/13	57°10'	160°35'	65.6
G13	57°00'	160°22'	65.6
F13	56°39'	160°20'	54.6
E13	56°23'	160°30'	37.5
F14	56°40'	159°45'	38.2
G14	57°01'	159°44'	56.6
G15	57°11'	160°00'	60.0
GH11/12	57°11'	161°18'	68.2
G10	57°01'	162°07'	59.1
F9	56°40'	162°50'	73.0

TOTAL STATIONS 191

TABLE I

CONTINUED

1976 Stations	Latitude	Longitude	Depth m
Z5	54°48'	165°17'	168.0
Z4	54°42'	163°38'	346.5
AZ5/6	54°50'	164°50'	72.4
A6	55°00'	164°35'	111.0
B7	55°19'	163°56'	71.0
AB7/8	55°09'	163°43'	46.0
B8	55°19'	163°24'	55.0
Z2	54°55'	166°42'	358.5
ZA2/3	54°54'	166°27'	160.9
A3	55°00'	166°16'	145.6
AB3/4	55°09'	166°01'	132.8
B4	55°19'	165°43'	113.2
BC4/5	55°31'	165°27'	117.3
C5	55°40'	165°10'	112.4
CD5/6	55°50'	164°53'	99.1
D6	55°56'	164°35'	96.4
DE6/7	56°08'	164°27'	91.8
DE3/4	56°10'	166°07'	110.1
D3	56°01'	166°20'	125.4
CD2/3	55°48'	166°39'	136.0
C2	55°40'	166°56'	138.3
BC1/2	55°30'	167°10'	140.1
B1	55°19'	167°28'	150.1
AB18/1	55°10'	167°43'	199.0
C19	55°36'	168°39'	277.5
CO19/18	55°49'	168°23'	143.7
D18	56°00'	168°07'	147.0
DC18/1	56°10'	167°50'	140.5
EF19/18	56°25'	168°33'	122.8
E19	56°15'	168°45'	153.0
AZ4/5	54°49'	165°23'	161.0
A5	54°59'	165°09'	116.4
AB5/6	55°09'	164°55'	155.0
B6	55°19'	164°34'	105.9
BC6/7	55°28'	164°16'	104.6
C7	55°42'	163°58'	100.1
D8	55°58'	163°22'	93.7
CD7/8	55°50'	163°42'	96.4
EF23/24	56°27'	171°24'	179.6
ED23/22	56°11'	170°51'	150.9
E22	56°19'	170°35'	127.1
EF21/22	56°29'	170°15'	115.2
F21	56°40'	170°03'	107.6
EF20/21	56°31'	169°41'	86.0
D21	56°01'	169°58'	144.4

TABLE I

CONTINUED

1976 Stations	Latitude	Longitude	Depth m
DE20/21	56°12'	169°42'	313.5
E20	56°19'	169°19'	155.4
EF19/20	56°31'	169°02'	105.7
F19	56°41'	168°47'	109.7
G20	57°01'	169°29'	67.7
FG21/20	56°52'	169°39'	75.4
G19	57°00'	168°50'	85.1
FG19/18	56°50'	168°33'	103.4
FG19/20	56°48'	169°07'	89.6
F20	56°41'	169°21'	80.5
E21	56°21'	169°56'	112.6
D22	56°03'	170°12'	142.1
EF24/25	56°34'	172°02'	181.0
F24	56°41'	171°51'	127.2
FG24/23	56°51'	171°32'	120.7
G23	57°00'	171°16'	111.1
HI25/24	57°30'	172°20'	114.3
H25	57°20'	172°35'	116.4
GH25/26	57°13'	172°45'	119.2
FG27/26	56°47'	173°22'	192.8
G26	57°00'	173°07'	135.1
IJ26/27	57°50'	173°38'	140.0
I27	57°50'	173°47'	327.0
KL28/27	58°34'	174°24'	199.3
L27	58°40'	174°12'	155.6
LM27/26	58°44'	174°02'	139.0
I24	57°36'	172°04'	113.0
MB13	55°31'	163°49'	48.0
MB4	56°45'	159°53'	28.0
Haul 103	56°09'	162°55'	84.0
MB9	57°50'	160°08'	54.0
MB25	58°19'	163°13'	37.5
MB22	57°50'	162°14'	45.7
MB10	57°18'	161°08'	65.9
MB19	56°40'	163°58'	76.8
MB16	54°53'	166°48'	102.7
MB55	57°37'	170°21'	75.7
MB69	57°56'	173°02'	116.5
MB86B	58°40'	173°16'	117.0
MB46	57°35'	168°04'	73.2
MB37	57°06'	167°01'	76.4
MB28	57°12'	165°02'	71.3
MB18A	56°01'	165°03'	97.0

TOTAL STATIONS 87

commercial size 400-mesh Eastern otter trawl. Multiple tows were made at selected stations for comparative purposes. At Station D7, a series of tows were made for the purpose of comparing data by different trawl durations. Due to the difficulties in maintaining station position a series of tows taken at a given station were not all taken precisely on station, but rather each tow sampled an area near the coordinates of the particular station. Large catches were weighed in their entirety and subsampled. All invertebrates were sorted out on shipboard, given tentative identifications, counted, weighed when time permitted, and aliquot samples of individual species preserved and labeled for final identification at the Institute of Marine Science, University of Alaska. Counts and weights of commercially important invertebrate species were recorded by the National Marine Fisheries Service biologists in accordance with contractual agreements, and data made available to the benthic invertebrate program.

For obvious logistic reasons all invertebrates could not be returned to the laboratory for verification. Therefore, a subsample of each field identification was returned to the University. Closer laboratory examination often revealed more than one species in a sample of what was designated in the field as one species. In such cases, the counts and weights of the species in question were expanded from the laboratory species ratio to the entire catch of the trawl.

Hermit crab weights did not include the shell.

Biomass per unit area (g/m^2) is calculated as follows: $\frac{w}{Tw(D x 1000)}$; where w = weight (grams), Tw = width of trawl opening (meters), and (D x 1000) is distance fished (kilometers x 1000). The data bases for all calculations of biomass are included with the station data submitted to NODC.

Selected fish species were collected or their stomachs removed and preserved; this material was given to Dr. Ron Smith (University of Alaska) for stomach content analysis in 1975 and 1976 (Smith, 1978).

The stomachs of variable numbers of red king crabs (*Paralithodes camtschatica*), snow crabs (*Chionoecetes opilio*), and selected species of fishes were examined to determine food habits. Some food items were identified onboard ship. Stomach contents were then placed in "Whirlpak" bags and fixed in 10% buffered formalin for final identifications at the

University of Alaska. Analysis of stomach contents was carried out using the frequency of occurrence method. In the latter method, prey organisms are expressed as the percent of stomachs containing various food items from the total number of stomachs analyzed.

VI. RESULTS

Distribution, Abundance and Biomass

Trawling operations during 1975 and 1976 resulted in the collection of animals from 11 phyla, 21 classes, 109 families, and 233 species (Tables II and III) of epifaunal invertebrates. In 1975, sampling was attempted at 191 stations (219 tows); 183 stations were successfully sampled (207 tows, Fig. 1). In 1976, sampling was attempted at only 87 stations (117 tows) and collections were made at 81 stations (104 tows, Fig. 2). It is probable that all dominant epifaunal species have been collected in the areas of investigation and only rare ones will be added with further trawl sampling.

The 1975 sampling period

The majority of the stations occupied in 1975 were within the 80-m contour (Fig. 1; Table I). Total epifaunal invertebrate biomass averaged 3.34 g/m^2. Four phyla dominated the epifaunal invertebrate biomass (Table IV). Ninety-five percent (95%) of the biomass was made up of these groups: Arthropoda (58.0%), Echinodermata (22.0%), Chordata (Ascidiacea) (8.5%), and Mollusca (6.5%).

A pattern of biomass dominance by a few families was found. Five families made up 87.5% of the total epifaunal invertebrate biomass (Table V). Similarly, only 11 species contributed over 1% each to the total epifaunal invertebrate biomass (Table VI).

The crabs, *Paralithodes camtschatica*, *Chionoecetes opilio*, *C. bairdi*, and the sea star, *Asterias amurensis*, contributed 69.7% of the total epifaunal biomass (Table VII).

Paralithodes camtschatica, the commercially important red king crab, was the dominant invertebrate, by weight, in the area. King crabs averaged slightly over 1 kg in weight and made up 21.1% of the total epifaunal

Text continued on Page 33

TABLE II

A LIST OF INVERTEBRATE SPECIES TAKEN BY TRAWL FROM THE S.E. BERING SEA ON THE NOAA SHIP *MILLER FREEMAN*, 1975 AND 1976

Phylum Porifera
- Unidentified species

Phylum Cnidaria
- Class Hydrozoa
  - Unidentified species
- Class Scyphozoa
  - Unidentified species
- Class Anthozoa
  - Unidentified species
  - Subclass Alcyonaria
    - Family Nephtheidae
      - *Eunephthya rubiformis* (Pallas)
    - Family Paragorgiidae
      - *Paragorgia arborea*
    - Family Virgulariidae
      - *Stylatula gracile* (Gabb)
    - Family Actiniidae
      - Unidentified species

Phylum Annelida
- Class Polychaeta
  - Unidentified species
  - Family Polynoidae
    - Unidentified species
  - Family Nereidae
    - Unidentified species
  - Family Flabelligeridae
    - *Brada sachalina*
  - Family Pectinariidae
    - *Cistenides hyperborea*
  - Family Serpulidae
    - *Crucigera irregularis*
  - Family Aphroditidae
    - *Aphrodita japonica* Marenzeller
- Class Hirudinea
  - *Notostomobdella* sp.
  - *Carcinobdella* sp.

Phylum Mollusca
- Class Pelecypoda
  - Unidentified species
  - Family Nuculanidae
    - *Nuculana fossa* Baird
    - *Yoldia myalis*
    - *Yoldia scissurata*
    - *Yoldia hyperborea* Torrell
    - *Yoldia seminuda* Dall
  - Family Mytilidae
    - *Mytilus edulis*
    - *Musculus niger* (Gray)

TABLE II

CONTINUED

Musculus discors (Linnaeus)
Modiolus modiolus
Family Pectinidae
Chlamys pseudoislandica
Chlamys rubida (Hinds)
Pecten caurinus
Family Anomiidae
Pododesmus macrochisma
Family Astartidae
Astarte montagui
Astarte alaskensis
Family Carditidae
Cyclocardia crebricostata Krase
Cyclocardia ventricosa
Cyclocardia crassidens
Family Kelliidae
Pseudopythina compressa
Family Cardiidae
Clinocardium ciliatum (Fabricius)
Clinocardium califoriense (Dall)
Serripes groenlandicus (Bruguiere)
Family Veneridae
Liocyma fluctuosa
Family Mactridae
Spisula polynyma (Stimpson)
Family Tellinidae
Macoma calcarea (Gmelin)
Tellina lutea Wood
Family Solenidae
Siliqua alta (Broderip and Sowerby)
Family Hiatellidae
Hiatella arctica (Linnaeus)
Family Teredinidae
Bankia setacea
Family Cuspidariidae
Cardiomya beringensis (Leche)
Class Gastropoda
Unidentified species
Family Trochidae
Margarites giganteus (Leche)
Margarites costalis (Gould)
Solariella obscura
Solariella micraulax
Family Turritellidae
Tachyrynchus erosus (Couthouyi)
Family Calyptraeidae
Crepidula grandis Middendorff
Family Trichotropididae
Trichotropis insignis

TABLE II

CONTINUED

Family Naticidae
- *Natica clausa* (Broderip and Sowerby)
- *Polinices pallida* (Broderip and Sowerby)

Family Velutinidae
- *Velutina* sp.
- *Velutina velutina* (Müller)
- *Velutina lanigera*

Family Cymatiidae
- *Fusitriton oregonensis* Redfield

Family Muricidae
- *Boreotrophon clathratus*
- *Boreotrophon pacificus* (Dall)
- *Boreotrophon dalli* (Kobelt)

Family Buccinidae
- *Buccinum* sp.
- *Buccinum angulosum* Gray
- *Buccinum scalariforme* (Möller)
- *Buccinum glaciale* Linnaeus
- *Buccinum solenum* (Dall)
- *Buccinum polare* Gray
- *Buccinum plectrum* Stimpson

Family Neptuneidae
- Unidentified species
- *Ancistrolepis eucosmia*
- *Ancistrolepis magna* Dall
- *Ancistrolepis ochotensis*
- *Beringius kennicotti* (Dall)
- *Beringius beringi* (Middendorff)
- *Beringius stimpsoni*
- *Beringius frielei* (Middendorff)
- *Beringius crebricostatus undatus*
- *Beringius* sp.
- *Colus* sp.
- *Colus spitzbergensis* (Reeve)
- *Colus herendeenii*
- *Colus halli* (Dall)
- *Colus hypolispus*
- *Colus aphelus* (Dall)
- *Colus dautzenbergi* (Dall)
- *Neptunea* sp.
- *Neptunea lyrata* (Gmelin)
- *Neptunea ventricosa* (Gmelin)
- *Neptunea pribiloffensis* (Dall)
- *Neptunea communis borealis*
- *Neptunea heros* (Gray)
- *Plicifusus kroyeri* (Möller)
- *Pyrulofusus* sp.
- *Pyrulofusus harpa*

TABLE II

CONTINUED

Pyrulofusus deformis
Volutopsius sp.
Volutopsius fragilis (Dall)
Volutopsius middendorfi
Volutopsius melonis (Dall)
Volutopsius trophonius
Volutopsius castanees (Dall)
Family Volutidae
Arctomelon stearnsii
Family Cancellariidae
Admete couthouyi (Jay)
Family Turridae
Aforia circinata
Family Dorididae
Unidentified species
Family Dendronotidae
Unidentified species
Family Tritoniidae
Unidentified species
Tritonia exsulans
Tochuina tetraquetra (Pallas)
Class Cephalopoda
Family Sepiolidae
Rossia pacifica
Family Gonatidae
Unidentified species
Family Octopodidae
Octopus sp.
Phylum Arthropoda
Class Pycnogonida
Family Phoxichilidiidae
Anaplodactylus erectus
Family Pycnogonidae
Unidentified species
Class Crustacea
Subclass Thoracica
Family Lepadidae
Lepas pectinata pacificus
Family Balanidae
Balanus balanus (Linnaeus)
Balanus evermani
Balanus rostratus
Balanus hesperius
Sub-class Malacostraca
Order Cumacea
Family Diastylidae
Diastylis bidentata (Dall)

TABLE II

CONTINUED

Order Mysidacea
    Family Mysidae
        Neomysis rayii
Order Isopoda
        Unidentified species
    Family Idoteidae
        Synidotea bicuspida (Owen)
    Family Sphaeromatidae
        Tecticeps alascensis (Richardson)
    Family Aegidae
        Rocinela augustata Richardson
    Family Bopyridae
        Argeia pugettensis Dana
Order Amphipoda
        Unidentified species
    Family Ampeliscidae
        Ampelisca eschrichti
    Family Gammaridae
        Melita dentata
        Jassa pulchella
    Family Lysianassidae
        Anonyx nugax pacifica (Krøyer)
    Family Hyperiidae
        Parathemisto libellula
    Family Caprellidae
        Unidentified species
Order Decapoda
    Family Pasiphaeidae
        Pasiphaea pacifica
    Family Pandalidae
        Pandalus borealis Krøyer
        Pandalus goniurus Stimpson
        Pandalus montagui tridens Rathbun
        Pandalopsis dispar
    Family Hippolytidae
        Spirontocaris lamellicornis (Dana)
        Spirontocaris ochotensis (Brandt)
        Spirontocaris sp.
        Eualus sp.
        Eualus macilenta (Krøyer)
        Eualus gaimardii belcheri
    Family Crangonidae
        Crangon dalli Rathbun
        Crangon communis Rathbun
        Sclerocrangon boreas
        Argis dentata (Rathbun)
        Argis ovifer

TABLE II

CONTINUED

Family Paguridae
- *Pagurus* sp.
- *Pagurus ochotensis* (Benedict)
- *Pagurus aleuticus* (Benedict)
- *Pagurus capillatus* (Benedict)
- *Pagurus kennerlyi*
- *Pagurus beringanus*
- *Pagurus confragosus* (Benedict)
- *Pagurus cornutus* (Benedict)
- *Pagurus trigonocheirus* (Stimpson)
- *Pagurus townsendi*
- *Pagurus rathbuni*
- *Elassochirus cavimanus* (Miers)
- *Elassochirus tenuimanus*
- *Elassochirus gilli*
- *Labidochirus splendescens* Owen

Family Lithodidae
- *Hapalogaster grebnitzkii*
- *Placetron woznessenskii*
- *Paralithodes camtschatica* (Tilesius)
- *Paralithodes platypus* Brandt
- *Lithodes aequispina*
- *Sculptolithodes derjugini*

Family Majiidae
- *Oregonia gracilis*
- *Hyas lyratus* Dana
- *Hyas coarctatus alutaceus* Brandt
- *Chionoecetes* (hybrid)
- *Chionoecetes opilio* (Fabricius)
- *Chionoecetes bairdi* Rathbun

Family Cancridae
- *Cancer oregonensis*

Family Atelecyclidae
- *Telmessus cheiragonus* (Tilesius)
- *Erimacrus isenbeckii* (Brandt)

Phylum Sipunculida
- Unidentified species

Phylum Echiurida
- Class Echiuroidea
  - Family Echiuridae
    - *Echiurus echiurus*

Phylum Ectoprocta
- Unidentified species

Phylum Brachiopoda
- Family Cancellothyrididae
  - *Terebratulina unguicula*

TABLE II

CONTINUED

Family Dallinidae
Laqueus californicus
Terebratalia transversa
Phylum Echinodermata
Class Asteroidea
Family Astropectinidae
Dipsacaster borealis Fisher
Family Benthopectinidae
Ludiaster dawsoni
Family Goniasteridae
Geophyreaster swifti
Ceramaster patagonicus Sladen
Pseudarchaster parelii
Family Porcellanasteridae
Ctenodiscus crispatus
Family Echinasteridae
Henricia aspera Fisher
Henricia beringiana
Henricia sp.
Family Pterasteridae
Diplopteraster multipes
Pteraster obscurus (Perrier)
Pteraster tesselatus
Family Solasteridae
Crossaster borealis (Fisher)
Crossaster papposus (Linnaeus)
Lophaster furcilliger
Solaster endeca
Solaster dawsoni
Family Asteridae
Asterias amurensis Lutkin
Evasterias echinosoma
Evasterias troschelii
Leptasterias polaris acervata (Stimpson)
Leptasterias sp.
Lethasterias nanimensis (Verrill)
Class Echinoidea
Family Echinarachniidae
Echinarachnius parma
Family Schizasteridae
Brisaster townsendi
Family Strongylocentrotidae
Strongylocentrotus droebachiensis (O. F. Müller)
Class Ophiuroidea
Unidentified species
Family Asteronychidae
Asteronyx loveni
Family Gorgonocephalidae
Gorgonocephalus caryi (Lyman)

TABLE II

CONTINUED

Family Ophiactidae
Ophiopholis aculeata (Linnaeus)
Family Ophiuridae
Ophiopenia tetracantha
Ophiura sarsi Lütkin
Stegophiura nodosa (Lütkin)
Class Holothuroidea
Unidentified species
Family Synaptidae
Unidentified species
Family Molpadiidae
Molpadia sp.
Family Stichopodidae
Parastichopus sp.
Family Cucumariidae
Cucumaria sp.
Class Crinoidea
Unidentified species
Phylum Chordata
Unidentified species
Class Stolidobranchia
Family Styelidae
Unidentified species
Styela rustica macrenteron
Family Pyuridae
Boltenia ovifera (Linnaeus)
Halocynthia aurantium (Pallas)

TABLE III

NUMBER OF SPECIES OF EPIFAUNAL INVERTEBRATES BY PHYLUM AND CLASS, S.E. BERING SEA, 1975 - 1976

Phylum	Class	Number of Species	Percent of Species
Porifera	-	1	0.4
Cnidaria	Hydrozoa	1	0.4
	Scyphozoa	1	0.4
	Anthozoa	5	2.1
Annelida	Polychaeta	7	3.0
	Hirudinea	2	0.9
Mollusca	Pelecypoda	31	13.3
	Gastropoda	65	27.9
	Cephalopoda	3	1.3
Arthropoda	Pycnogonida	2	0.9
	Crustacea	65	27.9
Sipunculida	-	1	0.4
Echiurida	Echiurida	1	0.4
Ectoprocta	-	1	0.4
Brachiopoda	Articulata	3	1.3
Echinodermata	Asteroidea	23	9.9
	Echinoidea	3	1.3
	Ophiuroidea	7	3.0
	Holothuroidea	5	2.1
	Crinoidea	1	0.4
Chordata	Urochordata	5	2.1
	Total	233	

TABLE IV

NUMBERS, WEIGHT, AND BIOMASS (g/m^2) OF MAJOR EPIFAUNAL INVERTEBRATE PHYLA OF THE S.E. BERING SEA, 1975. TRAWL SURVEY.

Phylum	Number of Organisms	Wet Weight (kg)	Percent of Total Weight	Mean Grams Per Square Meter ($\bar{x}$ g/m^2)
Porifera	159	303.65	1.1	0.035
Cnidaria	5580	1118.95	3.9	0.130
Annelida	1514	4.13	< .1	<0.001
Mollusca	21760	1890.76	6.5	0.219
Arthropoda (Crustacea)	124636	16729.99	58.0	1.937
Echinodermata	54629	6337.70	22.0	0.734
Chordata (Ascidiacea)	24700	2448.10	8.5	0.283
Total	232978	28833.28	100.0	3.338

TABLE V

NUMBERS, WEIGHT, AND BIOMASS (g/m^2) OF MAJOR EPIFAUNAL INVERTEBRATE FAMILIES OF THE S.E. BERING SEA, 1975. TRAWL SURVEY.

Family	Number of Organisms	Wet Weight (kg)	Percent of Total Weight	Mean Grams Per Square Meter ($\bar{x}$ g/m^2)
Neptuneidae	9671	1612.71	5.6	0.187
Lithodidae	6142	6209.24	21.5	0.719
Majidae	87589	9633.86	33.4	1.115
Asteridae	46059	5640.33	19.6	0.653
Styelidae	22595	2144.28	7.4	0.248
Total	172006	25240.42	87.5	2.922

TABLE VI

NUMBERS, WEIGHT, AND BIOMASS (g/m^2) OF 11 SPECIES CONTRIBUTING MORE THAN ONE PERCENT EACH TO THE TOTAL EPIFAUNAL INVERTEBRATE BIOMASS, S.E. BERING SEA, 1975. TRAWL SURVEY.

Species	Number of Organisms	Wet Weight (kg)	Percent of Total Weight	Mean Grams Per Square Meter ($\bar{x}$ g/m^2)
Neptunea ventricosa	2101	350.82	1.2	0.041
Neptunea heros	4250	692.18	2.4	0.080
Pagurus trigonocheirus	12302	370.29	1.3	0.043
Paralithodes camtschatica	6057	6097.13	21.1	0.706
Chionoecetes (hybrid)	3591	585.87	2.0	0.068
Chionoecetes opilio	72585	5740.87	19.9	0.665
Chionoecetes bairdi	9352	3120.29	10.8	0.361
Asterias amurensis	44421	5167.50	17.9	0.598
Leptasterias polaris acervata	1231	335.46	1.2	0.039
Gorgonocephalus caryi	1832	446.77	1.6	0.052
Styela rustica macrenteron	22595	2144.19	7.4	0.248
Total	180315	25051.37	86.8	2.901

TABLE VII

NUMBERS, WEIGHT, AND BIOMASS (g/m^2) OF THE MAJOR EPIFAUNAL SPECIES OF MOLLUSCA, ARTHROPODA, ECHINODERMATA, AND CHORDATA (ASCIDIACEA) FROM THE S.E. BERING SEA, 1975. TRAWL SURVEY.

Phylum	Species	Number of Organisms	Wet Weight (kg)	Percent of Total Weight	Percent of Phylum Weight	Mean Grams Per Square Meter ($\bar{x}$ g/m^2)
Mollusca	*Neptunea lyrata*	730	173.23	0.6	9.16	0.02
	N. ventricosa	2101	350.82	1.2	18.55	0.04
	N. pribiloffensis	730	143.40	0.5	7.58	0.02
	N. communis borealis	1380	191.15	0.7	10.11	0.02
	N. heros	4250	692.18	2.4	36.61	0.08
	Total	9191	1550.78	5.4	82.01	0.18
Arthropoda	*Paralithodes camtschatica*	6057	6097.13	21.1	36.44	0.71
	Chionoecetes opilio	72585	5740.88	19.9	34.31	0.66
	Chionoecetes bairdi	9352	3120.29	10.8	18.65	0.36
	Total	87994	14958.30	51.8	89.40	1.73
Echinodermata	*Asterias amurensis*	44421	5167.50	17.9	81.54	0.60
	Leptasterias polaris acervata	1231	335.46	1.2	5.29	0.04
	Gorgonocephalus caryi	1832	446.77	1.6	7.05	0.05
	Total	47484	5949.73	20.7	93.88	0.69
Chordata (Ascidiacea)	*Styela rustica macrenteron*	22595	2144.19	7.4	87.59	0.25
	Boltenia ovifera	1777	204.41	0.7	8.35	0.02
	Halocynthia aurantium	328	99.40	0.3	4.06	0.01
	Total	24700	2448.00	8.4	100.00	0.28

biomass (Table VI). The 1975 catch was mainly restricted to stations in Bristol Bay (Figs. 1 and 3). The average biomass was 0.706 g/m^2; however, the highest biomass was at Station FG9/10 with 68.3 g/m^2. Thirty-five percent (2,091 individuals) of all *P. camtschatica* caught in 1975 came from Station FG9/10.

Chionoecetes opilio, a commercially important brachyuran crab, averaged less than 0.1 kg per animal, but its numerical abundance was nearly 12 times that of king crabs. The biomass of *C. opilio* was 19.9% of the total invertebrate biomass (Table VI). The majority of *C. opilio* were caught at depths between 40 and 80 m. Stations in Bristol Bay were essentially void of this species while moderate concentrations were found at stations north of Unimak Pass. Station L21 had the highest biomass with 13.7 g/m^2 (6,534 individuals; Figs. 1 and 4).

Chionoecetes bairdi, another commercial crab, made up 10.8% of the total epifaunal weight and was found mainly at stations in Bristol Bay and north of Unimak Pass (Table VI; Fig. 5). The distribution of this species was limited to stations south of 58°30'N. The highest biomass was at Station Z5 with 3.1 g/m^2 (368 individuals).

The sea star, *Asterias amurensis*, made up 17.9% of the total epifaunal biomass (Table VI) and was the most ubiquitous species (137 stations), although it was absent from stations immediately north of Unimak Pass. Many high biomass stations were found in Bristol Bay, specifically at stations J12, JK11/12, J10, JK10/11, DE11/12, and E12 where the biomass ranged between 4.3 and 9.8 g/m^2 (Figs. 1 and 6). Station DE11/12 had the highest biomass of *A. amurensis* with 9.8 g/m^2 (3,688 individuals).

Frequency of occurrence varied from the presence of a particular species in only one tow to the presence of a species in as many as 140 tows (e.g., *A. amurensis*) (Table VIII). Twenty-seven species occurred in greater than 20% of the tows (Table VIII). High frequency of occurrence did not correlate with greatest biomass. The large crab *Paralithodes camtschatica* (21.1% of the total biomass) occurred in only 37.2% of the tows while the small individuals of the polychaetous annelid family Polynoidae (less than 0.01% of total biomass) occurred at 57.5% of the tows.

A summarization of general biological information collected by trawling in 1975 is included in Appendix I.

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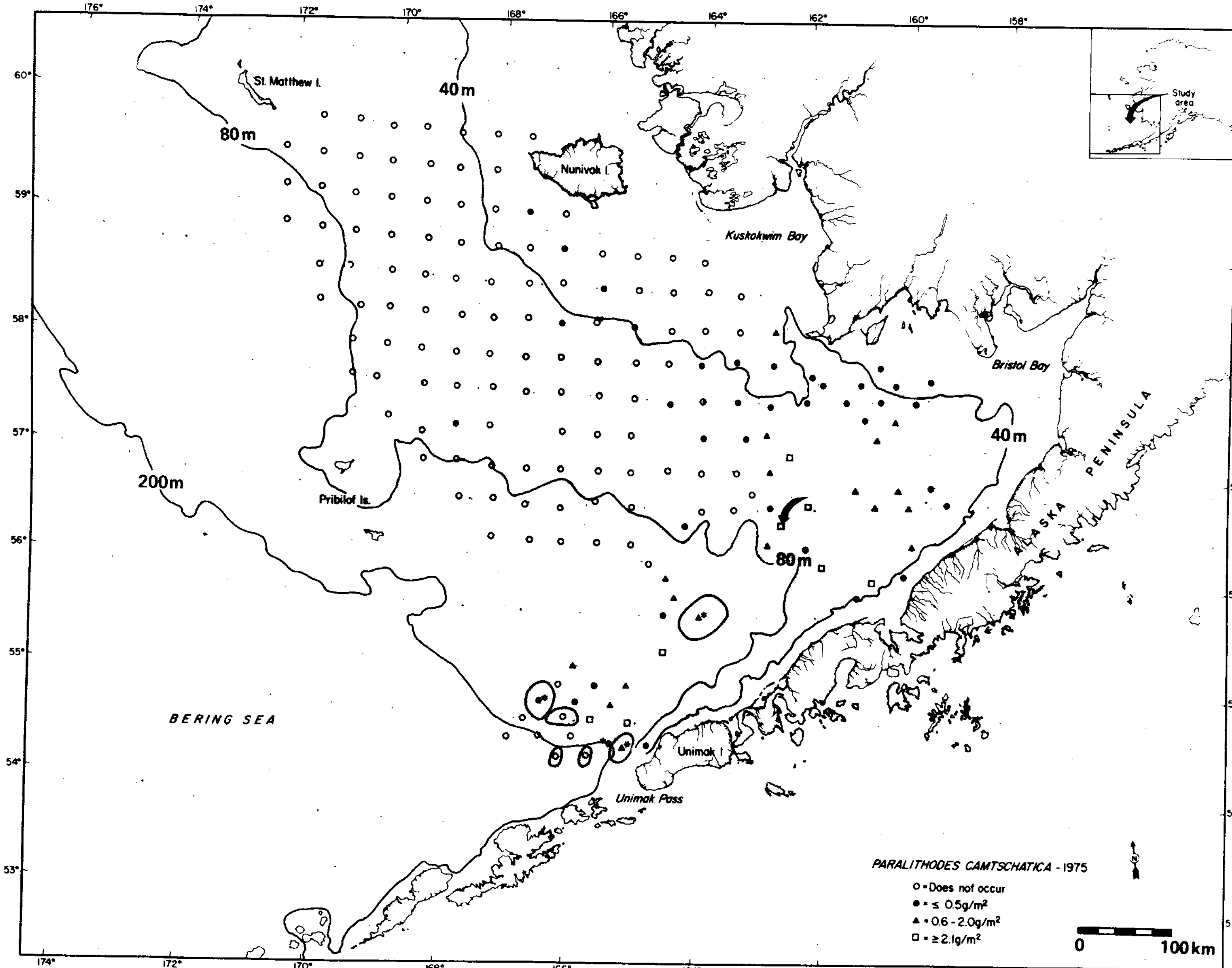

Figure 3. Distribution and biomass of the king crab, *Paralithodes camtschatica*, from the southeastern Bering Sea, 1975. Arrow indicates highest biomass station, i.e. 68.3 g/m^2 at Station FG 9/10. Asterisks indicate mean values from multiple tows.

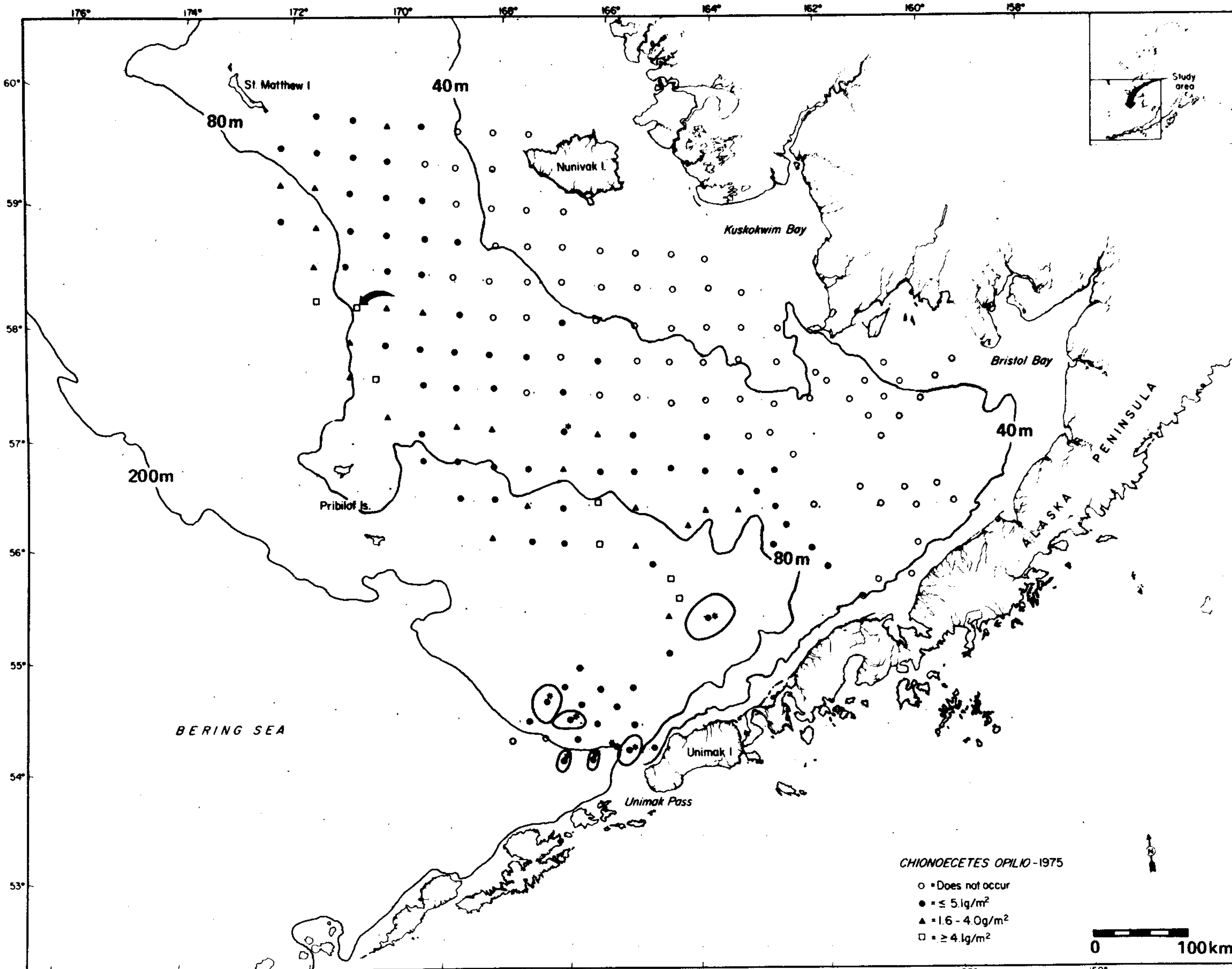

Figure 4. Distribution and biomass of the snow crab, *Chionoecetes opilio*, from the southeastern Bering Sea, 1975. Arrow indicates highest biomass station, i.e. 13.7 g/m^2 at Station L 21. Astericks indicate mean value from multiple tows.

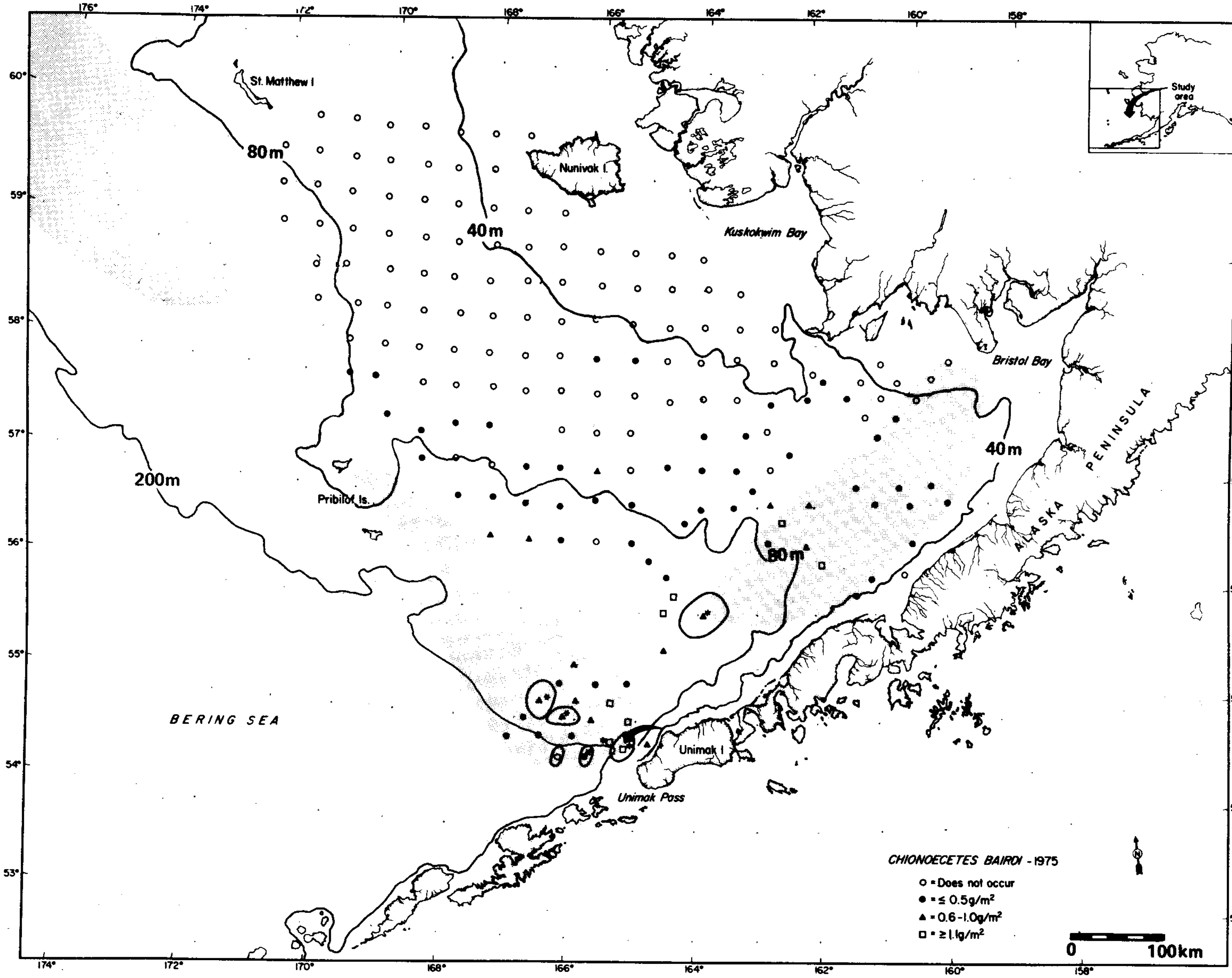

Figure 5. Distribution and biomass of the snow crab, *Chionoecetes bairdi*, from the southeastern Bering Sea, 1975. Arrow indicates highest biomass station, i.e. 3.1 g/m^2 at Station Z 5. Asterisks indicate mean values from multiple tows.

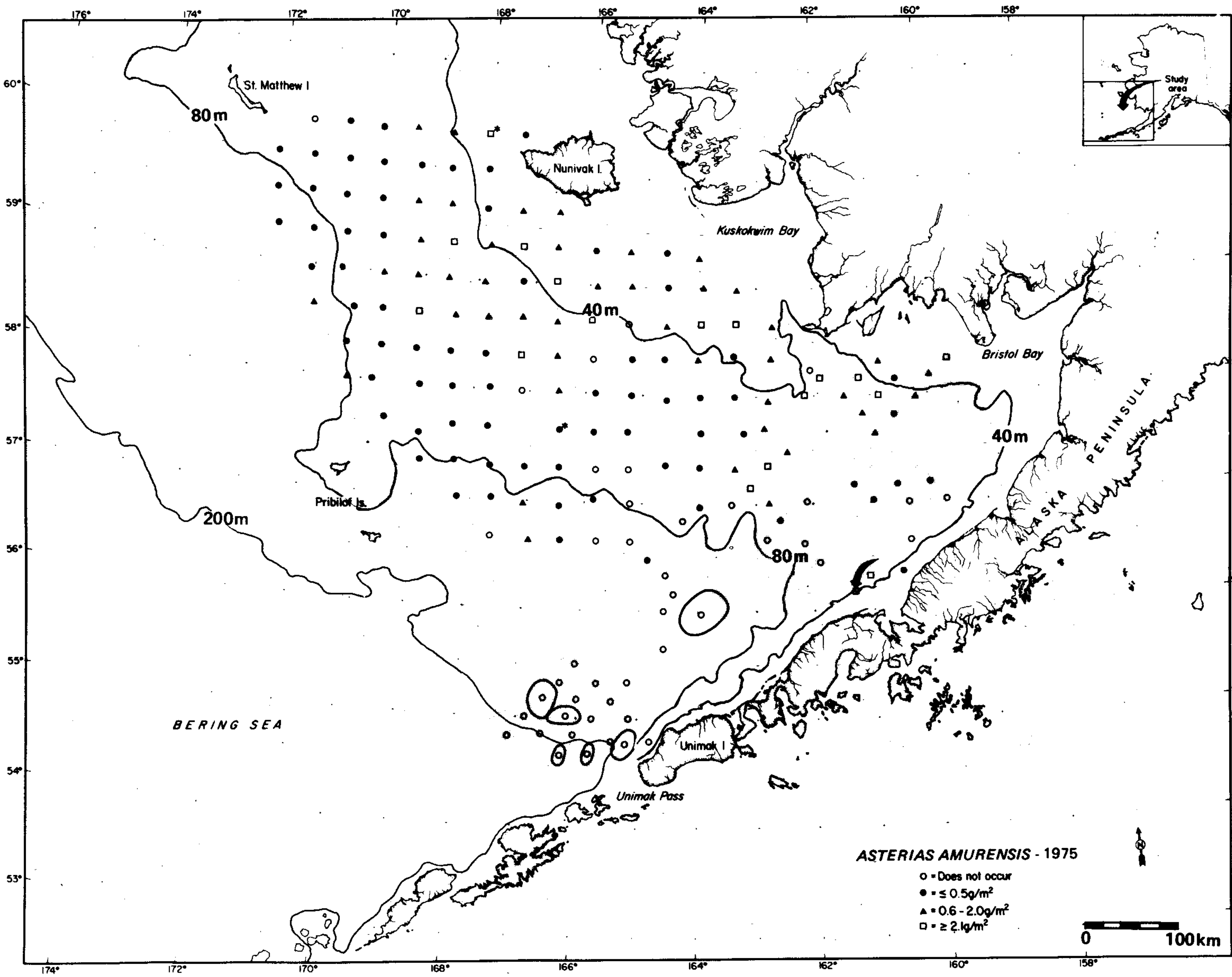

Figure 6. Distribution and biomass of the sea star, *Asterias amurensis*, from the southeastern Bering Sea, 1975. Arrow indicates highest biomass station, i.e. 9.8 g/m^2 at Station DE 11/12. Asterisks indicate mean values from multiple tows.

TABLE VIII

FREQUENCY OF OCCURRENCE OF EPIFAUNAL INVERTEBRATES FOUND AT GREATER THAN 20 PERCENT OF SUCCESSFUL S.E. BERING SEA TRAWL TOWS, 1975

Taxonomic Name	Number of Tows at which Organism Occurred	Percent of Tows at which Organism Occurred
Scyphozoa (unid. species)	54	26.1
Eunephthya rubiformis	48	23.2
Actiniidae (unid. species)	107	51.7
Polynoidae	119	57.5
Serripes groenlandicus	43	20.8
Neptunea ventricosa	74	35.7
N. heros	91	44.0
Tritoniidae (unid. species)	42	20.3
Pandalus borealis	46	22.2
P. goniurus	52	25.1
Crangon dalli	71	34.3
Argis dentata	65	31.4
Pagurus ochotensis	80	38.7
P. capillatus	96	46.4
P. trigonocheirus	95	45.9
Labidochirus splendescens	68	32.9
Paralithodes camtschatica	77	37.2
Hyas coarctatus alutaceus	99	47.8
Chionoecetes (hybrid)	102	49.3
C. opilio	126	60.9
C. bairdi	102	49.3
Erimacrus isenbeckii	53	25.6
Asterias amurensis	140	67.6
Leptasterias sp.	48	23.2
L. polaris acervata	52	25.1
Gorgonocephalus caryi	89	43.0
Styela rustica macrenteron	95	45.9

The 1976 sampling period

Most of the 1976 stations were at depths greater than 80 m (Fig. 2; Table 1).

Epifaunal invertebrate biomass averaged 4.87 g/m^2. The epifaunal invertebrate biomass was dominated by Arthropoda (66.9%) and Echinodermata (11.1%) with Porifera (8.8%) and Cnidaria (5.2%) of lesser importance (Table IX). Annelida, Sipunculida (the single additional phylum occurring in 1976), Echiurida, Ectoprocta, and Brachiopoda contributed less than 0.02% to the total biomass.

Seven of the 81 families of invertebrates collected made up 82% of the biomass (Table X) with Majidae contribution 48.4% (over three times the biomass of the second family, Lithodidae). Ten species contributed more than 1% each to the total biomass (Table XI). *Chionoecetes opilio* (28.8%), *C. bairdi* (16.7%), *Paralithodes camtschatica* (10.8%) and *Asterias amurensis* (4.7%) were the dominant individual species by weight. The order of importance for species shifted in 1976 as compared to 1975 with *P. camtschatica* moving from first to third. *Asterias amurensis* (third in 1975) was fourth in biomass. The 1976 list of species contributing over 1% to the biomass differed from the 1975 list by the addition of *Octopus* sp., the blue king crab (*Paralithodes platypus*), the Korean horsehair crab (*Erimacrus isenbeckii*), and the tunicate (*Halocynthia aurantium*) (Table XI). Species included in the 1975 list, but deleted from the 1976 list, included *Neptunea* (2 species), *Pagurus trigonocheirus*, *Leptasterias polaris*, and the tunicate, *Styela rustica macrenteron*.

Each major phylum again contained several dominant species by weight: *Neptunea* spp. (40.6%) and *Octopus* sp. (32.8%) for Mollusca; king crabs (*Paralithodes camtschatica* and *P. platypus*, 21.8%) and snow crabs (*Chionoecetes bairdi* and *C. opilio*, 68.1%) for Arthropoda; *Asterias amurensis* (42.7%), *Gorgonocephalus caryi* (40.0%) and *Parastichopus* sp. (8.0%) for Echinodermata (Table XII).

Major concentrations of *Paralithodes camtschatica* were near Unimak Island. The highest biomass of this crab was noted at Station BC6/7 with 6.2 g/m^2 (240 individuals) (Figs. 2 and 7).

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TABLE IX

NUMBERS, WEIGHT, AND BIOMASS (g/m^2) OF MAJOR EPIFAUNAL INVERTEBRATE PHYLA OF THE 1976 S.E. BERING SEA TRAWL SURVEY.

Phylum	Number of Organisms	Wet Weight (kg)	Percent of Total Weight	Mean Grams Per Square Meter ($\bar{x}$ g/m^2)
Porifera	110	1754.02	8.8	0.43
Cnidaria	3709	1029.00	5.2	0.25
Annelida	1217	3.41	<.1	<0.01
Mollusca	5506	911.43	4.6	0.22
Arthropoda (Crustacea)	97360	13298.73	66.9	3.27
Echinodermata	9756	2195.38	11.1	0.54
Chordata (Ascidiacea)	110	659.65	3.3	0.16
Total	117769	19851.62	100.0	4.87

TABLE X

NUMBERS, WEIGHT, AND BIOMASS (g/m^2) OF MAJOR EPIFAUNAL INVERTEBRATE FAMILIES OF THE 1976 BERING SEA TRAWL SURVEY.

Family	Number of Organisms	Wet Weight (kg)	Percent of Total Weight	Mean Grams Per Square Meter ($\bar{x}$ g/m^2)
Actiniidae	3385	772.90	3.9	0.19
Neptuneidae	2175	412.78	2.1	0.10
Lithodidae	2227	2932.37	14.8	0.72
Majidae	56914	9614.59	48.4	2.37
Asteridae	1047	1015.86	5.1	0.25
Gorgonocephalidae	3960	877.45	4.4	0.22
Pyuridae	not enumerated	631.65	3.2	0.16
Total		16257.60	81.9	4.01

TABLE XI

NUMBERS, WEIGHT, AND BIOMASS (g/m^2) OF 10 SPECIES CONTRIBUTING MORE THAN ONE PERCENT EACH TO THE TOTAL EPIFAUNAL INVERTEBRATE BIOMASS, 1976 S.E. BERING SEA TRAWL SURVEY.

Species	Number of Organisms	Wet Weight (kg)	Percent of Total Weight	Mean Grams Per Square Meter ($\bar{x}$ g/m^2)
Octopus sp.	51	298.60	1.5	0.07
Paralithodes camtschatica	1739	2152.60	10.8	0.53
P. platypus	452	744.63	3.8	0.18
Chionoecetes (hybrid)	1395	520.83	2.6	0.13
C. opilio	45592	5724.94	28.8	1.41
C. bairdi	9275	3322.42	16.7	0.82
Erimacrus isenbeckii	313	412.62	2.1	0.10
Asterias amurensis	842	936.67	4.7	0.23
Gorgonocephalus caryi	3960	877.45	4.4	0.22
Halocynthia aurantium	not enumerated	568.77	2.9	0.14
Total		15559.53	78.3	3.83

TABLE XII

NUMBERS, WEIGHT, AND BIOMASS (g/m^2) OF THE MAJOR EPIFAUNAL SPECIES OF MOLLUSCA, ARTHROPODA, AND ECHINODERMATA FROM THE 1976 BERING SEA TRAWL SURVEY.

Phylum	Species	Number of Organisms	Wet Weight (kg)	Percent of Total Weight	Percent of Phylum Weight	Mean Grams Per Square Meter ($\bar{x}$ g/m^2)
Mollusca	*Fusitriton oregonensis*	778	84.20	0.4	9.2	0.02
	Neptunea lyrata	586	144.51	0.7	15.9	0.04
	N. ventricosa	448	98.82	0.5	10.8	0.02
	N. pribiloffensis	503	80.74	0.4	8.9	0.02
	N. heros	262	45.76	0.2	5.0	0.01
	Octopus sp.	51	298.60	1.5	32.8	0.07
	Total	2628	752.61	3.7	82.6	0.18
Arthropoda	*Paralithodes camtschatica*	1739	2152.60	10.8	16.2	0.53
	P. platypus	452	744.63	3.8	5.6	0.18
	Chionoecetes opilio	45592	5724.94	28.8	43.1	1.41
	C. bairdi	9275	3322.42	16.7	25.0	0.82
	Total	57058	11944.59	60.1	89.9	2.94
Echinodermata	*Asterias amurensis*	842	936.67	4.7	42.7	0.23
	Gorgonocephalus caryi	3960	877.45	4.4	40.0	0.22
	Parastichopus sp.	510	176.74	0.9	8.0	0.04
	Total	5312	1990.86	10.0	90.7	0.49

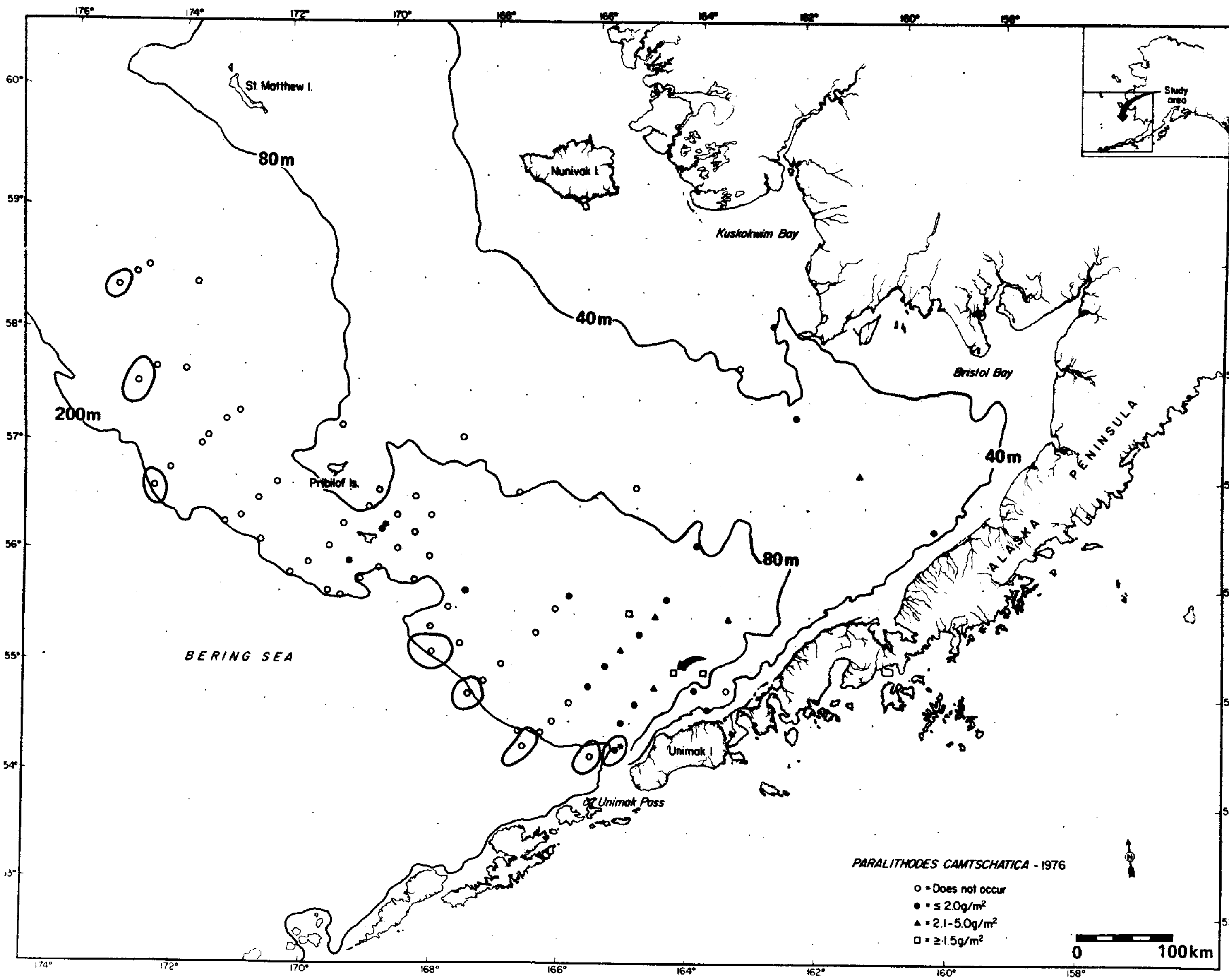

Figure 7. Distribution and biomass of king crab, *Paralithodes camtschatica*, from the southeastern Bering Sea, 1976. Arrow indicates highest biomass station, i.e. 6/2 g/m^2 at Station BC 6/7. Asterisks indicate mean values from multiple tows.

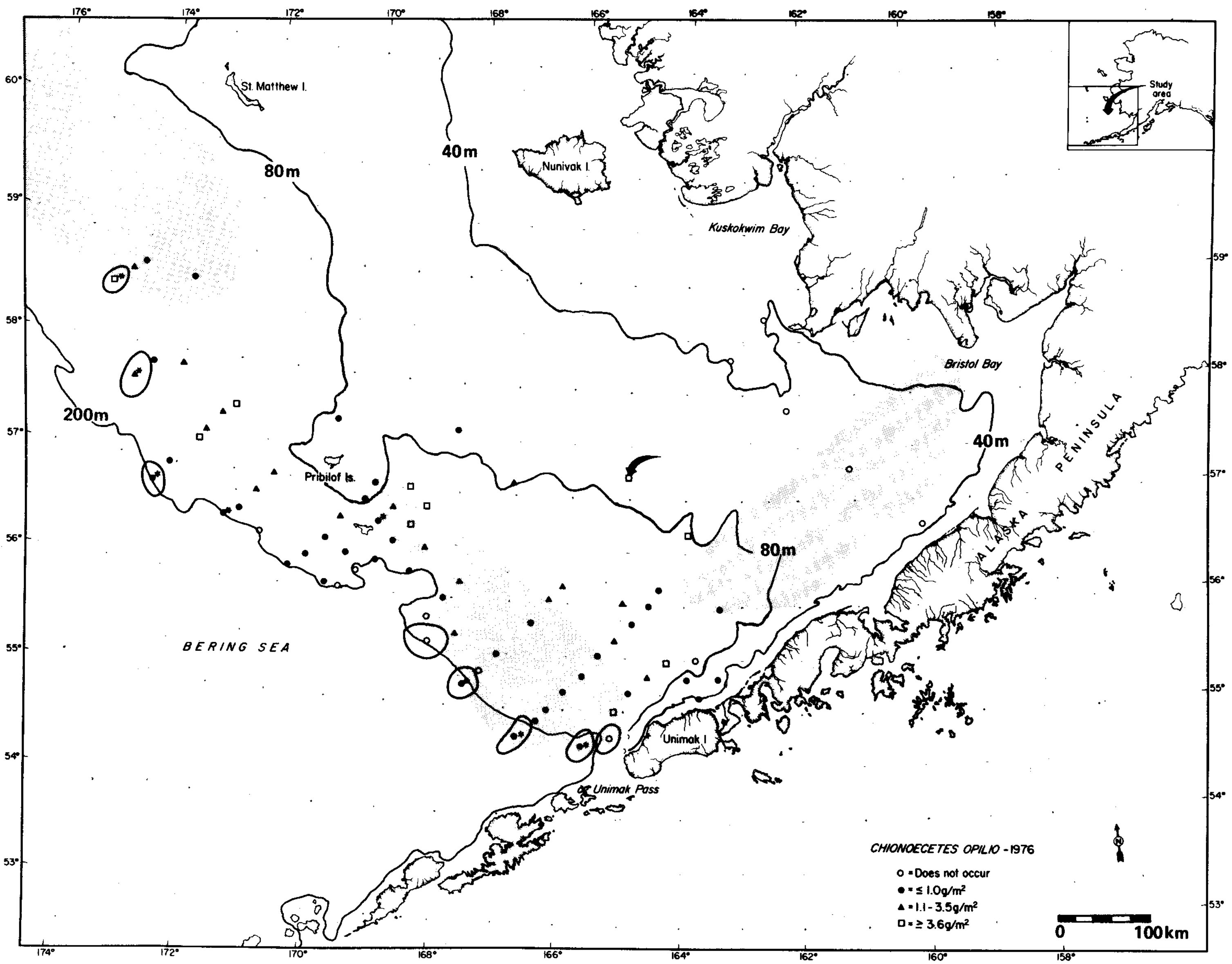

Figure 8. Distribution and biomass of the snow crab, *Chionoecetes opilio*, from the southeastern Bering Sea, 1976. Arrow indicates highest biomass station, i.e. 15.5 g/m^2 at Station MB 28. Asterisks indicate mean values from multiple tows.

The highest biomass station for *Chionoecetes opilio* in 1976 was MB28 with 15.5 g/m^2 (9,141 individuals) (Figs. 2 and 8). The distance fished at this station was 2.78 km. The highest biomass station of *C. bairdi*, BC6/7, was also 15.5 g/m^2; however, only 1,630 individuals were caught in 4.07 km (Figs. 2 and 9). Both *C. opilio* and *C. bairdi* were found at most of the 1976 stations.

Most occurrences of *Asterias amurensis* were at stations near the Pribilof Islands (Figs. 2 and 10). The highest biomass station was at MB9 with 6.9 g/m^2.

Frequency of occurrence in 1976 (Table XIII) was highest for *C. bairdi* which occurred at 87.5% of the tows. *Asterias amurensis*, the most widespread animal in 1975, occurred at only 37.5% of the 1976 tows.

A summarization of general biological information collected by trawling in 1976 is included in Appendix II.

Multiple Tows

Of the 264 stations sampled, 19 were occupied from two to nine times within the same year (Tables XIV and XV). At those stations where four or five tows were taken, 21.9 to 71.8% ($\bar{x}$ 43.0%) of the total number of species were obtained in the first tow (Table XIV). By the fourth tow of a 5-tow series, an average of 96.0% of the species were collected. At those stations where two or three tows were taken, the first tow obtained an average of 63.2% of the total number of species obtained at the particular station (Table XV). The species represented in the first tow of a series included those that were most abundant in number and in biomass. Subsequent tows in the same vicinity yielded species less important in number and in biomass.

In 1975, the area about Station D7 was sampled by ten tows, nine of which were successful. Five tows were 30 minutes in duration, while the other four were 60 minutes. A total of 44 taxa were collected by the combined tows (Table XVI). Thirty-nine taxa (88.6%) were collected by the five 30-minute tows; 36 taxa (81.8%) were collected by the four 60-minute tows. The mean count and weight of organisms collected by the 30-minute tows was 493 individuals and 128.43 kg respectively. The mean count and weight taken by the 60-minute tows was 883 individuals and 187.04 kg respectively. The mean estimate of biomass for the 30-minute tows was 3.67

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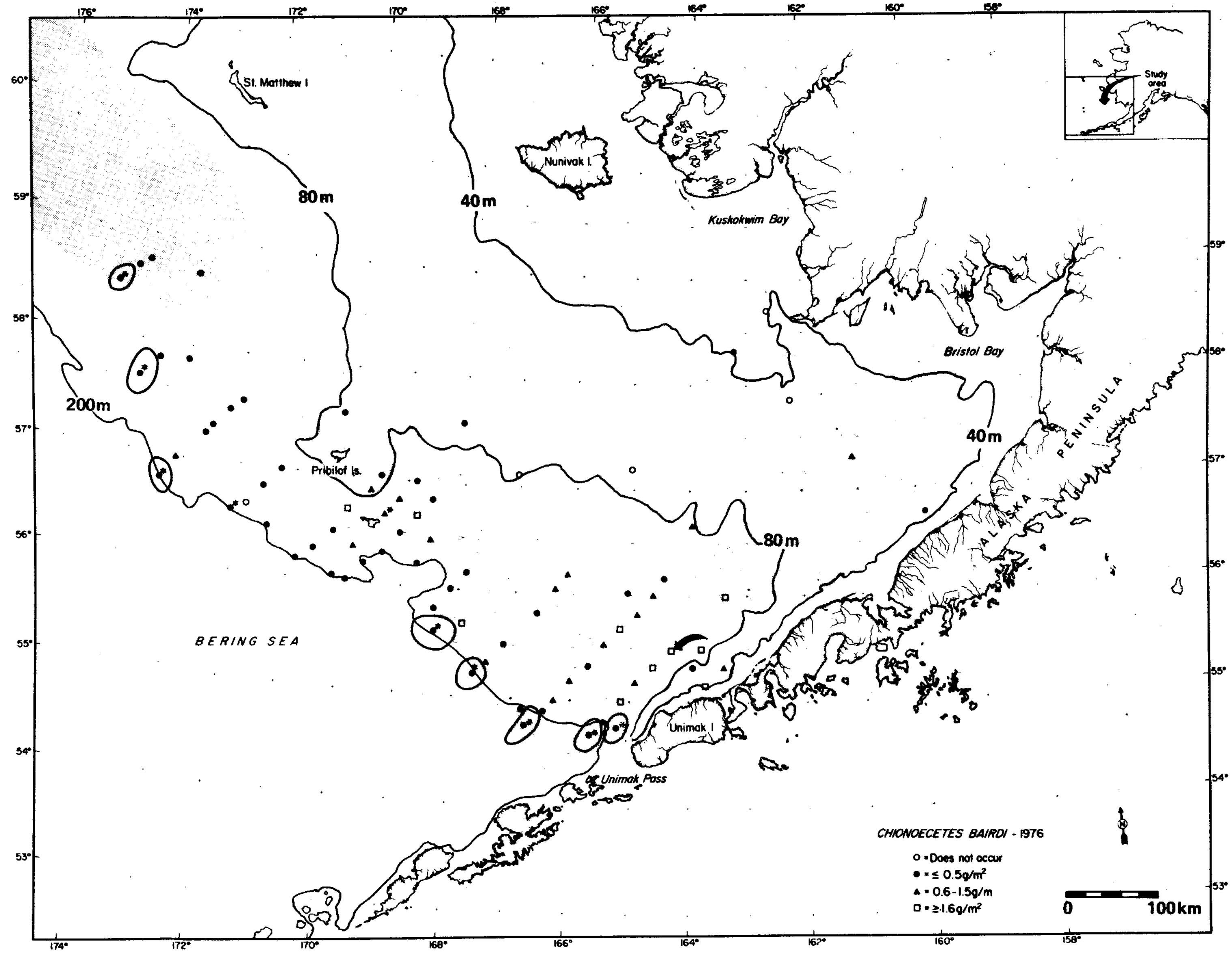

Figure 9. Distribution and biomass of the snow crab, *Chionoecetes bairdi*, from the southeastern Bering Sea, 1976. Arrow indicates highest biomass station, i.e. 15.5 g/m^2 at Station BC 6/7. Asterisks indicate mean values from multiple tows.

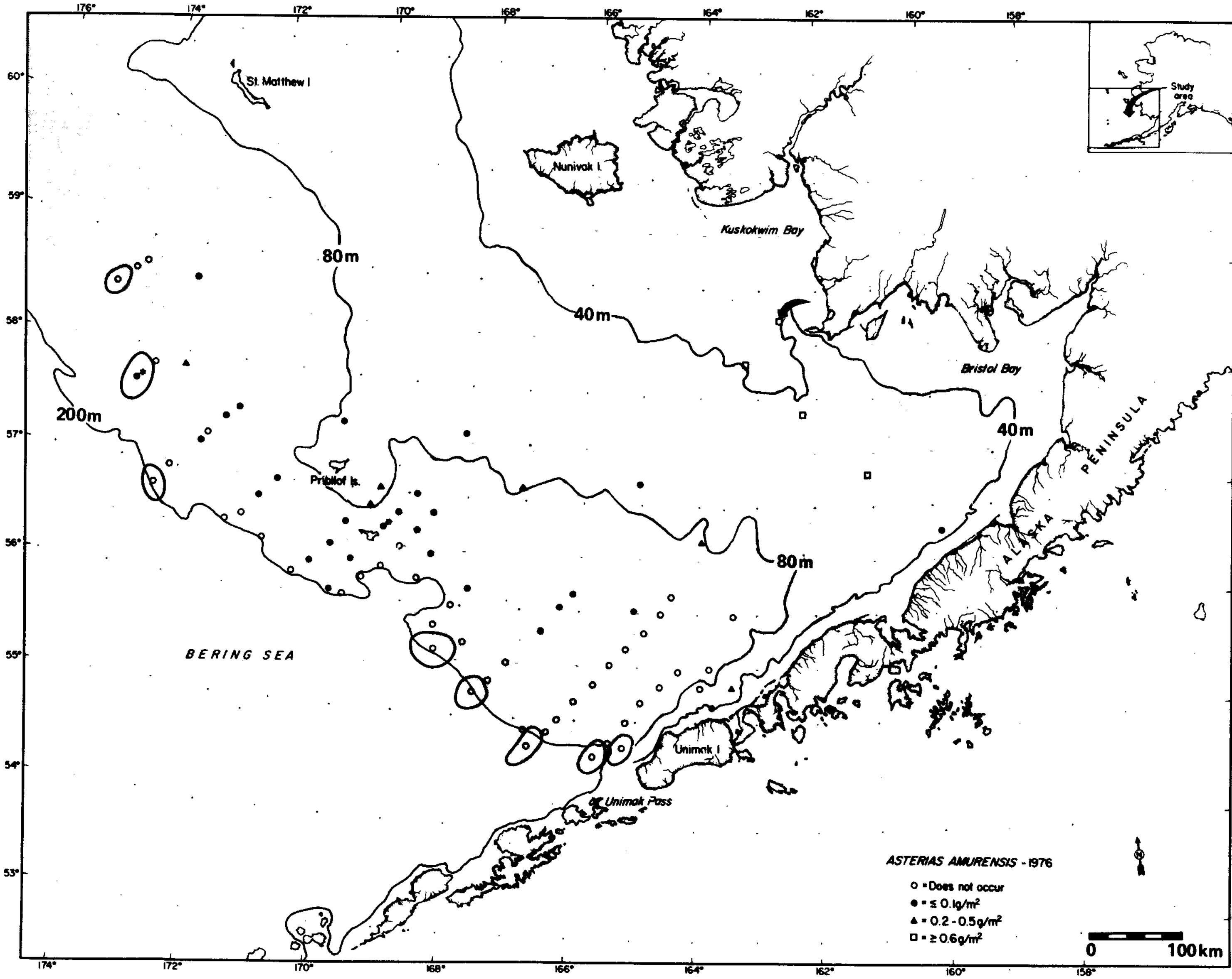

Figure 10. Distribution and biomass of the sea star, *Asterias amurensis*, from the southeastern Bering Sea, 1976. Arrows indicate highest biomass station, i.e. 6.9 g/m^2 at Station MB 9. Asterisks indicate mean values from multiple tows.

TABLE XIII

FREQUENCY OF OCCURRENCE OF EPIFAUNAL INVERTEBRATES FOUND AT GREATER THAN 20 PERCENT OF SUCCESSFUL S.E. BERING SEA TRAWL TOWS, 1976

Taxonomic Name	Number of Tows at which Organism Occurred	Percent of Tows at which organism Occurred
Porifera (Unid. species)	35	33.7
Scyphozoa (Unid. species)	22	21.2
Stylatula gracile	71	68.2
Polynoidae (Unid. species)	41	39.4
Notostomobdella sp.	29	27.9
Fusitriton oregonensis	53	50.9
Neptunea lyrata	41	39.4
N. ventricosa	26	25.0
N. pribiloffensis	44	42.3
Gonatidae (Unid. species)	25	24.0
Pandalus borealis	73	70.2
Crangon communis	25	24.0
Argis dentata	30	28.8
A. ovifer	22	21.1
Pagurus aleuticus	36	34.6
P. capillatus	28	26.9
P. confragosus	46	44.2
P. trigonocheirus	38	36.5
Elassochirus cavimanus	33	31.7
Paralithodes camtschatica	27	25.9
Hyas lyratus	23	22.1
Chionoecetes (hybrid)	58	55.8
C. opilio	77	74.0
C. bairdi	91	87.5
Erimacrus isenbeckii	33	31.7
Ceramaster patagonicus	25	24.0
Henricia	26	25.0
Asterias amurensis	39	37.5
Lethasterias nanimensis	28	26.9
Strongylocentrotus droebachiensis	23	22.1
Gorgonocephalus caryi	37	35.6
Ophiopholis aculeata	21	20.1

TABLE XIV

CUMULATIVE PERCENTAGE OF SPECIES ADDED BY SUBSEQUENT TOWS
FOR STATIONS SAMPLED BY FOUR OR MORE TOWS

Year	Station	No. of Successful Tows	Total No. of Species Collected	Cumulative Percentage of Species Added at Subsequent Tows: Tow 1	Tow 2	Tow 3	Tow 4	Tow 5
1975	AB23	5	23	56.5%	65.2%	87.0%	95.7%	100.0%
1975	D7	5 (30 min)	39	35.9%	61.5%	97.4%	100.0%	100.0%
1975	D7	4 (60 min)	36	36.1%	66.7%	83.3%	100.0%	-
1975	A3	4	30	40.0%	66.6%	96.7%	100.0%	-
1975	AZ45	5	33	42.4%	60.6%	81.8%	90.9%	100.0%
1976	Z4	4	32	21.9%	50.0%	87.5%	100.0%	-
1976	Z2	4	49	57.1%	79.6%	87.8%	100.0%	-
1976	AB18/1	4	36	25.0%	47.2%	77.8%	100.0%	-
1976	C19	5	39	71.8%	82.1%	84.6%	97.4%	100.0%
			$\bar{x}$	43.0%	64.4%	87.1%	96.0%	-
			S.D.	16.2%	11.6%	6.5%	3.8%	-

TABLE XV

THE CUMULATIVE PERCENTAGE OF SPECIES ADDED BY SUBSEQUENT TOWS FOR STATIONS SAMPLED BY TWO OR THREE TOWS

Year	Station	No. of Successful Tows	Total No. of Species Collected	Cumulative Percentage of Species at Subsequent Tows Tow 1	Tow 2	Tow 3
1975	Q1	2	21	57.1%	100.0%	-
1975	I3	2	26	80.1%	100.0%	-
1975	Z3	2	17	88.2%	100.0%	-
1975	Z4	2	20	55.0%	100.0%	-
1976	Z5	3	32	59.4%	68.8%	100.0%
1976	KL28/27	3	38	57.9%	84.2%	100.0%
1976	I27	2	27	55.6%	100.0%	-
1976	FG27/26	3	30	66.7%	76.7%	100.0%
1976	F20	2	44	56.8%	100.0%	-
1976	EF24/25	2	27	55.6%	100.0%	-
			$\bar{x}$	63.2%	76.7%	
			S.D.	11.7%	7.7%	

TABLE XVI

SPECIES LIST COMPILED FROM FOUR 60-MIN TOWS AND FIVE 30-MIN TOWS AT STATION D7, SEPTEMBER 1975 (TOWS 78, 101-108)

Taxon	30 MIN TOWS					60 MIN TOWS			
	Tow 78	Tow 101	Tow 103	Tow 106	Tow 108	Tow 102	Tow 104	Tow 105	Tow 107
Porifera	–	X	X	X	X	X	X	X	X
Hydrozoa	–	X	–	–	–	–	–	–	–
Eunephthya rubiformis	–	X	X	X	X	–	X	X	–
Scyphozoa	X	–	–	–	–	–	–	–	–
Actiniidae	–	X	X	X	–	–	X	X	X
Polychaeta	–	X	X	X	X	X	X	X	X
Polynoidae	X	X	X	X	X	X	X	X	X
Notostomobdella sp.	–	–	X	X	X	X	X	X	X
Clinocardium ciliatum	–	–	–	–	–	–	–	–	X
Serripes groenlandicus	–	X	–	X	–	–	–	X	X
Macoma calcarea	X	–	–	–	–	–	–	–	–
Tellina lutea alternidentata	–	X	–	–	–	–	X	–	–
Crepidula grandis	–	–	X	–	–	–	X	–	X
Natica clausa	–	–	X	–	–	–	–	–	–
Fusitriton oregonensis	X	X	X	X	X	–	X	X	X
Colus spitzbergensis	–	–	X	–	–	–	X	–	–
Beringius kennicotti	–	–	–	X	–	–	–	–	–
Neptunea lyrata	X	–	–	X	X	–	–	X	X
Neptunea ventricosa	–	X	–	–	X	–	–	X	X
Neptunea pribiloffensis	X	X	–	–	X	X	X	–	–
Neptunea heros	–	–	X	X	–	–	X	–	–
Plicifusus kroyeri	X	–	–	X	–	–	–	–	X
Tritoniidae	–	–	X	–	X	–	–	–	–
Octopus sp.	–	–	–	–	–	–	X	–	–
Melita dentata	–	–	–	–	–	–	–	–	X
Pandalus goniurus	–	–	X	X	X	–	X	X	X
Crangon dalli	–	–	X	–	X	–	–	–	–
Argis dentata	–	–	X	–	–	–	X	–	–

TABLE XVI

CONTINUED

Taxon	30 MIN TOWS					60 MIN TOWS			
	Tow 78	Tow 101	Tow 103	Tow 106	Tow 108	Tow 102	Tow 104	Tow 105	Tow 107
Pagurus aleuticus	X	X	X	X	X	X	X	X	X
Pagurus capillatus	X	X	X	X	X	X	X	X	X
Pagurus confragosus	–	–	X	X	X	–	X	X	X
Pagurus trigonocheirus	–	–	X	–	–	–	–	–	–
Paralithodes camtschatica	X	X	X	X	X	X	X	X	X
Hyas coarctatus alutaceus	–	–	–	–	–	–	–	X	–
Hyas lyratus	–	–	X	–	–	X	–	–	–
Chionoecetes (hybrid)	X	X	X	X	X	X	X	X	X
Chionoecetes opilio	X	X	X	X	X	X	X	X	X
Chionoecetes bairdi	X	X	X	X	X	X	X	X	X
Ectoprocta	–	X	X	X	X	–	–	X	X
Leptasterias polaris acervata	X	X	–	–	–	–	–	–	X
Gorgonocephalus caryi	–	X	–	–	–	–	–	X	–
Ophiopholis aculeata	–	X	X	X	X	–	–	–	X
Cucumaria sp.	–	–	X	–	–	–	–	–	X
Styela rustica macrenteron	–	–	–	–	–	X	–	–	–

TOTAL: 44 Taxa

	Tow 78	Tow 101	Tow 103	Tow 106	Tow 108	Tow 102	Tow 104	Tow 105	Tow 107
No. of Taxa	14	20	28	22	21	13	21	21	25
CNT:	468	648	358	498	491	703	605	1279	945
Mean CNT:			493					883	
Wet Wt. (kg)	138.92	140.63	41.49	217.92	103.23	164.31	70.50	301.61	211.73
Mean Wet Wt (kg):			128.48					187.04	

Mean Estimate of Biomass: 3.67 g/m^2 (30 min tows)

Mean Estimate of Biomass: 2.68 g/m^2 (60 min tows)

g/m^2, while the mean for the 60-minute tows was 2.68 g/m^2. No significant difference (α=0.05) in mean number of species and mean estimate of biomass was noted between tow periods.

Food Studies

Feeding relationships of epifaunal invertebrates and fishes in the southeastern Bering Sea were determined from direct observation and literature sources. Stomach contents were recorded for *Ophiura sarsi* in 1975 (Table XVII) and for six species of invertebrates (*Paralithodes camtschatica, Chionoecetes opilio, Asterias amurensis, Evasterias echinosoma, Leptasterias polaris acervata,* and *Pteraster* sp.) and more than 13 species of fishes (*Gadus macrocephalus, Myoxocephalus* spp., *Careproctus* sp., *Platichthys stellatus, Limanda aspera, Hemilepidotus papilio, Pleuronectes quadrituberculatus, Hippoglossus stenolepis, Glyptocephalus zachirus, Raja stellulata, Hippoglossoides elassodon, Reinhardtius hippoglossoides,* and *Lepidopsetta bilineata*) in 1976 (Table XVIII).

Paralithodes camtschatica fed primarily on the cockle *Clinocardium ciliatum,* the small snails *Solariella* spp., the nut shell *Nuculana fossa,* the polychaete *Cistenides* sp. and brittle stars of the family Amphiuridae. Polychaetes and brittle stars (ophiuroids) were the dominant food items in *Chionoecetes opilio* stomachs. Clams (pelecypods) and ophiuroids were the only two food items found to be very important to both crabs. Among the sea stars, *Asterias amurensis* concentrated on the humpy shrimp (*Pandalus goniurus*), Bryozoans (Ectoprocta) and cockles (Cardiidae, probably *Clinocardium* sp.) while the sea star *Leptasterias polaris acervata* fed exclusively on cockles. The fishes showed a variety of food preferences. The Pacific cod (*Gadus macrocephalus*) fed mainly on pink shrimp (*Pandalus borealis*) while the irish lord (*Hemilepidotus papilio*) consumed polychaetes, gammarid and caprellid amphipods, pollock (*Theragra chalcogramma*), and miscellaneous fishes with about equal frequency. The Greenland Halibut (*Reinhardtius hippoglossoides*) consumed mainly fishes.

Data from Tables XVII and XVIII and various literature sources (Pereyra *et al.*, 1976; Barr, 1970a,b; Skalkin, 1963, 1964; Moiseev, 1955; Takeuchi and Imai, 1959; Takahashi and Yamaguchi, 1972; Mito, 1974; Krivobok and Tarkouskaya, 1964; Shubnikov, 1963; Novikov, 1964; Wakabayashi, 1974;

Text continued on Page 61

TABLE XVII

STOMACH CONTENTS OF *OPHIURA SARSI* FROM THE BERING SEA, 1975

Predator		Percent Frequency of Occurrence
Ophiura sarsi (Brittle star)		
Stomachs examined: 10		
Stomachs with food: 9		
Stomach contents:	Detritus (9)	100.0%
	Sediment (6)	66.6%
	Unidentified nematode (3)	33.3%
	Unidentified crustacean (3)	33.3%
	Unidentified amphipod (1)	11.1%
	Unidentified mollusc (1)	11.1%
	Unidentified gastropod (1)	11.1%
	Plant fragments (1)	11.1%

TABLE XVIII

STOMACH CONTENTS OF SELECTED EPIFAUNAL INVERTEBRATES AND FISHES FROM THE BERING SEA, 1976

Predator		Percent Frequency of Occurrence
Paralithodes camtschatica (King Crab)		
Stomachs examined:	124	
Stomachs with food:	115	92.7%
Stomach contents:	*Clinocardium ciliatum* (83)	66.9%
	Solariella sp. (68)	54.8%
	Nuculana fossa (62)	50.0%
	Cistenides sp. (43)	34.7%
	Amphiuridae (43)	34.7%
	Unidentified snails (30)	24.2%
	Unidentified soft parts (26)	21.0%
	Sediment (22)	17.7%
	Unidentified Ophiuroidea (19)	15.3%
	Ophiopenia disacantha (18)	14.5%
	Unidentified Pelecypod (16)	12.9%
	Lyonsia norwegica (15)	12.1%
	Amphipholis pugetana (15)	12.1%
	Unidentified debris (15)	12.1%
	Chionoecetes sp. (9)	7.3%
	Turritellidae (8)	6.5%
	Cardita sp. (5)	4.0%
	Macoma sp. (4)	3.2%
	Eggs (4)	3.2%
	Unidentified crustaceans (4)	3.2%
	Unidentified amphipods (3)	2.4%
	Lischkeia sp. (3)	2.4%
	Ophiura sp. (3)	2.4%
	Fish Remains (3)	2.4%
	Unidentified crabs (2)	1.6%
	Unidentified polychaetes (2)	1.6%
	Balanus sp. (1)	0.8%
	Cylichna sp. (1)	0.8%
	Neptunea sp. (1)	0.8%
	Astarte sp. (1)	0.8%
	Dentalium sp. (1)	0.8%
	Plant material (1)	0.8%
	Elphidium sp. (1)	0.8%

TABLE XVIII

CONTINUED

Predator		Percent Frequency of Occurrence
Chionoecetes opilio (Snow crab)		
Stomachs examined:	23	
Stomachs with food:	16	69.6%
Stomach contents:	Unidentified polychaetes (12)	52.2%
	Ophiura sp. (6)	26.1%
	Unidentified debris (6)	26.1%
	Unidentified Ophiuroidea (4)	17.4%
	Unidentified soft parts (3)	13.0%
	Unidentified pelecypod (3)	13.0%
	Unidentified fish (3)	13.0%
	Unidentified amphipods (3)	13.0%
	Unidentified Paguridae (1)	4.3%
	Unidentified decapod (1)	4.3%
	Cyclocardia sp. (1)	4.3%
	Unidentified gastropod (1)	4.3%
Asterias amurensis (Sea star)		
Stomachs examined:	41	
Only animals with food in oral area examined		
Stomach contents:	*Pandalus goniurus* (7)	17.1%
	Unidentified Ectoprocta (7)	17.1%
	Unidentified Cardidae (6)	14.6%
	Unidentified sand dollar (5)	12.2%
	Unidentified Porifera (4)	9.8%
	Unidentified Balanidae (3)	7.3%
	Unidentified fish (3)	7.3%
	Unidentified Scyphozoa (2)	4.9%
	Spisula polynyma (2)	4.9%
	Crangon dalli (2)	4.9%
	Unidentified polychaete (2)	4.9%
	Parasitic copepods (2)	4.9%
	Unidentified soft parts (2)	4.9%
	Unidentified pelecypod (1)	2.4%
	Pagurus ochotensis (1)	2.4%
	Oregonia gracilis (1)	2.4%
	Chionoecetes sp. (1)	2.4%
	Unidentified Mysidae (1)	2.4%
Evasterias echinosoma (Sea star)		
Stomachs examined:	1	
Only animals with food in oral area were recorded		
Stomach contents:	*Boltenia ovifera*	100%

TABLE XVIII

CONTINUED

Predator		Percent Frequency of Occurrence
Leptasterias polaris acervata (Sea star)		
Stomachs examined: 12		
Only animals with food in oral area were recorded		
stomach contents:	Unidentified Cardidae (12)	100%
Pteraster sp. (Sea star)		
Stomachs examined: 1		
Only animals with food in oral area were recorded		
Stomach contents:	Unidentified Sabellidae (1)	100%
Gadus macrocephalus (Pacific cod)		
Stomachs examined: 29		
Stomachs with food: 29		100%
Stomach contents:	*Pandalus borealis* (15)	51.7%
	Theragra chalcogramma (5)	17.2%
	Unidentified amphipods (5)	17.2%
	Chionoecetes sp. (3)	10.3%
	Unidentified crabs (2)	6.9%
	Unidentified Pinnotheridae (1)	3.4%
	Unidentified Euphausiids (1)	3.4%
	Unidentified gastropods (1)	3.4%
	Unidentified Cottidae (1)	3.4%
	Pagurus trigonocheirus (1)	3.4%
	Unidentified soft parts (1)	3.4%
	Unidentified arthropods (1)	3.4%
	Unidentified polychaetes (1)	3.4%
	Unidentified cephalopods (1)	3.4%
Myoxocephalus spp. (Sculpin)		
Stomachs examined: 7		
Stomachs with food: 6		85.7%
Stomach contents:	*Chionoecetes* sp. (2)	28.6%
	Unidentified crab (2)	28.6%
	Unidentified amphipod (1)	14.3%
	Unidentified fish (1)	14.3%
	Unidentified Cottidae (1)	14.3%
	Mallotus villosus (1)	14.3%
Careproctus sp. (Snail fish)		
Stomachs examined: 1		
Stomachs with food: 1		100%
Stomach contents:	*Dasycottus* sp.	
	Ophiura sp.	
	Pandalus sp.	
	Chionoecetes opilio	

TABLE XVIII

CONTINUED

Predator		Percent Frequency of Occurrence
Platichthys stellatus (Starry flounder)		
Stomachs examined: 1		
Stomachs with food: 0		
Limanda aspera (Yellowfin sole)		
Stomachs examined: 4		
Stomachs with food: 0		
Hemilepidotus papilio (Sculpin)		
Stomachs examined: 9		
Stomachs with food: 8		88.9%
Stomach contents:	*Theragra chalcogramma* (2)	22.2%
	Unidentified fish (2)	22.2%
	Unidentified Caprellidea (2)	22.2%
	Unidentified Gammaridea (2)	22.2%
	Unidentified polychaetes (2)	22.2%
	Unidentified debris (2)	22.2%
	Crangon sp. (1)	11.1%
	Unidentified isopods (1)	11.1%
	Unidentified crabs (1)	11.1%
	Unidentified squid (1)	11.1%
	Unidentified Ophiuroidea (1)	11.1%
	Unidentified decapoda (1)	11.1%
Pleuronectes quadrituberculatus (Alaska Plaice)		
Stomachs examined: 6		
Stomachs with food: 2		33.3%
Stomach contents:	Unidentified polychaetes (1)	16.7%
	Unidentified pelecypod (1)	16.7%
	Unidentified amphipod (1)	16.7%
	Nemertean (1)	16.7%
	Unidentified annelid (1)	16.7%
Hippoglossus stenolepis (Pacific halibut)		
Stomachs examined: 3		
Stomachs with food: 2		66.6%
Stomach contents:	Unidentified fish (1)	33.3%
	Theragra chalcogramma (1)	33.3%
Glyptocephalus zachirus (Rex sole)		
Stomachs examined: 3		
Stomachs with food: 3		100%
Stomach contents:	Unidentified amphipods (3)	100%
	Unidentified polychaetes (2)	66.6%
	Unidentified nemertean (1)	33.3%
	Unidentified Hirudinea (1)	33.3%

TABLE XVIII

CONTINUED

Predator		Percent Frequency of Occurrence
Raja stellulata (Starry skate)		
Stomachs examined:	1	
Stomachs with food:	1	100%
Stomach contents:	Unidentified amphipods	100%
	Crangonid shrimp	100%
Hippoglossoides elassodon (Flathead sole)		
Stomachs examined:	4	
Stomachs with food:	0	
Reinhardtius hippoglossoides (Greenland halibut)		
Stomachs examined:	128	
Stomachs with food:	59	46.1%
Stomach contents:	Unidentified fish (37)	28.9%
	Theragra chalcogramma (9)	7.0%
	Unidentified Gadidae (8)	6.3%
	Mallotus villosus (1)	1.0%
	Unidentified Cottidae (1)	1.0%
	Unidentified decapod (1)	1.0%
Lepidopsetta bilineata (Rock sole)		
Stomachs examined:	1	
Stomachs with food:	0	

Shubnikov and Lisovenki, 1964; Mikawa, 1963; Mineva, 1964; Shuntov, 1965; Hameedi *et al.*, 1976) and marine mammal feeding (Moiseev, 1952; North Pacific Fur Seal Commission, 1962, 1971, 1975; Berzin, 1971; Tomlin, 1957; Kleinberg *et al.*, 1964, Townsend, 1942, Lowry *et al.*, 1977; Fay *et al.*, 1977) were used to complete the Bering Sea food web (Fig. 11). The food web is organized so that flow of carbon is generally from bottom to top, but always in the direction of the arrow. Bold lines indicate the most important food sources for a given animal. For example, bold lines connect *Clinocardium* sp. and Ophiuroidea to *Paralithodes camtschatica* since they are the major components of the diet of king crabs based on frequency of occurrence. Feeding relationships of five important species - king crabs (Fig. 12), snow crabs (Fig. 13), pollock (Fig. 14), Pacific cod (Fig. 15), and Pacific halibut (Fig. 16) - are shown individually.

Polychaetous annelids, snails, clams, isopods, amphipods, mysids, krill (euphausiids), caridean shrimps, crabs, bryozoans, sand dollars, and brittle stars are the main invertebrate components of the Bering Sea food web. Deposit-feeding bivalves (clams) (Table XIX) are important food sources for king crabs, snow crabs, and sea stars - the three major invertebrate components of the Bering Sea biomass.

Among fishes, the pollock, *Theragra chalcogramma*, appears to be a major component in the Bering Sea food web. Food of the pollock includes zooplankton (e.g., euphausiids), shrimps, and small fishes (small pollock were found in up to 99.7% of larger pollock stomachs by Mito, 1974). In turn, pollock are an important source of food for fur seals (North Pacific Fur Seal Commission, 1962, 1971, 1975), Pacific cod, halibut, Greenland halibut, and arrowtooth flounder (Feder, 1977; Pereyra *et al.*, 1976).

Most of the flatfishes prey on small benthic invertebrates such as polychaetes, pelecypods, and amphipods.

Among marine mammals, fishes and crustaceans as well as clams, polychaetes, and gastropods are important food items (Stoker, in prep; Fay *et al.*, 1977; Lowry *et al.*, 1977).

Pollutants on the Bottom

As discussed in this report, proposed oil development in the Bering Sea has led to intensive biological assessment surveys. The benthic trawl, used

Text continued on Page 73

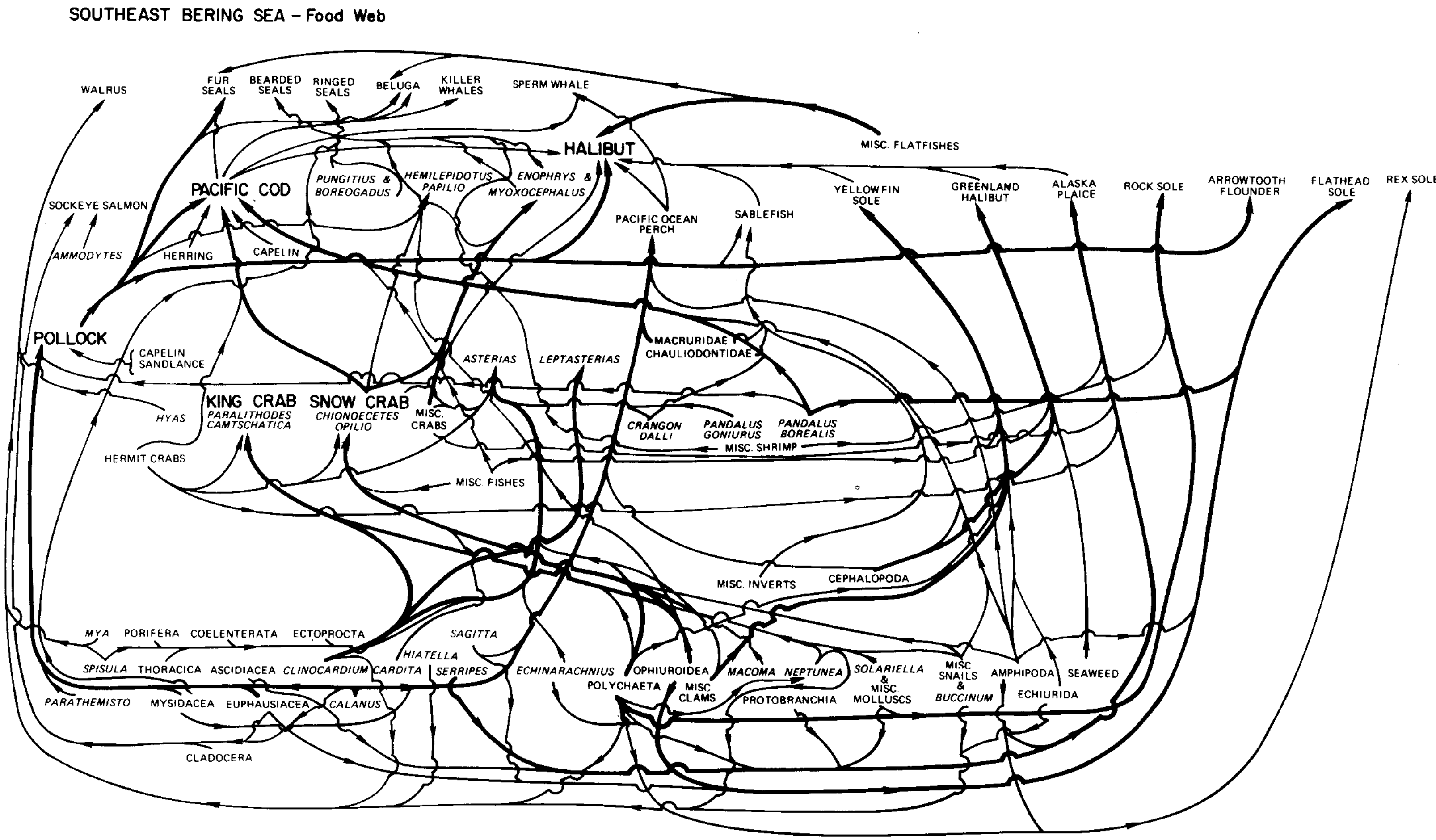

Figure 11. A food web based on the benthic invertebrates of the southeastern Bering Sea. Carbon flows generally in the direction of the arrows. Bold lines indicate major food sources based on frequency of occurrence.

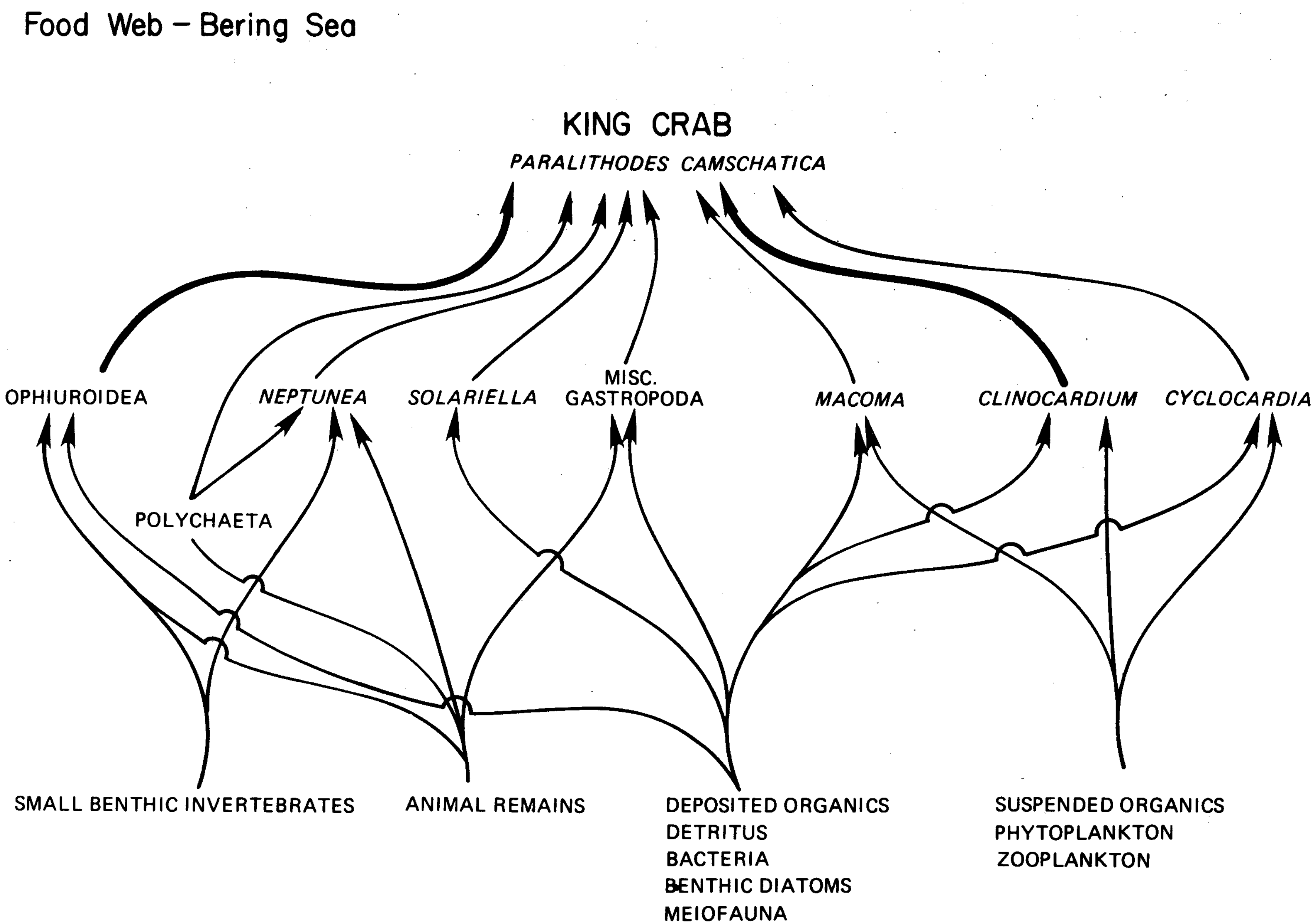

Figure 12. A food web showing carbon flow to king crab (*Paralithodes camtschatica*) in the southeastern Bering Sea. Bold lines indicate major food sources based on frequency of occurrence.

Food Web – Bering Sea

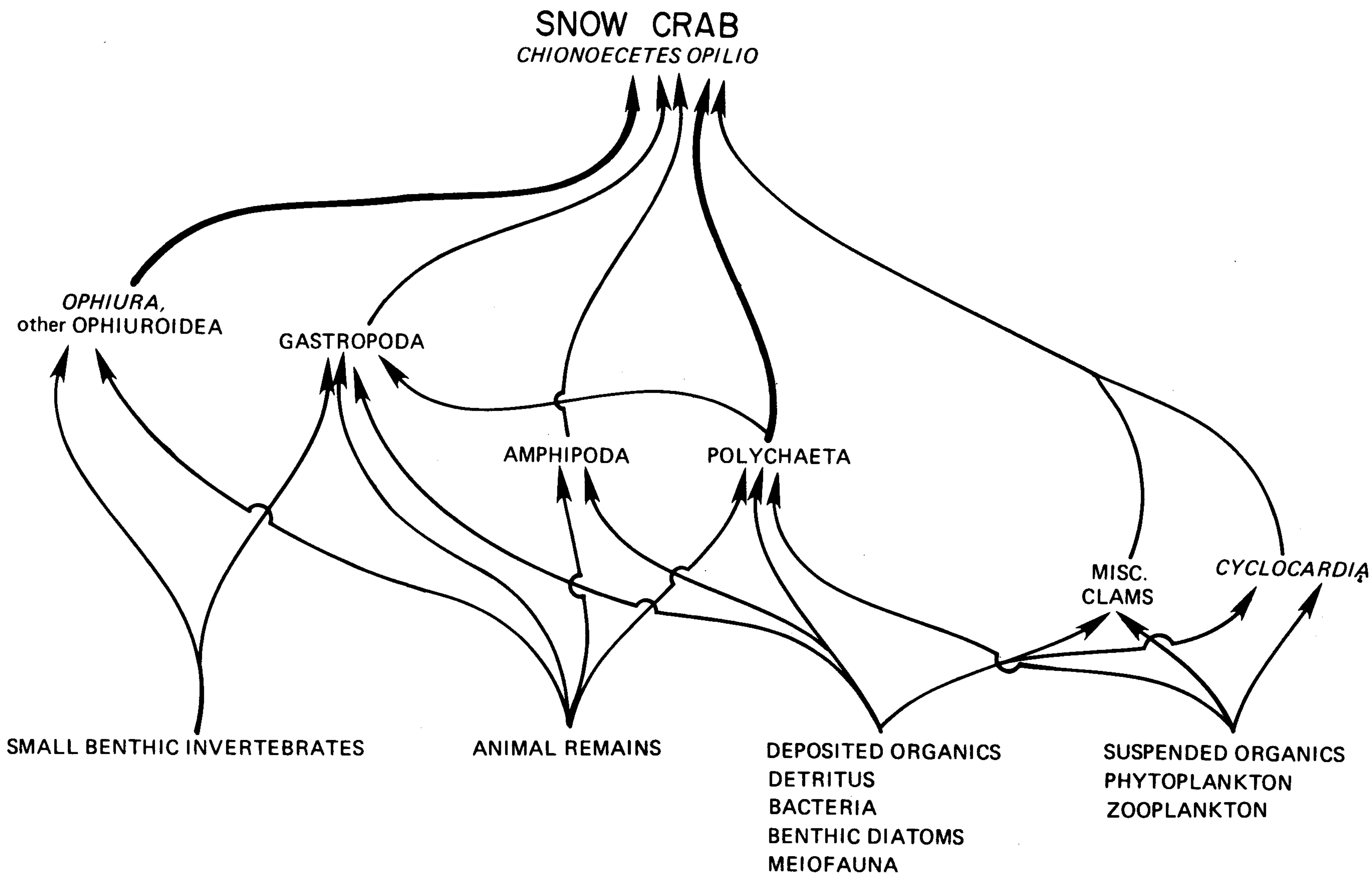

Figure 13. A food web showing carbon flow to snow crab (*Chionoecetes opilio*) in the southeastern Bering Sea. Bold lines indicate major food sources based on frequency of occurrence.

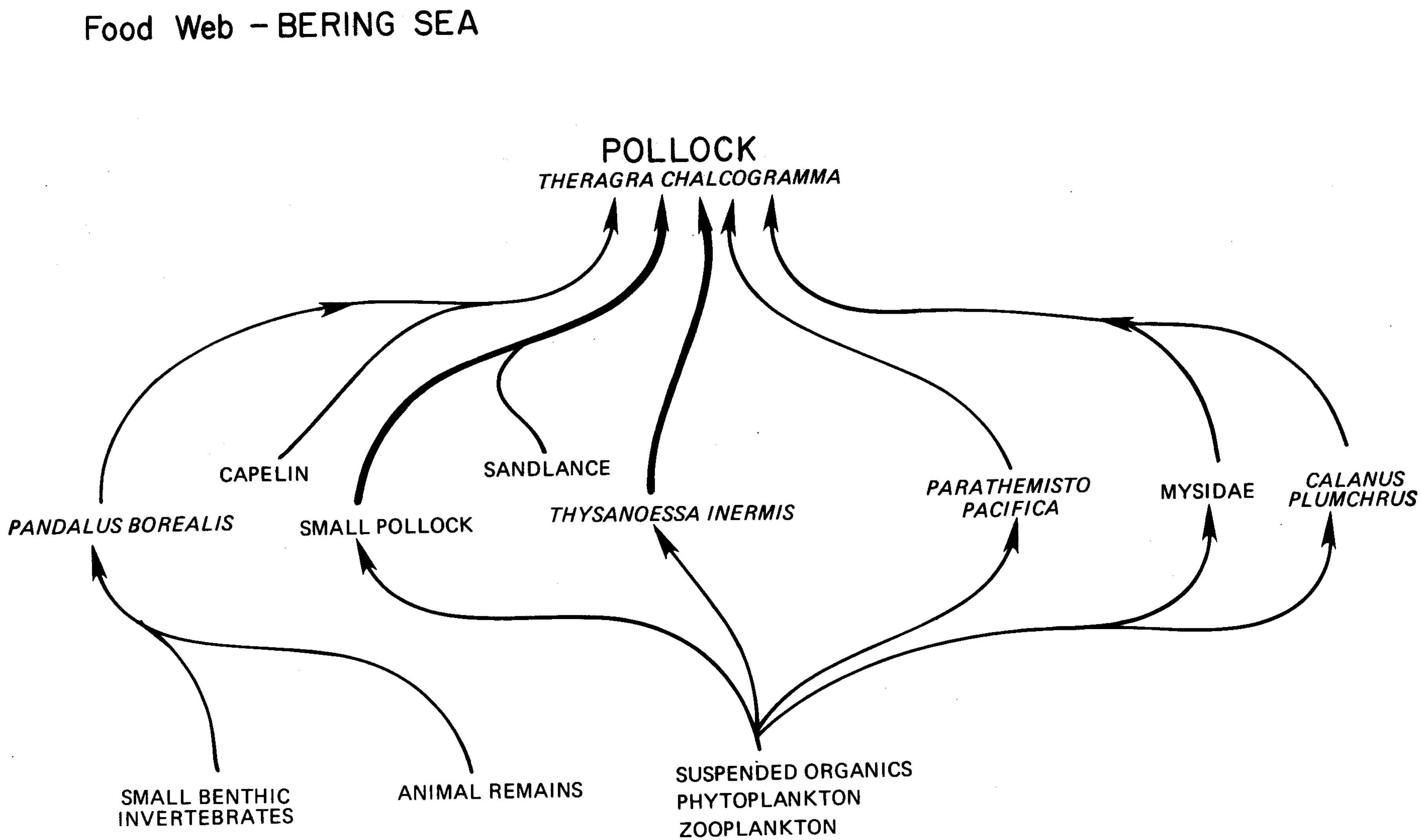

Figure 14. A food web showing carbon flow to pollock (*Theragra chalcogramma*) in the southeastern Bering Sea. Bold lines indicate major food sources based on frequency of occurrence.

Food Web – Bering Sea

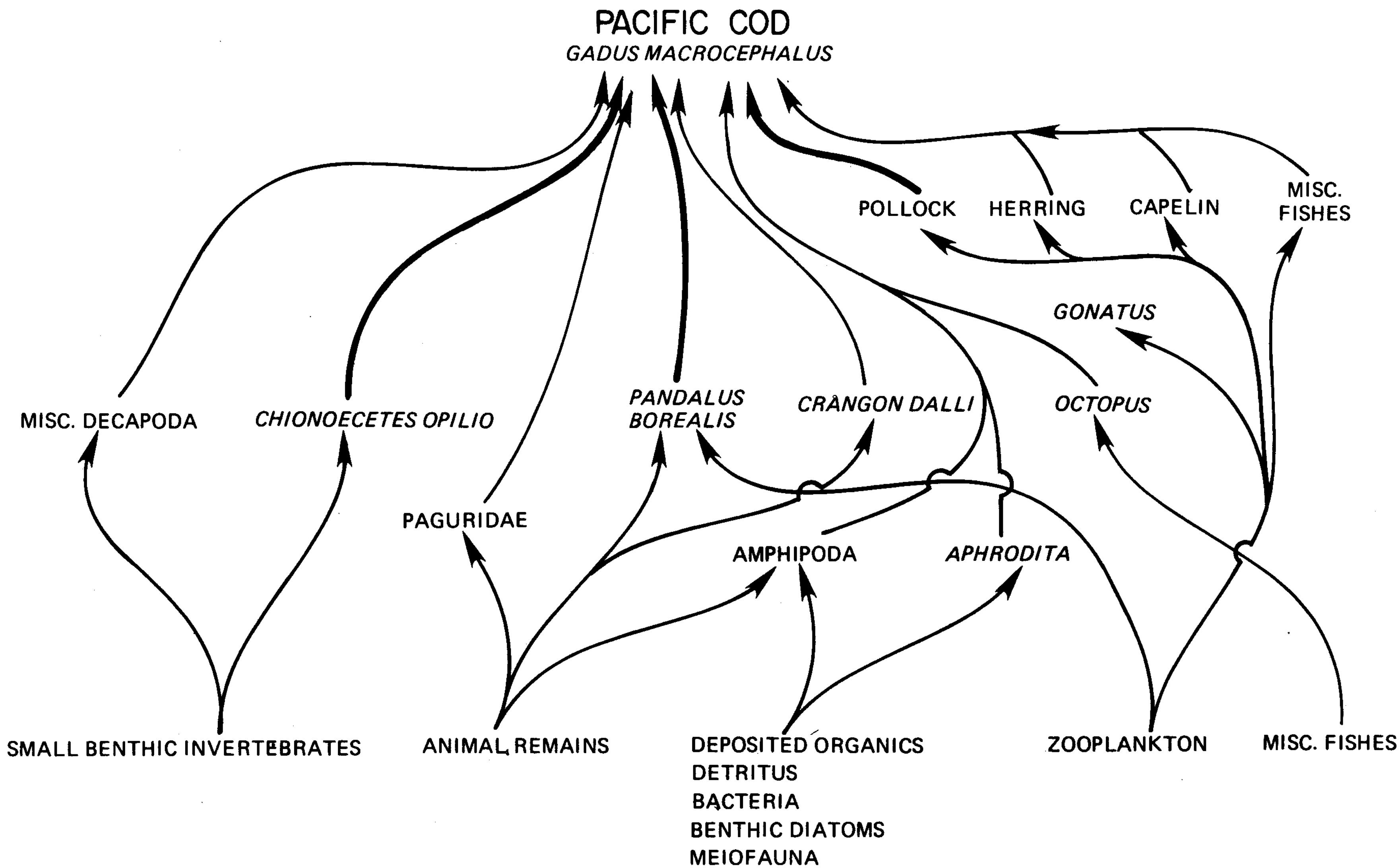

Figure 15. A food web showing carbon flow to Pacific cod (*Gadus macrocephalus*) in the southeastern Bering Sea. Bold lines indicate major food sources based on frequency of occurrence.

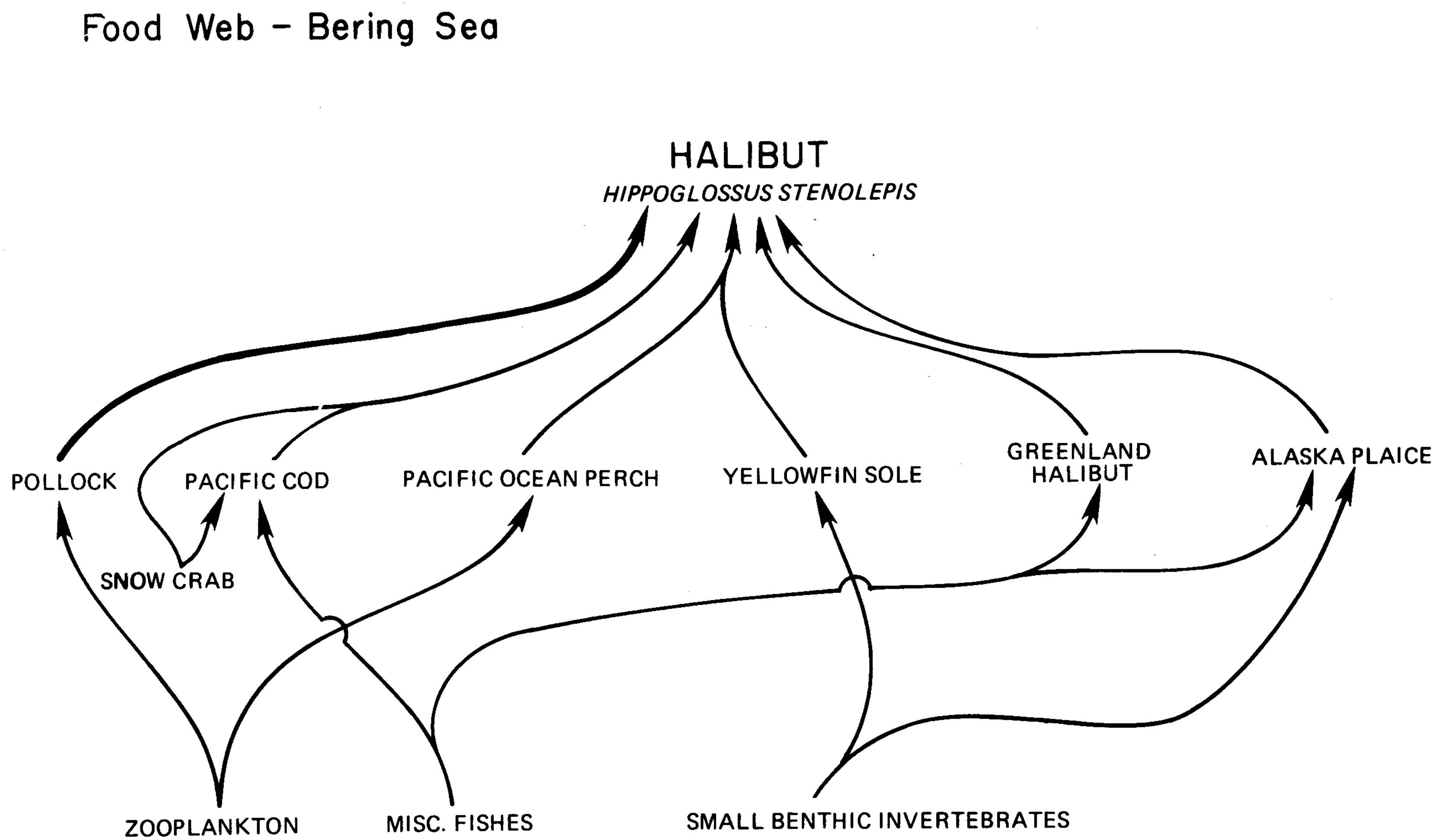

Figure 16. A food web showing carbon flow to Pacific halibut (*Hippoglossus stenolepis*) in the southeastern Bering Sea. Bold lines indicate major food sources based on frequency of occurrence.

TABLE XIX

FEEDING METHODS OF INVERTEBRATES AND FISHES INCLUDED IN THE S.E. BERING SEA FOOD WEB (SEE FIG. 11)[1]

Phyla abbreviations: P=Porifera; C=Coelenterata; A=Annelida; M=Mollusca; Art=Arthropoda; E=Echiurida; Etp=Ectoprocta; Ecd=Echinodermata; Ctn=Chaetognatha; Cho=Chordata.
(X=dominant feeding method; O=other feeding method)

Organism	Phylum	Deposit Feeder	Suspension Feeder	Scavenger	Predator	Unknown
Porifera	P	-	X	-	-	-
Coelenterata	C	-	-	-	X	-
Polychaeta	A	X	X	X	X	-
Aphrodita sp.	A	X	-	-	-	-
Solariella sp.	M	-	-	-	-	X
Neptunea sp.	M	-	-	X	X	-
Buccinum sp.	M	-	-	X	X	-
Protobranchia	M	X	O	-	-	-
Cyclocardia sp.	M	O	X	-	-	-
Clinocardium sp.	M	O	X	-	-	-
Spisula polynyma	M	-	X	-	-	-
Serripes groenlandicus	M	O	X	-	-	-
Mya sp.	M	O	X	-	-	-
Hiatella arctica	M	X	-	-	-	-

TABLE XIX

CONTINUED

Organism	Phylum	Deposit Feeder	Suspension Feeder	Scavenger	Predator	Unknown
Macoma sp.	M	X	O	-	-	-
Cephalopoda	M	-	-	-	X	-
Gonatus sp.	M	-	-	-	X	-
Calanus sp.	Art	-	X	-	-	-
Calanus plumchrus	Art	-	X	-	-	-
Thoracica	Art	-	X	-	-	-
Mysidacea	Art	-	X	X	X	-
Amphipoda	Art	X	-	X	-	-
Parathemisto pacifica	Art	-	-	-	X	-
Euphausiacea	Art	-	X	-	-	-
Thysanoessa inermis	Art	-	X	-	-	-
Pandalus borealis	Art	-	-	X	-	-
Pandalus goniurus	Art	-	-	X	-	-
Crangon dalli	Art	-	-	X	-	-
Paguridae	Art	-	-	X	X	-

TABLE XIX

CONTINUED

Organism	Phylum	Deposit Feeder	Suspension Feeder	Scavenger	Predator	Unknown
Paralithodes camtschatica	Art	-	-	X	X	-
Hyas sp.	Art	-	-	X	-	-
Chionoecetes opilio	Art	-	-	X	X	-
Echiurida	E	X	-	-	-	-
Ectoprocta	Etp	-	X	-	-	-
Echinarachnius parma	Ecd	X	-	-	-	-
Asterias amurensis	Ecd	-	-	-	X	-
Leptasterias sp.	Ecd	-	-	-	X	-
Ophiuroidea	Ecd	X	X	X	X	-
Ophiura sp.	Ecd	-	-	X	X	-
Sagitta sp.	Ctn	-	-	-	X	-
Ascidiacea	Cho	-	X	-	X	-
Clupea harengus pallasi (herring)	Cho	-	-	-	X	-
Mallotus villosus (capelin)	Cho	-	-	-	X	-

TABLE XIX

CONTINUED

Organism	Phylum	Deposit Feeder	Suspension Feeder	Scavenger	Predator	Unknown
Oncorhynchus nerka (red salmon)	Cho	-	-	-	X	-
Theragra chalcogramma (pollock)	Cho	-	-	-	X	-
Gadus macrocephalus (Pacific cod)	Cho	-	-	-	X	-
Boreogadus sp. (Arctic cod)	Cho	-	-	-	X	-
Pungitius sp. (nine-spine stickleback)	Cho	-	-	-	X	-
Hemilepidotus papilio (sculpin)	Cho	-	-	-	X	-
Myoxocephalus sp. (sculpin)	Cho	-	-	-	X	-
Enophrys sp. (sculpin)	Cho	-	-	-	X	-
Sebastes alutus (Pacific Ocean perch)	Cho	-	-	-	X	-
Anaplopoma fimbria (sablefish)	Cho	-	-	-	X	-

TABLE XIX

CONTINUED

Organism	Phylum	Deposit Feeder	Suspension Feeder	Scavenger	Predator	Unknown
Atheresthes stomias (arrowtooth flounder)	Cho	-	-	-	X	-
Glyptocephalus zachirus (rexsole)	Cho	-	-	-	X	-
Hippoglossoides elassodon (flathead sole)	Cho	-	-	-	X	-
Hippoglossus stenolepis (halibut)	Cho	-	-	-	X	-
Lepidopsetta bilineata (rock sole)	Cho	-	-	-	X	-
Limanda aspera (yellowfin sole)	Cho	-	-	-	X	-
Reinhardtius hippoglossoides (Greenland halibut)	Cho	-	-	-	X	-

[1]Based on Newell, 1970; Barnes, 1969; Pearce and Thorson, 1967; Rasmussen, 1973; Skalkin, 1963; Hart, 1973; and Feder, unpublished data.

to collect bottom invertebrates and fishes in these surveys, also retrieved man-made debris in its path. A description of this debris, its distribution, and frequency of occurrence are given for the southeastern Bering Sea in 1975 and 1976 (Feder *et al.*, 1978a).

Man-made debris found in the trawl was classified as metal, rope and twine, glass, plastic, fishing gear, cloth, rubber, wood, or paper product. Most classifications contained a wide variety of objects; for example, metal included wire, cans, and metal fragments; fishing gear included derelict crab pots, glass floats, and fish net. No item was placed in more than one classification. Debris was not always recorded in 1975, but was recorded for every trawl in 1976.

In 1975, debris was only recorded for 12 trawls; in 1976, 43 of 104 trawls (41.3%) contained debris. Occurrence of the various classes of debris was similar in both years except for plastic which was much more prevalent in 1975 (Table XX). Of the 55 trawls containing debris, 49 (90%) were made in the shaded area shown on Figure 17, a region of intensive fishing pressure. Debris-containing trawls outside this area were widely separated and apparently random. Debris of obvious Asian origin was found primarily in the shaded area west of 170°W longitude (Figure 17).

VII. DISCUSSION

Distribution, Abundance, and Biomass

The 1975 and 1976 trawl surveys covered only slightly overlapping areas. The 1975 area, mainly on the inner shelf, had an epifaunal standing stock of 3.3 g/m^2; the 1976 area, mainly on the outer shelf, averaged 4.9 g/m^2. The OCSEAP trawl survey made in the Northeast Gulf of Alaska resulted in an estimate of 2.6 g/m^2 (Jewett and Feder, 1976). Epifaunal studies in Norton Sound and the Chukchi Sea - Kotzebue Sound areas yielded similar biomass estimates of 3.7 and 3.3 g/m^2 respectively (Feder and Jewett, in press).

In the Bering Sea, major differences in species dominance were observed between the areas sampled in 1975 and 1976. *Chionoecetes* spp., typically deep-water crabs, increased from 32.7% of the invertebrate biomass in 1975

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TABLE XX

FREQUENCY OF OCCURRENCE OF MAN-MADE DEBRIS ON THE BERING SEA FLOOR

Type of Debris	Number of trawls in which debris was found		
	1975	1976	1975 and 1976 Combined
All types	12	43	55
Metal	2	16	18
Rope and Twine	3	11	14
Glass	2	9	11
Plastic	12	7	19
Fishing gear	1	5	6
Cloth	2	5	7
Rubber	1	3	4
Wood	0	3	3
Paper product	0	1	1

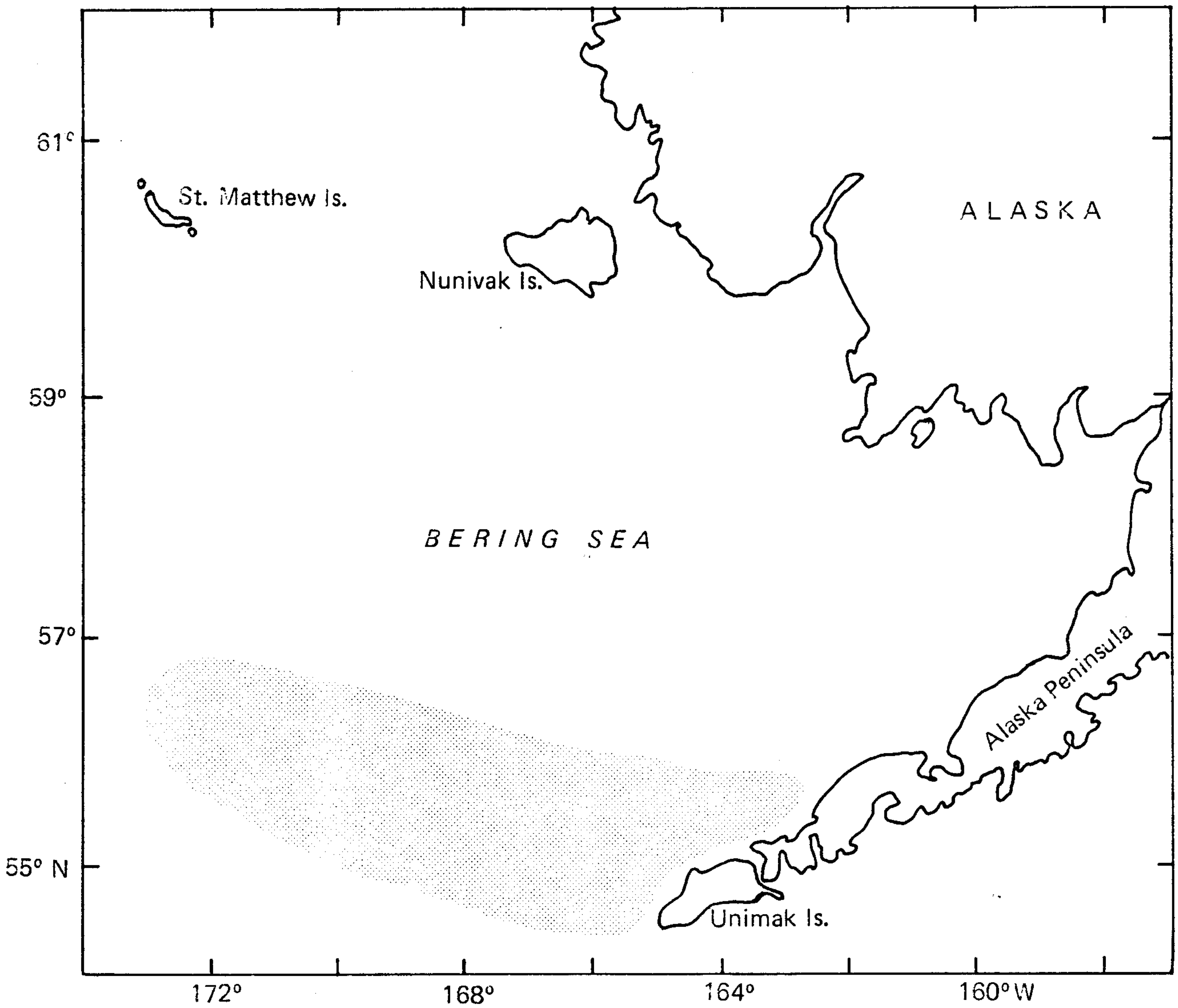

Figure 17. Study area showing location (shaded area) where 49 debris-containing trawls were made. Debris of Asian origin was found in the shaded area west of 170°W Longitude.

to 48.1% of the biomass in 1976 when the survey area moved into deeper water. The decreasing importance of *Paralithodes camtschatica* and *Asterias amurensis* from 1975 to 1976 is probably also due to this shift in depth. Arthropoda and Echinodermata appear to be the two dominant phyla in the southeast Bering Sea regardless of area. Arthropoda were clearly the dominant group, being 2.6 times as abundant as Echinodermata in the 1975 sampling area and 6.1 times as abundant in the 1976 sampling area. This dominance is attributable to the abundance of the large commercial crabs, *Paralithodes camtschatica, Chionoecetes opilio*, and *C. bairdi*, each of which supports a major fishery in the Bering Sea.

In decreasing order of percent of total weight, crustaceans, echinoderms, ascidians, and molluscs were the major epifaunal invertebrate groups taken in the 1975-76 trawl surveys. In general, the most common species were similar to those found by McLaughlin (1963), i.e., *Paralithodes camtschatica, Chionoecetes opilio, C. bairdi,* and *Asterias amurensis*.

Based on the present study, the distribution of *Paralithodes camtschatica* occurs immediately north of the Alaska Peninsula extending west to Unimak Island. This area is also the commercial fishing grounds for this crab. The pattern of distribution coincides with McLaughlin (1963). The major portion of the population occurs within an area in Bristol Bay which is under consideration for petroleum exploration (also see Pereyra *et al.*, 1976).

Chionoecetes opilio, a slightly smaller crab than *C. bairdi*, was the most widely distributed and dominant crab species encountered. Hybrids (*C. bairdi* x *C. opilio*) were often found. Further information of distribution, abundance, and biological features of the principal crab species can be found in Pereyra *et al.* (1976).

The genus *Pagurus* was the decapod with the most species collected. *Pagurus trigonocheirus* dominated the hermit crabs; however, *P. aleuticus*, and *P. capillatus* were also commonly taken. *Labidochirus splendescens*, a small, rapidly moving hermit crab, was normally found to use the shells of small gastropods such as *Natica* spp. or *Polinices* spp. These shelters were too small to allow the crab to fully withdraw within the shell, but *Labidochirus* is uniquely equipped with a heavily calcified exoskeleton for protection. Furthermore, *Labidochirus splendescens* was often found with its shell completely replaced by a sponge that had assumed the shape of the original shell (also, see MacGinitie and MacGinitie, 1968). An apparent advantage of this replacement is that the sponge is lighter than the original snail shell. The lighter shell may be a clue to the ability of *L. splendescens* to move rapidly so as to enable it to avoid predators. Another advantage may be that of predator avoidance since sponges are seldom preyed upon.

Sea stars of the Bering Sea were represented by 23 species; a similar number of species occurred in the northeast Gulf of Alaska (24 species) (Feder, 1977). Only 17 species were found in the Norton Sound and the Chukchi Sea-Kotzebue Sound areas (Feder and Jewett, 1977). Sea stars made up 19.6% and 5.1% of the total southeastern Bering Sea invertebrate biomass in 1975 and 1976 respectively. On the other hand, 69% and 48% of the total epifaunal invertebrate biomass in the Norton Sound and the Chukchi Sea-Kotzebue Sound areas were sea stars (Feder and Jewett, 1977). The forcipulate *Asterias amurensis* was the most abundant Bering Sea asteroid (92% of all sea stars from both sampling years). The sea star *Ceramaster patagonicus* occurred more frequently and in greater numbers in 1976 than in 1975. The latter species is common in the deeper waters of the continental shelf sampled in 1976.

Leptasterias polaris acervata occurred at 25.1% of the stations occupied in 1975, and was the second most commonly encountered sea star. In 1976 it was collected at only seven stations, most of which were located in shallow water on the shelf. This sea star was also an important member of the shallow water benthic community in the Norton Sound-Chukchi Sea area (Feder and Jewett, in press).

Tunicate composition also varied with depth. Ascidians accounted for 8.5% of the epifaunal biomass in 1975, while they comprised 3.3% in 1976. In 1975, where stations were mostly shallower than 80 m, *Styela rustica macrenteron* dominated. McLaughlin (1963) also found this species; however, *Boltenia ovifera* was the most widely distributed tunicate species she encountered. The station grid sampled in the 1975 study was far more extensive than that of McLaughlin (1963).

Among the molluscs, the most striking difference in distribution of a species between the 1975 and 1976 sampling periods is that of *Neptunea heros*. In 1975, the majority of the stations occupied were located on the shelf, in relatively shallow water. *Neptunea heros* occurred at 91 stations, and a total of 4250 individuals were collected. During the 1976 sampling period, when most stations were located in deeper water on the shelf slope, only nine stations yielded *N. heros*. A total of 262 individuals were collected, and the species comprised 5.0% of the total phylum weight. In 1975, *N. heros* comprised 36.6% of the phylum weight. *Neptunea heros* was also important in terms of numbers and weight in the Norton Sound and the Chukchi Sea-Kotzebue Sound area (Feder and Jewett, 1977).

Snails of the genus *Beringius* revealed an opposite trend as compared to *Neptunea heros*. *Beringius* spp. occurred in greater numbers and at more stations during the 1976 sampling period than during 1975. *Fusitriton oregonensis* also occurred more frequently in the deeper waters sampled in 1976.

Russian benthic investigations (Neyman, 1963) provide biomass estimates based on grab samples for infauna and small epifauna from the Bering Sea. The lowest value, 55 g/m^2, for the southeast Bering Sea is greater than our 3.3 g/m^2 (1975) and 4.9 g/m^2 (1976) for trawl collected epifauna from similar areas. Higher infaunal biomass values were reported (Neyman, 1963; summarized by Alton, 1974) for the northern Bering Sea - 905 g/m^2 in the Chirikov Basin and 468 g/m^2 in the Gulf of Anadyr. Use of a commercial trawl results in the loss of infaunal and small epifaunal organisms which are an important part of the benthic biomass. Therefore, the total benthic biomass value is probably best expressed by combining both grab and trawl values (infaunal data will be included in a separate OCSEAP report).

Alton (1974) points out that low biomass values in the southeast Bering Sea may be due to constant cropping by large demersal fish populations, and may not accurately reflect production rates in the area. Furthermore, Alton (1974) shows that, on a world-wide basis, large demersal fish harvests, as occur in the southeast Bering Sea, are not directly related to a large benthic standing stock.

A large proportion of the southeastern Bering Sea benthos is composed of species of direct use as food for man. King crabs, snow crabs, and snails of the genus *Neptunea* are among the most abundant epifaunal invertebrates present in the southeast Bering Sea. In addition, the area may also support clam resources of commercial magnitude (Steven Hughes, NWAFC, unpubl.; Feder *et al.*, 1978b).

The OCSEAP trawl surveys in the northeast Gulf of Alaska (NEGOA) in 1975 and in the Norton Sound and Chukchi Sea-Kotzebue Sound areas provided extensive information on epifauna that can be compared with data from the southeastern Bering Sea (Jewett and Feder, 1976; Ronholt *et al.*, 1976; Feder and Jewett, 1977). The southeastern Bering Sea exhibited greater 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 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, 1977). In general, the arthropod biomass decreased toward higher latitudes and the echinoderm biomass increased. Molluscan biomass was highest in the Norton Sound, Chukchi Sea-Kotzebue Sound area; biomass was similar in the other study areas.

Multiple Tows

Since multiple tows were not taken on exact station locations, these tows cannot be subjected to statistical analysis. However, the results of the intensive sampling of relatively small areas can be used to gain a better understanding of the patchiness of the benthic environment. Also, a somewhat better understanding of the effectiveness of the otter trawl in multiple sampling and trawling duration was achieved.

The number of species collected by a series of tows was not necessarily related to the total count and weight of organisms at a particular station. The number of tows in which a species occurred was indicative of the density of that species in the sampling area.

The comparison of the results of the five 30-minute tows and the four 60-minute tows taken at Station D7 seem to indicate that for practical purposes the 30-minute tow is as efficient as the 60-minute tow for sampling the benthic environment. However, further studies in this aspect of sampling should be undertaken to confirm this conclusion.

Food Studies

Of the major biomass components in the Bering Sea (i.e., king crab, snow crabs, and the sea star *Asterias amurensis*), only the feeding habits of the king crab have been examined intensively by numerous investigators.

Cunningham (1969) studied the food of Bering Sea king crabs (*Paralithodes camtschatica*) and determined that echinoderms (*Ophiura sarsi, Gorgonocephalus* sp., *Strongylocentrotus* sp., and *Echinarachnius* sp.) were the most important food category based on percent of total food weight (49.1%). Molluscs (*Nuculana radiata, Clinocardium californiense, Chlamys* sp., *Solariella* sp., and Buccinidae) and crustaceans (*Hyas coarctatus alutaceus, Erimacrus isenbeckii, Pagurus* sp., *Pandalus* sp., and Amphipoda) were next in importance with 37.2% and 10.1% respectively. As determined by Takeuchi (1959, 1967), molluscs, crustaceans, and echinoderms were the main king crab food items in decreasing order of importance. McLaughlin and Hebard (1961) determined percent frequency of occurrence for food items of male and female Bering Sea king crabs. Primary food items were molluscs (pelecypods) (76.9%, male; 60.6%, female), echinoderms (asteroids, ophiuroids and echinoids) (48.5%, male; 35.6%, female), and decapod crustaceans (Reptantia) (26%, male; 19.4%, female). Polychaetes, algae, and other crustaceans followed in descending order of importance. Feeding was not significantly different between the sexes. Feniuk (1945) found molluscs, crustaceans, and polychaetes, in that order, to be the important food items of king crabs from the west-Kamchatka shelf. Tsalkina (1969) reported that hydroids, primarily *Lafoeina maxima*, are the most preferred food items of early postlarval king crab. Results presented in the present report match other reports, i.e., molluscs, echinoderms, and crustaceans are important food resources for king crabs in the Bering Sea.

Inferences from the present study, as well as other snow crab food studies, suggest that food groups used by snow crabs are somewhat similar throughout their range. The deposit-feeding clam, *Nucula tenuis*, dominated the diet of *Chionoecetes opilio* from Norton Sound and the Chukchi Sea (Feder and Jewett, in press). *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, 1977). 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* in Port Valdez (Prince William Sound) contained polychaetes, clams, *C. bairdi*, other crustaceans, and detritial material (Feder, unpub. data). 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.

Asterias amurensis is a feeding generalist. Food items were from seven phyla with no single item being used by more than 17.1% of the sea stars examined. In contrast, the sea star *Leptasterias polaris acervata* fed solely on cockles (Cardiidae). Cockles are apparently quite common in the southeast Bering Sea as suggested by their importance as prey for *Paralithodes camtschatica, A. amurensis*, and *L. polaris acervata*. The great abundance and wide distribution of the moderately sized (100 g) sea star, *Asterias amurensis*, implies a great availability of food. It was estimated by Hatanaka and Kosaka (1958) in Sendai Bay, Japan that food consumed annually by the bottom fish population approximated 10,000 metric tons and the food consumed by *A. amurensis* amounted to about 8,000 metric tons. If the food requirements are similar for both bottom fishes and this sea star in the Bering Sea, the sea star population clearly has an important bearing on the production of useful fish.

Sea stars, together with such organisms as sponges, sea anemones, jellyfishes, and sea urchins, are usually considered as terminal members in food webs in marine ecosystems. Hatanaka and Kosaka (1958) calculated that 20-30% of the weight of *Asteria amurensis* in Tokyo Bay is gonadal material which is ultimately extruded during spawning (also see Feder, 1956 and 1970 for comments on the reproductive output of the sea star *Pisaster ochraceus*). Sea stars and the other invertebrates noted above generally exhibit distinct annual reproductive cycles; thus, species that shed their gametes into the surrounding water tend to liberate their sex products over short periods of time (Feder, 1956; Boolootian, 1966 unpubl. observations). Such pulses of high energy reproductive material during the spawning of large populations of sea stars and other invertebrates probably represent important components of secondary production in the study areas (see Isaacs, 1976 for a general discussion of this concept).

Tunicates are sessile, benthic organisms that feed by filtering suspended particles of organic material and small plankters from the water. It is a relatively successful group in some parts of the Bering Sea. Reduced sedimentation may, in part, contribute to their success. Trawling activities in the northeast Gulf of Alaska typically revealed few ascidians (Feder and Jewett, unpub. data), presumably due to high sedimentation rates there. The only known predator on ascidians in the Bering Sea is the walrus (Stoker, 1973).

Crustaceans and fishes dominated as food items for the Bering Sea Pacific cod. These findings are consistent with food of cod from the Kodiak shelf (Jewett, in press).

Bering Sea flatfishes were feeding heavily on clams. Most of these clams are probably using a combination of suspension and deposit feeding methods (Rasmussen, 1973; Reid and Reid, 1969; Feder, unpub. data) with one feeding strategy dominant and the other employed occasionally. Thus, addition of pollutants to the sediments may affect pelecypods not typically considered as deposit feeders. Pelecypods are intensively fed upon by king crabs, snow crabs, and Pacific cod, as well as flatfishes, and are of unquestionable importance as a basis for much of the Bering Sea food web.

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APPENDIX TABLE I

SUMMARIZATION OF GENERAL COMMENTS, MISCELLANEOUS BIOLOGICAL INFORMATION, REPRODUCTIVE AND FEEDING DATA, AND POLLUTANTS COLLECTED ON LEGS I-III OF THE NOAA SHIP *MILLER FREEMAN* S.E. BERING SEA CRUISE - 1975

Tow Number	Station Name	Comments
1	F2	Snail eggs found here. *Chionoecetes bairdi* - 32 males. *Chionoecetes opilio* - 69 males and 2 females. *Chionoecetes* (hybrid) - 13 males.
2	G2	Sex ratio for *Chionoecetes* based on 100% of sample. *Chionoecetes bairdi* - 17 males. *Chionoecetes opilio* - 369 males and 1176 females.
3	G1	*Chionoecetes opilio* - 141 males and 607 females. *Chionoecetes bairdi* - 1 male and 4 females. Snail eggs found here.
4	G18	Snail eggs on *Neptunea* spp. All *Chionoecetes* are males.
5	H18	*Chionoecetes opilio* - 266 males and 2262 females. *Chionoecetes* (hybrid) - 9 males.
6	H19	*Chionoecetes opilio* - 564 males and 96 females. *Chionoecetes bairdi* - 52 males and 4 females. *Chionoecetes* (hybrid) - 13 males and 4 females.
7	I19	*Chionoecetes opilio* - 156 males and 318 females. *Chionoecetes bairdi* - 4 males and 1 female. *Chionoecetes* (hybrid) - 2 males.
8	I20	*Chionoecetes opilio* - 259 males and 1508 females. *Chionoecetes bairdi* - 3 males. *Chionoecetes* (hybrid) - 4 males.
9	J20	*Chionoecetes opilio* - 1067 males and 1566 females. *Chionoecetes bairdi* - 3 males and 29 females.
10	J21	1 plastic bag found. *Chionoecetes opilio* - 508 males and 707 females. *Chionoecetes bairdi* - 3 males. *Chionoecetes* (hybrid) - 8 males.

APPENDIX TABLE I

CONTINUED

Tow Number	Station Name	Comments
11	K21	*Chionoecetes opilio* - 379 males and 1082 females. *Chionoecetes* (hybrid) - 2 males.
12	L21	*Chionoecetes opilio* - 2864 males and 3670 females. *Chionoecetes* (hybrid) - 1 male.
13	L22	*Chionoecetes opilio* - 1747 males and 2784 females. *Chionoecetes* (hybrid) - 1 male.
14	M22	*Chionoecetes opilio* - 1260 males and 1348 females.
15	N22	*Chionoecetes opilio* - 1411 males and 1665 females.
16	N23	*Chionoecetes opilio* - 215 males and 281 females.
17	O23	*Chionoecetes opilio* - 520 males and 794 females.
18	P23	*Chionoecetes opilio* - 300 males and 323 females.
19	Q22	*Chionoecetes opilio* - 118 males and 217 females.
20	Q21	*Chionoecetes opilio* - 205 males and 107 females. *Chionoecetes* (hybrid) - 1 male and 5 females.
21	Q20	*Chionoecetes opilio* - 363 males and 215 females.
22	Q19	*Chionoecetes opilio* - 102 males and 53 females.
29	P20	*Chionoecetes opilio* - 506 males and 578 females. *Chionoecetes* (hybrid) - 1 male and 5 females. One piece of plastic strapping found.
30	P21	*Chionoecetes opilio* - 175 males and 156 females. *Chionoecetes* (hybrid) - 1 male and 1 female.

APPENDIX TABLE I

CONTINUED

Tow Number	Station Name	Comments
32	O22	*Chionoecetes opilio* - 993 males and 2369 females.
33	O21	*Chionoecetes opilio* - 276 males and 364 females.
34	O20	*Chionoecetes opilio* - 88 males and 38 females.
35	O19	*Chionoecetes opilio* - 57 males and 25 females.
40	O4	Trawl ripped.
49	M04	Plastic was found in this trawl. All *Theragra chalcogramma* were juveniles.
54	N18	*Chionoecetes opilio* - 10 males and 14 females.
55	N19	40% of *Argis dentata* were ovigerous. *Chionoecetes opilio* - 9 males and 1 female.
56	N20	*Chionoecetes opilio* - 603 males and 344 females. *Chionoecetes* (hybrid) - 9 males.
57	N21	*Chionoecetes opilio* - 290 males and 300 females. *Chionoecetes* (hybrid) - 11 males and 6 females.
58	M21	*Chionoecetes opilio* - 203 males and 122 females.
60	M19	*Chionoecetes opilio* - 22 males and 10 females. *Chionoecetes* (hybrid) - 2 males.
61	M18	Juvenile *Theragra chalcogramma* - 18.144 Kg.
65	L18	*Chionoecetes opilio* - 91 males and 10 females.
66	L19	Plastic found here. *Chionoecetes opilio* - 473 males and 755 females. *Chionoecetes* (hybrid) - 13 males and 12 females.

APPENDIX TABLE I

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Tow Number	Station Name	Comments
67	L20	*Chionoecetes opilio* - 607 males and 1025 females. *Chionoecetes* (hybrid) - 19 males.
68	K20	*Chionoecetes opilio* - 280 males and 455 females.
69	K19	*Chionoecetes opilio* - 275 males and 516 females. *Chionoecetes* (hybrid) - 6 males.
70	K18	*Chionoecetes opilio* - 291 males and 421 females. *Chionoecetes* (hybrid) - 3 males.
71	K1	*Chionoecetes opilio* - 105 males and 62 females.
72	J1	*Chionoecetes opilio* - 171 males and 195 females.
73	J19	*Chionoecetes opilio* - 94 males and 127 females.
74	J18	*Chionoecetes opilio* - 367 males and 417 females. *Chionoecetes* (hybrid) - 55 males and 18 females.
75	I18	*Chionoecetes opilio* - 372 males and 220 females. *Chionoecetes* (hybrid) - 20 males and 8 females.
76	I1	*Chionoecetes opilio* - 680 males and 290 females. *Chionoecetes* (hybrid) - 25 males and 10 females.
77	H1	*Chionoecetes opilio* 168 males and 291 females.
78	D7	*Chionoecetes opilio* - 34 males and 71 females. *Chionoecetes bairdi* - 82 males and 18 females. *Chionoecetes* (hybrid) - 3 males and 1 female.
79	C6	*Chionoecetes opilio* - 11 males and 2 females. *Chionoecetes bairdi* - 37 males and 5 females. *Paralithodes camtschatica* - 32 males and 676 females.

APPENDIX TABLE I

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Tow Number	Station Name	Comments
80	B5	Plastic found here. *Chionoecetes bairdi* - 23 males and 1 female. *Paralithodes camtschatica* - 11 males and 12 females.
81	A4	*Paralithodes camtschatica* - 40 males and 3 females.
83	B3	*Chionoecetes bairdi* - 19 males and 19 females. *Chionoecetes opilio* - 8 males. *Chionoecetes* (hybrid) - 1 male and 3 females.
84	AB2/3	*Chionoecetes bairdi* - 33 males and 88 females. *Chionoecetes opilio* - 1 male and 2 females. *Chionoecetes* (hybrid) - 5 males and 17 females.
85	ZA1/2	*Chionoecetes bairdi* - 1 male and 1 female. *Chionoecetes* (hybrid) - 1 male and 3 females.
86	A2	Sex ratio for *Chionoecetes* based on 100% of sample. *Chionoecetes bairdi* - 10 males and 4 females. *Chionoecetes* (hybrid) - 2 males and 21 females. *Theragra chalcogramma* weight - 3878.3 Kg.
87	F1	*Pagurus aleuticus* - 5 gravid (eggs black). *Pandalus borealis* - 2 gravid (eggs purple). Yellow snail eggs on *Neptunea* shells. *Chionoecetes bairdi*, *Chionoecetes opilio*, and *Chionoecetes* (hybrid) were all males.
88	H2	*Chionoecetes bairdi* - 4 males and 1 female. *Chionoecetes opilio* - 140 males and 131 females. *Chionoecetes* (hybrid) - 6 males and 3 females.
89	-	Contents not enumerated.
90	I3	*Chionoecetes opilio* - 115 males and 34 females. *Chionoecetes* (hybrid) - 1 male. Snail eggs - 120 g. *Styela macrenteron*, *Eunephthya rubiformis* and snail eggs were found on snail shells.

APPENDIX TABLE I

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Tow Number	Station Name	Comments
91	I3	*Chionoecetes opilio* - 604 males and 174 females. *Chionoecetes* (hybrid) - 56 males and 29 females. Snail eggs - 430 g.
92	I4	*Chionoecetes opilio* - 758 males and 189 females. *Chionoecetes* (hybrid) - 37 males and 36 females. Snail eggs - 2.513 Kg.
93	H4	*Chionoecetes* (hybrid) - 9 males. *Chionoecetes bairdi* - 2 females. *Chionoecetes opilio* - 100 females and 195 males. Yellow snail eggs - 34 g.
94	G5	*Chionoecetes bairdi* - 4 males. *Chionoecetes* (hybrid) - 36 males and 12 females. *Chionoecetes opilio* - 679 males and 431 females. Snail eggs - 27.058 Kg. Comments are based on 100% of sample.
95	H5	Snail eggs - 2.118 Kg. *Chionoecetes opilio* - 234 males and 416 females. *Chionoecetes* (hybrid) - 9 males.
96	I5	Snail eggs - 1.315 Kg. *Chionoecetes opilio* - 376 males and 10 females. *Chionoecetes* (hybrid) - 17 males.
97	I6	Catch not enumerated.
98	H6	*Chionoecetes bairdi* - 2 males and 1 female. *Chionoecetes opilio* - 131 males and 8 females. *Chionoecetes* (hybrid) - 1 male. Snail eggs - 3.835 Kg.
99	G6	Catch not enumerated.
100	FG6/7	Snail eggs - 2.104 Kg. *Chionoecetes opilio* - 355 males and 373 females. *Chionoecetes* (hybrid) - 26 males and 8 females. *Chionoecetes bairdi* - 30 males and 28 females. *Paralithodes camtschatica* - 1 male. Juvenile *Theragra chalcogramma* - 5.171 Kg.

APPENDIX TABLE I

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Tow Number	Station Name	Comments
101	D7	# comparative trawl 1. *Chionoecetes bairdi* - 89 males and 38 females. *Chionoecetes opilio* - 127 males and 154 females. *Chionoecetes* (hybrid) - 12 males and 12 females. *Paralithodes camtschatica* - 1 male. Snail eggs - 98 g.
102	D7	# comparative trawl 2. Comments are based on 100% of sample. Snail eggs - 497 g. *Paralithodes camtschatica* - 2 males and 1 female. *Chionoecetes bairdi* - 83 males and 27 females. *Chionoecetes opilio* - 98 males and 293 females. *Chionoecetes* (hybrid) - 9 males and 3 females.
103	D7	# comparative trawl 3(5). *Chionoecetes opilio* - 18 males and 65 females. *Chionoecetes bairdi* - 22 males and 23 females. *Chionoecetes* (hybrid) - 4 males. Yellow snail eggs - 165 g.
104	D7	# comparative trawl 4(6). 2 *Pagurus aleuticus* - gravid (black eggs). White snail eggs - 50 g. Yellow snail eggs - 43 g. *Chionoecetes opilio* - 46 males and 83 females. *Chionoecetes bairdi* - 23 males and 9 females. *Chionoecetes* (hybrid) - 9 males.
105	D7	# comparative trawl 5(8). Snail eggs - 283 g. (Based on 100% of sample.) *Chionoecetes bairdi* - 93 males and 56 females. *Chionoecetes opilio* - 88 males and 126 females. *Chionoecetes* (hybrid) - 10 males and 5 females. *Paralithodes camtschatica* - 54 males and 1 female.
106	D7	# comparative trawl 6(9). Snail eggs - 82 g. *Chionoecetes bairdi* - 53 males and 110 females. *Chionoecetes opilio* - 43 males and 25 females. *Chionoecetes* (hybrid) - 3 males and 5 females. *Paralithodes camtschatica* - 62 males and 5 females.

APPENDIX TABLE I

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Tow Number	Station Name	Comments
107	D7	# comparative trawl 7(10). Snail eggs - 33 g. *Chionoecetes bairdi* - 99 males and 34 females. *Chionoecetes opilio* - 152 males and 169 females. *Chionoecetes* (hybrid) - 6 males and 7 females. *Paralithodes camtschatica* - 13 males and 2 females.
108	D7	# comparative trawl 8(12). Snail eggs - 12 g. 2 *Pagurus capillatus* with parasitic barnacle. *Chionoecetes bairdi* - 61 males and 22 females. *Chionoecetes opilio* - 73 males and 91 females. *Chionoecetes* (hybrid) - 4 males and 12 females. *Paralithodes camtschatica* - 8 males and 1 female.
109	D7	Catch not enumerated.
110	A3	*Chionoecetes bairdi* - 30 males and 1 female. *Chionoecetes opilio* - 7 males and 1 female. *Chionoecetes* (hybrid) - 4 males and 1 female.
111	A3	Snail eggs - 102 g. *Chionoecetes bairdi* - 85 males and 78 females. *Chionoecetes opilio* - 1 male and 12 females. *Chionoecetes* (hybrid) - 14 males and 70 females.
112	A3	Trawl contents emptied on deck in the process of removing a sea lion, not sampled.
113	A3	Sex ratio based on 100% of sample. *Chionoecetes bairdi* - 56 males and 70 females. *Chionoecetes opilio* - 1 male and 2 females. *Chionoecetes* (hybrid) - 5 males and 47 females.
114	A3	*Chionoecetes bairdi* - 15 males and 62 females. *Chionoecetes opilio* - 1 male. *Chionoecetes* (hybrid) - 7 males and 6 females.

APPENDIX TABLE I

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Tow Number	Station Name	Comments
115	AB2/3	# comparative trawl 1. Pollutants - 1 piece plastic and 1 bottle. *Chionoecetes bairdi* - 142 males and 158 females. *Chionoecetes opilio* - 10 males and 3 females. *Chionoecetes* (hybrid) - 5 males and 34 females. *Paralithodes camtschatica* - 2 males. 1 crab pot caught in trawl.
116	AB2/3	# comparative trawl 2. Snail eggs - 8 g. Wood with ship worms present - 247 g. *Chionoecetes bairdi* - 32 males and 65 females. *Chionoecetes opilio* - 4 males and 3 females. *Chionoecetes* (hybrid) - 4 males and 35 females.
117	AB2/3	# comparative trawl 3. *Chionoecetes bairdi* - 51 males and 84 females. *Chionoecetes opilio* - 3 males. *Chionoecetes* (hybrid) - 2 males and 27 females. *Paralithodes camtschatica* - 1 male.
118	AB2/3	# comparative trawl 4. *Chionoecetes bairdi* - 35 males and 32 females. *Chionoecetes opilio* - 2 males. *Chionoecetes* (hybrid) - 4 males and 12 females. *Paralithodes camtschatica* - 2 males.
119	AB2/3	# comparative trawl 5. Sex ratio based on 100% of sample. *Chionoecetes bairdi* - 55 males and 63 females. *Chionoecetes opilio* - 6 males and 4 females. *Chionoecetes* (hybrid) - 8 males and 30 females. *Paralithodes camtschatica* - 2 males.
120	F3	*Chionoecetes bairdi* - 3 males and 2 females. *Chionoecetes opilio* - 39 males and 7 females. *Chionoecetes* (hybrid) - 12 males and 1 female.
121	G3	Snail eggs - 233 g. 3 *Leptasterias polaris ascervata* feeding on *Clinocardium* sp. *Chionoecetes bairdi* - 4 males. *Chionoecetes opilio* - 100 males and 206 females. *Chionoecetes* (hybrid) - 14 males and 27 females.

APPENDIX TABLE I

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Tow Number	Station Name	Comments
122	Z3	# comparative trawl 1. Snail eggs - 157 g.
123	Z3	# comparative trawl 2. *Argis ovifer* - 2 gravid females - eggs turquoise-green.
124	AZ2/3	Comments based on 100% of sample. *Chionoecetes bairdi* - 8 males and 5 females. *Chionoecetes* (hybrid) - 1 male and 6 females.
125	AZ3/4	*Chionoecetes bairdi* - 15 males and 34 females. *Chionoecetes opilio* - 4 males and 3 females. *Chionoecetes* (hybrid) - 2 males and 43 females.
126	AZ4/5	# comparative trawl 1. *Chionoecetes bairdi* - 337 males and 251 females. *Chionoecetes* (hybrid) - 8 males and 48 females.
127	AZ4/5	# comparative trawl 2. Snail eggs - 55 g. *Chionoecetes bairdi* - 35 males and 16 females. Comments based on 100% of sample.
128	AZ4/5	# comparative trawl 3. Pollutants - 1 plastic bag, 2" x 6' rubber belt, 1 aluminium beer can, miscellaneous plastics. Snail egg - 70 g. *Chionoecetes bairdi* - 64 males and 58 females. *Chionoecetes* (hybrid) - 2 males and 4 females. *Paralithodes camtschatica* - 1 male.
129	AZ4/5	# comparative trawl 4. Pollutants - plastic and polypropylene. *Chionoecetes bairdi* - 407 males and 118 females. *Chionoecetes opilio* - 1 male. *Chionoecetes* (hybrid) - 5 males and 1 female. *Paralithodes camtschatica* - 25 males.
130	AZ4/5	# comparative trawl 5. Snail eggs - 32 g. *Chionoecetes bairdi* - 304 males and 144 females. *Chionoecetes* (hybrid) - 1 male. *Paralithodes camtschatica* - 15 males.

APPENDIX TABLE I

CONTINUED

Tow Number	Station Name	Comments
131	Z5	# comparative trawl 3. Pollutants - plastic and cloth. *Chionoecetes bairdi* - 266 males and 337 females. *Chionoecetes opilio* - 1 male. *Chionoecetes* (hybrid) - 1 female. *Paralithodes camtschatica* - 41 males and 10 females.
132	Z5	# comparative trawl 2. Catch not enumerated. Trawl ripped.
133	Z5	# comparative trawl 1. *Chionoecetes bairdi* - 114 males and 7 females. *Chionoecetes opilio* - 1 male. *Paralithodes camtschatica* - 5 males and 18 females.
134	Z5	# comparative trawl 4. Sex ratio based on 100% of sample. *Chionoecetes bairdi* - 237 males and 114 females. *Chionoecetes opilio* - 11 males. *Chionoecetes* (hybrid) - 3 males and 4 females. *Paralithodes camtschatica* - 4 males.
135	D6	*Chionoecetes bairdi* - 39 males and 169 females. *Chionoecetes opilio* - 71 males and 408 females. *Chionoecetes* (hybrid) - 33 females. *Paralithodes camtschatica* - 6 males and 5 females. 1 *Pagurus capillatus* with parasitic barnacle on abdomen.
136	DE6/7	Comments based on 100% of sample. *Chionoecetes bairdi* - 124 males and 36 females. *Chionoecetes opilio* - 410 males and 66 females. *Chionoecetes* (hybrid) - 59 males. *Paralithodes camtschatica* - 36 males. Snail eggs - 257 g.
137	E6	Snail eggs - 209 g. *Chionoecetes bairdi* - 60 males and 13 females. *Chionoecetes opilio* - 381 males and 541 females. *Chionoecetes* (hybrid) - 6 males and 6 females. *Paralithodes camtschatica* - 21 males. Juvenile *Theragra chalcogramma* - 23.042 Kg.

APPENDIX TABLE I

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Tow Number	Station Name	Comments
138	EF5/6	Snail eggs - 3.567 Kg. *Natica clausa* attached under the operculum of *Neptunea lyrata*. *Chionoecetes bairdi* - 7 males and 18 females. *Chionoecetes* (hybrid) - 23 males and 40 females. *Chionoecetes opilio* - 488 males and 1014 females. Juvenile *Theragra chalcogramma* 10.886 Kg.
139	F6	Catch not enumerated.
140	G7	*Chionoecetes bairdi* - 68 males and 94 females. *Chionoecetes opilio* - 894 males and 743 females. *Chionoecetes* (hybrid) - 8 females. Snail eggs - 714 g.
141	G8	Snail eggs - 726 g. *Chionoecetes bairdi* - 57 males and 81 females. *Chionoecetes opilio* - 570 males and 29 females. *Chionoecetes* (hybrid) - 24 males.
142	GH8/9	Pollutants - tin cans. Snail eggs - 7.625 Kg. *Chionoecetes bairdi* - 21 males and 21 females. *Chionoecetes opilio* - 97 males and 4 females. *Chionoecetes* (hybrid) - 8 males.
143	G9	Comments based on 100% of sample. Snail eggs - 7.262 Kg. *Chionoecetes bairdi* - 105 males and 149 females. *Chionoecetes opilio* - 136 males. *Chionoecetes* (hybrid) - 12 males and 2 females. *Paralithodes camtschatica* - 5 males.
144	FG9/10	Comments based on 100% of sample. Snail eggs - 87 g. *Chionoecetes bairdi* - 270 males and 213 females. *Chionoecetes opilio* - 152 males. *Paralithodes camtschatica* - 2091 males.
145	F10	Comments based on 100% of sample. *Chionoecetes bairdi* - 75 males and 54 females. *Chionoecetes opilio* - 17 males and 6 females. *Paralithodes camtschatica* - 13 males and 4 females. Juvenile *Theragra chalcogramma* - 53.842 Kg.

APPENDIX TABLE I

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Tow Number	Station Name	Comments
146	EF11/10	Comments based on 100% of sample. *Chionoecetes bairdi* - 98 males and 177 females. *Chionoecetes opilio* - 12 males and 5 females. *Paralithodes camtschatica* - 329 males and 449 females. Juvenile *Theragra chalcogramma* - 46.8069 Kg.
147	AZ5/6	*Chionoecetes bairdi* - 35 males and 70 females. *Chionoecetes opilio* - 2 males. *Paralithodes camtschatica* - 3 males and 1 female.
148	A5	Snail eggs - 96 g. *Chionoecetes bairdi* - 151 males and 7 females. *Chionoecetes opilio* - 1 male. *Paralithodes camtschatica* - 27 males and 80 females.
149	BA4/5	Comments based on 100% of sample. Snail eggs - 33 g. *Chionoecetes bairdi* - 61 males and 69 females. *Chionoecetes opilio* - 3 males. *Chionoecetes* (hybrid) - 2 males. *Paralithodes camtschatica* - 14 males and 13 females.
150	B4	Snail eggs - 15 g. Pollutants - plastic, rope and gloves. *Chionoecetes bairdi* - 32 males and 5 females. *Chionoecetes opilio* - 3 males. *Chionoecetes* (hybrid) - 1 male and 1 female. *Paralithodes camtschatica* - 6 males.
151	AB3/4	*Chionoecetes bairdi* - 146 males and 194 females. *Chionoecetes opilio* - 3 males and 4 females. *Chionoecetes* (hybrid) - 8 males and 54 females. *Paralithodes camtschatica* - 1 male.
152	Z4	# comparative trawl 1. Comments based on 100% of sample. Several thousand Ophiuridae, *Ctenodiscus crispatus* and *Ceramaster patagonicus* in trawl wings-irretrievable. *Chionoecetes bairdi* - 20 males and 15 females. *Chionoecetes opilio* - 5 females. *Chionoecetes* (hybrid) - 15 females.

APPENDIX TABLE I

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Tow Number	Station Name	Comments
153	Z4	# comparative trawl 2. *Chionoecetes bairdi* - 18 males and 14 females. *Chionoecetes* (hybrid) - 1 female. *Chionoecetes opilio* - 4 females. Pollutants - glass, rope and plastic.
154	H3	*Pandalus goniurus*, 1 gravid female with aqua colored eggs. *Chionoecetes bairdi* 1 male. *Chionoecetes opilio* - 731 males and 186 females. *Chionoecetes* (hybrid) - 30 males and 15 females. Snail eggs - 1.81 Kg. *Balanus* sp., *Styela macrenteron*, bryozoan and snail eggs attached to *Neptunea* shell.
155	G4	*Pandalus borealis*, 1 gravid with aqua colored eggs. *Chionoecetes bairdi* - 1 male. *Chionoecetes opilio* - 646 males and 1469 females. *Chionoecetes* (hybrid) - 38 males and 64 females. Snail eggs - 454 g. Empty shells - 26.300 Kg.
156	F4	Calculated for 100% of sample. *Chionoecetes opilio* - 1282 males and 1918 females. *Chionoecetes* (hybrid) - 50 males and 143 females. Empty shells - 82.6 Kg. Snail eggs - 7.6 Kg.
157	F5	*Chionoecetes bairdi* - 6 males and 14 females. *Chionoecetes opilio* - 549 males and 633 females. *Chionoecetes* (hybrid) - 25 males and 47 females. Empty shells - 22.8 Kg.
158	I7	Calculated to 100% of sample. *Chionoecetes opilio* - 108 males and 80 females. *Chionoecetes bairdi* - 16 males and 20 females. *Chionoecetes* (hybrid) - 8 males and 12 females. *Hyas coarctatus alutaceus* - 40 males and 124 females. Empty shells - 34.7 Kg. *Balanus* sp., *Styela macrenteron, Musculus* sp., bryozoan, and *Hiatella arctica* attached to *Neptunea* shells.

APPENDIX TABLE I

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Tow Number	Station Name	Comments
159	H7	Empty shell 103.7 Kg. *Chionoecetes opilio* - 162 males and 1 female. *Chionoecetes bairdi* - 3 males and 4 females. *Chionoecetes* (hybrid) - 28 males.
160	H8	*Chionoecetes opilio* - not sexed. *Chionoecetes bairdi* - 9 males and 9 females. *Chionoecetes* (hybrid) - 1 female. Empty shell - 26.7 Kg.
161	H9	Calculated to 100% of sample. *Chionoecetes bairdi* - 799 males and 43 females. *Chionoecetes opilio* - 6 males. *Chionoecetes* (hybrid) - 2 males.
162	IH9/10	Calculated to 100% of sample. *Chionoecetes bairdi* - 27 males. *Chionoecetes* (hybrid) - 7 males. Snail eggs, orange eyed eggs, and *Balanus* sp. attached to *Neptunea* shells.
163	I12	*Hyas coarctatus alutaceus* with *Mytilus edulis* attached to carapace. Empty shell - 1.1 Kg. *Hyas coarctatus alutaceus* - 6 males. *Chionoecetes bairdi* - 4 males. *Paralithodes camtschatica* - 29 males and 15 females.
164	IJ12/13	*Paralithodes camtschatica* - 10 males and 9 females. *Hyas coarctatus alutaceus* - 17 males and 5 females. *Chionoecetes bairdi* - 1 male. Type 16 sea anemone, *Balanus* sp., snail eggs and *Boltenia ovifera* attached to *Neptunea* shell.
165	J13	*Hyas coarctatus alutaceus* - 1 male. *Paralithodes camtschatica* - 4 males and 7 females. Juvenile *Theragra chalcogramma* weight - 3.628 Kg.
166	JK13/14	*Paralithodes camtschatica* - 6 females *Pandalus goniurus* - 80 gravid, eggs aqua colored.
168	K13	Trawl ripped, specimens were not enumerated.

APPENDIX TABLE I

CONTINUED

Tow Number	Station Name	Comments
169	JK12/13	Empty shells - 5.79 Kg. Snail eggs - 454 g. *Paralithodes camtschatica* - 1 male and 4 females. *Telmessus cheiragonus* - 2 males.
170	J12	*Styela macrenteron, Boltenia ovifera* and *Mytilus edulis* attached to *Neptunea* shells. Juvenile *Theragra chalcogramma* weight - 2.812 Kg. *Paralithodes camtschatica* - 1 male and 4 females.
171	IJ11/12	Type 16 sea anemone, *Styela macrenteron, Balanus* sp., *Boltenia ovifera*, and bryozoan attached to *Neptunea* shell. *Spisula* and *Serripes* shell fragments also present. *Paralithodes camtschatica* - 2 males.
172	J11	*Balanus rostratus*, type 7 and 16 sea anemone, *Boltenia ovifera, Styela macrenteron* and sponge attached to *Neptunea* shell. Sponge was also attached to the stipe of *Boltenia*. *Hyas lyratus* - 16 males and 4 females. *Hyas coarctatus alutaceus* - 16 males and 4 females. *Pandalus goniurus* - 330 gravid, eggs aqua colored. *Argis dentata* - 4 gravid, eggs aqua colored. *Chionoecetes bairdi* - 4 males. *Paralithodes camtschatica* - 1 male and 1 female. Juvenile *Theragra chalcogramma* weight - 42.048 Kg.
173	JK11/12	*Paralithodes camtschatica* - 8 males and and 7 females, 6 gravid with eggs black colored. *Pandalus goniurus* - 20 gravid, eggs aqua colored. Snail eggs present.
174	K12	*Balanus* sp. and type 19 sea anemone attached to *Mytilus edulis*. *Telmessus cheiragonus* - 7 males and 1 female. *Paralithodes camtschatica* - 1 female.
175	J10	*Chionoecetes bairdi* - 7 males and 2 females. *Telmessus cheiragonus* - 39 males and 3 females, 1 gravid with dark brown eggs. *Paralithodes camtschatica* - 8 males and 7 females. 1 *Pagurus capillatus* parasitized by a parasitic barnacle.

APPENDIX TABLE I

CONTINUED

Tow Number	Station Name	Comments
176	JK10/11	Snail eggs - .907 g. *Balanus* sp. attached to *Neptunea* shells. *Paralithodes camtschatica* - 13 females and 11 males, 12 gravid with brown eggs. *Telmessus cheiragonus* - 3 males. *Chionoecetes bairdi* - 1 female, gravid with orange eggs.
177	K11	Trawl ripped extensively, specimens were not enumerated.
178	K11	Trawl ripped extensively, a few interesting specimens collected, otherwise none were enumerated.
179	K10	*Telmessus cheiragonus* - 10 males and 4 females. *Paralithodes camtschatica* - 4 males and 4 females. *Hyas lyratus* - 4 males. *Balanus* sp. attached to *Neptunea* shells.
180	K9	*Balanus* sp. attached to *Neptunea* shells. *Paralithodes camtschatica* - 7 males. *Telmessus cheiragonus* - 3 males. *Hyas coarctatus alutaceus* - 2 males and 1 female.
184	L6	*Telmessus cheiragonus* - 2 males. Snail eggs - 1.31 Kg.
185	L5	*Paralithodes camtschatica* - 1 male.
187	Q11	*Balanus* sp. attached to *Neptunea* shells.
188	L2	*Erimacrus isenbeckii* - 4 males and 1 female. *Hyas lyratus* - 4 males. Juvenile *Theragra chalcogramma* weight - 33.240 Kg.
189	K2	Calculated to 100% of sample. *Chionoecetes* (hybrid) - 12 males. *Chionoecetes opilio* - 182 males. *Hyas lyratus* - 124 males and 41 females. *Styela macrenteron, Balanus* sp. and *Musculus discors* attached to *Neptunea* shells.
190	J2	Empty shells - 73.7 Kg.

APPENDIX TABLE I

CONTINUED

Tow Number	Station Name	Comments
191	L3	*Paralithodes camtschatica* - 1 female. *Chionoecetes opilio* - 120 males and 26 females. *Balanus* sp., *Musculus discors*, *Styela macrenteron*, snail eggs bryozoan and compd. tunicate attached to *Neptunea* shells. Empty shells - 8.7 Kg. Juvenile *Theragra chalcogramma* weight - 952 g.
192	K3	Bryozoan, *Tecticeps alascensis*, *Musculus discors*, compd. tunicate, *Balanus* sp., *Crepidula grandis*, and *Velutina lanigera* attached to *Neptunea* shells. Empty shell - 25.8 Kg. Juvenile *Theragra chalcogramma* weight - 31.752 Kg. *Hyas coarctatus alutaceus* - 65 males and 7 females.
193	J3	Empty shell - 79.6 Kg. *Chionoecetes opilio* - 476 males and 34 females. *Chionoecetes* (hybrid) - 18 males and 10 females.
194	J4	Juvenile *Theragra chalcogramma* weight - 14.379 Kg.
195	K4	*Chionoecetes opilio* - 157 males. *Chionoecetes bairdi* - 1 male. *Chionoecetes* (hybrid) - 27 males and 2 females. *Erimacrus isenbeckii* - 4 males and 1 female. Juvenile *Theragra chalcogramma* weight - 7.076 Kg.
196	J5	*Argis dentata* - 10 gravid, eggs aqua colored.
197	K5	*Balanus* sp., hydrozoan, snail eggs, *Crepidula grandis*, *Styela macrenteron*, *Musculus discors* attached to *Neptunea* shell. *Leptasterias* sp. in aperture of *Neptunea*. Juvenile *Theragra chalcogramma* weight - 14.515 Kg. *Hyas coarctatus alutaceus* - 18 males and 2 females. *Chionoecetes bairdi* - 1 male.
198	K6	*Balanus* sp., snail eggs, type 10 and 16 sea anemone, *Styela macrenteron*, *Musculus discors*, *Velutina lanigera* and *Synidotea bicuspida* attached to *Neptunea* shell. Scale worms found in aperture of *Neptunea*. *Hyas coarctatus alutaceus* - 22 males and 2 females. Empty shell - 7.4 Kg. Parasitic barnacle on abdomen of *Pagurus capillatus*.

APPENDIX TABLE I

CONTINUED

Tow Number	Station Name	Comments
199	K7	Empty shells - 16.7 Kg. *Balanus* sp., type 16 sea anemone, and snail attached to *Neptunea* shell. *Argis dentata* 1 gravid, eggs aqua colored. *Paralithodes camtschatica* - 1 female. *Hyas coarctatus alutaceus* - 15 females.
200	K8	Empty shells - 5.4 Kg. Snail eggs - .22 g. *Balanus* sp., snail eggs and type 16 sea anemone attached to *Neptunea* shells. *Hyas coarctatus alutaceus* - 3 males. *Paralithodes camtschatica* - 1 gravid, eggs colored purple.
201	J6	*Argis dentata* - 3 gravid, eggs aqua colored. *Hyas coarctatus alutaceus* - 25 males and 2 females. *Paralithodes camtschatica* - 1 male. *Balanus* sp., snail eggs, *Styela macrenteron*, and *Musculus discors* attached to *Neptunea* shell.
202	J7	*Hyas coarctatus alutaceus* - 20 males and 1 female. *Balanus* sp., snail eggs, and bryozoan attached to *Neptunea* shells.
203	J8	*Balanus* sp., snail eggs, and *Styela macrenteron* attached to *Neptunea* shells. Empty shells - 6.2 Kg.
204	J9	*Hyas coarctatus alutaceus* - 3 males. *Chionoecetes bairdi* - 1 male and 1 female. *Paralithodes camtschatica* - 9 males and 7 females. Empty shells - 9.4 Kg.
205	I9	*Paralithodes camtschatica* - 13 males and 3 females. 277.6 Kg of peat.
206	I8	*Paralithodes camtschatica* - 5 males. *Hyas coarctatus alutaceus* - 13 males and 1 female. *Chionoecetes bairdi* - 4 males and 1 female.
207	DE11/12	*Paralithodes camtschatica* - 7 females. *Chionoecetes* - 4 males and 1 female.

APPENDIX TABLE I

CONTINUED

Tow Number	Station Name	Comments
208	E12	Calculated to 100% of sample. *Paralithodes camtschatica* - 6 males and 167 females. *Erimacrus isenbeckii* - 6 males and 3 females. *Chionoecetes bairdi* - 9 males and 3 females.
209	G12	*Erimacrus isenbeckii* - 4 males. *Paralithodes camtschatica* - 57 males and 34 females. *Chionoecetes bairdi* - 14 males and 8 females.
210	GH12/13	*Paralithodes camtschatica* - 14 males and 28 females. *Balanus* sp., *Styela macrenteron* and *Boltenia ovifera* attached to *Neptunea* shells. Juvenile *Theragra chalcogramma* weight - 16.057 Kg.
211	G13	*Paralithodes camtschatica* - 6 males and 63 females. *Chionoecetes bairdi* - 17 males and 2 females.
213	E13	Sponge attached to kelp holdfast, both containing Polychaeta worms, *Hiatella arctica*, assorted brittle stars, *Musculus discors*, nemerteans, *Balanus rostratus*, juvenile *Paralithodes camtschatica*, *Hyas coarctatus alutaceus*, and *Oregonia gracilis*. *Balanus rostratus* was also attached to volcanic rock (basalt). The above species were also present in vacant *Balanus rostratus* shells. *Pododesmus macrochisma* apparently settled in the upper portion of a *Neptunea* shell occupied by *Pagurus kennerlyi*.
214	F14	Trawl ripped, no specimens enumerated.
215	G14	*Chionoecetes bairdi* - 2 females. *Hyas lyratus* - 1 male. *Hyas coarctatus alutaceus* - 2 females. *Paralithodes camtschatica* - 6 females, gravid - 2 purple-brown, 4 brown colored eggs. Approx. 266.8 Kg. of *Boltenia ovifera* on trawl warps and dandy lines. Juvenile *Theragra chalcogramma* weight - 3.674 Kg.

APPENDIX TABLE I

CONTINUED

Tow Number	Station Name	Comments
216	G15	Empty shells - 8.4 Kg. *Paralithodes camtschatica* - 3 males and 54 females. *Chionoecetes bairdi* - 3 males and 6 females. Hydrozoan attached to *Boltenia ovifera*. *Balanus* sp. attached to *Neptunea ventricosa*.
217	GH11/12	Rip in trawl. *Chionoecetes bairdi* - 3 males and 2 females. *Paralithodes camtschatica* - 35 males and 18 females. *Mytilus edulis* attached to *Paralithodes camtschatica* between carapace and telson. Juvenile *Theragra chalcogramma* weight - 7.4 Kg.
218	G10	*Chionoecetes bairdi* - not sexed.
219	F9	*Chionoecetes bairdi* - 73 males and 39 females. *Chionoecetes opilio* - 8 males. *Chionoecetes* (hybrid) - 35 males and 3 females.

APPENDIX TABLE II

SUMMARIZATION OF GENERAL COMMENTS, MISCELLANEOUS BIOLOGICAL INFORMATION, REPRODUCTIVE AND FEEDING DATA, AND POLLUTANTS COLLECTED ON LEGS I-III OF THE NOAA SHIP *MILLER FREEMAN* S.E. BERING SEA CRUISE - 1976

Tow Number	Station Name	Comments
1	Z5	Pollutants: Blue strapping material, nylon line approx. 1.0 m, and pieces of wire. *Paralithodes camtschatica*: 85 males, 170.4 kg; 2 females, 1.40 kg. *Chionoecetes bairdi*: 18 males, 6.08 kg; 16 females, .907 kg. *Erimacrus isenbeckii:* 12 males.
2	Z5	*Paralithodes camtschatica*: 21 males, 46.3 kg. *Chionoecetes bairdi*: 1 male. *Erimacrus isenbeckii*: 3 males.
3	Z5	Pollutants: 1 Canada Dry tonic water bottle. *Paralithodes camtschatica*: 3 males, 8.35 kg; 3 females 2.36 kg. *Chionoecetes bairdi*: 1 female, 0.045 kg; 4 males, 2.95 kg.
4	Z4	Encrusting sponges weighed with rock attached. Pollock: 6244 kg. *Chionoecetes bairdi*: 7 males, 0.64 kg; 14 females, 0.74 kg.
5	Z4	Pollutants: 1-5 x 25 cm plastic bag, rope, nylon line. Pollock: 6472 kg. *Chionoecetes bairdi*: 8 males, 1.11 kg; 8 females, 0.61 kg. Z04-3 & Z04-4 haul numbers 45 and 47.
8	B7	Pollutants: 1 plastic bag. *Paralithodes camtschatica*: 9 males. *Erimacrus isenbeckii*: 14 males. *Chionoecetes bairdi*: 6 males, 2.49 kg; 3 females, 0.817 kg.
10	B8	*Laminaria* sp.: 0.907 kg. Two *Pagurus capillatus* with parasitic barnacle on abdomen, three with polynoidae and sponge in shell, 20 gravid females with black eggs.
12	Z2	Pollutants: 1-25 cm diameter metal bowl.
13	Z2	Pollutants: 1 rubber glove, 1 sock, 20 cm of line, 2 glass containers. *Chionoecetes bairdi*: 13 males and 70 females. *C. opilio*: 1 male and 14 females. *Chionoecetes* (hybrid): 3 males and 1 female.

APPENDIX TABLE II

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Tow Number	Station Name	Comments
14	Z2	*Chionoecetes bairdi*: 3 males and 69 females. *C. opilio*: 1 male.
15	ZA2/3	Pollutants: 1 glove, 1-4.2 ℓ paint can. *Chionoecetes bairdi*: 14 males and 7 females. *C. opilio*: 1 male.
16	A3	*Chionoecetes bairdi*: 30 males and 4 females. *C. opilio*: 13 males. *C.* (hybrid): 3 males.
17	AB3/4	Pollutants: 0.454 g cotton webbing.
19	BC4/5	*Carcinobdella* sp. noted on ventral side of *Myoxocephalus* sp. and *Gadus macrocephalus*.
20	C5	Pollutants: 1 glass float. Yellowfin sole: 3190 kg.
24	DE3/4	Pollutants: 50 g plastic with leech egg cases attached. Juvenile pollock: 726 g.
28	BC1/2	Pollutants: 15 cm braided rope.
29	B1	Pollock weight 2452 kg.
30	AB18/1	Pollutants: 1 tin can.
31	AB18/1	Pollutants: 1 soda can, 1-1.5 ℓ glass bottle.
32	AB18/1	Pollutants: 1-20 ℓ glass jar, green plastic fragments.
33	AB18/1	Pollutants: 1 Asahi beer can.
35	C19	Pollutants: 1 tin can, 1 graduated sea water cylinder, 1-10 ℓ glass bottom (brown).
36	C19	Pollutants: 10 tin cans and soda cans.
37	C19	Pollutants: Piece of wire, 1 soda can.
38	C19	Pollutants: 1 bundle of wood stakes.
39	C19	Pollutants: 2 glass bottles - 1 ℓ and 1.5 ℓ.

APPENDIX TABLE II

CONTINUED

Tow Number	Station Name	Comments
41	D18	Pollutant: Metal fragment
42	DC18/1	Pollutants: 1 piece of plastic. Brittle stars, leechs, worms, snails noted in empty barnacle shells, worms also attached to outer surface. Juvenile pollock: 10.033 kg.
43	EF19/18	Juvenile pollock: 62 kg.
46	Z4	1 parasitized *Pandalus borealis*.
47	Z4	Pollock weight 8165 kg.
49	A5	Juvenile pollock: 0.050 kg.
50	AB5/6	Juvenile pollock: 2.59 kg.
51	B6	Neptunea shells covered with *Balanus* sp. 3 polynoidae in 3 *Pagurus capillatus* shells. Pollutants: 1 old crab pot. Rock sole: 3124 kg.
52	BC6/7	Two *Pagurus capillatus* parasitized by barnacle. Rock sole: 3748 kg. Juvenile pollock: 9.23 kg.
53	BC6/7	Non-standard tow. Invertebrates not enumerated.
54	C7	Trawl could not withstand the approximately 13,620 kg load of fish. Cod end of net broke. Station to be retrawled.
55	C7	Pollutants: 1-1800 ml glass bottle. Trawl could not withstand fish load, cod end broke. Approx. 22,700 kg.
56	D8	27 out of 66 *Pagurus capillatus* with polynoidae present within shell, 9 with parasitic barnacle attached to abdomen.
58	EF23/24	1st trawl of Leg II. Pollutants: 1 piece green twine, 46 cm.

APPENDIX TABLE II

CONTINUED

Tow Number	Station Name	Comments
60	E22	Many basket stars, sea pens from trawl wings (2 bushels). Pollutants: 33 m rope, several glass balls, 2 anchors.
61	EF21/22	Pollutants: 1 can mandarin oranges with Japanese writing on label.
65	DE20/21	Pollutants: 13 cm string, remains of 1 tin can (12 g). Dead and decaying fish more abundant than usual (approx. 10-15 found in this tow).
67	E20	Haul 66 - net set upside down. No catch records. Second set haul 67 successful. Pollutants: 30.4 x 15.2 x 1 cm piece of wood. Juvenile pollock 6.35 kg.
68	EF19/20	Pollutants: 1 piece of wood, similar to last trawl (30.4 x 15.2 x 1 cm).
70	G20	Amphipods numerous on mammal carcass (decomposed to bone, vertebrae and skull held together.)
71	FG21/20	Hermit crabs weighed with shells.
72	G19	Juvenile pollock 10.4 kg.
73	FG19/18	Pollutants: 1 piece of string 15.2 cm long. Juvenile pollock: 11.8 kg.
74	FG19/20	Juvenile pollock: 16.8 kg.
75	F20	Pollutants: several large pieces of string.
77	D22	Large numbers of basket stars on lead lines to trawl (estimated 227 kg). 34 minute trawl due to winch problem delaying retrieval.
79	EF24/25	Pollutants: cardboard with Japanese writing (60 x 60 cm).
81	FG24/23	Juvenile pollock: 60.8 kg.

APPENDIX TABLE II

CONTINUED

Tow Number	Station Name	Comments
82	G23	Juvenile pollock: 27.2 kg.
84	H25	Juvenile pollock: 15.4 kg.
85	GH25/26	Juvenile pollock: 70 kg.
86	FG27/26	Pollutants: 2 tin cans and 1 glove.
87	FG27/26	Pollutants: 1 pop bottle with Japanese labelling.
92	I27	Net snagged 3 minutes before 1/2 hour.
93	I27	Net torn, bad bottom.
94	I27	Net torn, bad bottom.
95	KL28/27	Pollutants: 1-10 oz. tomato juice can. Distance fished set equal to average distance fished for 11 randomly selected stations.
96	KL28/27	Pollutants: 1 Japanese coke can.
100	I24	Pollutants: Cotton cloth - no markings - 33 g.
101	F20	Distance fished set equal to average distance fished for 11 randomly selected stations.
102	MB13	First station of Leg III. Times are GMT. *Chionoecetes bairdi*: 240 females; 329 males. Few *Chionoecetes* with leech egg cases on the carapace. *Paralithodes camtschatica*: 94 males; 194 females. *Pagurus capillatus*: 80 males; 36 females. Three with eggs. *P. confragosus*: 58 males; 36 females. *P. aleuticus*: 38 males; 47 females. Polynoidae from Paguridae. Feeding data: *Paralithodes camtschatica*: 7 stomachs, feeding on brittle stars and snails. *Gadus macrocephalus*: 5 stomachs, feeding on crabs and fish. *Hippoglossoides*: 4 stomachs, empty. *Lepidopsetta lineata*: 1 stomach, empty. *Myoxocephalus*: 5 stomachs, empty.

APPENDIX TABLE II

CONTINUED

Tow Number	Station Name	Comments
102 (cont'd)	MB13	*Pleuronectes quadrituberculatus*: 3 stomachs, feeding on polychaetes and amphipods. *Glyptocephalus zachirus*: 3 stomachs, feeding on amphipods and polychaetes. *Raja stellulata*: 1 stomach, feeding on amphipods and crangonids.
104	MB4	*Hyas coarctatus alutaceus*: 15 males; 2 females, one with brown-orange eggs. *Pandalus goniurus*: 3 with eggs. *Oregonia gracilis*: 10 females, one with dark orange eggs. *Crangon dalli*: 9 with light blue eggs. Polynoidae: 2 with *Pagurus ochotensis* one with *P. capillatus*. *P. ochotensis*: 2 with blue-black eggs. *Sclerocrangon boreas*: 2 with olive eggs, leech cases on the pleopods. *Paralithodes camtschatica*: 2 females; 1 male. *Chionoecetes bairdi*: 1 female; 5 males. *Boltenia ovifera*: Digestive system dark green, hundreds were caught on the outside of the cod end. *Evasterias echinosoma* (humped up, stomach out) feeding on *Boltenia ovifera*. Juvenile *Gadus macrocephalus*: 0.454 kg.
105	MB9	*Hyas coarctatus alutaceus*: 50 males; 9 females, 4 with orange eggs, 2 with brown eggs. *Pagurus ochotensis*: 16 with black eggs. *Paralithodes camtschatica*: 2 males; 2 females. Feeding data: *Asterias amurensis*: 19 stomachs, feeding on *Pandalus goniurus*, clams, and sponge.
106	MB25	*Hyas coarctatus alutaceus*: 82 males; 28 females with bright orange eggs. *Crangon dalli*: 84 with light blue eggs.
107	MB22	*Paralithodes camtschatica*: 13 males; 16 females, 8 with egg color from bright orange to deep purple. *Pagurus ochotensis* with black eggs. *Hyas coarctatus alutaceus*: 3 males; 6 females with light blue eggs. Juvenile *Theragra chalcogramma*: 0.045 g. Juvenile *Gadus macrocephalus*: 0.045 g. Juvenile *Limanda aspera*: 21.24 kg. Feeding Data: *Asterias amurensis*: 4 stomachs,

APPENDIX TABLE II

CONTINUED

Tow Number	Station Name	Comments
107 (cont'd)	MB22	feeding on sand dollars and mysids. *Paralithodes camtschatica*: 6 stomachs, feeding on snails and crustaceans.
108	MB10	*Paralithodes camtschatica*: 113 females; 181 males. *Chionoecetes bairdi*: 65 females; 12 males. *Hyas coarctatus alutaceus*: 1 female with orange eggs. *Pagurus trigonocheirus*: 1 female with eggs. Juvenile *Theragra chalcogramma*: 0.18 g. Feeding Data: *Paralithodes camtschatica*: 13 stomachs, feeding on *Macoma* and *Cardita (=Cyclocardia)*.
109	MB19	Polynoidae in *Pagurus trigonocheirus* shell. Pollutants: 1 piece plastic (Japanese or Korean) with growth on it. 1 piece red rubber glove (small) with Bryozoa growth. *Pagurus trigonocheirus*: 6 females with brown eggs. *Hyas coarctatus alutaceus*: 9 females with orange eggs. *Labidochirus splendescens*: 6 females with brown eggs. *Chionoecetes bairdi*: 180 females; 150 males. *C. opilio*: 1083 females; 186 males. *Kronborgia* egg case. Juvenile *Theragra chalcogramma*: 3.17 kg. Feeding data: *Paralithodes camtschatica*: 7 stomachs, feeding on *Cyclocardia* and crustaceans.
110	MB16	*Chionoecetes bairdi*: 44 males; 43 females. *C.* (hybrid): 22 males; 58 females. Pollutant: 1 piece of fishing net and trash. Feeding data: *Gadus macrocephalus*: 16 stomachs, feeding on *Pandalus borealis* and fish. *Hippoglossus stenolepis*: 3 stomachs, feeding on fish.
111	MB55	*Pagurus trigonocheirus*: 3 with black eggs. Pollutant: 1 small piece of rope. No observable items in stomach of *Gorgonocephalus caryi*, orange gonads well developed. Nearly all Paguridae shells with polynoidae in apex of shell. *Paralithodes platypus*: 1 male; 1 female, male soft shell with empty stomach. *Chionoecetes bairdi*: 20 males; 17 females. *C. opilio*: 69 females; 15 males. *C.* (hybrid): 1 male; 9 females.

APPENDIX TABLE II

CONTINUED

Tow Number	Station Name	Comments
112	MB69	Two bopyroid isopods under carapace of *Pandalus borealis*, males small. *Argis dentata*: 2 with bright green eggs. Polynoidae in all Paguridae shells. *Chionoecetes* (hybrid): 4 meals. *C. opilio*: 1 male; 1 female. *C. bairdi*: 127 males; 20 females. Feeding data: *Chionoecetes opilio*: 23 stomachs, feeding on Ophiuroids and Polychaetes. *Gadus macrocephalus*: 3 stomachs, feeding on fish and crustaceans.
113	MB-86B	Pollutants: 1 large wine bottle, 1 piece rubber mat. *Chionoecetes opilio*: 31 males, half soft shell. *C. bairdi*: 5 males, soft shell. *C.* (hybrid): 60 males, 3 soft shell. *Pagurus trigonocheirus*: 3 with brown eggs. Empty *Panomya arctica* shells: 90, 42.2 lbs. Feeding data: Liparid: 1 stomach, feeding on fish and crustaceans. *Gadus macrocephalus*: 6 stomachs, feeding on pollock. *Hemilepidotus papilio*: 9 stomachs, feeding on Polychaetes and amphipods.
114	MB46	Empty *Panomya arctica* shells. *Leptasterias* sp.: 2 with orange eggs, all humped up in brooding position. *Hyas coarctatus alutaceus*: 23 males; 3 females with black eggs. *Chionoecetes opilio*: 466 females; 64 males. *C. bairdi*: 1 female. Polynoidae present in paguridae shells. *Kronborgia* egg cases. Masses of *Volutopsius* egg cases. *Polinices pallida* egg cases also present. Juvenile *Reinhardtius hippoglossoides*: 3.85 kg. Juvenile *Theragra chalcogramma*: 0.045 g. Juvenile *Gadus macrocephalus*: 0.045 g. Feeding data: *Platichthys stellatus*: 1 stomach, empty. *Limanda aspera*: 4 stomachs, empty. *Pleuronectes quadrituberculatus*: 3 stomachs, empty.
115	MB37	Most *Chionoecetes* in soft shell condition. Pollutants: Piece of netting. *Hyas coarctatus alutaceus*: 23 males; 5 females. *Erimacrus isenbeckii*: 2 males. *Pagurus trigonocheirus*: 316 males; 2 females with

APPENDIX TABLE II

CONTINUED

Tow Number	Station Name	Comments
115 (cont'd)	MB37	dark blue eggs. Polychaeta (tube worm) in Paguridae shells. *Chionoecetes opilio*: 72 females; 584 males. Juvenile *Gadus macrocephalus*: 0.136 g. Juvenile *Theragra chalcogramma*: 0.045 g. Feeding data: *Asterias amurensis*: 12 stomachs, feeding on Bryozoa. *Pteraster*: 1 stomach, feeding on a worm. *Myoxocephalus*: 3 stomachs, feeding on fish and crustaceans.
116	MB28	*Chionoecetes opilio*: 4326 males; 4815 females. *Pandalus goniurus*: 5 with eggs. Polychaete: Tube worm observed with Paguridae. *Hyas coarctatus alutaceus*: 5 males. *Kronborgia* egg cases. Feeding data: *Leptasterias polaris*: 13 stomachs, feeding on cockles. *Asterias amurensis*: 6 stomachs, feeding on cockles. *Myoxocephalus jaok*: 1 stomach, feeding on sculpins. *Myoxocephalus polyacanthocephalus*: 1 stomach, feeding on capelin and a snow crab. *Limanda aspera*: 10 stomachs, empty. *Pleuronectes quadri-tuberculatus*: 5 stomachs, empty. *Chionoecetes*: 1 stomach, miscellaneous soft parts.
117	MB-18A	*Pagurus capillatus*: 1 female, eggs brown; 10 males. *P. aleuticus*: 36 females, eggs brown; 40 males. *Paralithodes camtschatica*: 87 males; 2 females. *Chionoecetes opilio*: 139 males; 72 females. *C. bairdi*: 20 males; 12 females. *Hyas lyratus*: 1 female with purple-brown eggs. Juvenile Pacific cod: 0.090 kg. Juvenile pollock: 82.037 kg. Feeding data: *Paralithodes camtschatica*: 23 stomachs, feeding on cockles, brittle stars, *Solariella*, and Polychaetes. *Myoxocephalus*: 1 stomach, feeding on snow crabs.

ANNUAL REPORT

Contract No. 03-5-022-68, Task Order 5
Research Unit #6
Reporting Period: 1 April 1977-31 March 1978

The distribution, abundance, diversity and productivity of the western Beaufort Sea benthos.

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I. Summary of Objectives, Conclusions, and Implications with Respect to OCS Oil and Gas Development.

Extensive exploration and development for oil and gas on the Alaskan and Canadian continental shelf have the potential to significantly influence the marine environment of the Beaufort Sea. It is impossible with our present knowledge to accurately predict the consequences of petroleum development on the marine benthos.

The past and continuing goal of this project has been to acquire the knowledge of the ecology of benthic invertebrate faunas of the Beaufort Sea continental shelf necessary to evaluate the consequences of offshore oil and gas development. The distribution and abundance of the fauna has been examined in detail with studies of the spatial and temporal variability of these. These data will provide a baseline against which future changes in the benthic environment and community structure can be evaluated. Of current importance are: (1) the definition of temporal changes in sublittoral community structure, (2) the determination of the life histories and secondary production estimates of dominant and ecologically important species, (3) the description of the benthic food web, and (4) the study of the ecology of benthic invertebrates important as prey organisms to the marine mammals, birds, and fishes. Now that broad ecological patterns of benthic invertebrates on the Beaufort Sea shelf are becoming fairly well known, it is imperative to define the dynamic processes maintaining temporal and spatial structure.

II. Introduction

A. General nature and scope of the study.

The ecological studies of the shelf benthos include functional, process-oriented research that is built on a strong base of descriptive work on ecological patterns and their relationship to the environment. Seasonal changes in the numerical abundance and biomass of the large macro-infauna (>1.0 mm) are defined at stations across the continental shelf. The benthic food web and its relationship to bird, fish and mammalian predators are under investigation.

The species composition, distribution and abundance of the benthos are being defined in the southwestern Beaufort Sea. Species and station groupings are statistically analyzed and the relationships to the bottom environment explored. Dominant species are identified. These patterns provide an insight into the relative importance of various features of the environment in determining the distribution and abundance of the benthic invertebrate fauna.

B. Specific Objectives.

The specific objectives of the 1977/78 proposed research are listed in order of priority. The major emphasis will be on the delineation of the benthic food-web and description of the coastal benthos. Efforts to characterize the composition of the Beaufort Sea fauna to the species level will continue since this is a critical step toward understanding the dynamics of the benthic ecosystem.

a) Objective 1 - Beaufort Sea benthic foodweb analysis

1. The numerical density, biomass, and gross taxonomic composition of the the benthic macro-infauna at selected water column foodweb stations will be obtained.

2. The identification of prey species important in the benthic foodweb will be undertaken.

3. The gut contents of selected species of benthic invertebrates will be analyzed as far as possible to determine the foodweb links within the benthic communities.

Justification

Foodweb studies are important because these feeding links are the routes by which energy, elements and pollutants are transferred from one trophic level to another. Such studies are necessary to identify the keystone species and important feeding areas on the Beaufort Sea continental shelf.

b) Objective 2 - Beaufort Sea coastal benthos

The numerical density, biomass, and gross taxonomic composition of the coastal benthic macro-infauna will be obtained from grab samples taken at stations on the inner continental shelf and coastal zone. These samples were collected during the summer of 1976 on the R/V. ALUMIAK. This research is in large part supported by supplemental funds from NOAA/BLM in response to a letter proposal of April 5, 1977. This research will continue throughout the FY-78 contract year.

Justification

The coastal region has been designated by the Beaufort Sea synthesis meeting as a critical zone of foodweb interactions that could be impaired by oil pollution from planned petroleum exploration and production. At the present time little is known of the species composition, distribution, abundance and environmental interactions of the benthic fauna.

Research on coastal benthic invertebrates is proposed to fill the designated data gap that now exists in the southwestern Beaufort Sea within the depth zone of 5 to 25 meters. Because of the large standing stocks of benthic fauna in this shallow continental shelf environment, it is an important feeding ground for the shallow-water fish, diving birds, and marine mammals. The taxonomic composition and abundance of the benthos are strongly correlated with depth and distance from shore. The environmental effects of bottom water and sedimentary characteristics on the benthic communities in this transitional zone are not known at the present time.

c) Objective 3 - Benthic macro-infaunal ecology

1. Further identifications of abundant species will be undertaken from samples collected in the southwestern Beaufort Sea during the WEBSEC and OCS field trips and cruises.

2. Statistical analyses of species and station groups will be run, and correlations between these and various characteristics of the benthic environment will be made.

Justification

A complete description of the benthic fauna of the Beaufort Sea at the species level is needed to establish a baseline from which future faunal changes can be evaluated. Multivariate analysis of the spatial patterns of the benthic fauna will be useful in gaining insight into which environmental factors are important in controlling animal distributions in this area. This type of knowledge is critical to predicting the impact of environmental perturbations.

d) Objective 4 - Summary and synthesis of benthic environment characteristics.

1. Sediment samples from OCS benthos stations will be analyzed for particle size, organic carbon, and Kjeldahl nitrogen by Oregon State University or a subcontractor.

2. The bottom water characteristics of the southwestern Beaufort Sea continental shelf will be summarized as far as possible with the available information.

Justification

It has been demonstrated that sediment type is one of the key factors in controlling the distribution of benthic infaunal organisms. Therefore, it is useful to map the distribution of sediment characteristics in conjunction with the patterns of faunal distribution. The Beaufort Sea continental shelf is characterized by sediments which are patchy in distribution and of a broad range of types, and it is, therefore, essential that the sediments be defined as completely as possible at each sampling location.

C. Relevance to Problems Associated with Petroleum Development.

Extensive exploratory and production drilling for petroleum on the Alaskan and Canadian continental shelf has the potential to significantly influence the marine benthic environment and its associated biota. It is impossible with the present state of our knowledge of the benthos and the Arctic environment to accurately predict either the long or short term consequences of oil and gas development on the marine invertebrate benthos and the benthic food web. Only recently has descriptive baseline data on species distribution, composition, and abundance become available with estimates of variability in space and time.

II. C. (continued)

These data can be used as comparisons against which to assess the extent of major impacts on the benthic environment. These are a first step toward understanding the role of the sea floor fauna in the Beaufort Sea ecosystem and effects they might suffer from a major oil spill.

The objective of the second phase of the benthic ecological research is oriented toward the elucidation of energy pathways within the benthic food web, and the maintenance of community structure through the population dynamics of dominant species. When the major pathways of carbon flow within the benthic food web and to major marine mammal, bird and fish predators are known then critical pathways (e.g. dominant prey species) can be evaluated for their sensitivity to oil and other forms of pollution caused by man's activities off the northern Alaskan coast.

The measurement of rates and processes within the food web is ultimately a more difficult task but one that would allow more accurate estimates of environmental impacts. Changes in the metabolism, assimilation, growth and reproductive rates of species populations can be used to determine the extent of chronic effects of pollution (Widdows 1978). The partitioning of energy production and use in the benthos and ecosystem would provide a clearer understanding of the functioning of the ecological units and the degree to which they may be imparted by oil exploration and production.

Our (RU#6) benthic research on year-round reproductive activity of dominant benthic species on the continental shelf on the benthic food web, particularly in regards to marine mammals, birds, and fishes seeks to define some of the functional interactions among the community components. These must be known before the effects of environmental impacts can be predicted.

The benthic invertebrates constitute a major source of food for the top level carnivores, including birds, seals, and occasional walrus. Any decrease in benthic populations caused by oil pollution might eventually be reflected in the populations of these larger animals. Nearshore areas would be most sensitive since it would be in these regions that pollutants would be most likely to mix to the benthic boundary.

The timing of environmental disturbances in this strongly seasonal environment may be extremely critical in determining the stresses experienced by the benthic community. For example, an oil spill in the winter on top of the pack ice could be cleaned up with little or no resultant damage to the marine benthos, while a spill of the same magnitude during a summer of open water might have significant impact. It remains to be determined if the bottom-dwelling invertebrates are more or less sensitive to oil related pollution during the summer months, but the pelagic larvae and juvenile stages of the benthic organisms would be vulnerable to spills during periods of open water conditions.

It seems likely that the development of the oil and gas resources will bring about changes in the marine environment, but the extent of degradation in the benthic environment cannot be predicted. There remains a great scientific need

II. C. (continued)

for long term studies on the dynamics of the benthic populations, including year-round sampling with measurements on growth, metabolism, and reproductive activity.

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III. Current State of Knowledge

Since intensive sampling of the benthos of the southwestern Beaufort Sea beginning in 1971, ample collections have been made to define the broad ecological patterns of the bottom invertebrate organisms. These data have been submitted as part of the Final Report of NOAA/BLM-OCSEAP Contract No. 03-5-022-68, Task Order No. 4 submitted to NOAA by the Benthic Ecology Group at Oregon State University under Dr. Andrew G. Carey, Jr. in Quarterly and Annual Reports for Task Order No. 5 of RU #6, and in publications (Carey, Ruff, Castillo and Dickinson, 1974; Carey and Ruff, 1977).

Temporal and spatial variability are also fairly well defined, but the processes involved in maintaining these are not know. In some areas the scoring of the sea floor by ice gouging appears to increase the patchiness of the large infauna (Carey *et al.*, 1974 and Carey and Ruff, 1977). It is suggested that the temporal variability of the outer continental shelf communities are seasonal and caused by reproductive cycles, but no data are yet available to test this hypothesis (Carey, Ruff, and Montagna, unpublished M.S.).

Benthic invertebrates that are important as food sources of marine mammals and birds have been designated by other research groups (UR's 230, 232, 172 and 196), but the ecology of these particular prey species are not well known. Research has just been initiated on the benthic food web itself; it's structure and rates are not known at the present time.

In summary, most of our information about the benthic invertebrates is descriptive in nature, and the studies of the processes that cause the described patterns are only just in the beginning stages.

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IV. Study Area

The Beaufort Sea is an integral part of the Arctic Ocean (Coachman and Aagaard, 1974). Normally the sea ice melts and is advected seaward during July and August in the southern fringe of the sea over the continental shelf. This is a response to regional wind stresses which are variable from year to year. For example, in some years the polar pack ice can remain adjacent to the coastline throughout the entire season. The extent of ice cover during the sunlit summer months affects wind mixing of surface waters and the penetration of light into the water column. These factors affect the onset and intensity of phytoplankton production which is highly variable and of low magnitude (Horner, 1976;

Clasby, Alexander, and Horner, 1976). The keels of sea ice pressure ridges ploughing through the sediments cause significant disturbance of the benthic environment in water depts between 20 and 40 meters (Barnes and Reimnitz, 1974; Reimnitz and Barnes, 1974). They gouge the bottom as they are transported across the inner shelf by the Beaufort Sea gyral circulation and by wind stress.

Generally the bottom water masses of the southwestern Beaufort Sea are stable, and except for the shallow coastal zone, differ little in thermohaline characteristics throughout the year (Coachman and Aagaard, 1974). However, the outer shelf region from Point Barrow to about 150°W is influenced by Bering-Chukchi water that is advected as a subsurface layer and moves around Point Barrow throughout the year in pulses controlled in part by atmospheric pressure gradients (Hufford et al., 1977). Coastal upwelling was observed in the Barter Island region on the shelf near 143°W during the summer of 1971 when the pack ice had moved relatively far offshore (Mountain, 1974).

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V. Sources, Methods and Rationale of Data Collection

In general, two areas of continuing benthic ecological research are: (1) the extension of research into a food web project which is designed to elucidate the biological interactions within the benthos and between the benthic organisms and other portions of the ecosystem; and (2) the further accumulation of data from existing samples to provide a more complete understanding of the patterns of distribution and abundance of benthic invertebrates across the continental shelf. This descriptive detailing will provide baseline data with more accurate estimates of natural spatial and temporal variability.

To date, the experimental design has included a description of the benthic macro-infaunal and mega-epifaunal communities based on the WEBSEC and OCS samples. Numerical densities, total biomass, and major taxonomic composition have all been examined. As the species within the taxonomic groups have been identified, statistical anaylses have delimited species and station groupings, and these groups have been correlated with the environmental characteristics of the benthic boundary. Estimates of natural spatial variability have been of major concern, and the descriptive phases of the research have been extended through a twelve month period to provide estimates of temporal variability and to provide initial information of the life histories of the arctic invertebrates. The study of interactive pathways with other portions of the ecosystem through the food web is a logical extension of the current benthic research.

A. WEBSEC

A large series of Smith-McIntyre 0.1 m^2 grab samples were collected during the 1971 and 1972 WEBSEC cruises of the U.S. Coast Guard. These formed the basis for our initial survey of the large benthic infauna (>1.0 mm) and mega-epifauna (>1.3 cm). Five grab samples were collected per station. Details of methodology may be found in the 1977 Final Report for RU #6 Task Order #4, and in Carey and Ruff (1977). These samples form the source of much of the poly-chaete results reported here. Gordon R. Bilyard under support of the National Science Foundation and NOAA/BLM is analyzing these collections as part of his Ph.D. dissertation.

B. OCS - Coastal and Shelf

Continued sampling of the benthos for the OCS program has added survey information critical to the description and understanding of species distributions and abundances and ecological patterns. A minimum of 5 quantitative grabs per station has been adherred to as a sampling strategy whenever possible.

The OCSEAP-sponsored foodweb cruise in the Beaufort Sea during the 1977 summer sampling season allowed the sampling of further stations in previously unsurveyed areas (Figure 1) on the continental shelf and continental slope. The coastal areas sampled from the R/V ALUMIAK are summarized in Figure 2 and Table 1.

Figure 1: Station locations of the summer 1977 foodweb cruise.

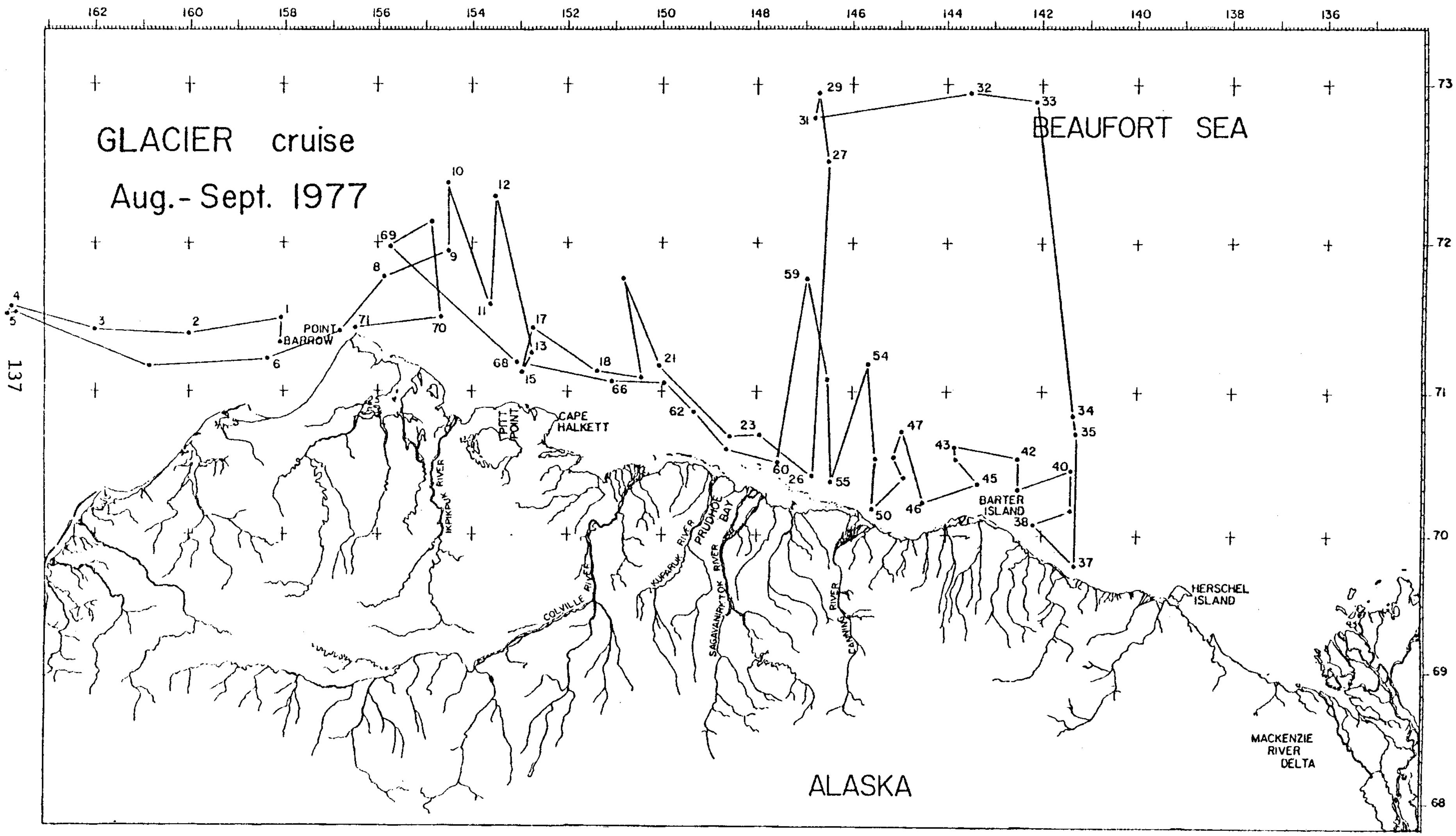


Figure 2: Locations of coastal stations taken aboard R/V ALUMIAK, summer 1976.

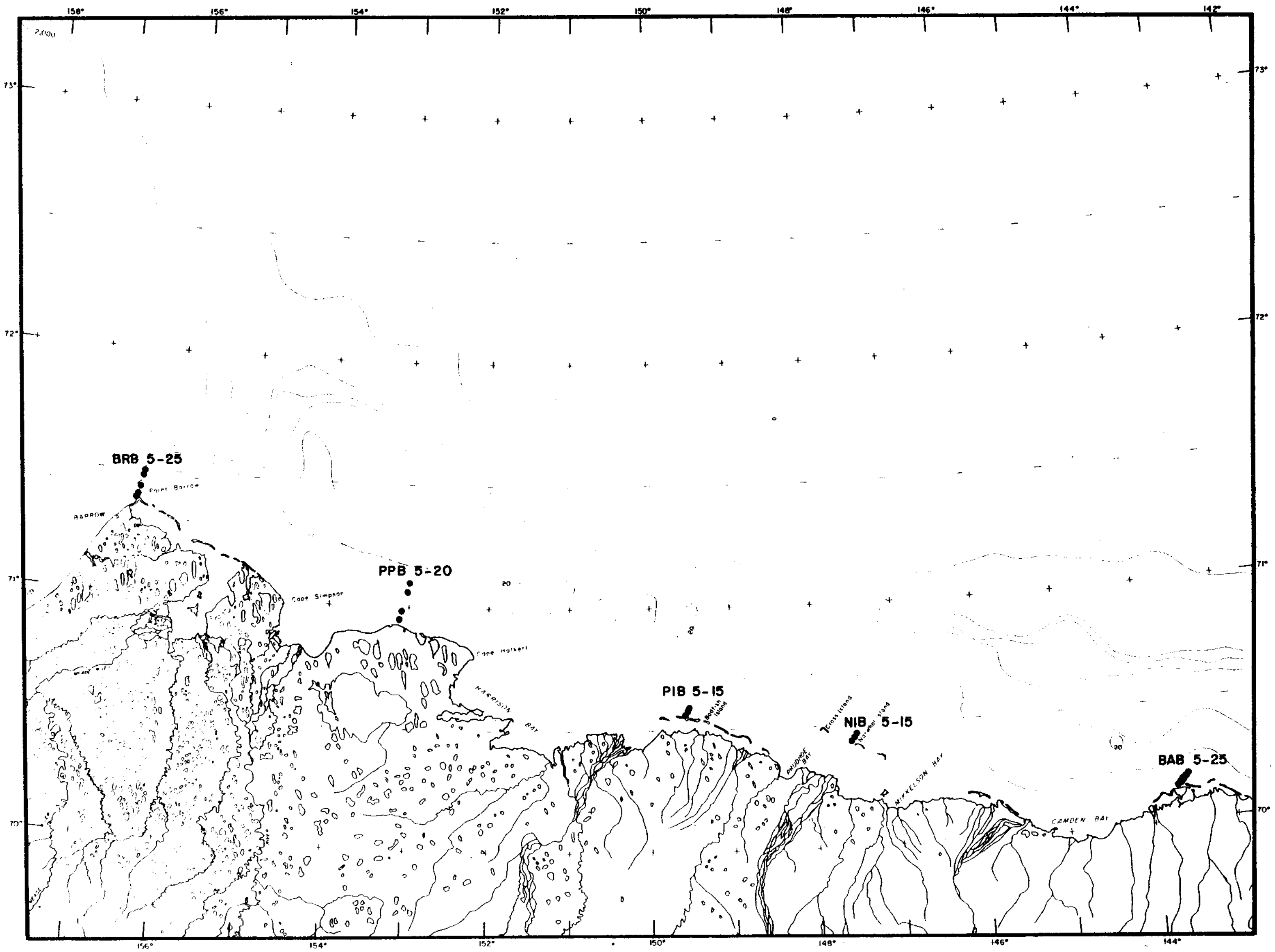


Table 1: Results of the R/V ALUMIAK cruise, summer 1976.

Transect	Date (1976)	Station	Position	Depth (m)	Cond.	Salinity (‰)	Temperature (°C)	No. Biol. Samples	No. Sed. Samples
Point Barrow	19 Aug.	BRB-25	71°27.3'N 156°22.3'W	25.9				5	1
		BRB-20	71°28.0'N 156°18.6'W	19.5				5	1
		BRB-15	71°28.2'N 156°13.1'W	15.5				5	1
		BRB-10	71°24.9'N 156°23.8'W	9.8				5	1
		BRB-5	71°23.4'N 156°27.1'W	5.2	25.00	27.00	3.50	5	1
Pitt Point	20 Aug.	PPB-20	71°05.2'N 152°58.7'W	19.2	11.10	12.70	-1.60	5	1
		PPB-15	71°04.4'N 153°01.5'W	14.9	25.50	31.20	-1.30	5	1
		PPB-10	70°59.1'N 153°08.8'W	9.9	25.10	27.77	-0.80	5	1
		PPB-5	70°56.4'N 153°12.9'W	5.5	23.20	25.10	-1.90	5	1
Pingok Island	22 Aug.	PIB-15	70°33.2'N 149°34.6'W	14.9	24.87	31.45	1.88	5	1
		PIB-10	70°34.8'N 149°32.3'W	10.2	23.00	22.32	2.15	5	1
		PIB-5	70°34.9'N 149°32.0'W	4.5	20.65	22.08	2.08	5	1
Narwhal Island	28 Aug.	NIB-15	70°26.0'N 147°26.2'W	16.2	24.93	31.76	-1.98	5	1
		NIB-10	70°24.3'N 147°29.2'W	9.8	24.50	31.02	-1.96	5	1
	27 Aug.	NIB-5	70°24.9'N 147°30.5'W	5.0	24.09	30.10	-0.88	5	1
Barter Island	31 Aug.	BAB-25	70°11.3'N 143°31.5'W	24.6	24.82	31.88	-2.00	5	1
		BAB-20	70°10.8'N 143°33.7'W	20.3	24.46	31.33	-2.00	5	1
	3 Sept.	BAB-15	70°09.5'N 143°36.2'W	15.1	24.24	30.78	-1.98	5	1
		BAB-10	70°09.0'N 143°32.2'W	10.1	24.28	30.75	-1.86	5	1
		BAB-5	70°08.4'N 143°37.7'W	5.0	23.47	28.40	-0.98	5	1
TOTALS									
5 Transects		20 stations						100 Biol. samples	20 Sed. samples

V. C. Temporal variability study methods

In October 1975 we initiated year-round sampling at standard stations across the southwestern Beaufort Sea continental shelf. Our major objectives were: (a) to determine the degree and timing of changes, if any, in the numerical abundance, biomass, and species composition of the benthic communities, and (b) to determine the size distribution and reproductive activity of dominant species throughout the year. Five stations at 15 meter depth intervals from 25 to 100 meters were sampled on five occasions over a 13-month period off Pitt Point, Alaska (Figure 3). Sampling was accomplished from an icebreaker during the summer field season and with the aid of a helicopter during the remainder of the year. A minimum of five standard 0.1 m^2 Smith-McIntyre grab samples were taken at each station occupied.

Navigation was by DEW station radar, depth sounder, and sometimes aided by OMEGA during ice field trips and by satellite navigator, Loran-C and depth sounder on the summer cruise. New techniques and lightweight gear were developed for use of the grab through the ice on airborne trips. The basic station set-up consisted of a steel pipe tripod positioned over a 1.2 m square hole in the ice and a p rtable gasoline hydro winch hauling 3/16" cable rigged through blocks.

The collected sediment was initially washed through 0.42 and 1.0 mm sieves, and the larger infaunal organisms (>1.0 mm) were sorted into major taxonomic groups, counted and weighed (wet) in the laboratory. Numerical density is based on all taxa (>1.0 mm) except foraminiferans and nematodes. Wet-preserved weight includes soft-bodied organisms (>1.0 mm); for greater accuracy and fidelity shelled molluscs, ophiuroids and 5 large, rare specimens weighing more than 3.0 g each were excluded. Significance of seasonal difference (P) was determined by the Kruskal-Wallis one-way analysis by ranks: J.M. Elliot, Some Methods for the Statistical Analysis of Samples of Benthic Invertebrates. (Freshwater Biological Association, Scientific Publication No. 25, Ambleside, England 1971), p. 118.

VI. Results

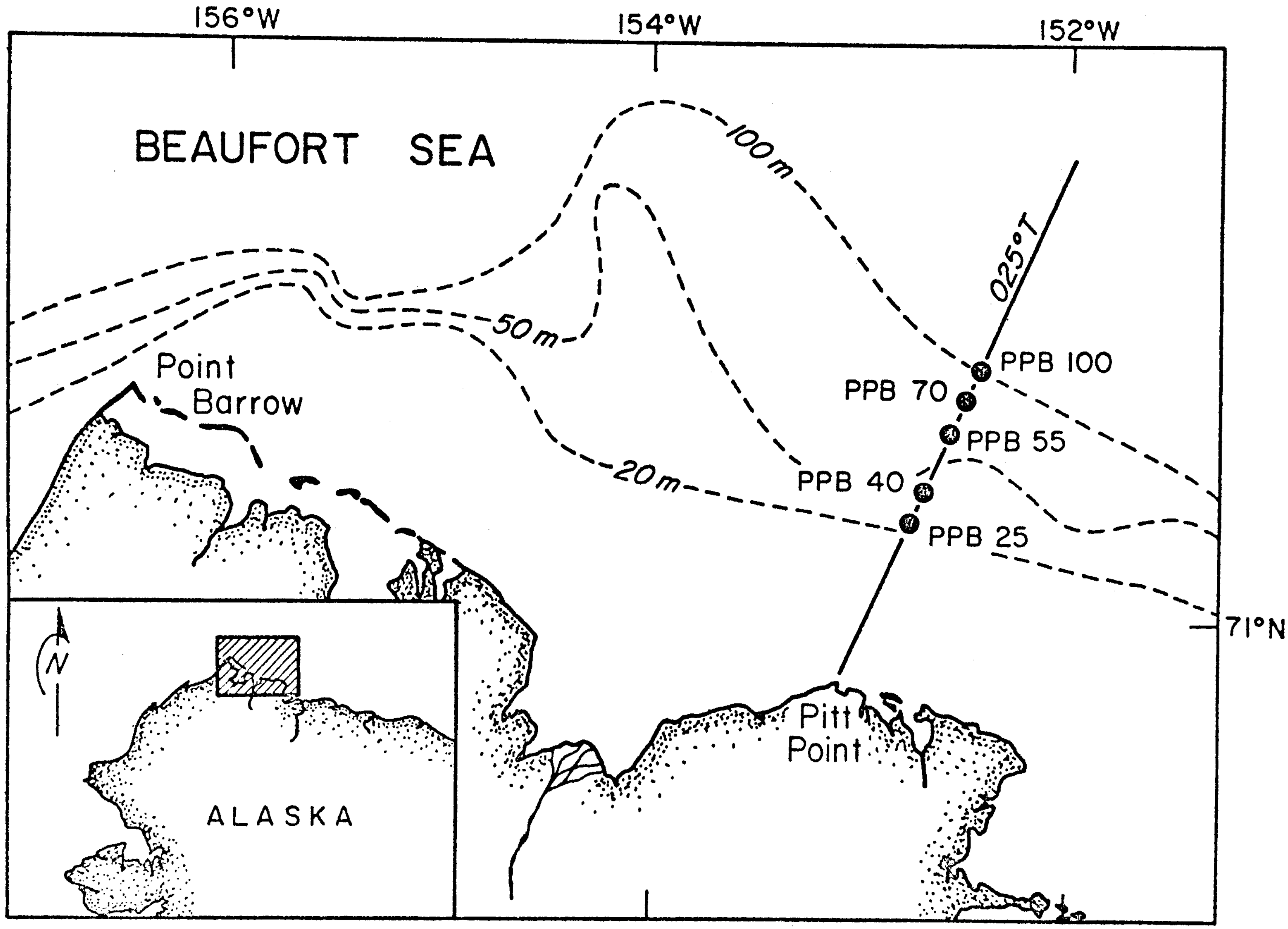
A. Polychaeta

The polychaete worms are among the dominant groups of infauna collected in the Beaufort Sea. Two major series of collections being studied are the WEBSEC-71 and 72 and the OCSEAP (1975-78) samples.

1. OCS - Polychaetous Annelids

The polychaetous annelids have been sorted to the family level from 125 grab samples obtained during the OCS-5 and OCS-7 cruises. The OCS-5 samples were taken from the ALUMIAK in 1976 in water depths between 5 and 25 meters along five transects between Barrow and Barter Island. In 1977, the standard benthic stations off Pitt Point were reoccupied by the GLACIER between 25 and 100 meters. Summary counts of the polychaetes by family from these grab samples are presented in the Current Quarterly report.

Figure 3. Southwestern Beaufort Sea: Point Barrow to Pitt Point, AK illustrating station locations.



VI. A. (continued)

The three most numerous families at each station were ranked in terms of percentage of the total polychaete fauna for three depths along the transects between Barrow and Barter Island (Table 2). From this compiled data, a few preliminary inferences can be drawn. Representatives of the family Spionidae tend to be ubiquitous across the Alaskan arctic shelf, as indeed they are worldwide. Members of the Pectinariidae dominate the polychaete fauna off Barrow, but are only rarely encountered elsewhere in the Beaufort Sea. This may be a reflection of differing environmental conditions due to proximity to the Chukchi Sea. It is of interest to note that fourteen different polychaete families are represented in the rankings. This is indicative of a heterogeneity of habitats occurring within a fairly confined depth range. Further conclusions, however, will have to await more detailed species information.

2. WEBSEC - Polychaetous Annelids

In addition to the use of gammarid amphipod data to further understand the Beaufort Sea ecosystem, data on the polychaetous annelids has served to elucidate many aspects of interactions between organisms and environment. Accumulation of data on the polychaetes requires concise taxonomic work. Dr. Kristian Fauchald (Allan Hancock Foundation, University of Southern California) has been most gracious in extending his help, including his personal expertise, use of the Allan Hancock Foundation Library, and use of the Allan Hancock Foundation biological collections. The desired level of taxonomic expertise could not have been achieved without his help.

Species found to date are listed in Table 3. Taxa bearing a letter designation (examples: Eclysippe sp. A, Genus A) have been confirmed as undescribed taxa. A taxonomic review of the Beaufort Sea polychaetous annelids is presently in the early stages of preparation, and will, when published, include descriptions of the letter-designated taxa.

Among the polychaete data being collected are the numerical abundances of the polychaete species found at stations across the Beaufort Sea continental shelf and clope. Five transects, consisting of 119 Smith-McIntyre Grab samples (divided into 24 stations) were selected for analysis. Three transects (Figure 4) have been completed to date; the remaining two transects are very near completion. The numbers of species with depth and the numbers of polychaete specimens with depth are plotted in Figures 5 and 6.

Maximum numbers of species along the three transects are found between 75 and 150 m depth (Figure 5). Although reasons for the observed general shape of the species curves remain unclear, certain factors have been suggested which may influence species richness (number of species) at a given site. Inshore stations (20-40 m) are within the ice gouge zone (Kovacs and Mellor, 1974), where continual sediment disturbance may prohibit certain species from establishing populations. At depths greater than 400 m species richness decreases with increasing depth, possibly a consequence of decreasing nutrient supply. Hence, the observed species maximum on the outer continental shelf and upper continental slope in the Western Beaufort Sea may result from a minimum of bottom disturbance, coupled with a relatively high nutrient input.

Table 2 : The most numerous families arranged in terms of percentage of the total polychaete fauna. The percentages are derived from grab samples taken along transects occupied by the ALUMIAK in 1976. Five grab samples were taken at each of the stations represented.

	5 - meters	10 - meters	15 - meters
BARROW TRANSECT:	49%-Spionidae 18%-Nephtyidae 12%-Hesionidae	77%-Pectinariidae 5%-Flabelligeridae 3%-Capitellidae	77%-Pectinariidae 6%-Polynoidae 4%-Spionidae
PITT POINT TRANSECT:	41%-Spionidae 16%-Ampharetidae 13%-Orbiniidae	34%-Sabellidae 17%-Spionidae 14%-Cirratulidae	86%-Spionidae 4%-Capitellidae 3%-Paraonidae
PINGOK ISLAND TRANSECT:	31%-Maldanidae 14%-Cirratulidae 11%-Spionidae	80%-Spionidae 7%-Sabellidae 4%-Sphaerodoridae	56%-Spionidae 28%-Ampharetidae 6%-Sabellidae
NARWHAL ISLAND TRANSECT:	40%-Spionidae 21%-Hesionidae 13%-Sabellidae	53%-Spionidae 27%-Ampharetidae 6%-Cirratulidae	25%-Cirratulidae 13%-Spionidae 7%-Capitellidae
BARTER ISLAND TRANSECT:	27%-Spionidae 24%-Ampharetidae 15%-Sphaerodoridae	66%-Spionidae 7%-Ampharetidae 6%-Cirratulidas	17%-Cirratulidae 17%-Spionidae 15%-Nephtyidae

Table 3

POLYCHAETOUS ANNELIDS OF THE WESTERN BEAUFORT SEA
(Family and genus designations follow Fauchald, 1977.The Polychaete Worms. Definitions and Keys to the Orders, Families and Genera. Science Series 28. Natural History Museum of Los Angeles County.)

AMPHARETIDAE
- Amage auricula Malmgren, 1866
- Ampharete acutifrons (Grube, 1860)
- Ampharete arctica Malmgren, 1866
- Ampharete vega (Wirén, 1883)
- Amphicteis gunneri (Sars, 1835)
- Eclysippe sp. A
- Glyphanostomum pallescens (Théel, 1879)
- Lysippe labiata Malmgren, 1866
- Melinna cristata (Sars, 1851)
- Sabellides borealis Sars, 1856
- Genus A

APISTOBRANCHIDAE
- Apistobranchus tullbergi (Théel, 1879)

CAPITELLIDAE
- Barantolla americana Hartman, 1963
- Capitella capitata (Fabricius, 1780)
- Heteromastus filiformis (Claparède, 1864)
- Parheteromastus sp. A

CHAETOPTERIDAE
- Spiochaetopterus typicus Sars, 1856

CIRRATULIDAE
- Chaetozone setosa Malmgren, 1867
- Cirratulus cirratus (Müller, 1776)
- Tharyx ? acutus Webster and Benedict, 1887

COSSURIDAE
- Cossura longocirrata Webster and Benedict, 1887
- Cossura sp. A

DORVILLEIDAE
- Schistomeringos caecus (Webster and Benedict, 1887)
- Schistomeringos sp. A

FLABELLIGERIDAE
- Brada incrustata Støp-Bowitz, 1948
- Brada inhabilis (Rathke, 1843)
- Brada villosa (Rathke, 1843)
- Diplocirrus hirsutus (Hansen, 1879)
- Diplocirrus longisetosus (v. Marenzeller, 1890)
- Pherusa plumosa (Müller, 1776)

GONIADIDAE
- Glycinde wireni Arwidsson, 1899

HESIONIDAE
- Nereimyra aphroditoides (Fabricius, 1780)

LUMBRINERIDAE
- Lumbrineris fragilis (Müller, 1776)
- Lumbrineris impatiens (Claparède, 1868)
- Lumbrineris minuta Théel, 1879
- Lumbrineris sp. A
- Lumbrineris sp. B

MAGELONIDAE
Magelona longicornis Johnson, 1901
MALDANIDAE
Clymenura polaris (Théel, 1879)
Lumbriclymene minor Arwidsson, 1907
Maldane sarsi Malmgren, 1865
Notoproctus oculatus var. arctica Arwidsson, 1907
Petaloproctus tenuis (Théel, 1879)
Praxillella praetermissa (Malmgren, 1865)
NEPHTYIDAE
Aglaophamus malmgreni (Théel, 1879)
Micronephtys minuta (Théel, 1879)
Nephtys ciliata (Müller, 1776)
Nephtys paradoxa Malm, 1874
NEREIDAE
Nereis zonata Malmgren, 1867
Nicon sp. A
ONUPHIDAE
Nothria conchylega (Sars, 1835)
Onuphis quadricuspis Sars, 1872
OPHELIIDAE
Ophelina acuminata Oersted, 1843
Ophelina cylindricaudatus (Hansen, 1879)
Ophelina sp. A
Ophelina abranchiata Støp-Bowitz, 1948
ORBINIIDAE
Scoloplos acutus (Verrill, 1873)
OWENIIDAE
Myriochele heeri Malmgren, 1867
Owenia fusiformis delle Chiaje, 1841
PARAONIDAE
Allia suecica (Elaison, 1920)
Allia sp. A
Aricidea ushakovi Zachs, 1925
Paraonis sp. A
Tauberia gracilis (Tauber, 1879)
PECTINARIIDAE
Cistenides hyperborea (Malmgren, 1865)
PHYLLODOCIDAE
Anaitides citrina (Malmgren, 1865)
Anaitides groenlandica (Oersted, 1843)
Eteone flava (Fabricius, 1780)
Eteone longa (Fabricius, 1780)
Mysta barbata (Malmgren, 1865)
Mystides borealis Théel, 1879
Paranaitis wahlbergi (Malmgren, 1865)
PILARGIIDAE
Sigambra tentaculata (Treadwell, 1941)
POLYNOIDAE
Antinoella badia (Théel, 1879)
Antinoella sarsi (Malmgren, 1865)
Arcteobia anticostiensis (McIntosh, 1874)
Enipo gracilis Verrill, 1874
Eucranta villosa Malmgren, 1865

POLYNOIDAE - CONT.
- Eunoe oerstedi (Malmgren, 1865)
- Gattyana cirrosa (Pallas, 1766)
- Harmothoe imbricata (Linneus, 1767)
- Lagisca extenuata (Grube, 1840)
- Melaenis loveni Malmgren, 1865

SABELLIDAE
- Branchiomma infarcta (Kröyer, 1856)
- Chone duneri Malmgren, 1867
- Chone murmanica Lukasch, 1910
- Euchone papillosa (Sars, 1851)
- Jasmineira schaudinni Augener, 1912

SCALIBREGMIDAE
- Polyphysia crassa (Oersted, 1843)
- Scalibregma inflatum Rathke, 1843

SERPULIDAE
- Apomatus globifer Théel, 1879

SIGALIONIDAE
- Pholoe minuta (Fabricius, 1780)

SPHAERODORIDAE
- Sphaerodoridium claparedii (Greef, 1866)
- Sphaerodoridium sp. A
- Sphaerodoropsis minuta (Webster and Benedict, 1887)
- Sphaerodoropsis sp. A
- Sphaerodoropsis sp. B
- Sphaerodoropsis sp. C
- Sphaerodorum gracilis (Rathke, 1843)

SPIONIDAE
- Laonice cirrata (Sars, 1851)
- Minuspio cirrifera (Wiren, 1883)
- Polydora caulleryi Mesnil, 1897
- Prionospio steenstrupi Malmgren, 1867

SPIRORBIDAE
- Dexiospira spirillum (Linneus, 1758)
- Spirorbis granulatus (Linneus, 1767)

STERNASPIDAE
- Sternaspis fossor Stimpson, 1854

SYLLIDAE
- Autolytus alexandri Malmgren, 1867
- Autolytus fallax Malmgren, 1867
- Exogone dispar (Webster, 1879)
- Exogone naidina Oersted, 1843
- Sphaerosyllis erinaceus (Claparède, 1863)
- Typosyllis cornuta (Rathke, 1843)
- Typosyllis fasciata (Malmgren, 1867)

TEREBELLIDAE
- Artacama proboscidea Malmgren, 1866
- Axionice flexuosa (Grube, 1860)
- Lanassa nordenskioldi Malmgren, 1866
- Lanassa venusta Malm, 1874
- Laphania boecki Malmgren, 1866
- Leaena abranchiata Malmgren, 1866
- Nicolea zostericola Oersted, 1844
- Polycirrus medusa Grube, 1855
- Proclea graffii (Langerhans, 1884)

TRICHOBRANCHIDAE

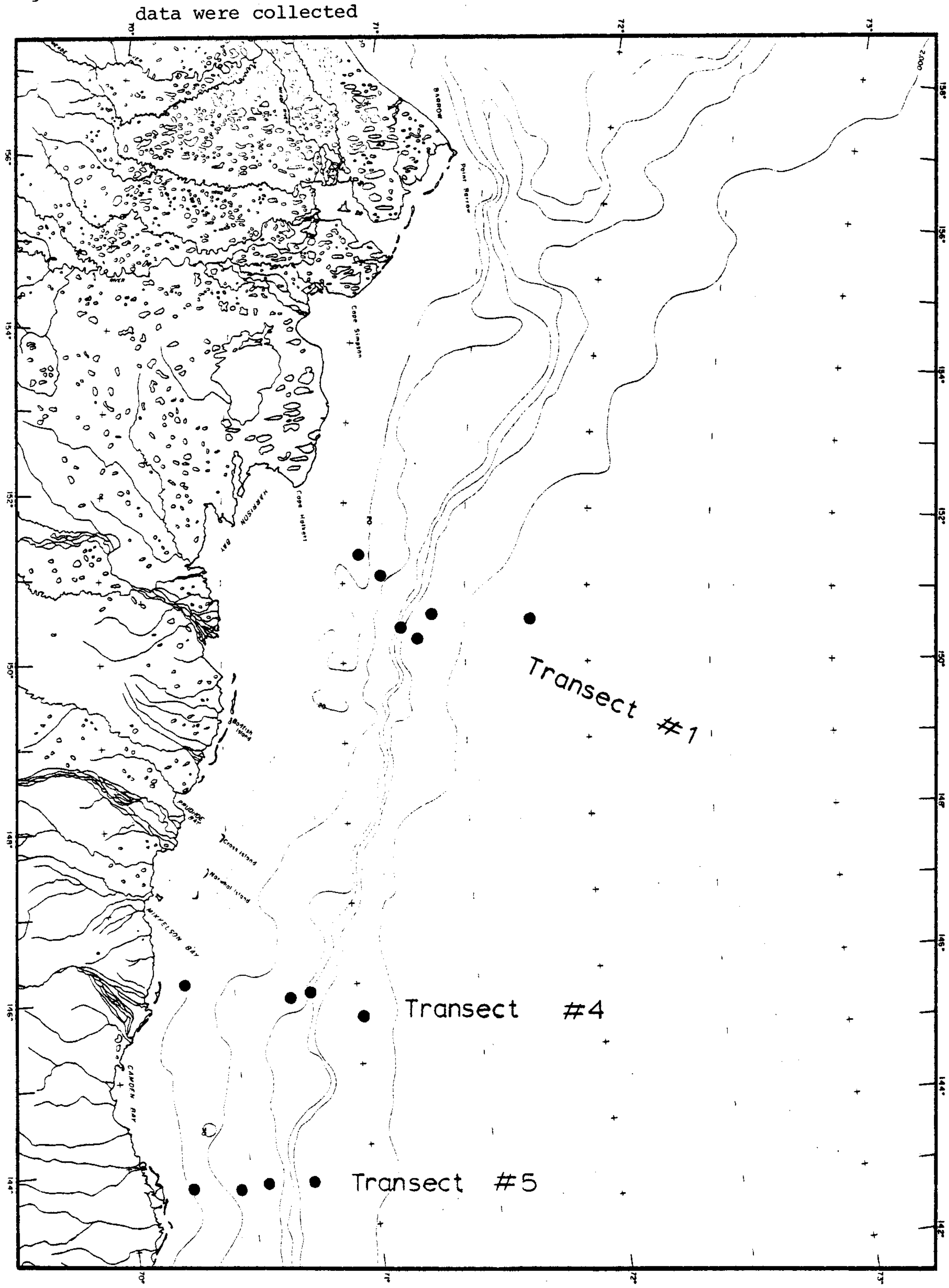
Terebellides stroemi Sars, 1835

Trichobranchus glacialis (Malmgren, 1866)

TROCHOCHAETIDAE

Trochochaeta carica (Birula, 1897)

Figure 4: Chart of station and transect locations at which polychaete data were collected



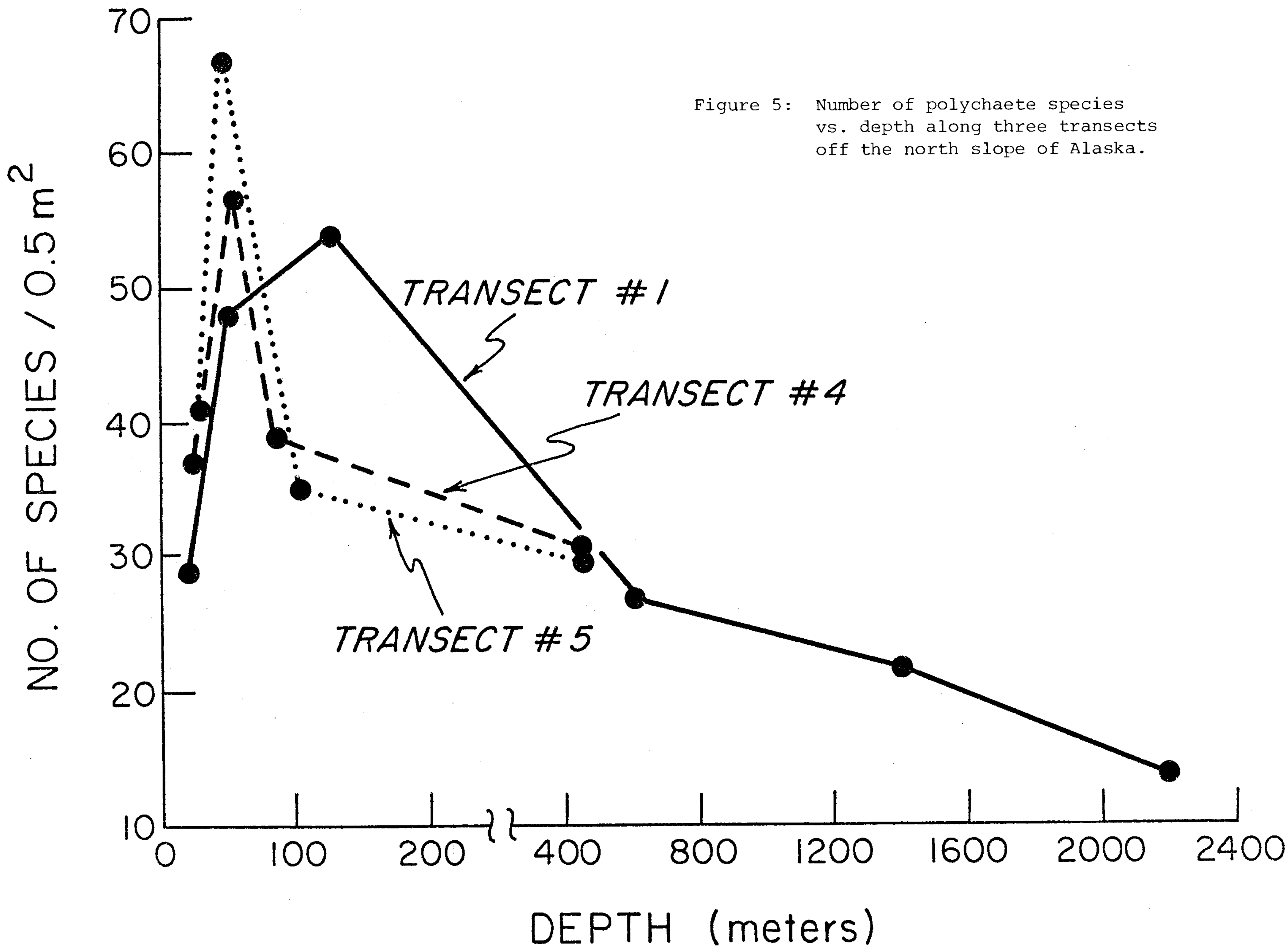
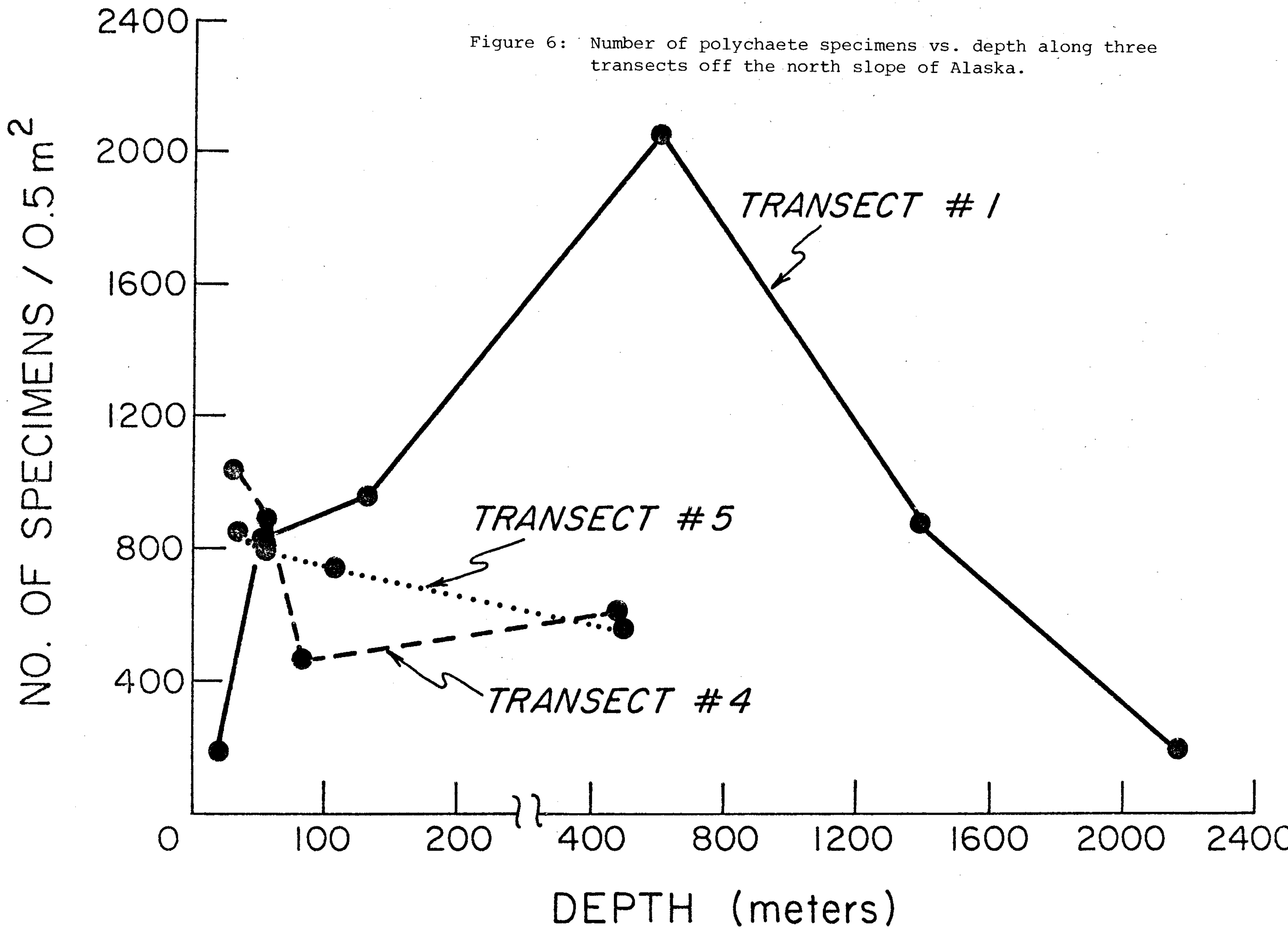


Figure 5: Number of polychaete species vs. depth along three transects off the north slope of Alaska.

Figure 6: Number of polychaete specimens vs. depth along three transects off the north slope of Alaska.



VI. A. 2 (continued)

The decrease in total abundance of polychaetes in Transects 4 and 5 (Figure 6) with increasing depth may also be attributed to decreasing nutrient supply offshore. Transect 1, however, exhibits a large, distinct abundance peak at depths of 400 to 800 m. Moving inshore and offshore from this upper continental slope abundance peak, the numerical abundances of the polychaetous annelids fall to very low values. The suggestion that particulate matter entrained with Bering Sea water is falling out of the water column and enriching the benthic community in this depth zone (Carey and Ruff, 1977) is supported by these polychaete data.

Minuspio cirrifera, a surface deposit feeder, and Owenia fusiformis, a filter feeder (Jumars and Fauchald, 1977) dominate the high abundance zone in Transect 1 by contributing 64% of the individuals found in this benthic community. The cominance of these two feeding types suggests a steady influx of particulates entering the benthic layer from the overlying water column. Completion of Transects 2 and 3 should provide additional information by which the hypothesis of nutrient input from Bering Sea water may be evaluated.

References

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Kovacs, A. and M. Mellor. 1974. Sea Ice Morphology and Ice as a Geologic Agent in the Southern Beaufort Sea. In: The Coast and Shelf of the Beaufort Sea, J.C. Reed and J.E. Sater, editors. Arctic Institute of North America. pp. 113-161.

B. Gammarid Amphipoda

The gammarid amphipods from 125 Smith-McIntyre grabs collected seasonally along a transect across the Beaufort Sea Continental Shelf were identified to species. Over 100 species were found including representatives of 21 gammarid families (Table 4). The samples from five stations ranging between 25 and 100 meters were obtained during four separate cruises covering all seasons. The amphipod assemblages at each station were rather homogeneous in their species composition and relative abundance throughout the year. However, detailed analyses of reproductive activities and population size (age) structures need to bedetermined at the stations across the continental shelf environments to ascertain the degree of seasonality.

There was clear evidence of depth zonation in the amphipod fauna across the shelf with three distinct assemblages being identifiable from inner-, mid-, and outer-shelf depths (Table 5; Figures 7-10).

Detailed listings of the gammarid species identified from each sample and their abundances can be found in the 1976-77 quarterly reports.

Table 4 : Gammarid Amphipoda collected in the Southwestern Beaufort Sea during the OCSEAP Benthic Ecology Program from 1975-1977.

Acanthonotozoma inflatum (Kroyer, 1842)
Acanthonotozoma serratum (Fabricius, 1780)
Acanthostepheia behringiensis (Lockington, 1877)
Acanthostepheia malmgreni Goes, 1866
Aceroides latipes G. Sars, 1892
Acidostoma laticorne G. Sars, 1879
Ampelisca birulai Bruggen, 1909
Ampelisca eschrichti Kroyer, 1842
Ampelisca latipes Stephensen, 1925
Ampelisca macrocephala macrocephala Liljeborg, 1852
Anonyx debruynii (Hoek, 1882)
Anonyx nugax (Phipps, 1774)
Apherusa glacialis (Hansen, 1887)
Apherusa retovskii Gurjanova, 1934
Apherusa sarsi Shoemaker, 1930
Argissa hamatipes (Norman, 1869)
Aristias tumidus (Kroyer, 1846)
Arrhinopsis longicornis Stappers, 1911
Arrhis luthkei Gurjanova, 1936
Arrhis phyllonyx (M. Sars, 1858)
Atylus bruggeni (Gurjanova, 1938)
Atylus smitti (Goes, 1866)
Bathymedon obtusifrons (Hansen, 1887)
Boeckosimus affinis (Hansen, 1886)
Boeckosimus normani (G. Sars, 1895)
Boeckosimus plautus (Kroyer, 1845)
Byblis arcticus Just, 1970
Centromedon fumilus (Liljeborg, 1865)
Corophium acherusicum Costa, 1857
Corophium clarencense Shoemaker, 1949
Dulichia abyssi Stephensen, 1944
Dulichia bispina Gurjanova, 1930
Dulichia falcata (Bate, 1857)
Dulichia tuberculata Boeck, 1871
Epimeria loricata G. Sars, 1879
Ericthonius megalops (G. Sars, 1879)
Ericthonius tolli Bruggen, 1909
Eusirus cuspidatus Kroyer, 1845
Gammaracanthus loricatus (Sabine, 1821)
Gammaropsis melanops (G. Sars, 1882)
Gammarus locusta (Linnaeus, 1758)
Gammarus oceanicus Segerstrale, 1947
Gitana abyssicola G. Sars, 1892
Gitana rostrata Boeck, 1871
Goesia depressa (Goes, 1866)
Guernea nordenskjoldi (Hansen, 1887)
Halirages quadridentatus G. Sars, 1876
Haploops laevis Hoek, 1882
Haploops setosa Boeck, 1871
Haploops sibirica Gurjanova, 1929

Table 4 (continued)

Haploops tubicola Liljeborg, 1855
Harpinia kobjakovae Bulycheva, 1936
Harpinia mucronata G. Sars, 1879
Harpinia pectinata G. Sars, 1981
Harpinia serrata G. Sars, 1879
Hippomedon abyssi (Goes, 1866)
Hippomedon denticulatus (Bate, 1857)
Hippomedon holbolli (Kroyer, 1846)
Hippomedon robustus Sars, 1894
Ischyrocerus chamissoi Gurjanova, 1951
Ischyrocerus commensalis Chevreux, 1900
Ischyrocerus latipes Kroyer, 1842
Ischyrocerus megacheir (Boeck, 1871)
Ischyrocerus megalops G. Sars, 1894
Lembos arcticus (Hansen, 1887)
Lepidepecreum eoum Gurjanova, 1938
Lepidepecreum umbo (Goes, 1866)
Liljeborgia fissicornis (M. Sars, 1858)
Maera danae (Stimpson, 1854)
Melita dentata (Kroyer, 1842)
Melita formosa Murdoch, 1866
Melita quadrispinosa Vosseler, 1889
Metopa robusta G. Sars, 1892
Metopa spinicoxa Shoemaker, 1955
Metopa tenuimana G. Sars, 1892
Metopella carinata (Hansen, 1887)
Metopella nasuta (Boeck, 1871)
Monoculodes borealis Boeck, 1871
Monoculodes carinatus (Bate, 1862)
Monoculodes diamesus Gurjanova, 1936
Monoculodes latimanus (Goes, 1866)
Monoculodes longirostris (Goes, 1866)
Monoculodes packardi Boeck, 1871
Monoculodes schneideri G. Sars, 1895
Monoculodes tesselatus Schneider, 1883
Monoculodes tuberculatus Boeck, 1871
Monoculopsis longicornis (Boeck, 1871)
Neohela monstrata (Boeck, 1861)
Neopleustes boecki (Hansen, 1887)
Neopleustes pulchellus (Kroyer, 1846)
Odius carinatus (Bate, 1862)
Odius kelleri Bruggen, 1907
Oediceros saginatus Kroyer, 1842
Onisimus litoralis (Kroyer, 1845)
Opisa eschricti (Kroyer, 1842)
Orchomene gronlandica (Hansen, 1887)
Orchomene minuta (Kroyer, 1846)
Orchomene serrata (Boeck, 1861)
Paradulichia typica Boeck, 1870
Paralibrotus setosus Stephensen, 1923
Parampithoe hystrix (Ross, 1835)

Table 4 (continued)

<u>Parampithoe polyacantha</u> (Murdoch, 1885)
<u>Paraphoxus oculatus</u> G. Sars, 1879
<u>Parapleustes assimilis</u> (G. Sars, 1882)
<u>Parapleustes gracilis</u> (Buchholz, 1874)
<u>Pardalisca cuspidata</u> Kroyer, 1842
<u>Pardalisca tenuipes</u> G. Sars, 1893
<u>Pardaliscella lavrovi</u> Gurjanova, 1934
<u>Pardaliscella malygini</u> Gurjanova, 1936
<u>Paroediceros lynceus</u> (M. Sars, 1858)
<u>Paroediceros propinquus</u> (Goes, 1866)
<u>Paronesimus barentsi</u> Stebbing, 1894
<u>Perioculodes longimanus</u> (Bate & Westwood, 1868)
<u>Photis reinhardi</u> Kroyer, 1842
<u>Photis tenuicornis</u> G. Sars, 1895
<u>Photis vinogradova</u> Gurjanova, 1953
<u>Pleustes medius</u> (Goes, 1866)
<u>Pleustes panopla</u> (Kroyer, 1838)
<u>Pleusymtes karianus</u> (Stappers, 1911)
<u>Podoceropsis inaequistylis</u> Shoemaker, 1930
<u>Podoceropsis lindahli</u> (Hansen, 1887)
<u>Pontoporeia affinis</u> (Lindstrom, 1855)
<u>Pontoporeia femorata</u> Kroyer, 1842
<u>Priscellina armata</u> (Boeck, 1861)
<u>Protomedeia fasciata</u> Kroyer, 1842
<u>Protomedeia grandimana</u> Bruggen, 1905
<u>Rhachotropis aculeata</u> (Lepechin, 1778)
<u>Rhachotropis helleri</u> (Boeck, 1871)
<u>Rhachotropis inflata</u> (G. Sars, 1882)
<u>Rhachotropis oculata</u> (Hansen, 1887)
<u>Rozinante fragilis</u> (Goes, 1866)
<u>Socarnes bidenticulata</u> (Bate, 1858)
<u>Stegocephalus inflatus</u> Kroyer, 1842
<u>Stenopleustes eldingi</u> Gurjanova, 1930
<u>Stenopleustes malmgreni</u> (Boeck, 1871)
<u>Syrrhoe crenulata</u> Goes, 1866
<u>Tiron spiniferum</u> (Stimpson, 1854)
<u>Tmetonyx cicada</u> (Fabricius, 1780)
<u>Tryphosella gronlandica</u> (Schellenberg, 1935)
<u>Tryphosella pusilla</u> (G. Sars, 1869)
<u>Tryphosella rusanovi</u> (Gurjanova, 1933)
<u>Unciola leucopis</u> Kroyer, 1845
<u>Westwoodilla caecula</u> (Bate, 1857)
<u>Westwoodilla megalops</u> G. Sars, 1882
<u>Weyprechtia heuglini</u> (Buchholz, 1874)
<u>Weyprechtia pinguis</u> (Kroyer, 1838)

Table 5 : Comparison of dominant amphipod species at PPB-25 and PPB-100.

	PPB-25	PPB-100
1.	Aceroides latipes	Unciola leucopis
2.	Gammarus sp. A	Tiron spiniferum
3.	Rozinante fragilis	Guernea nordenskioldi
4.	Ampelisca eschricti	Harpinia serrata
5.	Haploops tubicola	Photis vinogradova
6.		Podceropsis lindhaldi
7.		Photis rheinhardi
8.		Podoceropsis inaequistylis
9.		Hippomedon abyssi
10.		Protomedeia fasciata

Figure 7: The average distribution of two amphipod species on the Pitt Point Transect.

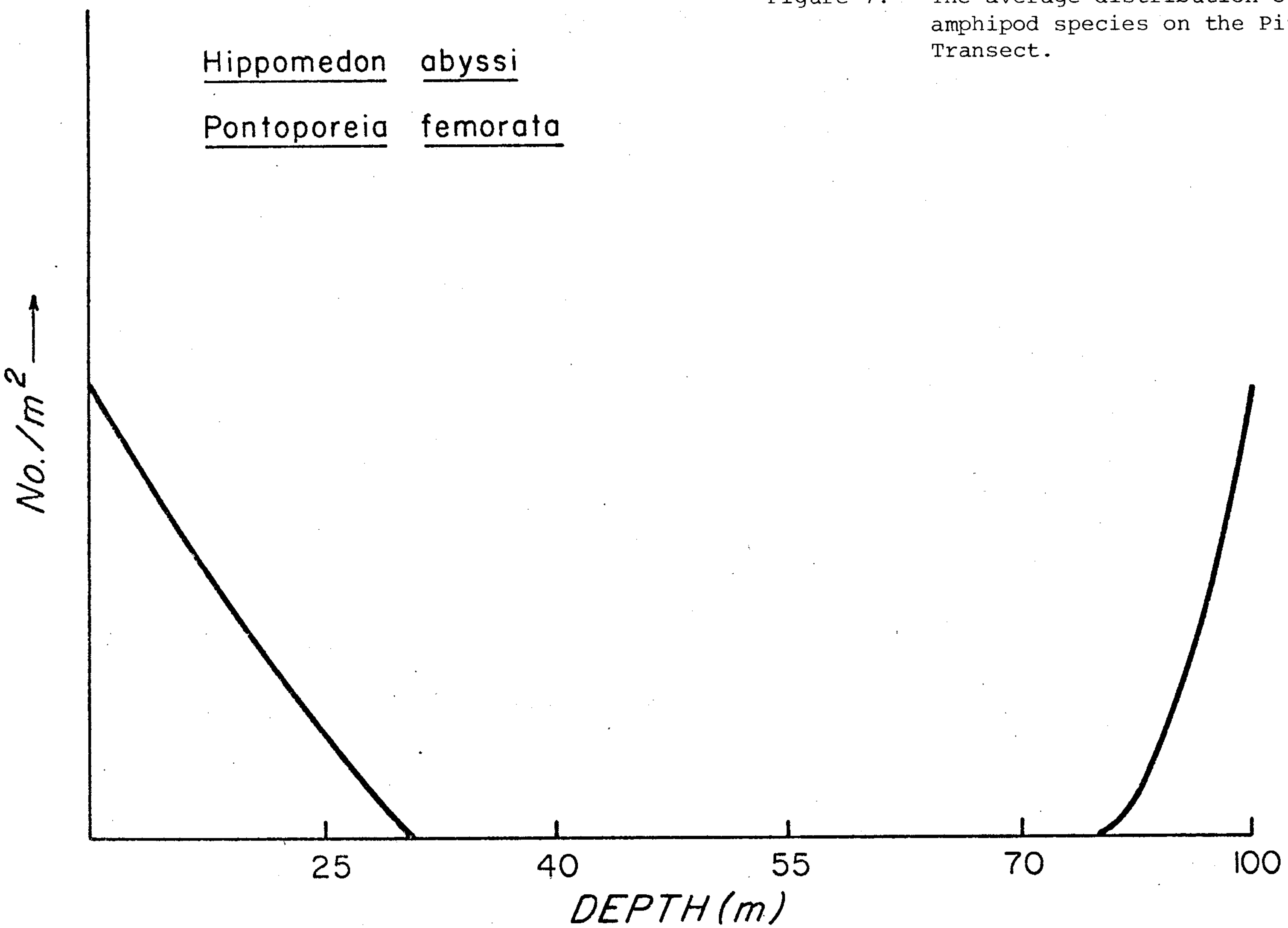


Figure 8: The average distribution of two amphipod species on the Pitt Point Transect.

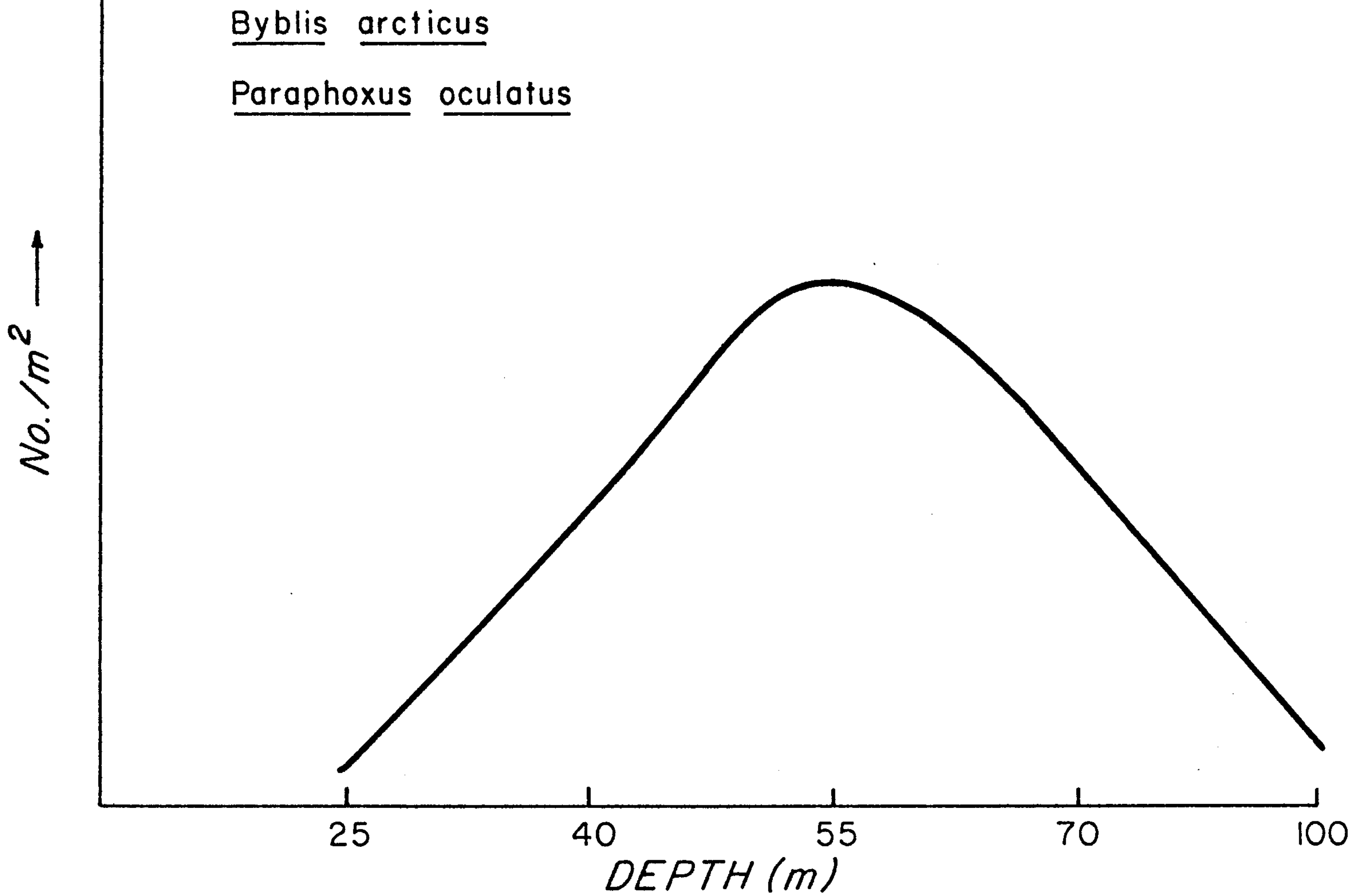


Figure 9: The average distribution of three amphipod species on the Pitt Point Transect.

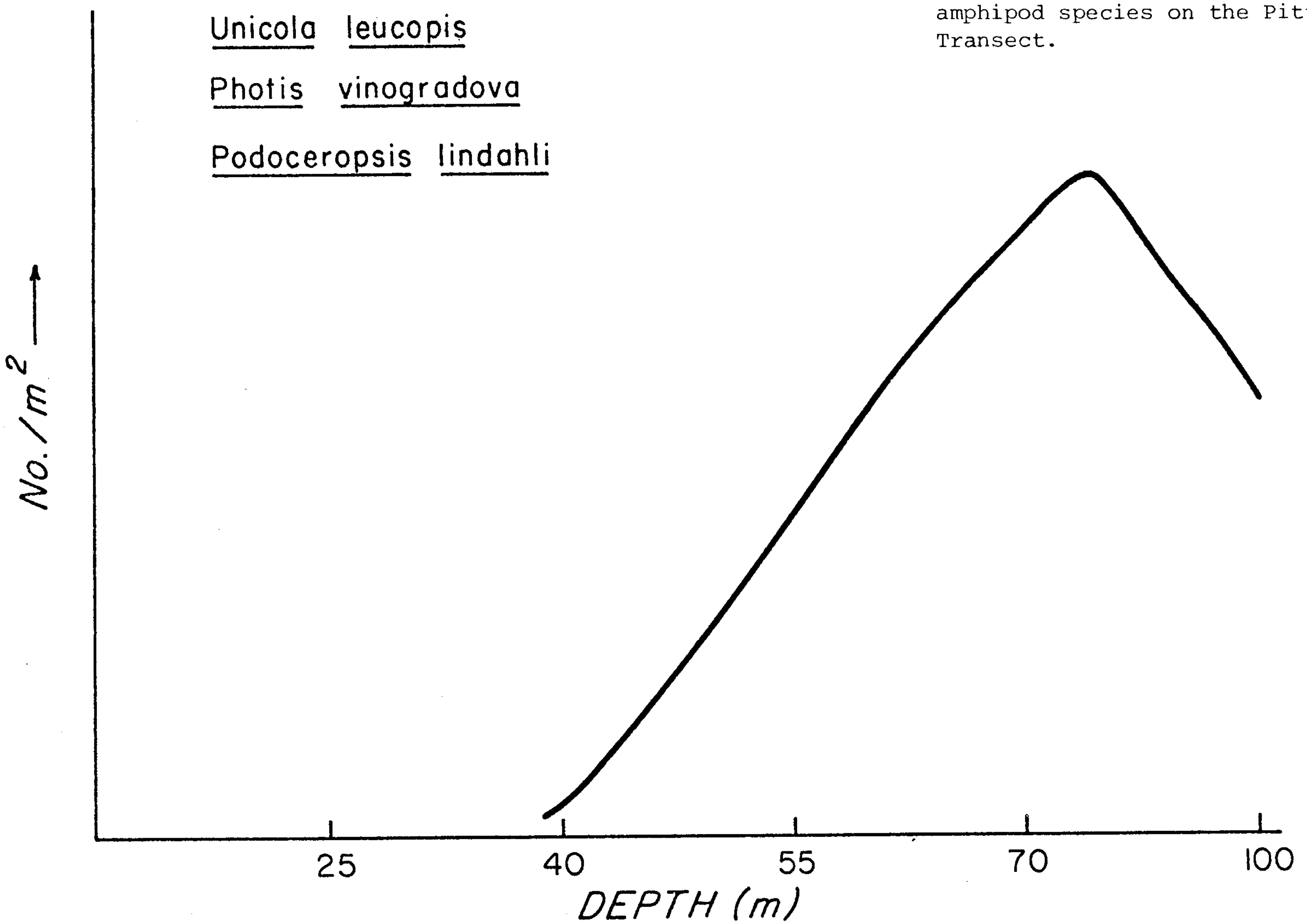
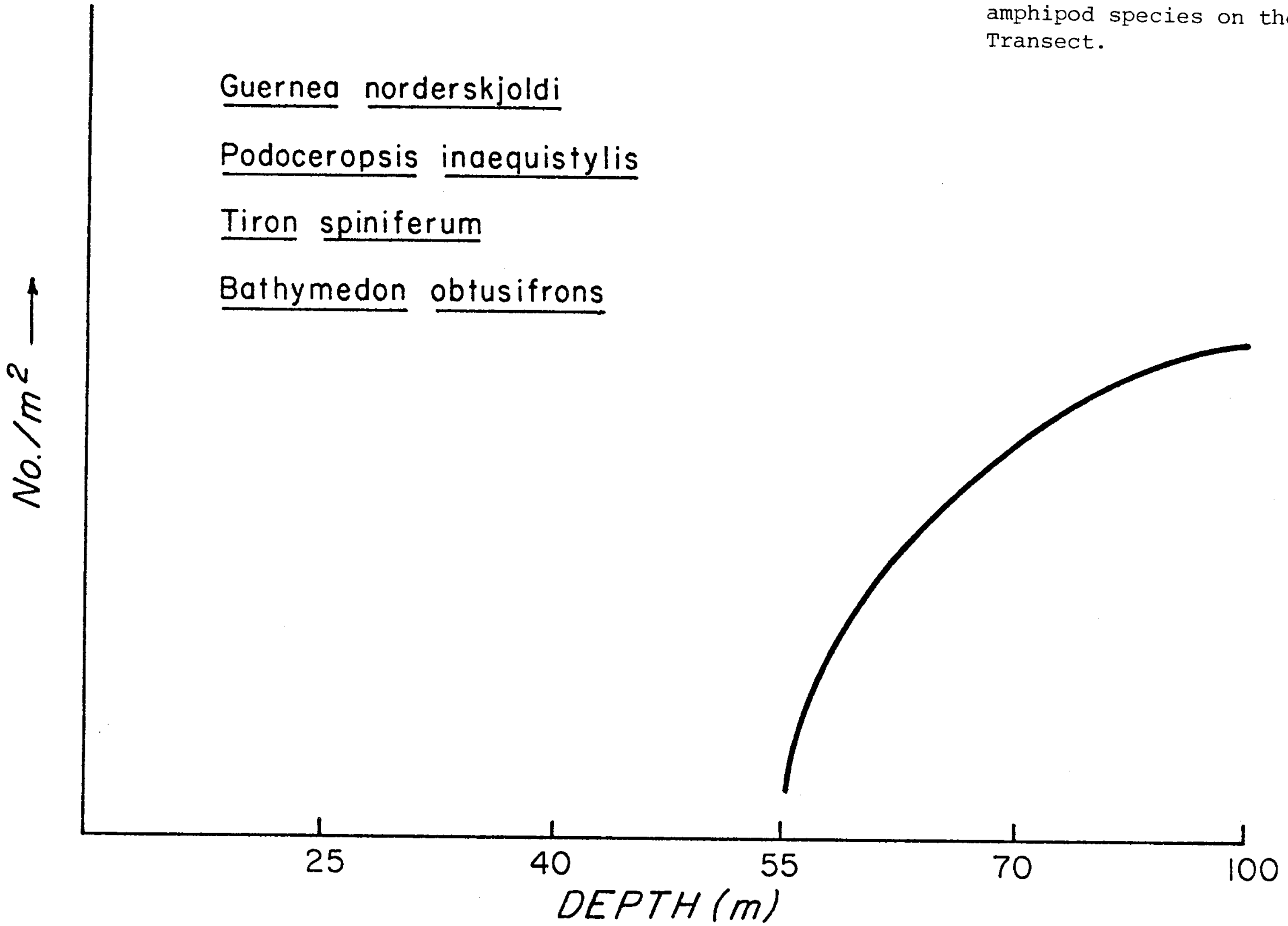


Figure 10: The average distribution of four amphipod species on the Pitt Point Transect.



VI. C. Coastal Fauna (5-25 meters depth)

The coastal large macrofauna (>1.0 mm) are generally more abundant inshore at 5 or 10 meters depth (Figures 11-15). Polychaetes comprise 70-85% of the total infauna in this zone. Biomass, in contrast, does not peak with density indicating that these organisms are small in size on the average (Figures 16-20).

The minimum numerical abundance zone at 15-25 meters depth coincides with the sea ice shear zone between the landfast ice and the moving polar pack. However, detailed studies of the effects of ice gouging on the benthic community are necessary before causality is assigned to this physical phenomonon.

When a grab sample contains a high concentration of peat, it often has a large number of organisms associated with it. Perhaps the peat acts as a source of detritus and organic materials for the benthic food web.

The range and variability of the biomass of the large macro-infauna (>1.0 mm) across the continental shelf off Pitt Point are similar to the remainder of the southwestern Beaufort Sea observed from grab samples taken in 1971. The numerical density on the Pitt Point Transect has a much greater variability. Perhaps the observed seasonal cycles are the cause for this greater range.

Figure 11. Coastal Zone. The abundance of large benthic infauna (1.0mm +) on the Point Barrow Transect.

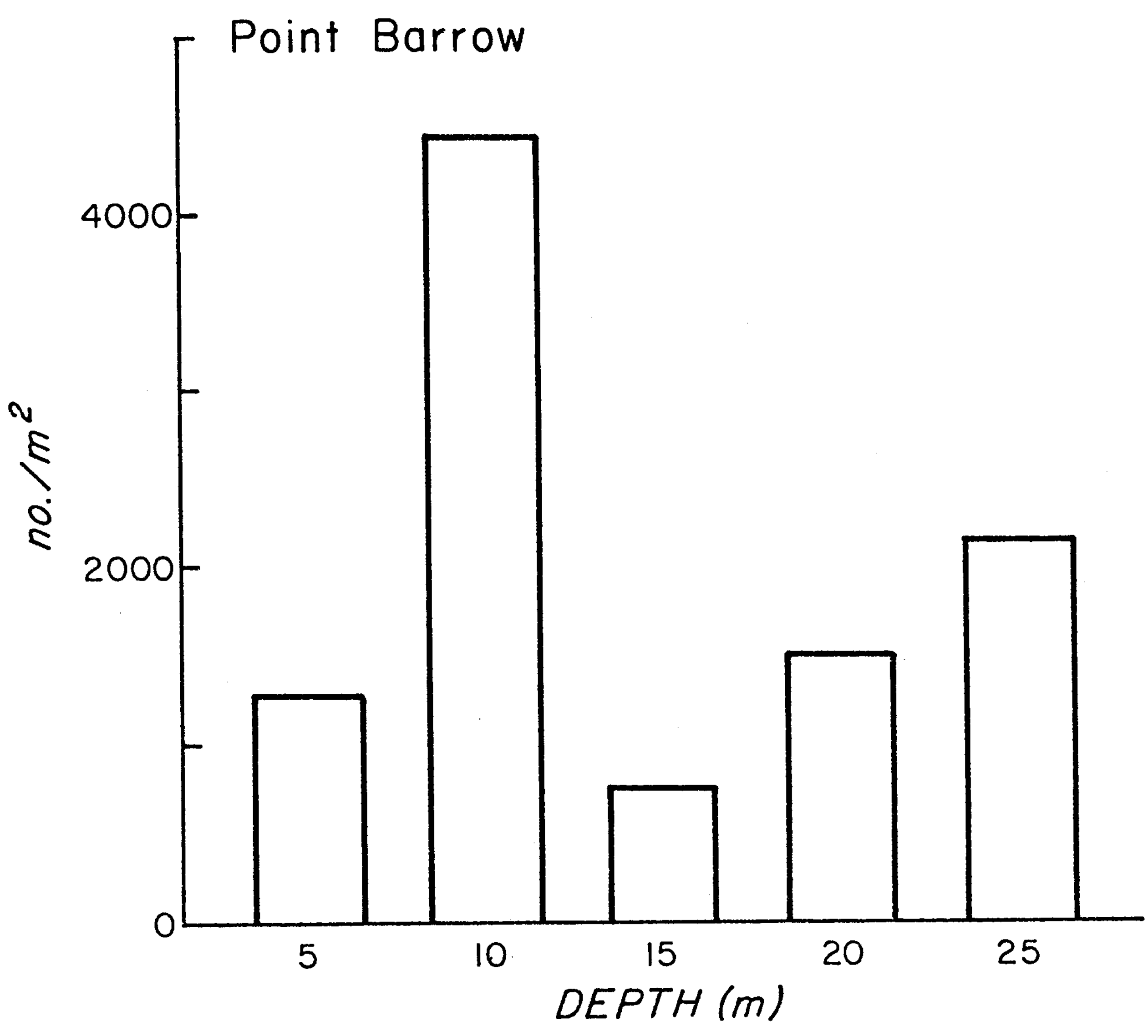


Figure 12. Coastal Zone. The abundance of large benthic infauna (1.0mm +) on the Pitt Point Transect.

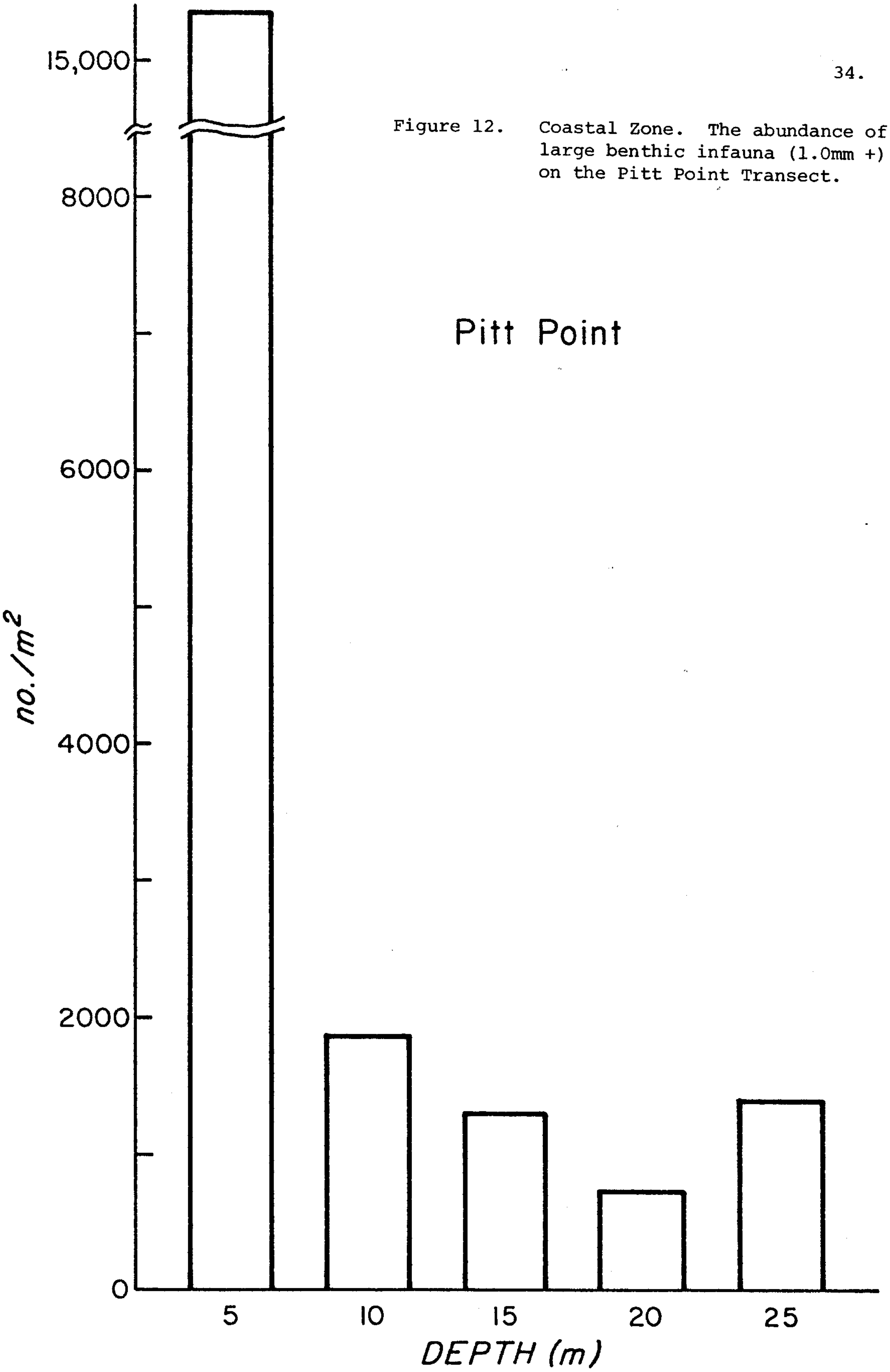


Figure 13. Coastal Zone. The abundance of large benthic infauna (1.0mm +) on the Pingok Island Transect.

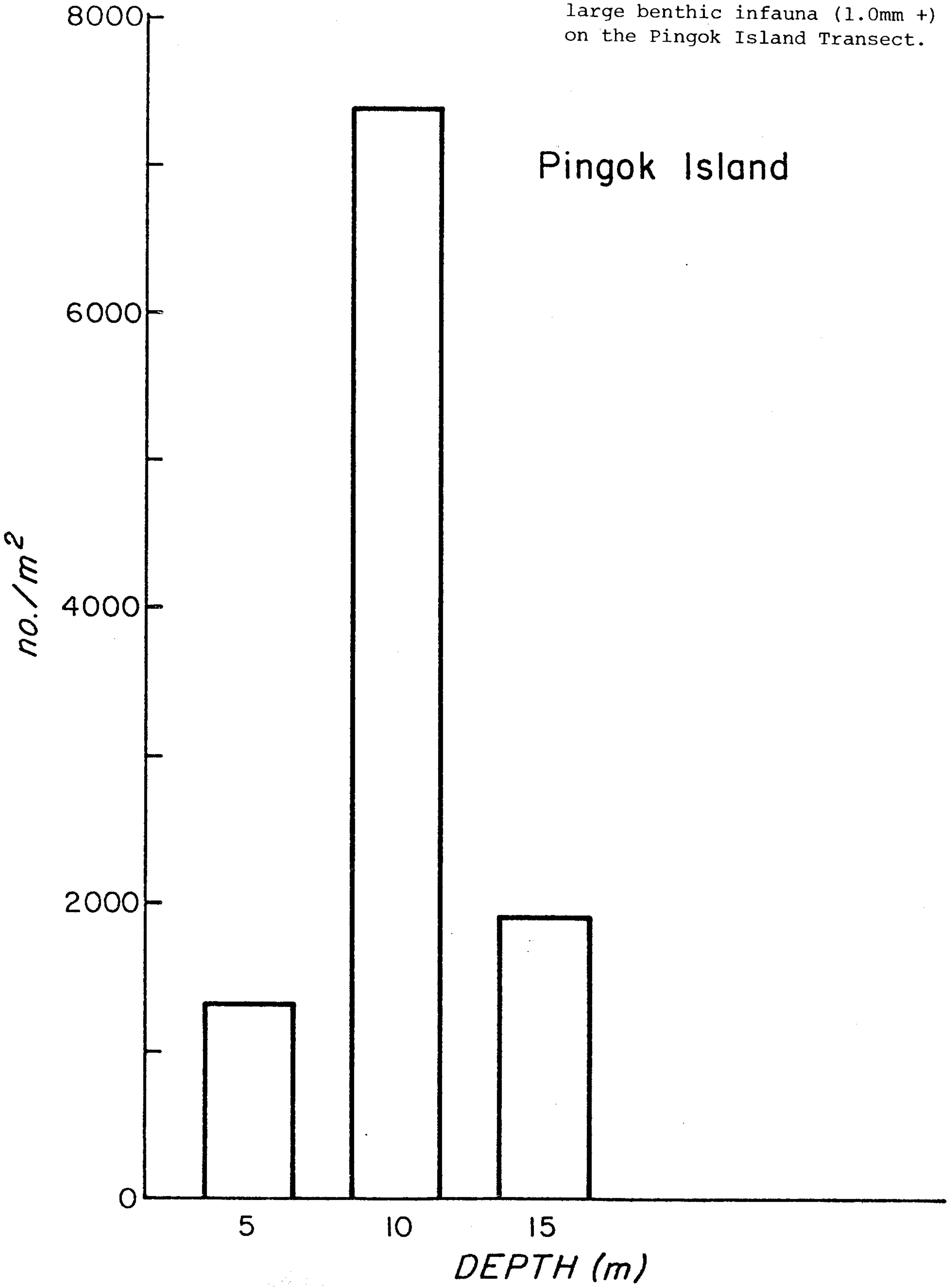


Figure 14. Coastal Zone. The abundance of large benthic infauna (1.0mm +) on the Narwhal Island Transect.

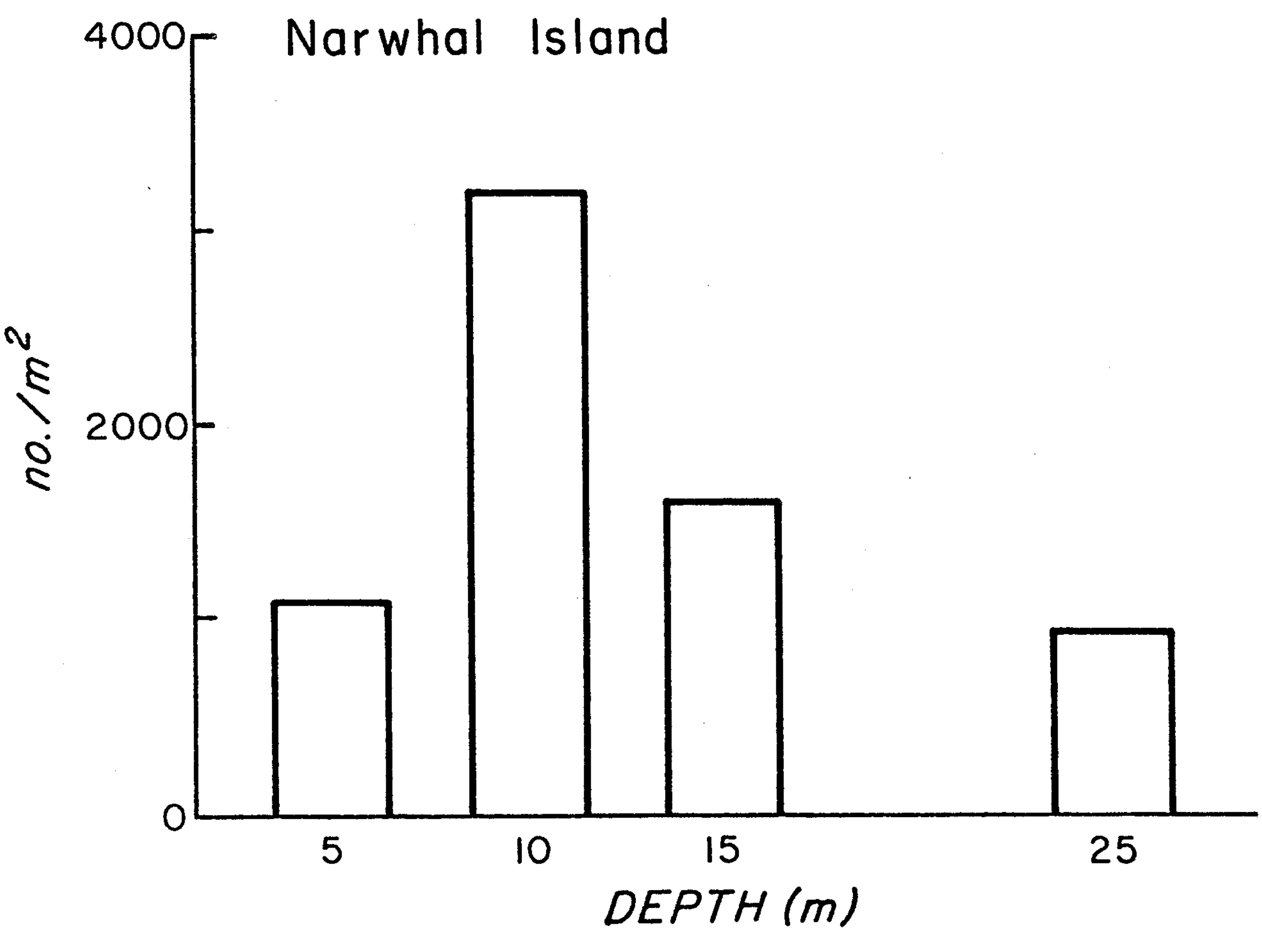


Figure 15. Coastal Zone. The abundance of large benthic infauna (1.0mm +) on the Barter Island Transect.

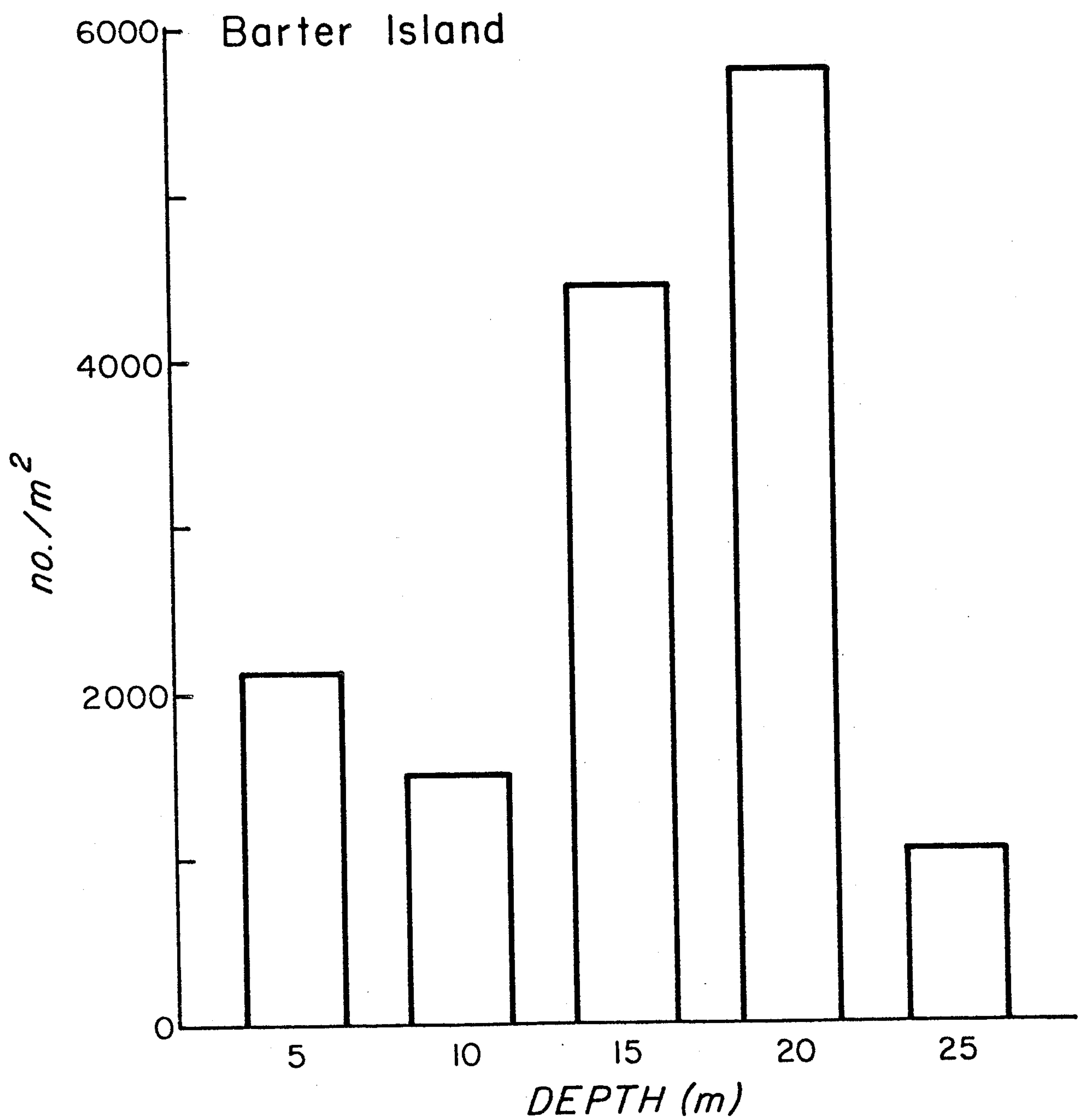


Figure 16. Coastal Zone. Biomass (grams preserved wet weight/m^2) of large soft-bodied benthic infauna (1.0mm +) on the Point Barrow Transect.

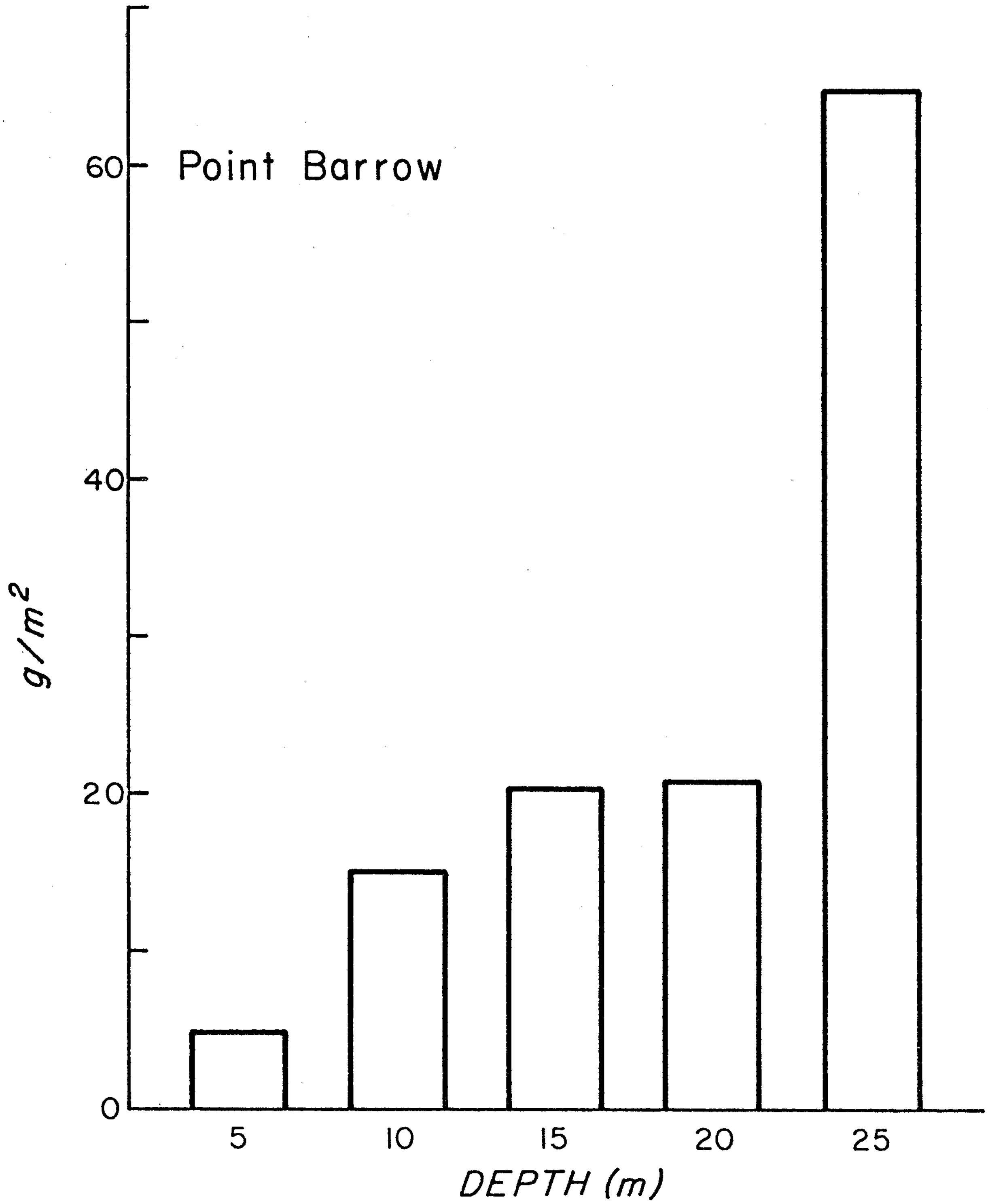


Figure 17. Coastal Zone. Biomass (grams preserved wet weight/m^2) of large soft-bodied benthic infauna (1.0mm +) on the Pitt Point Transect.

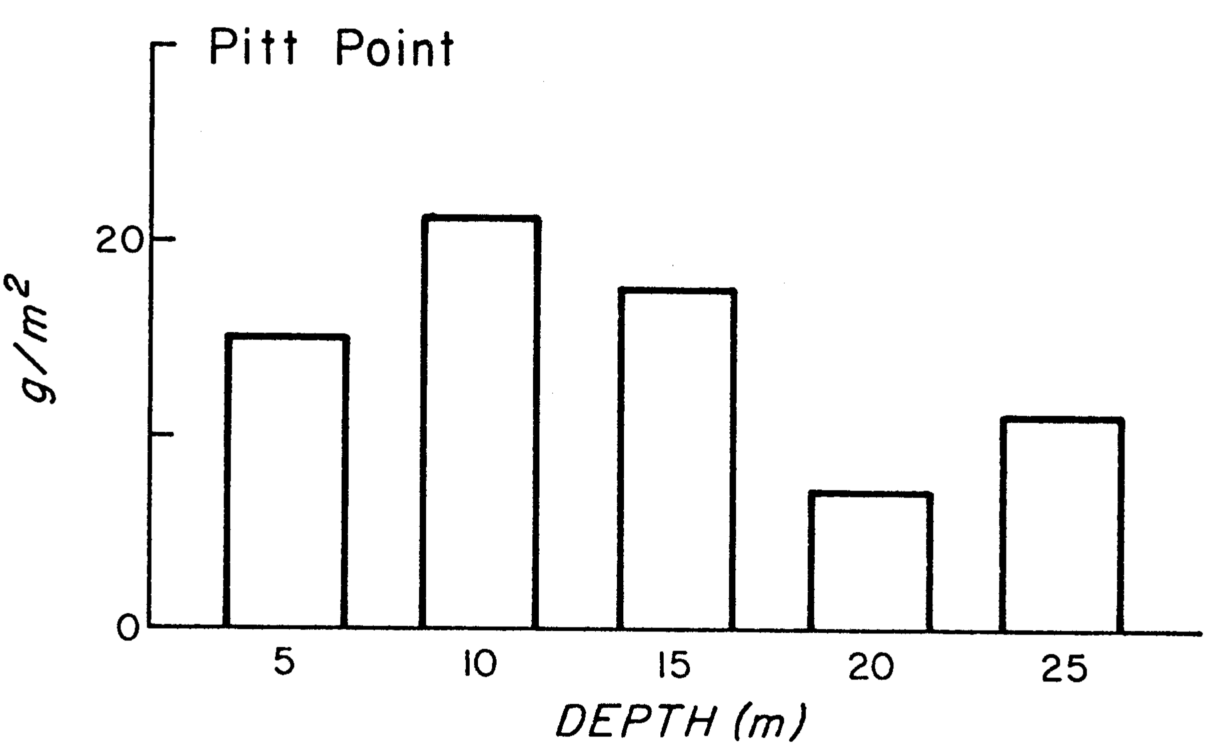


Figure 18. Coastal Zone. Biomass (grams preserved wet weight/m^2) of large soft-bodied benthic infauna (1.0mm +) on the Pingok Island Transect.

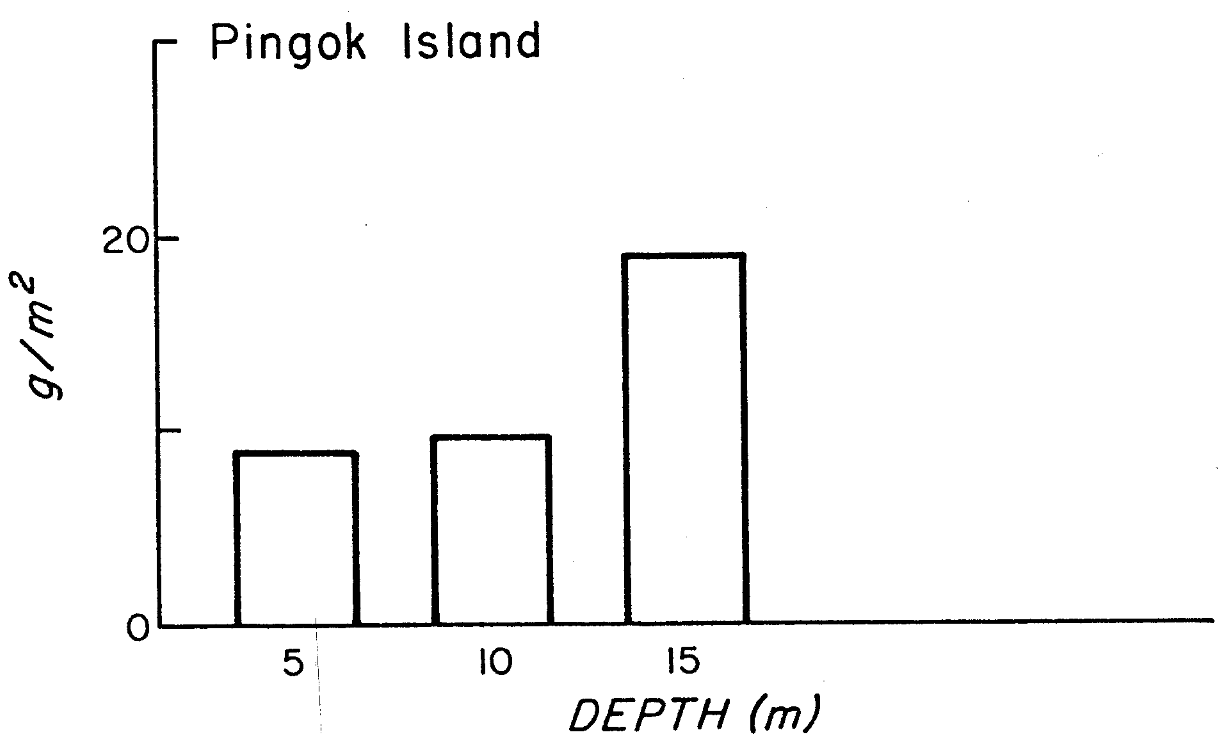


Figure 19. Coastal Zone. Biomass (grams preserved wet weight/m^2) of large soft-bodied benthic infauna (1.0mm +) on the Narwhal Island Transect.

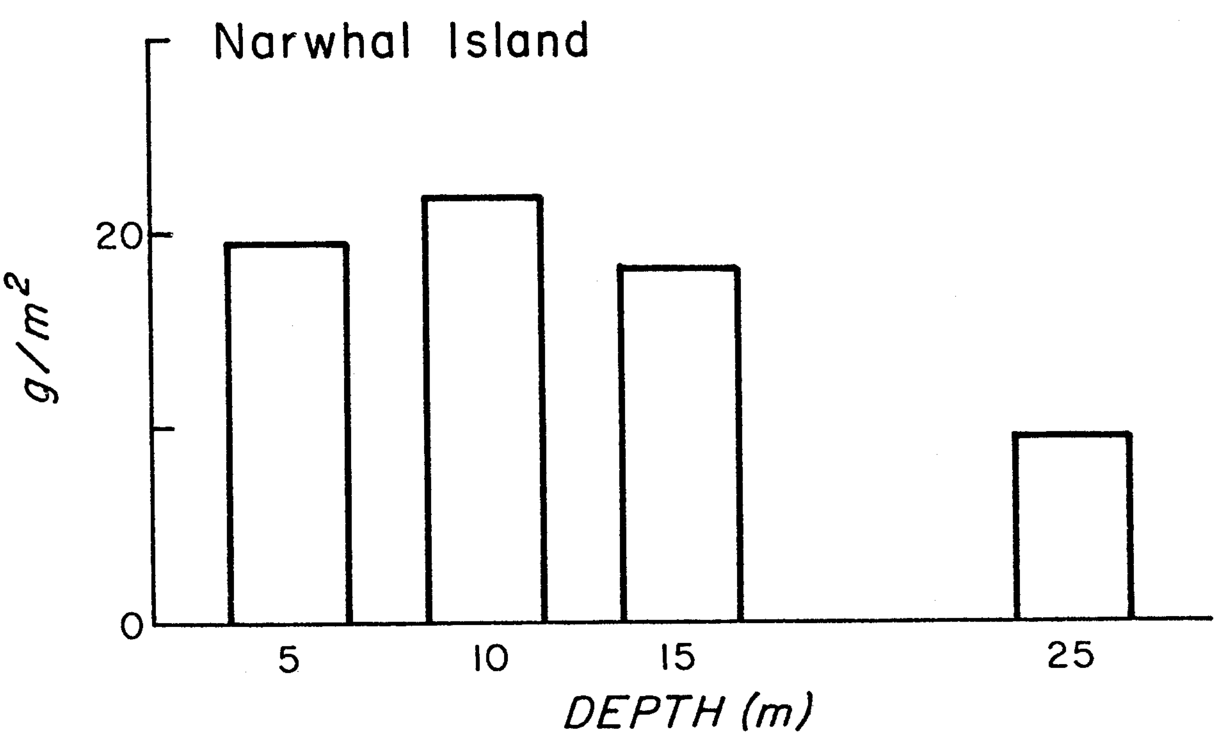
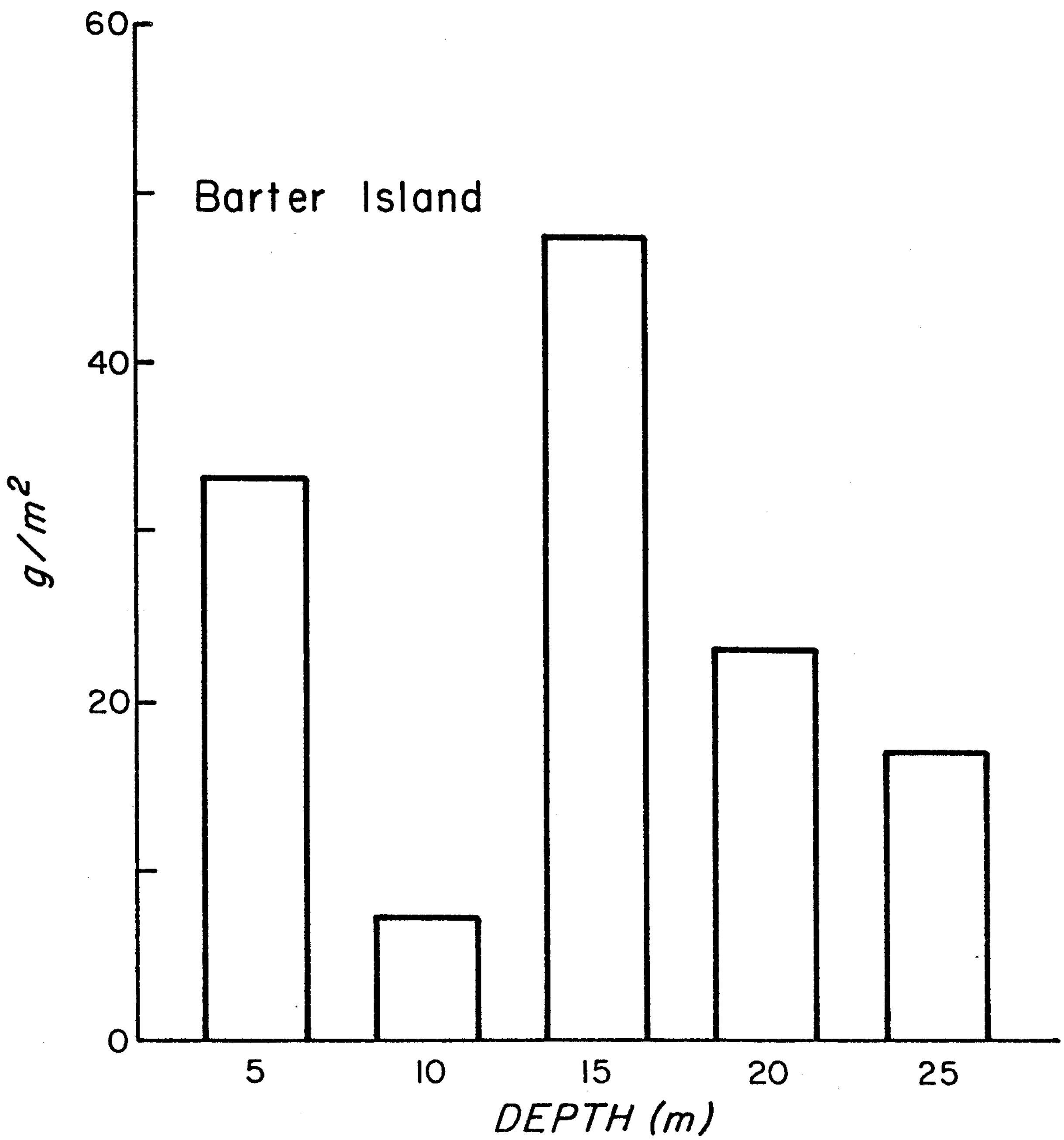


Figure 20. Coastal Zone. Biomass (grams preserved wet weight/m^2) of large soft-bodied benthic infauna (1.0mm +) on the Barter Island Transect.



VI. D. Shelf Fauna (5-100 meters depth)

By compiling stations taken during the two summer 1976 cruises (OCS-4 and OCS-5), two shore to shelf-break transects can be constructed (Figure 21). On the Pitt Point Transect, the trends in numerical density of the large macro-infauna indicate a maximum in abundance at the shallowest and the deepest depths (Figure 22). A bimodal pattern is also evident on the shorter transect off Narwhal Island near Prudhoe Bay (Figure 23). These two transects accentuate a minimum numerical density occurring at intermediate depths around 15-20 meters.

It is evident that several processes are probably in operation across the shelf. The nearshore zone often has concentrations of peat-like detritus. The minimum lies within the sea ice shear zone, the most active area of ice pressure ridging and bottom gouging. Ice encroachment on barrier islands may also depress the abundance of the nearshore fauna. The Narwhal Island data may be a result of this scour, as the pack ice generally rides up over the shoreline of the island.

E. Bathyal Fauna

Eleven deep-sea stations were occupied during the 1977 summer cruise (OCS-7) on board the USCGC GLACIER (Figure 1).

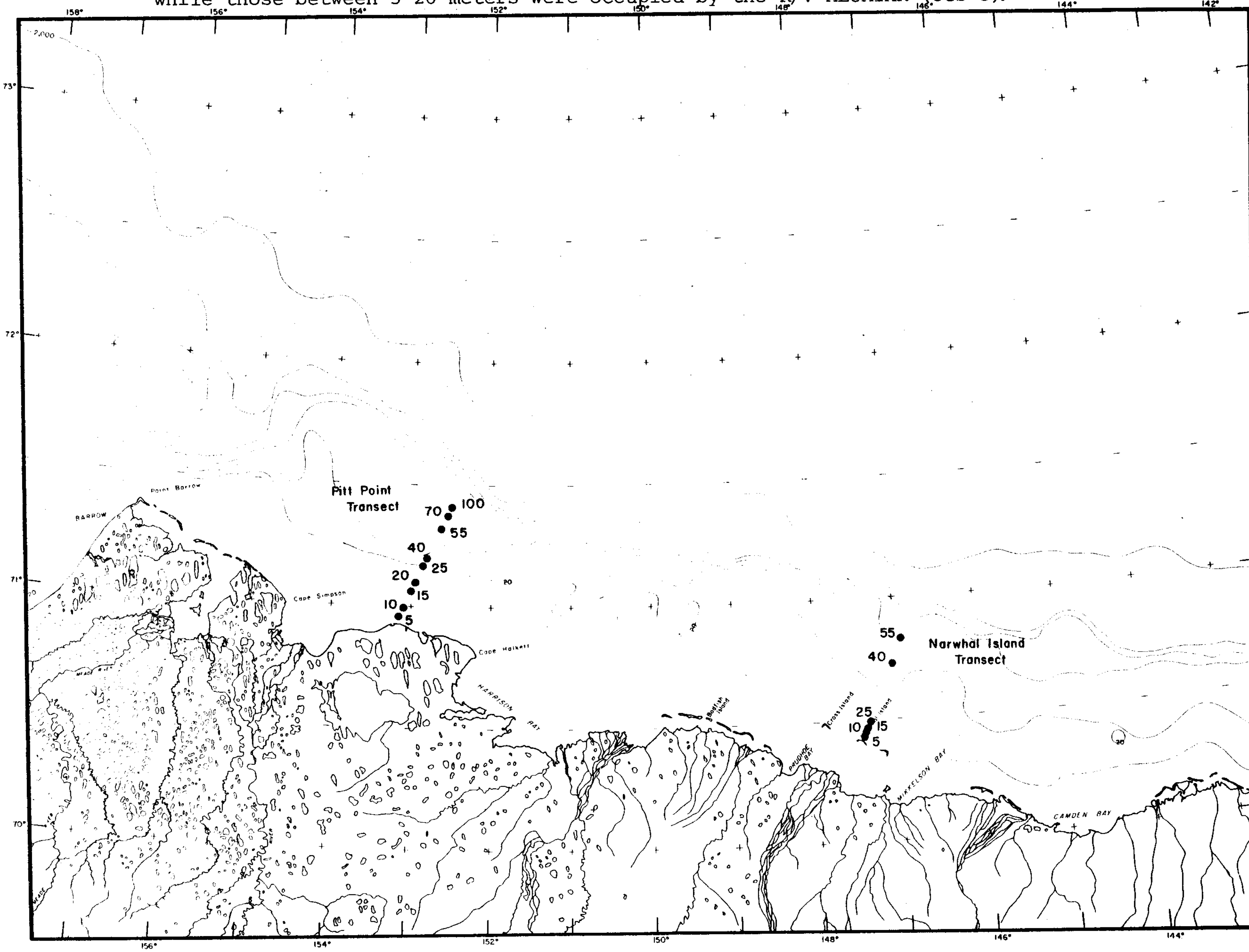
The numerical density of the benthic infauna (0.5mm +) decreases markedly with depth from $2400/m^2$ at 650 meters to $120/m^2$ at the four deepest stations (3300-3800 meters). There is a general trend toward a decrease in the size of the organisms with depth (Figure 24).

Over the depth range sampled the biomass of the larger infauna (1.0mm +) spans three orders of magnitude. The standing stocks decrease markedly with depth from 10 g (wet preserved weight)$/m^2$ at stations shallower than 1000 meters, to 1-5 g/m^2 between 1000-3000 meters depth, to 0.1-0.7 g/m^2 at depths greater than 3000 meters (Figure 25).

F. Temporal variability of benthic infauna across the continental shelf on the Pitt Point Transect (Extracted from unpublished manuscript: Carey, Ruff, and Montagna. Submitted to SCIENCE).

Large standing stocks of macro-infauna, equivalent to those of many temperate environments, have been found across much of the Beaufort Sea continental shelf off the Alaskan north coast (1). It has been generally assumed that this arctic environment, in contrast to analagous regions in the shallow Chukchi Sea to the west and in the Antarctic, supports a very low energy ecosystem. Low standing stocks and production rates have been recorded previously in the Beaufort Sea for both phytoplankton and zooplankton (2). The large populations of benthic invertebrates encountered on the shelf were, therefore, expected by us to exhibit low biological activity and to be in energetic equilibrium with the low inputs of nutritive material (1). It was anticipated that the biomass and total numerical abundance of the benthic community would not vary significantly throughout the year.

Figure 21. Sample locations occupied during the summer of 1976. The station designation is indicative of the water depth. Stations at 25 meters or deeper were occupied by the USCGC GLACIER (OCS-4), while those between 5-20 meters were occupied by the R/V ALUMIAK (OCS-5).



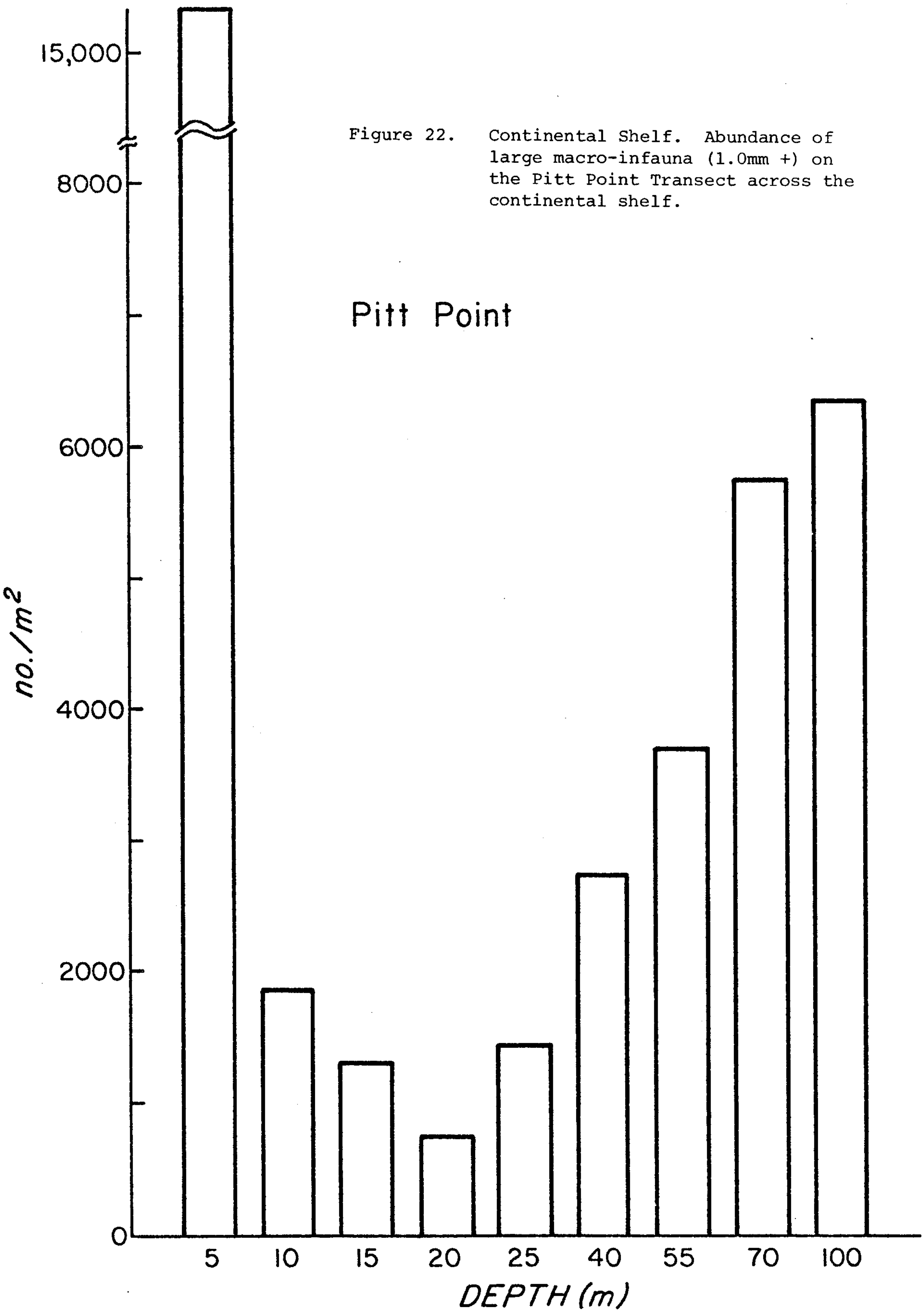


Figure 22. Continental Shelf. Abundance of large macro-infauna (1.0mm +) on the Pitt Point Transect across the continental shelf.

Figure 23. Continental Shelf. Abundance of large macro-infauna (].0mm +) on the Narwhal Isalnd Transect across the inner half of the continental shelf.

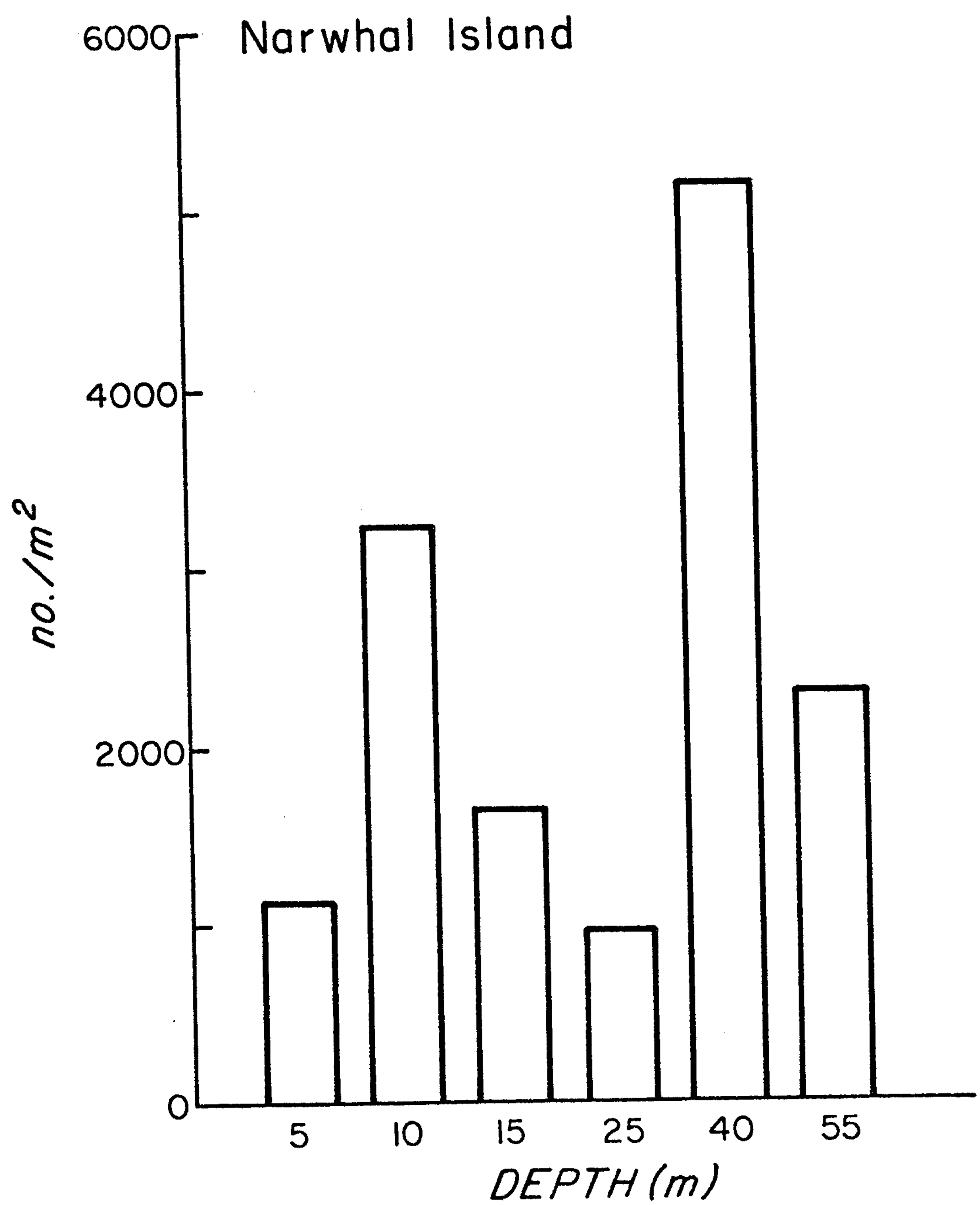


Figure 24. Bathyal. Abundance of the macro-infauna on the Demarcation Point Transect down the continental slope. Note the importance of the small macrofauna (0.5-1.0mm).

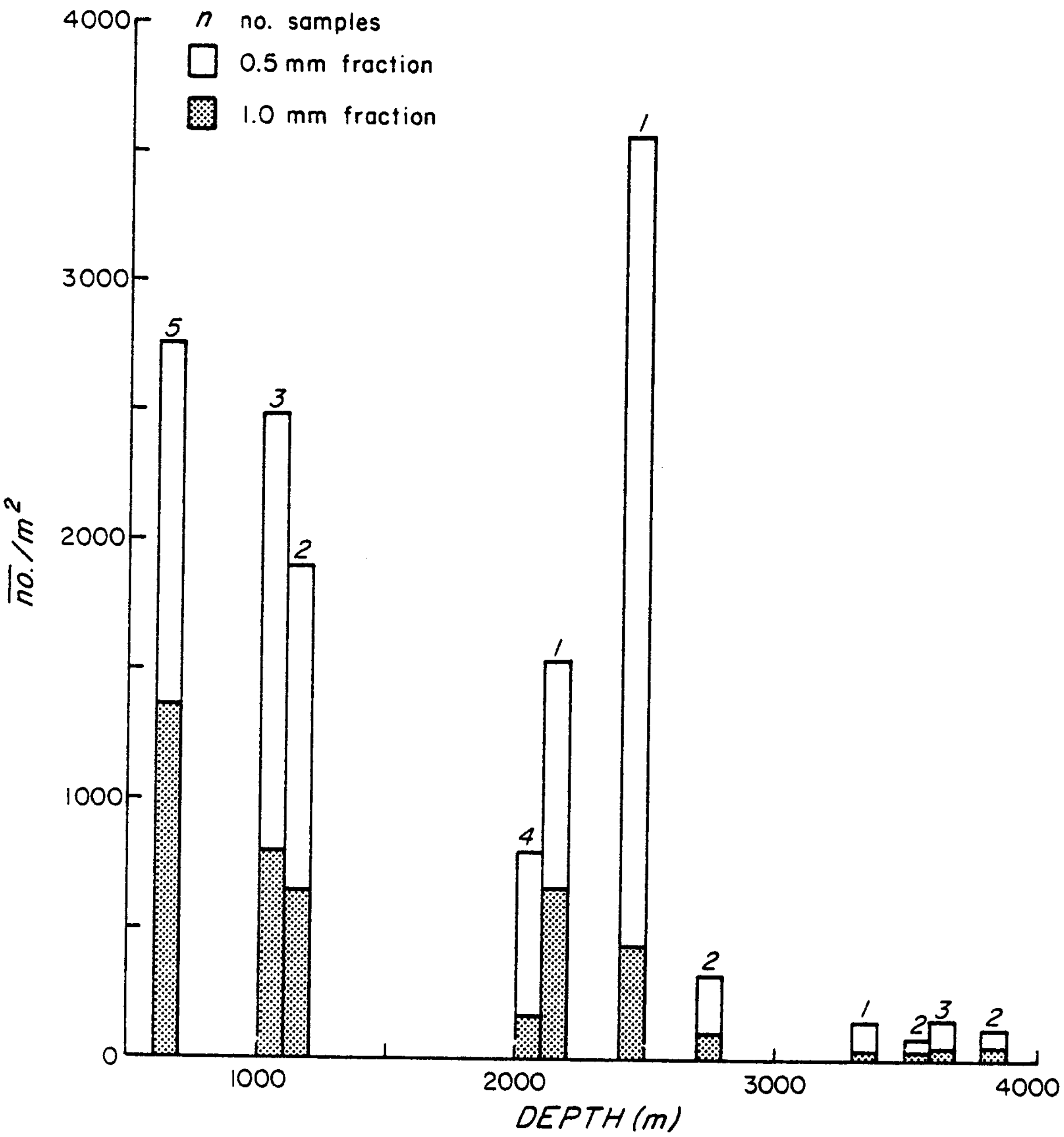
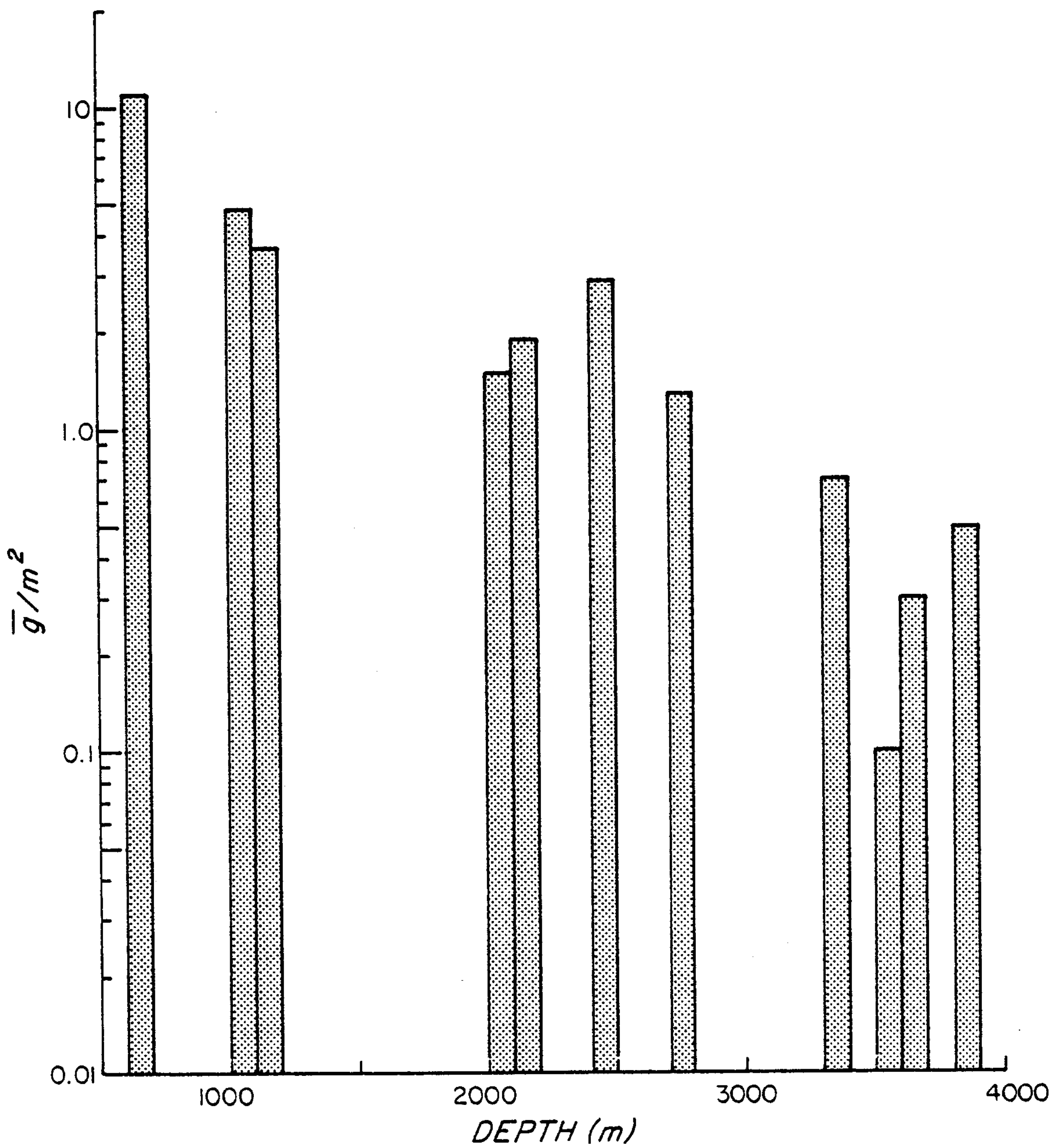


Figure 25. Bathyal. Biomass of the large macro-infauna (1.0mm +) on the Demarcation Point Transect down the continental slope.



VI. F. (continued)

Findings from samples taken seasonally across the Beaufort Sea continental shelf in 1975-76 strongly contradict these expectations. Changes in both the total numerical density and the soft-bodied infaunal biomass within the benthic population at stations on the middle and outer shelf were encountered. The magnitude and periodicity of fluctuations in numerical abundance are indicative of an annual reproductive cycle with a large peak in recruitment, and the temporal variability in biomass suggests possible seasonality. Similar changes are not found at the shallowest shelf station, indicating that different processes are operating there. The seasonal changes exhibited by the Beaufort Sea benthic community have compelled us to re-evaluate our concept of the productivity of this Arctic ecosystem.

At Stations PPB-55, PPB-70, and PPB-100 on the outer portion of the continental shelf the benthic assemblages showed marked variations in numerical density (Figure 26 and Table 5). Though these are not synchronous trends at all three depths, they appear to be periodic and are indicative of annual reproductive cycles. The average trends for these stations demonstrate an increase in animal numbers through the spring with a maximum of 8,500/m^2 reached in May and a subsequent decline occurring through the summer and fall. Presumably the spring increase in density is caused by recruitment to the (>1.0 mm) benthic community beginning early in the season. During the picking/sorting phase in the laboratory, we observed a much greater proportion of small individuals in the May samples than at any other time of the year. The summer-fall decrease in numerical abundances implies high mortality rates, caused perhaps by predation and/or competition.

Temporal changes in biomass were not as marked as those in numerical abundance, but the trends were strongly suggestive of seasonality (Table 5 and Figure 27). The biomass maximum appeared in August, not in May when peak densities occurred. This increase could be caused by growth of individuals after their recruitment to the benthic populations in the spring. The high growth rates that would have to exist to cause this seasonal increase are in contrast to the slow growth rates reported for Antarctic invertebrates (5).

Average trends in gross structure suggest that the benthic communities on the outer continental shelf of the Beaufort Sea are dynamic and undergo distinct seasonal cycles. Numerical density and biomass return to similar levels from one year to the next. Previous ideas concerning the benthos and their role in the ecosystem should now be questioned and further hypotheses suggested. From our data and observations we conclude that temporal cycles on the scale of seasons exist for infaunal numerical density.

In contrast to the outer shelf, the total yearly range in infaunal abundance at the shallowest station PPB-25 varies within narrow limits (Table 5). The amplitude of range for both indices is low, variances are high, and no seasonal trends are evident. The numerical densities of macro-infauna at the 40=meter station are similar to those at PPB-25, but because of the lack of fall samples from either year, it is difficult to determine whether these changes in gross structure are random or cyclic at this depth.

Figure 26. Numerical density of macro-infauna (1.0mm +) at standard stations at 5 sampling periods. Station PPB-40 is considered transitional and consists of 3 data points; it has been omitted for clarity. Each point represents an average of 5 samples. The solid line is the mean trend for the 3 outer stations.

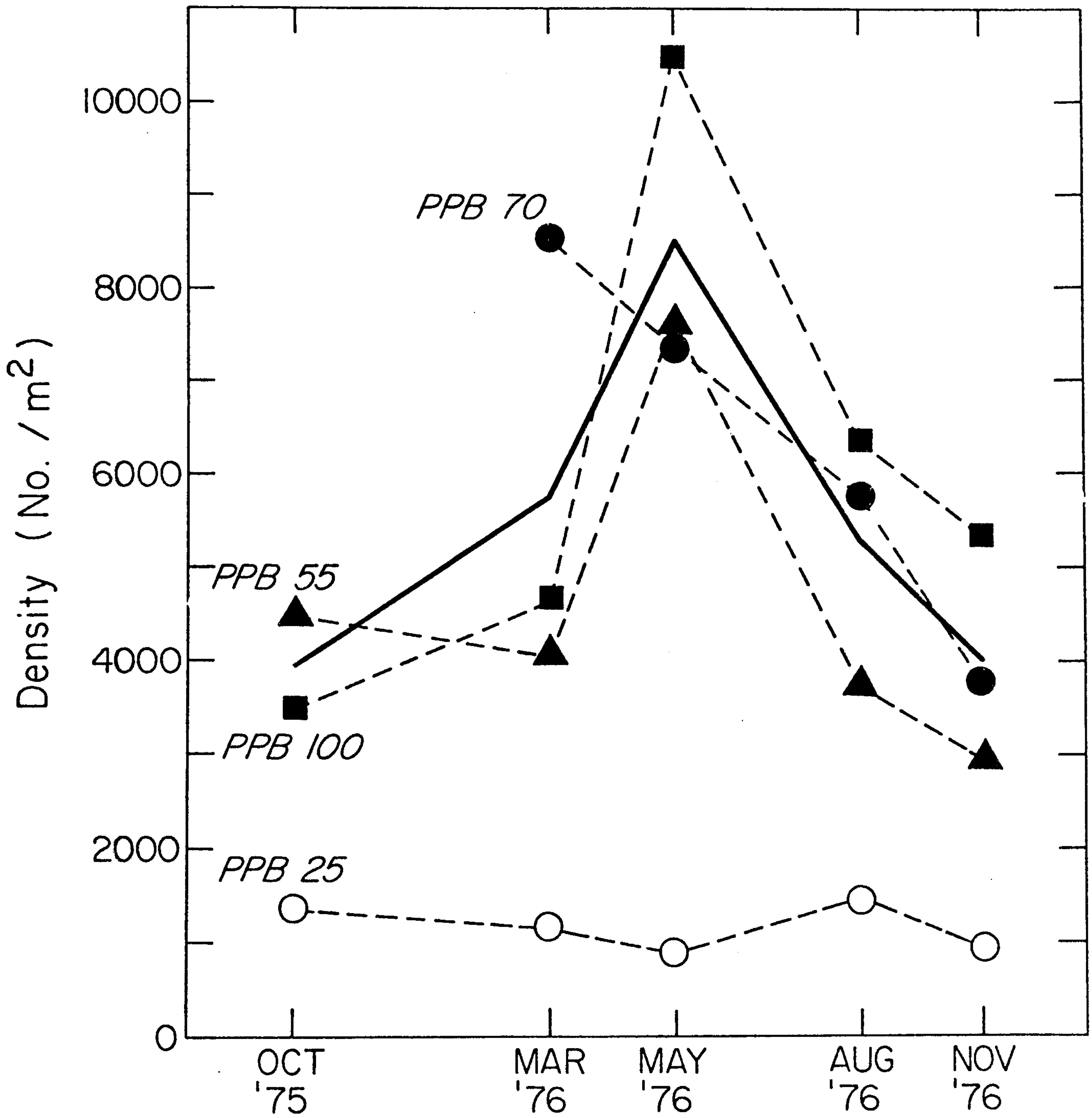


Table 5. Numerical density and biomass (g wet-preserved wt.) of benthic infauna at standard seasonal stations across the southwestern Beaufort Sea continental shelf. Data are averages with standard deviation of 5 samples per station. P is the probability that the seasonal means for a station are not equal (one-way analysis of variance). PPB = Pitt Point Benthos; station numbers designate depth in meters.

Shelf Sta.	Oct. 75 (no/m^2) (g/m^2)	Mar. 76 (no/m^2) (g/m^2)	May 76 (no/m^2) (g/m^2)	Aug. 76 (no/m^2) (g/m^2)	Nov. 76 (no/m^2) (g/m^2)	P
Inner	1,342±577	1,140±556	882±471	1,468±397	924±68	0.94
PPB-25	20.4±16.6	8.3±4.9	22.1±19.0	11.0±2.5	25.2±8.1	0.85
Trans.	---	632±319	936±197	2,768±478	---	1.00
PPB-40	---	4.7±3.3	27.8±8.5	59.5±21.5	---	1.00
Outer	4,472±1,831	4,044±2,352	7,654±4,620	3,722±927	2,942±1,400	1.00
PPB-55	31.4±10.6	20.9±5.8	21.1±5.9	67.8±13.3	25.4±11.0	0.94
PPB-70	---	8,526±5,528	7,382±3,410	5,772±1,092	3,756±496	1.00
	---	32.3±5.8	44.7±20.8	71.4±19.1	29.4±5.9	0.84
PPB-100	3,490±3,346	4,616±2,238	10,466±2,740	6,368±1,014	5,332±424	0.92
	40.2±35.3	34.8±10.4	61.2±32.0	39.6±6.5	57.5±5.8	1.00

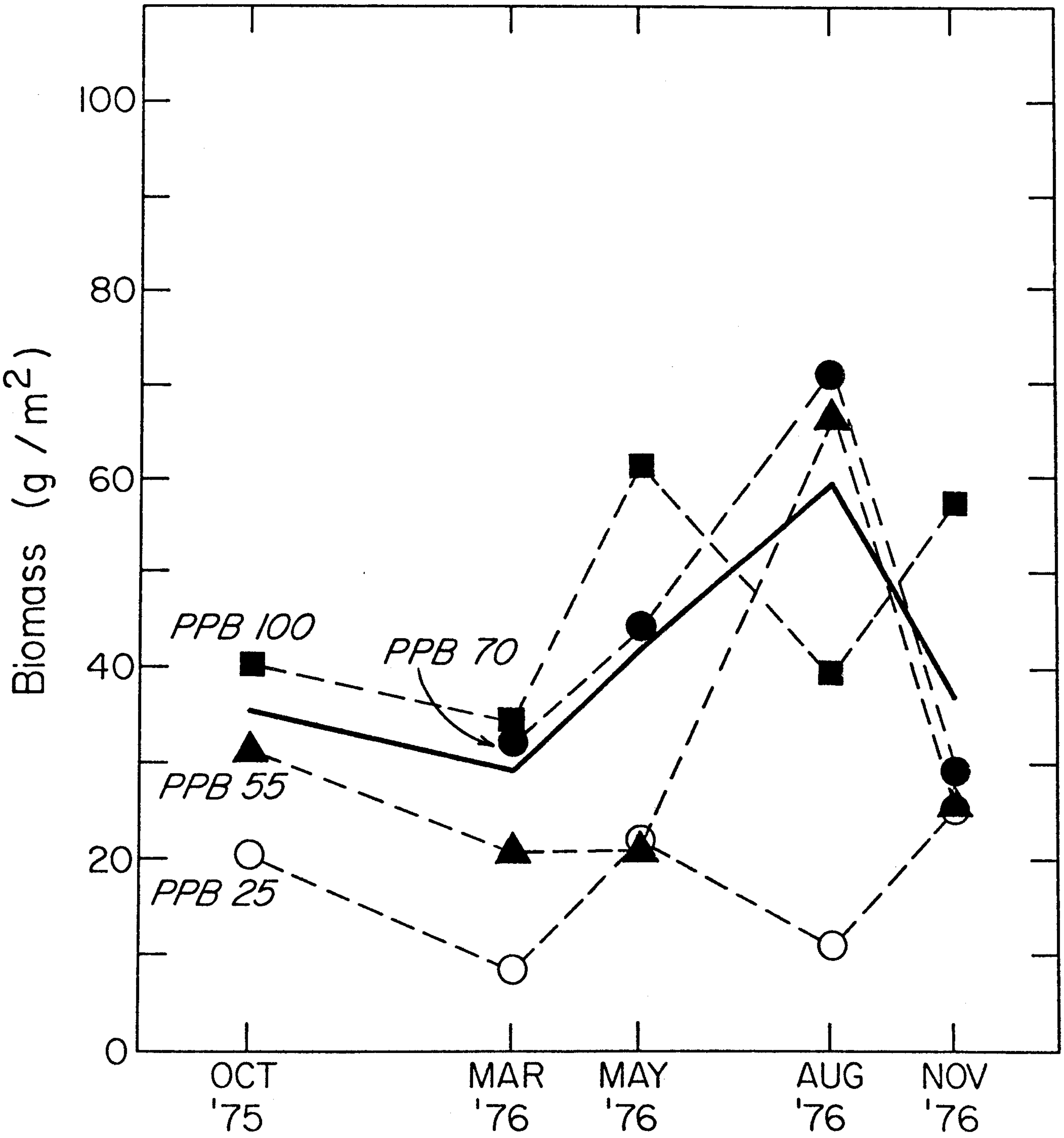


Figure 27. Biomass of soft-bodied infauna (grams wet-preserved weight) at standard stations at 5 sampling periods. Station PPB-40 is considered transitional and consists of 3 data points; it has been omitted for clarity. Each point represents an average of 5 samples. The solid line is the mean trend for the 3 outer stations.

Based on the amplitude and temporal pattern of total numerical abundance we can classify the benthic communities along the Pitt Point line into an inner- and an outer-shelf group. This abundance index varies within narrow limits at the inner-most station while it exhibits a broader range with distinct seasonal maxima and increasing statistical significance at the three deepest stations. Since the shallowest station lies within the active ice gouging zone, we suggest that this inner-shelf community is adapted to episodic destruction and is characterized by the presence of opportunistic species with asynchronous reproductive cycles that are not closely coupled to the other biological cycles around them. We suggest that the reproductive capacity of animals at the shallow station is influenced by the physical disturbances and that at the deeper stations it is accomodated to a seasonal food input. The benthic community at PPB-40 at the outer edge of the ice gouging zone is a transitional environment and could be expected to be comprised of a spectrum of species with a mix of life histories.

Food sources available to the continental shelf ecosystem could include: coastal benthic diatom production (6), tundra and peat erosion and continental run-off (1, 6), localized phytoplankton blooms induced by occasional coastal upwelling (8), diffuse and low level meritic phytoplankton production (4), advection of fauna and organics with the Bering Sea-Chukchi Sea water mass (8); and underice epontic diatoms (3, 4, 6). Except for the intrusion of the southern water mass, the neritic phytoplankton and the ice algae, these food sources are localized and influence only shallow lagoon or nearshore coastal environments. Though its areal extent and overall contribution to the ecosystem are unknown, carbon fixation by ice algae appears to be a likely energy source for the outer shelf biotic system. To account for the dynamic trends encountered within the benthic community, both a seasonal cue and an energy source capable of supporting annual benthic reproduction and recruitment are required. These conditions are met by ice algae. In the nearby Chukchi Sea, populations of these epontic diatoms begin to increase in April under very low ambient light intensities, reach maximum population densities and productivity in May, and decrease during the early summer. This underlayer of diatoms and associated biota sloughs off during the initial stages of ice melt and possibly sinks to the sea floor (6). Carbon fixation of ice algae per unit area during May can be ten times that of the later phytoplankton bloom in the water column (4, 7). Annual production is about 5 g C/m^2 off Point Barrow. Though not high when compared with more southern coastal areas, this may represent a major portion of the primary production in the offshore Beaufort Sea (4). Rapid sinking of the "inverted benthos" ice epontic community could carry much of this food rapidly through the pelagic zone and make it available to sea floor organisms during their period of recruitment.

In this report (submitted to SCIENCE) we have demonstrated significant average seasonal changes in basic community structure in the benthos that are probably caused by the collective annual reproductive cycles of the fauna. To drive these dynamics of offshore benthos, larger sources of energy are required than have been previously reported for the Beaufort Sea. We suggest ice algae as a likely cyclic food source that could make this Arctic ecosystem productive.

VI. F. (continued)

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G. Oregon State University Benthic Invertebrate Reference Museum

As part of the research program directed at the benthic infaunal organisms encountered on the Beaufort Sea continental shelf, efforts have been made to upgrade and consolidate the Oregon State University Benthic Invertebrate Reference Museum. This collection of arctic and North Pacific invertebrates is now housed in a separate, air-conditioned room adjacent to the benthic ecology laboratory, and is equipped with a dissecting scope, some pertinent arctic literature, and a desk to provide working space. In its present configuration, the collection has become an invaluable resource as a "biological library" for confirming or differentiating many of the difficult arctic invertebrate species being sorted from OCSEAP grab samples.

As of the last computer update (11 Jan 1978), the arctic portion of the benthic reference collection contains a total of 314 described species representing seven different phyla. Most of the identified specimens belong to the annelids, arthropods, or molluscs, since these three groups tend to predominate across the continental shelf in the Alaskan arctic. Efforts are now being initiated to examine some of the lesser groups, although a majority of taxonomic work still involves the identification of members of the three previously mentioned phyla. Generally, invertebrate species new to the collection are catalogued as soon as they are identified at Oregon State or are received from specialists. In addition, duplicates and other specimens representative of variations in morphology, depth, and range are entered into the collection whenever practical. Multiple specimens of each species make the reference museum a much more flexible and useful tool.

With this expansion of the invertebrate reference collection, the difficulties inherent in maintaining accurate cataloguing have grown increasingly complex. To cope with the mounting bookkeeping problems, computer data bases were developed to maintain the information pertinent to each specimen, mold this data into a standardized format which could be easily and routinely interpreted, and accommodate the expansion anticipated with continuous additions to the collection. These data bases are explained in specific detail in Appendix I . Generally, however, they allow us to store and retrieve all the relevent information for any specimen housed in the reference museum. All collection data and any secondary environmental data can be easily accessed. The correct scientific name, the reference to the original description, current or older synonyms, and the zoogeographic regions from which each species has been collected is maintained for every catalogued specimen. In addition, an index is provided which summarizes these specimens by taxa, keeping track of the number of species in the collection and listing internal checks which have detected any errors introduced into the system (Table 6). Room has been built into the data bases to allow for additional specimen information, which in the future will include data on sexual development, the names of specialists confirming particular identifications, and a bibliography of works specifically relevent to each species.

Where possible, species identifications have been made or confirmed by taxonomic specialists. The following authorities have had an input into upgrading the benthic invertebrate collection; or have agreed to examine particular groups:

Table 6 Computer data base summary index showing the number of identified taxa contained in the Benthic Reference Museum. When this index was compiled, there were 314 arctic species representing seven different phyla. Internal checks within the data base also revealed two catalogued specimens for which collection information was missing.

OREGON STATE UNIVERSITY BENTHIC ECOLOGY GROUP
DATE: 78/01/11 18.23.24 PAGE 32

OSU CODE	OSUBI CAT. NUMBERS	ARCTIC TAXA	N. PAC. TAXA	TOTAL TAXA	TOTAL NO. SPECIMENS
AA	632	145	120	259	1994
AB	33	0	15	15	208
AC	5	3	0	3	7
AD	2	0	0	1	17
AH	23	20	1	21	165
AI	2	2	0	2	32
AR	24	0	10	10	84
AU	91	34	0	34	268
DA	1	1	0	1	1
EA	4	2	0	2	42
EC	1	1	0	1	1
EE	31	1	3	11	93
EH	59	4	27	30	170
EO	95	12	12	43	575
FL	4	4	0	4	17
MA	5	0	5	5	3
MG	104	19	10	65	400
MO	8	3	4	7	20
MP	148	22	34	104	413
MS	24	0	8	8	169
TH	2	2	0	2	25
WM	205	39	152	152	796
XA	45	10	4	16	125
XC	1	0	0	1	1
XE	6	1	4	5	27
XM	11	2	1	6	34
TOTAL	1566	327	460	808	5692
DESCRIBED SPECIES	1503	314	451	780	5505

HIGHEST CATALOG NUMBER TO DATE: 1572

	MISSING CATALOG NO.	DUPLICATE CATALOG NO.
1)	1500	
2)	1501	

VI. G. (continued)

Dr. Charles E. Cutress University of Puerto Rico	-- anthozoa
Dr. Kristian Fauchald Allan Hancock Foundation	-- polychaetous annelids
Dr. Meredith L. Jones Smithsonian Institution	-- polychaetous annelids
Mr. Christer Erseus University of Goteborg, Sweden	-- oligochaetous annelids
Dr. Jean Just Universitets Zoologiske Museum, Denmark	-- gammarid amphipods
Dr. Diana Laubitz Museum of Natural Sciences, Ottawa, Canada	-- caprellid amphipods
Dr. Bruce C. Coull University of South Carolina	-- harpacticoid copepods
Dr. Norman S. Jones University of Liverpool, England	-- cumacea
Dr. Joel Hedgpeth Oregon State University (Emeritus)	-- pycnogonida
Dr. James H. McLean Natural History Museum, Los Angeles	-- gastropoda
Dr. Frank R. Bernard Pacific Biological Station, Nanaimo, Canada	-- pelecypoda
Ms. Amelie Scheltema Woods Hole Oceanographic Institution	-- solenogaster
Dr. G. Arthur Cooper Smithsonian Institution	-- brachiopoda
Dr. Leonard Soroka St. Cloud State University, Minnesota	-- bryozoa

With more identified specimens being returned from taxonomic specialists, the function and value of the benthic reference museum has expanded. The collection room provides a centralized location where the specimens can be properly stored and maintained. Temperature control, periodic curation, and removal of specimens from the collection can be routinely monitored. The collection also provides a nucleus of well-preserved specimens which will be valuable for anticipated reproductive studies. The major advantage of the benthic reference museum, however, is in its service as a working taxonomic library which

VI. G. (continued)

is readily available to the members of the Oregon State benthic group. It is a high-powered research tool which permits the examination of a variety of difficult questions concerning the taxonomy and ecology of the arctic invertebrate fauna. As such, the Oregon State University Benthic Invertebrate Reference Museum is an indispensable resource which continues to expand in scientific value.

VII. Discussion

From the data accumulated during the past year, it is evident that there are seasonal, offshore-onshore, and geographic patterns in the structure of the southwestern Beaufort Sea benthic infaunal communities.

Perhaps the most significant and surprising finding is the seasonality observed in the outer continental shelf communities. The abundant fauna appears to have a significant increase in numerical abundance in May with less marked change in biomass by the end of the summer. Because of the observed increase in small organisms with the communities in the late spring, recruitment to the populations (>1.0 mm) is a reasonable explanation for this phenomonon. Growth individuals would explain the increase in biomass observed in the August samples. There would also have to be high rates of mortality to explain the decrease during the late summer-early fall.

The implications to be derived from these results describing a biologically active fauna in an arctic region with low primary production are intriguing. These results imply a more productive Beaufort Sea ecosystem than previously thought. The average results point to the need for detailed life history studies of the most abundant species now on hand. Further field research to describe these seasonal changes in more detail and to measure usable carbon inputs to the ecosystem are also called for. Ice algae production and tundra peat detritus inputs are potential sources that should be defined throughout the year.

The abundance patterns of the larger benthic infauna (>1.0 mm) in the coastal zone demonstrate a nearshore maximum in numerical density with an intermediate low and an offshore maximum. Hypotheses for processes that maintain these patterns are suggested by the bimodality of numerical density and correlations with environmental festures. The abundance peak nearshore may be caused by inputs of detrital peat from coastal erosion and river run-off, while that near the edge of the shelf may be the region where the lower current energies allow oceanic detritus and fine sedimentary particles to settle out. The abundance low is strongly correlated with the sea ice shear zone region. It is not known how long-lasting the destructive effects of ice scour are; it is possible that such scours would take a long time to recover previous sedimentary cover and characteristics owing to the low sedimentation rates on the arctic Alaskan shelf.

VII. Discussion (continued)

Preliminary analysis of the distribution and abundance of polychaete species indicate that the eastern and western regions of the research area are different ecologically. The numbers of species and number of specimens at each station along the 3 transects summarized to date demonstrate a striking similarity between the 2 eastern transects and the contrast in pattern of the transect off Cape Halkett. Previous research (Carey 1977 Final Rpt. T.O. #4) has shown the uniqueness of the Barter Island area.

VIII. Conclusions

1. The benthic communities on the outer continental shelf undergo seasonal changes in numerical density and biomass. (Reasonably Firm)

2. The benthic infauna (>1.0 mm) are at maximum abundance nearshore and on the outer shelf with a minimum at 15-25 meters depth. (Reasonably Firm)

3. Gammarid amphipod species are influenced by depth; an inner, middle, and outer shelf fauna can be distinguished across the continental shelf off Pitt Point. (Reasonably Firm)

4. Polychaete worms are more abundant nearshore near the Barter Island region, and offshore to the west near Cape Halkett. (Reasonably Firm)

5. Environmental features most influencing the benthic invertebrate communities on the Beaufort Sea continental shelf include sediment type, depth, nearshore salinity, river and lagoon detritus export, organic inputs, ice gouging, and predation. (Preliminary)

APPENDIX I

Documentation of computer programs for Data Base Management (DBM System)

INTRODUCTION

The primary purpose of this document is to teach people how to code field and laboratory data on to computer cards, and how to organize these cards to satisfy the input requirements of the data base management (DBM) system. The DBM system is comprised of two data bases (BUG and MUD) and one computer program to manage each data base (programs STUFF and CRAM).

Before learning to code data some basic understanding of the structure common to data bases, and how the data bases and DBM programs interact is needed. Following that discussion each DBM program will be discussed in detail where the coding procedure will be specified. The documentation is not intended to give a thorough description of the programs STUFF and CRAM. Information about these programs is only given to help the coding procedure along.

After reading this manual one should be able to create and edit the information in either of the data bases using the directive cards read by the DBM programs.

GENERALIZED DATA BASE STRUCTURE

Terminology used to explain the structure of a data base can be confusing, but with the aid of Figure I and the glossary the following description will hopefully be understandable. A data base has a beginning, a middle, an end, and a primary key, only the latter may not be obvious. The primary key performs the same function for a data base as the Library of Congress number plays in a library. Without the Library of Congress number the library would be a hopelessly confused collection of books, with no systematic way of finding a book or reshelving a borrowed book. The primary key has two crucial characteristics: 1) it has a defined minimum and maximum value that specifies its range, and 2) it has an implicit order (e.g. numerically increasing). The analogue to books in a library are sections, whose order in the data base is determined by the value of its primary key. The first section of the data base is called the header section, which has a primary key equal to the key's defined minimum value. This section contains only a primary key. The next zero to many sections is where data is stored in the data base. Each section represents some independent entity (e.g. sample, or species) and contains the primary key in addition to other information collected. The last section in the data base is called the trailer section, which has a primary key equal to its maximum value. The trailer section signals the end of the data base and does not contain any other information. The header and trailer sections define the bounds of the data base and together form the minimum requirements to be called a data base.

THE ROLE OF DBM PROGRAMS

Now that the basic structure of a data base has been explained the next question is how does the DBM program use this structure? The purpose of the DBM programs is to create an edited data base (NEW data base) by combining the information in an existing data base[1] (OLD data base), with the card input read by the DBM program. The manual's prime concern is describing how the input cards are coded, and organized. To be more specific NEW is generated in roughly the following

BUG

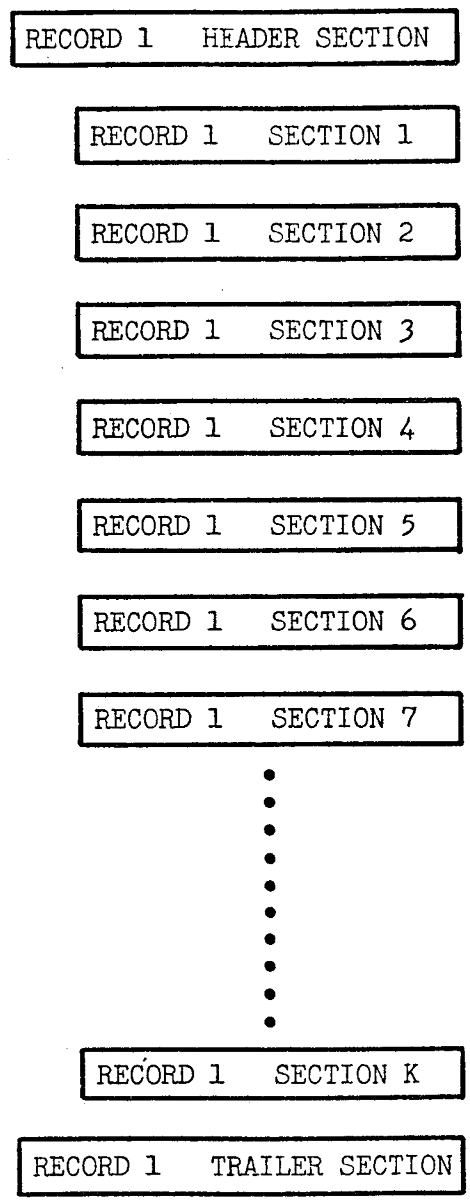
RECORD 1 HEADER SECTION
RECORD 1 SECTION 1
RECORD 1 SECTION 2
RECORD 1 SECTION 3
RECORD 1 SECTION 4
RECORD 1 SECTION 5
RECORD 1 SECTION 6
RECORD 1 SECTION 7
RECORD 1 SECTION K
RECORD 1 TRAILER SECTION

FIGURE I

manner. The header section is read from OLD and transferred to NEW. DBM program then begins to read input cards (also called directive cards) which contain: 1) a primary key, 2) a directive character, and 3) information to be stored. Sections are transferred from OLD to NEW until a primary key is found in OLD that equals or is greater than the primary key read on the input cards. A decision is made to determine if the section last read from OLD should be modified (primary keys equal) or a new section be inserted in NEW. The directive character signals what information is on the input card, which is stored into the appropriate variables in the section. The sequence of events is then repeated for the next input card, starting with the search for a primary key greater than or equal to the primary key on the input card. After all the input cards have been read the remaining sections in OLD, including the trailer section, are written on NEW. In the end you have two data bases. The original data base (OLD) has not been changed, but the second data base (NEW) is identical to OLD except for those sections that were modified, created or deleted by the directive cards.

PROGRAM STUFF

The taxonomic data base (BUG) can now be discussed in more detail. It has the simplest structure, each section is composed of one record that contains all the information about a taxonomic group. The term "taxonomic group" is purposely broad, it can refer to a described species, organisms lumped together at a higher classification (e.g. phylum, class, order, etc.) or even gross qualitative labels (e.g. detritus, unknown, eggs, etc.), any category that is judged to be necessary to sort and identify a sample. Each taxonomic group is assigned a unique OSU code which is the primary key for the BUG data base and is used to identify which section (taxonomic group) you want information about. The Sample data base (MUD) uses BUG as a repository of the most up-to-date information about a taxonomic group. This allows many minor taxonomic changes such as name changes, range extensions, addition of auxillary codes, or addition of OSUBI catalog numbers to be incorporated into the BUG data base when necessary but requiring no changes in the MUD data base. The following paragraphs describe the procedures and formats required by STUFF to manage the information in BUG. Information about the various codes, directive cards, file names, input structure, and diagnostic error statements will be covered to assure an adequate working knowledge necessary to use program STUFF.

CONVENTIONS AND CODES

The OSU code is the primary key for the BUG data base. The code consists of a two letter initial and a three digit number that are combined to form the five character OSU code. The initial protion of the code contains taxonomic information, a two letter combination is assigned each category of a rather arbitrary, but specified, taxonomic classification system. As an example, all amphipods would be given OSU codes that start with AA, and all polychaetes have codes that start with the two letter combination WM. To make the two letter

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[1] These programs can insert new sections into a data base, but cannot create a data base from scratch. The programs require an existing data base as input.

combinations unique a three digit integer is added to produce a code that conveys some taxonomic information but avoids many of the shortcomings of pure taxonomic codes. The OSU code has several limitations on how it is written. The code contains no blanks, is always five characters long, and the integer number must be right justified with zero fill if necessary.

OSU CODE EXAMPLES

Valid codes	Illegal codes
AB132	AA 3
AA001	ABC02
XA042	A0003
XX008	AB0004
	$C001

One of the characteristics of a primary key is an implicit order.[2] The order is determined alphabetically by the first two characters of the code and then numerically by the last three characters.

The program places several other constraints on the input. Taxon names and the original describing references can be no longer than 40 characters each. When these two data items are entered on the "*" directive card, the taxon is written first starting in the first column of the field. The name cannot have more than two consecutive blanks, the reason will be evident shortly. After the last character of the taxon name, two blanks must follow before the original describing reference is started. The field is only 60 characters long so a problem can occur if the number of characters in the two data items is greater than 58, they simply will not fit on one "*" directive card. To solve this dilemma two "*" directive cards must be used. One card has only the taxon name in the field starting in the first column, and the other card leaves the first two columns of the field blank, followed by the original describing reference.

There are other conventions used in coding that should be mentioned. Some of the taxonomic groups have representative individuals in the Oregon State University Benthic Invertebrate (OSUBI) reference collection, for which the BUG data base acts as a catalog. Two types of data are stored in a section that deals with the OSUBI reference collection, the OSUBI catalog number and the total number of specimens of the taxa present in the reference collection. For the purpose of programming, a taxa is considered in the collection if it has at least one catalog number stored in the section. Therefore, if you wish to remove a taxa from the reference collection (from the data base's point of view at least), all the catalog numbers must be deleted from the section with the "D" directive card. Catalog numbers must also conform to some limitations to guarantee smooth interfacing with other programs. Numbers are read and stored in BUG as hollerith data, but other programs that use the BUG data base may read them as integers.

[2] The implicit order is not obvious when viewed as five characters, but when the OSU code is stored into a real variable with a R5 format the resulting computer word looks identical to an integer constant, composed of the display codes for the five characters in the OSU code. Once the code has been transferred to an integer variable with a logical masking expression, to prevent normalization, the code can be compared to other codes with simple arithmetic tests. The implicit order of the code is now obvious.

These limitations require that they are always coded as five digit integers with leading zeros. A maximum of 490 numbers can be stored in each section. Duplicate catalog numbers are not allowed within a section, but no checks are made to assure that a catalog number in one section does not exist in other sections. The total number of specimens in a taxa present in the OSUBI reference collection is also stored in each section. The variable acts as a simple accumulator and it is the user's responsibility to verify that the value is accurate. The value for the number of specimens is divided into three categories. It may be empty, positive, or less than or equal to ($\leq$) zero. The empty condition indicates no information is available. The latter category applies when specimens have not been exactly counted, which is represented in the printout as three plus signs. If the variable is positive it is the number of specimens in the collection. The value of the variable in the data base is changed by adding to it the number (positive or negative) in its field on the "/" directive card. However, there are exceptions. When the data base variable is less than or equal to zero it is simply set equal to the value on the "/" directive card, or if the value on the directive card is -0.0 the data base variable is set to an empty condition. STUFF coordinates these section variables (catalog numbers and number of specimens) to avoid conflicts. When no catalog numbers are stored in a section, but the number of collection specimens is not empty, steps are taken to eliminate the conflict. Before the section is written onto the new data base, an informative diagnostic is printed, and the number of specimens is forced to an empty condition.

Three remaining codes should be briefly discussed to complete this topic. Zoogeographic information is stored in the data base through the use of location codes. Many geographic and depth zones have been established (Table I). When an organism is collected in one of these zones its presence is recorded in the data base by placing the appropirate location code on a "/" directive card. Location codes are three digit integers which must be right justified in any field.[3] Table I also contains Taxon Level codes, which are used to specify the taxonomic level the organism has been identified to. The code is self-explanatory and is entered as a two digit value on the "/" directive card. The remaining code is the NODC taxonomic code. This code is supported by the National Oceanographic Data Center (NODC) and may also be referred to as the VIMS code. The code is twelve digits long and left justified with no trailing zeros. Although the code is numeric it is treated as hollerith information.

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[3] Locations are stored as a bit map. Each location is assigned a bit, if this bit is on, the organism has been collected at the location, conversely if the bit is off it has not. The program must be changed to include additional location code descriptions if they are not found in Table I.

TABLE I

TAXONOMIC LEVEL CODE

Code	Taxon
94	Superphylum
90	Phylum
86	Subphylum
82	
78	Superclass
74	Class
70	Subclass
66	Series
62	Superorder
58	Order
54	Suborder
50	Section
46	Superfamily
42	Family
38	Subfamily
34	
30	Supergenus
26	Genus
22	Subgenus
18	
14	Superspecies
10	Species
6	Subspecies

LOCATION CODES

Code	Location
1	Beaufort Sea
2	Chukchi Sea
3	Bering Sea
4	N. Pacific, abyssal
5	N. Pacific, slope
6	N. Pacific, shelf
7	Estuarine
8	Arctic Basin
9	N. Pacific, pelagic
10	N. Pacific, intertidal
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	

Directive Cards

Information in the BUG data base can be manipulated using any of 5 directive cards, which are identified by the directive character in the first column of the card. These directive cards can be divided into functional groups which will be described separately. The "*", "/", and "D" directive cards will be discussed first, followed by the "=", and "≠" directive cards which have a much more limited use. An example of how these cards are used can be found in Appendix C.

Creation, and modification of sections

Sections can be created or modified through the use of the "*", "/", and "D" directive cards. If a section is being modified you can add new information into it or make corrections to existing information in the section. To illustrate the use of directive cards consider some hypothetical organism that we wish to enter into the data base. Since this organism does not exist in the data bases a new section must be created. The first task is to assign the organism a unique OSU code which will be the primary key. Each card must include a directive character and the OSU code. The OSU code controls where the new section is written in the new data base, and the directive character specifies what information is expected on the card. The information describing the organism is coded using the directive card formats summarized in Appendix B. The name, original describing reference, and phylum of the organism are the the 3 variables entered on the "*" directive card, with the name and original describing reference sharing a field (col. 2-67) as described above in "Codes and Conventions." The OSU code is placed in column 63-67, followed by the phylum in columns 71-80. "/" directive card has the OSU code in column 2-6. NODC Taxonomic code is the second field (col. 8-19) followed by the taxon level code (col. 21-22), situation code (col. 24-26) and the OSUBI collection specimens field (col. 27-32). The next 5 fields are reserved for OSUBI catalog numbers, followed by 3 fields used for zoogeographic location codes. These two directive cards contain all the information that can be stored in the BUG data base. The "*" directive card stores the OSU code into the new section, therefore, when a new section is being created a "*" directive card with the OSU code is the minimum requirement.

If the hypothetical organism was already in the data base and you wished to supplement the information stored in past executions of program STUFF, you would be modifying the organism's section in the data base. Information in the section can be added (changed from an empty state), changed (replace existing information), or deleted (change to an empty state). How these modifications are performed depends on the information.

Taxon name and original describing reference, phylum, and NODC code are stored as hollerith information and are added or changed in the same manner. The new information may be added to a section by placing it in the appropriate fields on the directive cards. Program STUFF replaces the information in the data base, whether empty, or not empty, with the information on the directive cards. Information is deleted by placing a semi-colon in the first column of the field, on the appropriate directive card, that corresponds to the variable you wish to delete.

The taxon level code and situation code are numeric codes and may be added or changed in the same manner as hollerith information, but to delete these numeric codes you place a -0 in the right most columns of the appropriate field.

The variable containing the number of OSUBI collection specimens is handled differently. How the information on the directive card is used depends on the value stored in the section. If the value in the section is empty or less than or equal to zero (represented as +++ on output) the value on the directive card replaces the value in the section. When the value in the data base is positive the value on the directive card is added to the value in the section. The value on the directive card may be negative but if the resulting value is less than or equal to zero it will be represented on the output as "+++." The value may be deleted by placing a -0.0 in the field.

OSUBI Catalog numbers and location codes are stored in lists within a section. They can be viewed as being present or absent in the list, so they are technically never changed only added or deleted. These codes are added by placing the codes in their respective fields on the "/" directive card, but they are deleted from the lists in the section in different ways. The location codes can be deleted from the list by entering the code on one of its fields on the "/" directive card preceded by a minus sign. Both positive (adding location codes) and negative (deleting location codes) location codes can be placed on the same "/" directive card. OSUBI Catalog numbers are added by entering the number in one of its fields on the "/" directive card. "D" directive cards are used to delete catalog numbers from the list. To delete catalog numbers you must include the OSU code for the target section and enter the catalog numbers to be deleted in the remaining fields on the card.

EDITING DIRECTIVE CARDS

The "*", "/", and "D" directive cards are the most commonly used but two more directive cards remain. The "=", and "≠" directive cards have specialized editing functions. The "≠" directive card contains only the directive character and an OSU code. This card prevents the section from being written on the new data base, effectively deleting the entire section. The remaining directive card should be used cautiously. The "=" directive card simply changes the OSU code in a section from its present value to a second prescribed value. The OSU code is the primary key for the BUG data base and the "=" directive card does not check the new data base to guarantee that the implicit order of the primary keys within the data base is maintained. It is the responsibility of the user to be sure that the use of the "=" directive card will not destroy this order. If the implicit order would be destroyed it is necessary to delete the entire section with the old OSU code and recreate the section with the new OSU code using the "*" and "/" directive cards as described above.

The directive cards are read by program STUFF sequentially and must be arranged in increasing order of OSU codes, although cards with the same OSU codes may be in any order. The program assumes the cards are so ordered and any cards out of order will be ignored and a diagnostic statement printed. Appendix C gives an example of a directive card deck, and the changes they create in a data base.

FILES

PROGRAM STUFF (INPUT,OUTPUT,TAPE1,TAPE2)

Four files are used by the program. INPUT contains the directive cards described in the previous discussion, sorted by OSU code, and terminated by an End-of-File (EOF) card. TAPE1 is a previous data base which is merged with the information on the directive cards and written on TAPE2. TAPE1 is referred to as the "OLD" data base, and TAPE2 is the "NEW" data base. OUTPUT (see Appendix C) contains 1) listing of data base information, 2) diagnostic statements, and 3) execution summaries. As the program reads directive cards it prints any diagnostic statements as problems arise. When a new, modified, or deleted section is processed the contents are printed (example in Appendix C) with an informative label (≡NEW≡, ≡MODE≡, ≡DEL≡ respectively) which indicates the action taken. An execution summary is printed when the program ends. This summary is often useful to determine if any diagnostic statements are buried in the preceding printout and as a tally of the number of section created, modified, or deleted.

DIAGNOSTICS

Appendix A gives many of the diagnostic statements the program prints along with an example of how the statements look on the printout. Most diagnostics list the number of the last directive card read which gives the user an idea where the error occurred, but is not necessarily the card in error. The errors not included in Appendix A mainly deal with parity errors while reading or writing the data bases or the unexpected occurrence of an EOF on any of the files. These errors have informative massages about the general cause of the error but often these errors will require the help of a programmer to uncover the problem. These situations should be rare.

APPENDIX A

STUFF ERROR MESSAGES

APPENDIX A

ERROR NUMBER	DIAGNOSTIC MESSAGES
1	___ IS AN INVALID RECORD TYPE. CARD IGNORED.
2	OSU CODE IS BLANK. CARD IGNORED.
3	MAXIMUM NO. OF INPUTED CATALOG NO. REACHED. EXTRA NO. IGNORED.
4	DUPLICATE CATALOG NUMBER FOUND.
5	FILE PROTECT POINTER VIOLATED. ALL CAT. NO. NOT STORED.
6	___ IS FIRST RECORD NUMBER OF DATA BASE. SHOULD BE ZERO.
7	___ IS WRONG DATA BASE PASSWORD. SHOULD BE OCSEAP.
8	FILE PROTECT POINTER OUT OF RANGE.
9	___ COULD NOT BE FOUND IN DATA BASE. REQUEST IGNORED.
10	INPUT CARDS NOT PROPERLY SORTED.
11	YOU CANNOT HAVE SPECIMENS W/O CATALOG NUMBERS. NUMBER PURGED.
12	EMPTY OSU CODE, SECTION NOT WRITTEN ON NEW DATA BASE.

COMMENTS

Error Number	
1	The directive character (Record type) is not one of the directive characters (*, /, D, =, ≠) described in this documentation. The card is ignored.
2	The OSU code on the directive card is blank. The card is ignored.
3	The inputed OSUBI catalog numbers would exceed the maximum number that can be stored in a section (490). Catalog numbers are stored until space is exhausted. The remaining catalog numbers are not stored. To increase the storage capacity would require reprogramming.
4	An OSUBI catalog number found on the "/" directive card already exists in the section. Duplicate catalog numbers are not allowed within a section so the catalog number is not stored.
5	This error is similar to error 3. The program attempted to exceed the dimension assigned to OSUBI catalog numbers. This error should be brought to the attention of a programmer.
6	The header section should have a primary key of zero, but the header section read from TAPE1 does not have the expected primary key. It is possible TAPE1 contains the wrong data base, or a file that is not in the BUG data base format.
7	The header section contains a password that is used to be sure the proper data base is accessed. The program expects the password to be "OCSEAP" but it is not. It is possible TAPE1 contains the wrong data base, or a file that is not in the BUG data base format.
8	The third variable in the header section contains a value that defines the dimension allowed to store OSUBI catalog numbers. This value is either less than or equal to zero or greater than the maximum number of variables per section. This error should be brought to the attention of a programmer.
9	The old data base OSU code on a "=" directive card cannot be found in the old data base. The card is ignored.
10	The directive cards are not sorted in increasing order by OSU code. The card is ignored. The cards that are out of order should be run in the next modification of the BUG data base or all the directive cards should be ordered properly and re-run.
11	OSUBI catalog specimens variable is not empty, but there are no catalog numbers stored in the section. This conflicting condition is solved by forcing the OSUBI catalog specimens variable to an empty condition before the section was written on the new data base.

Error Number

12 A section with an empty OSU code was not allowed to be written on the new data base. This condition can occur when a section is created but a "*" directive card was not included. If it was the user's true intention to create this new section, a "*" directive card must be included with the other directive cards (even if no other information is on it other than the "*" directive character and OSU code). Often it was not intended that a new section be created, but simply a keypunch error on the OSU code of a directive card. In this case the directive card is effectively ignored.

APPENDIX B

DIRECTIVE CARD FORMATS

* DIRECTIVE CARD — TAXON INFORMATION

COLUMN	DESCRIPTION	FORMAT
1	"*"	R1
2-61	Taxon name and original description	6A10
63-67	OSU code	R5
71-80	Phylum	A10

/ DIRECTIVE CARD — CODED INFORMATION

COLUMN	DESCRIPTION	FORMAT
1	"/"	R1
2-6	OSU code	R5
8-19	NODC taxonomic code	A10,A2
21-22	Taxon level code	F2.0
24-25	Situation code	F2.0
27-32	OSUBI Collection specimens	F6.0
34-38	OSUBI Catalog number (1)	A5
40-44	OSUBI Catalog number (2)	A5
46-50	OSUBI Catalog number (3)	A5
52-56	OSUBI Catalog number (4)	A5
58-62	OSUBI Catalog number (5)	A5
63-66	Location code (1)	F4.0
67-70	Location code (2)	F4.0
71-74	Location code (3)	F4.0

= DIRECTIVE CARD — REPLACE OSU CODE

COLUMN	DESCRIPTION	FORMAT
1	"="	R1
2-6	OSU code (OLD DATA BASE)	R5
8-12	OSU code (NEW DATA BASE)	R5

≠ DIRECTIVE CARD — DELETE SPECIES (SECTION)

COLUMN	DESCRIPTION	FORMAT
1	"≠"	R1
2-6	OSU code to be deleted from data base	R5

D DIRECTIVE CARD DELETE OSUBI CATALOG NUMBERS

COLUMN	DESCRIPTION	FORMAT
1	"D"	R1
2-6	OSU code	R5
8-12	Catalog number (1)	A5
14-18	Catalog number (2)	A5
20-24	:	A5
26-30	:	A5
32-36		A5
38-42		A5
44-48		A5
50-54		A5
56-60	:	A5
62-66	:	A5
68-72	Catalog number (11)	A5
74-78	Catalog number (12)	A5

APPENDIX C

This appendix contains an execution of program STUFF, to illustrate what the output looks like. The first page has specific sections taken from the data base printed, showing what information is in the data base before the information on the directive cards (the following page) are merged. The next two pages are the actual output from program STUFF when executed with the previous directive cards. The output shows how the information in the OLD data base has been modified and gives examples of two error diagnostic statements. The information on the directive cards was chosen to show how sections are created, modified, and deleted as well as how to delete, add and modify variables within a section.

There are two areas on the output that have not been discussed. The "MODIFY DATE/TIME" area contains the date (year/month/day) and time (hour/minute/second) that the section was created or last modified, which ever date and time is more recent. The second area is labeled "COLLECTION". This area is blank unless there are OSUBI Catalog numbers stored in the section, in which case the area has the word "YES" printed.

SPECIES DATA BASE
78/01/18. 17.16.55.

AA176

TAXON NAME	ORIGINAL DISCRIPTION REFERENCE	PHYLUM	VIMS CODE	MODIFY DATE/TIME
ONISIMUS NANSENI	(G. SARS, 1900)	ARTHROPODA		76/11/23 23.56.36

ZOOGEOGRAPHIC INFORMATION
1) BEAUFORT SEA

AA253

TAXON NAME	ORIGINAL DISCRIPTION REFERENCE	PHYLUM	VIMS CODE	MODIFY DATE/TIME
LEPECHINELLA ECHINATA	(CHEVREUX, 1914)	ARTHROPODA	000000000000	77/11/28 22.53.01

LEVEL	COLLECTION STATUS	COLLECTION SPECIMENS	OSUBI CATALOG NUMBERS
10	YES	3	01456 01457

ZOOGEOGRAPHIC INFORMATION
1) N. PACIFIC, ABYSSAL

AB001

TAXON NAME	ORIGINAL DISCRIPTION REFERENCE	PHYLUM	VIMS CODE	MODIFY DATE/TIME
MITELLA POLYMERUS	(SOWERBY, 1833)	ARTHROPODA		77/11/16 18.05.43

LEVEL	COLLECTION STATUS	COLLECTION SPECIMENS	OSUBI CATALOG NUMBERS
10	YES	15	00838 00839

ZOOGEOGRAPHIC INFORMATION
1) N. PAC., INTERTIDAL

AU002

TAXON NAME	ORIGINAL DISCRIPTION REFERENCE	PHYLUM	VIMS CODE	MODIFY DATE/TIME
BRACHYDIASTYLIS RESIMA	(KROYER, 1846)	ARTHROPODA	6154050301	77/11/28 22.53.01

LEVEL	COLLECTION STATUS	COLLECTION SPECIMENS	OSUBI CATALOG NUMBERS
10	YES	9	00447 00448 00449

ZOOGEOGRAPHIC INFORMATION
1) BEAUFORT SEA

(Listing of information from OLD DATA BASE (TAPE1))

AN EXAMPLE OF A
DIRECTIVE CARD SEQUENCE

```
          12345678901234567890123456789012345678901234567890123456789012345678901234567890 (Column index)

CARD 1    /AA176 000000000000 10        17                                 3   8   4
CARD 2    ≠AA253
CARD 3    /AU002 ;            -0  3     -5 01367                          -1    5   6
CARD 4    /AU002                                                           4  10
CARD 5    DAU002 00447
CARD 6    *ASABELLIDES SIBIRICA  (WIREN, 1883)                          WM004   ANNELIDA
CARD 7    /WM004 5001670801   10        -1 00345 01645 01646
CARD 8    /AB001                        17 00013

          12345678901234567890123456789012345678901234567890123456789012345678901234567890 (Column index)
```

```
                                   SPECIES  DATA BASE
                                   78/01/18. 15.18.36.

-----
AA176   =MODE=
   TAXON NAME                         ORIGINAL DISCRIPTION REFERENCE         PHYLUM    VIMS CODE    MODIFY  DATE/TIME
   ONISIMUS NANSENI                   (G. SARS, 1900)                    ARTHROPODA 000000000000 78/01/18 15.18.36

                                  COLLECTION
     LEVEL  COLLECTION  STATUS    SPECIMENS     OSUBI CATALOG NUMBERS
      10

     ZOOGEOGRAPHIC INFORMATION
       1) BEAUFORT SEA          2) BERING SEA            3) N. PACIFIC, ABYSSAL     4) ARCTIC BASIN

ERROR NUMBER  11 CALLED FROM    MAIN.  INPUT CARD NUMBER     2 WAS LAST CARD READ.
       YOU CAN NOT HAVE SPECIMENS W/O CATALOG NUMBERS. NUMBER PURGED.

-----
AA253   =DELE=
   TAXON NAME                         ORIGINAL DISCRIPTION REFERENCE         PHYLUM    VIMS CODE    MODIFY  DATE/TIME
   LEPECHINELLA ECHINATA              (CHEVREUX, 1914)                   ARTHROPODA 000000000000 78/01/18 15.18.36

                                  COLLECTION
     LEVEL  COLLECTION  STATUS    SPECIMENS     OSUBI CATALOG NUMBERS
      10         YES                   3        01456 01457

     ZOOGEOGRAPHIC INFORMATION
       1) N. PACIFIC, ABYSSAL

-----
AU002   =MODE=
   TAXON NAME                         ORIGINAL DISCRIPTION REFERENCE         PHYLUM    VIMS CODE    MODIFY  DATE/TIME
   BRACHYDIASTYLIS RESIMA             (KROYER, 1846)                     ARTHROPODA              78/01/18 15.18.36

                                  COLLECTION
     LEVEL  COLLECTION  STATUS    SPECIMENS     OSUBI CATALOG NUMBERS
                 YES        3          4        00448 00449 01367

     ZOOGEOGRAPHIC INFORMATION
       1) N. PACIFIC, ABYSSAL     2) N. PACIFIC, SLOPE      3) N. PACIFIC, SHELF       4) N. PAC., INTERTIDAL

ERROR NUMBER  10 CALLED FROM    MAIN.  INPUT CARD NUMBER     8 WAS LAST CARD READ.
       INPUT CARDS ARE NOT PROPERLY SORTED.

-----
WM004   =NEWE=
   TAXON NAME                         ORIGINAL DISCRIPTION REFERENCE         PHYLUM    VIMS CODE    MODIFY  DATE/TIME
   ASABELLIDES SIBIRICA               (WIREN, 1883)                      ANNELIDA   5001670801   78/01/18 15.18.36

                                  COLLECTION
     LEVEL  COLLECTION  STATUS    SPECIMENS     OSUBI CATALOG NUMBERS
      10         YES                  ***       00345 01645 01646
```

(STUFF output)

```
   8 CARDS READ.
2196 RECORDS IN OLD DATABASE.
2196 RECORDS IN NEW DATABASE.

   1 RECORDS CREATED.
   2 RECORDS MODIFIED.
   1 RECORDS DELETED.

   2 ERRORS DETECTED.
```

(STUFF output)

GLOSSARY

GLOSSARY

Bit - The bit is the basic unit of a computer word. These programs depend on a 60 bit word, numbered from left to right. The left most bit (commonly called the sign bit) is the number one bit. The right most bit is the 60th bit in a computer word.

[1]Block - This term refers to a collection of 1 to many records.

Database - A computer file containing 2 to many sections. The first section of the file must be a header section, and the last section must be a trailer section.

[1]Date - This refers to the year, month, day, and time a sample was taken. The date is written in the following format: YYMMDDHHMM. The date forms the prefix of the Date-Level key used by the sample database (MUD).

Directive Character - A character on the input cards used by the DBM programs to identify the type of information coded on it.

Empty - A variable is empty if it is equal to a -0.0 (77777777777777777777B).

Key - A computer word that controls the processing of one or more records associated with the key.

[1]Level - A group of one to six records whose key is a level number.

[1]Level Number - A consecutive two digit number that is unique within a section. 00 is always the level number for the first record of a section, and 99 is the level number for the last record in a section.

Primary Key - A computer word (i.e. variable) that is used to order sections in a database.

Record - A collection of parameters that are transmitted to and from the databases as a unit (i.e. each BUFFER OUT or BUFFER IN). A record can contain from one to many computer words.

Section - A group of records, which may be organized into a smaller group of blocks, that are associated with a primary key.

Variable - A computer word(s) associated with a specific class of data (e.g. salinity, temperature, NODC code, etc.), but whose value may change.

Word - This refers to a string of 60 bits, which are manipulated by the computer, and can store data.

---

[1]This term pertains only to the Sample database (MUD).

IX. Summary of 4th Quarter Operations (Fish-Benthos, RU #6)

A. Ship or Laboratory Activities

1. Ship or field trip schedule.
   No field work was undertaken this quarter

2. Scientific personnel.

   a. Andrew G. Carey, Jr. — Principal Investigator, Associate Professor

      Responsibilities: coordination, evaluation, analysis, and reporting

   b. James B. Gish — Research Assistant

      Responsibilities: data management, statistical analysis. NB: Gish resigned from the position on 9 March 1978; a search is underway for a replacement.

   c. Paul Montagna — Research Assistant

      Responsibilities: sample processing, biomass measurements, harpacticoid copepod and crustacean systematics, and field collection.

   d. R. Eugene Ruff — Research Assistant

      Responsibilities: species list compilation, sample processing, reference museum curation, polychaete systematics, field collection, and laboratory management.

   e. Paul Scott — Research Assistant

      Responsibilities: sample processing, data summary, molluscan systematics and sample collection.

3. Methods: laboratory analyses.

Laboratory methods have not been altered this quarter. The addition of a phase contrast compound microscope from a complementary NSF research program has greatly aided our identifications of invertebrate fauna.

4. Sample localities

   Listed in previous reports.

5. Data collected or analyzed.

a) Number and types of samples/observations.

No samples were collected this quarter.

b) Number and types of analyses.

1. Animal density and biomass

Sixty-five 0.1 m^2 Smith-McIntyre grab samples from OCS-5 (August-September 1976) have been picked and sorted to major taxa in the laboratory. The biomass of major phyla was estimated by preserved, wet weights and is summarized in Tables 1-13. Animal densities for the sixty-five grab samples are listed in Tables 14-26.

2. Pelecypod Molluscs

All pelecypod molluscs from the OCS-2 cruise (March 1976) have been sorted to family. This material includes 36 grab samples from five stations between 25 and 100 meters. Representatives of sixteen pelecypod families were found. The results including counts for each family within a grab sample are listed in Table 27. Families represented by shells only are also noted.

3. Polychaetous annelid worms.

All polychaetes from the coastal samples (5-25 meters depth) collected on the 1976 R/V ALUMIAK cruise and the Pitt Point transect line across the shelf have been sorted to family. Specimens from the 125 grab samples from 25 stations have been processed through this next stage of sorting and identification. The results including the number of individual specimens per family are summarized in Table no's 28 through 32.

4. Harpacticoid copepod crustaceans have been identified from 19 stations. These species and the abundance data are listed in Table 33. A total of 31 species have been identified to date (see Table 34).

6. Milestone chart and data submission schedule

a. No changes in the schedules for research work and data transmission are anticipated.

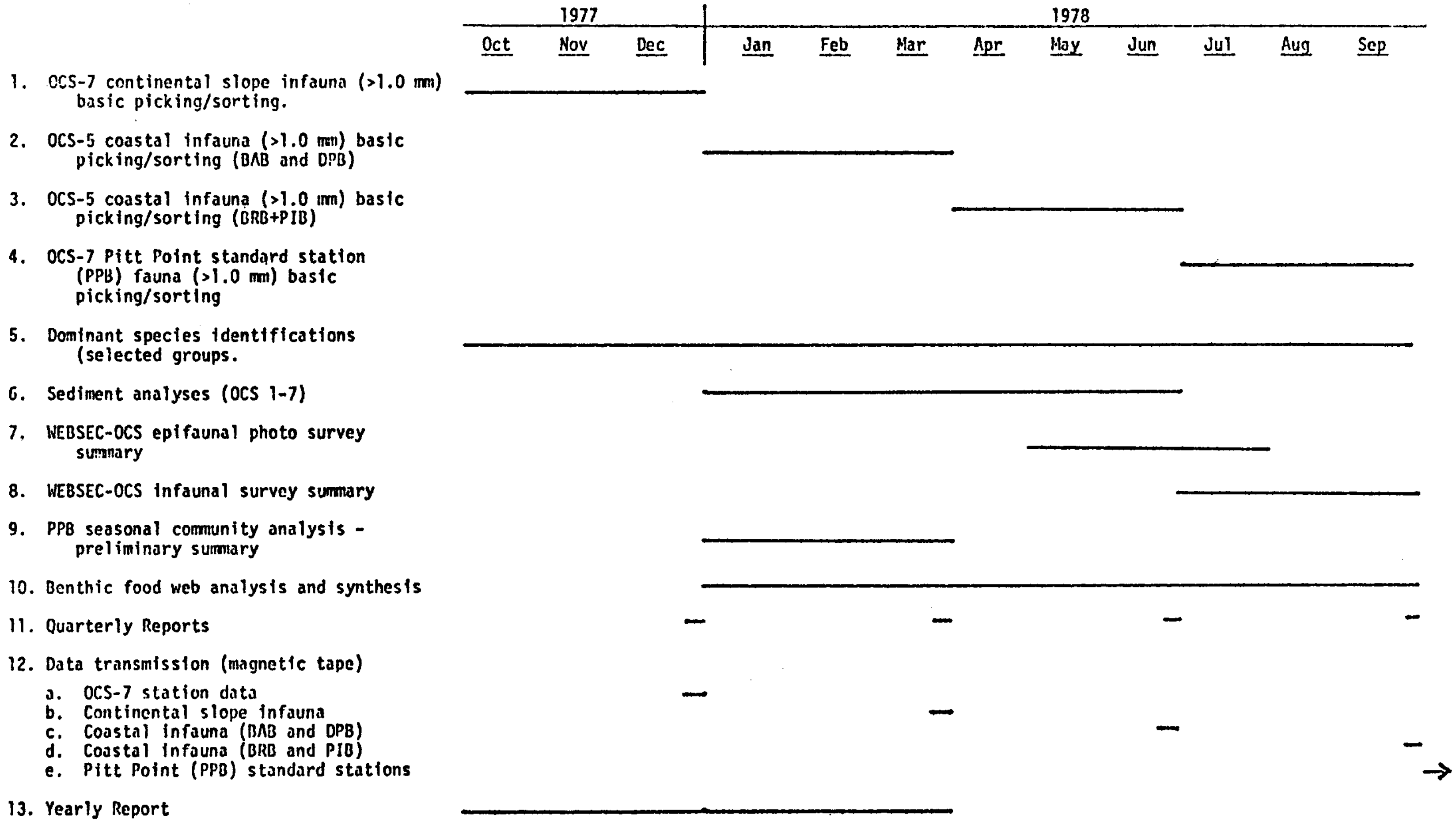
b. The 1977-78 laboratory schedule is shown in Figure 1.

B. Problems encountered/recommended changes.

The lack of time to work up the small macro-infauna from our samples continues to be a basic problem. Continuation of this objective for next contract year is recommended.

Figure 1.

1977-78 Laboratory Schedule - Contract No. 03-5-022-68, Task Order 5.



NOTE: OCS-5 = 1976 R/V ALUMIAK coastal cruise; OCS-7 = 1977 USCGC GLACIER summer cruise; WEBSEC = Western Beaufort Sea Ecological Cruise - USCG 1970-73; PPB = Pitt Point Benthos transect line; BAB = Barter Island Benthos transect line; DPB = Demarcation Point Benthos transect line; BRB = Barrow Benthos transect line; PIB = Pongok Island Benthos transect line.

Table 1 : Biomass, preserved wet weight in grams per 0.1 m^2 from BRB-5 (OCS-5), collected on 19 August 1976.

Group	Grab Number 1389	1390	1392	1393	1394	Total weight per m^2	% of biomass
Anthozoa	-	-	-	-	-	-	-
Sipuncula	-	-	-	-	-	-	-
Annelida	.98	.22	.04	.11	.35	3.40	67.5
Arthropoda	.17	.04	.02	.02	.01	.52	10.3
Mollusca	.02	.01	.02	.01	.04	.20	4.0
Echinodermata	-	-	-	-	-	-	-
Misc. Phyla	.04	.34	.04	.01	.03	.92	18.3
TOTAL	1.21	.61	.12	.15	.43	5.04	100.0

- = absence

Table 2 : Biomass, preserved wet weight in grams per 0.1 m^2 from BRB-10 (OCS-5), collected on 19 August 1976.

Group	Grab Number 1384	1385	1386	1387	1388	Total weight per m^2	% of biomass
Anthozoa	-	.26	-	-	-	.52	1.1
Sipuncula	-	-	-	-	-	-	-
Annelida	.87	.77	1.39	.25	.45	7.46	15.6
Arthropoda	.07	.65	.45	.83	.04	4.08	8.5
Mollusca	2.92	3.64	6.44	2.14	1.14	32.56	68.1
Echinodermata	-	+	+	-	-	-	-
Misc. Phyla	.54	.26	.34	.33	.12	3.18	6.7
TOTAL	4.40	5.58	8.62	3.55	1.75	47.80	100.0

+ = presence, not weighable
- = absence

Table 3 : Biomass, preserved wet weight in grams per 0.1 m^2 from BRB-15 (OCS-5), collected on 19 August 1976.

Group	Grab Number 1377	1378	1379	1381	1382	Total weight per m^2	% of biomass
Anthozoa	-	-	1.59	-	-	3.18	14.8
Sipuncula	-	-	-	-	-	-	-
Annelida	.22	.11	.09	.02	.01	.90	4.2
Arthropoda	.54	3.97	.06	3.10	.36	16.06	74.8
Mollusca	.05	.01	.05	.47	.03	1.22	5.7
Echinodermata	.01	-	+	-	-	.02	.1
Misc. Phyla	.01	.03	+	+	+	.08	.4
TOTAL	.83	4.12	1.79	3.59	.40	21.46	100.0

+ = presence, not weighable
- = absence

Table 4 : Biomass, preserved wet weights in grams per 0.1 m^2 from BRB-20 (OCS-5), collected on 19 August 1976.

Group	Grab Number 1371	1372	1374	1375	1376	Total weight per m^2	% of biomass
Anthozoa	.28	-	-	-	-	.56	2.4
Sipuncula	-	-	-	-	-	-	-
Annelida	5.04	.39	.11	.34	1.05	13.86	58.8
Arthropoda	.62	.13	1.67	.11	.33	5.72	24.3
Mollusca	1.29	.05	.13	.02	.06	3.10	13.1
Echinodermata	-	-	-	-	-	-	-
Misc. Phyla	.02	.02	.05	.03	.05	.34	1.4
TOTAL	7.25	.59	1.96	.50	1.49	23.58	100.0

- = absence

Table 5 : Biomass, preserved wet weight in grams per 0.1 m^2 from BRB-25 (OCS-5), collected on 19 August 1976.

Group	Grab Number 1365	1366	1367	1368	1369	Total weight per m^2	% of biomass
Anthozoa	6.52	-	.01	.38	-	13.82	11.4
Sipuncula	-	-	-	-	-	-	-
Annelida	4.93	1.06	2.10	1.69	.52	20.60	17.1
Arthropoda	8.25	3.51	.86	1.40	.23	28.50	23.6
Mollusca	13.70	.02	9.05	1.46	3.67	55.80	46.2
Echinodermata	.03	-	-	-	-	.06	0.1
Misc. Phyla	.49	.11	-	.05	.37	2.04	1.7
TOTAL	33.92	4.70	12.02	4.98	4.79	120.82	100.0

- = absence

Table 6 : Biomass, preserved wet weight in grams per 0.1 m^2 from PIB-5 (OCS-5), collected on 22 August 1976.

Group	Grab Number 1419	1420	1421	1423	1424	Total weight per m^2	% of biomass
Anthozoa	-	-	-	-	-	-	-
Sipuncula	-	-	-	-	-	-	-
Annelida	.58	.60	.49	.84	1.16	7.34	83.2
Arthropoda	.03	.47	.06	.05	.02	1.26	14.3
Mollusca	.03	-	.01	-	+	.08	0.9
Echinodermata	-	-	+	-	-	-	-
Misc. Phyla	.01	.02	.02	.02	+	.14	1.6
TOTAL	.65	1.09	.58	.91	1.18	8.82	100.0

+ = presence, not weighable
- = absence

Table 7 : Biomass, preserved wet weight in grams per 0.1 m^2 from PIB-10 (OCS-5), collected on 22 August 1976.

Group	Grab Number 1425	1426	1427	1429	1430	Total weight per m^2	% of biomass
Anthozoa	-	-	-	-	-	-	-
Sipuncula	-	-	-	-	-	-	-
Annelida	.87	.78	.87	.77	1.20	8.98	50.7
Arthropoda	.04	.04	.03	.07	.12	.60	3.4
Mollusca	.19	-	1.90	1.12	.70	7.82	44.2
Echinodermata	+	-	-	-	-	-	-
Misc. Phyla	.07	.01	.04	.02	.01	.30	1.7
TOTAL	1.17	.87	2.84	1.98	2.03	17.70	100.0

+ = presence, not weighable
- = absence

Table 8 : Biomass, preserved wet weight in grams per 0.1 m^2 from PIB-15 (OCS-5), collected on 22 August 1976.

Group	Grab Number 1432	1433	1434	1435	1436	Total weight per m^2	% of biomass
Anthozoa	-	-	-	-	-	-	-
Sipuncula	-	-	-	-	-	-	-
Annelida	1.92	3.65	1.20	1.12	.61	17.00	12.8
Arthropoda	.29	.13	.07	.18	.19	1.72	1.3
Mollusca	4.71	10.24	5.10	9.21	11.44	81.40	61.6
Echinodermata	.02	.12	.04	.08	-	.52	.4
Misc. Phyla	.74	2.73	5.87	3.27	3.19	31.60	23.9
TOTAL	7.68	16.87	12.28	13.86	15.43	132.24	100.0

- = absence

Table 9 : Biomass, preserved wet weights in grams per 0.1 m^2 from BAB-5 (OCS-5) collected on 3 September 1976.

Group	Grab Number 1479	1480	1481	1482	1483	Total weight per m^2	% of biomass
Anthozoa	-	-	-	-	-	-	-
Sipuncula	-	-	-	-	-	-	-
Annelida	.86	1.77	.58	2.18	.96	12.70	37.6
Arthropoda	.04	2.61	.92	.69	5.05	18.62	55.2
Mollusca	-	.26	.02	.02	-	.60	1.8
Echinodermata	-	-	-	-	-	-	-
Misc. Phyla	.02	.01	.04	.05	.79	1.82	5.4
TOTAL	.92	4.65	1.56	2.94	6.80	33.74	100.0

- = absence

Table 10: Biomass, preserved wet weights in grams per 0.1 m^2 from BAB-10 (OCS-5), collected on 3 September 1976.

Group	Grab Number 1473	1475	1476	1477	1478	Total weight per m^2	% of biomass
Anthozoa	-	-	-	-	-	-	-
Sipuncula	-	-	-	-	-	-	-
Annelida	1.15	.17	.47	.67	.26	5.44	46.1
Arthropoda	.06	.01	.10	.03	.04	.48	4.1
Mollusca	.22	.26	.58	.64	.62	4.64	39.3
Echinodermata	-	-	-	-	-	-	-
Misc. Phyla	.24	.05	.15	.03	.15	1.24	10.5
TOTAL	1.67	.49	1.30	1.37	1.07	11.80	100.0

- = absence

Table 11: Biomass, preserved wet weights in grams per 0.1 m^2 from BAB-15 (OCS-5), collected on 31 August 1976.

Group	Grab Number 1467	1468	1469	1470	1471	Total weight per m^2	% of biomass
Anthozoa	1.25	-	-	.01	.07	2.66	3.5
Sipuncula	-	+	-	.03	-	.06	0.1
Annelida	1.92	1.63	1.93	1.25	1.12	15.70	20.8
Arthropoda	.14	.08	.06	.06	.03	.74	1.0
Mollusca	1.55	3.07	1.24	6.50	1.46	27.64	36.6
Echinodermata	-	.04	+	+	.02	.12	0.2
Misc. Phyla	.03	3.16	6.30	4.26	.53	28.56	37.8
TOTAL	4.89	7.98	9.53	12.11	3.23	75.48	100.0

+ = presence, not weighable
- = absence

Table 12: Biomass, preserved wet weights in grams per 0.1 m^2 from BAB-20 (OCS-5), collected on 31 August 1976.

Group	Grab Number 1461	1462	1463	1464	1466	Total weight per m^2	% of biomass
Anthozoa	-	-	-	.81	-	1.62	5.1
Sipuncula	-	+	-	.02	-	.04	0.1
Annelida	.73	.20	.21	2.33	2.82	12.58	39.3
Arthropoda	.12	.19	.19	.11	.11	1.44	4.5
Mollusca	.17	.19	.12	1.60	1.63	7.42	23.2
Echinodermata	.53	+	+	-	.22	1.50	4.7
Misc. Phyla	.08	2.44*	.03	.21	.94	7.40	23.1
TOTAL	1.63	3.02	.55	5.08	5.72	32.00	100.0

+ = presence, not weighable
- = absence
*Biomass biased by rare, large specimen

Table 13: Biomass, preserved wet weights in grams per 0.1 m^2 from BAB-25 (OCS-5), collected on 31 August 1976.

Group	Grab Number 1455	1456	1457	1459	1460	Total weight per m^2	% of biomass
Anthozoa	-	-	-	-	-	-	-
Sipuncula	-	-	-	-	-	-	-
Annelida	1.46	2.38	.09	2.49	.68	14.20	64.1
Arthropoda	.05	.08	.10	.15	.20	1.16	5.2
Mollusca	.25	.81	.81	.14	.66	5.34	24.1
Echinodermata	.12	.03	.01	.01	.28	.90	4.1
Misc. Phyla	.03	.03	.01	.10	.10	.54	2.4
TOTAL	1.91	3.33	1.02	2.89	1.92	22.14	100.0

- = absence

Table 14: Animal densities for BRB-5 (OCS-5) collected on 19 August 1976.

Phylum	Class	Order	Grab Number 1389	1390	1392	1393	1394	Total per m^2	% of fauna
Nematoda			5	2	3	9	8	54	4.1
Nemertinea			--	4	--	2	1	14	1.1
Annelida:	Polychaeta		124	98	78	104	98	1004	76.2
Echiura			10	3	2	3	11	58	4.4
Priapulida			--	--	--	1	--	2	0.2
Arthropoda:	Crustacea:	Amphipoda	8	4	5	7	6	60	4.6
		Harpacticoida	1	1	--	8	--	20	1.5
		Ostracoda	--	--	--	2	--	4	0.3
		Cumacea	--	1	--	--	--	2	0.2
Mollusca:	Pelecypoda		10	5	10	12	10	94	7.1
	Gastropoda		--	2	--	--	--	4	0.3
Echinodermata:	Holothuroidea		1	--	--	--	--	2	0.2
TOTAL			159	120	98	148	134	1318	100.0

Table 15: Animal densities for BRB-10 (OCS-5) collected on 19 August 1976.

Phylum	Class	Order	Grab Number 1384	1385	1386	1387	1388	Total per m^2	% of fauna
Cnidaria:	Anthozoa		--	2	1	--	--	6	0.1
Nematoda			46	9	46	10	17	256	5.8
Nemertinea			--	3	3	2	6	28	0.6
Annelida:	Polychaeta		807	107	229	178	298	3238	72.9
Echiura			--	--	--	2	2	8	0.2
Priapulida			6	--	--	--	--	12	0.3
Arthropoda:	Crustacea:	Amphipoda	19	11	26	18	8	164	3.7
		Harpacticoida	--	--	--	--	6	12	0.3
		Isopoda	--	--	1	1	--	4	0.1
		Ostracoda	--	1	--	--	3	8	0.2
		Cumacea	1	5	2	4	7	38	0.9
Mollusca:	Pelecypoda		34	81	58	15	17	410	9.2
	Gastropoda		18	17	7	5	5	104	2.3
Echinodermata:	Ophiuroidea		--	2	1	--	--	6	0.1
	Holothuroidea		--	--	--	1	--	2	--
Chordata:	Ascidacea		27	12	21	14	--	148	3.3
TOTAL			958	250	395	250	369	4444	100.0

Table 16: Animal densities for BRB-15 (OCS-5) collected on 19 August 1976.

Phylum	Class	Order	Grab Number 1377	1378	1379	1381	1382	Total per m^2	% of fauna
Cnidaria:	Anthozoa		--	--	1	--	--	2	0.3
Nematoda			--	--	1	6	--	14	1.8
Nemertinea			1	--	--	--	--	2	0.3
Annelida:	Polychaeta		196	13	16	1	1	454	58.1
Echiura			11	--	5	1	--	34	4.3
Priapulida			--	--	1	--	--	2	0.3
Arthropoda:	Crustacea:	Amphipoda	21	32	6	31	10	200	25.6
		Cumacea	2	1	2	--	--	10	1.3
Mollusca:	Pelecypoda		4	2	10	8	3	54	6.9
	Gastropoda		--	--	1	--	--	2	0.3
Echinodermata:	Ophiuroidea		2	--	1	--	--	6	0.8
	Holothuroidea		--	--	1	--	--	2	0.3
TOTAL			237	48	45	47	14	782	100.0

Table 17: Animal densities for BRB-20 (OCS-5) collected on 19 August 1976.

Phylum	Class	Order	Grab Number 1371	1372	1374	1375	1376	Total per m^2	% of fauna
Cnidaria:	Anthozoa		2	--	--	--	--	4	0.3
Nematoda			3	1	--	--	--	8	0.5
Nemertinea			--	1	--	--	--	2	0.1
Annelida:	Polychaeta		444	25	11	15	16	1022	68.1
Echiura			2	14	21	9	9	110	7.3
Arthropoda:	Crustacea:	Amphipoda	13	18	80	5	11	254	16.9
		Harpacticoida	1	--	--	--	--	2	0.1
		Tanaidacea	1	--	--	--	--	2	0.1
		Cumacea	9	6	2	1	2	40	2.7
Mollusca:	Pelecypoda		22	--	--	1	1	48	3.2
	Gastropoda		1	2	--	--	--	6	0.4
Echinodermata:	Holothuroidea		--	--	--	1	--	2	0.1
TOTAL			498	67	114	32	39	1500	100.0

Table 18: Animal densities for BRB-25 (OCS-5) collected on 19 August 1976.

Phylum	Class	Order	Grab Number 1365	1366	1367	1368	1369	Total per m^2	% of fauna
Cnidaria:	Anthozoa		3	--	4	1	--	16	0.6
Nematoda			21	5	--	--	5	62	2.3
Nemertinea			2	3	--	--	--	10	0.4
Annelida:	Polychaeta		196	155	23	69	33	952	35.3
Echiura			26	18	13	5	186	496	18.4
Arthropoda:	Crustacea:	Amphipoda	127	244	27	32	27	914	33.9
		Ostracoda	2	--	--	--	--	4	0.1
		Tanaidacea	3	5	--	--	--	16	0.6
		Cumacea	16	7	5	9	3	80	3.0
	Pycnogonida		3	3	--	--	--	12	0.4
Mollusca:	Pelecypoda		32	10	11	8	4	130	4.8
	Gastropoda		--	1	--	--	--	2	0.1
Chordata:	Ascidacea		1	--	--	--	--	2	0.1
TOTAL			432	451	83	124	258	2696	100.0

Table 19: Animal densities for PIB-5 (OCS-5) collected on 22 August 1976.

Phylum	Class	Order	Grab Number 1419	1420	1421	1423	1424	Total per m^2	% of fauna
Nematoda			1	--	2	1	4	16	1.2
Nemertinea			1	2	3	--	--	12	0.9
Annelida:	Polychaeta		71	110	104	112	176	1146	87.2
Priapulida			4	5	7	3	2	42	3.2
Arthropoda:	Crustacea:	Amphipoda	17	5	2	4	4	64	4.9
		Isopoda	--	1	1	2	--	8	0.6
		Cumacea	1	--	1	6	--	16	1.2
Mollusca:	Pelecypoda		2	--	1	--	2	10	0.8
TOTAL			97	123	121	128	188	1314	100.0

Table 20: Animal densities for PIB-10 (OCS-5) collected on 22 August 1976.

			Grab Number						
Phylum	Class	Order	1425	1426	1427	1429	1430	Total per m^2	% of fauna
Nematoda			2	8	33	30	12	170	2.3
Annelida:	Polychaeta		475	683	606	436	860	6120	82.9
Priapulida			1	1	4	7	--	26	0.4
Arthropoda:	Crustacea:	Amphipoda	--	1	1	21	3	52	0.7
		Harpacticoida	--	--	6	--	--	12	0.2
		Isopoda	2	--	1	--	4	14	0.2
		Ostracoda	--	16	17	6	--	78	1.1
		Tanaidacea	--	--	1	4	1	12	0.2
		Cumacea	1	2	2	4	3	24	0.3
Mollusca:	Pelecypoda		39	67	109	104	101	840	11.4
	Gastropoda		--	6	6	3	3	36	0.5
TOTAL			520	784	786	615	987	7384	100.0

Table 21: Animal densities for PIB-15 (OCS-5) collected on 24 August 1976.

Phylum	Class	Order	Grab Number 1432	1433	1434	1435	1436	Total per m^2	% of fauna
Cnidaria:	Anthozoa		2	1	1	--	--	8	0.4
Nematoda			--	1	2	2	--	10	0.5
Nemertinea			--	3	3	1	3	20	1.1
Annelida:	Polychaeta		53	73	86	107	83	804	42.2
Priapulida			--	--	--	--	1	2	0.1
Arthropoda:	Crustacea:	Amphipoda	4	9	17	12	14	112	5.9
		Isopoda	--	--	3	1	1	10	0.5
		Ostracoda	--	--	4	2	--	12	0.6
		Tanaidacea	--	--	7	--	--	14	0.7
		Cumacea	8	4	1	14	3	60	3.2
	Pycnogonida		--	--	--	--	1	2	0.1
Mollusca:	Pelecypoda		25	53	31	53	58	440	23.1
	Gastropoda		5	3	1	7	7	46	2.4
Echinodermata:	Holothuroidea		2	3	2	1	--	16	0.8
Hemichordata			1	--	--	--	--	2	0.1
Chordata:	Ascidacea		10	47	60	16	40	346	18.2
TOTAL			110	197	218	216	211	1904	100.0

Table 22: Animal densities for BAB-5 (OCS-5) collected on 2 September 1976.

Phylum	Class	Order	Grab Number 1479	1480	1481	1482	1483	Total per m^2	% of fauna
Nematoda			1	14	11	15	1	84	3.9
Nemertinea			3	1	6	1	3	28	1.3
Annelida:	Polychaeta		82	307	136	228	187	1880	87.1
	Oligochaeta		--	--	1	1	--	4	0.2
Priapulida			2	2	1	5	2	24	1.1
Arthropoda:	Crustacea:	Amphipoda	3	4	5	5	7	48	2.2
		Isopoda	--	3	1	1	3	16	0.7
		Ostracoda	1	9	2	4	1	34	1.6
		Cumacea	1	1	--	1	--	6	0.3
Mollusca:	Pelecypoda		--	10	2	5	--	34	1.6
	Gastropoda		--	1	--	--	--	2	0.1
Chordata:	Ascidacea		--	--	--	--	1	2	0.1
TOTAL			93	352	165	265	204	2158	100.0

Table 23: Animal densities for BAB-10 collected on 2 September 1976.

Phylum	Class	Order	Grab Number 1473	1475	1476	1477	1478	Total per m^2	% of fauna
Nematoda			5	9	1	1	10	52	3.4
Nemertinea			2	3	4	5	3	34	2.2
Annelida:	Polychaeta		159	193	75	36	88	1102	71.6
	Oligochaeta		--	--	1	1	--	4	0.3
Priapulida			1	--	--	--	1	4	0.3
Arthropoda:	Crustacea:	Amphipoda	4	1	5	2	5	34	2.2
		Harpacticoida	1	5	--	--	--	12	0.8
		Ostracoda	1	2	2	--	2	14	0.9
		Tanaidacea	--	--	--	1	--	2	0.1
		Cumacea	--	2	--	--	--	4	0.3
Mollusca:	Pelecypoda		14	4	30	11	39	196	12.7
	Gastropoda		4	12	4	5	7	64	4.2
Chordata:	Ascidacea		2	--	2	3	1	16	1.0
TOTAL			193	232	124	65	156	1540	100.0

Table 24: Animal densities for BAB-15 (OCS-5) collected on 31 August 1976.

Phylum	Class	Order	Grab Number 1467	1468	1469	1470	1471	Total per m^2	% of fauna
Cnidaria:	Anthozoa		1	--	--	1	1	6	0.1
Nematoda			44	38	22	21	8	266	6.0
Nemertinea			6	4	5	10	4	58	1.3
Annelida:	Polychaeta		268	272	211	111	117	1958	44.1
	Oligochaeta		2	5	--	--	1	16	0.4
Sipuncula			--	1	--	13	--	28	0.6
Priapulida			2	1	1	1	3	16	0.4
Kinorhyncha			--	--	--	2	--	4	0.1
Arthropoda:	Crustacea:	Amphipoda	20	6	2	3	3	68	1.5
		Harpacticoida	92	77	10	33	2	428	9.6
		Isopoda	1	--	--	2	1	8	0.2
		Ostracoda	54	52	20	31	3	320	7.2
		Tanaidacea	7	3	21	16	1	96	2.2
		Cumacea	5	3	5	1	1	30	0.7
Mollusca:	Pelecypoda		37	123	57	94	83	788	17.7
	Gastropoda		16	20	16	19	13	168	3.8
Echinodermata:	Ophiuroidea		--	19	3	1	3	52	1.2
Chordata:	Ascidacea		5	11	8	27	16	134	3.0
TOTAL			560	635	381	386	259	4442	100.0

Table 25: Animal densities for BAB-20 (OCS-5) collected on 31 August 1977.

Phylum	Class	Order	Grab Number 1461	1462	1463	1464	1466	Total per m^2	% of fauna
Cnidaria:	Anthozoa		--	--	--	5	1	12	0.2
Nematoda			80	--	3	21	415	1038	18.1
Nemertinea			10	1	6	5	10	64	1.1
Kinorhyncha			--	--	--	--	7	14	0.2
Annelida:	Polychaeta		131	50	42	104	973	2600	45.2
	Oligochaeta		17	--	--	1	27	90	1.6
Sipuncula			1	1	--	4	1	14	0.2
Priapulida			5	2	1	4	5	34	0.6
Arthropoda:	Crustacea:	Amphipoda	5	17	19	12	20	146	2.5
		Harpacticoida	8	--	2	--	225	470	8.2
		Isopoda	--	--	2	--	19	42	0.7
		Ostracoda	9	--	--	--	82	182	3.2
		Tanaidacea	41	2	11	8	89	302	5.3
		Cumacea	9	8	10	18	13	116	2.0
Mollusca:	Pelecypoda		25	16	11	25	196	546	9.5
	Gastropoda		2	2	3	4	14	50	0.9
Echinodermata:	Ophiuroidea		1	--	--	1	1	6	0.1
	Holothuroidea		--	--	2	--	1	6	0.1
Hemichordata			--	--	--	--	2	4	0.1
TOTAL			344	99	113	213	2104	5746	100.0

Table 26: Animal densities for BAB-25 (OCS-5) collected on 31 August 1976.

Phylum	Class	Order	Grab Number 1455	1456	1457	1459	1460	Total per m^2	% of fauna
Cnidaria:	Anthozoa		1	--	--	--	--	2	0.2
Nematoda			8	10	--	6	57	162	15.9
Nemertinea			2	1	1	5	8	34	3.3
Annelida:	Polychaeta		27	33	26	12	76	348	34.2
	Oligochaeta		--	--	--	--	2	4	0.4
Priapulida			2	4	--	1	5	24	2.4
Arthropoda:	Crustacea:	Amphipoda	4	2	6	6	5	46	4.5
		Isopoda	--	1	--	--	--	2	0.2
		Tanaidacea	--	1	--	--	--	2	0.2
		Cumacea	2	4	5	5	28	88	8.6
Mollusca:	Pelecypoda		25	30	28	7	32	244	24.0
	Gastropoda		4	2	2	3	9	40	3.9
Echinodermata:	Ophiuroidea		1	--	--	--	3	8	0.8
	Holothuroidea		3	1	1	1	1	14	1.4
TOTAL			79	89	69	46	226	1018	100.0

Table 27: Counts of individual specimens in each family of pelecypod molluscs from OCS-2, collected in March 1976. * Denotes presence of shell only.

STATION: PPB-25

Grab Number	Family	Count of live specimens
1103	Nuculanidae	*
	Pandoridae	*
	Nuculidae	*
	Veneridae	*
	Tellinidae	*
		0
1104	Nuculanidae	12
	Thyasiridae	4
	Nuculidae	1
	Pectinidae	*
	Lyonsiidae	*
	Veneridae	*
	Cardiidae	*
		17
1105	Nuculanidae	6
	Thyasiridae	3
	Pandoridae	*
	Nuculidae	*
	Cardiidae	*
	Myidae	*
		9
1106	Nuculanidae	1
	Nuculidae	*
		1
1107	Nuculidae	3
	Thyasiridae	1
	Nuculanidae	*
	Cardiidae	*
	Tellinidae	*
	Myidae	*
		4

STATION: PPB-40

Grab Number	Family	Count of live specimens
1115	Nuculanidae	3
	Thyasiridae	2
	Lyonsiidae	1
	Nuculidae	*
	Astartidae	*
	Tellinidae	*
		6

Table 27: (continued)

STATION: PPB-40 (cont.)

Grab Number	Family	Count of live specimens
1116	Thyasiridae	1
	Tellinidae	1
	Nuculidae	*
	Nuculanidae	*
	Pectinidae	*
		2
1117	Thyasiridae	1
	Nuculidae	*
	Nuculanidae	*
	Tellinidae	*
	Astartidae	*
	Pectinidae	*
		1
1118	Nuculidae	1
	Nuculanidae	*
	Astartidae	*
	Tellinidae	*
	Pectinidae	*
		1
1119	Nuculanidae	*
	Astartidae	*
		0
1120	Nuculidae	2
	Thyasiridae	1
	Nuculanidae	*
	Astartidae	*
	Tellinidae	*
		3

STATION: PPB-55

Grab Number	Family	Count of live specimens
1121	Nuculidae	1
	Nuculanidae	16
	Astartidae	22
	Tellinidae	1
	Pectinidae	6
	Mytilidae	2
	Veneridae	2
	Hiatellidae	*
	Pandoridae	*
	Cardiidae	*
		50

Table 27:(continued)

STATION: PPB-55 (cont.)

Grab Number	Family	Count of live specimens
1122	Nuculidae	2
	Nuculanidae	14
	Astartidae	7
	Pectinidae	6
	Cardiidae	1
	Pandoridae	1
	Veneridae	2
	Tellinidae	*
	Carditidae	*
	Lyonsiidae	*
		33
1123	Nuculidae	2
	Nuculanidae	8
	Astartidae	17
	Tellinidae	1
	Pectinidae	3
	Cardiidae	2
	Pandoridae	1
	Carditidae	1
	Veneridae	5
	Mytilidae	*
		40
1124	Nuculanidae	*
	Astartidae	*
	Pectinidae	*
	Veneridae	*
		0
1125	Nuculanidae	2
	Astartidae	1
	Nuculidae	*
	Carditidae	*
		3
1126	Nuculidae	4
	Nuculanidae	6
	Astartidae	8
	Tellinidae	4
	Pectinidae	2
	Cardiidae	1
	Veneridae	3
		28

Table 27:(continued)

STATION: PPB-55 (cont.)

Grab Number	Family	Count of live specimens
1127	Nuculidae	1
	Nuculanidae	1
	Astartidae	4
	Tellinidae	1
	Veneridae	2
	Pectinidae	*
	Cardiidae	*
	Pandoridae	*
		9
1128	Nuculidae	*
	Nuculanidae	*
	Astartidae	*
	Pectinidae	*
	Cardiidae	*
	Tellinidae	*
	Veneridae	*
		0
1129	Nuculanidae	1
	Astartidae	4
	Carditidae	1
	Nuculidae	*
	Tellinidae	*
	Pectinidae	*
	Cardiidae	*
	Veneridae	*
	Mytilidae	*
		6
1130	Nuculidae	3
	Nuculanidae	6
	Astartidae	9
	Tellinidae	1
	Veneridae	1
	Carditidae	2
	Pandoridae	*
	Mytilidae	*
		22

STATION: PPB-70

Grab Number	Family	Count of live specimens
1108	Nuculidae	5
	Nuculanidae	6
	Pectinidae	1
	Cardiidae	1

Table 27:(continued)

STATION: PPB-70 (cont.)

Grab Number	Family	Count of live specimens
1108 (cont.)	Astartidae	14
	Mytilidae	2
	Lyonsiidae	1
	Pandoridae	1
	Tellinidae	*
	Veneridae	*
		31
1109	Nuculidae	5
	Nuculanidae	12
	Astartidae	18
	Tellinidae	6
	Pectinidae	1
	Cardiidae	2
	Pandoridae	2
	Mytilidae	5
	Veneridae	1
		51
1110	Nuculidae	2
	Nuculanidae	11
	Astartidae	8
	Pectinidae	2
	Cardiidae	1
	Thraciidae	1
	Lyonsiidae	2
	Veneridae	1
	Myidae	*
	Tellinidae	*
		28
1111	Nuculidae	4
	Nuculanidae	8
	Astartidae	15
	Tellinidae	2
	Cardiidae	1
	Pandoridae	1
	Lyonsiidae	1
	Hiatellidae	1
		33
1114	Nuculidae	3
	Nuculanidae	3
	Astartidae	8
	Tellinidae	1
	Pectinidae	3

Table 27: (continued)

STATION: PPB-70 (cont.)

Grab Number	Family	Count of live specimens
1114 (cont.)	Cardiidae	2
	Mytilidae	5
	Hiatellidae	1
		26

STATION: PPB-100

Grab Number	Family	Count of live specimens
1131	Nuculidae	8
	Nuculanidae	2
	Astartidae	13
	Tellinidae	2
	Thyasiridae	1
	Pectinidae	1
	Mytilidae	1
	Veneridae	1
	Hiatellidae	1
	Carditidae	*
		30
1132	Nuculidae	3
	Astartidae	6
	Tellinidae	1
	Thyasiridae	1
		11
1133	Nuculidae	6
	Astartidae	7
	Pectinidae	1
	Veneridae	1
	Carditidae	2
		17
1134	Nuculanidae	1
	Astartidae	5
	Thyasiridae	1
		7
1135	Nuculidae	2
	Nuculanidae	1
	Astartidae	2
	Veneridae	1
	Carditidae	*
		6
1136	Nuculidae	5
	Astartidae	6
	Veneridae	2
	Nuculanidae	*
		13

Table 27: (continued)

STATION PPB-100 (cont.)

Grab Number	Family	Count of live specimens
1137	Nuculidae	4
	Nuculanidae	2
	Astartidae	9
	Veneridae	1
	Carditidae	*
		16
1138	Nuculidae	5
	Nuculanidae	1
	Astartidae	6
	Tellinidae	1
	Veneridae	1
	Malletidae	*
		14
1139	Nuculidae	1
	Nuculanidae	2
	Astartidae	7
	Tellinidae	1
	Mytilidae	1
	Lyonsiidae	1
	Veneridae	1
	Cardiidae	*
		14
1140	Nuculidae	3
	Nuculanidae	1
	Astartidae	11
	Thyasiridae	1
	Carditidae	*
		16

Table 28: Polychaete totals by family from grab samples taken off Barrow, Alaska. Five Smith-McIntyre grabs were obtained at each station, and the counts represent 0.5 m^2 of ocean bottom. The station designations are indicative of the water depth in meters.

	BRB 5	BRB 10	BRB 15	BRB 20	BRB 25
AMPHARETIDAE :	6	13		7	22
APISTOBRANCHIDAE:					
CAPITELLIDAE :	13	47	3	7	36
CHAETOPTERIDAE :					
CIRRATULIDAE :	14	24	2	9	18
COSSURIDAE :				1	
DORVILLEIDAE :	1	4			
FLABELLIGERIDAE :	1	70	2	2	
GONIADIDAE :					
HESIONIDAE :	51	1			4
LUMBRINERIDAE :				1	1
MAGELONIDAE :		1			
MALDANIDAE :					
NEPHTYIDAE :	81	38	6	158	44
NEREIDAE :					
ONUPHIDAE :					
OPHELIIDAE :		1			
ORBINIIDAE :	17	30	1	2	12
OWENIIDAE :					
PARAONIDAE :		1			
PECTINARIIDAE :	6	1150	175	244	173
PHYLLODOCIDAE :	18	45	7	19	48
POLYNOIDAE :	5	7	14	13	24
SABELLIDAE :	12	10			
SCALIBREGMIDAE :		1			
SERPULIDAE :					
SIGALIONIDAE :		7	2	1	25
SPHAERODORIDAE :					
SPINTHERIDAE :					
SPIONIDAE :	215	33	9	24	58
STERNASPIDAE :				4	2
SYLLIDAE :		4	4		
TEREBELLIDAE :		2			
TRICHOBRANCHIDAE:		4	1		
TROCHOCHAETIDAE :					
unidentified :					
TOTALS :	440	1493	226	492	467

Table 29: Polychaete totals by family from grab samples taken off Pitt Point, Alaska. Five Smith-McIntyre grabs were obtained at each station, and the counts represent 0.5 m^2 of ocean bottom. The station designations are indicative of the water depth in meters.

		PPB 5	PPB 10	PPB 15	PPB 20
AMPHARETIDAE	:	296	2		5
APISTOBRANCHIDAE	:	5	1	1	
CAPITELLIDAE	:	35	26	11	38
CHAETOPTERIDAE	:				
CIRRATULIDAE	:	40	59	2	18
COSSURIDAE	:	1		4	8
DORVILLEIDAE	:	10			
FLABELLIGERIDAE	:		1		
GONIADIDAE	:				
HESIONIDAE	:			2	5
LUMBRINERIDAE	:				
MAGELONIDAE	:				
MALDANIDAE	:		1		1
NEPHTYIDAE	:	1	7	7	9
NEREIDAE	:				
ONUPHIDAE	:				
OPHELIIDAE	:	1		1	2
ORBINIIDAE	:	243	20		
OWENIIDAE	:				
PARAONIDAE	:		13	8	28
PECTINARIIDAE	:				4
PHYLLODOCIDAE	:	39	16	2	4
POLYNOIDAE	:		4		4
SABELLIDAE	:	185	142		
SCALIBREGMIDAE	:		6		
SERPULIDAE	:				
SIGALIONIDAE	:	13			1
SPHAERODORIDAE	:	98	3	1	
SPINTHERIDAE	:				
SPIONIDAE	:	769	70	243	19
STERNASPIDAE	:		6		1
SYLLIDAE	:	1		1	1
TEREBELLIDAE	:	4	24		1
TRICHOBRANCHIDAE	:	151	14		
TROCHOCHAETIDAE	:				2
unidentified	:				
TOTALS	:	1892	415	283	151

Table 29: (cont.) Polychaete totals by family from grab samples taken off Pitt Point, Alaska. Five Smith-McIntyre grabs were obtained at each station, and the counts represent 0.5 m^2 of ocean bottom. The station designations are indicative of the water depth in meters.

	PPB 25	PPB 40	PPB 55	PPB 70	PPB 100
AMPHARETIDAE :	2	27	101	59	33
APISTOBRANCHIDAE:	36	4	7		15
CAPITELLIDAE :	1	54	49	12	180
CHAETOPTERIDAE :					33
CIRRATULIDAE :	52	125	68	105	164
COSSURIDAE :	22			1	57
DORVILLEIDAE :	1	10	15	10	6
FLABELLIGERIDAE :		1	41	26	1
GONIADIDAE :			6		1
HESIONIDAE :		2	5	20	6
LUMBRINERIDAE :	4	38	45	53	119
MAGELONIDAE :		6			
MALDANIDAE :	1	115	44	27	42
NEPHTYIDAE :	66	14	53	31	201
NEREIDAE :					
ONUPHIDAE :		38	25	2	42
OPHELIIDAE :	8	2	26	6	7
ORBINIIDAE :	2	14	6		64
OWENIIDAE :		1	51	35	14
PARAONIDAE :	65	111	47	45	97
PECTINARIIDAE :	4		1		
PHYLLODOCIDAE :		12	21	14	14
POLYNOIDAE :	2	12	20	12	7
SABELLIDAE :	4	49	97	158	15
SCALIBREGMIDAE :			3	6	
SERPULIDAE :		2			
SIGALIONIDAE :	1	34	117	199	60
SPHAERODORIDAE :	11		6	6	8
SPINTHERIDAE :			1		
SPIONIDAE :	15	66	120	267	22
STERNASPIDAE :	46	12			2
SYLLIDAE :	1	13	26	31	5
TEREBELLIDAE :	14	7	15	31	5
TRICHOBRANCHIDAE:		17	120	78	12
TROCHOCHAETIDAE :		1	3		2
unidentified :					
TOTALS :	358	787	1139	1234	1231

Table 30: Polychaete totals by family from grab samples taken off Pingok Island, Alaska. Five Smith-McIntyre grabs were obtained at each station, and the counts represent p.5 m^2 of ocean bottom. The station designations are indicative of the water depth in meters.

	PIB 5	PIB 10	PIB 15
AMPHARETIDAE :	22	11	158
APISTOBRANCHIDAE:	1		
CAPITELLIDAE :	6	26	15
CHAETOPTERIDAE :			
CIRRATULIDAE :	55	75	16
COSSURIDAE :		39	
DORVILLEIDAE :	3	7	
FLABELLIGERIDAE :	8		
GONIADIDAE :			
HESIONIDAE :	17		
LUMBRINERIDAE :			
MAGELONIDAE :			
MALDANIDAE :	123	1	
NEPHTYIDAE :	18	43	1
NEREIDAE :			
ONUPHIDAE :			
OPHELIIDAE :	4		
ORBINIIDAE :	25		3
OWENIIDAE :			
PARAONIDAE :	2	1	
PECTINARIIDAE :			
PHYLLODOCIDAE :	9	23	7
POLYNOIDAE :	4	1	
SABELLIDAE :	16	212	33
SCALIBREGMIDAE :	5	1	
SERPULIDAE :	1		
SIGALIONIDAE :	29		
SPHAERODORIDAE :	1	127	16
SPINTHERIDAE :			
SPIONIDAE :	43	2369	322
STERNASPIDAE :	4	7	
SYLLIDAE :			
TEREBELLIDAE :			
TRICHOBRANCHIDAE:	2	5	1
TROCHOCHAETIDAE :			
unidentified :	1		
TOTALS :	399	2948	572

Table 31: Polychaete totals by family from grab samples taken off Narwhal Island, Alaska. Five Smith-McIntyre grabs were obtained at each station, and the counts represent 0.5 m^2 of ocean bottom. The station designations are indicative of the water depth in meters.

	NIB 5	NIB 10	NIB 15
AMPHARETIDAE :	35	385	14
APISTOBRANCHIDAE:			1
CAPITELLIDAE :	37	9	24
CHAETOPTERIDAE :			
CIRRATULIDAE :	29	90	87
COSSURIDAE :			
DORVILLEIDAE :	5	2	19
FLABELLIGERIDAE :	5	8	10
GONIADIDAE :			
HESIONIDAE :	130	25	16
LUMBRINERIDAE :			1
MAGELONIDAE :			
MALDANIDAE :	3	5	20
NEPHTYIDAE :		2	24
NEREIDAE :			
ONUPHIDAE :			
OPHELIIDAE :		3	9
ORBINIIDAE :		2	5
OWENIIDAE :			
PARAONIDAE :			1
PECTINARIIDAE :			
PHYLLODOCIDAE :	2	25	26
POLYNOIDAE :	2	5	5
SABELLIDAE :	79	8	15
SCALIBREGMIDAE :	5	45	4
SERPULIDAE :			
SIGALIONIDAE :			9
SPHAERODORIDAE :		15	1
SPINTHERIDAE :			
SPIONIDAE :	249	752	47
STERNASPIDAE :			
SYLLIDAE :		5	8
TEREBELLIDAE :	11	2	
TRICHOBRANCHIDAE:	32	37	5
TROCHOCHAETIDAE :			
unidentified :		1	
TOTALS :	624	1426	352

Table 32: Polychaete totals by family from grab samples taken off Barter Island, Alaska. Five Smith-McIntyre grabs were obtained at each station, and the counts represent 0.5 m^2 of ocean bottom. The station designations are indicative of the water depth in meters.

	BAB 5	BAB 10	BAB 15	BAB 20	BAB 25
AMPHARETIDAE :	225	40	12	48	1
APISTOBRANCHIDAE:		10	16	90	2
CAPITELLIDAE :	20	13	38	75	43
CHAETOPTERIDAE :					
CIRRATULIDAE :	27	32	168	332	43
COSSURIDAE :				31	6
DORVILLEIDAE :	3	3	72	19	3
FLABELLIGERIDAE :		3	42	173	5
GONIADIDAE :					
HESIONIDAE :	5	1	88	54	4
LUMBRINERIDAE :			1	1	
MAGELONIDAE :					
MALDANIDAE :		1	125	49	1
NEPHTYIDAE :		18	143	151	14
NEREIDAE :					
ONUPHIDAE :					1
OPHELIIDAE :			7	47	14
ORBINIIDAE :	117	16	2	17	4
OWENIIDAE :					
PARAONIDAE :		1	25	79	
PECTINARIIDAE :			1	5	
PHYLLODOCIDAE :	8	15	15	7	7
POLYNOIDAE :	3		6	5	5
SABELLIDAE :	128		20	14	
SCALIBREGMIDAE :		7	3	6	
SERPULIDAE :					
SIGALIONIDAE :			6	25	3
SPHAERODORIDAE :	137	4		3	
SPINTHERIDAE :					
SPIONIDAE :	252	365	167	21	17
STERNASPIDAE :				16	
SYLLIDAE :	1		1	3	
TEREBELLIDAE :	3	4		3	
TRICHOBRANCHIDAE:	11	18	7	21	1
TROCHOCHAETIDAE :					
unidentified :			14	6	
TOTALS :	940	551	979	1301	174

Table 33: Harpacticoid copepods found during seasonal sampling of the Pitt Point transect.

Cruise	Station	Species	No./m^2
OCS-1 Oct. '75	PPB-55	Tisbe furcata	6
		Harpacticus superflexus	4
		Pseudocervinia magna	2
		Typhlamphiascus lamellifer	2
		Halectinosoma neglectum	2
		Total	16
	PPB-100	Tisbe furcata	50
		Halectinosoma neglectum	32
		Pseudocervinia magna	26
		Parananopus echinipes	24
		Harpacticus superflexus	12
		Typhlamphiascus lamellifer	12
		Danielssenia fusiformis	8
		Thalestris figida	4
		Bradya typica	2
		Total	170
OCS-2 Mar. '76	PPB-25	Pseudocervinia magna	2
	PPB-25	Paramphiascopsis giesbrechti	2
	PPB-55	Pseudocervinia magna	7
		Paramphiascopsis giesbrechti	7
		Harpacticus superflexus	1
		Thalestris frigida	1
		Halectinosoma neglectum	1
		Total	17
	PPB-70	Pseudocervinia magna	20
		Bradya typica	2
		Halectinosoma neglectum	2
		Total	24
	PPB-100	Pseudocervinia magna	10
		Paramphiascopsis giesbrechti	7
		Bradya typica	3
		Typhlamphiascus lamellifer	2
		Parathalestris jacksoni	2
		Parananopus echinipes	1
		Cervinia synarthra	1
		Total	26

Table 33:(continued)

Cruise	Station	Species	No./m^2
OCS-3 May '76	PPB-25	*Pseudocervinia magna*	1
		Paramphiascopsis giesbrechti	1
		Total	2
	PPB-40	*Typhlamphiascus lamellifer*	4
		Halectinosoma neglectum	4
		Total	8
	PPB-55	*Pseudocervinia magna*	30
		Paramphiascopsis giesbrechti	11
		Bradya typica	10
		Paranannopus echinipes	5
		Argestes mollis	4
		Eurycletodes arcticus	4
		Eurycletodes serratus	2
		Halectinosoma neglectum	2
		Zaus sp. A	2
		Zosime sp. A	2
		Total	72
	PPB-70	*Paramphiascopsis giesbrechti*	8
		Pseudocervinia magna	2
		Typhlamphiascus lamellifer	2
		Sarsameira elongata	2
		Total	14
	PPB-100	*Paranannopus echinipes*	30
		Paramphiascopsis giesbrechti	26
		Pseudocervinia magna	10
		Bradya typica	8
		Eurycletodes arcticus	4
		Halectinosoma neglectum	2
		Total	80
OCS-4 Aug. '76	PPB-25	Pseudocervinia magna	6
	PPB-55	*Paranannopus echinipes*	12
		Pseudocervinia magna	10
		Harpacticus superflexus	2
		Typhlamphiascus lamellifer	2
		Total	26
	PPB-70	*Harpacticus superflexus*	2
	PPB-100	*Harpacticus superflexus*	18
		Paranannopus echinipes	10
		Pseudocervinia magna	2
		Paramphiascopsis giesbrechti	2
		Bradya typica	2
		Proameira dubia	2
		Total	36

Table 33:(continued)

Cruise	Station	Species	No./m^2
OCS-6 Nov. '76	PPB-55	Parananopus echinipes	10
		Harpacticus superflexus	2
		Zaus sp. A	2
		Total	14
	PPB-70	Pseudocervinia magna	2
		Harpacticus superflexus	2
		Total	4
	PPB-100	Parananopus echinipes	2
		Pseudocervinia magna	2
		Total	4

Table 34: Updated List for the Beaufort Sea Harpacticoida (Copepoda), 31 species found.

Ameiridae

Proameira dubia (Sars, 1920)
Sarsameira elongata (Sars, 1909)

Cerviniidae

Cervinia bradya Norman, 1878
Cervinia synarthra Sars, 1903
Pseudocervinia magna (Smirnov, 1946)

Cletodidae

Argestes mollis Sars, 1910
Eurycletodes arcticus Lang, 1936
Eurycletodes serratus Sars, 1920
Mesocletodes monensis (I.C. Thompson, 1893)
Parananopus echinipes Smirnov, 1946

Diosaccidae

Amphiascus propinqvus Sars, 1906
Paramphiascella fulvofasciata Rosenfield and Coull, 1975
Paramphiascopsis giesbrechti (Sars, 1906)
Stenhelia proxima Sars, 1911
Stenhelia nuwukensis M.S. Wilson, 1965
Stenhelia sp. B
Stenhelia sp. C
Typhlamphiascus lamellifer (Sars, 1911)

Ectinosomidae

Bradya confluens Lang, 1936
Bradya typica Boeck, 1872
Halectinosoma neglectum (Sars, 1940)
Halectinosoma sp. A

Harpacticidae

Harpacticus superflexus Willey, 1920
Harpacticus uniremis Kroyer, 1842
Zaus sp. A

Tachidiidae

Danielssenia fusiformis (Brady and Robertson, 1875)
Thompsonula hyaenae (I.C. Thompson, 1889)

Thalestridae

Parathalestris jacksoni (T.Scott, 1898)
Thalestris frigida T. Scott, 1898

Tisbidae

Tisbe furcata (Baird, 1837)
Zosime sp. A

Annual Report

R.U. 19
Apr 77 - Mar 78
Two pages

FINFISH RESOURCE SURVEYS IN NORTON SOUND AND KOTZEBUE SOUND

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March 1978

I. Task Objectives

The objectives of this research unit are to:

1) Determine the spatial and temporal distribution, species composition and relative abundance of finfishes in the coastal waters of Norton Sound and Kotzebue Sound east of 166 Degrees West 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 and Kotzebue Sound east of 166 Degrees West 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.

II. Field Activities

A brief summary of results for the 1977 field season has been provided in the OCS quarterly reports submitted in July, September and December. Detailed analysis and discussion of these results is being prepared in the project completion report due September 30, 1978. Activities this past quarter (January through March) have been associated entirely with drafting of this latter report, with the exception of a single winter trip. A trip was made in March, 1978 to the Port Clarence area where gillnets were set under the ice in order to obtain winter herring samples for AWL analysis.

III. Results and Preliminary Interpretation

No species of fish were captured during the winter sampling trip to Port Clarence in March, 1978. As stated, results of the 1977 season will be presented in the project completion report. A first draft of this report was about 50 percent completed by the end of this quarter.

IV. Problems and Changes

None during this quarter. Problems experienced in the 1977 field season will be included in the project completion report.

V. Estimate of Funds Expended

A balance of approximately $35,000 remains for RU 19 studies. These monies will cover salaries needed to finalize the project completion report. A limited amount will be used for printing costs and computer time.

ANNUAL REPORT

Contract No.
Research Unit #78
Reporting Period-April 1, 1978-March 31, 1978
Number of Pages - 161

BASELINE/RECONNAIS^ANCE CHARACTERIZATION LITTORAL BIOTA, GULF OF ALASKA AND BERING SEA

by

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OUTER CONTINENTAL SHELF ENERGY ASSESSMENT PROGRAM
Sponsored by
U.S. Department of the Interior
Bureau of Land Management

April 1, 1978

* Dr. S.T. Zimmerman was principal investigator during the planning and execution of the sampling program.

I. Summary of objectives, conclusions and implications with respect to OCS oil and gas development.

Our objective here is to describe the distribution and relative abundance patterns of littoral plants and invertebrates at representative sites in the eastern Gulf of Alaska. Eighteen sites were chosen for study. In addition we examined, insofar as the data permit, those factors which are likely to play important roles in structuring intertidal communities. Since biological interactions have been shown to be important to community organization we look for evidence of key interactions among our general field observations and attempt to evaluate their role in structuring the communities.

Understanding how communities are organized is important for predicting the effects of oil and gas development on community composition and on the dynamics of all populations in the community because the impact of oil on a population will depend not only on the susceptibility of individuals in that population to oil toxicity but also on the effect of oil on predators or competitors of those individuals.

Although physical disturbance such as movement of boulders at exposed sites with extensive boulder fields and ice scouring may be of overriding importance to community structure in some localities (e.g. Ocean Cape and Cape Yakataga) our studies did not adequately assess the role of biological interactions in controlling that structure.

Within the limitations of our data we examine the role of an important interaction in intertidal communities, competition for space, especially competition among dominant competitors and accompanying effects on subdominants. Our data indicate that total species richness tends to be greater in patches of intertidal area dominated by Mytilus edulis than in patches dominated by Fucus distichus, and that the difference is accounted for by increased species richness of small subdominants in *Mytilus* dominated areas. *Mytilus* does not appear to have a greater adverse effect on competitively inferior large subdominants than does *Fucus*.

The use of multispectral scanning as a technique for mapping the distribution of intertidal macrophytes needs further evaluation. Successful evaluation will require the simultaneous collection of data by multispectral scanning of intertidal areas with adequately marked algal zones and by observers on the ground.

II. Introduction

A. General nature and scope of study

The first study of the local distributuion of intertidal organisms in a locality north of Vancouver Island in the North Pacific was that of Gurjanova (1935; see also Gurjanova 1966) on Be ing Island in the Commander Islands. Hers was the only published study on the ecology of intertidal species assemblages in this region until that of Nybakken (1969). Since Nybakken there have been a number of studies of intertidal species assemblages at various localities mostly in southeastern and southcentral Alaska. With the exception of Haven's (1971) study of the effects of an unplanned experiment in Prince William Sound all these studies have been descriptive. Feder and Mueller (1972) review them (for recent additions to the list see Zimmerman et al. 1978).

B. Specific objectives

Here we describe the patterns of distribution and abundance of littoral plants and invertebrates at 18 sites in the Eastern Gulf of Alaska based on sampling conducted there in spring, summer, and early fall from 1974 through 1976. In addition we evaluate multispectral scanning (MSS) as a technique for mapping the distribution and estimating the abundance (areal coverage) of littoral macrophytes. Finally we examine species richness and the species-abundance relations among organisms in patches of intertidal area dominated either by *Mytilus edulis* or *Fucus distichus* to gain insight into the mechanisms that structure the intertidal community at upper levels.

Other aspects of our research in the eastern Gulf of Alaska are published elsewhere. Sears and Zimmerman (1977) provide maps of the general physical composition (e.g. bedrock, boulder, sand, etc.), slope, and biological cover of beaches from Yakutat to the southern Kenai Peninsula excluding most of Prince William Sound. Palmisano (in preparation; see also Appendix 1 of Zimmerman and Merrell 1976a) examines the composition and rates of accumulation of marine organisms in the high tidal zone (drift zone) on three beaches in the eastern Gulf of Alaska.

C. Relevance of the Study to Petroleum Development

In a recent report on the effects of organic contaminants on ecosystem processes prepared for the National Science Foundation by the Institute of Ecology Neuhold and Ruggerio (1976) stress the importance of understanding species interactions for predicting the effect of a given toxicant on an ecosystem. They conclude that "one of the largest gaps in our present knowledge concerns species interactions". Others have questioned traditional approaches to the study of the effects of toxicants, enrichment, and habitat disruption on benthic ecosystems, and have expressed the need for information on how species interact as fundamental to these studies (Lewis 1972, Spight 1976, and Gray 1976). Pollution by oil and oil dispersants has been shown to produce major changes in the abundances of algae and invertebrates indirectly by temporarily eliminating herbivores (North et al. 1964, Smith 1968, Nelson-Smith 1972) which ultimately can delay recolonization for up to 9-10 years (Southward and Southward 1978). In these studies the most important effect of oil and oil dispersants was the temporary reduction of a key biological interaction, herbivory by limpets and urchins.

III. Current State of Knowledge

There are three ways to measure the role of biological interactions. We relate them briefly here. See Connell (1975) for a fuller discussion. The first is through controlled field experiments. This is the best approach provided that a proper control can be established because it allows one to alter the abundances of the species involved in the interaction while permitting other environmental factors to vary naturally.

The second approach involves the study of "natural experiments". This is appropriate in situations where a key species may be present in a particular community in one locality but absent in a nearby locality. The main disadvantage of this approach is that it lacks a control. It is extremely unlikely that important aspects of the environment are identical at both localities except for the absence of one species

The third approach is to describe the pattern that exists in a community at one or more points in time and see whether or not it fits the predictions of the model. This is the least desirable of the three approaches, but it can detect patterns which may suggest hypotheses to test.

The descriptive approach which typically characterizes baseline studies (the present one included) almost inevitably restricts the choices among the three approaches to the description of pattern in the community. Here we consider patterns of abundance of individuals among species at upper levels in the intertidal community and try to explain them on theoretical grounds.

IV. Study Areas

The geographical area included in this report is that section of the coast of Alaska bordering the Gulf of Alaska from Yakutat (lat. 59° 32'N, long. 139° 51'W) to Port Dick (lat. 59° 13'N, long. 151° 01'W) near the southern tip of the Kenai Peninsula (Fig. 1). Five types of beaches based on substratum were designated for study. Figure 2 shows the general distribution of these beaches within the study area. Half of the study sites were on beaches composed mostly of bedrock, about 1/4 on sand beaches and the rest on boulder or mud beaches (Table 1). A detailed description of each site is included in the results section below.

V. Methods

The sampling methods that we used in the eastern Gulf of Alaska were similar to those of Zimmerman et al. (1978). We review them briefly here.

Transect lines.

Transect lines were used for systematic sampling of populations of intertidal organisms at regular intervals along their vertical distributions. The lines

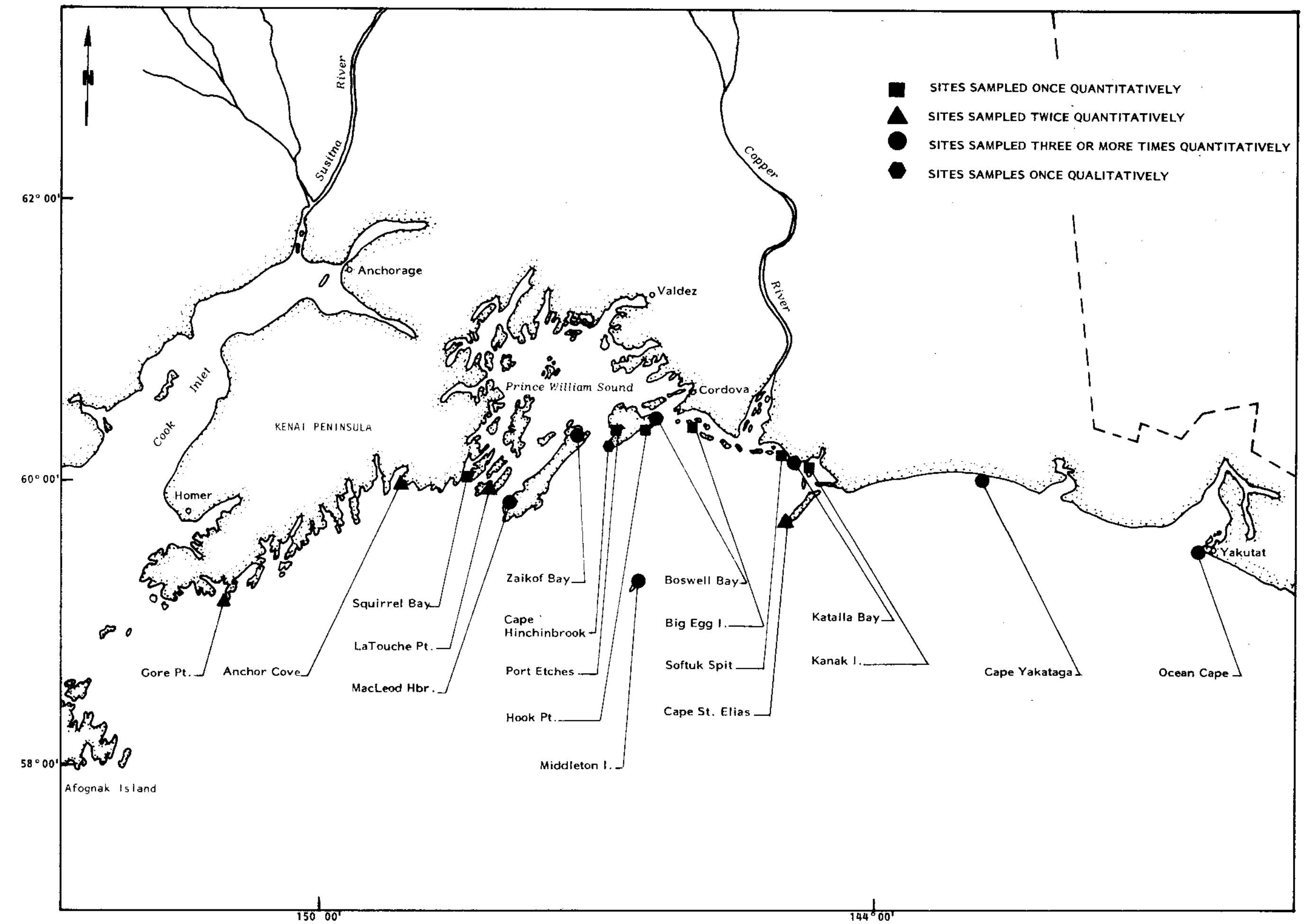


Fig. 1. Locations of sites sampled in the eastern Gulf of Alaska.

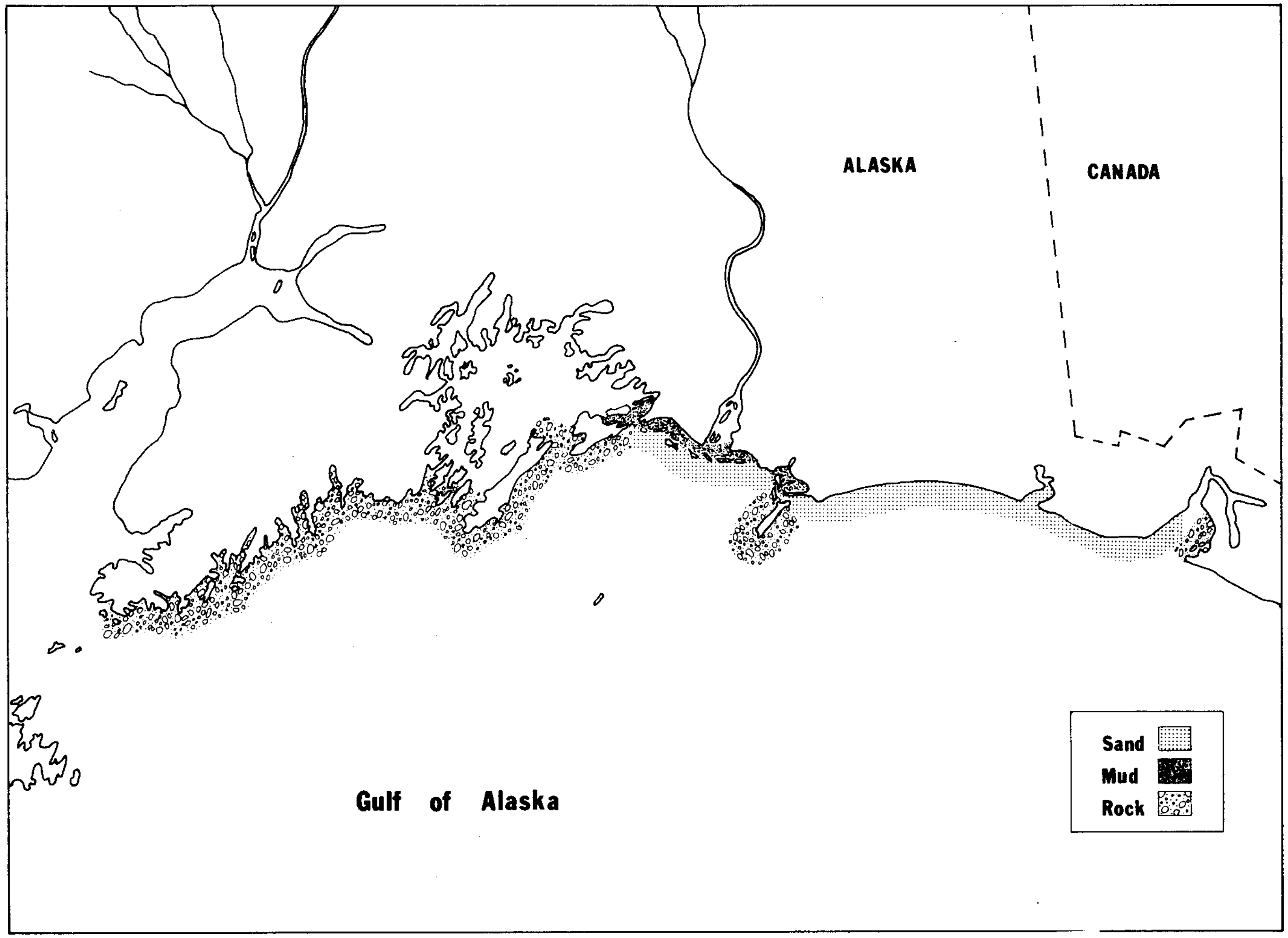


Fig. 2. Distribution of intertidal habitat types in NEGOA. Bedrock, boulder and gravel have been combined (Sears and Zimmerman, 1977).

Table 1 . Description of intertidal sites and types of samples in the East Gulf of Alaska 1974-1976.

QUANTITATIVE

Location	Substrate	Dates Sampled	Elevation Range Sampled (feet)	Sampling Method: Arrow	Sampling Method: Quantitative Collection	Sampling Method: Core	Sampling Method: Visual Enumeration	Quantitative Sample Size	Total N° of Quantitative Transects
Ocean Cape	Boulder Sand	10-11-74 10-12-74 6-10-75 9-4-75 9-5-75	+11.9 → -3.8	X	X	X	X	$1/16\ m^2$ 1 liter n = 42*	1
Cape Yakataga	Bedrock Sand	10-12-74 10-13-74 6-10-75 6-11-75 9-5-75 9-6-75	+15.6 → +2.3	X	X	X	X	$1/16\ m^2$ $1/64\ m^2$ 1 liter n = 118*	9
Cape St. Elias	Bedrock Boulder	9-9-75 4-18-76 4-19-76	+ 9.2 → -2.8		X		X	$1/16\ m^2$ n = 36*	2
Kanak Island	Sand Mud	4-17-76	+ 6.3 → -2.3			X		1 liter n = 23*	1
Katalla Bay	Boulder Bedrock	10-15-74 4-28-75 9-9-75	+ 8.7 → -0.9	X	X	X	X	$1/16\ m^2$ n= 83*	6
Softuk Spit	Sand	4-18-76	+ 3.4 → -1.4			X		1 liter n = 15*	1
Big Egg Island	Sand	4-15-76	+11.5 → -3.0			X		1 liter n = 26*	2
Boswell Bay	Mud	9-18-74 5-1-75 9-7-75 4-14-76	+ 7.9 → -2.2	X		X		1 liter $1/16\ m^2$ n = 133*	5

Table 1 . Description of intertidal sites and types of samples in the East Gulf of Alaska 1974-1976.

QUANTITATIVE

Location	Substrate	Dates Sampled	Elevation Range Sampled (feet)	Sampling Method				Quantitative Sample Size	Total N° of Quantitative Transects
				Arrow	Quantitative Collection	Core	Visual Enumeration		
Hook Point	Sand Mud	4-13-76	+5.8→ -1.4			X		1 liter n = 18*	1
Middleton Island	Mud	10-14-74 4-28-75 9-6-75	-------		X	X		1 liter 1/16 m^2 n = 19*	2
Port Etches	Bedrock	4-27-75	+5.5→ -1.6	X	X			1/16 m^2 n = 15*	1
Zaikof Bay	Bedrock	9-12-74 4-25-75 4-26-75 9-6-75	+10.2→ -2.4	X	X		X	1/16 m^2 1/8 m^2 1/64 m^2 1/32 m^2 n = 99*	4
MacLeod Harbor	Bedrock	9-16-74 9-17-74 4-24-75 9-5-75	+10.2→ +0.3	X	X		X	1/16 m^2 1/8 m^2 1/64 m^2 1/32 m^2 n = 35*	6
Latouche Point	Bedrock	4-23-75 4-24-75 9-4-75 9-5-75	+10.9→ -1.22	X	X		X	1/16 m^2 n = 67*	2
Squirrel Bay	Bedrock Boulder	9-13-74	+15.1→ +2.2	X	X		X	1/16 m^2 1/8 m^2 1/64 m^2 1/32 m^2 n = 41*	1

Table 1 . Description of intertidal sites and types of samples in the East Gulf of Alaska 1974-1976.

QUANTITATIVE

Location	Substrate	Dates Sampled	Elevation Range Sampled (feet)	Sampling Method: Arrow	Sampling Method: Quantitative Collection	Sampling Method: Core	Sampling Method: Visual Enumeration	Quantitative Sample Size	Total N° of Quantitative Transects
Anchor Cove	Bedrock	9-15-74 9-16-74 4-22-75 4-23-75 9-3-75 9-4-75	+10.9→ -0.3	X	X		X	1/16 m^2 1/64 m^2 1/32 m^2 n = 86*	6
Gore Point	Bedrock Boulder	5-21-75 5-22-75 8-6-75	+13.2→ +1.1	X	X			1/16 m^2 1/64 m^2 1/32 m^2 n = 56*	3

* Total number of samples of all sizes taken

QUALITATIVE

Location	Substrate	Dates Sampled	Elevation Range Sampled (feet)
Cape Hinchinbrook	Boulder Bedrock	4-12-76 4-15-76	+11.38→ -0.35

were laid roughly perpendicular to the shoreline usually from the level of mean high water or above (Table 1) to the water's edge at low tide. The number of lines at each site depended on the slope, width, and biological homogeneity of the beach (Table 1).

On bedrock and boulder beaches sampling frames 1/16 m^2 in size were placed at regular intervals along the transect line. The area within each frame was photographed to obtain the coverage of obvious organisms (visual estimates of this coverage were often made as well), and then the plot was scraped to bare rock and the organisms bagged and fixed in 10% formalin.

At sandy and muddy sites a 1 liter (10 cm on a side) corer was used to sample epi- and infaunal organisms on the transects. Often the substrate was sampled at two depths, 0 to -10 cm and -10 to -20 cm depending on the fluidity of the substrate, the presence and location of a reduction layer and the likely presence of macroscopic organisms as determined by taking shovelfuls of sand or mud and sieving it through a 1 mm screen. Two pairs of replicate samples were often collected from each point on the transect line. Larger areas were dug with shovels to estimate the relative abundance of larger less numerous organisms.

Arrow method.

The "arrow" sampling method (developed by R. Myren) is a random sampling method used primarily on vertical or near vertical surfaces such as the sides of large boulders and rock outcrops. With this method a facsimile of the area to be sampled and the general pattern of distribution of dominant organisms was sketched on a sheet of Mylar plastic. Numbered uniformly distributed dots were then placed on the sketch. The positions of a fraction (usually about 25%) of the dots were selected from a random number table. The locations on the rock surface corresponding to the randomly selected dots were marked with numbered arrows. A quadrat (1/16 m^2) was then placed at the tip of each arrow, photographed and its elevation determined (see below). The "arrow" site was not disturbed. Plots of the same size with similar biological cover in a nearby area were scraped clean of organisms which were collected for identification and enumeration.

Nested quadrats.

This method was used occasionally, primarily to study the effect of sample size (quadrat area) on species richness and diversity and to evaluate sampling variability. The results of this aspect of sampling are reported in Zimmerman and Merrell (1976b). The method involved a 1/4 m^2 frame which was divided into 16 1/64 m^2 subareas by strings stretched between opposite sides of the frame. Various sized subareas from 1/64 to 1/8 m^2 were sampled.

The elevations of samples taken by all of the above methods were determined with a transit and level rod using standard surveying techniques. The reference level was the level of low tide predicted in the Tide Tables.

In addition to quantitative and qualitative collections general observations of biological interactions and the distribution, relative abundance and natural history of obvious organisms were made. Minor deviations from the procedures reviewed above are included in the descriptions for each site when appropriate.

Laboratory procedures.

All samples were sorted by the Alaska Marine Sorting Center of the University of Alaska. All organisms were identified, counted (except organisms for which individuals could not be readily distinguished such as many species of algae, sponges, bryozoans, etc.), and weighed (wet weight and dry weight). Organisms from most major phyla were identified to species. Invertebrates from the following taxa were not usually identified by the Sorting Center: Porifera, Cnidaria, Platyhelminthes, Rhynchocoela, Nematoda, Oligochaeta, Insecta and Bryozoa.

The reproductive stages of the two most common genera of algae, Fucus spp and *Alaria* spp, were noted and weights for the different stages were recorded separately. Counts and weights of mussels and limpets were recorded separately for two or three size categories. Finally when most organisms had been removed and all that remained was a diverse mass of small fragments, estimates of the remaining individuals were determined by subsampling the residue.

Sources of bias and error.

None of the sampling methods used adequately sampled large and less common organisms such as starfish and urchins. With regard to intertidal community structure and how oil pollution might affect it, these two groups of organisms probably have an influence which is disproportionate to their abundance and biomass (see results section) and therefore the lack of data is particularly noteworthy.

None of the samples taken for laboratory analysis were strictly random. Whether the lack of randomness vitiates a particular statistical test depends on the questions that are asked of the data and will be discussed when each test is introduced.

The objective of this sampling program was to visit as many "representative" sites as possible and within each site to sample as many habitats as possible. Therefore, despite the large number of samples at most sites, it was difficult to obtain an adequate sample size to test specific hypotheses.

Other sources of bias and error that affect the usefulness of the data from particular sites are included in the descriptions of those sites.

VI. Results

In this section we first give descriptions of each site visited in the eastern Gulf of Alaska. Each description includes the physical description and location of the site, the distribution and abundance patterns of dominant organisms and where appropriate a discussion of factors which may be important to community structure at each site. Then we present our results of the analysis of species-richness and species-abundance relations at selected sites in the eastern Gulf of Alaska.

OCEAN CAPE, YAKUTAT

Physical Description and Location

Ocean Cape (lat. 59° 32.2'N, long. 139° 51.3'W) is at the southeastern entrance to Yakutat Bay (Plate EG-1, Sears and Zimmerman 1977; and Figures 1 and 3). This site is the most exposed of all the eastern Gulf of Alaska sites; waves to a height of 88 ft (26.8 m) have been recorded there (Wade, U.S. Coast Guard, Juneau, pers. comm.). The area we sampled is a field of boulders from cobble size to over 4 m high. Sand beaches dominate the coastline for many miles north and south of the boulder field (Fig. 2). The sand beach upon which the boulders lie is gently sloping; a 60 m transect ran from -0.4 to +2.7 ft (-0.1 to +0.8 m). We used the arrow method (Fig. 4) to sample the biota on the boulders, and collected sand cores along a transect at the border of the boulder field. Palmisano (in preparation) conducted a study of the remains of organisms in windrows on the beach in an area northeast of the Cape. Table 1 is a listing of methods, dates, and tidal range of sampling.

Dominant Organisms

Invertebrates were more abundant than macrophytes in the boulder field at Ocean Cape. Table 2 shows range of tidal elevation, range of numbers per 1/16 m^2, and height of greatest abundance for selected species. *Mytilus edulis* is more abundant at Ocean Cape than at any other of our northeastern Gulf of Alaska sampling sites. *Mytilus* was collected at every elevation we sampled except one (+11.9 ft (+3.6 m)). *Balanus glandula* is another abundant animal at Ocean Cape. At the tidal height where numbers of large *Mytilus* were most abundant (+9.5 ft (+2.9 m)) one of us (N. Calvin) noted many dead *B. glandula* beneath the *Mytilus*. Fig. 5 shows the patchily dense cover of *Mytilus edulis* at the lower limit

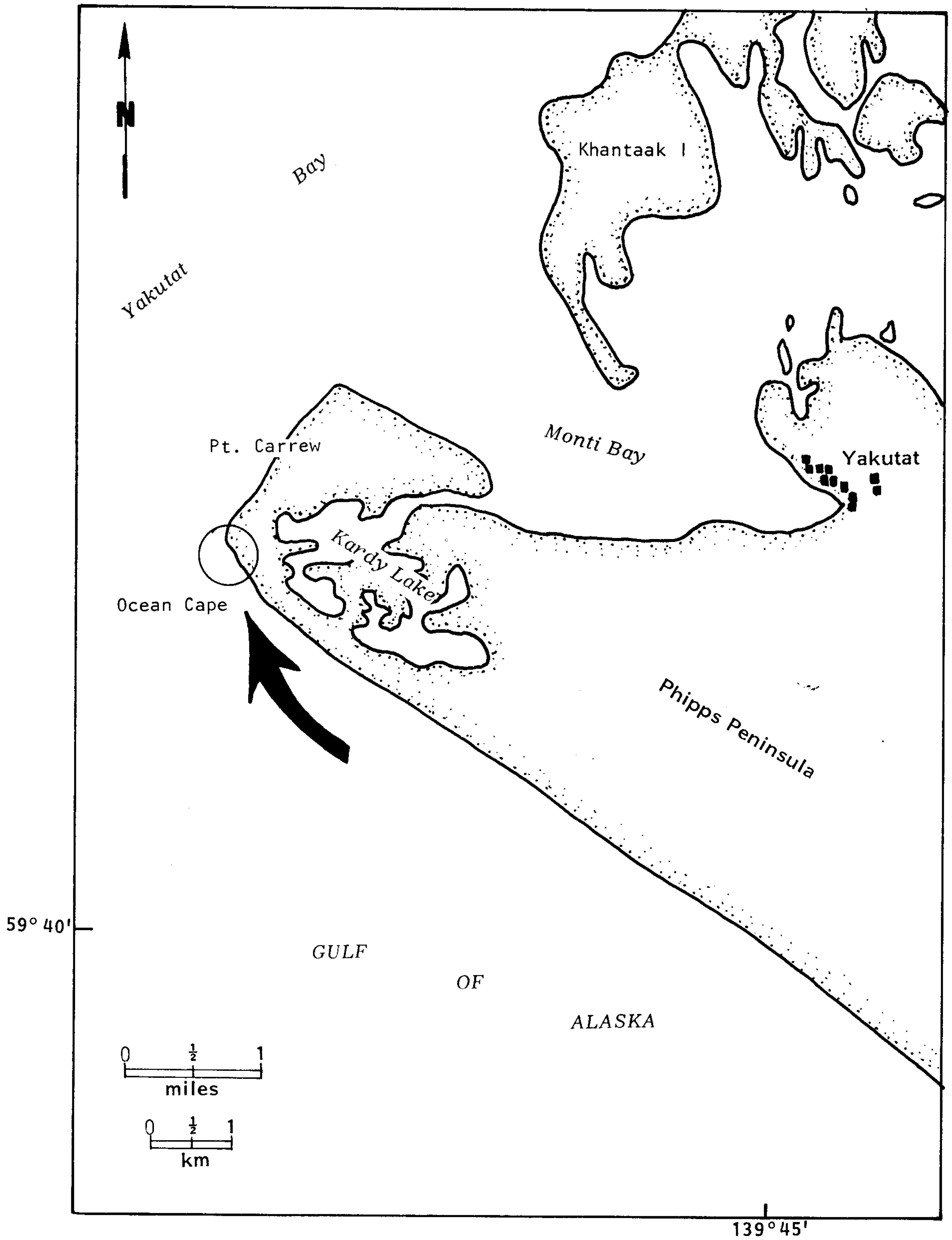


Figure 3 . Ocean Cape site.

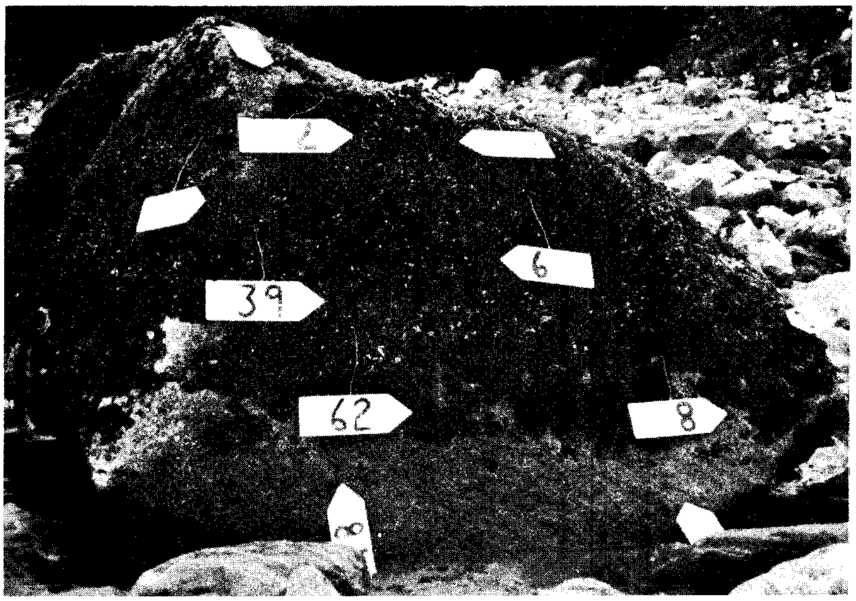


Fig. 4 . High zone boulder with heavy cover of Mytilus edulus. Arrows have been placed randomly for qualitative sampling. Taken in September 1975.

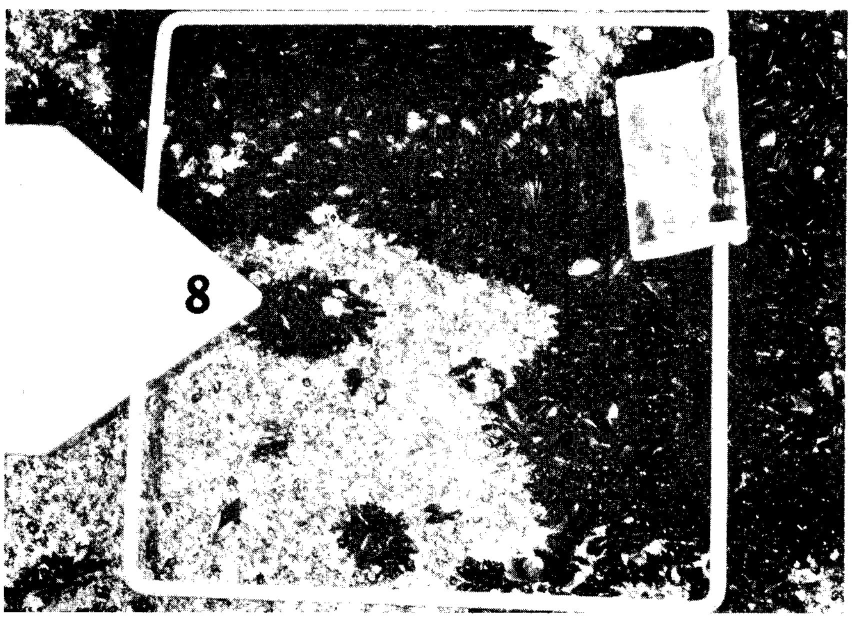


Fig. 5. Patchily dense cover of Mytilus edulis (dark area) on a boulder at Ocean Cape. Taken in September 1975.

Table 2. Range of tidal elevation, numbers per 1/16 m^2, and height of greatest abundance of selected species at Ocean Cape, Yakutat, Alaska.

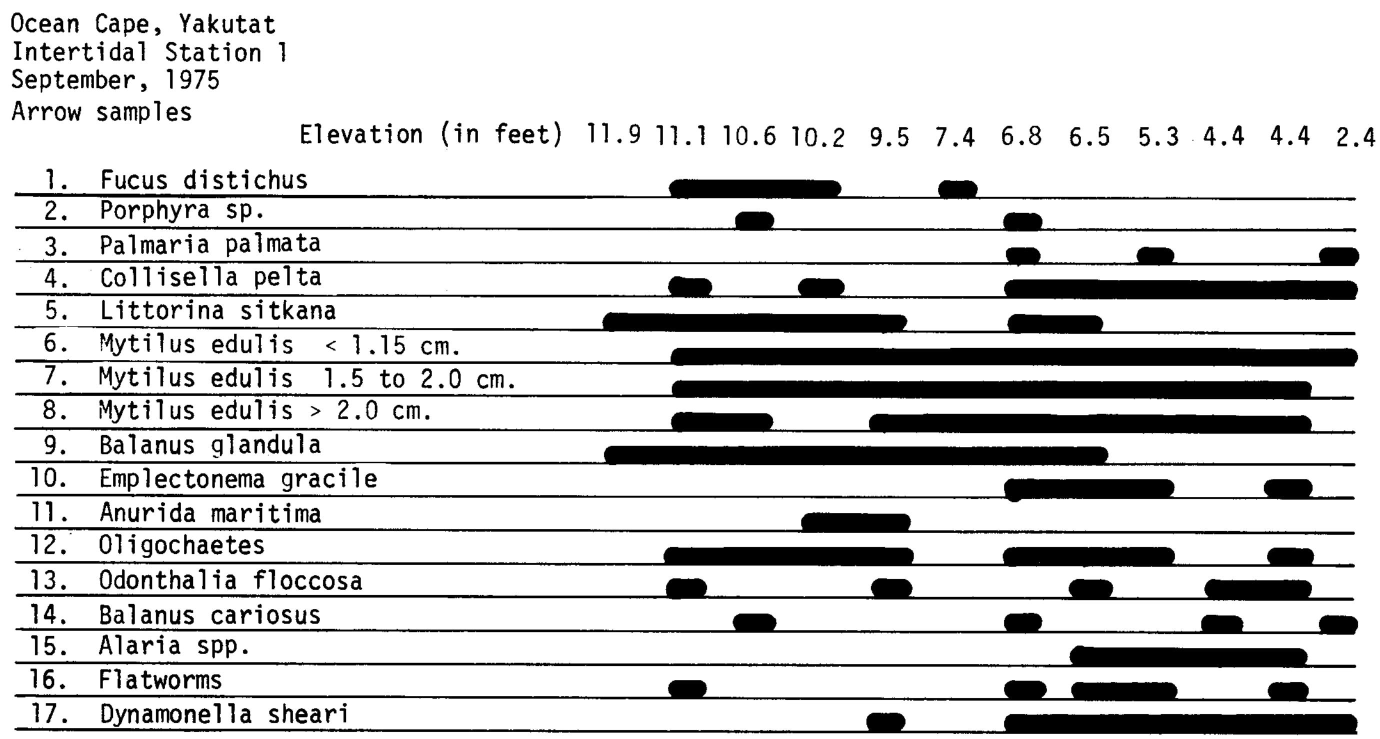
Species	Range of tidal elevation	Range of numbers per 1/16 m^2	Height of greatest abundance
Balanus glandula	+11.9 to +1.9 ft (+3.4 to +0.6 m)	0 to 840	+7.0 to +8.0 ft (+2.1 to +2.4 m)
Mytilus edulis			
<1.5 cm	+11.1 to -0.2 ft (+3.4 to -0.1 m)	7 to 25475	+5.5 ft (+1.7 m)
1.5 to 2.0 cm	+11.1 to +1.8 ft (+3.4 to +0.6 m)	0 to 560	+7.0 ft (+2.1 m)
>2.0 cm	+11.1 to +1.8 ft (+3.4 to +0.6 m)	0 to 550	+9.5 ft (+2.9 m)
Balanus cariosus	+11.9 to -0.2 ft (+3.4 to -0.1 m)	0 to 141	+2.7 ft (+0.8 m)

of the mussel. Balanus cariosus was common at Ocean Cape. In the range where they were most abundant we found them on the seaward side of vertical or sloping boulders. The barnacles were large, thick-walled, and often covered with mussels and algae, especially Palmaria palmata (= Rhodymenia palmata).

Predation on mussels and barnacles did not appear to be a dominant structuring factor at Ocean Cape. We did not collect large sea stars in the quadrats, but we noted a few Evasterias troschelii at the foot of boulders in the low zone. Nucella lima (= Thais lima) was found in the quadrats drilling mussels and barnacles. Numerous flatworms were present in the quadrats. Most Turbellaria are carnivorous (Hyman 1951). Glynn (1965, p. 70) has noted a polyclad worm preying on a limpet; other prey items include nematodes, annelids, snails, isopods, amphipods, barnacles bivalves and ascidians (Hyman 1951). The flatworms in our samples were not identified specifically, and we do not have observations on their food habits. Limpets, fly larvae, and the collembolan, Anurida maritima, are described by Lewis (1964, p. 75-76) as minor fauna of barnacle dominated shores. All of these were present at Ocean Cape, especially in the zone where B. glandula is most abundant; the limpet found most commonly was Collisella pelta.

Macrophyte cover was not heavy. Fucus distichus was most abundant on boulder tops in the high zone (Figs. 6 and 7) Odonthalia floccosa was found on the sides of boulders, mostly in the high zone. Low zone algae were Palmaria palmata and several species of Alaria. Porphyra sp. was common in June but rare in the fall (Fig. 6). We found it on the tops of very large boulders and completely covering low boulders in the high zone.

The sand cores we collected in September 1975 contained very few species and individuals. We found a mysid, crab larvae, a calanoid copepod, fly larvae, and three species of amphipods (Appendix 2).



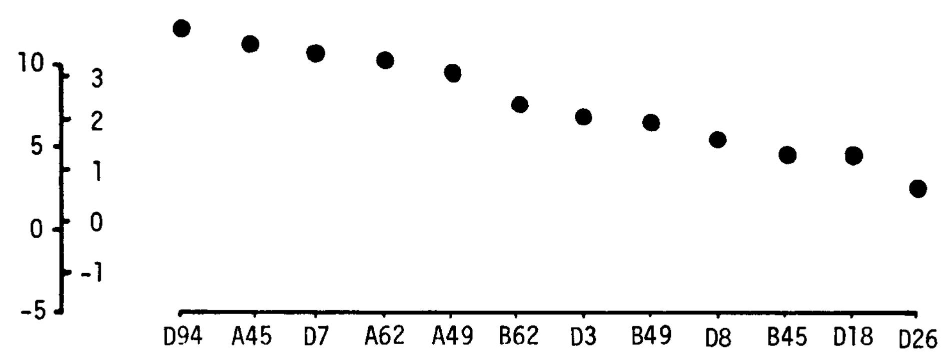
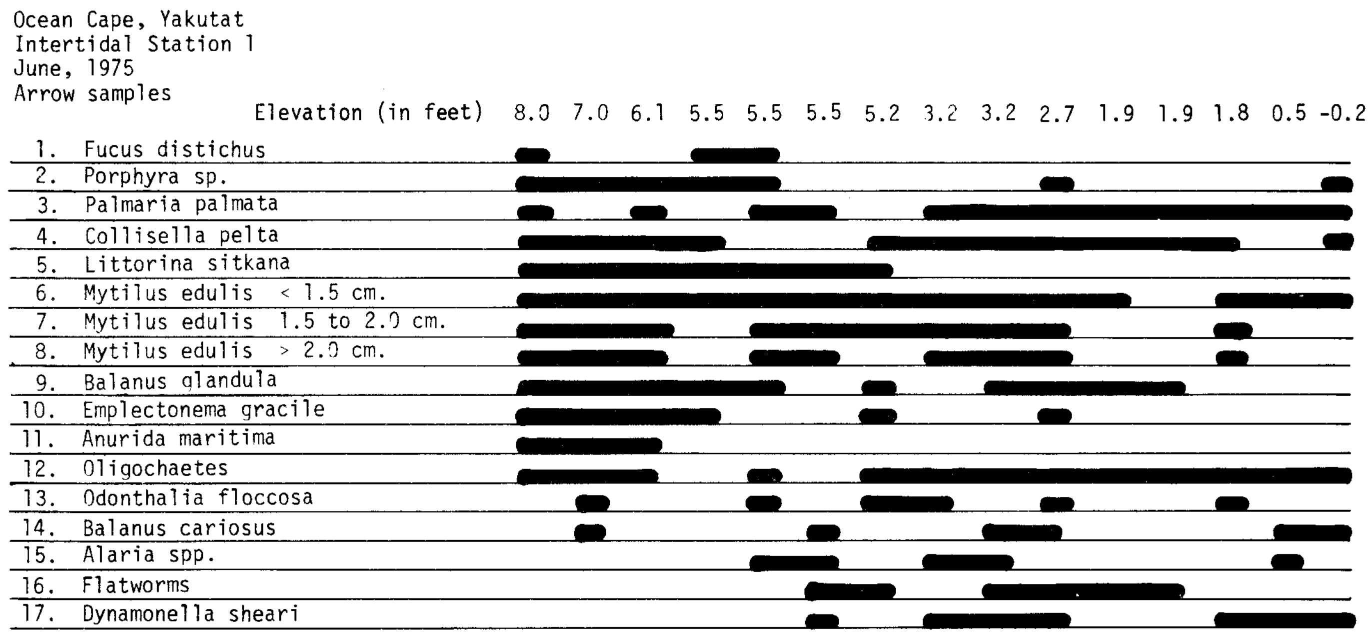


Fig. 6 .

Horizontal and vertical distribution of selected algae and invertebrates from 1/16m^2 quadrat collections



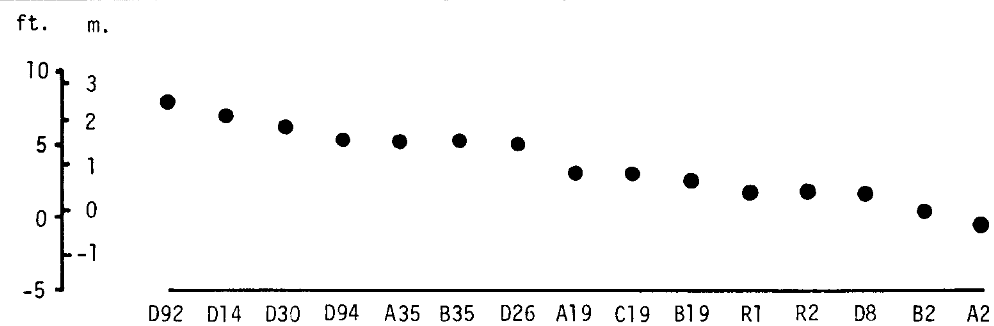


Fig. 7.

Horizontal and vertical distribution of selected algae and invertebrates from 1/16m² quadrat collections

Interactions between Mytilus edulis, Balanus glandula, and Balanus cariosus would be interesting to follow at Ocean Cape. Lewis, in Stephenson and Stephenson, (1972, p. 362) suggests that in the British Isles, "...the almost erratic local distribution of Mytilus simply reflects stages in irregular cycles of settlement, competition with barnacles, predation, denudation, and resettlement, which vary in phase from one site to another". On the basis of a few short visits to this site it is impossible to determine whether such a cycle occurs at Ocean Cape, and if so, what stage of it we were observing.

CAPE YAKATAGA

Location and Physical Description

Cape Yakataga (lat. 60° 3.8'N, long. 147° 25.9"W) is a bedrock reef projecting into the Gulf of Alaska along the coast northwest of the Alaska Panhandle. (Plate EG 12, Sears and Zimmerman 1977 and Figs. 1, 8, and 9). The coast of Alaska from Icy Bay (17 m (31.4 km) east of Cape Yakataga) to Cape Suckling (24 miles (44.5 km) west of Cape Yakataga is sand beach except for Cape Yakataga (Fig. 2). The area of the reef we sampled is a mudstone and conglomerate platform with two prominant hummocks. Fossil shells are common in the bedrock. The platform is covered with a film of standing water up to 4 cm deep. Sand is often swept onto the platform by wave action; during some periods the layer is thin, but following storms sand may accumulate to a depth of about 10 cm. glacial ice (Fig. 10), presumably from Icy Bay, has been observed on the beach (John Palmisano, pers. comm.). Table 1 is a synopsis of sampling at Cape Yakataga. We were not able to sample the reef at the water's edge because continuous surf made it impracticable (Fig. 11).

Dominant Organisms

Cape Yakataga is characterized by small numbers of individuals of many species. Many of the species were ephemeral or in very patchy distribution, being collected only in one season or year. Mytilus edulis is the only species found along

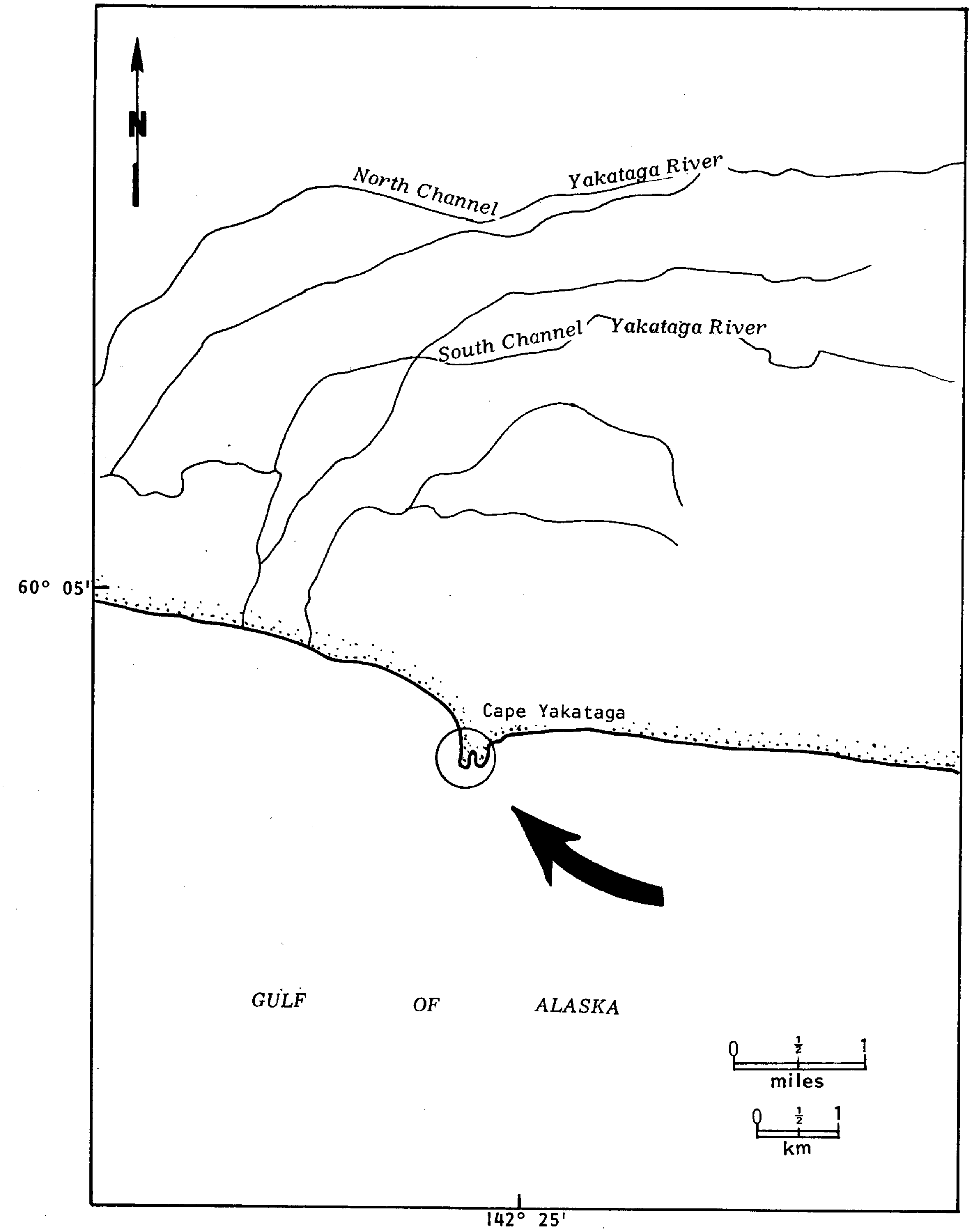


Figure 8 . Cape Yakataga site.

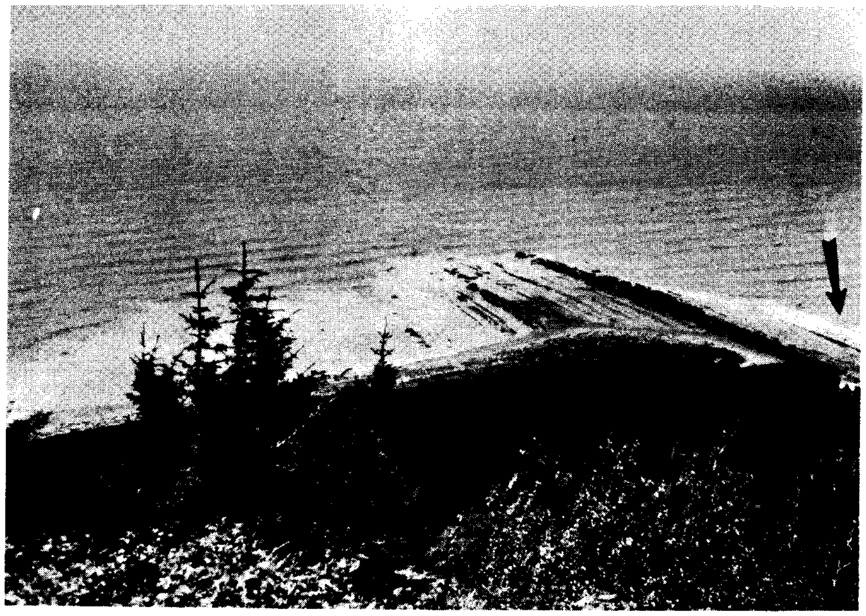


Fig 9. Bedrock reef at Cape Yakataga. Sampling area is at extreme right of reef (arrow). Taken in June 1976.

Fig.10. Glacial ice on the beach at Cape Yakataga. Ice scouring may inhibit the establishment of stable association of attached biota. Taken in February 1975.

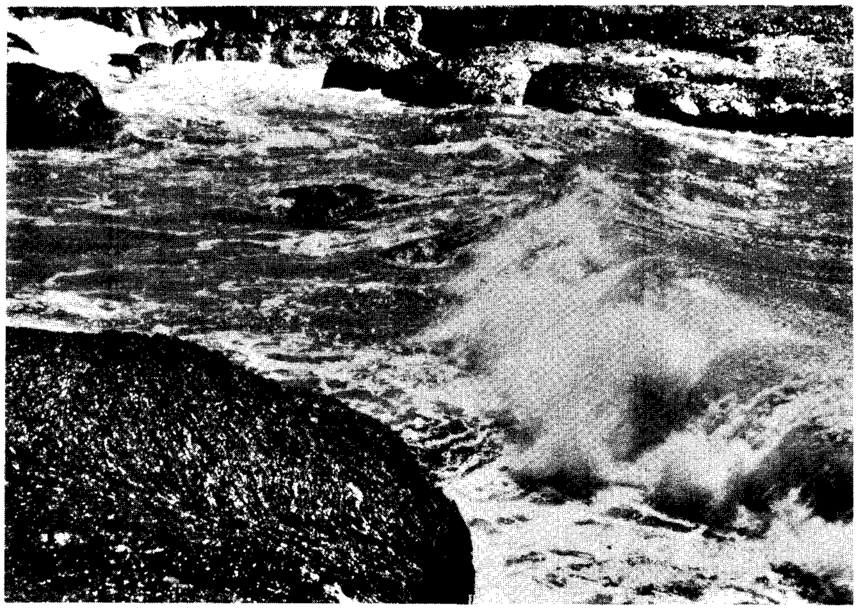


Fig. 11. Surf zone at Cape Yakataga. The outer edges of the reef had surf continuously, making sampling impractical. Taken in June 1976.

Fig. 12. "Upper hummock" transect. Note sand and standing water on bench between hummocks. Taken in September 1975.

all three transects in all seasons. All of the Mytilus were 1.5 cm except for one quadrat on the "upper hummock" transect in September 1975, where there were 253 Mytilus < 1.5 cm; 4, 1.5 - 2.0 cm; and 6 > 2.0 cm. Tables 3, 4, and 5 show the relative frequency and number or weight of selected species collected along three transects during three sampling periods at Cape Yakataga. Appendix 1 lists all species collected at Cape Yakataga for all sampling visits.

Although stable associations were not evident, we did note that mussels and barnacles were most abundant on the landward side of the hummocks, especially on the lower hummock (Figs. 12 and 13). One of the landmarks we used for arrow sampling on the lower hummock was a large colony of sabellid worms, Eudistylia sp, which grew in a fissure at the base of the hummock and thus was offered some protection. Limpets, especially Collisella pelta, were collected in some of the quadrats, but they were more abundant on the higher bedrock reef southeast of of the sampling site. Rounded cavities had been worn in the rock and most of these depressions were occupied by large limpets, mostly Notoacmea persona. Generally, Littorina sitkana is the most abundant gastropod on rocky intertidal beaches along the Gulf of Alaska, at Cape Yakataga however, Lacuna marmorata was generally more abundant than Littorina sitkana although numbers and distribution of each species varied.

Several species of filamentous green and brown algae were collected in quadrats. These were more numerous than other algal groups. In a recolonization study at Amchitka, Alaska, Lebednick and Palmisano (1977) found that the order of succession in a disturbed area was (1) diatoms and filamentous brown and green algae, (2) ulvoids, (3) macrophytic red and brown algae. Table 6 shows numbers of these groups collected along each transect during each sampling period at Cape Yakataga. The predominance of filamentous browns and green algae and diatoms

Table 3. Relative frequency and average number (invertebrates) or weight in grams (algae) for selected species per 1/16 m^2 along the "*Fucus*" transect for three sampling periods, Cape Yakataga.

Species	Date October 1974 Relative Frequency	Total Species 33 Average No. or Wt.	Date June 1975 Relative Frequency	Total Species 38 Average No. or Wt.	Date September 1975 Relative Frequency	Total Species 46 Average No. or Wt.
Fucus distichus	7/8	52.0 g	5/7	6.4 g	7/13	84.9 g
Odonthalia floccosa	7/8	2.4 g	4/7	1.2 g	7/13	22.1 g
Lacuna vincta	4/8	22	0	0	0	0
Lacuna marmorata	5/8	60	2/7	5	5/13	9
Mytilus edulis <1.5 cm.	8/8	72	7/7	121	13/13	254
Flatworms	5/8	3	0	0	5/13	14
Balanus glandula	4/8	14	2/7	1	5/13	69
Amphipods (5 sp.)	5/8	4	3/7	1	12/13	72
Pylaiella littoralis	2/8	.01 g	7/7	0.8 g	10/13	20.2 g
Collisella pelta	3/8	1	5/7	4	6/13	3
Palmaria palmata	1/8	.001 g	6/7	0.8 g	8/13	1.9 g
Filamentous diatoms	0	0	7/7	0.9 g	0	0
Diptera larvae	0	0	5/7	2	7/13	84

Table 4. Relative frequency and average number (animals) or weight in grams (algae) of selected species per 1/16 m^2 quadrat along the "upper hummock" transect for three sampling periods, Cape Yakataga.

Species	Date October 1974 Relative Frequency	Total Species 32 Average No. or Wt.	Date June 1975 Relative Frequency	Total Species 40 Average No. or Wt.	Date September 1975 Relative Frequency	Total Species 34 Average No. or Wt.
Mytilus edulis <1.5 cm.	5/5	419	10/10	913	11/11	723
Fucus distichus	5/5	3.6 g	10/10	31.2 g	9/11	29.9 g
Balanus glandula	5/5	242	9/10	160	10/11	522
Diptera larvae	1/5	19	10/10	47	5/11	85
Palmaria palmata	0	0	9/10	16.0 g	8/11	28.8 g
Pylaiella littoralis	0	0	8/10	15.3 g	11/11	15.8 g
Littorina sitkana	2/5	2	8/10	57	7/11	114
Littorina scutulata	0	0	1/10	2	7/11	11
Oligochaetes	3/5	148	8/10	254	6/11	201
Lacuna marmorata	5/5	112	0	0	3/11	10
Collisella pelta	3/5	3	4/10	3	6/11	10
Ectocarpus simulans	3/5	43.1 g	1/10	0.5 g	1/11	unknown
Sphacelaria sp.	0	0	4/10	1.9 g	6/11	16.5 g
Amphipods	4/5	41	6/10	29	8/11	71
Porphyra sp.	0	0	8/10	2.3 g	7/11	16.3 g

Table 5. Relative frequency and average number (invertebrates) or weight in grams (algae) for selected species per 1/16 m^2 along the "Palmaria" transect for two sampling periods, Cape Yakataga.

Species	Date June 1975 Relative Frequency	Total Species 27 Average No. or Wt. per 1/16m^2	Date September 1975 Relative Frequency	Total Species 36 Average No. or Wt. per 1/16m^2
Palmaria palmata	6/6	37.8 g	8/8	27.3 g
Amphipods (4 sp.)	4/6	6	8/8	23
Mytilus edulis <1.5 cm.	6/6	848	8/8	262
Lacuna marmorata	6/6	83	4/8	31
Sphacelaria sp.	4/6	2.5 g	8/8	4.2 g
Odonthalia floccosa	1/6	0.2 g	6/8	4.2 g
Pycogonids	2/6	2	8/8	12
Pylaiella littoralis	1/6	.001 g	6/8	1.8 g
Balanus glandula	1/6	<1	5/8	7
Typosyllis sp.	3/6	2	6/8	7
Eteone longa	3/6	4	5/8	5
Petalonia fascia	0	0	5/8	0.6 g

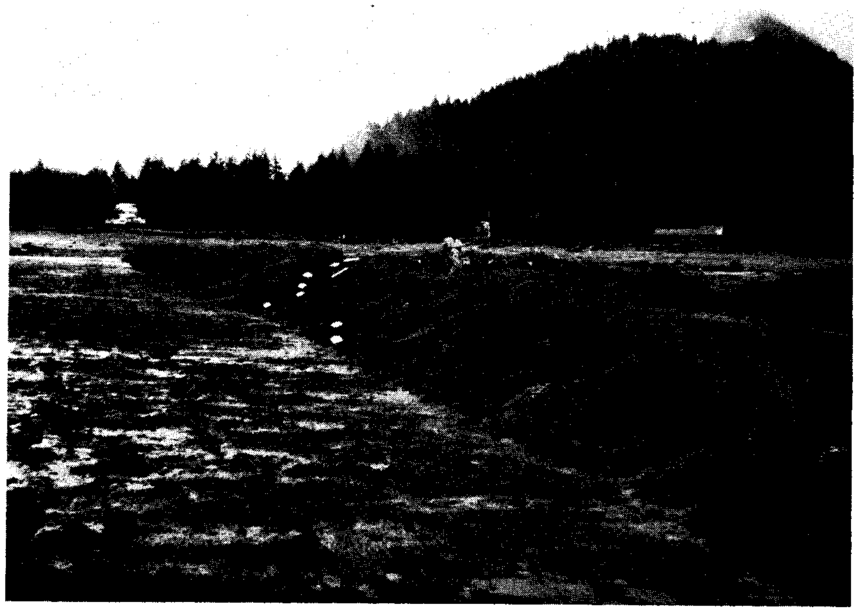


Fig. 13. "Palmaria bench"; site of Palmaria transect, and lower hummock showing arrows in place. Taken in June 1975.

Table 6. Number of species of (1) filamentous green and brown algae, and diatoms, (2) ulvoids, (3) macrophytic red and brown algae collected along three transects during three sampling periods at Cape Yakataga.

Algal Group	October 1974 No. of species *F	H	June 1975 No. of species F	H	P	September 1974 No. of species F	H	P
Group 1	13	8	8	12	5	13	8	5
Group 2	2	1	2	4	0	1	2	1
Group 3	4	5	7	6	4	5	5	2

* F = Fucus, H = Hummock, P = Palmaria

over other groups seems to indicate that Cape Yakataga is a disturbed site. In addition to wave action, periodic accumulation of sand, and glacial ice drifting onto the beach, erosion at Cape Yakataga is a visible process; residents of the area have observed changes in the beach from year-to-year (M. Eggebrotten, pers. comm.). All of these factors combine to make Cape Yakataga a difficult place for any group of organisms to form stable associations.

CAPE ST. ELIAS, KAYAK ISLAND

Location and Physical Description

Kayak Island is a narrow island, 28.2 km long, jutting into the Gulf of Alaska in a southwesterly direction (Fig. 1). Its extension into the currents of the Alaska Gyre and the prevailing southeasterly winds result in extensive drift accumulations on the southeast shore of the island. The width of the drift zone approaches 1/2 km in places along the coastal bench indicating that this shore is a site for the potential accumulation of floating pollutants.

Cape St. Elias (lat. 59° 47.8'N, long. 144° 36.3'W), is at the southwest tip of Kayak Island (Fig. 14). The average annual temperature is 4.4°C and the average annual precipitation is 279.4 cm, with 180.3 cm of snow (25.4 cm of snow = 1 cm of rain) (Anonymous 1964). There are several shoals and reefs in the vicinity of Cape St. Elias which may break the full force of waves coming from the Gulf of Alaska, but few directly offshore of our sampling site which is about 0.8 km north of the Cape on the western shore of the island. The site is a low-gradient bedrock platform (Sears and Zimmerman 1977, Plate EG-18) cut by shallow channels and with dams which restrict tidal drainage. There are a few small boulders strewn across the platform; these are more densely aggregated at the head of the beach (Fig. 15 and 16).

Dominant Organisms

Macrophytes were more obvious than invertebrates at the Cape St. Elias

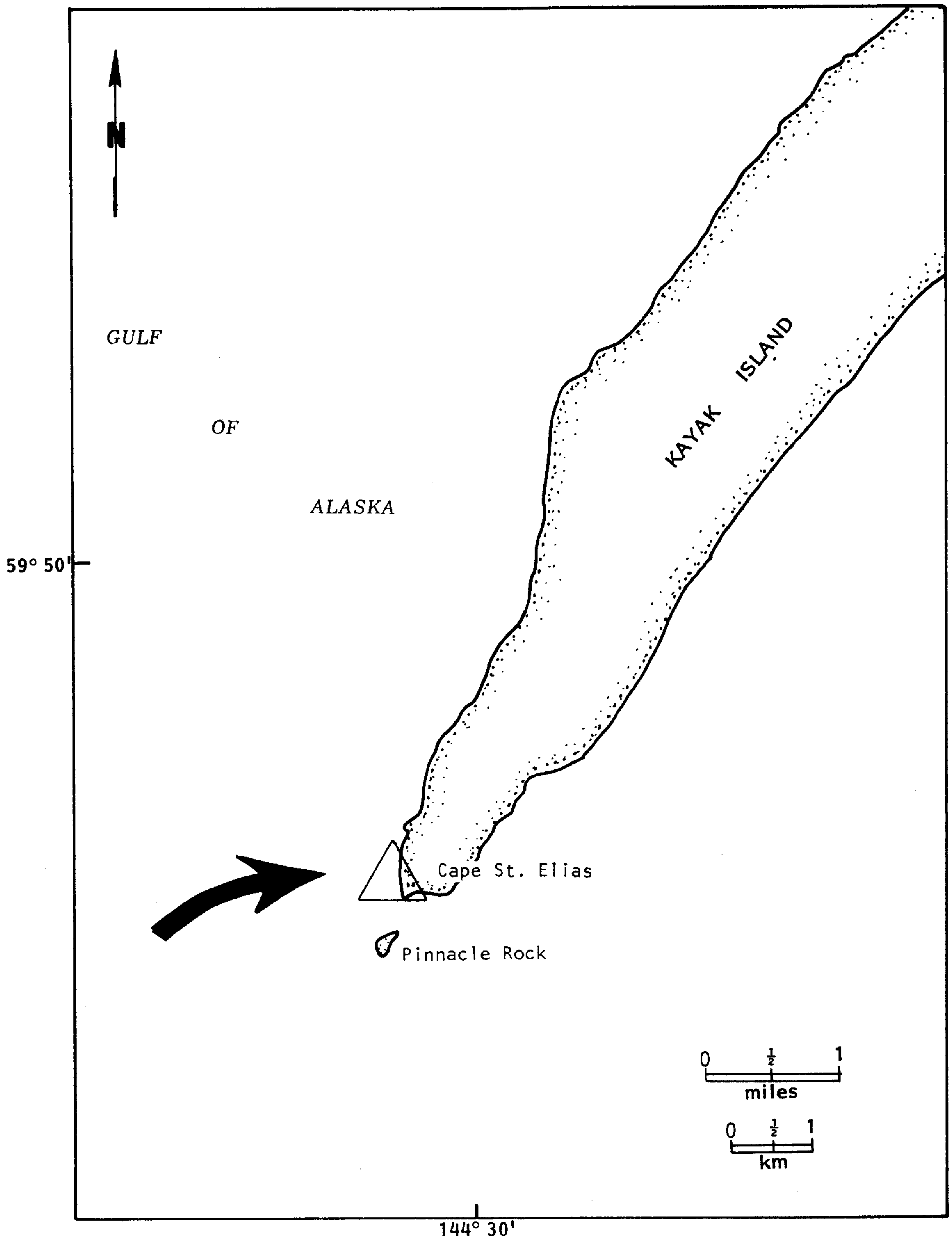


Figure 14. Cape St. Elias site.

Fig.15. View of transect looking toward the cape. Cape St. Elias rises steeply from the beach and shades it from the east. Taken in April 1976.

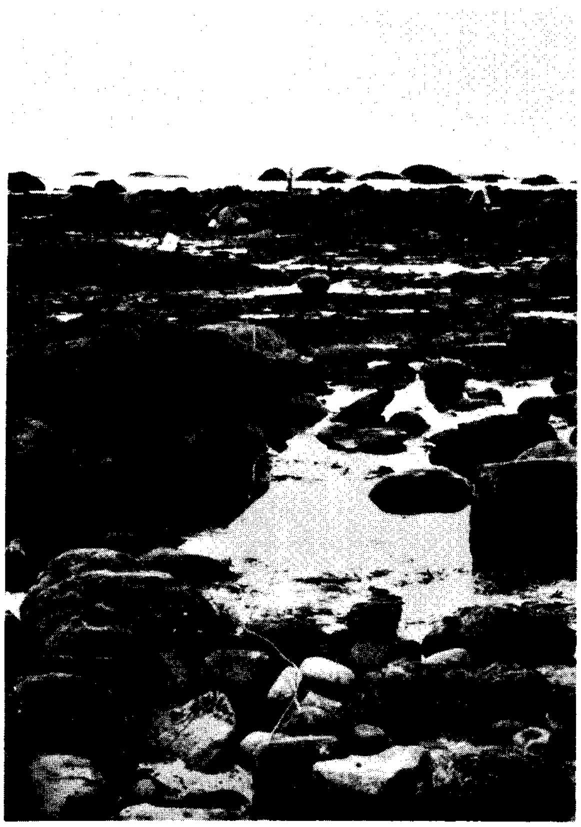


Fig.16. View of transect looking seaward. The sampling site is a low gradient platform strewn with boulders. Taken in April 1976.

sampling site. Appendix 1 is a list of all species collected at Kayak Island during all sampling visits. The distributions of some selected intertidal organisms are shown in Figs.17 and 18 for fall 1975 and spring 1976. Dates and methods of sampling at Kayak are listed in Table 1. In April 1976 we made percent-cover estimates at each meter along a 117-m transect using 1/16 m^2 quadrats. The cover of five dominant species of algae on the quadrats averaged 50%. Many other species of algae were present in smaller amounts. Palmaria palmata (L.) Stackhouse (=Rhodymenia palmata (L.) Grev.) (Guiry 1974), was most abundant with 21% cover. Lewis (1964, p. 99) has observed in Scotland that Palmaria is most abundant on flat, slow-draining platforms on shores dominated by mussels. Mussels are sparse at this site, but the slope and topography of the beach were apparently favorable to Palmaria. Cape St. Elias, a steep rocky ridge about 1 m (1.6 km) long and 1665 ft (507.5 m) high, shades our site from the East. Lewis (1964) has also noted that Palmaria thrives in shaded situations, so this may be another factor contributing to its abundance. In the spring much of the Palmaria was old-growth, thick, leathery, nearly black, and covered with an epiphytic growth of Ectocarpus spp. and Monostroma zostericola. Small, red, new blades of Palmaria were also present. In the fall most blades were bleached. Munda (1972 p. 14) in her observations in the coastal shallows of Iceland, noted that Palmaria was yellow (bleached) and covered with epiphytes in August. At Cape St. Elias in the fall only small amounts of Ectocarpus were present as epiphytes on Palmaria.

The "Odonthalia-Rhodomela complex", consisting mostly of Odonthalia floccosa with smaller amounts of Rhodomela larix, averaged 19% cover per quadrat. The two species are difficult to separate morphologically. They often occur together and have no apparent ecological differences so we combine them here. Odonthalia-Rhodomela also occur abundantly on several slow-draining, low-gradient beaches on southern Kodiak Island (Zimmerman et al. 1978). Their finely divided form provides an excellent refuge for small motile invertebrates such as amphipods,

Cape St. Elias
Intertidal Station 4
September 1975

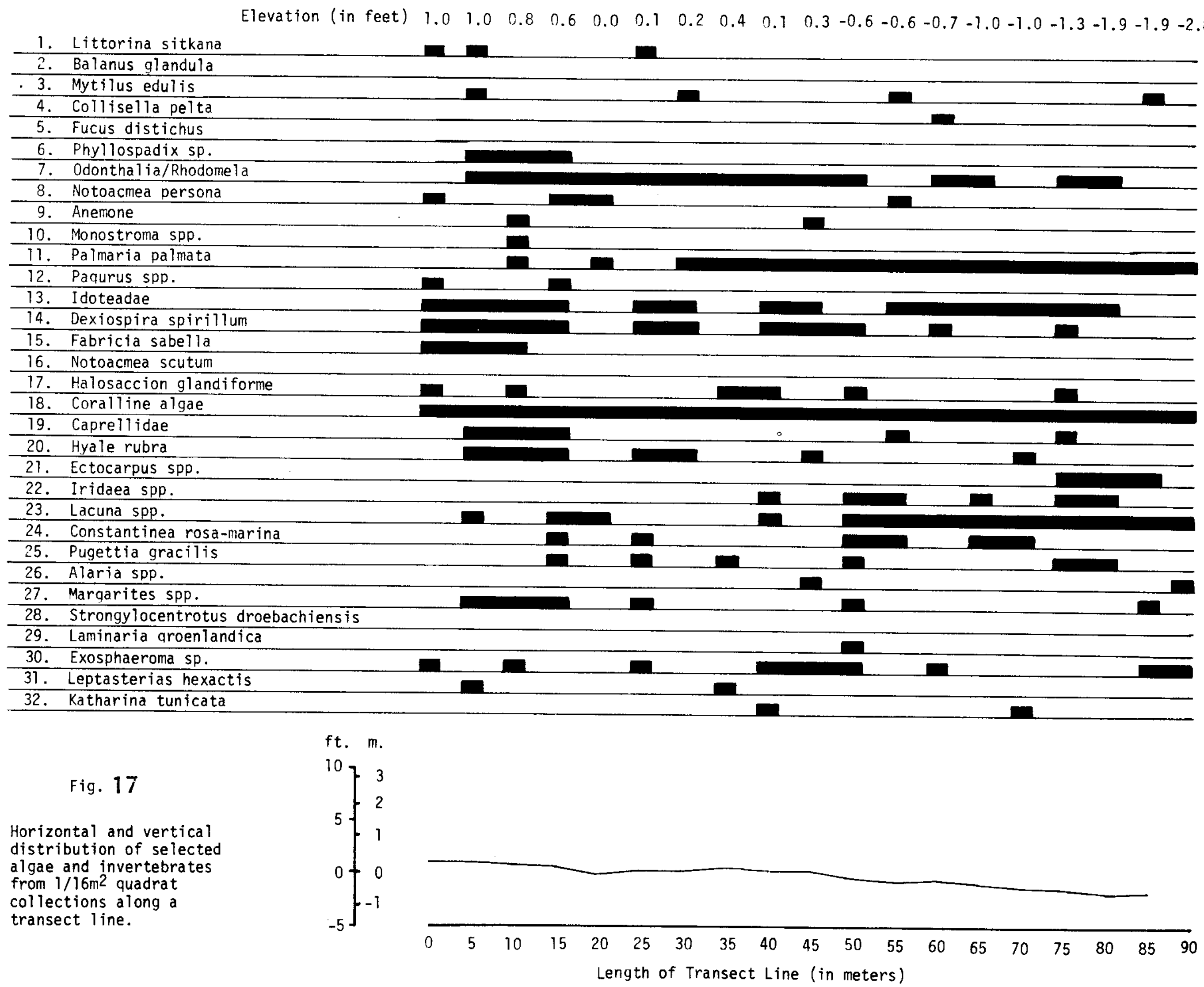
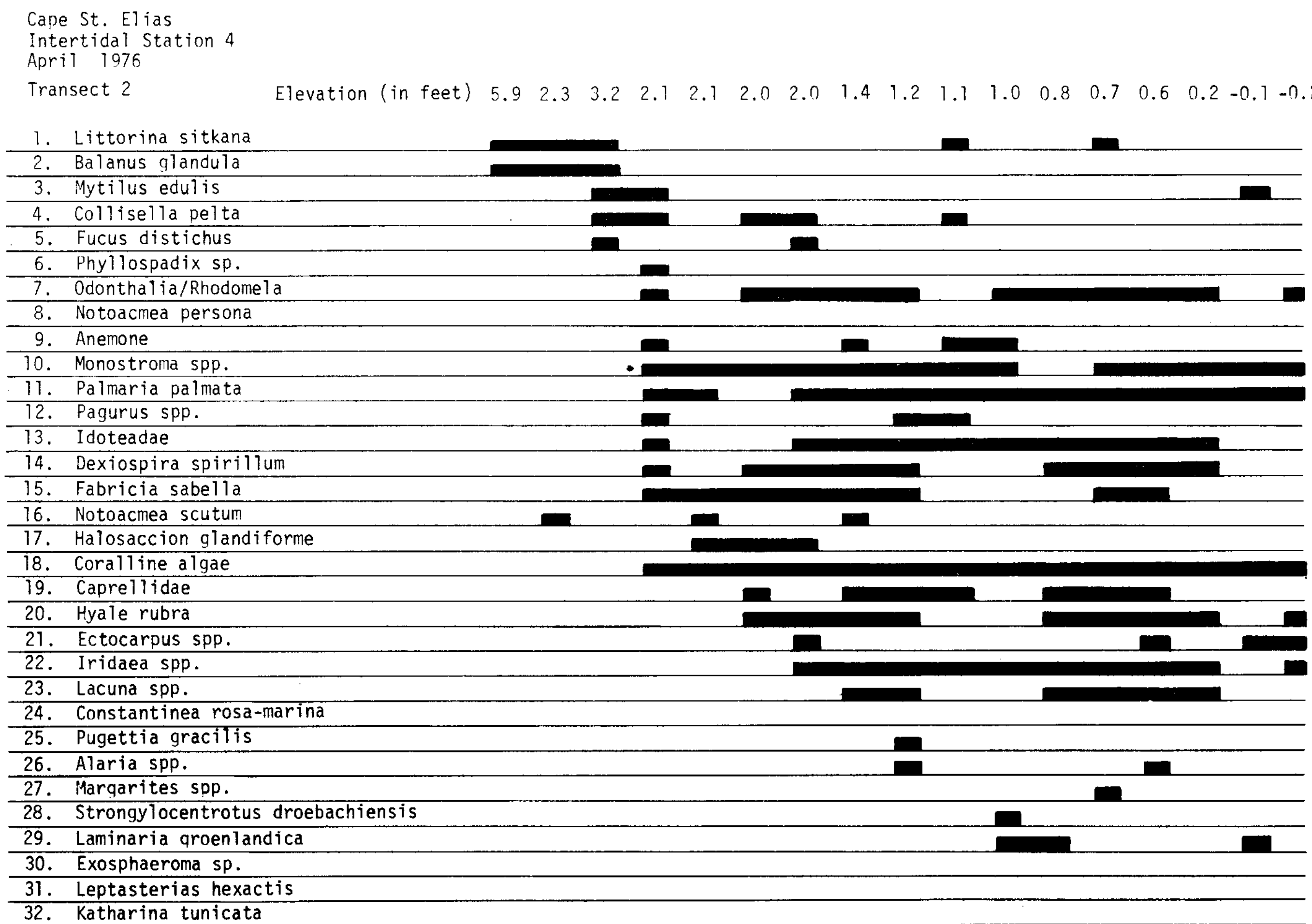


Fig. 17

Horizontal and vertical distribution of selected algae and invertebrates from 1/16m² quadrat collections along a transect line.



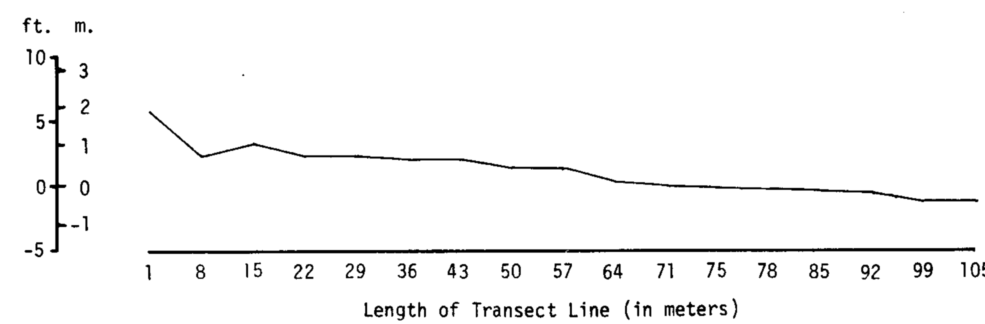


Fig. **18**

Horizontal and vertical distribution of selected algae and invertebrates from 1/16 m^2 quadrat collections along a transect line.

isopods, and gastropods. Turtonia occidentalis, a bivalve, attaches its byssal threads to these species as well as other Rhodophycean turf species. The Turtonia-rhodophycean association was also common at Kodiak, and at Latouche Point (see description of Latouche Point).

Monostroma spp. showed an estimated average cover per quadrat of 9% in the spring, but was not collected in the fall. Its presence as an epiphyte on Palmaria was especially noteworthy because of its unusually heavy cover. Palmaria had only small amounts of epiphytic Ectocarpus spp. Non-epiphytic Monostroma also occurred only in the spring; its biomass was less than that of the epiphytic Monostroma.

Several species of coralline algae, articulated and encrusting, were collected at Cape St. Elias. We observed corallines growing at elevations of -0.7 to +2.0 ft (-0.2 to +0.6 m), higher than would be expected. Lewis (1964, p 150-1) has observed corallines growing at high elevations in pools and postulates that dessication is the most important factor controlling their upper limits on open rock.

Phyllospadix sp. averaged 6% cover along the transect; this species was poorly sampled by the transect, however. We observed it growing in thick patches in and along the borders of shallow pools high on the beach, probably at about the +2.0 ft (0.6 m) level, and beginning at about 75 m on the transect. When we walked along the beach we noted that in places it formed a belt several meters wide. Phyllospadix was also observed to grow abundantly on slow-draining beaches on Kodiak Island, especially at Cape Sitkinak and the Geese Islands (Zimmerman et al. 1978). Latouche Point also had a heavy cover of Phyllospadix, but this is probably due more to deep tide pools than to a low gradient beach.

Barnacles and mussels were sparse at Cape St. Elias, but motile and cryptic species were common. No barnacles were collected in September 1975, but no collections were made above the +1.0 ft (+0.3 m) elevation. In April 1976 Chthamalus dalli was abundant at the +5.9 ft (+1.8 m) level on a large boulder and was present (5 per quadrat) in two other 1/16 m^2 quadrats at about the +2.0 ft (+0.6 m) level. Balanus glandula was collected in five quadrats from +1.1 to +5.9 ft (+0.3 to +1.8 m) elevation in numbers ranging from 5 to 550 per quadrat ($\bar{x}$ = 199).

Mytilus edulis was collected in September 1975 and in April 1976. It was found at elevations ranging from -1.9 to +3.2 ft (-0.6 to +1.0 m) in numbers ranging from 2 to 25 per quadrat ($\bar{x}$ = 7.5). All of the Mytilus were $<$1.5 cm in length. Modiolus modiolus averaged 16 per quadrat in two quadrats in September 1975. Only one Modiolus was collected in April 1976. All of these mussels were small.

Channels cut in the rock provided suitable habitat for urchins. Five Strongylocentrotus droebachiensis were collected at the +0.8 ft (+0.2 m) level. S. franciscanus was observed in the intertidal area away from the transect; this species is usually found subtidally.

The rock at our collecting site is a friable mudstone. It may be too easily eroded by wave action, drift logs, and tumbled boulders for sessile organisms to to become well established. Species which find refuge in pools and channels are able to survive, as well as small, motile invertebrates which cling to algae or hide in crevices.

KATALLA

Location and Physical Description

Katalla (lat. 60° 16.5'N, long. 144° 36.5'W) is a south-facing beach on the north shore of the Gulf of Alaska, and is fully exposed to the oceanic conditions of the Gulf (Figs. 1 and 19). Shoal waters offshore cause oceanic swell to pile up creating a heavy surf there. The sampling site is a low-gradient reef composed of cobbles and small, large, and occasionally very large boulders surrounded on all but the seaward side by sand beach. (Sears and Zimmerman 1977, Plate EG-20). Table 1 lists dates and sampling methods used at Katalla.

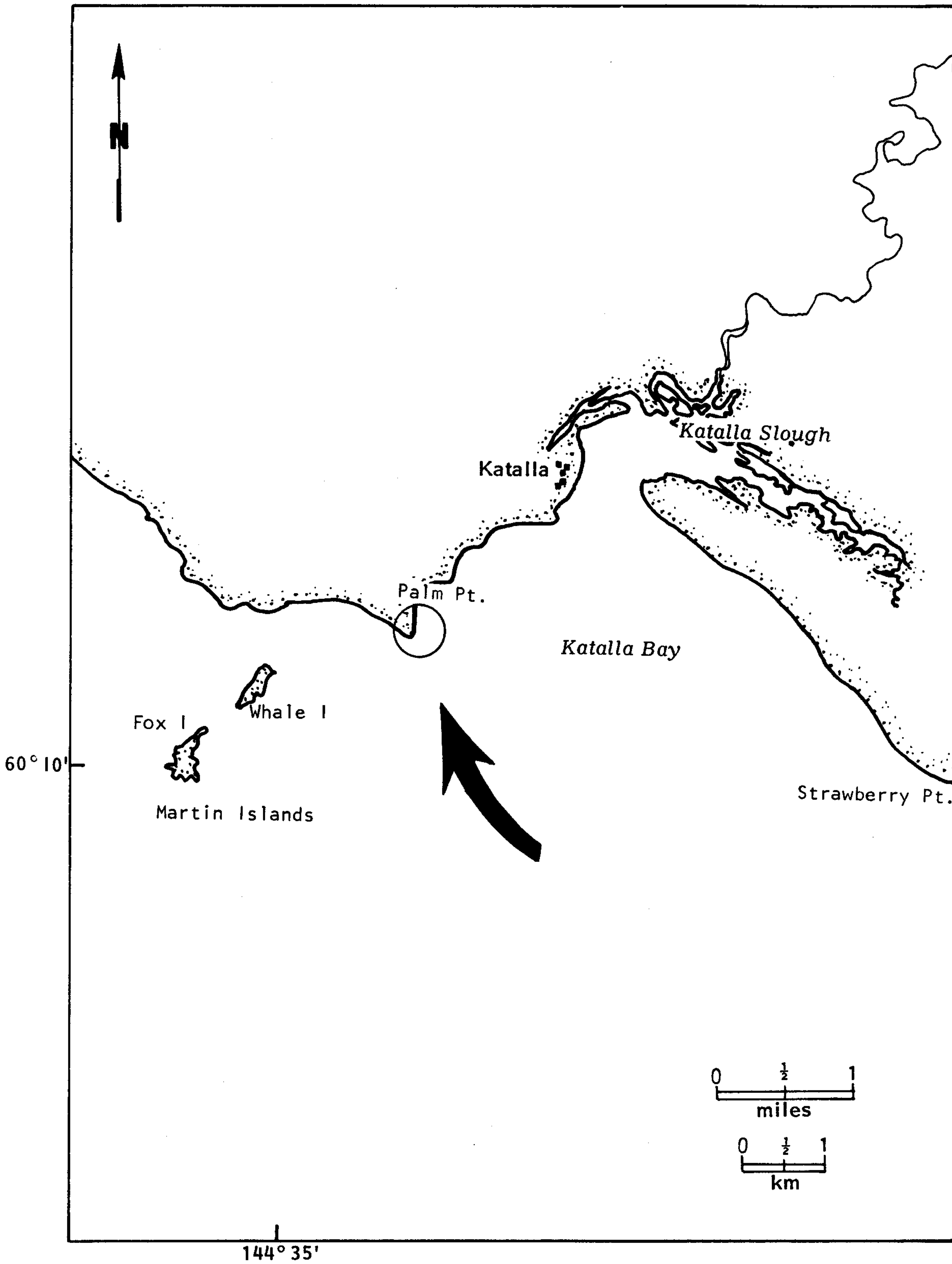


Figure 19 . Katalla Bay site.

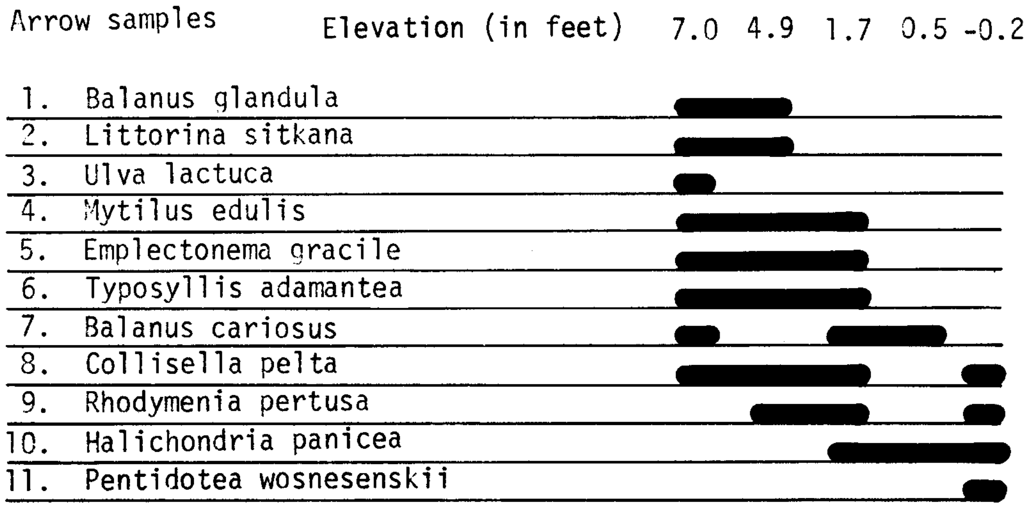
Appendix 1 lists all species collected at Katalla for all sampling visits. Fig. 20 shows the distribution of some selected species from the "arrow" sampling, April 1975.

At our study sites most of the sessile organisms were associated with the largest boulders, particularly on the shoreward sides. We sampled one of these boulders with the "arrow" sampling method (quadrat size 1/16 m^2) in April 1975 (Figs. 20 and 21). The red alga, Porphyra sp., was recorded at the highest level that we sampled on the rock (+13.1 ft (3.9 m)). The upper limit of barnacles began about +11 ft (+3.3 m) and increased to a coverage of about 50% on one quadrat at +9 ft (+2.7 m) (arrows 18 and 20 in Fig. 21,). At +7 ft (+2.1 m) primary space was completely covered by barnacles and mussels (arrows 8 and 30, Fig. 21). A 1/16 m^2 sample scraped from the rocks elsewhere, but at the same tidal level as and in a patch of intertidal area superficially similar to that containing "arrow" plot 30 contained 18 species of organisms including 2439 Mytilus edulis (wt = 1035 gm), 780 Balanus glandula, 120 B. cariosus, littorines, worms (5 species), and minute quantities of the algae, Scytosiphon lomentaria and Ulva lactuca. At about +5 ft (+1.5 m) mussel and barnacle cover was slightly less (arrow 35 and 45, Fig. 21), but species richness was about the same. A sample scraped from rock at this level contained 19 species.

Below the zone of heavy Mytilus cover (about +2 ft (+0.6 m); arrow 3, Fig. 21) B. cariosus increased in abundance. M. edulis was represented mainly by tiny individuals in that quadrat. The +2 ft level marked the approximate upper limit of Halichondria panicea. The algae Rhodymenia pertusa and Polysiphonia hendrii were the only species of algae collected at this level.

At the lowest level studied (-0.2 ft (-0.6 m); arrows 10 and 11 Figs. 21 and 22) Halichondria panicea biomass was great (620 gm wet wt in one 1/16 m^2 sample). The sample of high biomass scraped from rock at the same level as arrow 10 contained 12 other species, primarily worms and amphipods. Barnacles were absent.

Katalla Bay
Intertidal Station 3
April 1975
Arrow samples



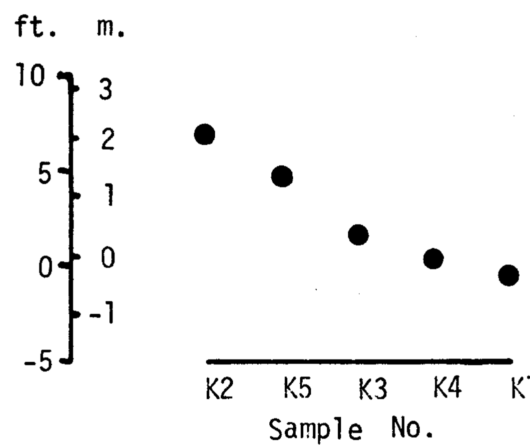


Fig. 20.

Horizontal and vertical distribution of selected algae and invertebrates from 1/16m^2 quadrat collections

Fig. 21. Shoreward side of large boulder sampled by the arrow method. This was the heaviest biotic cover found at the site. Taken in April 1975.

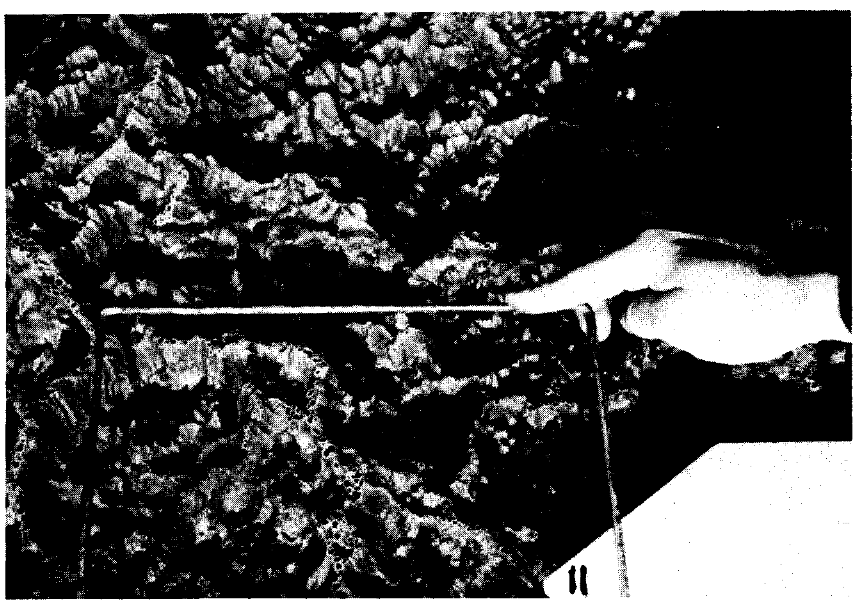


Fig. 22. Sponge cover at arrow II, at +0.5 feet (0.15m) Taken in April 1975.

The abundance of macroflora and macrofauna was generally low on the boulder beach. In October 1974 we established a grid among cobbles and boulders in the *Fucus* zone and sampled it randomly (Table 1). The conspicuous organisms of this zone, *Fucus distichus* and *M. edulis*, differed in frequency of occurrence, but were both low in biomass. *Fucus* occurred in all quadrats and averaged 23.2 gm per quadrat (range, 0.2 - 42 gm per quadrat). *Mytilus* occurred in only 40% of the quadrats and averaged 35 gm per quadrat (range, 0.2 - 119 gm per quadrat) in those quadrats in which it was found.

In April 1975 we established three transects at Katalla (Table 1). Transect 1 was laid on the boulder beach in an area similar to that randomly sampled in October 1974. The results revealed a situation similar to that recorded in October. *Fucus* occurred in 62% of the quadrats at a relatively low biomass ($\bar{x}$ = 58.6 gm). *Mytilus* also showed a low biomass ($\bar{x}$ = 3.5 gm/quadrat; range, .002 to 10.7 gm/quadrat), but occurred more frequently (88% of quadrats) on the transect than on the grid.

Transect 2 was placed in the lower intertidal area of the boulder beach. Twenty-four species of algae and 47 species of animals were recorded in samples from this transect, but biomass here as at higher levels was low. *Laminaria groenlandica* showed the greatest biomass (up to 100 gm/ 1/16 m^2); other species of algae usually totaled less than 10 gm/quadrat, and were often too small to identify. The animals were mostly minute crustaceans (e.g. caprellids) and worms.

Transect 3 was placed across a large (12 m diameter) tidepool ranging in depth from a few inches to over a foot in the upper intertidal area. The bottom was covered with small boulders and cobbles which had a 50-80% cover of encrusting coralline algae. In addition there were occasional *Laminaria* plants (mean wt. 114.8 gm per 1/16 m^2) and scattered individuals of other species of algae. Mytilus abundance averaged 1.2 per 1/16 m^2 (range, 1-6 per 1/16 m^2 its frequency of occurrence was 67%. One Nucella lamellosa was recorded. The small herbivorous gastropod, Lacuna marmorata, was common throughout the pool (mean number, 155.5 per 1/16 m^2).

Our data indicate that potential ecological dominants (e.g. M. edulis) occupied only a small portion of available space on the boulder/cobble beach. We can think of two types of physical disturbance that could account for this anomalous situation. The first results from frequent, heavy wave action which causes the cobbles and small boulders to roll around and collide constantly creating bare space and preventing competitive dominants from establishing large populations.

The second mechanism involves scouring of the boulder/cobble substrate by water-borne sand from the surrounding sand beach. This mechanism is less likely because large boulders (Fig. 21) adjacent to sand showed heavy biological cover, and quite low quantities of sand were seen in the boulder/cobble area. Our data are inadequate for distinguishing between these two mechanisms with confidence.

Sand Beach Study Sites

The four beaches (Hook Point, Big Egg Island, Kanak Island, and Softuk Bar) described below can be characterized as low-gradient sand beaches, exposed to the oceanic conditions of the Gulf of Alaska. They form part of a chain of such beaches and islands which stretch from Hinchinbrook Island across the Copper Copper River Delta to Controller Bay (Fig. 1). On these beaches physical factors such as small grain size, instability of substrate, and wave action, influence the scope of biological activity.

We visited each site once, in April 1976, and sampled it with transect lines extending from low tide to the drift zone (Table 1). One-liter core samples were collected at various intervals along the lines, both at the surface and below it; the deepest samples extended to a depth of 20 cm. The sand from haphazard cores and trenches dug with shovels was sieved with a 1 mm screen. A species list for each site (Appendix 2) was compiled from this sample data supplemented by visual observations. The composition and amount of accumulation of drift was noted.

At the western end of the chain, Hook Point forms part of a bedrock headland projecting into the Gulf of Alaska on the southeastern shore of Hinchinbrook Island (Fig. 1 and Sears and Zimmerman 1977, Plate EG-24). A small cove (lat. 60° 20'N, long. 146° 15'W) to the west of Hook Point was sampled (Fig. 23). The intertidal zone consisted of a wide sandy beach gradually sloping at a 1% grade. Running parallel to the shoreline were shallow troughs, apparently formed by wave action, containing standing water.

Eteone longa, a mysid, and a few unidentified Forminifera, nemerteans, and polychaetes were the only organisms present in our samples (Appendix 2). These occurred in the tidal range -.8 ft (-0.3 m) to +1.1 ft (+0.3 m), mainly in one area of standing water. One amphipod was collected at a higher tidal level. There was virtually no accumulation of drift.

Big Egg Island (lat. 60° 22'N, long. 145° 44'W) (Figs. 1, 24 and Sears and Zimmerman 1977, Plate EG-23) is the largest of a group of sand bar islands. Colonies of nesting gulls occur on the islands. Two transects each 60 m long were sampled and several trenches dug. Three live amphipods, Eohaustorius washingtonianus copepods, Calanus plumchrus, and two polychaetes, Thoracophelia sp. were found (Appendix 2). Drift consisted primarily of razor clam shells. Although we found no live clams, the area is indicated as supporting a razor clam population in the intertidal and nearshore subtidal regions (Anonymous, 1976, Fig. 18, p. 169).

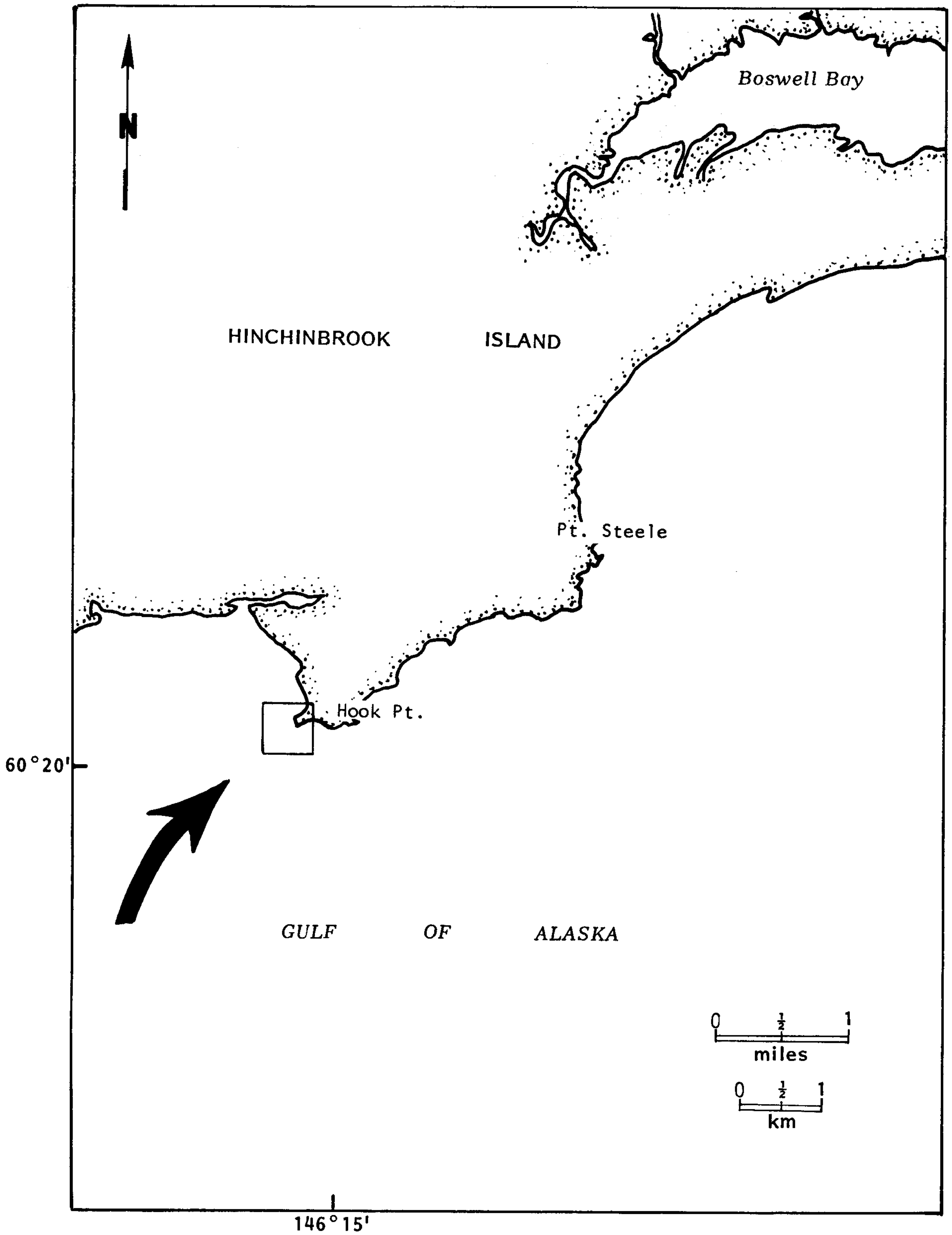


Figure 23. Hook Point site.

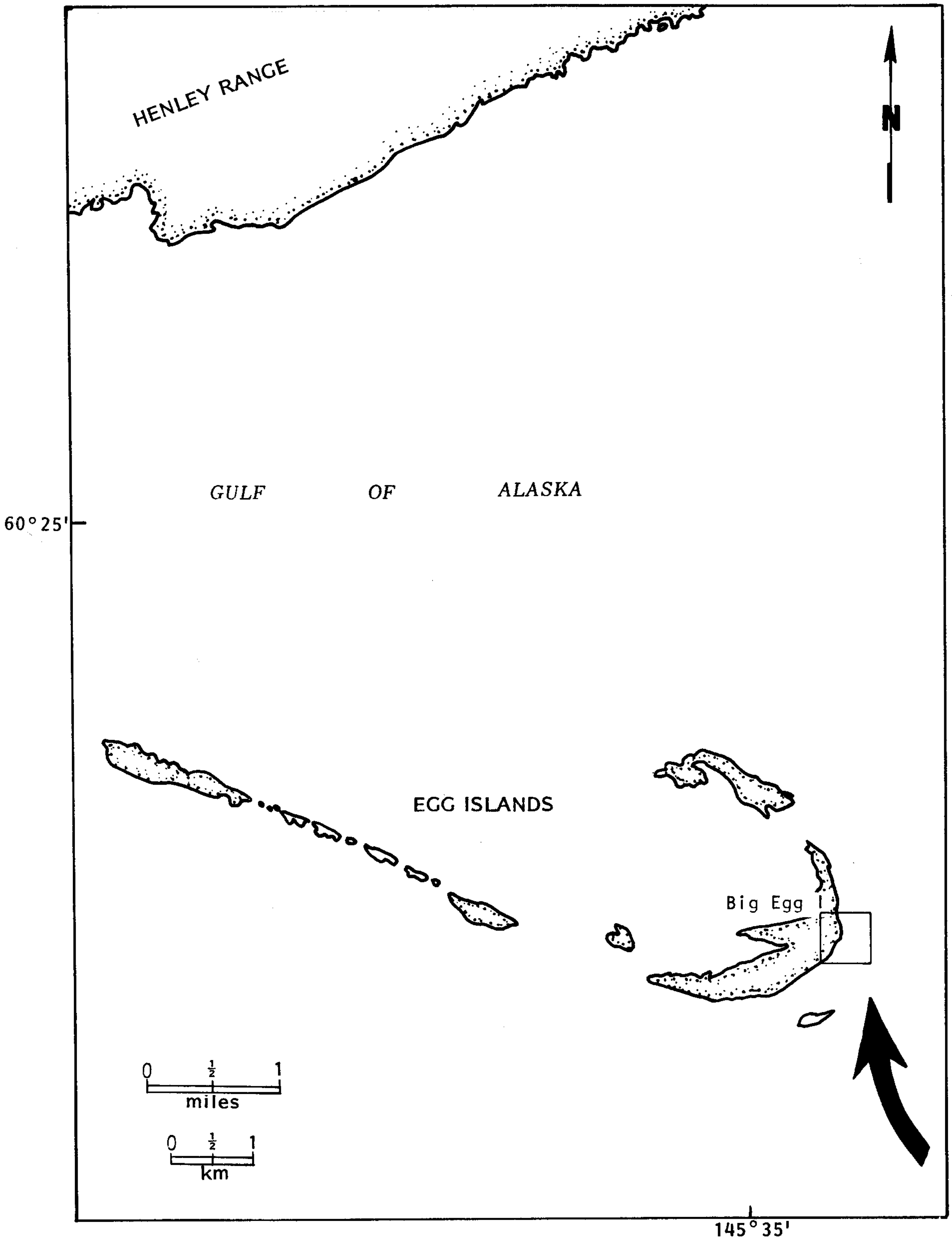


Figure 24. Big Egg Island site.

The Kanak Island site (lat. 60° 7.5'N, long. 144° 20'W) is located on the southeastern side of the island (Figs. 1, 25 and, Sears and Zimmerman 1977, Plates EG-19 and EG-20). The beach is approximately 270 m wide and flat. The substrate changed from muddy sand at the low end of the transect (+2.3 ft to -0.3 ft) to loose sand at elevations up to +6.3 ft (+1.9 m) at the high end. This site supported the largest diversitv and biomass of organisms of the four beaches sampled (Appendix 2). Dominant organisms (in terms of biomass) were polychaetes (nine species and the bivalve, Macoma balthica. Nephtys spp, Scoloplos armiger and Eteone longa were found over the entire tidal range. Excluding these species, species composition appeared to change with substrate composition. The greatest diversity of organisms was found at the muddy, low tidal levels. Red and green algae and gammarids were found only at these levels. Numerous unidentified castings were seen there.

At the sandy, upper levels, both the number of higher taxa and species within each taxon decreased. Macoma balthica was found from +3.0 ft (+0.9 m) to +6.3 ft (+1.9 m), the highest level sampled. Nematodes and the cumacean, Lamprops sp. also appeared in small numbers in this area.

Softuk Bar extends about 3 miles into the Gulf west of Katalla Bay (lat. 60° 12'N, long. 144° 42'W) and forms the eastern end of the chain of bars off the Copper River Delta (Figs. 1, 26, and Sears and Zimmerman 1977, Plates EG-20 and EG-21). An extensive shallow muddy lagoon is enclosed by the bar and the mainland to the northeast. The southern side of the bar is sand. Samples were taken on the sandy side. Shifting surface sand contained only a few individuals of four species, Archaeomysis grebnitzkii, Emplectonema gracile, Eteone longa, and Eohaustorius washingtonianus. The packed sand layer beneath yielded only amphipod fragments. One razor clam shell and one crab fragment were found as drift.

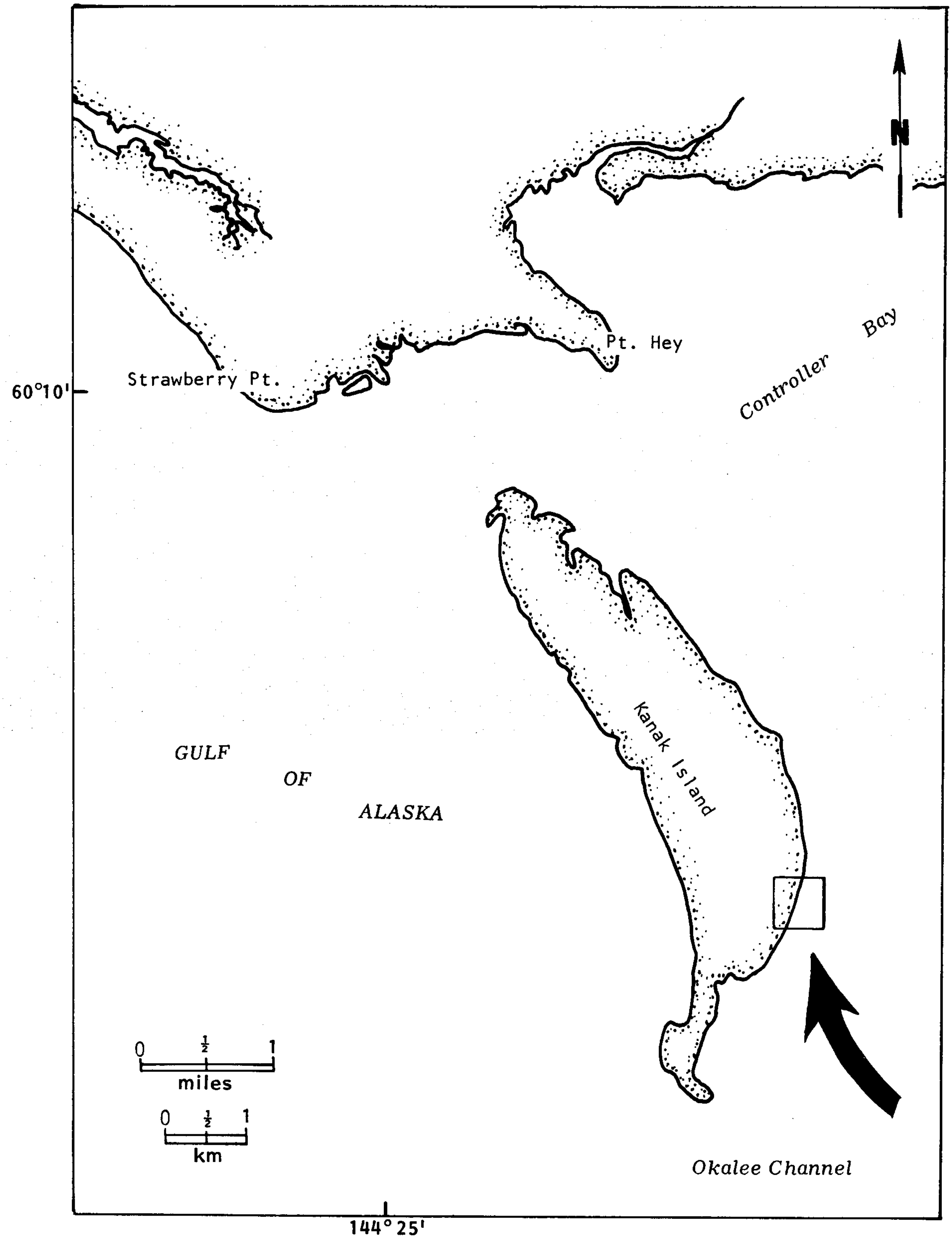


Figure 25. Kanak Island site.

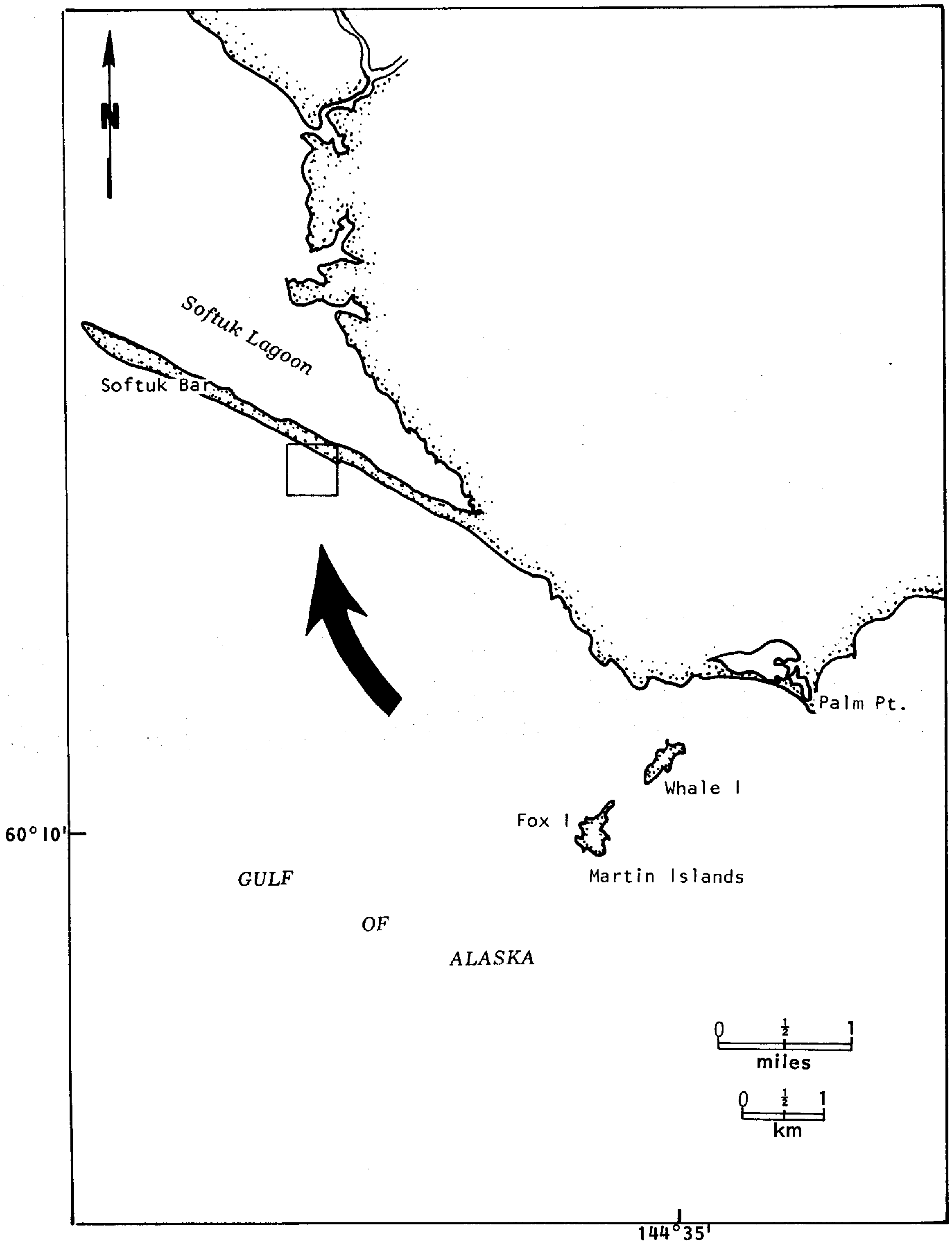


Figure 26. Softuk Spit site.

BOSWELL BAY

Location and Physical Description

Boswell Bay is an estuary indenting the eastern end of Hinchinbrook Island (lat. 60° 24' 36"N, long. 146° 6' 18"W) (Fig. 1). A large part of the bay is shoal with mud (Sears and Zimmerman 1977, Plate EG-24). Its entrance is a narrow channel in which tidal currents of two knots have been reported (Anonymous 1964). The site sampled is on the north shore, just inside the entrance (Fig. 27) with a monolithic rock island just offshore (Fig. 28) which can be reached from the sampling site by wading at low tide. In September silt was suspended in the water and covered the rocks (Fig. 29). Surface salinity was 13.9 ppt. Most sampling was done on a gravel-sand-mud beach (Fig. 28). Some additional work was done on a large rock nearby (Fig. 30).

Dominant Organisms

On rock throughout the intertidal zone Balanus balanoides and B. glandula formed the heaviest cover, in some areas approaching 100%. Mytilus edulis formed heavy cover only in patches, and were often themselves covered with barnacles. As would be expected at a low-salinity, estuarine site, there were no B. cariosus or echinoderms (urchins or starfish). Seaweeds were notably sparse. For example, Fucus distichus was present in only one of 20 1/16 m^2 arrow quadrats on rock ranging from +0.8 ft (+0.3 m) to +8.5 ft (+2.5 m) (Fig. 30).

On the mud beach, the most numerous species were the small clam, Macoma balthica, and oligochaetous worms which in September 1974 numbered as many as 213 and 476 per sample (1 liter) respectively. Fig. 31 shows the distributions of some species in September 1974. The clam Mya arenaria was present, but our quadrat size (1 liter) was too small to sample it adequately.

Mud core samples were taken in September 1974, May 1975, September 1975 and April 1976. The samples taken during the last three periods were

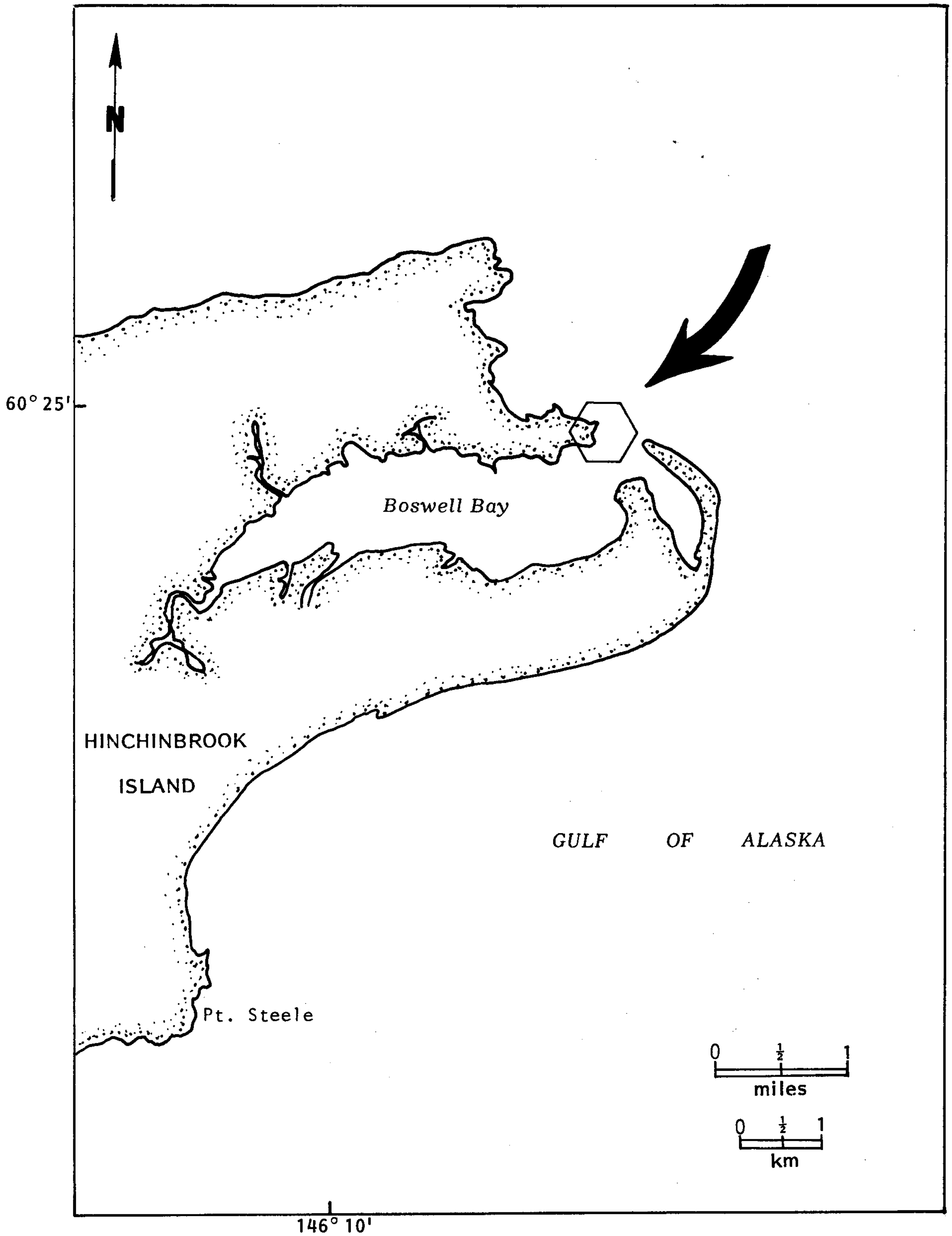


Figure 27 . Boswell Bay site.

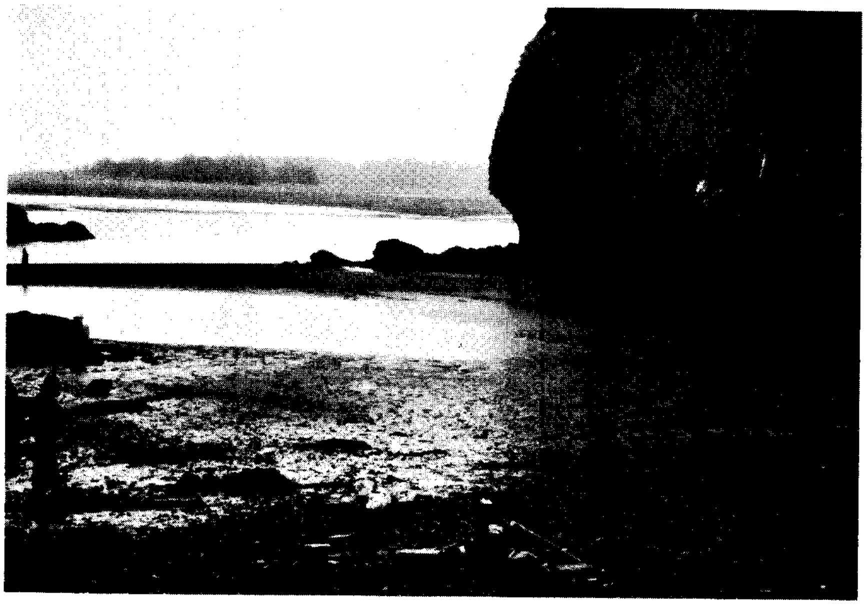


Fig. 28. Mud and gravel beach at low tide showing off-shore monolith. Taken in September 1975.

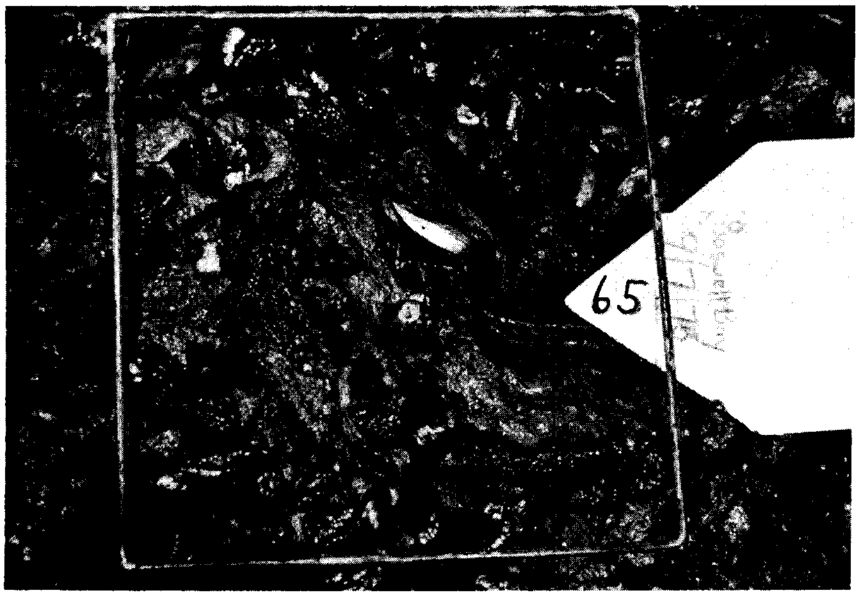


Fig. 29. Arrow 65 on lower part of rock. Note heavy silt deposit between mussels and barnacles on mussel valves. Taken in September 1975.

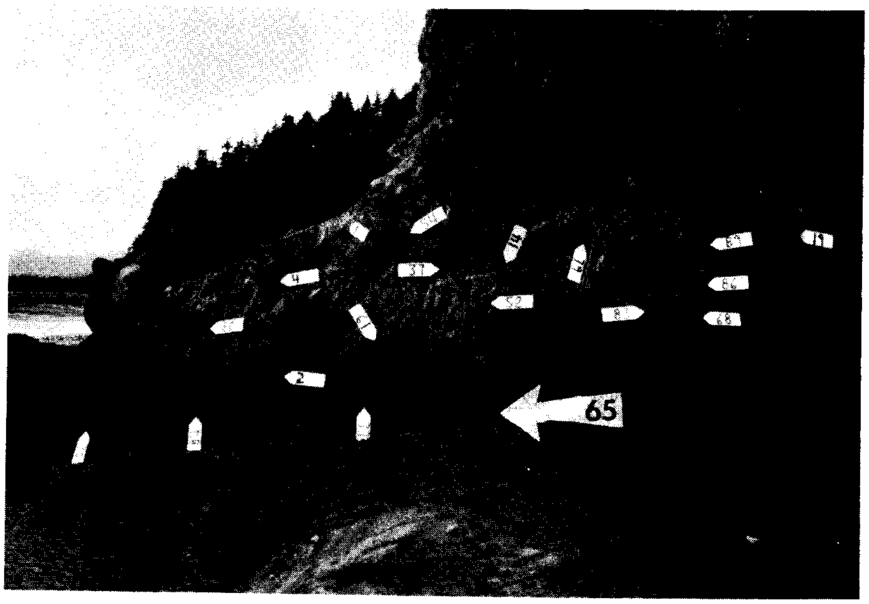


Fig. 30. Arrow site with heavy barnacle cover above and patchy mussel cover below. Taken in September 1975.

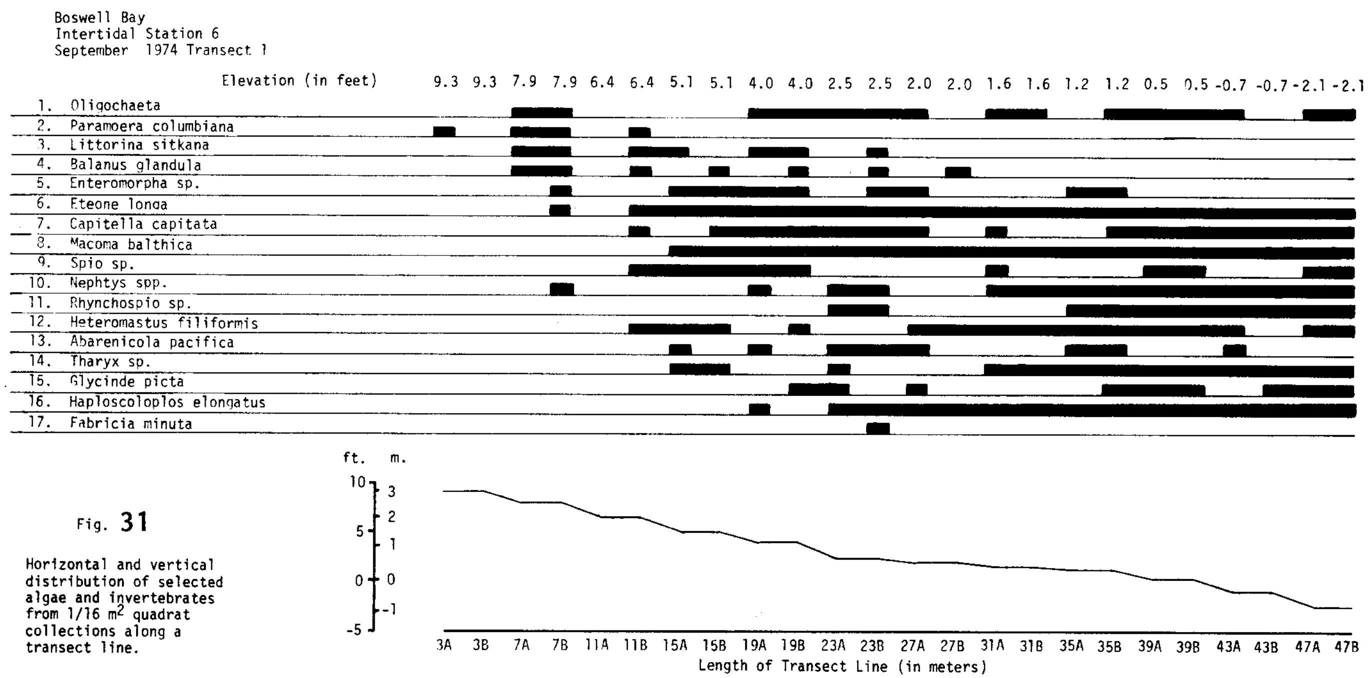


Fig. **31**

Horizontal and vertical distribution of selected algae and invertebrates from 1/16 m^2 quadrat collections along a transect line.

not adequately fixed, and soft bodied, delicate organisms, especially polychaetes, fragmented and passed through our sieves.

MIDDLETON ISLAND

Location and Physical Description

Middleton Island (lat. 59° 25.2'N, long. 146° 22.5'W) is a low (elevation 125 ft (38.4 m)) island (Fig. 32) in the northern Gulf of Alaska, about 50 mi (92.6 km) south of the entrance to Prince William Sound (Fig. 1). The island is fringed with reefs, rocks, and heavy kelp to a distance of 0.4 mi (0.7 km). Breakers occur at greater distances. The island was uplifted 15 to 20 ft (4.6 to 6.1 m) in the 1964 earthquake (Anonymous, 1964). The sampling area, (Fig. 33 and Fig. 34), is a mudflat strewn with boulders. We collected 10 1-liter cores in October 1974 and in April 1975, and 9 cores in September 1975.

Dominant Organisms

Four polychaete worms, Abarenicola pacifica, Capitella capitata, Rhynchospio sp., and Pygospio sp., were abundant in all seasons. Nereid worms, Nereis procera, Nereis vexillosa, and Nereis sp. were collected only in the fall. Although algal fragments, insect larvae, amphipods and other marine invertebrates are represented in the collections, polychaete worms are the dominant group, and Abarenicola pacifica is the most conspicuous (Appendix 3). Several species of shore birds, ducks, and geese were observed feeding and resting in this area in September 1975.

The boulders throughout the area, almost to the water's edge, have Fucus distichus, Littorina sitkana, and Balanus sp. growing on them. A large aggregation (thousands) of Littorina sitkana was observed high on the beach. Large limpets, probably Notoacmea persona, were common. Mussels (Mytilus edulis) were very sparse and were found on boulders close to the water's edge. Filamentous green algae, Porphyra sp., and colonial diatoms were also found on

Fig. 32. Middleton Island showing low bluffs and sand beach. Taken in December 1975.

Fig. 33. Middleton Island sampling area. The beach is mud and boulder, extending about 0.5 mi to the water. Taken in December 1975.

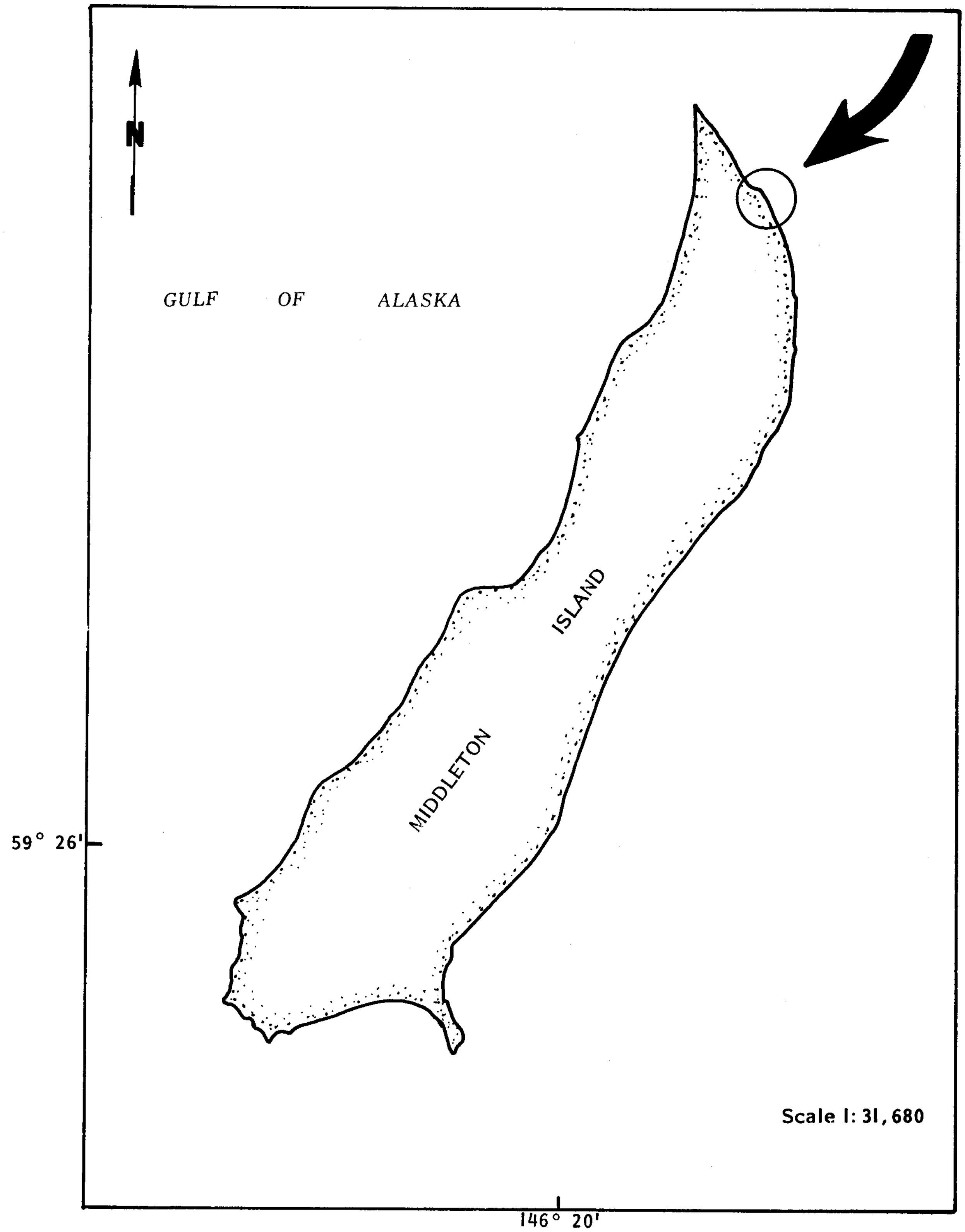


Figure 34. Middleton Island site.

boulders. Rhodomela larix and Bossiella sp. were found in standing water. Laminaria sp. was observed growing on boulders in pools at the outer edge of the beach. Several species of algae, mostly Nereocystis lutkeana and Palmaria palmata, were found in the drift. Shells of Mytilus californianus were also present.

CAPE HINCHINBROOK, HINCHINBROOK ISLAND

Location and Physical Description

Cape Hinchinbrook (lat. 60° 14.3'N, long. 146° 38.8'W) is on the southernmost tip of Hinchinbrook Island, on the eastern side of Hinchinbrook Entrance (Figs. 1 and 35). The Cape juts into the Gulf of Alaska and in a southerly gale is subject to heavy wave action. During our sampling period in April 1976, wind and storm surge pushed the tide high on the beach.

There are steep cliffs above the beach (Fig. 36). Cape Hinchinbrook light is located on the cliffs above our site and is 235 ft (71.6 m) above the water (Anonymous 1964). The beach is bisected by a small fresh water stream. We made qualitative observations along two transects, one to the west (transect 1) and one to the east (transect 2) of the stream. Transect 1 is in an area of sedimentary bedrock which has been tilted so that the layers are vertical. The bedrock surface is strewn with numerous large (0.5 to 3 m on a side) chunky, often flat-topped boulders and small cobbles (Fig. 37). Transect 1 was 40 m long, and extended from the -0.4 ft (-0.1 m) to the 11.4 ft (3.5 m) tidal level. Transect 2 is similar to transect 1 but with the bedrock substratum rising abruptly from the water line along a short near-vertical face and then continuing in a series of hummocks to the base of the cliffs. The boulder field is more dense than along transect 1 and the average size of the boulders is smaller (Fig. 38). There are several small tidepools along the transect and an area of fresh water runoff near the upper end of it. Transect 2 was 46 m long and spanned the tidal levels +0.4 to +10.6 ft (0.1 to 3.2 m).

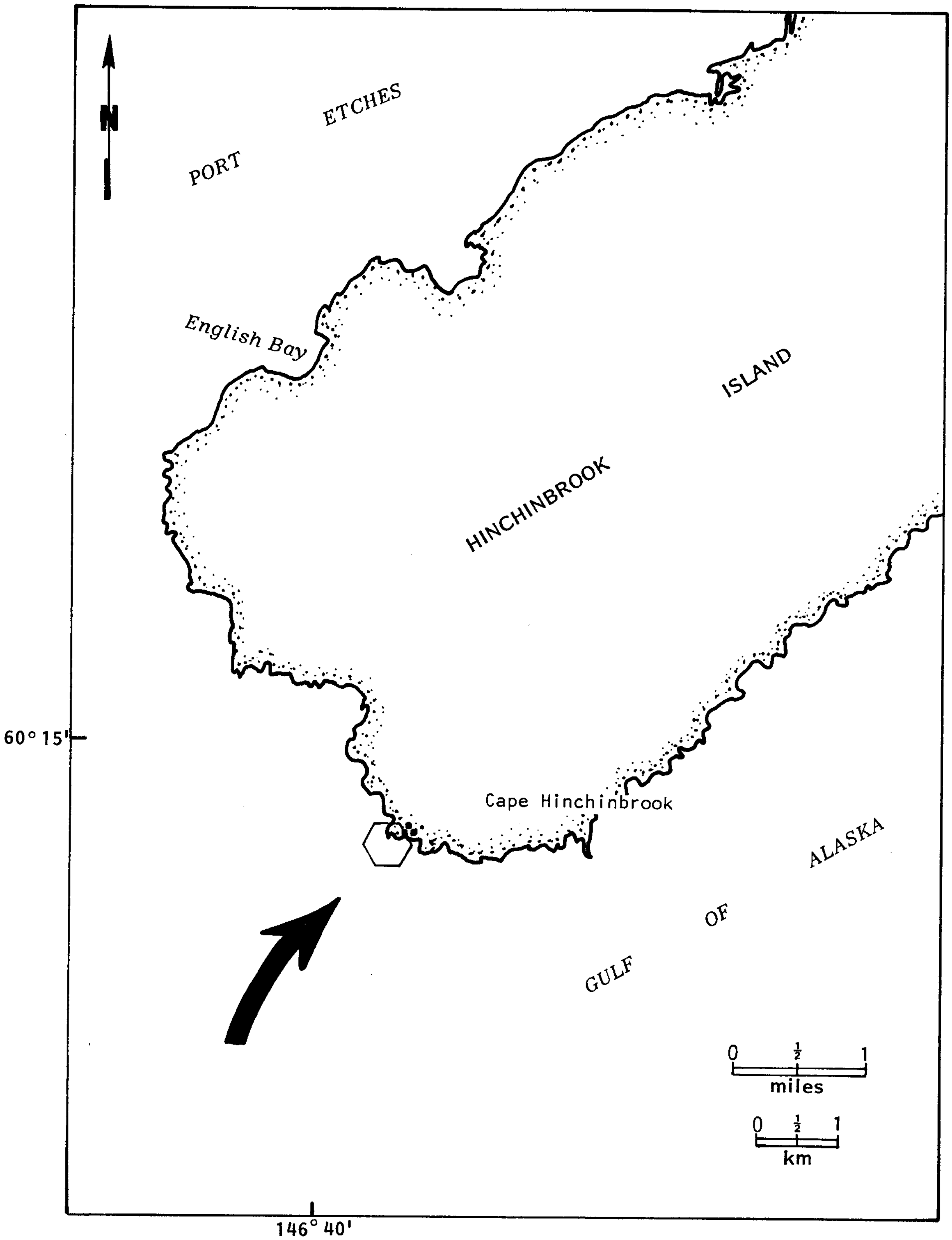


Figure 35. Cape Hinchinbrook site.

Fig. 36. View of sampling site at Cape Hinchenbrook showing general location of transect 1. The beach consisted of boulders on low gradient bedrock rising abruptly to a steep cliff. Taken in April 1976.

Fig. 37. Upper end of transect 1 showing tilted bedrock and large chunky boulders. Taken in April 1976.

Fig. 38 . View along transect 2 showing boulders and hummocky bedrock. Taken in April 1976.

Dominant Organisms

Transect 1 (Fig. 37): Palmaria palmata (=Rhodymenia palmata) was the dominant macrophyte along transect 1, observed in 26 of 40 quadrats. It occurred with 100% cover in three quadrats falling on a slow-draining bedrock bench, a favored habitat (Lewis 1964). A heavy coating of diatoms was observed in 13 quadrats. Endocladia muricata also occurred in 13 quadrats, most of them in the high zone. Gigartina papillata occurred in 11 quadrats. Porphyra spp. was observed in 10 quadrats; one species occurred in small amounts in the mid-zone, and a second species was confined to the +11.4 ft (+3.5 m) level where it covered the entire quadrat. Fucus distichus was sparse; it occurred in only six quadrats and percent cover was <10. Balanus sp. was the animal with the highest relative frequency along transect 1. It occurred in 27 of 40 quadrats, but percent cover was generally low. Unidentified limpets were present in 15 quadrats. In the low zone they occurred singly or in small numbers and were about 1 to 3 cm in length; in the high zone they were generally small (5 mm) and were clustered in small depressions or crevices. Mytilus edulis was observed in 14 quadrats; most of these mussels were small (<1.5 cm) and were attached to sprigs of algae, on barnacles, or in rock crevices. Predators were rare; two Leptasterias hexactis were seen at the +1.7 ft. (0.5 m) level, and three Nucella lima were seen at the +4.8 ft (1.5 m) level. A cluster of N. lima was seen adjacent to those in the quadrat; none of them were feeding.

Transect 2 (Fig. 38): Palmaria palmata was the dominant algae in the low zone and Fucus distichus and Endocladia muricata were dominant at higher elevations. Macrophyte cover was light. Barnacles (mostly Balanus glandula) occurred most frequently, but percent cover was low, and there were several scars of dead barnacles. Coralline algae, small plants of Alaria sp. and Laminaria sp., sponge, anemones and Pagurus sp. were found in tidepools.

Unidentified limpets and the littorine snails, *Littorina* sitkana and *L. scutulata* were common. Predators were uncommon; one *Leptasterias hexactis* was found in the low zone, and *Nucella lima* was found in five quadrats. An aggregation of 30 *N. lima* (not feeding) was observed at about the +7 ft (2.1 m) elevation, but elsewhere only one or two *N. lima* were observed.

POINT BARBER, HINCHINBROOK ISLAND

Location and Physical Description

Point Barber (lat. 60° 19.8'N, long. 146° 39.5'W) marks the southwestern end of the northwestern shore of Port Etches, Hinchinbrook Island (Figs. 1 and 39). The mid and lower intertidal region at Point Barber is a gently sloping bedrock platform, but the upper intertidal region has localized areas of vertical relief. (Fig. 40; see also Plate EG-26 of Sears and Zimmerman 1977). Exposed rocks along a section of coast near the study area are "massive graywacke" alternating in stretches with "highly contorted thin bedded argillite and graywacke" (Moffit 1954). The bedding planes of the rock comprising the intertidal platform are strongly tilted. Point Barber is partially protected from open ocean waves and swells by the southwestern peninsula of Hinchinbrook Island and nearby Porpoise Rocks, but it probably receives severe wave shock during winter storms.

The area of Prince William Sound near Point Barber was uplifted in the range of 6 to 8 ft (1.8 to 2.4 m) during the Great Alaska Earthquake of 1964 (Fig. 1 of Haven 1971). In May 1977 we observed empty shells of the rock boring piddock, *Penitella penita*, partially protruding from the surface of the rock platform in the mid-intertidal zone among *Fucus distichus* and *Mytilus edulis*. These bivalves normally occur in lower intertidal and subtidal regions [although Evans (1968) has recorded *P. penita* as high as +0.6 m in the intertidal zone at Coos Bay, Oregon], and probably died when they were lifted above their

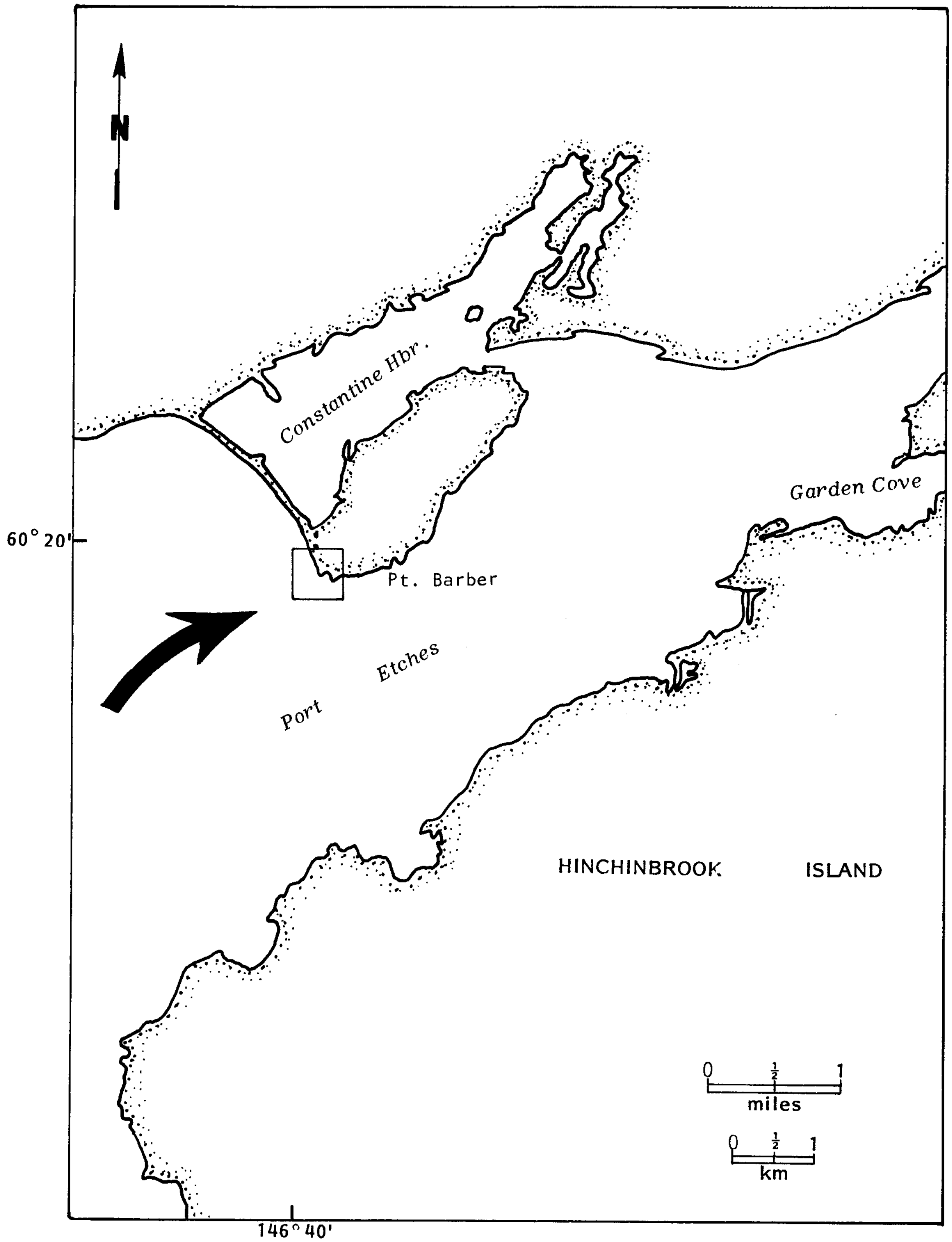


Figure 39 . Port Etches site.

Fig. 40. Oblique view of study area at Pt. Barber looking across Hinchenbrook Entrance to Montague Island. Taken on 7 May 1977 by C.E. O'Clair.

upper physiological limits by the earthquake. The empty shells are becoming gradually exposed as the surface of the rock platform erodes away.

Dominant organisms and community patterns

We made qualitative observations of intertidal communities in May and July/August, 1977. The upper and mid-intertidal zones were dominated by *Fucus distichus* with *Balanus* spp. (mostly *B. glandula*; *B. balanoides* was not recorded, but may have been present) dominant on rock outcrops above the *Fucus*. Although small *M. edulis* (mean shell length of 439 haphazardly collected individuals was 1.1 cm, SD 0.9 cm) were abundant in the *Fucus* zone in May, there were few large (shell length $>$ 3 cm) *Mytilus* except in patches on the southeastern side of the site (Fig. 41). By contrast, in 1973 two of us (N. Calvin and J. Gnagy) noted that large *M. edulis* were abundant especially on the northeastern side of the point.

Pisaster ochraceus was common at Point Barber during both observation periods, but it was less obvious in May because many individuals were in tidepools hidden beneath over-hanging rock around the periphery of the pools. In July/August most *Pisaster* were plainly visible on the platform surface. Scattered individuals of *Nucella* sp. (*N. lima* or *N. emarginata*) and *N. lamellosa* were observed in upper and mid-intertidal zones.

Most of the lower intertidal platform was covered by *Palmaria palmata* and *Alaria* sp. (Fig. 42). A large number of *Alaria* were small (blade length 50 cm). *Rhodomela larix* was generally abundant in poorly drained areas in the upper part of the lower intertidal zone; *Phyllospadix* sp. occupied this type of habitat at lower levels.

Leptasterias hexactis was common throughout the mid and lower intertidal zones. One female was observed brooding eggs in May. Other starfish in the lower intertidal zone were *Evasterias troschelii* (rare, only one individual seen), *Dermasterias*

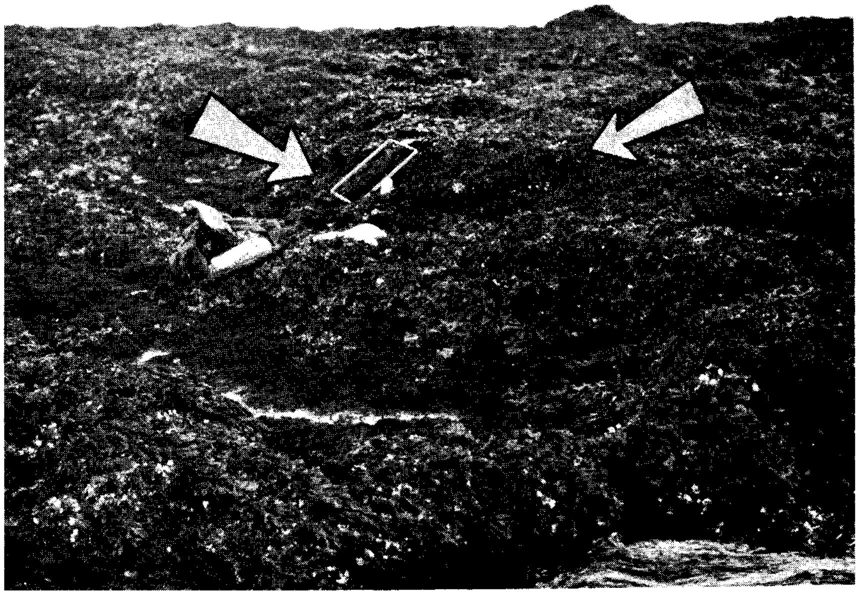


Fig.41. Patches of large Mytilus at Pt. Barber taken on 6 May 1977 by C.E. O'Clair.

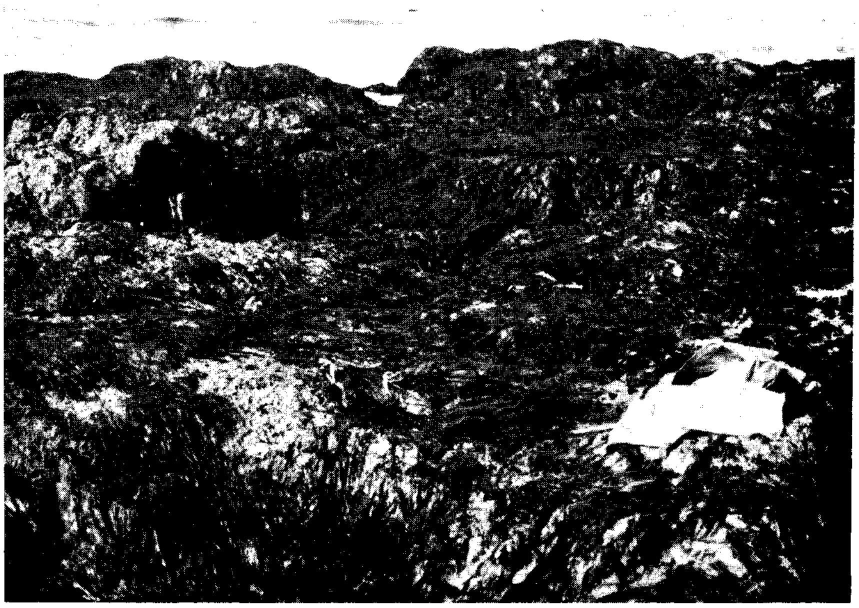


Fig.42. View of lower intertidal platform at Pt. Barber. Taken on 5 May 1977 by C.E. O'Clair.

imbricata, and Pycnopodia helianthoides. Scattered individuals of Balanus cariosus were present throughout the mid and lower intertidal zones. Chthamalus dalli were numerous on ridges and hummocks near the seaward edge of the intertidal platform. Large patches of the encrusting sponge Halichondria panicea accompanied by the nudibranch Archidoris montereyensis were abundant near the seaward edge of the platform (Fig. 42). In Washington 74% of the diet of A. montereyensis consists of H. panicea (Bloom 1974).

At the lowest reaches of the intertidal region and in tide pools the major canopy species was Laminaria dentigera intermixed with a few L. yezoensis plants. Obvious invertebrates in these habitats were the cnidarians Anthopleura elegantissima (in upper pools) and Tealia crassicornis, an occasional decapod crustacean (Oregonia gracilis, Pugettia gracilis, or very rarely Placetron wosnesenskii), and a few small urchins, Strongylocentrotus droebachiensis.

Factors affecting community structure

It is impossible to examine adequately the dominant factors that determine community structure by observing a community twice, but our descriptive studies at Point Barber suggest several factors that are likely to be important to community organization there.

Physical disturbance can be important to community structure. Theory predicts that frequent, severe, or chronic disturbance will reduce species richness, but infrequent and/or local disturbance can increase species richness by creating patches which competitively inferior species can colonize (Levin and Paine 1974). Dayton's (1971) study of the effects of wave-borne logs on intertidal community structure supports this theory. We noted evidence of recent physical disturbance at Point Barber, especially in May 1977, by the presence of patches of bare rock apparently created by erosion of large pieces of rock from the surface of the intertidal platform; other patches had apparently been cleared earlier since they were covered with foliose green algae (Ulva and/or Monostroma); both genera are rapidly growing and ephemeral, and frequently appear early on freshly cleared surfaces (Northcraft 1948, Dayton 1971, Lebednik and Palmisano 1977). Most recently disturbed areas are small and uncommon at Point Barber, and it does not appear that exfoliation of the bedrock surface is an important determinant of intertidal community structure there.

Another disturbance which could be important to biotic populations on the northwestern side of Point Barber is scouring by sand and gravel suspended in longshore currents from the beach northwest of the Point. The absence of adult M. edulis in this area may be a result of scouring, but predation by Pisaster (and possibly Nucella) (see below discussion) is a more likely cause because adults of other organisms (e.g. F. distichus and B. cariosus) which would have been removed by scouring by sand, gravel or ice were common. As stated above, the size and abundance of disturbed areas suggest that storm and log damage and freeze-thawing were not important structuring factors of the community at these levels at Point Barber.

Biological interactions, especially predation, have been shown experimentally to be important structuring agents in intertidal communities. Paine (1966, 1974) has shown that Pisaster ochraceus plays a dominant role in the structure of rocky intertidal communities on the outer coast of Washington by preying on Mytilus californianus, a species which dominates in competition for space. M. edulis reaches a smaller average adult size than M. californianus, but Menge (1976) has shown that M. edulis is capable of dominating the mid-intertidal region on horizontal and inclined surfaces in exposed and (in the absence predation by Thais (Nucella)) protected areas. In May 1977 adult Mytilus were abundant in but a few small patches on the southeastern side of Point Barber. One permanent 1/4 m^2 quadrat was placed haphazardly in each of three Mytilus patches in the upper intertidal and photographed in May. The quadrats were rephotographed in July. One plot showed a striking decrease in coverage (from 37% to 2%) in the interval from May to July (Figs. 43 and 44). Several Pisaster and empty shells and plates of M. edulis and B. cariosus respectively were near the plot in July. Predation by Nucella is an unlikely source of mortality of Mytilus at the plot because few were observed at Point Barber in May and July.

The patches of Mytilus were probably near the upper limit of Pisaster. Below these patches the intertidal bench gradually slopes to the sea; there are few drainage channels to allow Pisaster ready access to shoreward areas. Apparently these patches had been free from Pisaster predation for at least 2 to 3 years allowing Mytilus to attain a large size.

On the northwestern side of Point Barber adult Mytilus were scarce probably because of Pisaster predation since 1973. Large drainage channels give Pisaster access to shoreward areas of the bench here (Fig. 45). Dense coverage of young Mytilus indicate that the habitat is still suitable for the settlement and persistence of young Mytilus.

ZAIKOF BAY

Location and Physical Description

Zaikof Bay is a 2.5 mile wide embayment located on the northeastern end of Montague Island at the west side of Hinchinbrook Entrance to Prince William Sound (Fig. 1). The intertidal survey site is located on a rocky point (lat. 60° 17' 54"N, long. 147° 00'00"W) on the south side of the Bay (Fig. 46and 47). The point is a moderately sloping bedrock reef extending northeasterly, slightly into the bay and consisting of several large bedrock hummocks separated by crevices. The point is bordered on the east by a gravel beach; to the west the beach rapidly grades from a medium boulder to a gravel substratum (Sears and Zimmerman 1977, Plate EG-29).

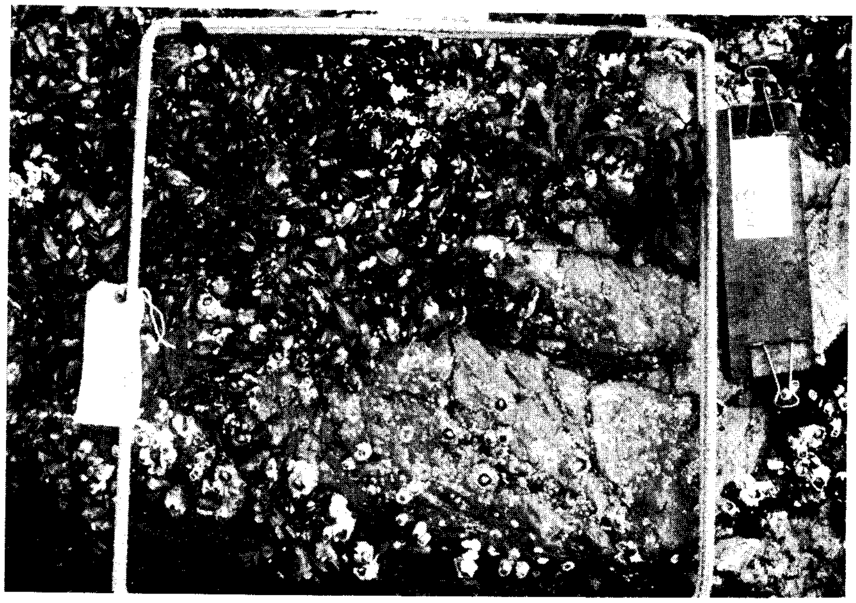


Fig.43. View of a quadrat in a patch of Mytilus at Pt. Barber. Compare with Fig.44. Taken on 6 May 1977 by C.E. O'Clair.

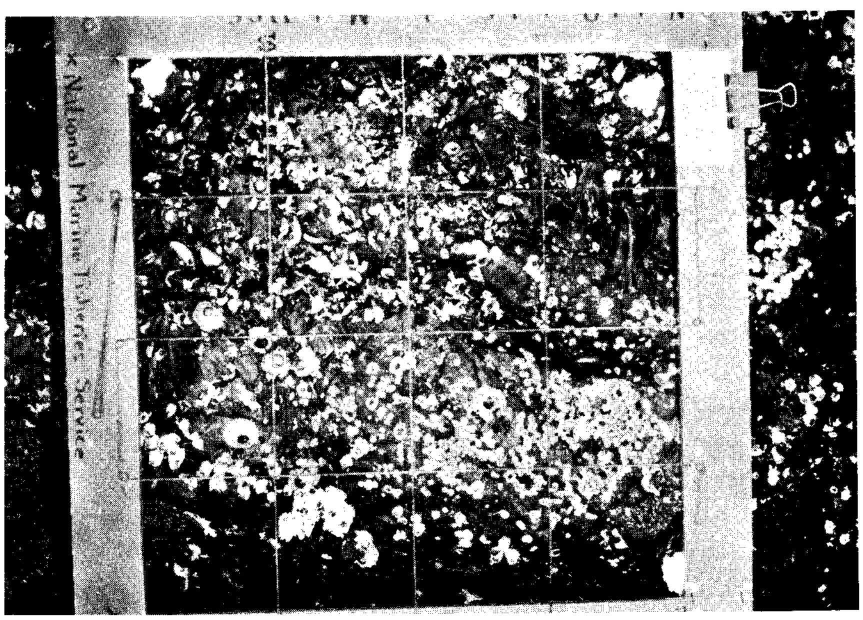


Fig.44. View of a quadrat in an area formerly occupied by Mytilus at Pt. Barber. Compare with Fig.43. Taken on 31 July 1977 by C.E. O'Clair.

Fig. 45. View of drainage channel at northwestern side of Pt. Barber. Taken on 6 May 1977 by C.E. O'Clair.

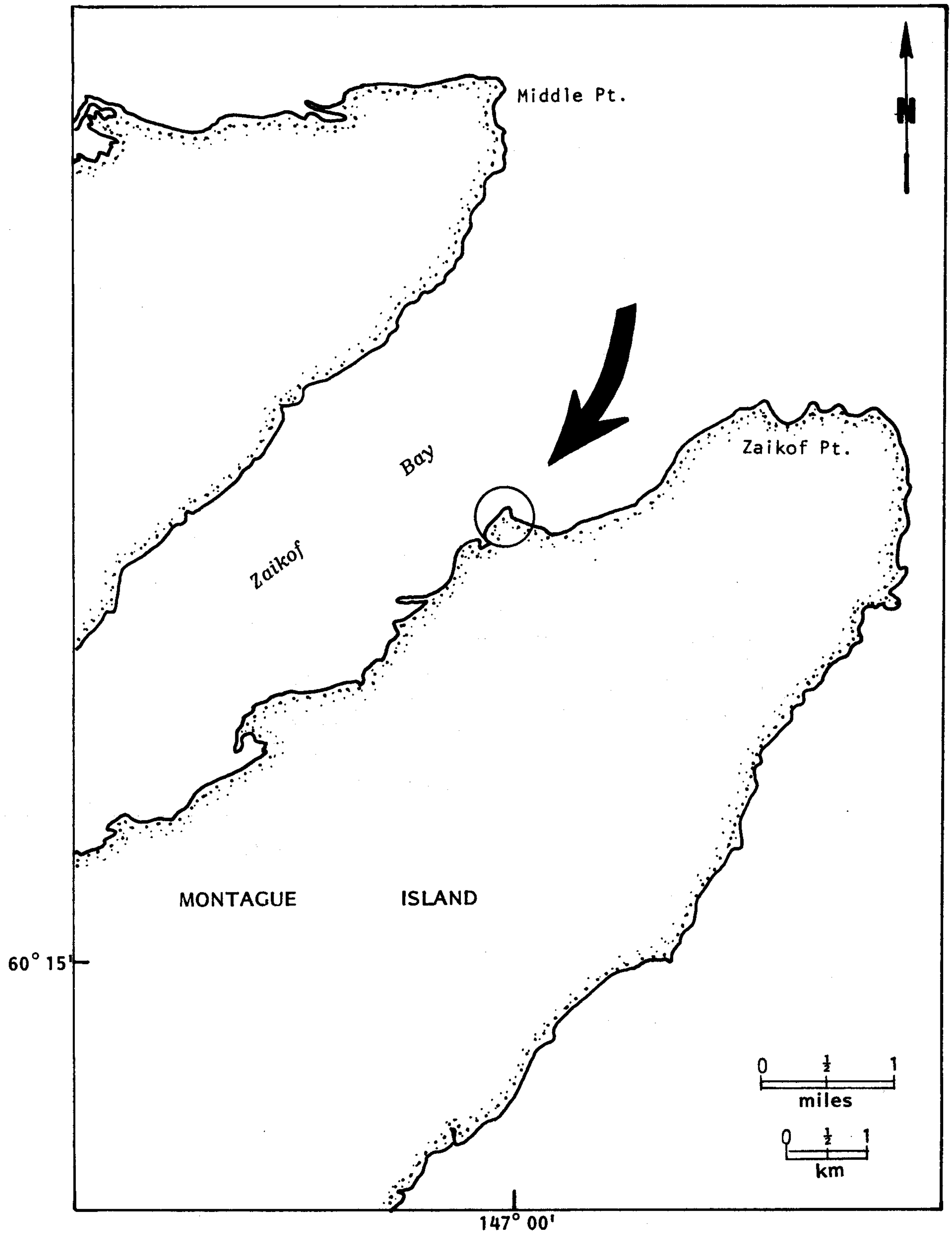


Figure 46. Zaikof Bay site.

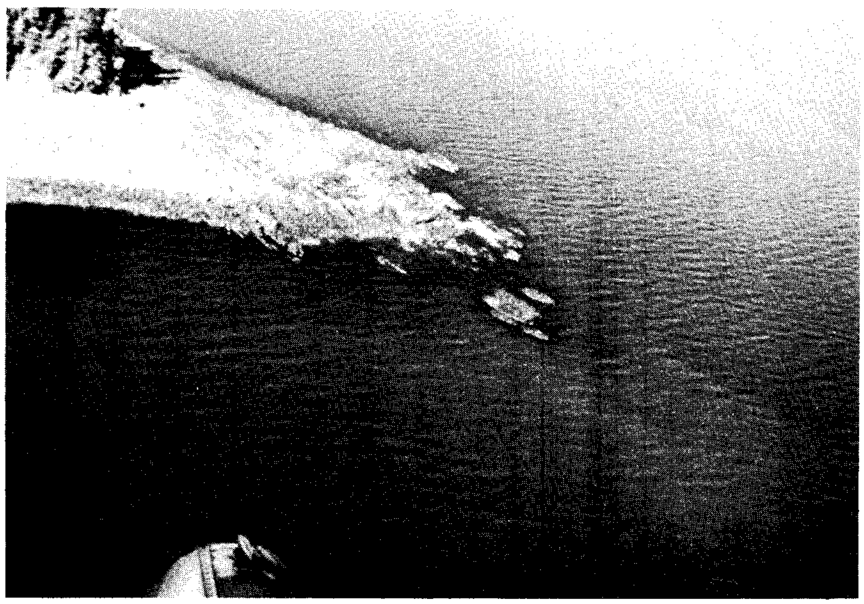


Fig. 47. Aerial view of Zaikol Bay sampling site.
Taken in May 1974.

Dates and methods of sampling at Zaikof Bay are listed in Table 1. The distribution of some selected intertidal organisms is shown in Fig. 48 for fall, 1975. Appendix 1 contains a list of all species collected on the transects for all sampling visits. Rosenthal et al. (1977) include a description of the shallow sublittoral area adjacent to our intertidal site at Zaikof Bay.

Fucus formed the most conspicuous algal belt in the high intertidal zone at Zaikof Bay in 1974 and 1975 (see also Rosenthal et al. 1977). It occurred in greatest density from +9 ft (+2.7 m) to +5 ft (+1.5 m) but was found as low as +2 ft (+0.6 m). Dense concentrations of the mussel Mytilus edulis often occurred with the Fucus. With the Fucus/Mytilus assemblage were large numbers of inconspicuous organisms whose role in the intertidal system is not known. These include marine mites, pseudoscorpians, dipterans, oligochaetes and nematodes. Also present in quantity were the amphipod, Oligochinus lightii, and the isopod, Munna chromatocephala.

Below the +6 ft (+1.8 m) level the algal community included Palmaria palmata, Halosaccion glandiforme, Rhodomela/Odonthalia complex, Pterosiphonia bipinnata, Iridaea sp., and Cryptosiphonia woodii, listed in order of relative abundance. With this assemblage were many small molluscs, including Lacuna sp., Alvinia sp., Mitrella sp., Margarites sp., Musculus sp., Hiatella arctica and Tonicella lineata and the crustaceans Pugettia gracilis, Pentidotea wosnesenskii, and Cancer oregonensis. The barnacle Balanus cariosus was distributed in densely concentrated patches from the +6 ft (+1.8 m) level to the +1.5 ft. (+0.4 m) level. At approximately the +3.5 ft. (+1.0 m) level Alaria marginata began to occur. This canopy species was common at the MLLW mark (0.0 m).

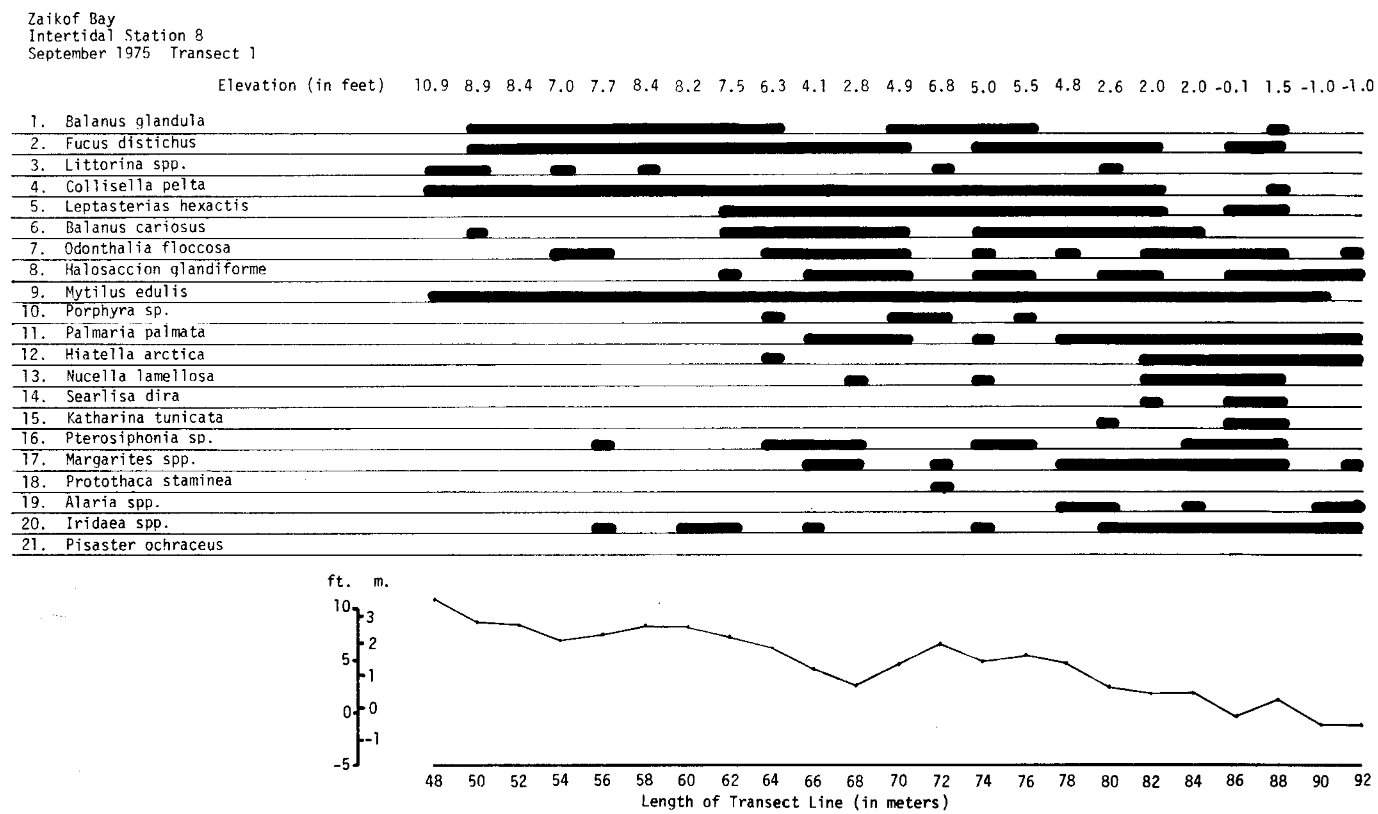


Fig. 48. Distribution of selected algae and invertebrates in 1/16 m^2 quadrats along transect 1 at Zaikof Bay in September 1975.

The sea star, Pisaster ochraceus was present in quantity although it appeared on only one transect line. During June 1976, intense Pisaster predation on Mytilus and Balanus spp. resulted in many patches of rock cleared of mussels and barnacles. These bare areas were then opened to colonization by species which suffer in competition for space with barnacles and mussels. A similar situation described by Paine (1966) resulted in an increase in species diversity by providing space, the major limiting resource in the rocky intertidal region (Paine 1966, 1971; Connell 1972; Dayton 1971).

MACLEOD HARBOR

Location and Physical Description

MacLeod Harbor (lat. 59° 53.4'N, long. 147° 47.7'W) is at the southwest end of Montague Island. Its broad mouth opens on Montague Strait (Fig. 1, and Sears and Zimmerman 1977, Plate EG-32). Our intertidal sampling site was on the north shore near the entrance of the bay, facing south, where it is partially exposed to seas from Montague Strait (Fig. 49).

The southwest end of Montague Island was raised about 9 m on March 27, 1964 by the Great Alaska Earthquake, which raised the entire intertidal zone of MacLeod Harbor well above the reach of highest tides, and moved substrate which had been subtidal into the intertidal region. Mass mortalities of algae and invertebrates resulted. An interdisciplinary post-earthquake study of Prince William Sound, led by G. Dallas Hanna (1971) included a visit to MacLeod Harbor on June 26-27, 1965. Johansen (1971) and Haven (1971) give accounts of post-earthquake algal and invertebrate distribution, respectively. At MacLeod Harbor in 1965, Porphyra spp. were the dominant colonizing algae, forming a heavy band from +8.0 ft (+2.4 m) to +3.9 ft (+1.2 m), the tidal range usually occupied by Fucus distichus, of which there were only a few isolated individuals

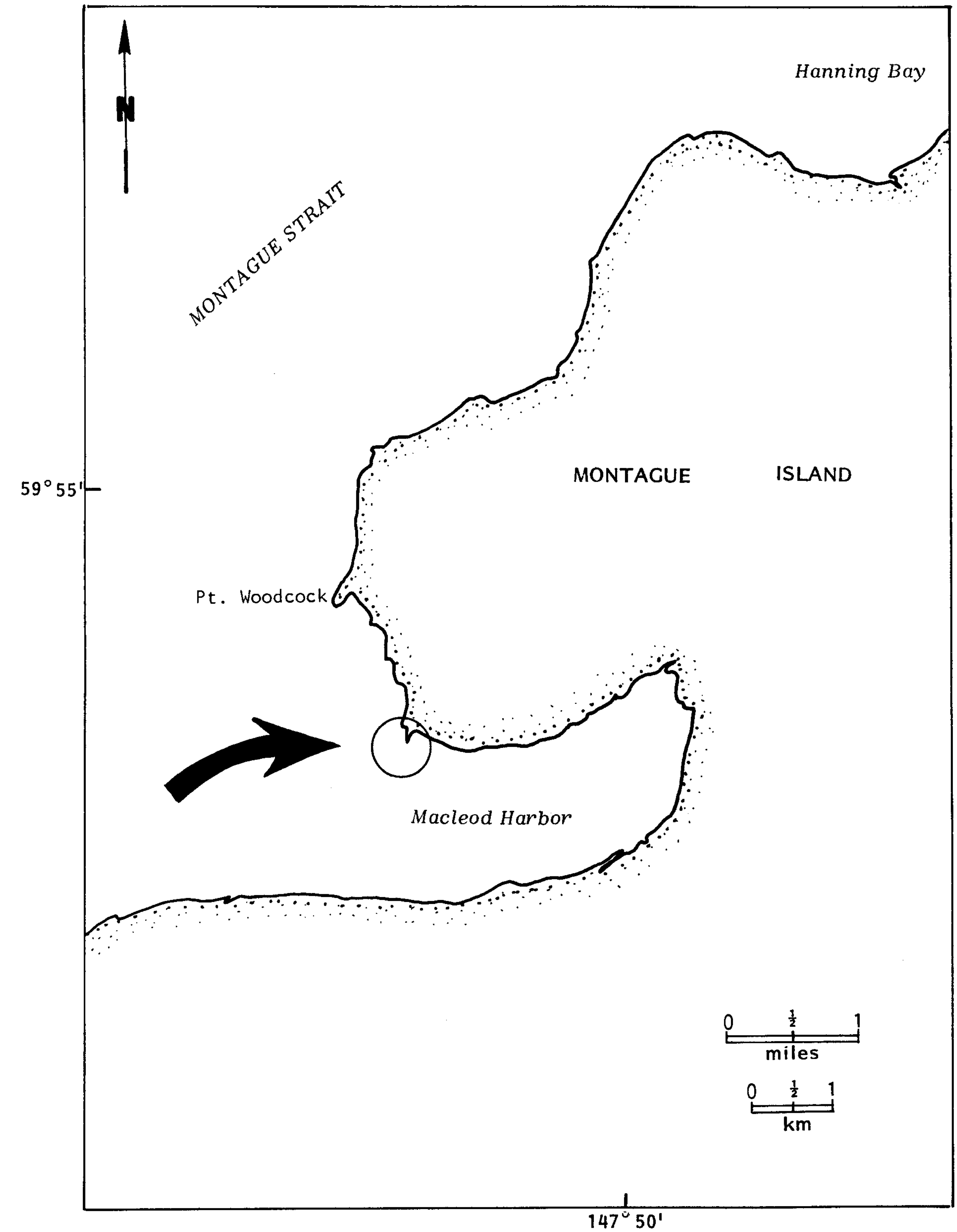


Figure 49. MacLeod Harbor site.

(Johansen 1971). When Haven (1971) revisited the site in August 1968, and later when we visited it in 1974 and 1975 Fucus was the dominant alga of this zone.

Dates and methods of sampling are listed in Table 1. Appendix 1 lists all species collected at MacLeod Harbor for all sampling visits. Fig. 50 shows the distribution of some selected intertidal organisms at MacLeod Harbor in September 1975.

Our sampling site was largely bedrock, layers of which had buckled and heaved to create steep-sided "fingers" of rock which extend offshore from the high intertidal like fingers from a hand (Figs. 51 and 52). The upper part of these "fingers" was sampled with transect lines (Fig. 53) and the lower by arrow sampling (Fig. 51). The lower part of each transect traversed a low gradient, flat, bedrock shelf in the Alaria zone (which extends approximately from +5.0 ft (+1.5 m) to +1.0 ft (+0.3 m).

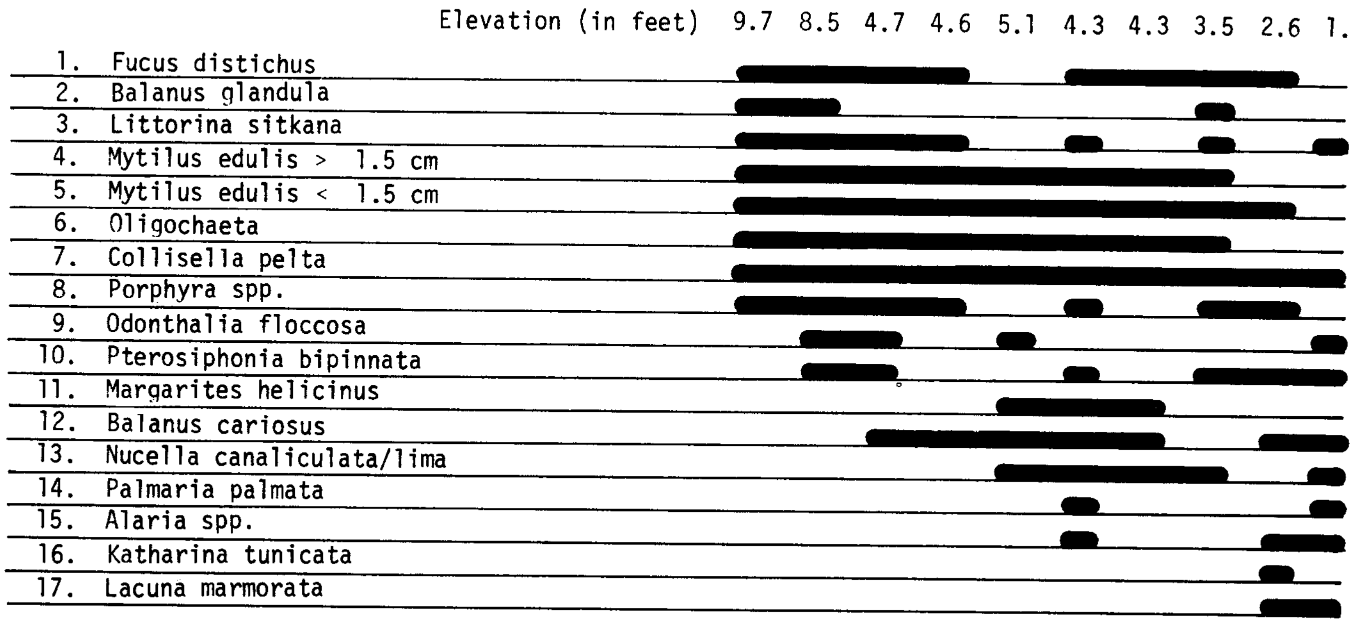
Dominant Organisms

Upper Zone

As at almost every rocky site sampled, the upper zone at MacLeod Harbor was occupied by Littorina sitkana, Balanus glandula, Fucus distichus and Mytilus edulis. Unlike other sites, on most transects collected at MacLeod Harbor, these species occurred in every zone we sampled down to +0.3 ft (0.1 m). Collisella pelta and oligochaetes were also distributed throughout the intertidal zone. An exception was Mytilus over 1.5 cm long which did not extend below +3.0 ft (+0.9 m) Pisaster ochraceus, which were observed in the low zone, may pass over small Mytilus edulis to select larger ones. Paine (1976) has found that there is a minimal size below which M. californianus are not attractive to large Pisaster.

In April 1975, Littorina sitkana were much less numerous in the collected quadrats than in September of 1974 and 1975 (average abundance in quadrats in

MacLeod Harbor
Intertidal Station 9
September 1975 Transect 2



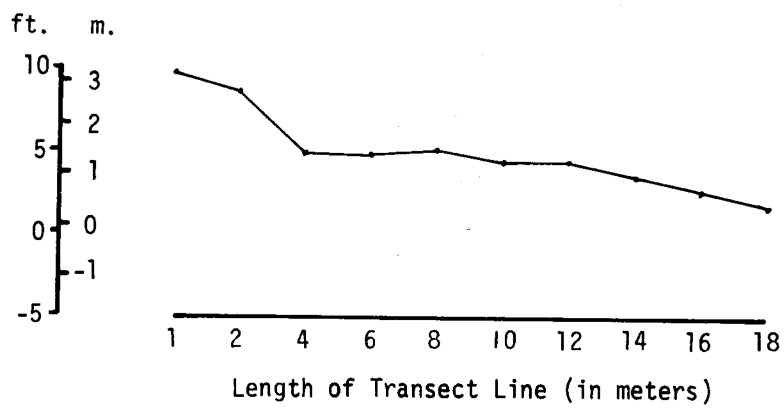


Fig. 50

Horizontal and vertical distribution of selected algae and invertebrates from 1/16 m^2 quadrat collections along a transect line.

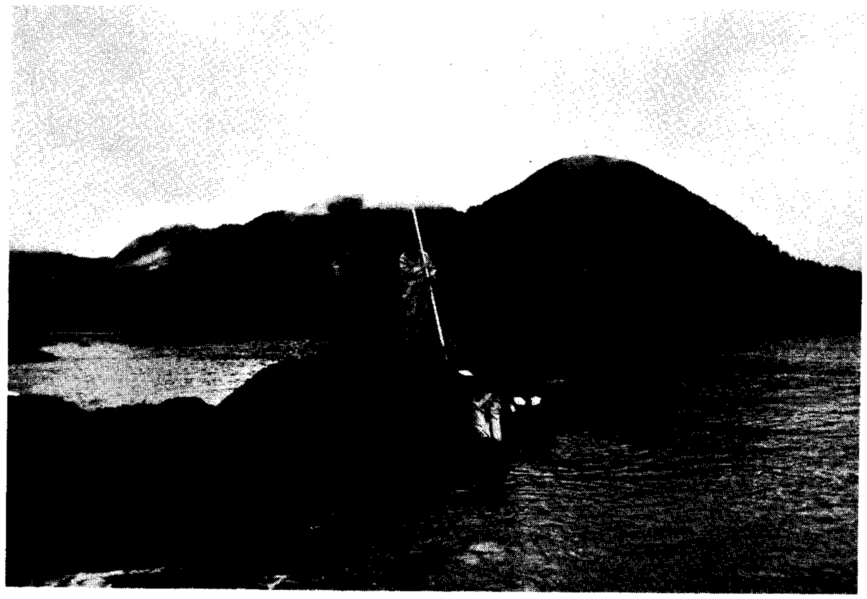


Fig. 51. Arrow sampling on a typical bedrock reef at MacLeod Harbor. Taken in September 1974.

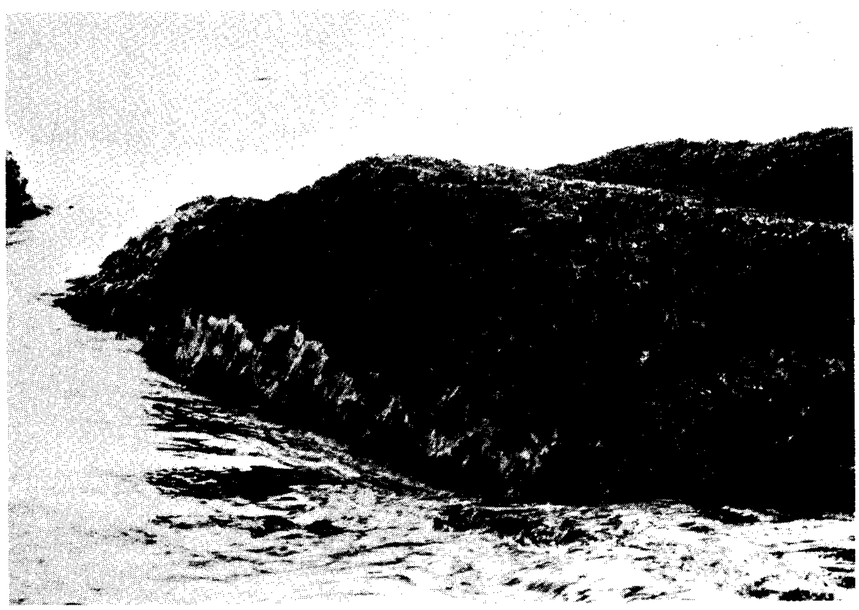


Fig. 52. Low zone on reef showing heavy cover of mussels and algae. Taken in April 1975.

Fig. 53. Transect sampling in the upper zone at MacLeod Harbor. Taken in September 1975.

which they occurred was 7.9, April 1975; 104.4, September 1974; 71.6, September 1975). Near freezing weather during the April sampling period may have forced most *L. sitkana* to seek shelter in cracks, crevices and under rocks. These individuals would have been overlooked.

Middle and Low Zones

Mytilus, formed a heavy cover in the middle zone, particularly on the projecting reefs (Figs. 51 and 52). In the low zone the cover of *Alaria* spp. was relatively sparse. In September most of the *Alaria* plants still had their blades, although they were dissected to the mid-rib. In the extreme low zone, under water, we saw the starfish, *Pisaster ochraceus* and *Pyncnopodia helianthoides*, and the perennial red alga, *Constantinea* sp.

A prominent zone of the red alga, *Palmaria palmata* was absent at this site. All of our samples each had less than a gram of *Palmaria*. At other sites, weights of over 100 g of *P. palmata* per 1/16 m^2 quadrat were common.

LATOUCHE POINT, LATOUCHE ISLAND

Location and Physical Description

Latouche Point (lat. 59° 57.1'N, long. 148° 03.4'W) is on the southwestern tip of Latouche Island (Fig. 1 and 54 and Sears and Zimmerman 1977, Plate EG-33). "The point is exposed to westerly swells, and a great deal of drift accumulates along the beachline, especially during early fall and spring. Tidal currents are typically moderate to weak in the lee of the point. However, further offshore or in Latouche Passage where the water mass is not deflected by land, the tidal currents can exceed 2 nautical miles per hour". (Rosenthal et al. 1977). Latouche Island was uplifted during the 1964 earthquake; the difference between the old barnacle line and the present barnacle line is about 3 m (Fig. 55). The sampling area is in the shape of a broad horseshoe bounded on the west by high

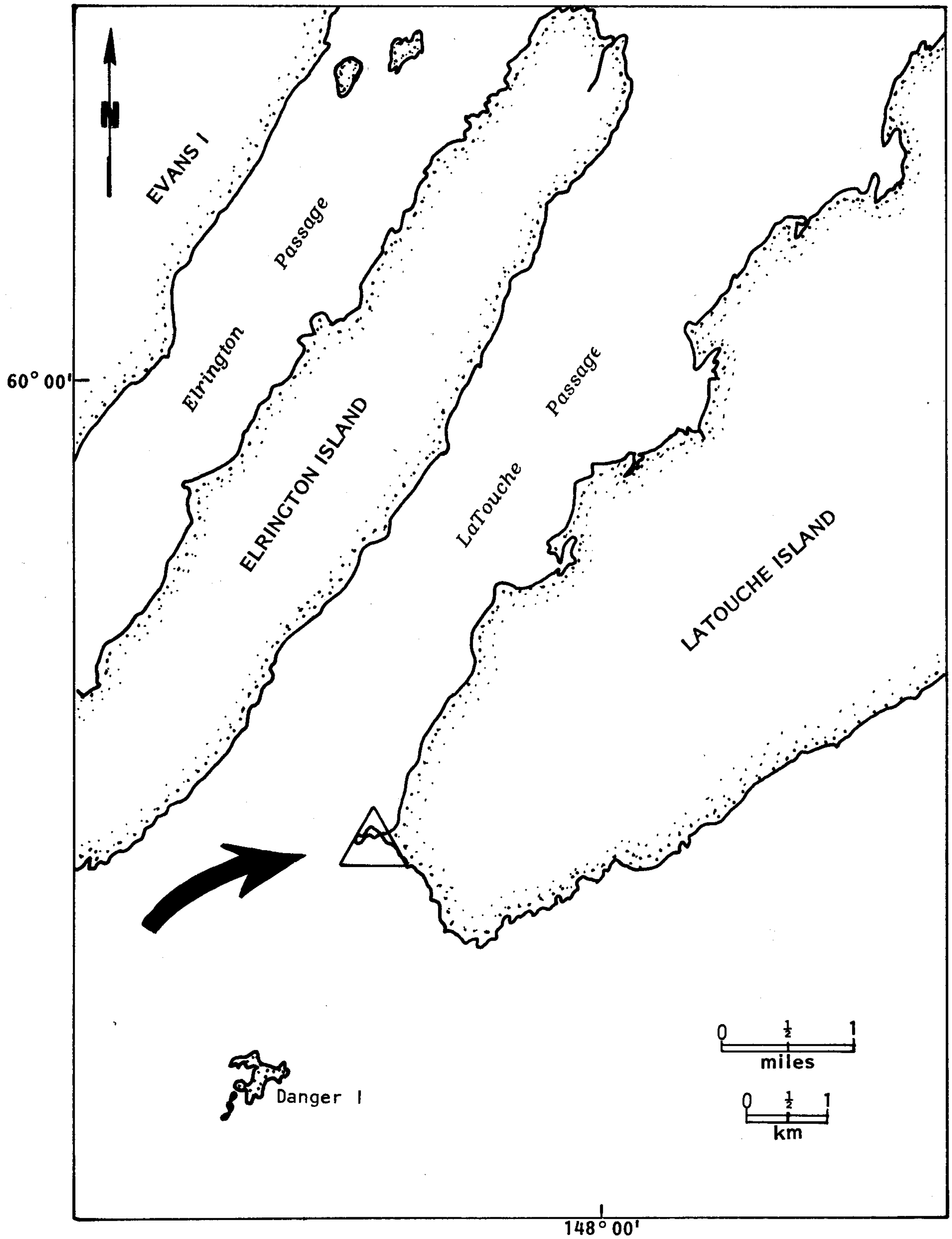


Figure 54. LaTouche Point site.

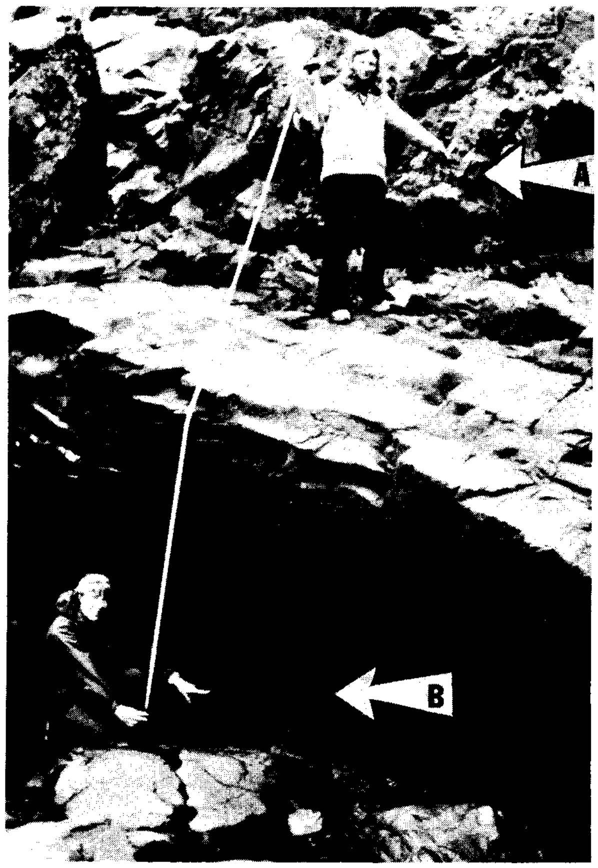


Fig. 55. Pre-earthquake (A) and present (B) barnacle lines at Latouche Pt. Uplift was approximately 3m. Taken in June 1976.

spruce-covered cliffs, and on the East by hummocky bedrock (Fig. 56). The intertidal area is about 200 m broad and is gently sloping. The substratum is shale bedrock cut by many deep surge channels with sand and mud bottoms. There are several large, deep tidepools which we have never observed to go entirely dry.

Table 1 lists dates and sampling methods used at Latouche. Appendix 1 lists all species collected there for all sampling visits.

Dominant Organisms

In 1975 we established a transect along the west side of the beach in an area where large tidepools were common. Figs. 57 and 58 show the distribution of selected species along atransect sampled in April and September. We found that macrophytes and small invertebrates were abundant. In general the pools modified the effect of tidal elevation creating a mosaic pattern of distribution of macrophytes. Fucus distichus was most often observed in the high zone above the tidepools or on rock tops near tide pools. Dense patches of the surf grass, Phyllospadix sp. were associated with the borders or on the sloping sides of large tidepools (Fig. 59). Sand had collected among the rhizomes of this plant and many polychaete and oligochaete worms, clams, isopods, and amphipods were collected with the Phyllospadix plants. Many species of red algae, especially Ptilota filicina, and kelps were found at a higher tidal elevation than one would expect them to occur, probably because of the effect of surge channels and tidepools which reduce dessication at upper levels.

Most of the invertebrates in our collection were small herbivores, (Littorina sitkana, Siphonaria thersites, and Collisella pelta), filter feeders (bivalve mollusks including Musculus discors and Turtonia occidentalis), or

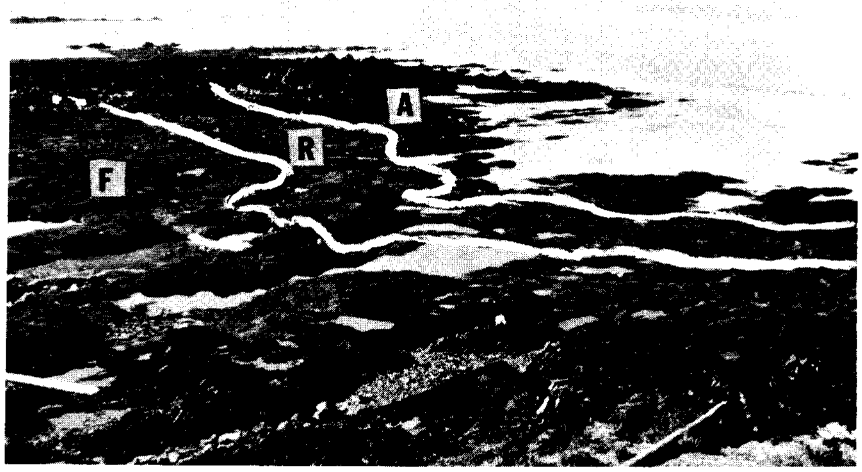


Fig.56. The two undulating white lines indicate the boundaries of the main algal zones during the ERIM study of 1976. F, <u>Fucus</u> zone; A, red algae and <u>Alaria</u>; R, diverse cover of red algae (see text). Taken in June 1976.

Intertidal study site at Latouche Point.

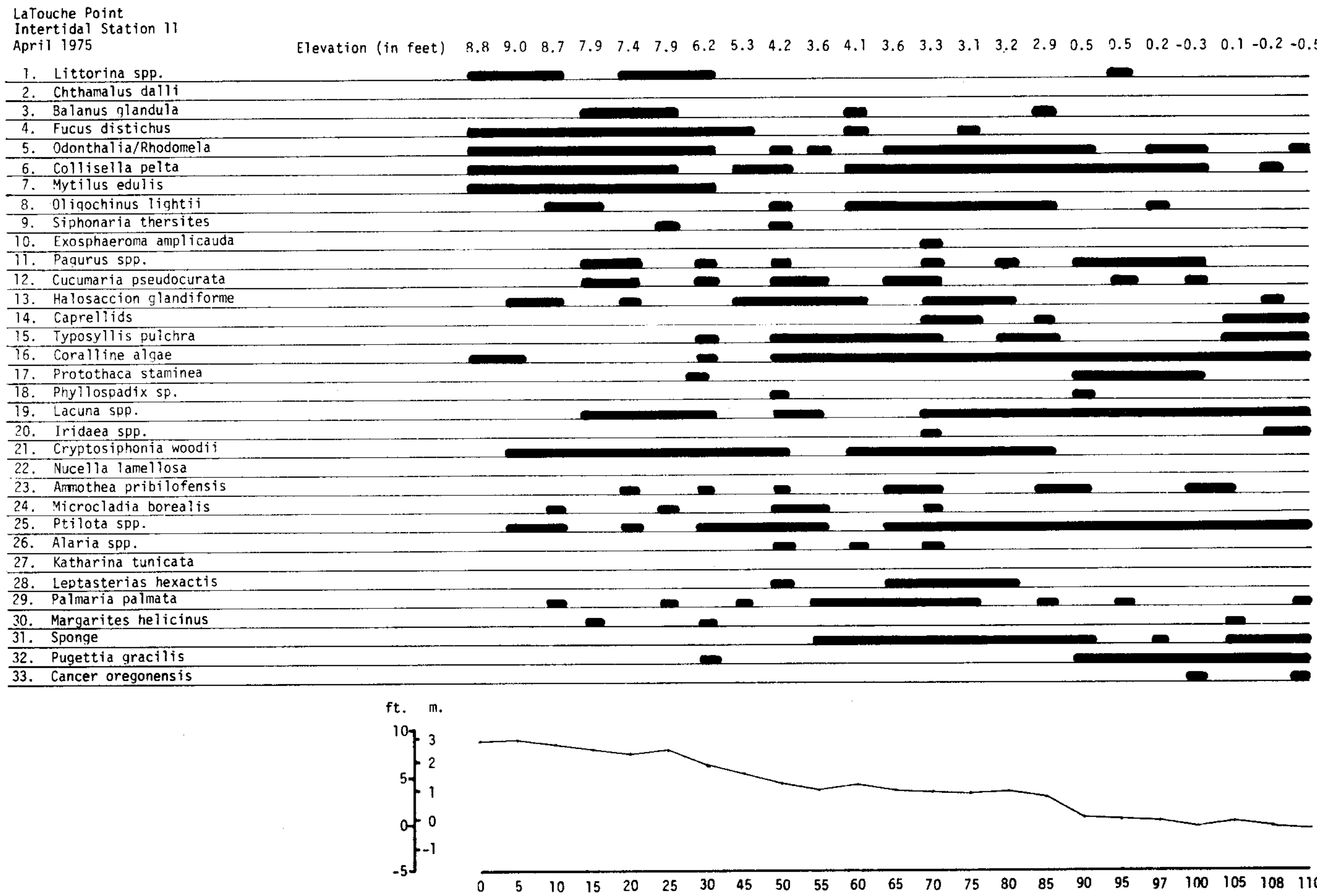


Fig. 57. Distribution of selected plants and invertebrates in 1/16 m^2 quadrats at station 11 at Latouche Point in April 1975.

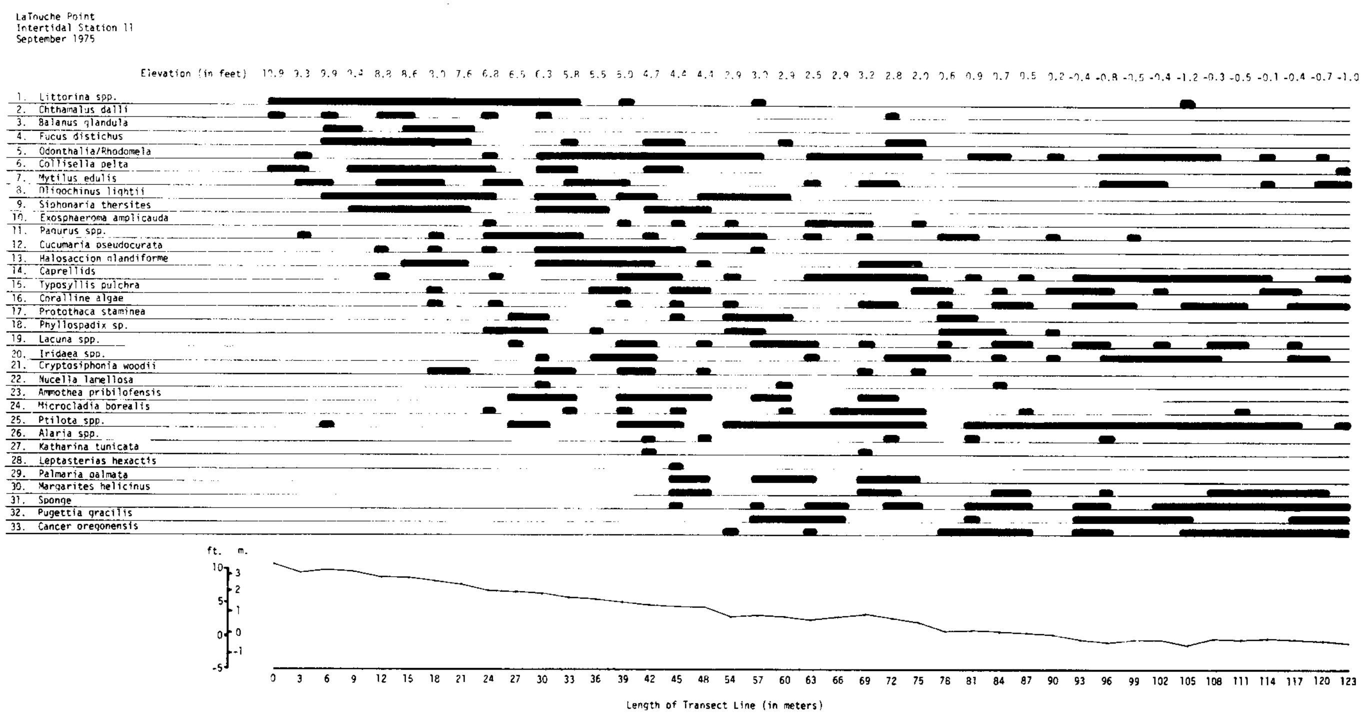


Fig. 58. Distribution of selected plants and invertebrates in 1/16 m^2 quadrats at station 11 at Latouche Point in September 1975.

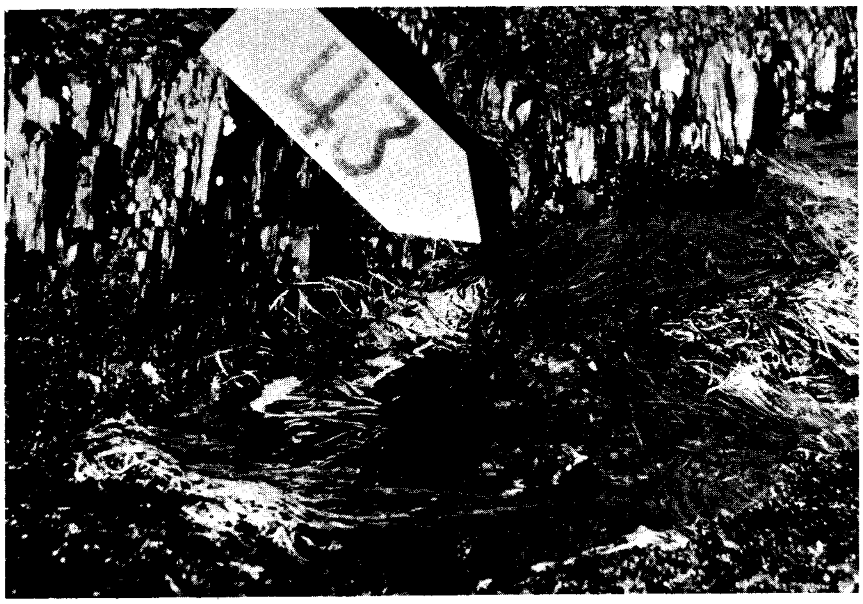


Fig. 59. Phyllospadix growing on the sides of a deep tidepool. Taken in April 1975.

detrital feeders (amphipods, *Cucumaria pseudocurata*, and *Pagurus hirsuitiusculus*), often associated with macrophytes. Predators were rare. We found only five *Nucella* (*Nucella* sp. and *N. lamellosa*) in our quadrat collections for April and September. We collected 12 *Leptasterias hexactis* in April and only four in September. Juvenile sea stars, too small to identify[1/] were abundant in September. We collected 122 juvenile sea stars in seven quadrats ($\bar{x}$=17.4/quadrat) at elevations ranging from +2.0 to +4.7 ft (+0.6 to +1.4 m). Mussels and barnacles were uncommon along the transect. Most of the mussels collected were less than <1.5 cm. Barnacles (*Balanus glandula*, *B. cariosus*, and *Chthamalus dalli*) were found on occasional boulders which may be tumbled during storms and on shale bedrock which is friable (Fig. 60). We observed denser aggregations of mussels and barnacles on stable bedrock outcrops east and west of our sampling area.

In 1976 we made a qualitative survey on the same beach, as part of a cooperative study with the Environmental Research Institute of Michigan (ERIM), to determine if multi-spectral scanning by aircraft could be used to determine macrophyte distribution and abundance in the littoral zone. A 200-meter transect line was run along the east side of the beach and estimates of percent cover were made for each meter along the transect. The east side of the beach had many surge channels but had fewer tidepools than the west side previously investigated. *Fucus* formed a broad band, about 65 m wide, in the high zone (Fig. 56). Below this band a narrow zone of several species of red algae was found; *Alaria* sp. formed the canopy in the lower end of this zone (Figs. 56 and 61). The lowest zone was

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1/ From data sheets of the sorting center of the Institute of Marine Sciences, University of Alaska, Fairbanks.

Fig. 60. Barnacles growing on shale bedrock and on boulders. Taken in September 1975.

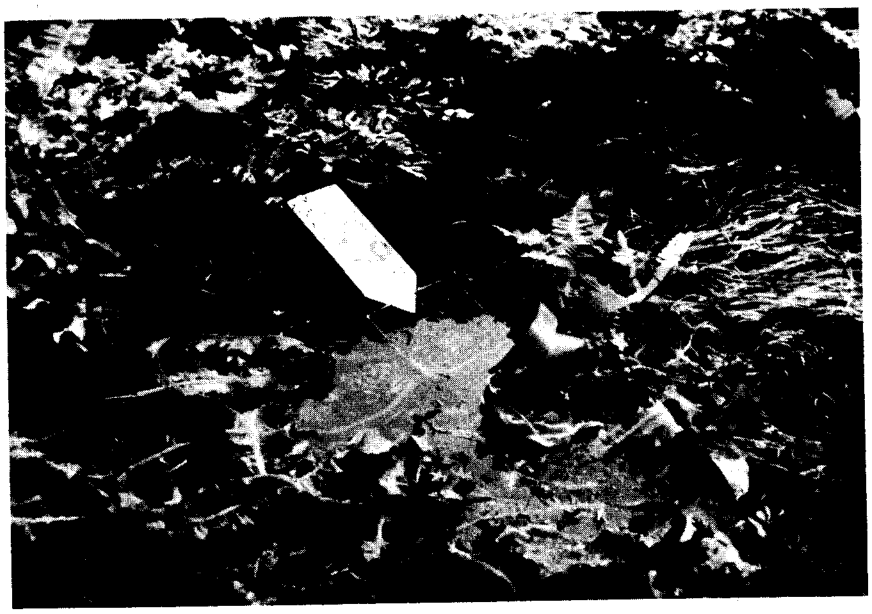


Fig. 61. Lower and mid-intertidal zone with cover of Rhodophycean turf species, Alaria canopy, Laminaria in the tide pool and Phyllospadix at the pool border. Taken in September 1975.

formed of flat peninsulas separated by surge channels. These peninsulas had a dense cover of Ptilota filicina, Odonthalia floccosa, Iridaea cornicopiae, and Iridaea heterocarpa. The surge channels were filled with the kelps Laminaria sp., Cymathere triplicata, and Agarum cribrosum, as well as the subtidal red alga Constantinea rosa-marina.

Rosenthal et al. (1977) have studied sublittoral plant and animal assemblages at Latouche Point.

SQUIRREL BAY

Location and Physical Description

Squirrel Bay is a semicircular bay on the southwestern tip of Evans Island that opens on the southern entrance of Prince of Wales Passage into Prince William Sound (Fig. 1 and Plate EG-34, Sears and Zimmerman 1977). Because of its wide mouth much of the bay is exposed to oceanic swell from Blying Sound to the southwest, but our sampling site on the south shore near the entrance (lat. 59° 59' 54"N, long. 148° 08'58"W) was relatively protected from these swells (Fig. 62).

The site had an especially "hummocky" topography created by boulders in a wide range of sizes. A moderate cover of algae on the boulders made the beach difficult to traverse. We visited Squirrel Bay in September 1974 only, and our collections and observations are limited.

In the collected quadrats Fucus biomass was highest at and above +6.7 ft (+2.0 m) (n=6, mean wet wt. = 265.4 gm, SD=89.5 gm). Within this tidal range 53% (by wet wt.) of the Fucus plants showed signs of fertility. From +6.1 ft (+1.9 m) to +2.7 ft (+0.8 m) Fucus biomass was much less (n=8, mean wet wt. = 23.9 gm, SD=27.7 gm) and fertile plants occurred in only 25% of the quadrats (9% by weight were fertile).

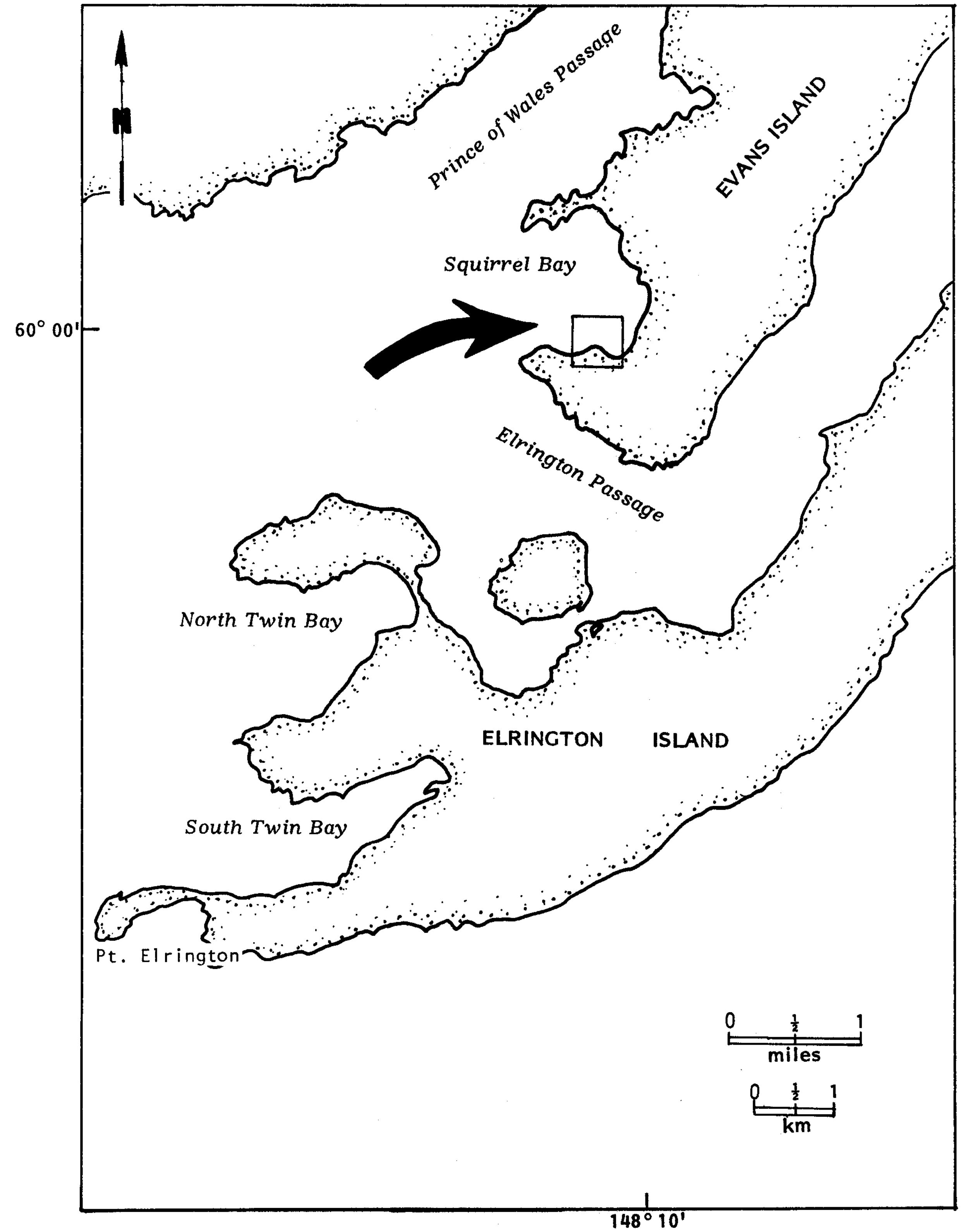


Figure 62. Squirrel Bay site.

The distribution of biota at the site was patchy. This may have been partly related to the varied slope and aspect imparted by boulders of a variety of sizes, providing a wide variety of habitats, which in the lower zone particularly were populated by a rich fauna. Algae in the area were limited to the tops and sides of boulders presumably either by herbivores or by the availability of light, the lower and undersides of the boulders provided space and shelter for many animals. Because of the limitations of the transect sampling method, many of these habitats were not sampled. As an example of the diversity of organisms among the boulders in the low zone we made field identifications of the following organisms on one boulder (about 60 cm in diameter) not on the transect: encrusting bryozoans, sponges, four species of anemone (*Tealia crassicornis*, *Anthopleura artemesia*, *Metridium senile*, and one unidentified species), a nemertean, the polychaete, *Spirorbis* sp., three species of echinoderm (a brittle star, *Leptasterias* sp., and *Pisaster ochraceus*), snails (*Margarites beringensis* and *Nucella lamellosa*), the hermit crab, *Pagurus* h. *hirsutiusculus*, a small chiton, *Mopalia*, and tunicates. Appendix 1 lists all species collected in samples from Squirrel Bay.

ANCHOR COVE

Location and Physical Description

Anchor Cove is a 3/4 mile wide recess in the eastern shore of Day Harbor, a larger embayment opening into Blying Sound in the Gulf of Alaska (Fig. 1). The intertidal survey site is located on the unnamed point (lat. 59° 59'42"N, long. 149° 06'06"W) that forms the southern boundary of Anchor Cove (Fig. 63). The point is a short bedrock reef of moderate slope. It is bordered on either side by near-vertical bedrock substratum (Sears and Zimmerman 1977, Plate EG-36). Dates and methods of sampling are listed in Table 1.

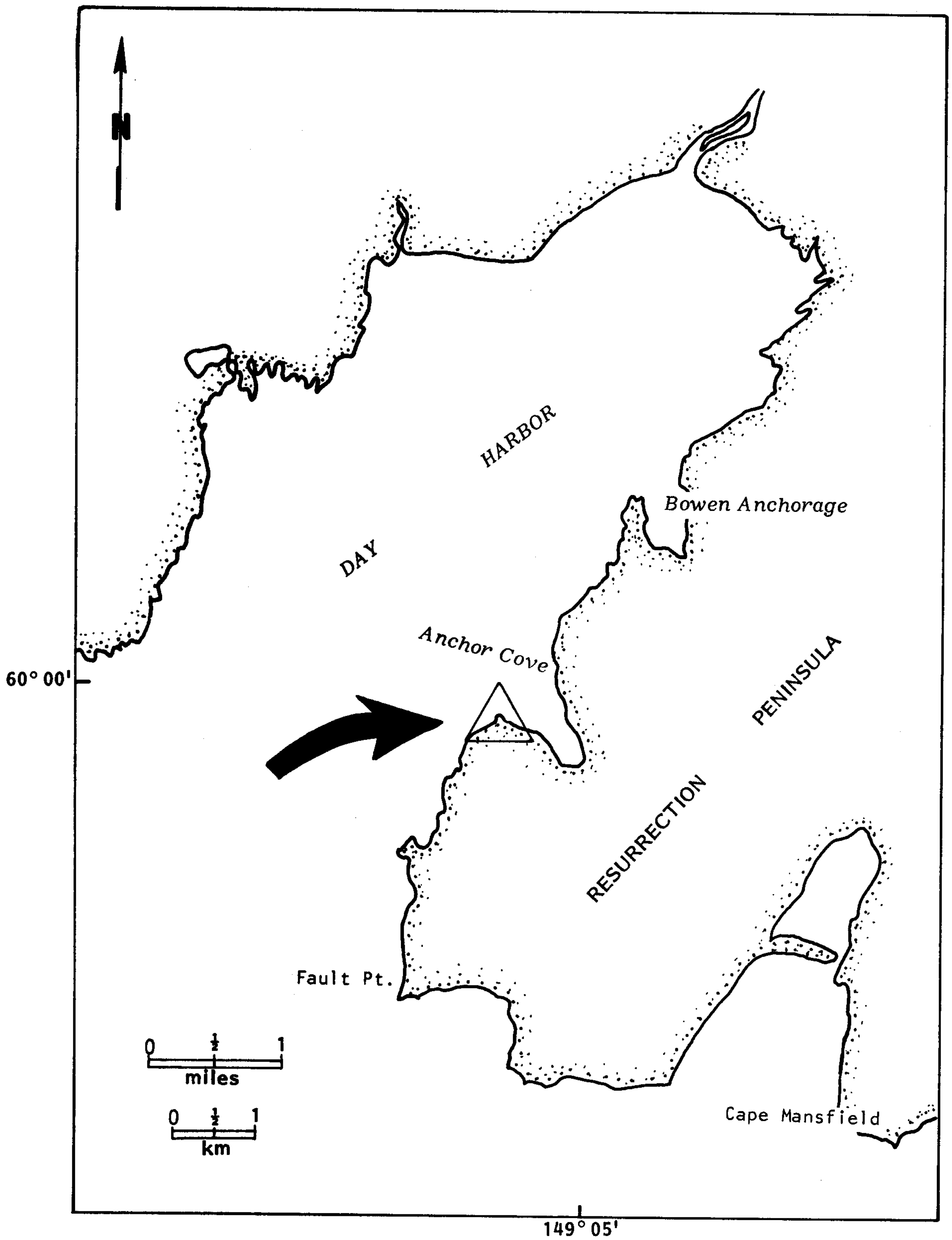


Figure 63 . Anchor Cove site.

The distributions of some selected species collected along one transect are shown in Fig. 64 for September 1975. Appendix 1 contains a list of all species collected on the transects at Anchor Cove.

There was a striking difference in the pattern of abundance of mid-intertidal biota between the spring and fall visits in 1975. This can be seen in Figs. 65, 66, 67, and 68. In May, a large area of the reef was covered with a dense growth of the mussel, Mytilus edulis, over-laying live Balanus cariosus. By September the total area of mussel coverage had been reduced by an estimated 80% to a few isolated patches on small hummocks and was being replaced by algae (Halosaccion glandiforme and Ulva sp). A similar pattern of Mytilus-abundance to that in September 1975 was noted a year earlier at the same study area(Figs. 69 and 70).

The reduction in size of the mussel bed was probably a result of predation by the gastropods Nucella lamellosa and N. lima and the sea star Pisaster ochraceus. The few remaining mussel patches were surrounded by actively preying Nucella and drilled, empty mussel valves (Figs. 66, 67, 68, and 70). Nucella spp. usually feed on barnacles (Balanus spp. and Chthamalus spp. (Moore 1938, Connell 1970, Dayton 1971, Bertness 1977)). However, Menge (1976) correlated an increase in the proportion of mussels, M. edulis, in the diet of Nucella lapillus with an increase in the abundance of mussels and that Nucella severely reduces populations of mussels in protected situations.

Predation by Pisaster was not observed as it eats primarily while submerged and seeks refuge at low tide (Mauzey 1966). However, Landenberger,(1968) Mauzey et al. (1968) and others have shown that Pisaster has a definite preference for mussels. Paine (1966) has shown experimentally that Pisaster is of primary importance in determining the composition of rocky intertidal biota.

It is not likely that the loss of mussels was the result of other factors such as storm damage or predation by mink, crows or sea birds. Storm damage would

Anchor Cove
Intertidal Station 12
September 1975 Transect 1

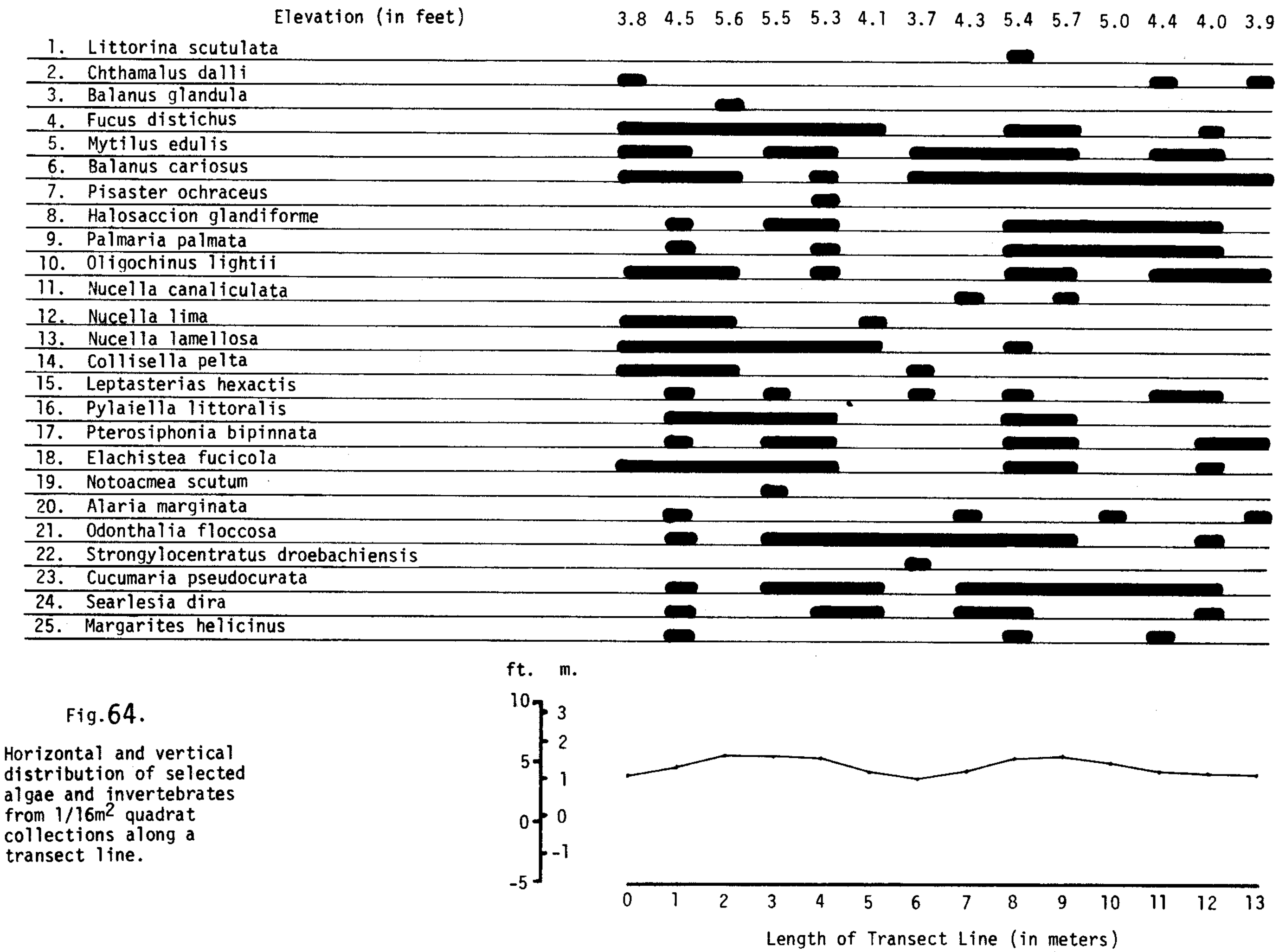


Fig. 64.

Horizontal and vertical distribution of selected algae and invertebrates from 1/16m^2 quadrat collections along a transect line.

Fig.65. Anchor Cove, May 1975. Much of the area around the two biologists is covered by *M. edulus*.

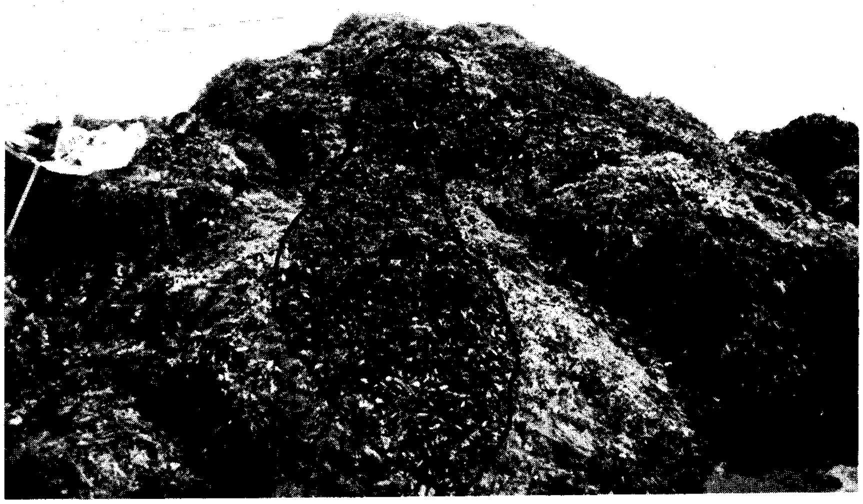


Fig.66. Anchor Cove, September 1975. Showing extent of *Mytilus* coverage (within black line). Location is immediately to the left (viewer right) of the people in Fig.65).

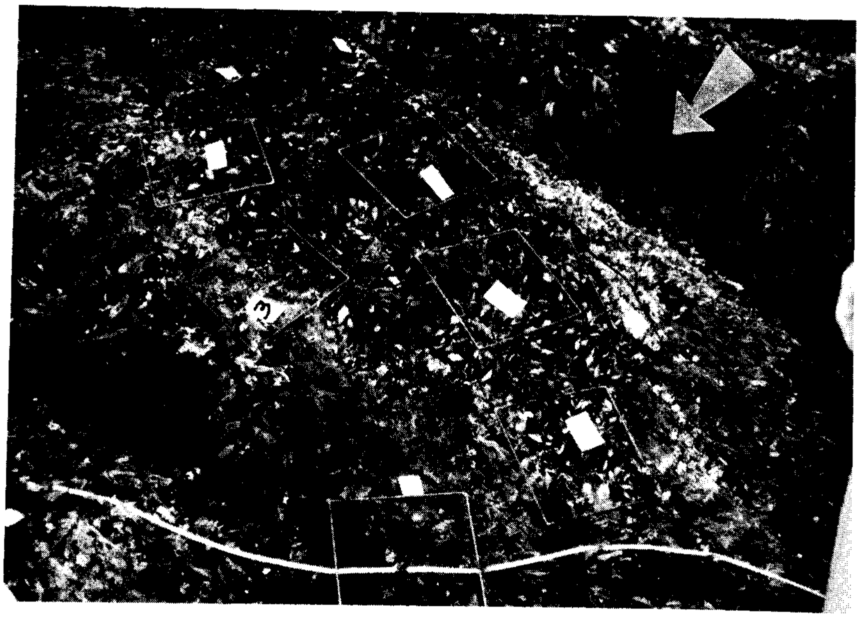


Fig. 67. Close-up of study area at Anchor Cove showing Nucella (mostly N. lamellosa) preying on M. edulis. Note also the concentration of Pisaster ochraceus (arrow). Taken on 3 September 1975.

Fig. 68. Close-up of one quadrat in Fig. 67 showing shells of Mytilus (arrows) which have been drilled by Nucella. Taken on 3 September 1975 by C. Mattson.

Fig.69. Study area at Anchor Cove. Taken on 15 September 1974 by R. Myren. Note wave of *Nucella* to the right of line marking edge of *Mytilus* patch.

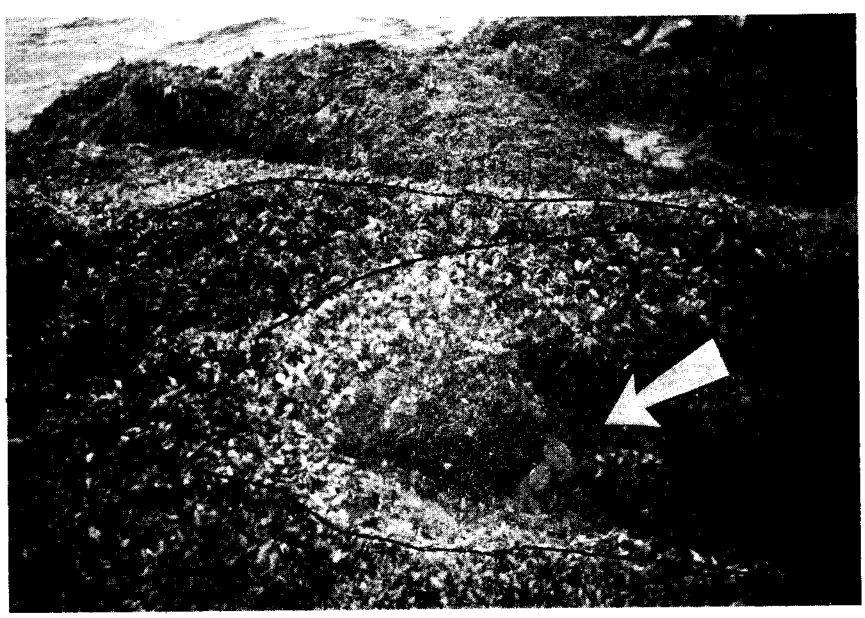


Fig.70. Close-up of a wave of *Nucella* from Fig. 69(line denotes margin of *Mytilus* patch). Note several *Pisaster* (arrow). Taken on 15 September 1974 by R. Myren.

have occurred primarily on the seaward side. This was not the case as predation was not oriented with respect to wave impact. Predation by mink, crows or sea birds would have been from above, or in a descending direction, however, since the remaining mussels were confined to the tops of hummocks, predation must have occurred from below, or in an ascending direction (Figs. 66 and 69).

That the mussel bed was so extensive and relatively predator-free in the spring can be explained by the habits of the predators. Mauzey (1966) reports a seasonal feeding periodicity in Pisaster in which the percentage of feeding individuals observed varied from 80% in the summer to 0% in the winter. On San Juan Island, Washington Nucella lamellosa moves from lower intertidal levels in spring to higher levels in fall as it depletes its primary food source (barnacles); most Nucella stop feeding from November through February (Connell 1970).

GORE POINT

Location and Physical Description

Our intertidal station (lat. 59° 13'20"N, long. 151° 01'00"W) was located approximately 2 miles northwest of Gore Point, in the entrance to Port Dick (Figs. 1 and 71). The beach consists of moderately sloped bedrock overlain by a few boulders (Fig. 72; Sears and Zimmerman 1977, Plate EG-46).

Table 1 shows the dates we visited Gore Point and our sampling methods. Figs. 73 and 74 illustrate the distributions of some selected species collected along a transect in May 1975 and August 1975. Appendix 1 lists all species collected on the transects for all sampling periods.

The upper intertidal zone (+11 to +13 ft (+3.3 to +3.9 m) was covered by a heavy (often 100% coverage) growth of the red alga, Porphyra sp. Also present were insect larvae, Balanus glandula, Littorina sitkana and Collisella digitalis, none of which were unusually abundant.

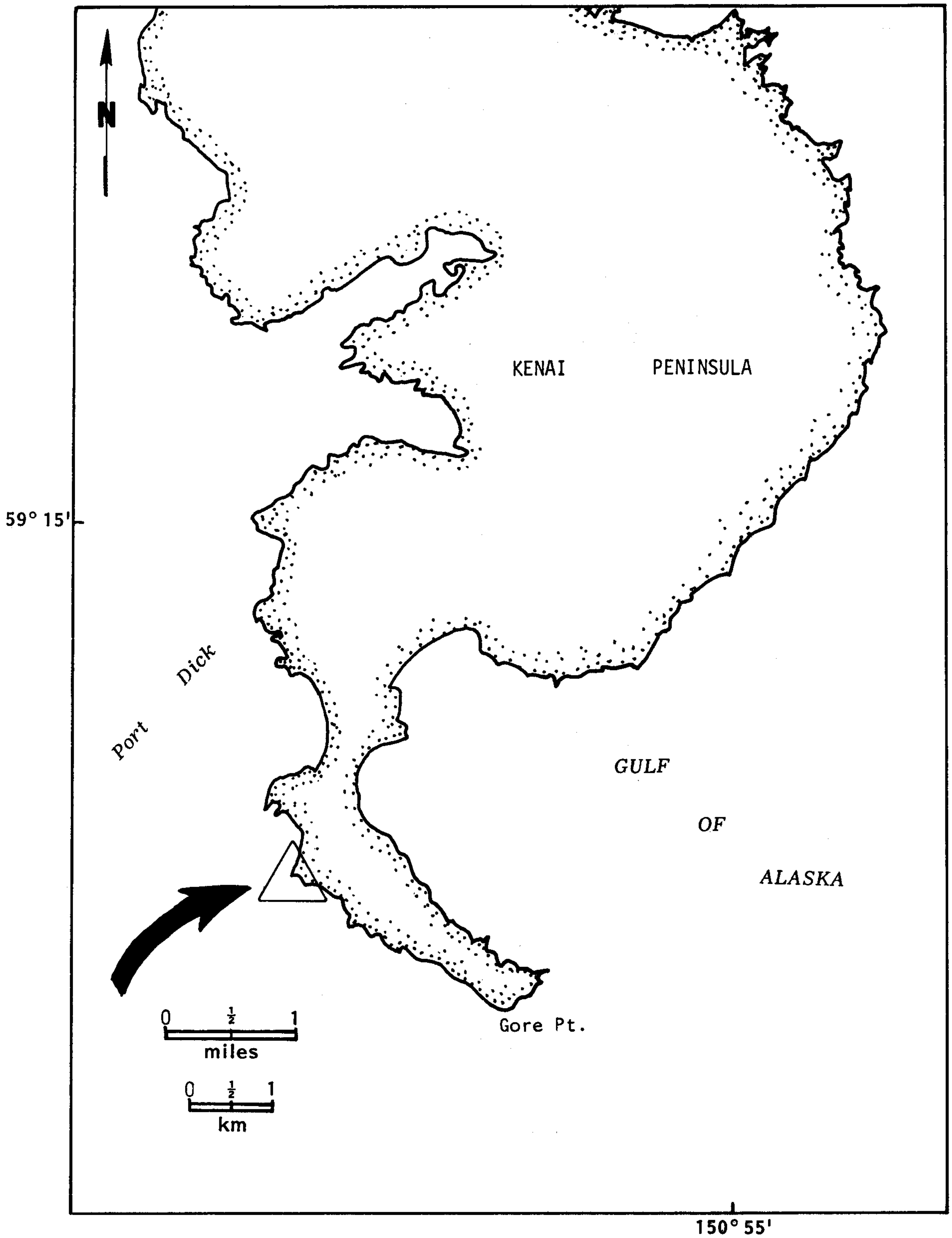


Figure 71 Gore Point site

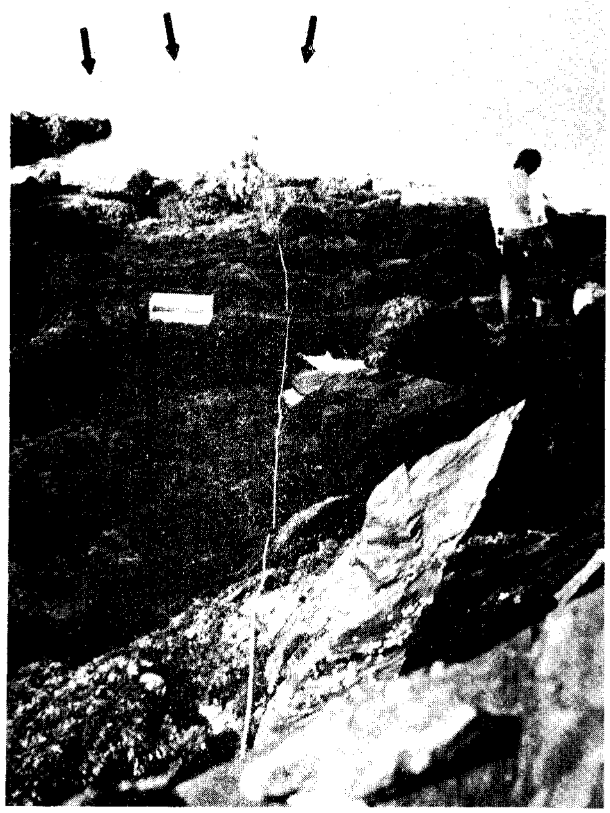
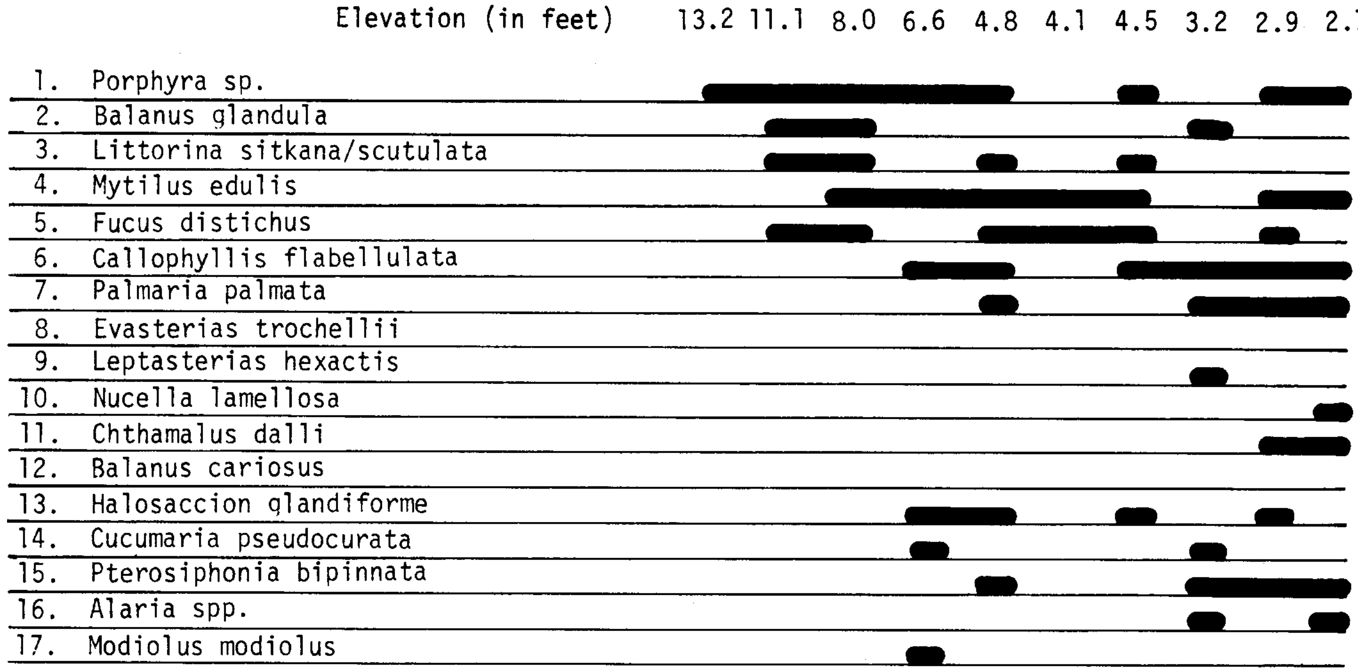


Fig. 72. Transect line at Gore Pt. in August 1975. The floating kelp Nereocystis leutkeana is visible immediately offshore (arrows).

Gore Point
Intertidal Station 13
May 1975



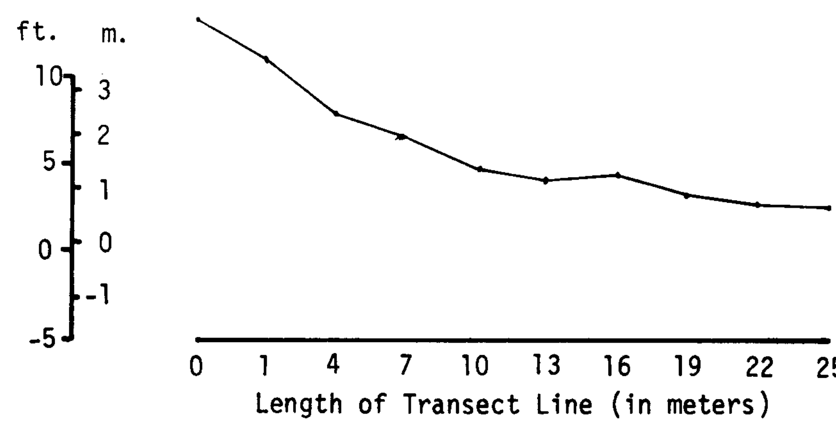


Fig. 73

Horizontal and vertical distribution of selected algae and invertebrates from 1/16m^2 quadrat collections along a transect line.

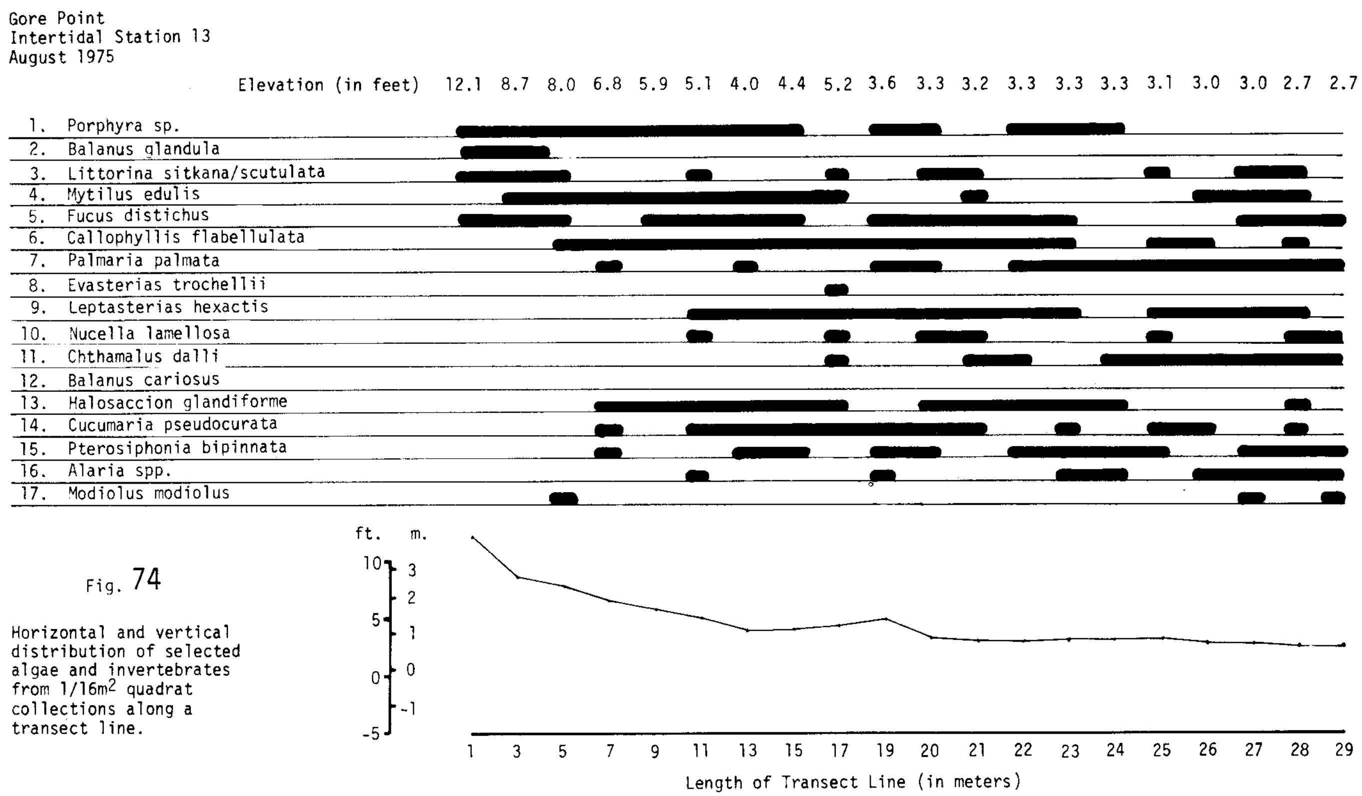


Fig. 74

Horizontal and vertical distribution of selected algae and invertebrates from 1/16m^2 quadrat collections along a transect line.

Below this zone (from +5 to + 11 ft (+1.5 to +3.3 m)), *Mytilus edulis* and the assemblage of inconspicuous microfauna (oligochaetes, polychaetes, flatworms amphipods, isopods and small molluscs) among its byssal threads formed a discontinuous but dense mat over the substratum. Although *Evasterias troschelli*, *Leptasterias hexactis* and *Nucella lamellosa* were present, evidence of heavy predation was not observed.

Below the upper barnacle-mussel zone, *Palmaria palmata* and *Callophyllis flabellulata* covered extensive areas of bedrock (+3 to +8 ft (+0.9 to +2.4 m). *Halosaccion glandiforme*, *Porphyra* sp., *Pylliella littoralis* and *Monostroma fuscum* often co-occurred with *Palmaria* and *Callophylis* but were patchy in distribution. The barnacle *Balanus cariosus*, which commonly is a dominant in this zone (Dayton 1971) was conspicuously low in abundance. However, the small barnacle *Chthamalus dalli* was distributed extensively in this zone. Dayton (1971) has shown that competition for primary space (the main limiting resource in the intertidal zone) results in clear dominance heirarchies in which *B. cariosus* is dominant over both *B. glandula* and *C. dalli*, and *B. glandula* is domiant over *C. dalli*. The upper limit of *C. dalli* is higher than those of *Balanus* spp. and *C. dalli* is normally excluded only at lower levels where *Balanus* spp. are abundant. The abundance of *C. dalli* may have resulted from the scarcity of both species of *Balanus*, but our data are inadequate for examining the question.

Alaria sp. formed a canopy below +3.5 ft (+1.0 m). *Cryptosiphonia woodii*, *Pterosiphonia bipinnata*, *Ptilota* sp., *Callophylis* and *Palmaria* were abundant. Also numerous were *Searlesia dira*, *Katharina tunicata*, *Modiolus modiolus* *Cucumaria pseudocurata* and *Musculus* sp. Close offshore was a bed of the floating kelp *Nereocystis leutkeana* (Fig. 72).

Species Diversity

We consider species diversity in the broad sense including (1) species richness as approximated by average species counts in 1/16 m^2 quadrats and species-area (sample size) curves, and (2) the distribution of individuals among species. A number of indices combining these two aspects of species diversity have been offered in the literature (see Peet 1974 for a recent review). Diversity indices are of dubious value for determining the biological mechanisms that are basic to community organization (Hurlbert 1971, Goodman 1975) and are insensitive to changes in the character of the distribution functions of species abundance in those situations when the functions should be most informative (May 1975). We do not use diversity indices here.

Average species counts

Species counts in samples from quadrats scraped in September 1975 are shown in Table 4. Nearly all samples at most rocky intertidal sites were taken between mean high water (MHW) and mean low water (MLW) except at Cape St. Elias where all rocky intertidal samples were taken below MLW in September 1975. The region between MHW and MLW at all sites was divided into upper and lower intertidal zones following Rigg and Miller's (1949) scheme for the outer coast of Washington (Table 4).

Three of our rocky intertidal sites are excluded from Table 4, Port Etches and Gore Point because they were not sampled in September, and Cape St. Elias because all samples were collected from below MLW, and therefore were not comparable to the other sites. Squirrel Bay was not sampled in September 1975; data from September 1974 are shown in Table 4. Counts of the following taxa are excluded because organisms from them were usually not identified more specifically than to phylum or class: Porifera, Cnidaria, Platyhelminthes, Nemertea (except *Emplectonema gracilis*), Oligochaeta, Copepoda, Insecta (except

Table 4. Average species counts of plants and invertebrates in quadrats (1/16 m^2) at rocky intertidal areas in the Eastern Gulf of Alaska.

Site	Upper intertidal area Number of quadrats	Upper intertidal area Species count		Lower intertidal area Number of quadrats	Lower intertidal area species count	
	N	$\bar{x}$	SD	N	$\bar{x}$	SD
Ocean Cape	5	10.4	2.5	6	13.7	5
Cape Yakataga	18	14.4	3.4	15	15	4.1
Katalla Bay	9	8.8	3.8	20	13.4	4.4
Zaikof Bay	16	15	5.6	16	25.9	6.7
Macleod Harbor	13	14.2	4.5	17	19.5	6.4
Squirrel Bay	9	8.2	3.2	8	14.9	7.3
Latouche Point	9	18.9	7.6	19	32.7	8.3
Anchor Cove	8	19.4	4.2	26	25.2	6.9

Anurida maritima), Acarina, Sipuncula, Bryozoa and Ascidiacea.

Highest species counts both in the upper and lower intertidal areas were recorded at Anchor Cove, Latouche Point and Zaikof Bay (Table 4). These three sites are relatively exposed to open ocean swell. Increased wave exposure raises the "effective wetting level" (Lewis 1964) of the sea and consequently the upper limits of marine organisms. Therefore, one might expect more species to occur at higher levels in the intertidal region on exposed shores. Nevertheless, relatively low species counts were recorded for the exposed sites, Ocean Cape and Cape Yakataga. There, frequent disturbance by wave-induced boulder movement and ice and sand scouring may offset the "diversifying" effect of increased exposure, but the nature of our studies did not allow an adequate examination of other factors which could affect species richness such as competition and predation. Intense predation on populations of M. edulis by P. ochraceus was noted at Anchor Cove and Zaikof Bay (but not Latouche Point), whereas large predatory starfish appeared to be uncommon at Ocean Cape and Cape Yakataga (see descriptions of sites earlier in this section). Predation by Pisaster has an important diversifying effect on an intertidal community (Paine 1966; see earlier site descriptions of Anchor Cove and Zaikof Bay). Therefore, the presence or absence of large predatory starfish may influence species richness at our sites to a great extent.

Species area curves

To study species richness and species abundance relations more closely we examined associations of organisms found at about mean tide level (MTL; +1.5- +2 m in the eastern Gulf of Alaska depending on the locality) because on the average the sea-surface passes this level more frequently than any other intertidal level. This level would therefore be expected to be contaminated more frequently than any other by oil floating on the sea after an oil spill (although wave action would probably cause the oil to be mixed to levels well below the sea-surface). Specifically we considered data from plots dominated either by Mytilus edulis or Fucus spp.. These two species overlap nearly completely in vertical range (+1 m to +3.3 m) at our study sites, although Fucus spp. was usually found both above and below Mytilus.

Fucus and Mytilus were considered to dominate when their wet weights exceeded 110 gm and 600 gm respectively. Comparisons of data on wet weight and percent cover from Anchor Cove indicated that percent cover of Mytilus edulis and Fucus spp. exceeded 80% when wet weights exceeded 110 gm and 600 gm. Using these criteria an adequate sample size ($n \geq 5$) was available from three sites, Ocean Cape, Zaikof Bay, and Anchor Cove. However, only at Zaikof Bay did the sample size approach that required to include all species in the assemblage (the taxa excluded are the same as those excluded from the mean species counts) associated with each dominant (Fig. 75). There was not an adequate number of Fucus dominated plots collected at Ocean Cape. In order to obtain an adequate sample size for Anchor Cove and Ocean Cape samples from September 1974 and 1975 were lumped.

The slopes and heights of the species-area curves for mussel-dominated plots at Anchor Cove and Zaikof Bay were greater than those for Ocean Cape (Fig. 75). The Smirnov test (Conover 1971) of the empirical species-area distributions showed that the tendency for the cumulative species counts to exceed those of Ocean Cape was significant for Zaikof Bay but not Anchor Cove (Table 5). As noted above, the species-area curve for Anchor Cove shows no indication of leveling off (Fig. 75). Therefore, the species association on Mytilus-dominated plots was not adequately sampled there. These results support the conclusion that species

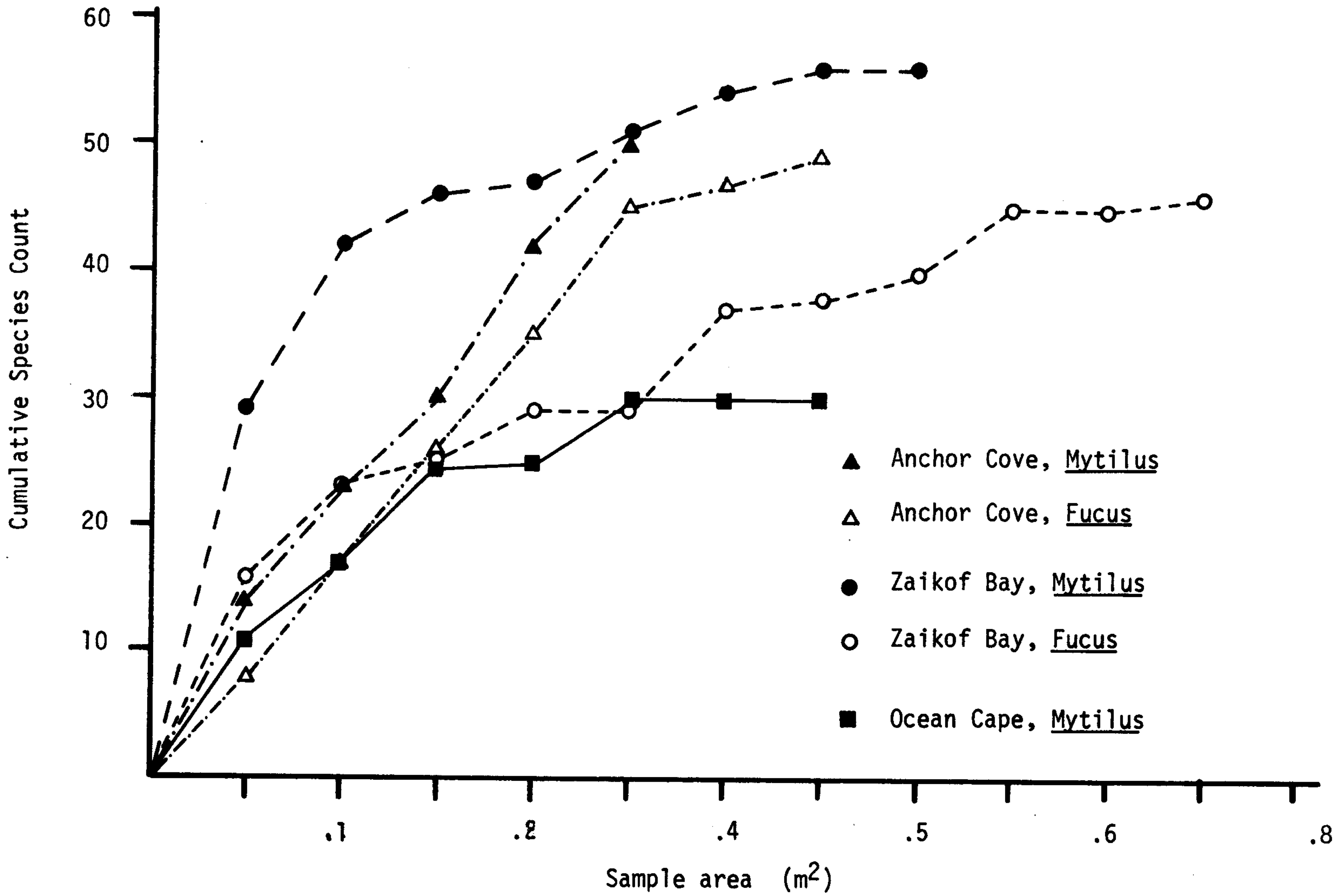


Fig.75. Species-area curves of plots dominated by *Mytilus* and *Fucus* at Anchor Cove, Zaikof Bay, and Ocean Cape.

Table 5. Smirnov test of differences in species-area curves in plots dominated by *Mytilus edulis* or *Fucus* spp. at Anchor Cove, Zaikof Bay, and Ocean Cape.

Contrast	Test Statistic*	Sample Size		Significance
	T1	N1	N2	
Mytilus				
Anchor Cove vs Ocean Cape	.400	5	7	n.s.
Zaikof Bay vs Ocean Cape	.875	7	8	$p < .005$
Fucus vs *Mytilus*				
Anchor Cove	.200	5	7	n.s.
Zaikof Bay	.659	8	11	$p < .025$

* All tests are one-sided.

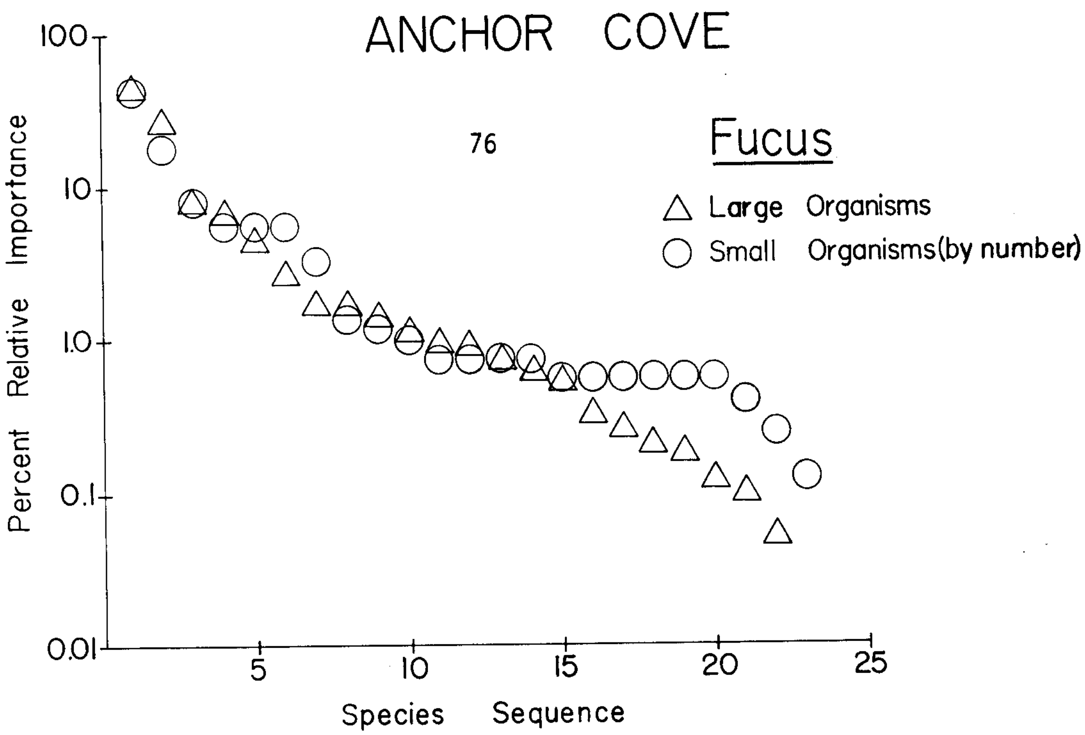
richness in the upper intertidal at Zaikof Bay (and probably also Anchor Cove) is greater than that at Ocean Cape.

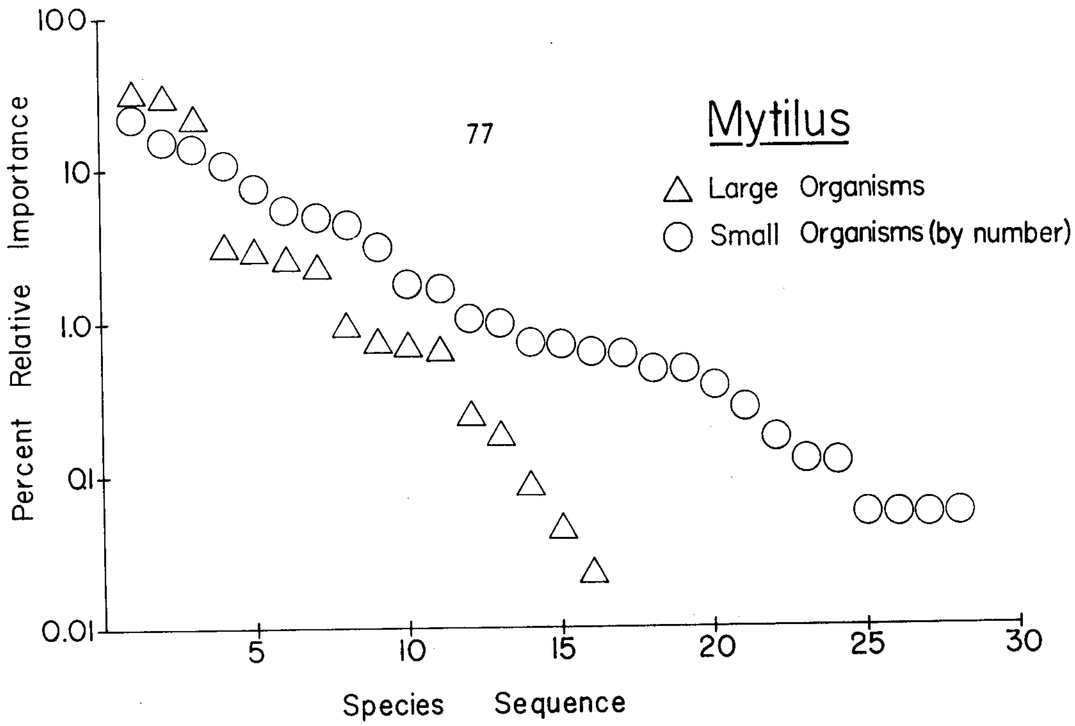
Fig. 75 shows that the slopes and heights of the species-area curves for plots dominated by Mytilus at Zaikof Bay and Anchor Cove were greater than for those dominated by Fucus at the respective sites. This difference was significant for Zaikof Bay but not Anchor Cove (Table 5; the difference could not be tested at Ocean Cape because only two plots met the criteria for Fucus-dominated plots). An inadequate sample size (Mytilus-dominated plots) may have been responsible for the lack of significance in the test of the species-area curves of Mytilus-vs Fucus-dominated plots at Anchor Cove.

Species abundance relations

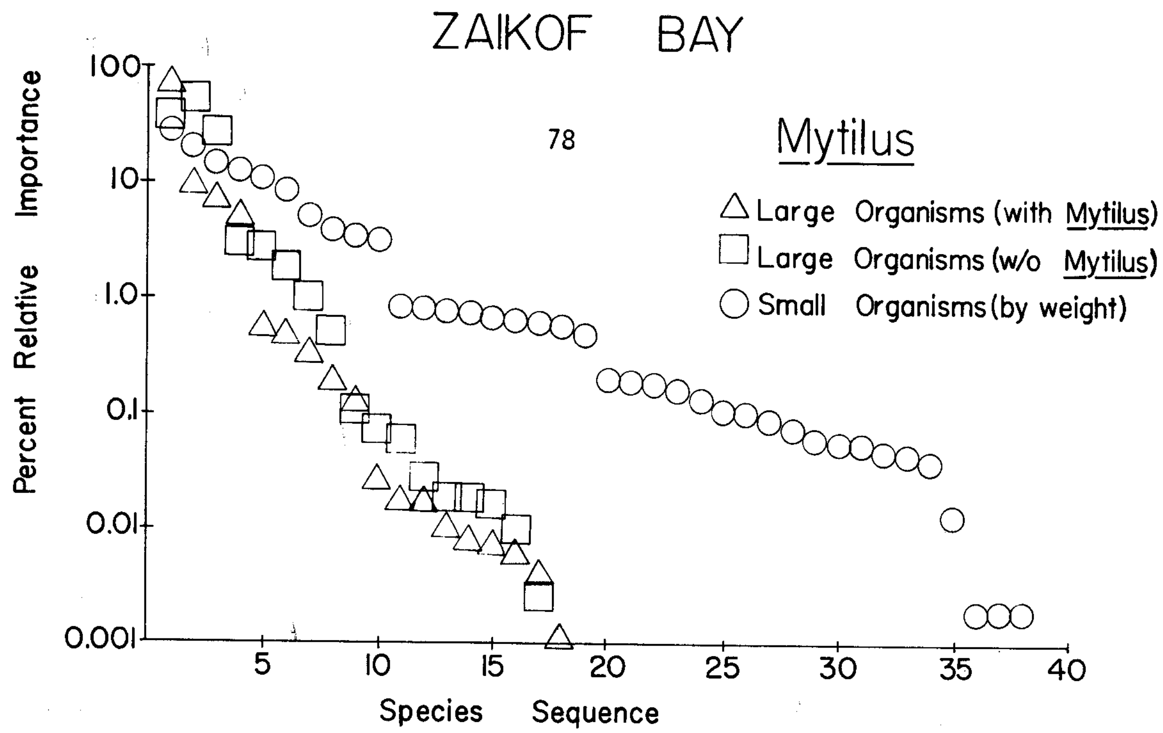
Dominance-diversity curves (Whittaker 1965, 1970, 1972) were used to study species-abundance relations among subdominants in Mytilus-and Fucus-dominated plots at Anchor Cove, Zaikof Bay, and Ocean Cape (Figs. 76 to 80). The curves are constructed by plotting the importance (in terms of abundance, biomass or productivity) of a species on the "y" axis opposite its respective rank on "x" axis. Species are ranked from most to least important on the "x" axis.

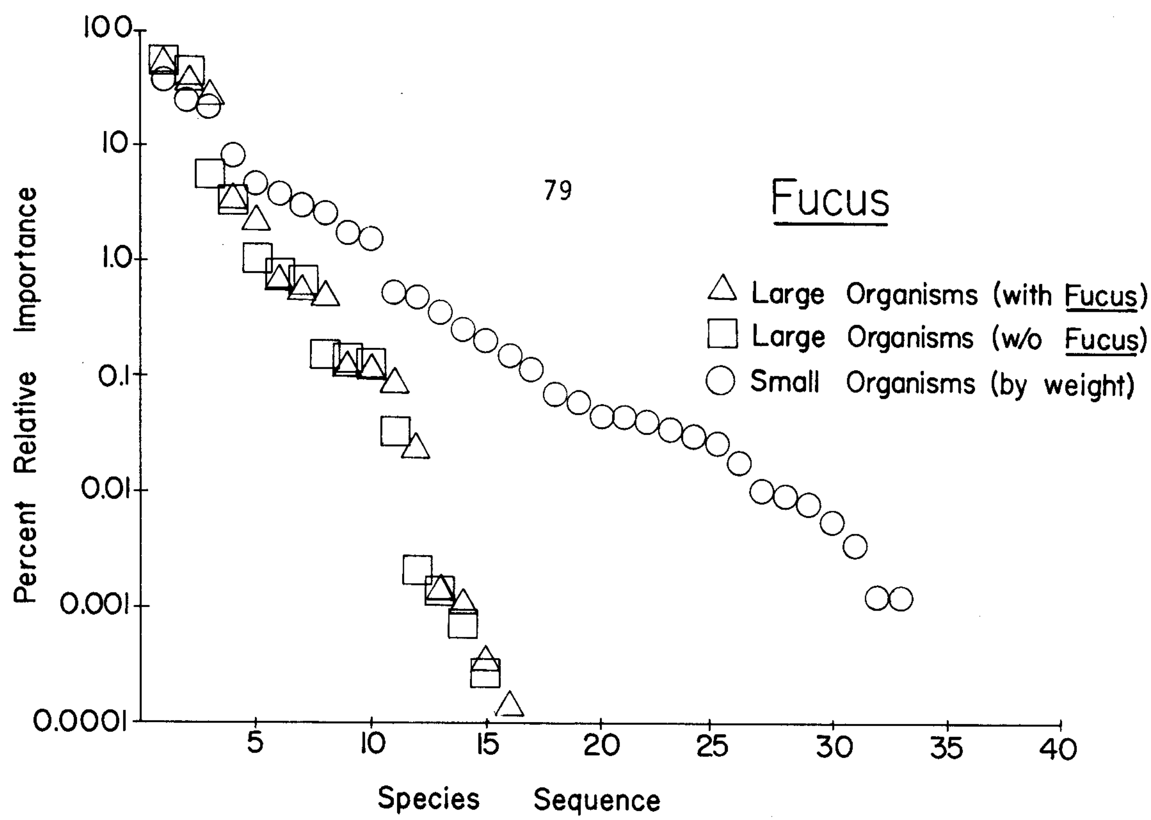
Subdominants were divided into large and small species based on the wet weight of an average adult; the dividing line was one gram. We distinguished between large and small species because a priori the former, because of their large body size, might be expected to suffer in competition for space with the dominants (Mytilus and Fucus), whereas the latter would "view" the holdfast, stipe and fronds of Fucus and the complex network of byssal threads and accumulated sediment beneath the shelter of Mytilus shells as elements of their physical environment. The hypothesis is that because of the different growth forms of the community dominants and the mechanisms by which they acquire and secure primary space (rock substratum) they will differ in their effect on subdominants,





Figs. 76 and 77. Relationship between relative importance (abundance or biomass expressed as a percentage on a logarithmic scale) and rank of large and small subdominants in plots dominated by *Fucus* (Fig. 76) or *Mytilus* (Fig. 77) at Anchor Cove, Alaska.





Figs. 78 and 79. Relationship between relative importance (abundance and/or biomass expressed as a percentage on a logarithmic scale) and rank of large and small subdominants in plots dominated by <u>Fucus</u> (Fig. 78) or <u>Mytilus</u> (Fig. 79) at Zaikof Bay, Alaska.

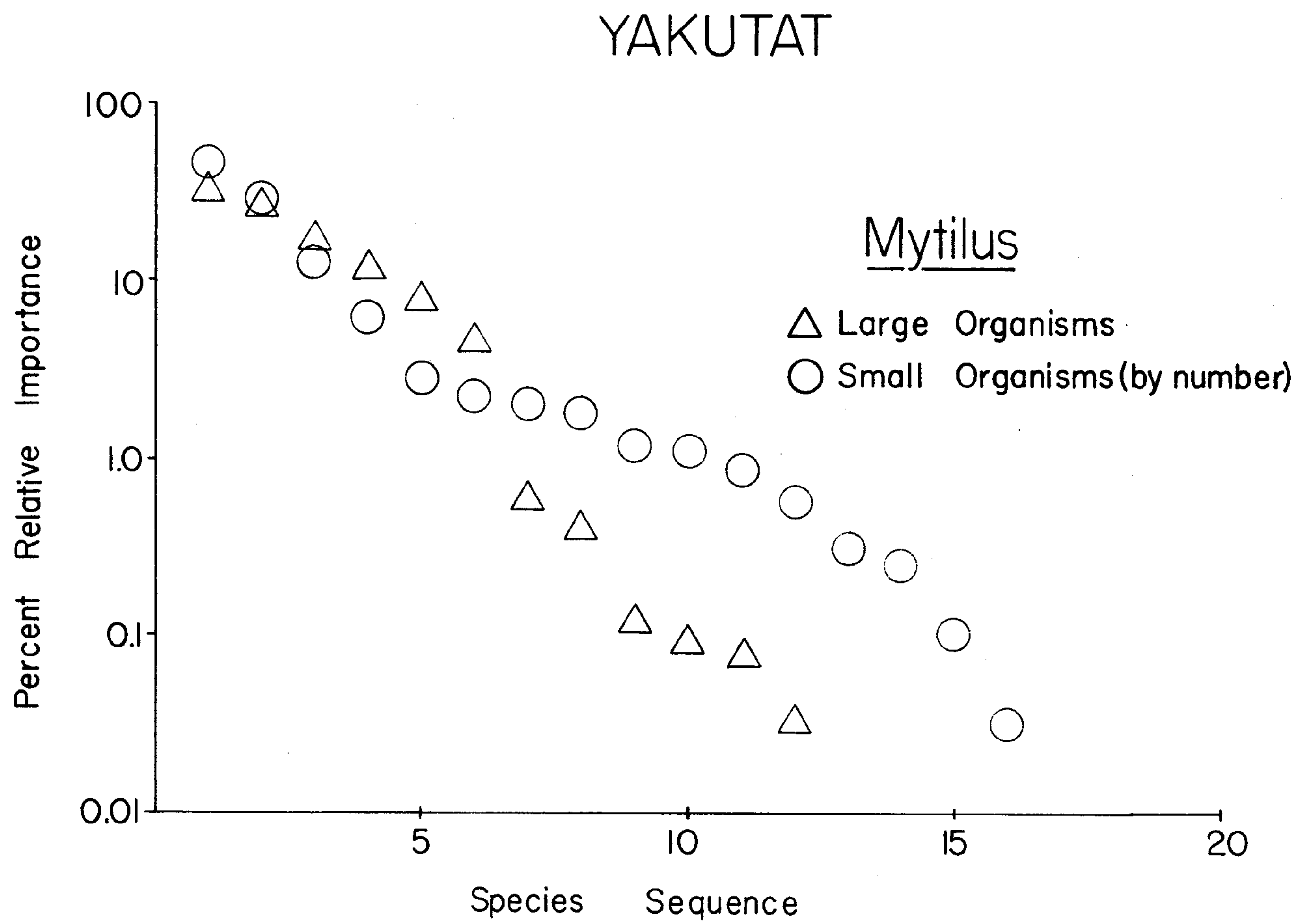


Fig. 80. Relationship between relative importance (abundance or biomass expressed as a percentage on a logarithmic scale) and rank of large and small subdominants in plots dominated by *Mytilus* at Ocean Cape, Yakutat, Alaska.

and that the difference should be reflected in the species abundance relations among subdominants.

Mytilus can completely blanket primary space and would be expected to have a greater negative effect on large subdominants than *Fucus* which has a small holdfast and a long narrow stipe. The holdfasts of adult *Fucus* usually do not pack primary space. *Fucus* would not be expected to adversely affect large subdominants other than those negatively affected by shading or whiplash (Dayton 1971, Menge 1976).

Wet weight was used as a measure of importance among large subdominants in Figs. 76 to 80. Dominants (*Mytilus* and *Fucus*) were not included in the statistical analyses involving those plots which they were considered to dominate (e.g. *Fucus* was excluded from the analyses of *Fucus*-dominated plots). Curves of dominance-diversity among subdominants with and without dominants are shown in Figs. 78 and 79 for comparison; they are nearly identical.

The results from Anchor Cove tended to support the hypothesis. The curves for large subdominants in *Mytilus*-dominated plots show a lower species richness and greater concentration of dominance than those in *Fucus*-dominated plots (Figs. 76 and 77). However, the differences between the empirical distribution functions of the two curves was not significant (Table 6). Data from Zaikof Bay did not support the hypothesis (Figs. 78 and 79).

Abundance and wet weight were used as measures of importance of small subdominants in dominance-diversity curves for Anchor Cove and Zaikof Bay respectively (Figs. 76 to 79). In addition, curves of wet weights were drawn for the subdominants of Anchor Cove (not shown in Fig. 76). The curves of abundance and weights had the same form. Weights were used in the statistical analyses.

Species richness of small subdominants tended to be greater in *Mytilus* dominated plots than in *Fucus* dominated plots at Anchor Cove and Zaikof Bay,

Table 6 . Smirnov test of the differences in the empirical distribution functions of individuals among species in plots dominated by Mytilus and Fucus at Anchor Cove and Zaikof Bay.

Contrast	Test Statistic	Sample Size N1	Sample Size N2	Significance
Large subdominants				
Mytilus vs Fucus				
Anchor Cove	.210	16	22	n.s.
Small subdominants				
Mytilus vs Fucus				
Anchor Cove	.228	36	30	n.s.
Zaikof Bay	.065	38	33	n.s.

but the form of the species-abundance curves was the same (Figs. 76 to 79). The Smirnov Test showed no significant difference between the curves for Fucus and Mytilus at either site (Table 6).

Multispectral Scanning

In June 1976 we began a cooperative study with the Environmental Research Institute (ERI) of Michigan to evaluate multispectral scanning (MSS) as a tool for mapping the distribution and abundance (aerial coverage) of littoral macrophytes from the air. Our role in the study was to map the vertical distribution of canopy macrophytes in the intertidal region and to compare the results with aerial MSS images of the region. Three sites were overflown during this study: Zaikof Bay, Latouche Point, and Cape Yakataga. At Latouche Point we used aluminum foil to delineate the boundaries of major zones dominated by macrophytes and to outline prominent landmarks prior to the scheduled overflight of the MSS aircraft. Unfortunately the aircraft did not arrive as scheduled. The flight was completed 2 weeks later without the benefit of ground markers.

In August 1977 S. Zimmerman and J. Hanson met with ERI scientists in Ann Arbor, Michigan and assisted in selecting pure spectral signatures of major environmental features such as water, spruce trees and distinct algal zones to act as standards for "training the computer", and to evaluate the classification of spectral signatures by the computer by comparing them with data from field observations.

The results were inconclusive. Interpretation of the MSS data was limited because there were no ground markers, the tide was not low enough, and the sky was overcast when the data were collected. The spectral signatures of major earth features such as water and spruce trees could be classified reliably, but the main objective of mapping the distribution and relative abundance of littoral macrophytes was not accomplished. Successful accomplishment of this objective will depend upon simultaneous collection of MSS and ground truth data.

VII. Discussion

Changes in species diversity measured in one way or another are commonly used to study the effects of human activities on natural communities (Jacobs 1975 reviews several studies). We consider two components of species diversity, species richness and the distribution of individuals among species: emphasizing especially the relationship between dominants and the diversity of subdominants in the intertidal community at upper levels. An understanding of this relationship is important to the study of the effects of perturbations (e.g. oil spills or shoreline development associated with offshore oil drilling) on intertidal communities if the degree to which potential community dominants can monopolize primary space differs from species to species and is functionally related to the diversity of subdominants. If this relationship exists then the effect of a perturbation on the diversity of a community would depend on which species dominates the community and how the perturbation affects the interactions between dominants and subdominants. Ultimately we would want to know what factors control populations of the community dominants.

Although higher species counts and higher and steeper species-area curves tended to be associated with relatively exposed bedrock sites where the frequency and scale of physical disturbance is low (Anchor Cove and Zaikof Bay) as opposed to exposed sites where physical disturbance is frequent and widespread (Ocean Cape and Cape Yakataga), the design of our study was inadequate for completely assessing the mechanisms controlling species diversity at these sites. Biological interactions (especially predation) may be important and were not adequately taken into account.

The relationship between the growth form of community dominants and the diversity of subdominants is not clear. Species richness (empirical distribution function of the species-area curve) was significantly greater in *Mytilus*-dominated plots than in *Fucus*-dominated plots at Zaikof Bay. Comparison of species-abundance patterns of large and small subdominants tended to indicate that the diversity of small subdominants was responsible for the difference but the trends were not significant. Similar trends were found for Anchor Cove, but none of the statistical tests were significant. An inadequate sample size at Anchor Cove is probably responsible for the lack of significance of at least one statistical test (of differences in species-area curves) of these trends.

There is little evidence to support the hypothesis that *Mytilus* has a greater negative effect on large subdominants than does *Fucus*. Large subdominants in *Mytilus*-dominated plots tended to show lower species richness and greater concentration of dominance than those in *Fucus*-dominated plots at Anchor Cove, but the results were not significant. There appeared to be no difference in slope or form of the species-abundance curves for *Mytilus* vs *Fucus* at Zaikof Bay.

VIII Conclusions

1. Frequent and widespread physical disturbance from boulder movement and ice scouring at Ocean Cape and Cape Yakataga offset the tendency for increased species richness in exposed localities. (Tentative)

2. Total species richness tends to be greater in patches of intertidal area dominated by *Mytilus* than in patches dominated by *Fucus* in the eastern Gulf of Alaska. (Preliminary)

3. Small species tend to be greater in number and show a greater evenness in the distribution of individuals among species in *Mytilus*- vs *Fucus*-dominated areas. (Preliminary)

4. *Mytilus* as a dominant competitor for space does not appear to have a greater adverse effect on associated larger subdominants through competition for primary space than does *Fucus*. (Preliminary)

5. The success of multispectral scanning (MSS) imagery for mapping the distribution of intertidal macrophytes requires the simultaneous collection of MSS and "ground truth" data. (Reasonably firm)

IX. Summary of Fourth Quarter Operations

A. No field trips were scheduled. The number and types of data analyses done this quarter are discussed in the methods and results sections of this report.

Milestone chart and data submission schedules

Milestone	Submission schedule Proposed	Submission schedule Actual
Completion of processed report on the Western Gulf of Alaska (Kodiak Island area)	January 1978	April 1978
Submission of rest of 1975 data to NODC	February 1978	April 1978
Completion of annual report with emphasis on EGOA	April 1, 1978	April 7, 1978
Submission of data from St. George Basin to NODC	July 1, 1978	
Completion of Quarterly Report with emphasis on St. George Basin	July 1, 1978	
Submission of data from Bristol Bay to NODC	October 1, 1978	
Completion of Quarterly Report with emphasis on Bristol Bay	October 1, 1978	
Submission of data from Norton Sound to NODC	3 months after reception of data from Institute of Marine Sciences (IMS)	
Completion of Quarterly Report with emphasis on Norton Sound	In that quarter which occurs 3 months after reception of data from IMS	

Justifications of Slippages

The completion of the processed report on the Western Gulf of Alaska (Kodiak Island area) was delayed because of unexpected resignations and resultant shortages in clerical staff. Submission of rest of 1975 data to NODC was delayed because of unanticipated difficulties with the emulators of the computer system used for OCS data and increased restrictions on access to that system.

B. Problems encountered/recommended changes

Broad surveys of intertidal communities aiming to characterize representative communities on the basis of the distribution and abundance patterns of component organisms with the hope of predicting community composition at unstudied locations are of dubious value as baseline studies for assessing the effects of human activities on natural communities. At best they provide a static view of some community attributes. Attempts to ask of the data from such surveys specific questions which might provide insight into those factors controlling community structure are often frustrated because the sampling programs are so broadly conceived that specific hypotheses cannot be adequately tested.

We need to take a more dynamic view of intertidal communities, to examine community organization and what controls it, in order to predict how oil or oil drilling activities will affect community structure. We have proposed studies to examine controlling mechanisms in intertidal communities with the ultimate goal of experimentally testing hypotheses in the field, but because of cuts in funding our proposal was not accepted. We are convinced that a more direct approach (involving the formulation and testing of specific hypotheses) to the question of how oil and gas development will affect the organization of nearshore communities is needed and urge that such an approach be adopted.

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Appendix 1. Presence (x) or absence (blank) of species of plants, invertebrates, and fish in the rocky intertidal area at eleven sites in the eastern Gulf of Alaska.

SPECIES	Ocean Cape	Cape Yakataga	Katalla Bay	Cape St Elias	Port Etches	Zaikof Bay	Macleod Harbor	Squirrel Bay	Latouche Point	Anchor Cove	Gore Point
CHLOROPHYTA											
Chlorophyta	X	X	X		X	X	X	X	X	X	X
Ulothrix sp.		X			X	X	X	X		X	X
Monostroma sp.		X		X		X			X	X	X
Monostroma arcticum					X						
Monostroma fuscum	X	X	X	X	X	X	X	X	X	X	X
Monostroma zostericola		X		X	X	X	X			X	
Enteromorpha sp.		X								X	
Enteromorpha intestinalis	X	X					X		X	X	X
Enteromorpha linza		X			X	X	X			X	
Ulva sp.	X	X	X			X		X		X	X
Ulva fenestrata				X	X	X	X	X		X	X
Ulva lactuca		X	X	X	X	X	X	X	X	X	X
Ulva rigida						X	X			X	
Percursaria percursa	X									X	
Rosenvingiella sp.											X
Rosenvingiella polyrhiza											X
Cladophoraceae				X							X
Rhizoclonium sp.						X					
Rhizoclonium implexum						X					
Rhizoclonium riparium	X	X		X	X	X	X		X	X	
Lola lubrica	X	X				X	X				X
Urospora sp.				X		X					X
Urospora mirabilis	X	X				X	X				X
Chaetomorpha sp.		X				X					
Chaetomorpha cannabina										X	
Cladophora sp.	X	X	X		X	X				X	
Cladophora flexuosa			X		X		X		X	X	
Cladophora gracilis						X					
Cladophora seriacea	X				X	X			X	X	
Spongomorpha sp.				X			X				
Spongomorpha mertensii				X						X	
Spongomorpha spinescens	X	X		X		X				X	X
Codium fragile		X	X								
Halicystis ovalis			X								
CRYSOPHYTA											
Crysophyta		X					X				X
Bacillariophyceae		X	X		X	X	X			X	X
Centrales				X							

SPECIES	Ocean Cape	Cape Yakataga	Katalla Bay	Cape St Elias	Port Etches	Zaikof Bay	Macleod Harbor	Squirrel Bay	Latouche Point	Anchor Cove	Gore Point
CRYSOPHYTA-continued											
Isthmia nervosa			X								
Navicula sp.			X				X			X	
PHAEOPHYTA	X	X	X	X	X	X	X	X	X	X	X
Ectocarpales		X									
Ectocarpaceae						X					
Ectocarpus sp.	X	X		X		X					
Ectocarpus parvus		X		X							
Ectocarpus siliculosus										X	
Ectocarpus simulans	X	X		X	X	X	X		X	X	
Pylaiella littoralis	X	X	X		X	X	X	X	X	X	X
Ralfsiaceae				X							
Ralfsia sp.			X	X							
Ralfsia fungiformis			X	X	X	X			X	X	
Ralfisa pacifica		X									
Sphacelaria sp.	X	X				X	X				X
Sphacelaria subfusca						X	X			X	
Elachistea fucicola		X				X	X	X	X	X	X
Leathesia difformis						X					
Haplogloia andersonii		X									
Chordaria sp.		X									
Chordaria flagelliformis		X									
Analipus japonicus		X									X
Desmarestia aculeata			X				X				
Soranthera ulvoidea		X				X	X		X	X	
Melanosiphon intestinale		X				X					X
Petalonia sp.		X									
Petalonia fascia		X	X				X	X			
Colpomenia bullosa				X							
Phaestrophion irregulare				X							
Scytosiphon sp.						X					
Scytosiphon lomentaria	X	X	X		X	X	X		X	X	
Coilodesme sp.		X									
Laminaria sp.		X				X			X	X	
Laminaria groenlandica		X	X	X		X			X	X	
Laminaria saccharina			X			X			X		
Laminaria setchellii			X		X				X	X	
Laminaria yezoensis			X	X		X			X		
Alaria sp.	X	X	X	X	X	X	X	X	X	X	X
Alaria crispa								X			
Alaria marginata		X		X	X	X	X	X	X	X	X

SPECIES	Ocean Cape	Cape Yakataga	Katalla Bay	Cape St Elias	Port Etches	Zaikof Bay	Macleod Harbor	Squirrel Bay	Latouche Point	Anchor Cove	Gore Point
PHAEOPHYTA-continued											
Alaria nana	X					X				X	
Alaria praelonga						X	X	X		X	
Alaria taeniata	X					X	X		X	X	X
Fucus sp.	X	X	X	X		X	X		X	X	X
Fucus distichus	X	X	X			X	X	X	X	X	X
Fucus spiralis	X	X								X	
Cystoseira geminata					X						
RHODOPHYTA		X	X	X	X	X	X		X	X	X
Erythrotrichea sp.		X									
Erythrotrichea carmea						X					
Smithora naiadum			X								
Bangia fuscopurpurea										X	
Porphyra sp.	X	X	X			X	X	X	X	X	X
Porphyra perforata		X	X		X		X	X		X	
Porphyra smithii									X		
Acrochaetium sp.				X		X					X
Acrochaetium pacificum						X					
Cryptonemiales						X					
Cryptosiphonia sp.						X					
Cryptosiphonia woodii		X	X	X	X	X	X		X	X	X
Dilsea californica				X							X
Dumontia incrassata						X	X				
Farlowia compressa							X				
Constantinea sp.							X				
Constantinea simplex				X	X				X		
Constantinea subulifera				X		X			X		
Endocladia muricata	X						X		X	X	X
Gloiopeltis sp.						X				X	
Gloiopeltis furcata				X		X	X	X		X	X
Peyssonellia pacifica							X				
Hildenbrandia sp.			X								
Petrocelis sp.										X	X
Petrocelis franciscana											X
Corallinaceae			X	X			X		X		
Tenarea dispar						X					
Mesophyllum sp.			X						X		
Mesophyllum lamellatum											
Clathromorphum sp.				X							

Appendix 1 . Continued

SPECIES	Ocean Cape	Cape Yakataga	Katalla Bay	Cape St Elias	Port Etches	Zaikof Bay	Macleod Harbor	Squirrel Bay	Latouche Point	Anchor Cove	Gore Point
RHODOPHYTA-continued											
Bossiella sp.			X	X		X	X	X	X	X	X
Bossiella californica					X		X				
Bossiella chiloensis	X		X		X	X	X		X	X	
Bossiella plumosa			X	X		X	X		X	X	
Serraticardia macmillani				X							
Corallina sp.				X	X	X	X		X	X	
Corallina officinalis				X							
Corallina vancouveriensis				X		X			X		
Corallina frondescens						X	X				
Lithothamnium sp.		X	X	X		X			X	X	
Cryptonemiaceae				X							
Prionitis sp.							X				
Prionitis lanceolata										X	
Pugetia fragilissima								X			
Callophyllis sp.							X				X
Callophyllis adhaerens								X			
Callophyllis flabellulata		X				X	X	X		X	X
Gigartinales									X		
Neoagardhiella baileyi		X					X				
Plocamium tenue									X		
Ahnfeltia plicata			X	X		X			X	X	X
Ahnfeltia gigartinoides			X						X		
Gymnogongrus platyphyllus								X			
Gigartinaceae							X		X		
Gigartina sp.	X	X				X		X		X	X
Gigartina papillata		X	X		X		X	X	X	X	
Gigartina agardhii						X					
Gigartina latissima	X	X	X		X			X	X	X	
Gigartina stellata		X				X			X	X	X
Iridaea sp.	X	X	X	X		X	X	X	X	X	X
Iridaea cordata						X				X	
Iridaea cornucopiae		X		X	X	X	X	X	X	X	X
Iridaea heterocarpa						X	X	X	X	X	X
Iridaea lineare			X								
Rhodoglossum californicum	X		X		X	X	X	X	X	X	
Rhodymeniaceae										X	
Fauchea laciniata										X	
Halosaccion glandiforme		X	X	X	X	X	X	X	X	X	X
Rhodymenia liniformis					X			X			
Rhodymenia sp.								X		X	

Appendix 1 . Continued

SPECIES	Ocean Cape	Cape Yakataga	Katalla Bay	Cape St Elias	Port Etches	Zaikof Bay	Macleod Harbor	Squirrel Bay	Latouche Point	Anchor Cove	Gore Point
RHODOPHYTA-continued											
Palmaria palmata	X	X	X	X	X	X	X	X	X	X	X
Rhodymenia pertusa			X		X		X		X	X	
Ceramiaceae									X	X	
Antithamnion sp.						X	X			X	
Antithamnion dendroideum						X					
Antithamnion kylinii	X				X	X	X	X		X	
Antithamnion simulans						X					
Antithamnionella pacifica					X		X			X	
Scagelia occidentale						X				X	
Hollenbergia nigricans						X					
Callithamnion pikeanum	X						X			X	
Ceramium pacificum				X							
Microcladia borealis				X					X		X
Microcladia coulteri									X		
Ptilota sp.					X	X		X	X	X	X
Ptilota filicina					X	X		X	X	X	X
Ptilota tenuis					X	X	X		X		
Neoptilota sp.							X		X	X	X
Neoptilota asplenioides				X	X	X	X	X	X	X	X
Neoptilota hypnoides			X			X				X	
Delesseriaceae			X			X	X			X	X
Tokidadendron sp.						X	X			X	
Tokidadendron bullata					X	X	X			X	X
Phycodrys sp.						X				X	
Phycodrys riggii						X					
Hypophyllum sp.						X					
Hypophyllum dentatum						X					
Rhodomelaceae		X		X			X		X	X	X
Polysiphonia sp.						X			X	X	
Polysiphonia hendryi			X	X	X	X	X		X	X	
Polysiphonia pacifica	X				X	X	X			X	
Pterosiphonia sp.			X	X		X	X			X	
Pterosiphonia arctica	X						X			X	
Pterosiphonia bipinnata	X	X	X	X		X	X	X	X	X	X
Pterosiphonia dendroidea										X	
Laurencia spectabilis	X										
Rhodomela sp.						X					
Rhodomela larix	X	X	X	X	X	X	X		X	X	
Odonthalia sp.	X	X	X	X		X	X		X	X	X

Appendix 1 . Continued

SPECIES	Ocean Cape	Cape Yakataga	Katalla Bay	Cape St Elias	Port Etches	Zaikof Bay	Macleod Harbor	Squirrel Bay	Latouche Point	Anchor Cove	Gore Point
RHODOPHYTA-continued											
Odonthalia aleutica								X		X	
Odonthalia floccosa	X	X	X	X	X	X	X	X	X	X	X
Odonthalia kamschatica						X				X	
Odonthalia lyallii										X	
Odonthalia washingtoniensis	X		X		X	X	X		X	X	X
PHYCOMYCETES											
Phycomycetes		X	X			X	X				
ANTHOPHYTA											
Monocotyledoneae									X		
Potamogetonaceae				X					X		
Phyllospadix sp.				X	X	X	X		X		
Zostera marina	X										
PORIFERA											
Demospongia	X		X	X	X	X	X	X	X	X	X
CNIDARIA											
Hydroidea	X	X				X				X	X
Clava multiformis											X
Eudendrium sp.	X									X	
Eudendrium annulatum	X	X	X								
Eudendrium ramosum							X				
Obelia sp.											X
Sertulariidae							X				
Sertularella tricuspidata		X									
Abietinaria sp.		X									
Anthozoa		X	X	X	X	X	X	X	X	X	X
Anthopleura sp.			X			X					
Tealia sp.			X								
TURBELLARIA											
Turbellaria	X	X	X	X	X	X	X	X	X	X	X
RHYNCHOCOELA											
Rhynchocoela	X	X	X	X	X	X	X	X	X	X	X
Emplectonema sp.		X									
Emplectonema gracile	X	X	X		X	X	X	X	X	X	X

Appendix 1 . Continued

SPECIES	Ocean Cape	Cape Yakataga	Katalla Bay	Cape St. Elias	Port Etches	Zaikof Bay	Macleod Harbor	Squirrel Bay	Latouche Point	Anchor Cove	Gore Point	
NEMATODA												
Nematoda		X	X	X	X	X	X	X	X	X		
ANNELIDA												
Annelida		X				X				X		
Polychaeta		X		X	X	X	X		X		X	
Polynoidae						X			X	X		
Gattyana ciliata									X			
Halosydna brevisetosa				X					X			
Harmothoe sp.						X						
Harmothoe imbricata			X	X	X	X			X	X		
Lepidonotus squamatus			X			X			X			
Pholoe minuta	X		X			X				X		
Paleonotus bellis										X		
Dysponetus sp.									X			
Phyllodocidae		X		X	X	X	X		X	X	X	
Anaitides maculata				X		X						
Eteone sp.		X									X	
Eteone pacifica		X	X		X	X	X			X		
Eteone longa		X	X				X			X	X	
Eulalia sp.				X				X	X		X	
Eulalia viridis		X		X		X	X	X		X		
Eulalia bilineata											X	
Eulalia quadrioculata	X	X		X		X	X		X	X	X	
Notophyllum imbricatum					X							
Genetyllis castanea					X					X		
Syllidae				X		X	X			X	X	
Autolytus sp.		X		X		X			X	X	X	
Autolytus cornutus	X									X		
Autolytus prismaticus					X	X			X	X		
Typosyllis sp.	X	X	X	X			X	X	X	X	X	
Typosyllis alternata	X	X	X		X	X	X	X	X	X	X	
Typosyllis armillaris									X	X		
Typosyllis pulchra	X	X	X			X	X	X	X	X	X	
Typosyllis stewarti					X		X		X	X		
Typosyllis fasciata	X	X	X				X	X	X	X		
Typosyllis a. adamantea	X	X	X			X	X	X	X	X	X	
Typosyllis harti	X											
Typosyllis hyalina				X						X		
Eusyllis sp.										X		
Eusyllis assimilis							X					

Appendix 1 . Continued

SPECIES	Ocean Cape	Cape Yakataga	Katalla Bay	Cape St. Elias	Port Etches	Zaikof Bay	Macleod Harbor	Squirrel Bay	Latouche Point	Anchor Cove	Gore Point
ANNELIDA-continued											
Eusyllis blomstrandi							X				
Exogone sp.				X					X		
Exogone gemmifera			X	X		X			X	X	X
Exogone lourei				X		X			X		
Exogone molesta				X					X		
Exogone verrugera		X		X			X		X	X	
Sphaerosyllis sp.				X			X		X	X	X
Sphaerosyllis hystrix						X				X	
Sphaerosyllis pirifera											X
Brania brevipharyngea							X				
Brania clavata										X	
Odontosyllis parva									X		
Odontosyllis phosphorea										X	
Syllides japonica						X			X		
Nereidae		X									
Nereis sp.	X	X	X	X	X	X	X	X	X	X	X
Nereis pelagica			X	X		X	X		X	X	X
Nereis procera			X		X	X	X		X	X	
Nereis vexillosa	X	X	X	X		X	X		X	X	X
Nereis zonata									X	X	
Nereis grubei										X	
Platynereis bicanaliculata						X				X	
Nephtys sp.						X					
Nephtys cornuta									X		
Spaerodoridium gracilis						X	X				
Sphaerodoropsis minutum				X		X	X		X		
Glyceridae										X	
Glycera capitata							X				
Glycinde picta						X		X	X		
Onuphis sp.									X		
Onuphis geofiliformis									X		
Onuphis iridescens									X		
Onuphis stigmatis									X		
Eunicidae									X		
Eunice sp.									X		
Eunice valens						X			X		
Eunice kobiensis									X		
Lumbrineridae						X			X		
Lumbrineris sp.				X					X		
Lumbrineris similabris									X		

SPECIES	Ocean Cape	Cape Yakataga	Katalla Bay	Cape St. Elias	Port Etches	Zaikof Bay	Macleod Harbor	Squirrel Bay	Latouche Point	Anchor Cove	Gore Point
ANNELIDA-continued											
Lumbrineris zonata						X	X		X		
Lumbrineris japonica	X								X		
Lumbrineris inflata				X	X	X			X	X	
Haploscoloplos elongatus					X				X		
Naineris sp.				X							
Naineris dendritica									X		
Naineris quadricuspida				X					X		
Naineris laevigata				X					X		
Aricidea suecica								X			
Tauberia gracilis							X				
Spionidae		X	X	X	X	X	X		X	X	
Polydora sp.			X	X	X	X			X		
Polydora ciliata	X					X	X				
Prionospio cirrifera										X	
Spio filicornis		X	X		X	X	X	X	X	X	
Boccardia sp.									X		
Boccardia columbiana						X	X	X	X	X	
Boccardia natrix		X					X				
Boccardia proboscidea						X				X	
Spiophanes bombyx			X				X				
Spiophanes cirrata							X				
Rhynchospio sp.		X	X								
Pygospio sp.		X									
Pygospio elegans		X					X		X		
Cirratulidae			X								
Cirratulus cirratus	X		X	X		X	X		X	X	X
Caulleriella sp.						X	X				
Tharyx sp.				X		X			X	X	
Brada villosa							X			X	
Pherusa papillata						X				X	
Opheliidae						X					
Ammotrypane aulogaster									X		
Armandia brevis						X			X		
Ophelia limacina				X							
Capitellidae		X									
Capitella sp.										X	
Capitella capitata		X	X		X	X	X	X	X	X	
Heteromastus filiformis										X	
Abarenicola pacifica						X					

Appendix 1 . Continued

SPECIES	Ocean Cape	Cape Yakataga	Katalla Bay	Cape St. Elias	Port Etches	Zaikof Bay	Macleod Harbor	Squirrel Bay	Latouche Point	Anchor Cove	Gore Point
ANNELIDA-continued											
Maldanidae			x						x		
Nicomache lumbricalis									x		
Nicomache personata			x						x		
Axiothella rubrocincta									x		
Praxillella affinis									x		
Owenia fusiformis			x								
Myriochele heeri			x								
Cistenides brevicoma					x	x	x		x		
Pectinaria belgica					x		x				
Ampharetidae						x					
Ampharete arctica						x			x		
Asabellides sibirica		x				x	x		x		
Nicolea zostericola						x					
Polycirrus caliendrum						x					
Polycirrus medusa									x		
Terebellides stroemi									x		
Sabellidae		x				x		x			
Chone gracilis		x							x		x
Chone infundibuliformis		x									
Potamilla sp.		x							x		
Potamilla neglecta									x		
Pseudopotamilla reniformis [1]	x										
Schizobranchia insignis			x						x		
Amphiglena pacifica									x		x
Fabricia sabella		x		x		x		x	x	x	x
Fabricia minuta [2]								x	x	x	
Fabricia pacifica [3]	x								x		
Fabricia crenicollis		x		x							x
Laonome sp.							x	x			
Serpulidae			x						x		
Serpula vermicularis						x					
Laeospira granulatus										x	
Dexiospira spirillum				x	x	x	x		x	x	x
Oligochaeta	x	x	x	x		x	x				x
Enchytraidae	x	x	x		x	x	x	x	x	x	
MOLLUSCA											
Mollusca	x					x	x	x			x
Polyplacophora		x			x	x				x	

1 Banse = Potamilla intermedia (Moore)

2 Banse = Oriopsis minuta (Berkeley and Berkeley)

3 Banse = Fabriciola berkeleyi Banse

Appendix 1 . Continued

SPECIES	Ocean Cape	Cape Yakataga	Katalla Bay	Cape St. Elias	Port Etches	Zaikof Bay	Macleod Harbor	Squirrel Bay	Latouche Point	Anchor Cove	Gore Point
MOLLUSCA-continued											
Cynoplax sp.										X	
Cynoplax dentiens				X		X			X	X	
Tonicella lineata			X		X	X	X		X	X	
Tonicella marmorea					X						
Tonicella rubra							X			X	
Dendrochiton thamnopora						X					
Katharina tunicata	X			X	X	X	X	X	X	X	X
Mopalia sp.	X					X				X	
Mopalia cirrata										X	
Mopalia ciliata		X			X	X	X		X	X	
Mopalia lignosa										X	
Mopalia muscosa											
Mopalia sinuata										X	
Schizoplax brandtii			X					X	X	X	
Hanleya hanleyi							X				
Pelecypoda	X		X	X		X			X		
Nucula tenuis								X		X	
Nuculana pernula										X	
Mytilus edulis	X	X	X	X	X	X	X		X	X	X
Musculus sp.			X			X			X		X
Musculus niger						X					
Musculus discors					X	X	X	X	X	X	X
Musculus vernicosus						X	X				
Dacrydium sp.						X			X	X	
Modiolus modiolus			X	X		X			X	X	X
Pododesmus macroschisma						X					
Axinopsida serricata			X								
Mysella planata									X		
Turtonia minuta						X			X		X
Turtonia occidentalis				X		X	X		X		X
Saxidomus gigantea									X	X	
Protothaca sp.			X			X					
Protothaca staminea		X	X	X	X	X	X		X	X	X
Macoma sp.			X			X	X				
Macoma balthica			X		X	X	X		X		
Mya sp.		X									
Mya arenaria			X								
Cyrtodaria kurriana						X					
Hiatella sp.						X					
Hiatella arctica	X		X	X	X	X	X	X	X	X	X
Hiatella striata						X				X	

Appendix 1. Continued

SPECIES	Ocean Cape	Cape Yakataga	Katalla Bay	Cape St. Elias	Port Etches	Zaikof Bay	Macleod Harbor	Squirrel Bay	Latouche Point	Anchor Cove	Gore Point
MOLLUSCA-continued											
Entodesma saxicola	X										
Thracia sp.						X					
Gastropoda	X	X	X	X		X		X	X	X	X
Puncturella sp.							X				
Puncturella cucullata							X				
Acmaeidae								X			
Acmaea sp.		X					X			X	
Acmaea mitra				X							
Acmaea rosacea							X				
Collisella sp.		X	X			X			X	X	X
Collisella pelta	X		X	X	X	X	X	X	X	X	X
Collisella digitalis	X		X			X	X		X	X	X
Collisella ochracea						X					
Notoacmea scutum	X	X	X	X				X	X	X	X
Notoacmea persona				X		X	X	X		X	
Notoacmea fenestrata			X				X				
Cryptobranchia alba						X					
Calliostoma ligatum						X					
Margarites sp.			X			X		X	X		X
Margarites olivaceus							X				
Margarites helicinus		X	X	X		X	X	X	X	X	X
Margarites pupillus			X		X	X	X		X		X
Margarites succinctus											X
Margarites beringensis				X							X
Littorina sitkana	X	X	X	X	X	X	X	X	X	X	X
Littorina scutulata	X	X	X	X	X	X	X	X	X	X	X
Littorina saxatilis										X	
Lacuna sp.		X				X	X	X	X	X	X
Lacuna carinata		X	X			X	X	X	X	X	
Lacuna variagata				X							
Lacuna marmorata	X	X	X	X	X	X	X	X	X	X	X
Lacuna vincta		X	X	X	X		X	X	X		X
Alvinia sp.						X			X		X
Alvinia aurivillii				X							
Alvinia compacta				X	X	X	X		X		X
Cingula sp.				X		X			X		X
Barleeia sp.				X					X		X
Barleeia haliotifila									X		
Barleeia subtenuis									X		

Appendix 1 . Continued

SPECIES	Ocean Cape	Cape Yakataga	Katalla Bay	Cape St. Elias	Port Etches	Zaikof Bay	Macleod Harbor	Squirrel Bay	Latouche Point	Anchor Cove	Gore Point
MOLLUSCA-continued											
Bittium sp.									X		
Bittium munitum						X	X				
Cerithiopsis sp.			X		X		X	X	X	X	
Cerithiopsis stejnegeri			X	X			X		X	X	
Cerithiopsis stephansae									X		
Crepidula sp.						X	X				
Crepidula nummaria						X			X	X	
Trichotropis insignis					X	X			X		
Trichotropis cancellata						X					
Natica clausa					X						
Velutina sp.			X								
Fusitriton oregonensis			X								
Ocenebra interfossa						X			X		
Urosalpinx lurida									X		
Trophonopsis multicostatus									X		
Nucella sp.	X		X			X	X		X		X
Nucella canaliculata						X	X			X	X
Nucella lamellosa		X	X	X	X	X	X	X	X	X	X
Nucella lima	X	X	X				X		X	X	X
Buccinum sp.	X					X	X				
Buccinum baeri				X			X		X		X
Searlesia dira			X	X	X		X		X	X	X
Amphissa columbiana						X					
Mitrella sp.							X				X
Mitrella rosacea							X		X		
Mitrella tuberosa					X		X		X		
Mitrella gouldi							X		X		X
Nassarius mendicus									X		
Odostomia sp.		X	X	X	X		X	X	X	X	
Odostomia hagemeisteri						X					
Turbonella sp.									X		
Diaphana minuta							X				
Cylichna alba						X			X		
Dorididae						X			X		
Acanthodoris sp.						X					
Onchidella borealis	X				X		X	X	X	X	X
Siphonaria thersites		X						X	X	X	X
Aglaja diomedeum								X			
Granulina margaritula						X					

Appendix 1 . Continued

SPECIES	Ocean Cape	Cape Yakataga	Katalla Bay	Cape St. Elias	Port Etches	Zaikof Bay	Macleod Harbor	Squirrel Bay	Latouche Point	Anchor Cove	Gore Point
ARACHNIDA											
Acarina			X								X
Halacaridae	X				X	X	X	X	X	X	X
Pseudoscorpionida						X			X	X	X
Pycnogonida			X	X			X			X	
Phoxichilidium quadradentatum			X			X			X		
Phoxichilidium femoratum					X	X				X	X
Ammothea sp.							X		X		
Ammothea alaskensis							X				
Ammothea gracilipes							X	X			
Ammothea latifrons							X				
Ammothea pribilofensis	X	X		X			X		X		X
Achelia chelata							X				X
Achelia borealis											X
Pycnogonidae		X									
CRUSTACEA											
Platycopa		X			X	X	X		X	X	
Harpacticoida	X	X		X		X	X	X			X
Peltidaidae						X				X	
Calanus sp.						X					
Calanus plumchrus	X										
Metridia lucens		X									
Thoracica		X	X								
Balanidae						X					
Balanus sp.		X	X	X		X	X			X	
Balanus balanoides			X			X	X				
Balanus cariosus	X	X	X		X	X	X	X		X	X
Balanus crenatus	X										
Balanus glandula	X	X	X	X	X	X	X	X	X	X	X
Balanus nubilis						X					
Balanus rostratus			X								
Chthamalus dalli		X	X	X		X	X		X	X	X
Mysidacea				X							
Mysis sp.				X							
Eudorella emarginata						X					
Diastylis sulcata										X	
Campylaspis sp.			X			X	X				
Campylaspis verrucosa			X			X	X				
Campylaspis affinis			X			X	X				
Cumacea			X	X							X

Appendix 1 . Continued

SPECIES	Ocean Cape	Cape Yakataga	Katalla Bay	Cape St. Elias	Port Etches	Zaikof Bay	Macleod Harbor	Squirrel Bay	Latouche Point	Anchor Cove	Gore Point	
CRUSTACEA-continued												
Cumella sp.			x			x	x		x			
Tanaidacea			x				x					
Tanaidae			x	x		x	x		x	x		
Isopoda				x		x						
Synidotea sp.				x								
Synidotea ritterii				x								
Pentidotea resecta		x										
Pentidotea wosnesenskii	x	x	x	x	x	x	x	x	x	x	x	
Idotea fewkesi			x	x			x		x	x	x	
Sphaeromatidae	x	x	x			x	x	x		x		
Gnorimosphaeroma oregonensis	x	x	x	x	x	x	x		x			
Exosphaeroma sp.			x	x	x				x		x	
Exosphaeroma amplicauda		x	x	x					x		x	
Dynamenella sp.							x					
Dynamenella sheareri	x		x	x					x	x	x	
Ianiropsis k. kincaidi	x		x	x		x	x		x			
Munna sp.	x		x		x	x	x	x	x	x	x	
Munna stephenseni			x		x	x	x	x	x	x	x	
Munna chromatocephala	x			x		x			x	x		
Amphipoda	x	x	x	x		x	x	x	x	x	x	
Odius carinatus						x						
Ampithoe sp.				x		x				x		
Ampithoe similans	x	x	x	x	x	x	x	x	x	x	x	
Ampithoe lindbergi						x				x		
Atylus sp.			x			x						
Calliopiidae		x				x						
Oligochinus lighti		x	x		x	x	x	x	x	x	x	
Calliopiella pratti		x	x	x		x	x	x	x			
Corophiidae			x									
Corophium sp.			x	x		x			x			
Eusiridae		x	x			x			x	x	x	
Paramoera sp.						x		x		x		
Paramoera columbiana		x	x	x	x	x	x	x	x	x	x	
Pontogeneia sp.		x	x	x		x			x			
Gammaridae			x									
Anisogammarus sp.		x	x									
Anisogammarus subcarinatus		x	x									
Melita sp.						x	x	x				
Eohaustorius washingtoniensis	x											
Pontoporeia sp.						x						

Appendix 1 . Continued

SPECIES	Ocean Cape	Cape Yakataga	Katalla Bay	Cape St. Elias	Port Etches	Zaikof Bay	Macleod Harbor	Squirrel Bay	Latouche Point	Anchor Cove	Gore Point
CRUSTACEA-continued											
Najna conciliorum				X					X	X	
Hyalidae	X			X		X	X	X	X	X	X
Allorchestes sp.	X										
Allorchestes maleolus					X		X				
Allorchestes angustus							X				
Hyale sp.		X				X	X		X		
Hyale rubra			X	X	X	X	X	X	X	X	X
Hyale grandicornis									X		
Parallorchestes sp.		X	X				X	X			
Parallorchestes ochotensis	X	X	X	X	X	X	X	X	X	X	X
Photis sp.							X		X		
Photis brevipes						X			X		
Photis spasskii									X		
Photis bifurcata									X		
Protomedeia sp.									X		
Protomedeia fasciata										X	
Ischyrocerus sp.	X	X	X	X		X	X		X	X	
Ischyrocerus anguipes				X		X	X		X		
Jassa sp.	X										
Jassa pulcella				X			X		X		
Anonyx sp.		X									
Oedicerotidae										X	
Pleustidae	X			X		X				X	
Parapleustes sp.					X						
Parapleustes nautilus			X	X	X	X	X	X	X	X	
Parapleustes pugettensis						X	X		X		
Pleustes sp.						X			X		
Pleustes panopia						X					
Stenopleustes uncigera						X			X		
Podoceridae									X		
Stenothoidae						X			X	X	X
Metopella sp.						X					
Metopelloides sp.						X	X	X	X	X	
Caulloramphus spiniferum									X		
Talitridae		X	X				X	X			
Parathemisto libellula						X					
Caprellidae		X		X	X		X		X	X	
Decapoda							X		X	X	
Heptacarpus brevirostris			X								

Appendix 1 . Continued

SPECIES	Ocean Cape	Cape Yakataga	Katalla Bay	Cape St Elias	Port Etches	Zaikof Bay	Macleod Harbor	Squirrel Bay	Latouche Point	Anchor Cove	Gore Point
						SITES					
CRUSTACEA-continued											
Callianassa sp.						X		X			
Paguridae											X
Pagurus sp.			X	X		X				X	
Pagurus beringanus								X	X	X	
Pagurus h. hirsutiusculus		X	X	X	X	X	X	X	X	X	X
Chionoecetes sp.		X									
Pugettia gracilis			X	X	X	X			X	X	X
Cancer productus						X	X				
Cancer oregonensis				X		X	X		X	X	
Telemessus cheiragonus						X	X				
INSECTA											
Insecta	X	X	X	X	X	X	X	X	X	X	X
Anurida maritima	X							X	X	X	X
Diptera	X	X	X	X		X	X			X	X
Chironomidae	X	X	X	X	X	X	X	X	X	X	
Culicidae	X	X									
Dolichopodidae	X										X
Coleoptera		X	X			X				X	
Staphinidae	X	X		X		X	X				X
SIPUNCULIDA											
Sipunculida				X	X	X			X	X	
ECHUROIDEA											
Bonelliopsis alaskana				X							
Echiurus e. alaskanus			X		X	X	X				
BRYOZOA											
Bryozoa		X	X	X	X	X	X	X	X	X	X
Membranipora membranacea						X					
Terminoflustra sp.								X			
Terminoflustra membraceotruncata			X								
Cauloramphus spiniferum			X		X		X				
Callopora sp.			X		X						
Callopora lineata								X			
Tegella robertsoniae					X						
Microporina sp.		X		X			X			X	

Appendix 1 . Continued

SPECIES	Ocean Cape	Cape Yakataga	Katalla Bay	Cape St. Elias	Port Etches	Zaikof Bay	Macleod Harbor	Squirrel Bay	Latouche Point	Anchor Cove	Gore Point
BRYOZOA-continued											
Microporina borealis					X	X	X	X	X		
Tricellaria occidentalis									X		
Dendrobeania lichenoides					X			X			
Hippothoa cornuta									X		
Hippothoa hyalina		X			X	X	X	X	X	X	
Hipplodiplosia sp.							X	X			
Microporella sp.			X						X		
Microporella cribrosa			X								
Microporella vibraculifera							X				
Cryptosula pallasiana					X	X		X		X	
Lagenipora socialis					X		X	X			
Costazia sp.			X								
Costazia surcularis			X								
Costazia ventricosa			X								
Costazia robertsoniae							X				
Myriozoum coarctatum							X				
Myriozoum subgracile							X				
Myriozoella plana					X		X	X			
Diaperoecia sp.					X						
Filicrisia sp.										X	
Crisea sp.									X		
Crisea occidentalis					X		X	X		X	
Heteropora sp.							X				
Borgiola pustulosa						X					
Disporella sp.				X	X	X					
Alcyonidium sp.										X	
Alcyonidium polyoum										X	
Flustrellidae									X		
Flustrella sp.								X			
Flustrella corniculata								X			
Bowerbankia imbricata										X	
BRACHIOPODA											
Terebratalia transversa						X					
ECHINODERMATA											
Asteroidea		X				X		X	X	X	X
Henricia sp.						X	X				
Henricia leviuscula									X	X	

Appendix 1 . Continued

SPECIES	Ocean Cape	Cape Yakataga	Katalla Bay	Cape St. Elias	Port Etches	Zaikof Bay	Macleod Harbor	Squirrel Bay	Latouche Point	Anchor Cove	Gore Point
ECHINODERMATA-continued											
Evasterias troschelii					x						x
Leptasterias sp.			x			x					x
Leptasterias groenlandica											x
Leptasterias hexactis	x	x	x	x	x	x		x		x	x
Pisaster ochraceus						x				x	
Pycnopodia helianthoides						x					
Strongylocentrotus droebachiensis			x	x	x	x	x		x	x	
Strongylocentrotus purpuratus										x	
Ophiuroidea		x				x					
Cucumaria sp.										x	
Cucumaria pseudocurata					x	x			x	x	x
UROCHORDATA											
Urochordata				x	x	x		x	x		
TELEOSTEI											
Teleostei											x
Clinocottus acuticeps						x	x				
Oligocottus maculosus											x
Liparis callyodon											x
Anoplarchus purpurescens										x	
Phytichthys chirus									x	x	x
Xiphister mucosa						x					
Pholis laeta						x					
Total Species	109	178	200	183	155	339	267	136	301	284	169

Appendix 2. Presence (x) or absence (blank) of species of plants and invertebrates on sandy beaches at six sites in the eastern Gulf of Alaska.

SPECIES	Ocean Cape	Cape Yakataga	Kanak Island	Softuk Spit	Big Egg Island	Hook Point
CHLOROPHYTA						
Chlorophyta			x			x
Monostroma sp.			x			
CRYSOPHYTA						
Crysophyta			x			
Bacillariophyceae			x			
Centrales			x			
Pennales				x		
PHAEOPHYTA						
Ectocarpus sp.						x
RHODOPHYTA						
Rhodophyta			x			
Corallinaceae			x			x
Iridaea sp.			x			
Palmaria palmata			x			
Neoptilota sp.					x	
Odonthalia sp.			x			
PROTOZOA						
Foraminifera						x
Cnidaria						
Cnidaria		x				
RHYNCHOCOELA						
Rhynchocoela		x	x			x
Emplectonema gracile				x		
ANNELIDA						
Polychaeta			x			x
Anaitides maculata			x			
Eteone longa		x	x	x		x
Syllidae			x			
Nephtys sp.			x			
Nephtys caeca			x			
Glycinde armigera			x			
Scoloplos armiger			x			

Appendix 2 Continued

SPECIES	Ocean Cape	Cape Yakataga	Kanak Island	Softuk Spit	Big Egg Island	Hook Point
ANNELIDA-continued						
Paraonis sp.			x			
Spionidae			x			
Pygospio sp.		x				
Nerine cirratulus			x			
Magelona pitelkai			x			
Cirratulus cirratus			x			
Thoracophelia sp.					x	
MOLLUSCA						
Pelecypoda			x			
Mytilus edulis		x				
Macoma balthica			x			
Lacuna vincta		x				
CRUSTACEA						
Harpacticoidea			x			
Calanus plumchrus	x				x	
Metridia lucens		x				
Mysidacea						x
Archeomysis grebnitzkii	x		x	x		
Cumacea			x			
Lamprops sp.			x			
Lamprops quadriplicata			x			
Amphipoda	x	x	x	x		x
Eohaustorius washingtoniensis			x	x	x	
Hyale rubra			x			
Paraphoxus sp.			x			
Majiidae	x					
Chionoecetes sp	x					
INSECTA						
Culicidae	x					
BRYOZOA						
Bryozoa		x				
OPHIUROIDEA						
Ophiuroidea		x				
Total Species	6	10	35	6	4	9

Appendix 3. Presence (x) or absence (blank) of species of plants and invertebrates on muddy beaches at two sites in the eastern Gulf of Alaska.

SPECIES	SITES: Boswell Bay	Middleton Island
CHLOROPHYTA		
Chlorophyta	x	x
Enteromorpha sp.	x	
Enteromorpha clathrata	x	
Enteromorpha crinita	x	
Enteromorpha intestinalis	x	
Ulva sp.		x
Ulva lactuca		x
Cladophora sp.	x	
CRYSOPHYTA		
Crysophyta	x	
Bacillariophyceae	x	
PHAEOPHYTA		
Phaeophyta	x	
Dictyosiphonales	x	
Scytosiphon lomentaria	x	
Fucus distichus	x	x
RHODOPHYTA		
Rhodophyta	x	
Cryptosiphonia woodii	x	
Bossiella plumosa		x
Gigartina papillata		x
Palmaria palmata		x
Rhodymenia pertusa		x
Pterosiphonia bipinnata	x	
Odonthalia floccosa	x	x
PHYCOMYCETES		
Phycomycetes	x	
ANTHOPHYTA		
Potamogetonaceae	x	
PROTOZOA		
Protozoa	x	
Foraminifera	x	

Appendix 3 . Continued

SPECIES	Boswell Bay	Middleton Island
CNIDARIA		
Eudendrium sp.	X	
TURBELLARIA		
Turbellaria	X	
RHYNCHOCOELA		
Rhynchocoela	X	X
Emplectonema gracile	X	
NEMATODA		
Nematoda	X	X
ANNELIDA	X	X
Polychaeta	X	X
Polynoidae	X	
Gattyana cirrosa	X	
Gattyana treadwelli	X	
Harmothoe imbricata	X	
Polyodontidae		X
Pholoe minuta	X	
Phyllodocidae	X	
Anaitides maculata	X	
Eteone sp.	X	
Eteone pacifica	X	X
Eteone longa	X	X
Eulalia viridis	X	
Mysta barbata	X	
Syllis sp.	X	
Typosyllis alternata	X	
Typosyllis elongata	X	
Typosyllis pulchra	X	
Typosyllis fasciata		X
Typosyllis hyalina	X	
Exogone molesta	X	
Exogone verrugera	X	
Syllides japonica		X
Nereis sp.	X	X
Nereis procera		X
Nereis vexillosa		X

Appendix 3 . Continued

SPECIES	Boswell Bay	Middleton Island										
ANNELIDA-continued												
Nephtys sp.	X											
Nephtys ciliata	X											
Nephtys caeca	X											
Nephtys cornuta	X											
Nephtys schmitti	X											
Glycera capitata		X										
Glycinde picta	X											
Haploscoloplos sp.	X											
Haploscoloplos elongatus	X											
Haploscoloplos panamensis	X											
Scoloplos armiger	X											
Aricidea sp.	X											
Aricidea suecica	X											
Tauberia gracilis	X											
Polydora sp.	X											
Polydora caeca	X											
Polydora caulleryi	X											
Polydora ciliata	X											
Polydora quadrilobata	X											
Spio filicornis	X	X										
Spiophanes bombyx	X	X										
Spiophanes cirrata	X	X										
Rhynchospio sp.	X	X										
Pygospio sp.		X										
Pygospio californica		X										
Pygospio elegans		X										
Cirratulidae	X											
Caulleriella sp.	X											
Tharyx sp.	X											
Tharyx multifilis	X											
Tharyx parvus	X											
Chaetozone setosa	X											
Dodecaceria sp.	X											
Capitellidae	X	X										
Capitella capitata		X										
Heteromastus filiformis	X	X										
Abarenicola sp.	X											
Abarenicola pacifica	X	X										
Maldanidae	X											

SITES

Appendix 3 . Continued

SPECIES	SITES: Boswell Bay	Middleton Island										
ANNELIDA-continued												
Owenia fusiformis	X											
Owenia pacifica	X											
Myriochele heeri		X										
Cistenides brevicoma	X											
Pectinaria belgica	X											
Ampharete arctica	X											
Asabellides sibirica	X											
Glyphanostomum pallescens	X											
Sabellidae	X											
Chone infundibuliformis	X											
Chone cincta	X											
Fabricia sabella	X											
Fabricia minuta [1]	X											
Laonome sp.	X											
Pseudosabellides littoralis	X											
Oligochaeta	X	X										
Enchytraeidae	X	X										
MOLLUSCA												
Pelecypoda	X											
Mytilus edulis	X	X										
Pseudopythina compressa	X											
Clinocardium sp.	X											
Clinocardium ciliatum	X											
Clinocardium nuttallii	X											
Saxidomus gigantea	X											
Protothaca staminea	X											
Macoma sp.	X											
Macoma obliqua	X											
Macoma balthica	X	X										
Mya sp.	X											
Mya arenaria	X											
Mya elegans	X											
Hiatella arctica	X											
Gastropoda	X											
Collisella pelta	X											
Collisella ochracea	X											
Margarites helicinus	X											
Littorina sitkana	X	X										

[1] Banse = Oriopsis minuta (Berkeley and Berkeley)

SITES

SPECIES	Boswell Bay	Middleton Island
MOLLUSCA-continued		
Littorina aleutica	x	
Littorina scutulata	x	
Lacuna carinata	x	
Lacuna marmorata	x	
Cerithiopsis sp.	x	
Cerithiopsis stejnegeri	x	
Nucella sp.	x	
Nucella lamellosa	x	
Nucella lima	x	
Odostomia sp.	x	
Cylichna sp.	x	
Aglaja diomedeum	x	
ARACHNIDA		
Halacaridae	x	
Pseudoscorpionida	x	
CRUSTACEA		
Crustacea	x	
Platycopa	x	x
Harpacticoidea	x	x
Calanus plumchrus	x	
Balanidae	x	
Balanus sp.	x	
Balanus balanoides	x	
Balanus crenatus	x	
Balanus glandula	x	
Chthamalus dalli	x	
Cumacea	x	
Campylaspis sp.	x	
Campylaspis verrucosa	x	
Campylaspis affinis	x	
Tanaidacea	x	
Pentidotea wosensenskii		x
Gnorimosphaeroma oregonensis	x	
Amphipoda	x	
Ampithoe simulans		x
Calliopiidae	x	
Oligochinus lighti	x	x

Appendix 3 . Continued

SPECIES	SITES: Boswell Bay	SITES: Middleton Island
CRUSTACEA-continued		
Corophiidae	x	
Corophium sp.	x	
Paramoera columbiana	x	
Anisogammarus sp.	x	x
Anisogammarus locustoides	x	
Parallorchestes sp.	x	
Parallorchestes ochotensis	x	
Parapleustes nautilus	x	
Talitrus sp.	x	
Callianassa sp.	x	
Pagurus sp.	x	
Pagurus h. hirsutiusculus	x	
Chionoecetes sp		x
INSECTA		
Insecta	x	x
Diptera	x	
Chironomidae	x	x
ECHIUROIDEA		
Echiuroidea	x	
Echiurus E. alaskanus	x	
BRYOZOA		
Bryozoa	x	x
BRACHIOPODA		
Brachiopoda		x
Total Species	168	50

ANNUAL REPORT

CONTRACT: #03-5-022-56
TASK ORDER: #15
RESEARCH UNIT: #281/5/303
REPORTING PERIOD: 4/1/77-3/31/78
NUMBER OF PAGES: 315

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

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March 1978

ACKNOWLEDGEMENTS

We would like to thank the officers and crew of the NOAA vessels involved in sampling. We would also like to thank the following Institute of Marine Science, University of Alaska personnel: Dave Nebert, Rosemary Hobson, Cydney Hansen and James Dryden for assistance in data processing; and Ana Lea Vincent, Helen Stockholm and the IMS Publications staff for aid in preparation of this report.

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SECTION I

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

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

The long-term objectives of this study are: 1) a qualitative and quantitative inventory of benthic species within and adjacent to identified oil-lease sites in the northeast Gulf of Alaska (NEGOA), the Kodiak shelf, lower Cook Inlet and the Bering Sea, 2) a description of spatial distribution patterns of selected species in the designated study areas, and 3) observations of biological interrelationships, specifically trophic interactions, between components of the benthic biota in designated study areas.

Forty-two widely dispersed permanent stations for quantitative grab sampling have been established in the northeastern Gulf of Alaska, and these stations represent a reasonable nucleus around which a monitoring program can be developed. Sixty-one widely dispersed stations were occupied with a van Veen grab in Cook Inlet; thirteen of these stations were ultimately selected for detailed analysis. A total of 77 widely dispersed permanent stations for quantitative grab sampling were established in the Bering Sea.

A pipe dredge was used in lower Cook Inlet and the Bering Sea to compliment data obtained by grab and trawl, and was also valuable for obtaining large numbers of clams used in age-growth studies.

The general patchiness of fauna initially observed at most stations in the Gulf of Alaska and the Bering Sea suggested that at least five replicates be taken per station. At least this number of replicates were taken at all stations during the project period. Analysis of grab data by the end of the project period should enable us to suggest the optimum number of replicates per station for monitoring programs.

One hundred and forty stations were occupied with an otter trawl in the northeastern Gulf of Alaska. Fifty-three stations were occupied by trawl in two bays (Alitak and Ugak) of Kodiak Island. Forty-seven stations were occupied with three types of trawls in Cook Inlet. Two-hundred and eight stations were occupied by otter trawl in the Bering Sea in 1975 and 104 stations were occupied by otter trawl in 1976.

Four hundred and fifty-seven invertebrate species were collected in the grab sampling program, and 168 invertebrate species were taken in the trawl program in the northeast Gulf of Alaska. One hundred and six invertebrate species were determined for the two Kodiak bays. Two hundred and eleven species have been determined from the grab sampling program, and 189 invertebrate species from the trawl and dredge programs in Cook Inlet. Six hundred and forty-three invertebrate species have been isolated from the grab-sampling program and 225 invertebrate species from the trawl program in the Bering Sea. It is probable that all species with numerical and biomass importance have been collected in all areas of investigation and that only rare species will be added in future sampling.

No seasonal information is available for the Bering Sea benthos but a continuing series of cruises during the first year of the investigation made available samples (now being processed or temporarily archived) from the spring, summer and early fall. Limited seasonal data are found in the literature.

Basic information on diversity, dominance and evenness is now available for all permanent stations on the NEGOA grid and for 27 stations on the Bering Sea grid. Caution is indicated in the interpretation of these values until further data are available over a longer time base.

Criteria established for Biologically Important Taxa (BIT) have delineated 95 invertebrate species in the northeast Gulf of Alaska. These species have been used to comprehend station/species aggregations by cluster analysis. Preliminary groupings of stations into three basic clusters have been accomplished. Further understanding of station clustering has been gained by clustering species, and constructing a two-way coincidence table of species vs. station groups. By this means, specific groupings of species can be related to station clusters, and intermediate positions of stations (or clusters) can be determined by the particular groupings of species they have in common.

Criteria established for BIT have delineated 89 species in the Bering Sea. These species form the basis of a cluster analysis that will be used to understand species aggregations there.

The joint National Marine Fisheries Service trawl charter for investigation of epifaunal invertebrates and demersal fishes in the northeast Gulf of Alaska was effective, and excellent spatial coverage was achieved.

However, no seasonal information was obtained for this area. There is now a satisfactory knowledge, for the summer and fall, of the distribution and abundance of the major epifaunal invertebrates for two bays of Kodiak Island. Two trawl surveys in lower Cook Inlet on the R/V *Moana Wave* and NOAA Ship *Miller Freeman* achieved good coverage, although only limited seasonal data were obtained. The joint National Marine Fisheries Service trawl survey on the NOAA Ship *Miller Freeman* for investigation of epifaunal invertebrates in the Bering Sea was effective, and excellent coverage was achieved in the areas examined. Some seasonal data were obtained. Integration of information from these cruises with infaunal benthic data will enhance our understanding of these shelf ecosystems.

Information on feeding biology of species collected by grab and trawl is available from literature analysis and information collected on Outer Continental Shelf Environmental Assessment Program (OCSEAP) cruises. A Kodiak Island food web has been developed. The major food items in the web were polychaetes, gastropods (snails), pelecypods (clams), amphipods, hermit crabs, true crabs, and shrimps. Snow and king crabs fed heavily on benthic animals that, in turn, relied in whole or in part on sediment-associated organic material, detritus, bacteria, and benthic diatoms for food. The invertebrates in the two Kodiak bays relied on a variety of feeding methods while fishes tended to be predators. The principal food groups used by the Pacific cod, *Gadus macrocephalus*, at all sites in the northeast Gulf of Alaska and the Kodiak shelf were molluscs, crustaceans, and fishes. There were some small quantities (less than 10% of the total occurrence) of annelids, euphausiids and mysids, isopods and echinoderms taken by cod. The frequency of occurrence of snow crab, *Chionoecetes bairdi*, as food for cod for 1973-1975 on the Kodiak Shelf was 40, 36, and 36 percent, respectively. A food web, inclusive of major epifaunal species, for Cook Inlet is also available. The snow crab, *Chionoecetes bairdi*, fed, in order of decreasing importance, on clams, hermit crabs, barnacles and crangonid shrimps. King crabs, *Paralithodes camtschatica*, in Cook Inlet fed on two deposit-feeding clams, *Nuculana* and *Macoma*, and barnacles. Food items of Bering Sea crabs differed from crabs in Cook Inlet. King crabs in the former area were primarily taking *Clinocardium*, small snails and ophiuroids; snow crabs (*Chionoecetes* spp.) were taking mainly polychaetes and ophiuroids. The pollock, target of one of the world's largest fisheries in the Bering Sea, is an important link in the food web for that area.

Clam studies in Cook Inlet have resulted in age-growth data for six species: *Nucula tenuis, Nuculana fossa, Glycymeris subobsoleta, Macoma calcarea, Tellina nuculoides* and *Spisula polynyma*. Further age-growth data on clam species from the Bering Sea will be available for the Final Report for that area. Such age-growth analyses will make available biological parameters useful for long-range monitoring programs in these areas.

Initial assessment of all data suggests that: 1) sufficient station and/or area uniqueness exists to permit development of monitoring programs based on species composition at selected stations utilizing both grab and trawl sampling techniques, and 2) adequate numbers of biologically well-known, unique, abundant, and/or large species are available to permit nomination of likely monitoring candidates for the areas once industrial activity is initiated.

II. INTRODUCTION

General Nature and Scope of Study

The operations connected with oil exploration, production, and transportation in the Gulf of Alaska and the Bering Sea present a wide spectrum of potential dangers to the marine environment (see Olson and Burgess, 1967, for general discussion of marine pollution problems). Adverse effects on the marine environment of these areas 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 and recruitment of species in that environment, can lead to erroneous interpretations of changes in types and density of species that might occur if the area becomes altered (see 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 communication). Such fluctuations are typically unexplainable because of absence of long-term data on physical and chemical environmental parameters in association with biological information on the species involved (Lewis, 1970, and personal communication).

Benthic organisms (primarily the infauna but also sessile and slow-moving epifauna) are particularly 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, the 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 the Gulf of Alaska and the Bering Sea further dictates the necessity of understanding benthic communities since many commercial species feed on infaunal and small epifaunal residents of the benthos (see Zenkevitch, 1963, for a discussion of the interaction of commercial species and the benthos; also see appropriate discussions in Feder, 1977). Any drastic changes in density of the food benthos could affect the health and numbers of these commercially important species.

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

The benthic biological program in the northeast Gulf of Alaska (NEGOA) has emphasized development of an inventory of species as part of the examination of biological, physical and chemical components of those portions of the shelf slated for oil exploration and drilling activity. In addition, initiation of a program designed to quantitatively assess assemblages (communities) of benthic species on the NEGOA shelf will expand the understanding of distribution patterns of species here. A developing investigation concerned with the biology (primarily concerned with feeding activity) of selected species on the Kodiak shelf and in Cook Inlet will further the understanding of the trophic dynamics of the Gulf of Alaska benthic system.

The benthic macrofauna of the Bering Sea is relatively well known taxonomically, and some data on distribution, abundance, and feeding mechanisms are reported in the literature (Feder *et al.*, 1976a; Feder and Mueller, 1977; Feder, 1977). The relationship of specific infaunal feeding types to certain substrate conditions has limited documentation as well. However, detailed information on the temporal and spatial variability of the benthic fauna is sparse, and the relationship of benthic species to the overlying seasonal ice cover is not known. Some of the macrofaunal benthic species may be impacted by oil-related activities. An understanding of these species and their interactions with each other and various aspects of the abiotic features of their environment are essential to the development of environmental predictive capabilities required for the Bering Sea.

The benthic biological program in the Bering Sea emphasized development of an inventory of species as part of the examination of the biological, physical and chemical components of those portions of the shelf slated for oil exploration. In addition, development of computer programs for use with data from NEGOA, designed to quantitatively assess assemblages of benthic species on the shelf there, are applicable to the Bering Sea. The resultant computer analysis will expand the understanding of distributional patterns of species in the latter area. Further studies in the Bering Sea have encompassed limited investigations of trophic interactions between selected epifaunal species.

The study program was designed to survey the benthic fauna on the Alaska continental shelf in regions of potential oil and gas concentrations. During the first phases of research, data were obtained on faunal composition and abundance to develop baselines to which future changes can be compared. Long-term studies on life histories and trophic interactions of identified important species should define aspects of communities and ecosystems potentially vulnerable to environmental damage, and should help to determine rates at which damaged environments can recover.

Relevance to Problems of Petroleum Development

Lack of an adequate data base elsewhere makes it difficult at present to predict the effects of oil-related activity on the subtidal benthos of the Gulf of Alaska and the Bering Sea. However, the rapid expansion of research activities in both areas should ultimately enable us to point with some confidence to certain species or areas that might bear closer scrutiny once industrial activity is initiated. It must always be emphasized that a considerable time frame is needed to comprehend long-term fluctuations in density of marine benthic species; thus, it cannot be expected that short-term research programs will result in predictive capabilities. Assessment of the environment must be conducted on a continuing basis.

As indicated previously, infaunal benthic organisms 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 Mueller, 1975, and NODC data on file for examples of such stations). Changes in the environment at stations with relatively large numbers of species might be reflected by a decrease in diversity with increased dominance of a few species (see Nelson-Smith, 1973 for further discussion of oil-related changes in diversity). Likewise, stations with substantial numbers of epifaunal species should be assessed on a continuing basis (see Feder and Mueller, 1975; Feder, 1977; Jewett and Feder, 1976 for references to relevant stations). The potential effects of loss of species to the trophic structure in the Gulf of Alaska and the Bering Sea cannot be assessed at this time, but the problem can be better addressed once benthic food studies resulting from current projects are available (Feder, unpublished data from Cook Inlet and the Bering Sea; Jewett and Feder, 1976; Feder, 1977; Feder and Jewett, 1977; Smith *et al.*, 1977).

Data indicating the effects of oil on most subtidal benthic invertebrates are fragmentary (see Boesch, *et al.*, 1974; Malins, 1977 for review; Baker, 1977 for a general review of marine ecology and oil pollution), but echinoderms are "notoriously sensitive to any reduction in water quality" (Nelson-Smith, 1973). Echinoderms (ophiuroids, asteroids, and holothuroids) are conspicuous members of the benthos of the Gulf of Alaska and the Bering Sea (see Feder, 1977 for references to relevant stations in the northeast Gulf of Alaska and Bering Sea), and could be affected by oil activities there. Asteroids (sea stars) and ophiuroids (brittle stars) are components of the diet of large crabs (for example King crabs feed on sea stars and brittle stars: unpub. data, Guy Powell, Alaska Dept. of Fish and Game; Feder, 1977) and demersal fishes. Snow crabs (*Chionoecetes* spp.) are conspicuous members of the shallow shelf of the Gulf of Alaska and the Bering Sea, and support commercial fisheries of considerable importance. Laboratory experiments with this species have shown that postmolt individuals lose most of their legs after exposure to Prudhoe Bay crude oil; obviously this aspect of the biology of the snow crab must be considered in the continuing assessment of this species (Karinen and Rice, 1974). Little other direct data based on laboratory experiments are available for subtidal benthic species (see Nelson-Smith, 1973). Experimentation on toxic effects of oil on other common members of the subtidal benthos should be strongly encouraged for the near future in OCS programs.

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

As suggested above, upon completion of initial baseline studies in pollution prone areas, selected stations should be examined regularly on a long-term basis. Cluster analysis techniques discussed below, supplemented by principal components and/or principal coordinate analysis, should provide techniques for the selection of stations useful for monitoring the infauna. In addition, these techniques should provide an insight into normal ecosystem variation (Clifford and Stephenson, 1975; Williams and Stephenson, 1973; Stephenson *et al.*, 1974). Also, intensive examination of the biology (e.g., age, growth, condition, reproduction, recruitment, and feeding habits) of selected species should afford obvious clues of environmental alteration.

III. CURRENT STATE OF KNOWLEDGE

Gulf of Alaska

Little was known about the biology of the invertebrate benthos of the Gulf of Alaska at the time that 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 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 (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 (Echinoidea), snow crabs (*Chionoecetes bairdi*), sea stars (Asteroidea), Dungeness crabs (*Cancer magister*), scallops (*Pecten caurinus*), shrimps (*Pandalus borealis*, *P. platyceros*, and *Pandalopsis dispar*), king crabs (*Paralithodes camtschatica*), and miscellaneous invertebrates (shells, sponges, etc.) (Hitz and Rathjen, 1965). Heart urchins accounted for about 50 percent of the invertebrate catch and snow crabs ranked second, representing about 22 percent. Approximately 20 percent 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 *et al.* (1976b), and Feder, (1977) represent the first intensive qualitative and quantitative examinations of the benthic infauna and epifauna of the Gulf of Alaska.

Data on the infauna collected in the first year (1974-1975) of the OCSEAP study in the northeast Gulf of Alaska served as a springboard and an intensive data base for the studies in 1975-1977. Information in the literature will aid in the interpretation of the biology of some dominant infaunal organisms in the Gulf of Alaska. The use of cluster and multivariate techniques for the analysis of infaunal data (now being applied to our data from the Gulf of Alaska and the Bering Sea) has been widely used by numerous investigators examining shallow-water marine environments. Techniques are well reviewed in Clifford and Stephenson (1975).

Few data on non-commercially important invertebrate components of the shallow, nearshore benthos of the Kodiak shelf were available until recent OCSEAP studies were initiated (Feder, 1977; Feder and Jewett, 1977). To date, Russian workers have published most of the data from the western Gulf of Alaska (AEIDC, 1974), but OCSEAP investigations in the northeast Gulf of Alaska provide some comparable data from adjacent areas (Feder, 1977). The benthic invertebrate biomass on the Kodiak shelf appears to be greater than that of the NEGOA area, and a higher percentage of the Kodiak biomass is believed to be available as food for fishes (see summary draft report by MacDonald and Petersen, 1976). Additional summary information for the Gulf of Alaska is also available in the literature review of Rosenberg (1972). The Soviet benthic work was accomplished in the deeper waters of the Kodiak shelf, and was of a semi-quantitative nature with little hard data to permit extrapolations useful for predictive analyses of the effects of oil on the benthos. The exploratory trawl program of the National Marine Fisheries Service is the most extensive investigation of commercially important species of the Kodiak shelf (unpub. data; reports available from the National Marine Fisheries Service Laboratory, Kodiak). However, most of the invertebrate data from the latter investigation are difficult to interpret, but the dominant organisms likely to be encountered in the offshore waters of the Kodiak shelf are suggested by these studies.

Additional, but unpublished, information on the epifauna in the vicinity of Kodiak Island is available as a by-product of the Alaska Department of Fish and Game King Crab Indexing Surveys (inquiries concerning these reports may be directed to Alaska Department of Fish and Game, Box 686, Kodiak). The International Pacific Halibut Commission surveys parts of the Kodiak shelf annually, but only records commercially important species of crab and fishes; non-commercially important invertebrate and fish species are generally lumped together in the survey reports with little specific information available. A compilation of some relevant data on renewable resources of the Kodiak shelf is available (AEIDC, 1974). The only recent inshore survey of the invertebrate benthos of the Kodiak shelf is that of Feder and Jewett, (1977) accomplished in conjunction with the fish studies of the Alaska Department of Fish and Game (Blackburn, 1977). These studies intensively investigated the benthos of two bays of Kodiak Island, Alitak and Ugak, and described the distribution and abundance of epifaunal invertebrates and demersal fishes there. Sufficient data were available from these studies to develop a preliminary food web for these two bays and inshore waters around Kodiak Island. Feder and Jewett (1977) discusses the relevance of the inshore benthic study in the two bays, and the Kodiak shelf in general, to petroleum development there.

Commercial catch statistics of Kodiak king crab stocks in past years showed classic exploitation patterns with a peak year catch occurring in the 1965-66 season. Since that time, annual harvest levels (quotas) have been imposed. Recent data substantiate that king crab stocks are responding to the reduced fishing pressure resulting from this management decision, and populations are apparently in the rebuilding phase. The two most commercially utilized stocks are southern district stocks II and III which cover Kodiak Island's southern waters to the continental shelf edge (Guy Powell and Alaska Department of Fish and Game Reports, unpub.). Recent trawl studies conducted in two Kodiak Bays (Alitak and Ugak) show king crabs as the dominant species there (Feder and Jewett, 1977). Alitak Bay is also a major king crab breeding area (Gray and Powell, 1966; Kingsbury and James, 1971).

Based on OCSEAP feeding studies initiated in the northeast Gulf of Alaska (inclusive of Cook Inlet) and two bays on Kodiak Island (Feder, 1977; Feder and Jewett, 1977), it is apparent that benthic invertebrates play a major role in the food dynamics of commercial crab and demersal fishes on the Kodiak shelf.

Few data on non-commercially important benthic invertebrates of Cook Inlet were available until recent OCSEAP studies were initiated [Feder, 1977 and D. Lees, unpub. data and reports; draft copy of lower Cook Inlet Synthesis Report, 1977 (Scientific applications, 1977)]. The primary data available were principally catch and assessment records for commercial shellfish species. Based on OCSEAP feeding studies accomplished in lower Cook Inlet, it is apparent that benthic invertebrates play an important role in the food dynamics of commercial crabs and demersal fishes there.

Dennis Lees (unpub. data) suggests that the macrophytes of the intertidal and shallow subtidal regions produce materials utilized by detritivores in shallow and deep waters throughout Cook Inlet. Many of the organisms depending on these plant materials are either of commercial importance or are food items important to commercial species. Lees indicates that in the past few years information linking the macrophyte producers to commercially important species has begun to emerge but that the full importance of this linkage has yet to be recognized. He also points out that many marine birds and mammals depend heavily on organisms living in the inshore areas which in turn are dependent on plant material produced by macrophytes. Studies by D. Lees and Feder (OCSEAP data) very strongly suggest that the abundant deposit feeders in lower Cook Inlet are concentrated in regions of detrital accumulations (e.g. Kamashak Bay).

Bering Sea

The macrofauna of the Bering Sea is well known taxonomically, and data on distribution, abundance, and feeding mechanisms for infaunal species are reported in the literature (Feder *et al.*, 1976a; Filatova and Barsanova, 1964; Kuznetsov, 1964; Neyman, 1960; Stoker, 1973). The relationship of specific infaunal feeding types to certain hydrographic and sediment conditions has been documented (Neyman, 1960; Stoker, 1973). However, the relationship of these feeding types to the overlying winter ice cover and its contained algal material and to primary productivity in the water column is not known.

Epifauna of the eastern Bering Sea has been little studied since the trawling activities of the Harriman Alaska Expedition (Merriam, 1904) and the voyages of the *Albatross*. Limited information can be obtained from the report of the pre-World War II king crab investigations (Fishery Market News, 1942) and from the report of the *Pacific Explorer*, fishing and processing operations in 1948 (Wigutoff and Carlson, 1950). Some information on species found in the area is included in reports of the U.S. Fish and Wildlife Service, Alaska exploratory fishing expedition in 1948 (Ellson *et al.*, 1949) and the exploratory fishing expedition to the northern Bering Sea in 1949 (Ellson *et al.*, 1950). Neyman (1960) has published a quantitative report, in Russian, on the molluscan communities in the eastern Bering Sea. A phase of the research program conducted by the King Crab Investigation of the Bureau of Commercial Fisheries for the International North Pacific Fisheries Commission included an ecological study of the eastern Bering Sea during the summers of 1958 and 1959 (McLaughlin, 1963). Sparks and Pereyra (1966) have presented a partial checklist and general discussion of the benthic fauna encountered during a marine survey of the southeastern Chukchi Sea during the summer of 1959. Their marine survey was carried out in the southeastern Chukchi Sea from the Bering Straits to just north of Cape Lisburne and west to 169°W. Some species described by them in the Chukchi Sea extend into the Bering Sea and are important there. A recent survey of the epifauna of the northeastern Bering Sea is included in Feder and Jewett (in press).

The biomass and productivity of microscopic sediment-dwelling bacteria, diatoms, microfauna, and meiofauna have not been determined, and it is important that their roles be clarified. It is possible that these organisms are vital biological agents for recycling nutrients and energy from sediment to the overlying water column (see Fenchel, 1969 for review). Of unique interest is the relationship of the ice edge and under-ice primary productivity to the benthos.

Crabs and bottom-feeding fishes of the Bering Sea exploit a variety of food types, benthic invertebrates being most important. Most of these predators feed on the nutrient-enriched upper slope during the winter, but move into the shallower and warmer waters of the shelf of the southeastern Bering Sea for intensive feeding and spawning during the summer.

Occasionally they exploit the colder northern portions of the Bering Sea shelf. This differential distribution is reflected by catch statistics which demonstrate that the southeastern shelf area is a major fishing area for crabs and bottom fishes. The effect of intensive predatory activity in the southern vs. the northern part of the shelf appears to be partially responsible for the lower standing stock of the food benthos in the southeastern Bering Sea (Neyman, 1960, 1963). Thus, it is apparent that bottom-feeding species of fisheries importance are exploiting the southeastern Bering Sea shelf, and are cropping what appear to be slow-growing species (Feder, unpublished observations) such as polychaetous annelids, snails, and clams. However, nektobenthic and pelagic crustacea such as amphipods and euphausids may grow more rapidly in the nutrient-rich water at the shelf edge, and may provide additional important food resources there.

Some marine mammals of the Bering Sea feed on benthic species (see Lowry and Burns, 1976). Walrus feed predominantly on what appear to be slow-growing species of molluscs, but seals prefer the more rapidly growing crustaceans and fishes in their diets (Fay *et al.*, 1975). Although showing food preferences, marine mammals are opportunistic feeders. As a consequence of the broad spectrum of food utilized and exploitation of secondary and tertiary consumers, marine mammals are difficult to place in a food web and to assess in terms of energy cycling. Intensive trawling and oil-related activities on the Bering Sea shelf may have important ecological effects on benthic organisms used as food by marine mammals. If benthic trophic relationships are altered by these industrial activities, marine mammals may have their food regimes altered.

IV. STUDY AREAS

The established stations for Kodiak, the NEGOA, Cook Inlet and Bering Sea study areas are tabulated, figured and discussed in the 1977 OCSEAP Annual Reports (Feder, 1977; also see Feder and Jewett, 1977). Stations for the 1978 Kodiak inshore and offshore studies will be determined in conjunction with ADF&G and National Marine Fisheries Service (NMFS).

V. SOURCES, METHODS AND RATIONALE OF DATA COLLECTION

Kodiak Shelf

Invertebrates obtained by trawl were separated, enumerated and weighed according to the methodology described in Feder (1977) and Feder and Jewett (1977). All invertebrates were given tentative identifications, and representative samples of individual species preserved and labeled for final identification at the Institute of Marine Science, University of Alaska, Fairbanks.

Lower Cook Inlet

Methodology for the investigations of 1976-77 is included in Feder (1977). Sampling was accomplished with an Eastern otter trawl, try net, Agassiz trawl, pipe dredge, and van Veen grab. Preliminary workup of trawl material was accomplished onboard ship. All dredge and grab material were washed on 1.0 mm screens. All invertebrates were given tentative identifications, and representative samples of individual species preserved in 10% buffered formalin, and labeled for final identification at the Institute of Marine Science and the Marine Sorting Center, University of Alaska, Fairbanks. Stomachs of selected species (e.g. shrimps, king crabs, snow crabs, hermit crabs) were either examined on shipboard or in the laboratory. All species used in feeding studies were measured, separated by sex where readily possible (e.g., in crabs but not necessarily in shrimps), and separated into as many size groups as possible. Clams used in growth studies were separated from sediments on shipboard and in the laboratory, and measurements made on them in the laboratory.

Final analysis of material was accomplished in the laboratory and the Marine Sorting Center, University of Alaska, by methods developed in past offshore OCSEAP studies (Jewett and Feder, 1976; Feder, 1977; Feder and Jewett, 1977). All species were assigned Taxon Code numbers, and summarized according to computer programs developed for other benthic studies by Feder (for example, see Feder, 1977).

All data were summarized and analyzed with the aid of available or specially written computer programs at the University of Alaska. Growth-history analyses of clam species was applied according to techniques described in Feder and Paul (1974) and Paul *et al.* (1976).

Food webs were constructed.

Northeast Gulf of Alaska (NEGOA)

No sampling or laboratory activities took place on this project in 1977. Activities in 1977 were concerned with preparation of infaunal data for a Final Report (see Feder, 1977 for methodology employed for workup of quantitative data collected on past cruises).

Bering Sea

No sampling or laboratory activities took place on this project in 1977. Activities in 1977 were concerned with preparation of infaunal and epifaunal data for a Final Report (see Feder, 1977 for methodology employed for workup of data collected on past cruises).

VI. RESULTS

Kodiak Shelf

A final report, based on collections made on board the M/V *Big Valley* in June, July, August 1976 and March 1977 in two bays (Alitak and Ugak), has been completed, and has been submitted to OCSEAP (Feder and Jewett, 1977).

Activities for this fiscal year have consisted of planning sessions at the Institute of Marine Science, and a NOAA/BLM sponsored coordination meeting in Anchorage in February 1977.

Lower Cook Inlet

A final report, based on cruises of the R/V *Moana Wave* and NOAA Ship *Miller Freeman* in 1976, has been completed and is included with this annual report (Final Report, Sect. II; also see Feder, 1977).

Food Studies

Currently, University of Alaska food studies in Cook Inlet are centered on the snow crab, *Chionoecetes bairdi* and its known prey species. The goal of these studies is to expand the food web presented in the previous report (Feder, 1977). The results of these studies will be useful in (1) explaining the distribution of adult and juvenile snow crabs, (2) understanding the interrelationships of snow crabs to other organisms, such as king crabs or some bottom fishes, which also feed in the benthic environment, and (3) describing the effect of snow crab feeding on the populations of prey species. Initial collections were carried out in Cook Inlet aboard the NOAA Ship *Miller Freeman*. Trawl stations were established throughout the Inlet, and eleven stations with large numbers of crabs were selected for the food study. Sampling with dredges, grabs and trawls at each station made it possible to obtain information on potential prey, and facilitated identification of stomach contents.

Food occurred in 428 (60%) of 715 snow crabs examined and included representatives of four phyla and seventeen genera (Paul *et al.*, in press). Clams, hermit crabs and barnacles were the dominant food organisms (Fig. 1). The most frequently occurring food items were small clams, especially *Macoma* spp; remains of this clam were found in 149 stomachs from six of the eleven stations. The majority of the clams preyed upon by snow crabs were small and rarely exceeded 25 mm in length. Hermit crabs (family Paguridae) were next in importance, and occurred in 147 stomachs from nine of the eleven stations. Gray shrimps (family Crangonidae) and barnacles (*Balanus* spp.) were found in 47 and 76 stomachs from seven and eight stations respectively. Juvenile snow crabs were found in the stomachs of five mature crabs. Polychaetes, amphipods, and ophiuroids occurred occasionally. Fifty-one stomachs contained only sediment.

Stomachs with food commonly contained the remains of several barnacles or clams. In one stomach, sixteen young-of-the-year clams, *Macoma* spp. were found. Few stomachs contained more than one of the larger prey species, i.e., crabs or shrimps. No difference was detected in the frequency of occurrence of prey in *C. bairdi* of different size or sex. Juvenile snow crabs simply ate smaller individuals of the prey species than did the mature crabs.

The stomach contents of the common hermit crabs of Cook Inlet, collected in November 1977, have been examined. Important prey items include small clams, barnacles, other hermit crabs, and plant material. In addition, large amounts of sediment (i.e., stomachs 1/4 to 1/2 filled with sediment) generally occurred in the stomachs (Table I).

Collections of gray shrimps, *Crangon dalli* and *Argis dentata*, and the pink shrimp, *Pandalus borealis*, were also made in November 1977. One collection of newly settled snow crabs has also been made.

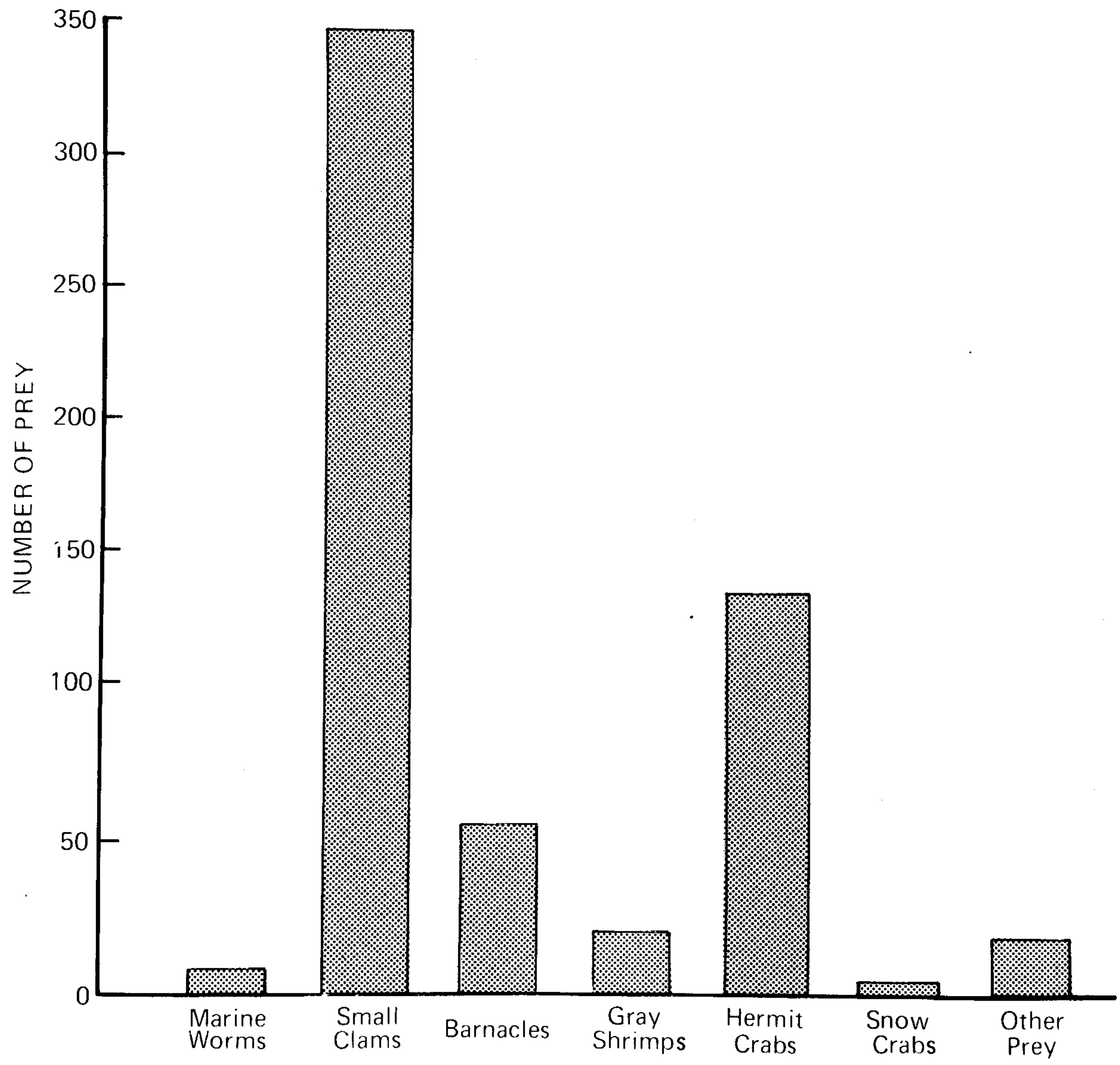

Figure 1. The number of prey found in 715 snow crabs from lower Cook Inlet.

TABLE I

FREQUENCY AND PERCENT FREQUENCY OF OCCURRENCE OF FOOD ITEMS IN STOMACHS OF HERMIT CRABS, COLLECTED IN LOWER COOK INLET, NOVEMBER 1977. N=NUMBER EXAMINED.

		PREY ITEMS								
		Foraminifera	Small Clams	Snails	Unidentified Crustaceans	Barnacles	Hermit Crabs	Plant Material	Sediment	Empty
Species	N	FREQUENCY								
Pagurus ochotensis	91	2	47	4	3	18	13	17	69	7
P. capillatus	23	8	-	1	2	3	1	1	6	1
P. beringanus	31	-	-	-	5	1	6	4	19	2
Elassochirus tenuimanus	15	-	-	-	2	2	8	-	6	1
TOTAL FREQUENCY OF OCCURRENCE	160	10	47	5	12	24	28	22	100	11
PERCENT FREQUENCY OF OCCURRENCE		6.2	29.4	3.1	7.5	15.0	17.5	13.8	62.5	6.9

Biology of Bivalves

Bivalves are an important link in benthic food webs leading to snow crabs, king crabs, dungeness crabs, hermit crabs, flatfishes and other organisms in Cook Inlet. The biology of some common subtidal clams has been examined. The ultimate goal of this study was to provide data useful for monitoring oil-induced changes in the environment and to determine the productivity of these important infaunal organisms.

The age structure of six species of clams from several Cook Inlet stations is presented in Table II.[1] It is evident from aging studies that annual recruitment success can be expected for the six species of clams investigated. However, such recruitment does not necessarily take place every year at each station, and in fact, the number of clams of any given age varies considerably from station to station. As a result of this variability, population monitoring at individual stations may not be feasible. However, yearly growth and growth histories of these clams can be determined by the annular aging method. Measurement of growth and examination of growth histories provide promising techniques for detecting changes in the environment which may affect the growth rates of bivalves. These data are also necessary for the determination of mortality rates and secondary production of clams. The latter studies are now in progress.

Effect of Augustine Island Volcanic Eruption on the Benthic Environment

Cook Inlet benthic Station 35 (latitude 59°26.2', longitude 153°19.0'), just north of Augustine Island was occupied in April and October of 1976 (the year the most recent eruption of this volcano occurred) and again in November 1977 (see Feder, 1977 and Section II of the present report for station location). A large amount of volcanic pumice, the result of the eruption, occurred in benthic trawls in the 1976 survey. Prior to the eruption, the bottom around the island had little rocky substrate and settling organisms, such as barnacles, were restricted primarily to biological substrates such as shells and crab carapaces.

During our 1976 survey, samples of pumice were examined for settling organisms. No settlement was observed. Similar samples taken from two

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[1]Also see detailed treatment of Cook Inlet clam data in the attached Final Report, Section II.

TABLE II

AGE AND MEAN SHELL LENGTHS (mm) OF SIX SPECIES OF BENTHIC BIVALVES FROM SEVERAL LOWER COOK INLET STATIONS

Age (Years)	*Nucula tenuis*	*Nuculana fossa*	*Glycymeris subobsoleta*	*Spisula polynyma*	*Macoma calcarea*	*Tellina nuculoides*
0	1.7	2.1	2.1	5	1.9	2.3
1	2.3	3.7	3.6	10	3.4	3.6
2	3.3	6.7	5.0	15	5.3	5.4
3	4.3	9.0	8.3	21	7.4	7.5
4	5.3	10.9	10.8	26	9.2	8.8
5	6.2	12.9	13.6	38	11.9	10.2
6	-	14.0	16.3	43	14.3	10.7
7	9.3	16.2	18.4	-	16.9	11.4
8	-	-	19.8	82	18.2	12.4
9	-	-	21.8	80	20.1	12.8
10	-	-	26.0	92	22.4	13.5
11	-	-	27.0	98	24.2	14.2
12	-	-	-	107	26.7	15.0
13	-	-	-	112	28.3	16.4
14	-	-	-	114	31.4	-
15	-	-	-	120	-	-
16	-	-	-	118	-	-

trawls at stations in 1977 showed that large numbers of barnacles, *Balanus* sp., had settled on most of the pumice examined.

The average exposed surface area of ten pieces of pumice randomly selected from two trawls was approximately 21.2 cm^2 and 6.2 cm^2 respectively. The percentage of surface of the pumice covered by the barnacles was estimated utilizing a metric grid and calipers. The average percentage of rock surface covered by barnacles for the two trawls was similar, approximately 31.7% and 31.1%, in both sets of samples. The average number of barnacles on the pumice from the two trawls was 15 and 6 respectively (Table III). The range of distribution was between 0 and 32 barnacles per rock. Only one piece of pumice was free of barnacles. There were two distinct size classes of barnacles present on the pumice. The average height and diameter of the larger and more common barnacle size class was 8.0 (standard deviation [S.D.] = 1.3) mm and 7.6 (S.D. = 1.4) mm respectively (Table III). The small standard deviations of shell heights and diameters of the large barnacle size class and the fact that no barnacles were observed on pumice in the original collections of October 1976 suggest that the large barnacles are the product of a single settlement in the late fall or early winter of 1976.

Four of the twenty pieces of pumice examined in November also had newly settled barnacles (average height of 1.3 mm and diameter of 1.9 mm) present. The occurrence of these newly settled barnacles in November 1977, the existence of ripe gonads in the adults examined in November 1977, and the failure to find barnacles on pumice in October 1976 suggest that this species, in Cook Inlet, may spawn and settle during the late fall and early winter.

The stomach contents of potential barnacle predators taken in trawls were examined. Thirty king crabs, *Paralithodes camtschatica*, collected at Station 35 had full stomachs. All crabs had barnacles in their stomachs; 60% of these crabs were feeding exclusively on barnacles. The stomach contents of all king crabs feeding exclusively on barnacles were digested in KOH, and the shell weight remaining after KOH digestion determined. In addition, the average shell weights of barnacles, randomly selected and counted on pieces of pumice taken in trawls, were determined in a similar manner. Utilizing this data, an estimation of the average number of barnacles in each of the king crab stomachs was made. The stomachs contained

TABLE III

BARNACLE SIZE AND DENSITY ON SUBTIDAL VOLCANIC PUMICE FROM LOWER COOK INLET STATION 35, NOVEMBER 1977

Number of pumice pieces	Mean exposed pumice surface area	% surface covered by barnacles	$\bar{X}$ number of barnacles	$\bar{X}$ barnacle height	$\bar{X}$ barnacle diameter
Trawl 1					
10	21.2 cm^2	31.7	15.2	8.0 mm	7.6 mm
Trawl 2					
10	6.2 cm^2	31.1	6.1	7.6 mm	7.2 mm

barnacle shells equivalent to an average of 11.2 (S.D. = 7.4) barnacles per crab. King crabs were not present in trawl catches from station 35 in 1976; this suggests that this predator has been attracted by the presence of barnacles, a new and abundant food source.

Other organisms taken in the trawls with barnacles in their stomachs were the hermit crab (*Pagurus ochotensis*) and the snow crab (*Chionoecetes bairdi*). Of twenty-five *P. ochotensis* examined at Station 35, 55% had barnacles in their stomachs. *Pagurus ochotensis* is also an important prey species for the commercially important snow crab *Chionoecetes bairdi*. Two *C. bairdi* were also captured with barnacles in their stomachs at this station. Barnacles are frequently eaten by *C. bairdi* throughout most of Cook Inlet (Feder, OCSEAP Reports).

Based on the information available for Station 35, it is apparent that the substrate provided by the volcanic eruption of Augustine Island has had an important effect on population densities of barnacles and the food habits of benthic crabs. Further study of the extent of this newly added hard substrate, barnacle settlement, the effect of this settlement on local food webs, and the reproductive biology of benthic invertebrates should be encouraged. Continuing studies of king crabs, snow crabs, and other crustacean feeding habits throughout lower Cook Inlet are planned as part of our continuing OCSEAP investigations there.

Laboratory Studies Currently in Progress

A cruise on the NOAA Ship *Surveyor* resulted in the collection of large numbers of epifaunal organisms. Live snow and king crabs, hermit crabs and some pandalid shrimps were returned to the Seward Marine Laboratory for behavioral, reproductive and feeding studies. These animals are feeding, and have survived with minimal mortality. Snow, king, and hermit crabs have molted in the tanks. Snow and king crabs have also copulated, and some of these females are now ovigerous. One female king crab released larvae in one of the tanks; the larvae have survived for two weeks on a diet of live copepods. Additional detailed information should be available for the next progress report.

Northeast Gulf of Alaska (NEGOA)

Benthic Infaunal Program

The infaunal sampling program conducted in the field is now completed (see Feder, 1977 for further details). A discussion of the results of cluster analysis of all data available to date is included in Appendix VI of the Annual Report for 1977 (Feder, 1977). All data from the NOAA Ship *Discoverer* cruise D5001 have been processed and analyzed using cluster and principal coordinate analysis routines. We are presently in the process of interpreting this data and comparing it with the results obtained from previous cruises (Feder, 1977; Feder *et al.*, 1976b; Matheke *et al.*, in press).

Trawl Program

The basic intent of the joint benthic invertebrate-demersal fish program was fulfilled by collection of invertebrate samples and fish stomachs on three legs (25 days per leg) of the Northwest and Alaska Fishery Center trawl charter, from May through August, 1975.

All samples have been processed, species identified, and all data tabulated (stored on magnetic tape at NODC).

Taxonomic analysis delineated 9 phyla, 19 classes, 82 families, 124 genera, and 168 species of invertebrates from 140 stations. Mollusca, Arthropoda (Crustacea), and Echinodermata dominated species representation with 47, 42 and 36 species taken respectively. The same phyla made up 95% of the invertebrate biomass in this order: Arthropoda (71.4%), Echinodermata (19.0%), and Mollusca (4.6%).

All data have been reported in detail in Feder (1977) and Jewett and Feder (1976).

Cod Feeding Studies

All data for this section are included in the OCSEAP Annual Report (Feder, 1977) and in Jewett (1977; and in press).

Bering Sea

General Comments

A final report, based in part on grab, pipe dredge, and trawl collections discussed in Feder (1977), is in preparation.

The grab data representing the stations listed in Table IV have been analyzed to determine station groupings. A total of 62 stations were analyzed; 59 of these were previously examined (Feder, 1977). The stations were classified with respect to both 180 and 218 species as variables. The former case includes all individuals occurring in at least five stations; the latter represents individuals occurring at least three times. The criterion for inclusion in this year's study was the representation of each station by at least three grabs. Several methods were used to determine station groupings: cluster analysis (hierarchical, average-linkage, using Czekanowski's coefficient: see Feder, 1977), principle coordinates (using Czekanowski's coefficient as a distance measure) and principle components (using the taxon-taxon correlation matrix). A composite picture of the results is presented in Figure 2.

In all three analyses the raw data was untransformed or ln-transformed numbers of individuals per square meter for the 180 taxon data set. Both the 218 taxon data set (counts and weights) and wet weights from the 180 taxon data set proved to be too poorly structured to yield interpretable results.

The station groupings shown in Figure 2 are a decided compromise between the results of the three methods. The inclusion of the station string 60-65 (data not available in 1977) has resulted in only minor changes in the interpretation of this data. Most noteworthy is the development of a continuous outershelf group (STA 16, 17, 18, 31, 29, 36, 54, 64, 65, 70) giving the impression of contiguous communities lying in bands oriented along major bathymetric zones (i.e. near shelf break, mid-shelf, near shore). In general, the stations at the extreme ends of the groups were difficult to classify, showing different affinities with different techniques. These ambiguities will be dealt with in detail in the final report.

An Analysis of Invertebrate (Primarily clams) Distribution in Relation to Sediment Types

The clam distribution data were obtained from 44 stations located on the eastern Bering Sea shelf.

The four most abundant species of clams, *Nucula tenuis*, *Nuculana fossa*, *Cyclocardia crebricostata* and *Macoma calcarea*, were selected for

TABLE IV

BERING SEA BENTHIC GRAB STATIONS USED IN THE AGGLOMERATIVE HIERARCHICAL CLUSTER ANALYSIS

Station	Latitude	Longitude
1	55°18'	163°18'
2	55°51'	162°17'
3	56°17'	161°02'
4	56°46'	159°52'
5	57°21'	158°58'
6	57°43'	159°05'
7	57°58'	158°15'
8	58°17'	159°32'
9	57°55'	160°08'
10	57°19'	161°06'
11	56°45'	161°59'
12	56°09'	162°56'
13	55°33'	163°49'
14	54°39'	165°25'
15	54°18'	167°36'
16	54°53'	166°44'
17	65°29'	165°50'
18	56°06'	164°54'
19	56°40'	163°57'
20	57°15'	163°05'
22	57°50'	162°11'
23	58°20'	161°21'
24	58°46'	162°29'
25	58°19'	163°13'
27	57°40'	164°16'
28	57°10'	165°04'
29	56°36'	165°57'
30	56°00'	166°51'
31	55°22'	167°47'
35	56°13'	168°20'

TABLE IV

CONTINUED

Station	Latitude	Longitude
36	56°31'	167°55'
37	58°40'	169°00'
38	57°40'	166°06'
39	58°03'	165°29'
40	58°08'	165°16'
41	58°47'	164°15'
42	59°16'	165°20'
43	58°42'	166°17'
45	58°10'	167°10'
49	56°25'	169°56'
57	58°36'	168°13'
59	59°12'	167°18'
60	59°43'	166°24'
61	59°39'	168°22'
62	59°06'	169°15'
63	58°33'	170°10'
64	58°01'	171°08'
65	57°25'	172°05'
924	57°28'	167°28'
935	58°50'	169°19'
937	58°41'	169°18'
939	58°29'	169°19'
941	58°20'	169°19'
942	58°28'	169°23'
47	56°58'	169°01'
55	57°29'	170°08'
70	58°29'	172°11'
71	59°04'	171°10'
72	59°34'	170°19'
73	60°02'	169°29'
82	60°33'	170°29'
83	60°02'	171°26'

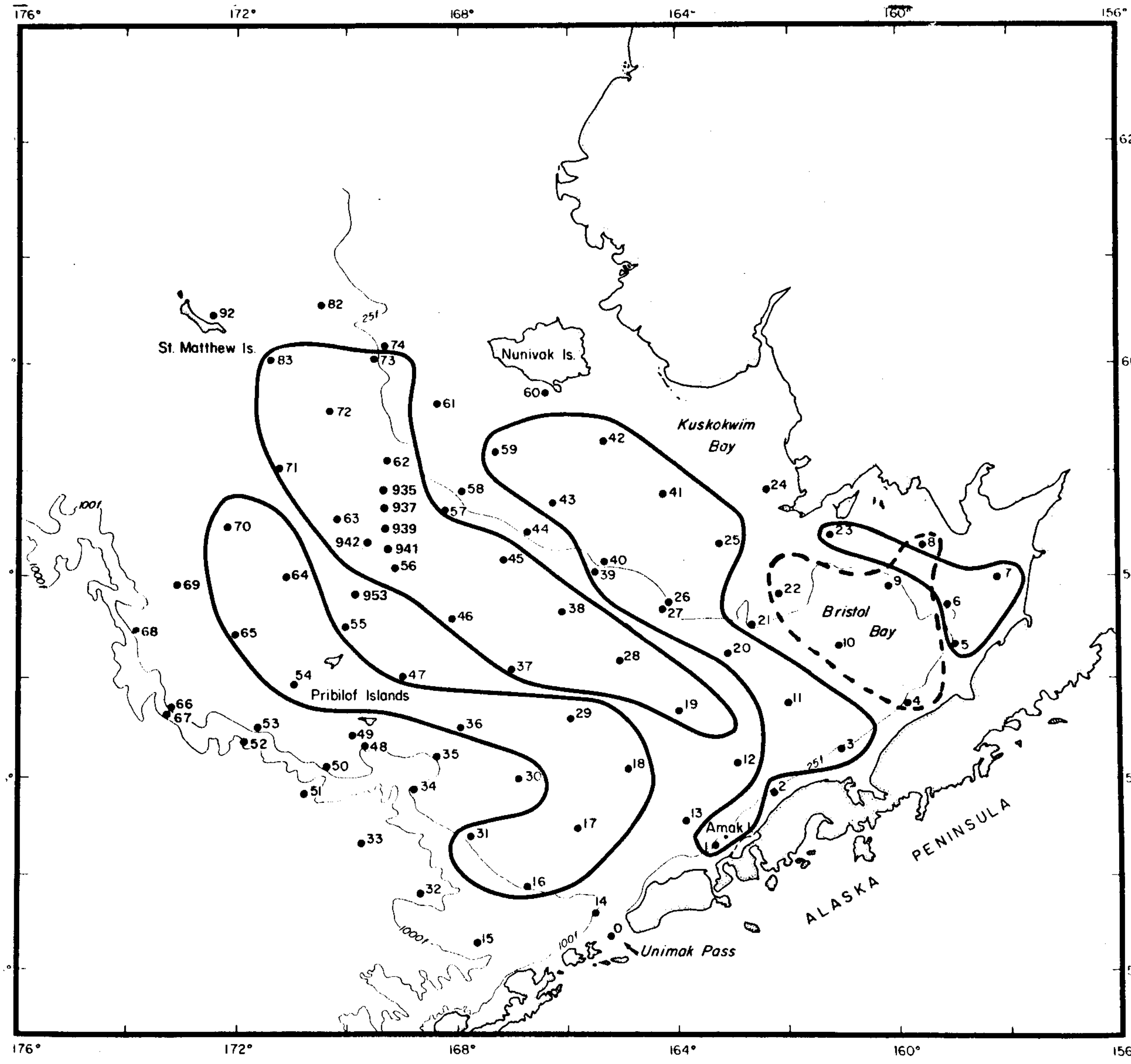

Figure 2. Major station groups identified by cluster, principle components and principle coordinates analyses of 62 stations, variables are LN (C + 1), C = # individuals/m^2.

consideration from 76 species. *Tellina lutea* did not fit the chosen criteria, but was also selected due to its potential commercial value.

The sediment (ϕ) phi values increased with distance from shore, depth and decreased circulation. A low species diversity and abundance occurred in shallow water with coarse unsorted sediments. The greatest diversity and abundance occurred in deep water where finely sorted sediments were combined with high organic carbon values.

Macoma calcarea and *Cyclocardia crebricostata* exhibited the widest distribution in relation to sediment particle size and depth, while *Nucula tenuis* and *Nuculana fossa* distributions were confined to finely sorted sediments on the mid-shelf area. *Tellina lutea* was confined to the inner shelf area of moderately sorted sediments.

VII. DISCUSSION

Kodiak Shelf and NEGOA

Data and discussions for these two regions are available in the OCSEAP Annual Report for 1977 (Feder, 1977), the Final Report for two bays of Kodiak (Feder and Jewett, 1977), and the Final Report for the Northeast Gulf of Alaska (Jewett and Feder, 1976).

Further OCSEAP research activities are planned for the spring and summer in Kodiak, and are currently underway for Cook Inlet by way of laboratory and cruise activity.

Lower Cook Inlet

A full discussion of the cruises of the R/V *Moana Wave* and NOAA Ship *Miller Freeman* in 1976 are included in the section on Cook Inlet appended to this Annual Report as Section II.

Bering Sea

Data and preliminary discussion of this region is presented in the 1977 OCSEAP Annual Report (Feder, 1977). Final reports that will encompass two years of data collection are in preparation. These reports will contain information obtained by van Veen grab, pipe dredge and trawl. Special attention will be given to mathematical treatment of grab sample data, feeding interactions and clam biology.

VIII. CONCLUSIONS

Kodiak Shelf

Fifty-three permanent stations have been established in two bays of Kodiak Island - Alitak (28 stations) and Ugak (25 stations) bays (see Final Report: Feder and Jewett, 1977). There is now a satisfactory knowledge, on a station basis (for the months sampled), of the distribution and abundance of the major epifaunal invertebrates of the two study bays. Twelve phyla were represented in the collections. The important groups, in terms of species, in descending order of importance were Arthropoda (Crustacea), Mollusca, Echinodermata and Annelida. The latter three groups accounted for less than 1.0% of the biomass collected in each bay, while Arthropoda accounted for 95.8 and 99.1% of the biomass in Ugak and Alitak Bay respectively.

Additional seasonal data are essential. It is only when such continuing information is available that a reasonable biological assessment of the effect of an oil spill on these bays can be made.

Differences in sex composition and stage of maturity of king and snow crabs between and within the two bays were evident. Throughout the sampling period in Alitak Bay, king crabs occurred mainly at the outer stations and consisted primarily of egg-bearing females and juveniles of both sexes. King crabs were well dispersed throughout Ugak Bay during this period, and consisted mainly of juveniles. Snow crabs in Alitak Bay were primarily juveniles while mainly adult males inhabited Ugak Bay. Life history data for these crabs for March, June, July and August are now available.

Preliminary feeding data for the most common epifaunal species of the two bays is presented in Feder and Jewett (1977). Of special importance is the food data compiled for the two commercially important crabs of the Kodiak area - snow and king crabs. These data in conjunction with similar data compiled for these two species in Cook Inlet and the Bering Sea (Feder, 1977) should contribute to an understanding of the trophic role of these crabs in their respecive ecosystems and the impact of oil on crab-dominated systems such as those found in Alitak and Ugak Bays.

The importance of deposit-feeding clams in the diet of king and snow crabs is demonstrated for the two bays; this situation is also true for crabs observed elsewhere. A high probability exists that oil hydrocarbons will enter crabs *via* these deposit-feeding molluscs, suggesting that studies interrelating sediment, oil, deposit feeding clams, and crabs should be initiated soon.

Sampling crabs and fishes using trawls and stomach analysis has made it possible to understand a major component (the epifauna) of two Kodiak bays. However, a full comprehension of the benthic systems there will only be achieved when these studies are expanded to include an assessment of infauna as well. Data available suggest that adequate numbers of unique, abundant, and/or large species are available to permit nomination of likely monitoring candidates. Presumably, a monitoring program would be based primarily on recruitment, growth, food habits, and reproduction of the chosen species.

Lower Cook Inlet

The Final Report (attached as Section II) summarizes the benthic invertebrate work accomplished in Cook Inlet in 1976, and discusses the major findings for this period. The Conclusions for this period of activity are included in Section II of this Report.

Northeast Gulf of Alaska (NEGOA)

Data collected since the inception of the studies in NEGOA in 1974 have made it possible to comprehend various aspects of the distribution, abundance, and general biology of the more important invertebrate components of the shelf. Some generalization are now possible, and are included below (also see Feder and Mueller, 1975; Feder *et al.*, 1976b; Feder, 1977 for the data base used for conclusions below).

Forty-two widely dispersed permanent stations have been established to sample the infauna in the northeastern Gulf of Alaska in conjunction with the physical, chemical, heavy metals and hydrocarbon programs. These stations represent a reasonable nucleus around which a monitoring program can be developed (Feder, 1977).

The sampling device chosen, the van Veen grab, functioned effectively in all weather and adequately sampled the infauna at most stations. Penetration was excellent in the soft sediments characteristic of the majority of stations; poor penetration occurred at a few stations where the substratum was sandy or gravelly. General patchiness of many components of the infauna and quantitative field testing for optimum number of replicates per station suggest that five replicate grabs are adequate.

There is now a reasonable understanding, for grab stations occupied on the NEGOA shelf, of the invertebrate species present and general species distribution. Four hundred and fifty-seven (457) species have been identified. Fourteen marine phyla are represented in the collections. The important groups, in terms of number of species in descending order, are the polychaetous annelids, mollusca, arthropod crustaceans, and echinoderms. It is probable that all species with numerical and biomass importance have been collected and that only rare species will be added to the list in the future.

The diversity indices included in the 1976 Annual Report (Feder *et al.*, 1976b), Simpson, Brillouin, and Shannon-Wiener, are complimentary since the former reflects dominance of a few species and the latter two are weighted in favor of rare species. Values calculated in the 1977 Annual Report (Feder, 1977), in general, reflect these weightings. A preliminary examination of the two measures of evenness (or equitability) indicates a reasonable relationship to the calculated diversity values. In general, high measures of evenness show numerical codominance of many species (with low Simpson index and high Shannon-Wiener and Brillouin indices) while low evenness measures imply marked dominance of a few species (high Simpson index and low Shannon-Wiener and Brillouin indices). All of these indices and measures must still be interpreted with considerable caution until more data are available. Further assessment of the meaning of the calculated values will be included in the NEGOA Final Report.

Criteria established for Biologically Important Taxa (BIT) for the grab data have delineated 95 species. These species have been subjected to detailed analysis in an attempt to comprehend station species aggregations or communities. Representative members of the BIT should be the organisms most intensively studied for their general biology in future work on the NEGOA shelf.

Information on feeding biology of most species has been compiled. Most of the information for the northeast Gulf of Alaska is from literature source material; it is suggested that experimental work on feeding biology of selected species be encouraged for this region.

Clustering techniques have supplied us with valuable insights into species distributions on the shelf of the northeast Gulf of Alaska. The preliminary grouping of stations by three different classification schemes has delineated three basic clusters - Group I, which is characterized by a group of stations south of Prince William Sound; Group II, which generally consists of stations close to shore; and Group III, composed of stations that are at or near the shelf edge. Further insight into the meaning of stations clustered by our analysis is gained by means of the two-way coincidence table of station groups vs. species groups. Specific groupings of species can be related to station clusters, and intermediate positions of stations (or clusters) can be determined by the particular groupings of species they have in common. Some insight into the stability of the cluster groups should be gleaned by examination of clustering of the second year station data. Analysis of this data is still in progress and will be considered in the Final Report (preliminary data and analysis are included as appendix Table V in Feder, 1977).

Initial qualitative assessment of data printouts of infaunal species (data to be stored at the National Evnironmental Data Center) indicates that (1) sufficient station uniqueness exists to permit development of an adequate monitoring program based on species composition at selected stations, and (2) adequate numbers of unique, abundant, and/or large species are available to ultimately permit nomination of likely monitoring candidates.

The trawl survey on the NEGOA shelf for investigation of epifaunal invertebrates and demersal fishes was effective (Jewett and Feder, 1976). The major limitations of the survey were those imposed by the selectivity of the gear used and the seasonal movements of certain species taken. In addition, rocky-bottom areas were not sampled since otter trawls of the type used in the survey could only be fished on relatively smooth bottom. However, the study was effective for determining the epibenthic invertebrates and demersal fishes present on sediment bottom and for achieving maximum spatial coverage of the area. Integration of this information with data on the infaunal benthos (Feder *et al.*, 1976b; Feder, 1977) will enhance our understanding of the shelf ecosystem.

To date this investigation represents the only intensive taxonomic survey of epibenthic invertebrates in the Gulf of Alaska. Although Hitz and Rathjen (1965) surveyed invertebrates and bottom fishes on the continental shelf of the northeast Gulf of Alaska in 1961 and 1962, invertebrates taken in their trawl were of secondary interest. Only major invertebrate species and/or groups were recorded, and organisms were grouped into eight categories in descending order of importance: heart urchins (Echinoides), snow crabs (*Chionoecetes bairdi*), scallops (*Pecten caurinus*), shrimps (*Pandalus borealis, P. platyceros*, and *Pandalopsis dispar*), king crabs (*Paralithodes camtschatica*), and miscellaneous invertebrates (shells, sponges, etc.). Additional data on commercially important shellfishes are available in Ronholt *et al.* (1976).

Preliminary analysis of epifaunal data from the present investigation indicates that molluscs, crustaceans, and echinoderms are the leading invertebrate groups on the shelf with the commercially important crab, *Chionoecetes bairdi*, clearly dominating all other species. Furthermore, stomach analysis of the Pacific cod, *Gadus macrocephalus*, on the Kodiak shelf area, reveals that *C. bairdi* is a dominant food item of that fish. Thus, the Pacific cod, a non-commercial species which has commerical potential (Jewett, 1977; and in press), is preying intensively on a species of great commercial significance. Laboratory experiments with *C. bairdi* have shown that postmolt individuals lose most of their lags after exposure to Prudhoe Bay crude oil (Karinen and Rice, 1974). The results of these experiments must be seriously considered in the course of development of petroleum resources in the Gulf of Alaska.

Highest densities of *Chionoecetes bairdi, Pandalus borealis, Ophiura sarsi, Ctenodiscus crispatus*, and fishes were recorded in the vicinity of the Copper River delta southwest to Kayak Island (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. Furthermore, enhanced productivity there may be related to the presence of gyres that extend vertically from the water surface to the bottom (Galt, 1976).

Availability of many readily identifiable, biologically well-understood infaunal and epifaunal invertebrates 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.

Bering Sea

Data collected since the inception of the studies in the Bering Sea have made it possible to comprehend various aspects of the distribution, abundance, and general biology of the more important invertebrate components of the shelf. Some generalizations are now possible, and are included below (also see Feder *et al.*, 1976a; Feder, 1977 for the data base for the conclusions below).

Seventy-seven widely dispersed permanent stations and seven stations of opportunity have been established in conjunction with the chemical, hydrocarbon, heavy metals, and geological programs. These station represent a reasonable nucleus around which a monitoring program can be developed. Sixty-two stations have been processed and analyzed to date.

The sampling device chosen, the van Veen grab, functioned effectively in all weather, and adequately sampled the infauna at stations with a sandy-mud or mud bottom. Poor penetration occurred at the stations where the substratum was sandy or gravelly. Since coarse sediments are more characteristic of the Bering Sea than the Gulf of Alaska, reduced volumes were found in most grabs throughout the station grid. However, an initial qualitative assessment of grab volumes obtained on most of the stations on the grid indicate that the majority of the stations can be considered quantitative (i.e., grab volumes greater than 5 ℓ). The general patchiness of many components of the Bering Sea fauna suggests that the five to six replicate samples taken per station are the minimum number that should be taken.

There is now a satisfactory data base for the invertebrate species (infauna and epifauna) for that portion of the Bering Sea shelf grid analyzed to date. Six hundred and forty-three (643) species have been isolated. Thirteen (13) marine phyla are represented in the collections. The important groups, in terms of number of species, are the Annelida (180 species), Arthropoda (129 species), Mollusca (109 species), and Echinodermata (17 species). It is probable that all infaunal and slow-moving epifaunal species with numerical and biomass importance were collected during the intensive sampling program of the spring, summer, and early fall of 1975 and 1976. It is assumed that only rare species will be added to the list in the future.

Insufficient data from the cruises of the NOAA Ships *Miller Freeman* and *Discoverer* are available to test for seasonal fluctuations in species by station. However, the series of cruises of these vessels in the spring, summer, and early fall of 1975 and 1976 made available some limited seasonal grab station data; no funds are currently available for processing these samples. Some mid-winter quantitative grab data are available from stations within the study area by way of investigations of Fay *et al.* (1975) and Stoker (1973). Additional qualitative information on distributions of infaunal species in the study area at various periods can be found in the Soviet literature (see Alton, 1974 for review).

The two diversity indices applied to infauna included in the 1976 Annual Report (Feder *et al.*, 1976b), Simpson and Shannon-Wiener, are complementary to each other since the former reflects dominance of a few species and the latter index is weighted in favor of rare species. No interpretations can be made at present on the available station data. These indices should be interpreted with caution until more data are analyzed.

Criteria established for Biologically Important Taxa (BIT) have delineated 121 species (Feder *et al.*, 1976a). These species will be ranked, and most of those of high rank subjected to detailed analysis in an attempt to comprehend species aggregations. Representative members of the BIT will be the organisms most intensively studied for their general biology.

Information on feeding biology of most species collected by grab has been compiled. Most of this information is from literature source material; it is recommended that experimental work on feeding biology for selected species be encouraged. Some qualitative assessment of the distribution of some infaunal species, their feeding methods, and the type of sediment found where they live has been included in the 1976 Annual Report (Feder *et al.*, 1976a). As analysis of sediments collected at each benthic station is completed, further integration of sediment parameters and resident biota will be made (see Hoskin, 1976 for preliminary comments on the relationship of sediments to biota).

The seasonal ice cover over much of the Bering Sea shelf, some indication of primary productivity several meters over the bottom, and seasonal upwelling in Bristol Bay suggest unique variations in energy flux and nutrient cycling. Explanations for benthic community structure in the Bering Sea should be sought, in part, in the unique variations of the ecosystem there. "A description of the structural components of that ecosystem and estimates of the rates at which the underlying processes operate will lead...to increased knowledge of such systems in general,..." (Hood, 1973). The shallow shelf benthic system will be examined by multivariate statistical techniques applied to species present in an attempt to cluster or aggregate groups of stations and species. Once this is accomplished, community structure will be examined by examining trophic interactions of resident species within clusters. Additional infaunal information obtained using the pipe dredge, which samples deeper into the sediment, will obviously increase the number of known species. Pipe dredge data will also greatly assist in the analysis and understanding of some of the crab and fish feeding data.

The joint National Marine Fisheries Service trawl charter for investigation of epifaunal benthos was effective, and maximum spatial coverage was achieved. Integration of this information with the benthic infauna data will enhance our understanding of the shelf ecosystem.

Although other investigations of benthic epifauna have been accomplished in the Bering Sea, our work results in more thorough and complete numerical and weight determinations. The invertebrate species most commonly found at the trawling stations of the *Miller Freeman* cruises of 1975 and 1976 (Feder *et al.*, 1976b) were *Asterias amurensis, Chionoecetes opilio, Neptunea* spp., *Buccinum* spp., *Gorgonocephalus caryi, Pagurus ochotensis, P. trigonocheirus, Halocynthia aurantium* and *H. igaboja*. The area sampled in 1975 was generally not deeper than 73 m (40 fathoms). Stations occupied in 1976 were generally deeper than 73 m. Obvious differences in species representation were noted with depth. Additional data will be presented and discussed in the Final Report.

In conclusion, it can be stated that sampling by means of grabs, pipe dredge, and trawls as well as stomach analysis of demersal fishes is essential if we are to fully comprehend trophic interactions in the benthic environment of the Bering Sea.

IX. NEEDS FOR FURTHER STUDY

Kodiak Shelf

Although the trawling activities were satisfactory for determination of the distribution and abundance of epifauna, a substantial component of both bays - the infauna - was not sampled. Since infaunal species represent important food items, it is essential that dredging be accomplished at the bay stations in the near future.

The present study has produced a data base describing the abundance, density, and distribution of epibenthic invertebrates as well as notes on reproductive biology of commercially important crabs during June, July, and August 1976, and March 1977. Additional studies are needed during other seasons and years to describe seasonal and year-to-year variations in the distribution and relative abundance of the epifauna.

Seasonal predator-prey relationships should be examined in conjunction with simultaneous infaunal sampling.

It is essential that large samples of the dominant clam prey species be obtained to initiate recruitment, age, growth, and mortality studies. These data will then be comparable to similar data being collected for clams of Cook Inlet and the Bering Sea (Feder, 1977). Any future modeling efforts concerned with carbon or energy flow in the Kodiak area will need this type of information.

No physical, chemical, and sediment data are currently available. This information should be obtained in the future in conjunction with all biological sampling efforts.

Lower Cook Inlet and NEGOA

The number of grab stations occupied in lower Cook Inlet and NEGOA was dictated by available ship time and funding essential to complete processing of the samples. Thus, a relatively small number of stations were occupied on the extensive shelf of the northeastern Gulf of Alaska. It is possible that some areas of significant biological importance were omitted. Additional stations should be occupied in the future to develop baseline data for some of the larger unsampled areas.

All samples taken on a semi-seasonal basis in lower Cook Inlet and NEGOA should be processed, and all data made available to the general program of study of the benthic stations for the area. Analysis of all archived samples will make it possible to develop better feelings for seasonality of benthic infauna.

Selected members of the infaunal Biologically Important Taxa (BIT) should be chosen for intensive study as soon as possible so that basic information will be available for development of 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.

The advantage of cluster analysis techniques used to examine infauna, is that it provides a method for delineating station groups useful for developing monitoring schemes and delimiting areas that can be used for studies of food-web interactions. It is obvious that food webs will vary in areas encompassing differing species assemblages. An inaccurate or even erroneous description of the shelf ecosystem could occur if trophic data collected on species from one station cluster (with its complement of species) is loosely applied to another area encompassing a totally different station cluster (with its differing complement of species). Thus, continuing development of clustering and other multivariate techniques should be pursued to refine methods to be certain the best methodology is available to a offshore monitoring program.

It appears that temporal change in species groups at stations will lead to confusion in the interpretation of station groups if stations are always pooled in time. Williams and Stephenson's (1973) technique (species x time x sites) provides an excellent solution to this problem, but it requires that a study area be completely sampled at least three times per year.

The cruises on NOAA vessels for grab-sampling and dredging, and the extensive trawl program in lower Cook Inlet and NEGOA resulted in relatively complete coverage of the benthos for invertebrate organisms. The needs for the future are development of a monitoring plan, additional trawl data on a seasonal basis inclusive of intensive sampling of stomachs of a diversity of species, assessment of sediment - deposit feeder - predator relationships, and further grab-sampling, dredging, and trawl sampling.

It is highly recommended that serious thought be given to the development of an extensive modeling effort in the northeastern Gulf of Alaska inclusive of Kodiak and Cook Inlet. The substantial body of data on trophic interactions of organisms of the benthos, collected by Feder (1977), Feder and Jewett (1977), and Smith *et al.* (1977) for this region, suggests that a sufficiently large data base may now be available to initiate such an effort or at least to begin workshops to asses the possibility of a modeling effort.

Bering Sea

Although the van Veen grab is satisfactory for use in the Bering Sea at stations with soft sediments, it is less satisfactory at stations with coarse fractions. Penetration of the grab was often not sufficient at the latter stations, and large infaunal species may have been missed by the grab. The use of a pipe dredge in 1976 collected some species that were deeper in the sediment. However, use of a box core sampler at some of these stations is indicated, and is suggested for the near future.

The number of grab stations occupied was dictated by available ship time and funding essential to complete processing of the samples. Thus, a relatively small number of additional stations should be occupied in the future to develop some baseline data for the unsampled areas. Additional funds should be made available to complete the additional stations.

Seasonal data on an approximately quarterly basis would be useful. It is especially recommended that under-ice samples be obtained when Coast Guard icebreaker capabilities are increased.

Selected members of the infaunal Biologically Important Taxa (BIT) 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.

The advantage of the cluster analysis technique for examining infauna is that it provides a method for delineating station groups that can be used for developing monitoring schemes and delimiting areas that can be used for studies of food-webs. It is obvious that food webs will vary in areas encompassing differing species assemblages. An inaccurate or even erroneous description of the shelf ecosystem could occur if trophic data collected on species from one station cluster (with its complement of species) is loosely applied to another area encompassing a totally different station cluster (with its differing complement of species). Thus, development of clustering and other multivariate techniques should be pursued to refine methods to be certain the best methodology is available to the projected offshore monitoring program.

A closer integration with the geological program is essential to better comprehend faunal-sediment interactions. It is recommended that our studies be closely coordinated sediment geologists in preparation of the Final Report.

The extensive trawl program in conjunction with the National Marine Fisheries Service permitted complete coverage of the benthos for invertebrate organisms. Considerable effort is still needed to complete this program in the current contract period, and the following is needed: maps of distribution and abundance for selected species, calculations of diversity indices, derivation of a list of Biologically Important Taxa application of cluster analysis techniques to groups of species and stations, and further assessment of the results of food studies. The needs for the future to trawling activity are development of a monitoring plan as well as collection of additional trawl data on a seasonal basis. Additional food data are essential.

The body of data on trophic interaction between organisms of the benthos in the Bering Sea (Feder, 1977; Smith *et al.*, 1977) suggests that a sufficiently large data base may now be available to initiate a modeling effort for the Bering Sea or at least to initiate workshops to assess the possibilities that exist for such an effort.

X. SUMMARY OF FOURTH QUARTER OPERATIONS

A. Ship or Laboratory Activities

1. Ship or field activities:

   a. NOAA Ship *Surveyor*, November 1977

   b. R/V *Acona*, November 1977

2. Scientific Party

   a. NOAA Ship *Surveyor* - A. J. Paul, J. McDonald, Phyllis Shoemaker

   b. R/V *Acona* - A. J. Paul, J. McDonald, H. M. Feder, Phyllis Shoemaker, Randy Rice

3. Methods, results and discussion

   a. A final report on Ugak and Alitak Bay (Kodiak) was submitted.

   b. A NOAA/BLM Kodiak Coordination meeting was attended by H. M. Feder in Anchorage.

   c. A final report for Cook Inlet, based on the first two years of activities in the Inlet, has been completed.

   d. A NOAA/BLM Cook Inlet synthesis meeting was attended by H. M. Feder, A. J. Paul, and Stephen Jewett.

   e. All grab data from NEGOA are being analyzed in preparation for the development of a final report for the area.

   f. The two year backlog of Bering Sea trawl data is being organized into a final report; tables and figures are in progress for that report.

   g. All grab and pipe-dredge data from the Bering Sea are being processed and organized in preparation for development of a final report.

   h. Snow crabs, king crabs, and hermit crabs collected in Cook Inlet on the NOAA Ship *Surveyor* in November are living in running seawater tanks of the Institute of Marine Science, Seward Marine Laboratory. Initial experiments on feeding interactions, food and crab condition and reproductive biology are in progress at the Seward Marine Laboratory.

   i. Procedures designed to examine bacterial biomass are being examined using sediments from Port Valdez, as part of a pilot project; procedures are to be applied to Cook Inlet sediments.

   j. Stomach analyses of juvenile snow crabs from Cook Inlet are in progress at the Marine Sorting Center, University of Alaska.

B. Problems Encountered

No major problems were encountered during this quarter.

C. Milestones

It is intended to maintain a consistent schedule for report preparation. Some of the reports will be subdivided into sections, each section to be submitted as it is completed. The latter procedure should increase the data flow and data interpretation available to OCSEAP. The schedule for report submissions are as follows:

1. Kodiak (Alitak and Ugak Bays) - Completed and submitted November.
2. Norton Sound-Chukchi Sea - Completed and submitted February.
3. Cook Inlet - Completed and submitted mid-March.
4. Bering Sea Trawl Report - To be submitted Late April.
5. NEGOA grab and trawl report - To be submitted Early May.
6. Bering Sea grab and pipe dredge report - To be submitted Early June.

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SECTION II

SUMMARY REPORT

DISTRIBUTION, ABUNDANCE, BIOMASS, AND TROPHIC RELATIONSHIPS OF THE INVERTEBRATE BENTHOS OF LOWER COOK INLET

ACKNOWLEDGEMENTS

We would like to thank the crews of the R/V *Moana Wave*, NOAA Ship *Miller Freeman*, and the M/V *Puffin* for logistic support. Thanks to the Alaska Department of Fish and Game for providing the bottom-skimmer samples as well as the *Spisula polynyma* used for the age-growth study. Special thanks are given to the following University of Alaska, Institute of Marine Science personnel: Rosemary Hobson for assistance in data processing; Ana Lea Vincent for drafting; Helen Stockholm and the Publications Department for aid in the completion of this report.

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

It was the intent of this investigation to broaden the background on composition, distribution, and biology of the infaunal and epifaunal invertebrates of lower Cook Inlet. The specific objectives were: (1) a quantitative and qualitative inventory of dominant benthic invertebrate species, (2) a description of spatial distribution patterns of selected species, and (3) preliminary observations of biological interrelationships between selected segments of the benthic biota.

Much of the baseline data on infaunal and epifaunal species needed prior to onset of petroleum-related activities in lower Cook Inlet is now documented. The van Veen grab, the only quantitative infaunal sampling device used, was of limited value because the high proportion of sand in sediments generally impeded grab penetration. On the other hand, a pipe dredge, also used to sample the infauna, provided valuable qualitative data. Agassiz and Eastern otter trawls made it possible to quantitatively sample the larger, more motile species.

In general, species composition decreased with larger sampling gear. Although only 13 stations were sampled with the van Veen grab, they yielded 211 species. The number of species taken by the small Agassiz trawl (149) exceeded the number taken by large Eastern otter trawl (53).

Biomass (g/m^2) from grabs and trawls were strikingly different. Use of trawls resulted in loss of infaunal and small epifaunal organisms, important components of the benthic biomass. Therefore, the total benthic biomass value is best expressed by combining both grab and trawl values.

Seventy-four percent of the species taken by grab were polychaetous annelids and molluscs; 56% of the pipe-dredge species were polychaetes and molluscs. Snow crabs (*Chionoecetes bairdi*) dominated the catches at most trawl stations. Based on the high number of juvenile snow crabs taken by trawls and found in fish stomachs from the deep-water region east of Cape Douglas, this area appears to be a major snow crab nursery site. The importance of this crustacean in lower Cook Inlet is further emphasized by the existence of an intensive fishery for *C. bairdi* in lower Cook Inlet.

Food data for snow crabs (*Chionoecetes bairdi*), king crabs (*Paralithodes camtschatica*), and 19 species of fishes are presented. The importance of deposit-feeding clams in the diet of king and snow crabs is demonstrated. It is suggested that comprehension of the relationship between oil, sediment, deposit-feeding clams, king and snow crabs is essential to an understanding of the potential impact of oil on the latter two commercially important species.

Based on grab and pipe dredge sampling, it is clear that bivalve molluscs are widely distributed and important components of the lower Cook Inlet subtidal sediment system. Analysis of clam growth histories provides a useful tool for assessing the general condition of these molluscs, i.e., any disruption of shell growth may reflect environmental changes. Growth-history analyses are available for six species of common subtidal clams from lower Cook Inlet: *Nucula tenuis, Nuculana fossa, Macoma calcarea, Tellina nuculoides, Spisula polynyma,* and *Glycymeris subobsoleta.*

Initial assessment of all data suggests that: (1) sufficient station uniqueness exists to permit development of monitoring programs based on species composition at selected stations utilizing grab, dredge, and trawl sampling techniques, and (2) adequate numbers of biologically well-known, unique, and/or large species are available to permit nomination of likely monitoring candidates once industrial activity is initiated.

II. INTRODUCTION

General Nature and Scope of Study

The operations connected with oil exploration, production, and transportation in Cook Inlet present a wide spectrum of potential dangers to the marine environment (see Olson and Burgess, 1967, for general discussion of marine pollution problems). Adverse effects of oil on the marine environment of these areas cannot be 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 types and density of species that might occur if the area becomes altered (see Lewis, 1970; Nelson-Smith, 1973; Pearson, 1971, 1972;

Rosenberg, 1973, for general discussions on benthic biological investigations in industrialized marine areas).

Benthic invertebrates (primarily the infauna, 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 numerous benthic epifaunal species of actual or potential commercial importance (crabs, shrimps, fin fishes) in lower Cook Inlet emphasizes the need to understand benthic communities there since many commercial species feed on infaunal and small epifaunal residents of the benthos (see Zenkevitch, 1963; Feder, 1977a; Feder and Jewett, 1977; Jewett, in press; Paul *et al.*, in press; and this report for discussions of the interaction of commercial species and the invertebrate benthos). Any drastic changes in density of the food benthos would directly impact these commercially important species.

Experience in pollution-prone areas of England (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 determine any changes in species composition, diversity, abundance and biomass. Such long-term data acquisition should make it possible to differentiate between normal ecosystem variation and pollutant-induced biological alteration. Intensive investigations of the benthos of lower Cook Inlet are also essential to understand trophic interactions there and to predict changes that might take place once oil-related activities are initiated.

A benthic biological program in the northeast Gulf of Alaska (NEGOA) provided a qualitative and quantitative inventory of prominent species of the benthic infauna and epifauna there (Feder *et al.*, 1976; Jewett and Feder, 1976). In addition, investigations concerned with the biology of selected benthic species from NEGOA and the Kodiak shelf (Jewett and Feder, 1976; Feder and Jewett, 1977; Jewett, in press) have furthered our understanding of the overall Gulf of Alaska benthic system (Feder, 1977a). Initiation of a program designed to examine the subtidal benthos of lower Cook Inlet expanded coverage of the Gulf of Alaska benthic system and extended the assessment of fauna of the Gulf into little-known shallow-water benthic systems. The study reported here is a preliminary assessment of the sediment-dwelling benthic fauna of lower Cook Inlet, and is intended to precede a greater overall investigation of lower Cook Inlet (Feder, 1977b).

Relevance to Problems of Petroleum Development

The effects of oil pollution on subtidal benthic systems have, until recently, been neglected, and only a few studies on such systems, conducted after serious oil spills, have been published (see Boesch *et al.*, 1974; Malins, 1977; Nelson-Smith, 1973, for reviews; Baker, 1976, for a general review of marine ecology and oil pollution). Lack of a broad data base makes it difficult to predict the effects of oil-related activity on the subtidal benthos of lower Cook Inlet. However, the rapid expansion of Outer Continental Shelf Environmental Assessment Program (OCSEAP)-sponsored research activities in this body of water should ultimately enable us to point with some confidence to certain species or areas that might bear closer scrutiny once industrial activity is initiated. It must be re-emphasized that a considerable time frame is needed to comprehend long-term fluctuations in density of marine benthic species; thus, it cannot be expected that short-term research programs will result in predictive capabilities.

As indicated previously, infaunal benthic organisms 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 Mueller, 1975; National Oceanic Data Center (NODC) data on file for examples of such stations). Changes in the environment at these stations 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 potential effects of loss of species to the overall trophic structure in lower Cook Inlet can be partially assessed on the basis of benthic food studies (e.g. see, Jewett and Feder, 1976; Feder, 1977a; Feder and Jewett, 1977).

The snow crab (*Chionoecetes bairdi*) is a conspicuous member of the shallow shelf of lower Cook Inlet, and supports a commercial fishery of considerable importance there. Laboratory experiments with this species have shown that postmolt individuals lose most of their legs after exposure to Prudhoe Bay crude oil; obviously this aspect of the biology of the snow crab must be considered in the continuing assessment of this species (Karinen and Rice, 1974). Few other direct data based on laboratory experiments are available for subtidal benthic species (Nelson-Smith, 1973; also see Malins, 1977). Experimentation on toxic effects of oil on other common members of the subtidal benthos should be strongly encouraged in lower Cook Inlet as well as for all Outer Continental Shelf (OCS) areas of investigation. In addition, potential effects of loss of sensitive species to the trophic structure of Cook Inlet must be examined.

A direct relationship between trophic structure (feeding type) and bottom stability has been demonstrated by Rhoads (see Rhoads, 1974, for review). He describes a diesel fuel spill that resulted in oil becoming adsorbed on sediment particles which in turn caused death 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 common members of the infauna of lower Cook Inlet 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 there. In addition, the commercially important king (*Paralithodes camtschatica*) and snow crabs (*Chionoecetes bairdi*), and some bottom fishes, use deposit feeding invertebrates as food; also, varying amounts of sediment are found in the digestive tract of snow crabs (Feder, 1977a; Feder and Jewett, 1977). Thus, contamination of the bottom by oil might directly or indirectly affect these commercial species in lower Cook Inlet.

III. CURRENT STATE OF KNOWLEDGE

A compilation of data is available on commercially important shellfish of lower Cook Inlet. The U.S. Bureau of Commercial Fisheries (National Marine Fisheries Service) have conducted distribution and abundance surveys in this area on shrimps and crabs since 1958 (see references below). More recent investigations on larval and/or adult stages of shellfish species have been carried out (Hennick, 1973; ADF&G, 1976; Feder, 1977a). A detailed examination of the food of snow crabs from lower Cook Inlet is included in Paul *et al.* (in press). Data on non-commercial, benthic invertebrates are not as extensive as that available for commercial species in lower Cook Inlet (U.S. Bureau of Commercial Fisheries, 1958, 1961, 1963 cited in U.S Dept. Inter., 1977; Feder, 1977a). Further studies on the interactions of selected benthic invertebrate species from lower Cook Inlet are currently underway (Feder, 1977b). Littoral zone studies have been conducted (Dames and Moore, 1977) and are being continued by Lees (1977).

IV. STUDY AREA

A station grid, in addition to several stations of opportunity, were established for benthic sampling in lower Cook Inlet (Fig. 1; Table I).

V. SOURCES, METHODS, AND RATIONALE OF DATA COLLECTION

Benthic infauna and epifauna were collected aboard the R/V *Moana Wave* from March 30-April 15, 1976; the M/V *Puffin* from August 10-12, 1976; and the NOAA Ship *Miller Freeman* from October 18-29, 1976. Sampling in April was carried out using a 0.1 m^2 van Veen grab, a pipe dredge (36 x 91 cm), an Agassiz trawl (2.0 m horizontal opening), a try-net (3.7 m horizontal opening), and a clam dredge. Sampling in August was conducted in the nearshore waters of outer Kenai Peninsula (Fig. 2)[1] by the Alaska Department of Fish and Game with a 0.61 m wide by 0.91 m long sled-like bottom skimmer. Tows covered approximately 0.2 mile. October sampling was conducted with a pipe dredge, Agassiz trawl, 400-mesh Eastern otter trawl (12.2 m horizontal opening), and a clam dredge. The pipe

[1]Specific station location data available from ADF&G, Homer, Alaska.

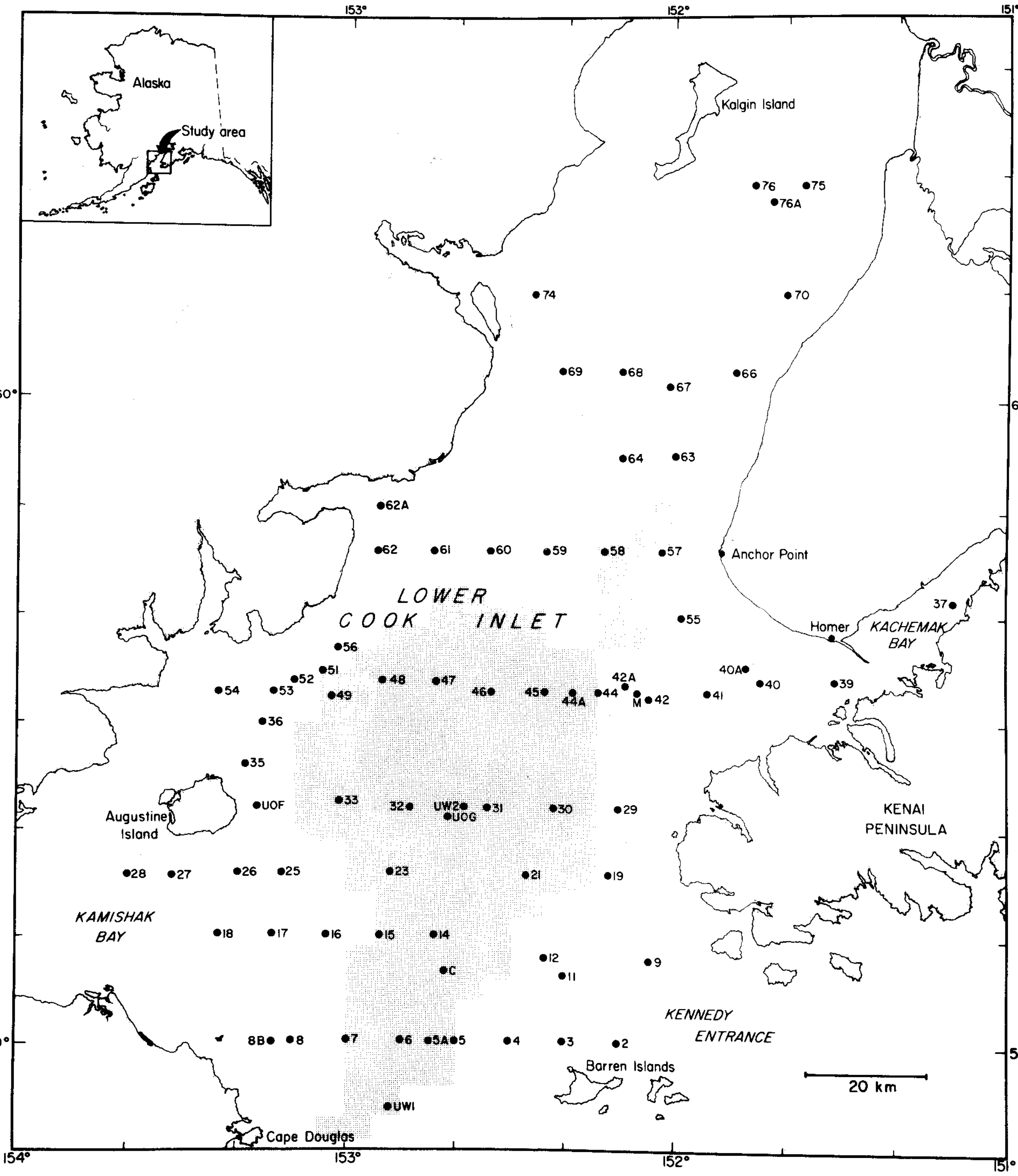

Figure 1. Lower Cook Inlet benthic stations occupied by the R/V *Moana Wave* April, 1976 and NOAA Ship *Miller Freeman* October, 1976. The shaded portion represents the tract selection area.

TABLE I

BENTHIC STATIONS SAMPLED AND TYPE OF GEAR USED IN LOWER COOK INLET
APRIL AND OCTOBER, 1976

Station Name	Pipe Dredge		Agassiz Trawl		Try-net	van[1] Veen Grab	Eastern Otter Trawl	Clam Dredge	
	April	October	April	October	April	April	October	April	October
2	–	X	–	–	–	–	–	–	–
3	–	X	–	–	–	–	–	–	–
4	X	–	–	–	–	–	–	–	–
5	X	X	X	X	–	–	X	–	–
5A	–	–	–	X	–	–	–	–	–
6	–	X	–	X	–	X	–	–	–
7	X	X	X	–	–	–	X	–	–
8	X	X	X	–	–	–	X	–	–
8B	–	–	–	X	–	–	–	–	–
9	X	X	–	–	–	–	–	–	–
11	X	–	–	–	–	–	–	–	–
12	X	X	–	–	–	–	–	–	–
14	–	X	–	–	–	–	X	–	–
15	X	–	–	–	–	–	–	–	–
16	X	X	–	–	–	–	–	–	–
17	X	–	–	–	–	–	–	–	–
18	–	X	–	–	–	X	X	–	–
19	–	X	–	–	–	–	–	–	–
21	–	X	–	–	–	–	–	–	–
23	–	X	–	–	–	–	X	–	–
25	–	X	–	–	–	–	X	–	–
26	X	–	–	–	–	–	–	–	–
27	X	X	X	–	–	X	X	–	–
28	X	X	X	–	–	–	X	–	–
29	X	X	–	–	–	–	–	–	–
30	X	X	–	–	–	–	–	–	–
31	X	X	–	–	–	X	–	–	–
33	X	X	–	–	–	X	–	–	–
35	–	X	–	X	X	–	–	–	–
36	–	–	–	–	X	–	–	–	–
37	–	X	–	X	X	–	–	–	–
39	–	X	–	–	–	–	–	–	–
40	X	X	–	–	–	X	–	–	–
40A	–	X	X	–	–	–	X	X	X
41	X	X	–	–	–	–	X	X	X
42	X	X	X	–	–	X	–	–	–
42A	–	X	–	–	–	–	–	–	–
44	X	X	–	–	–	–	–	–	X
44A	X	X	X	–	–	–	–	–	–
45	X	X	–	–	–	X	–	–	–
46	X	X	–	–	–	X	–	–	–
47	–	X	–	–	–	–	–	–	–
48	X	–	–	–	–	X	–	–	–
49	X	X	X	X	–	X	–	X	–

TABLE I

CONTINUED

Station* Name	Pipe Dredge April	Pipe Dredge October	Agassiz Trawl April	Agassiz Trawl October	Try-net April	van[1] Veen Grab April	Eastern Otter Trawl October	Clam Dredge April	Clam Dredge October
51	-	-	-	-	X	-	-	-	-
52	-	-	-	-	X	-	-	-	-
53	X	X	X	-	-	-	X	-	-
54	X	X	-	-	-	X	X	-	-
55	X	X	-	-	-	-	-	-	-
56	-	-	-	-	X	-	-	-	-
57	-	X	-	-	-	-	-	-	-
58	X	-	-	-	-	-	-	-	-
59	X	X	-	-	-	-	-	-	-
60	X	X	-	-	-	-	-	-	-
61	X	X	-	-	-	-	-	-	-
62	X	-	-	-	-	-	-	-	-
62A	-	X	-	-	-	-	X	-	-
63	X	X	-	-	-	-	-	-	-
64	X	X	-	-	-	-	-	-	-
66	-	X	-	-	-	-	-	-	-
67	X	-	-	-	-	-	-	-	-
68	X	X	-	-	-	-	-	-	-
69	X	X	-	-	-	X	-	-	-
70	-	X	-	-	-	-	X	-	-
74	-	X	-	-	-	-	-	-	-
75	X	X	-	-	-	-	-	-	-
76	-	-	-	-	-	-	-	-	-
76A	-	X	-	-	-	-	X	-	-
C	-	X	-	-	-	-	-	-	-
M	-	X	-	-	-	-	-	-	-
UW1	-	X	-	-	-	-	-	-	-
UW2	-	X	-	-	-	-	-	-	-
UOF	-	X	-	-	-	-	-	-	-
UOG	-	X	-	-	-	-	-	-	-
TOTALS	40	58	10	7	6	13	16	3	3

* Total number of stations sampled = 74

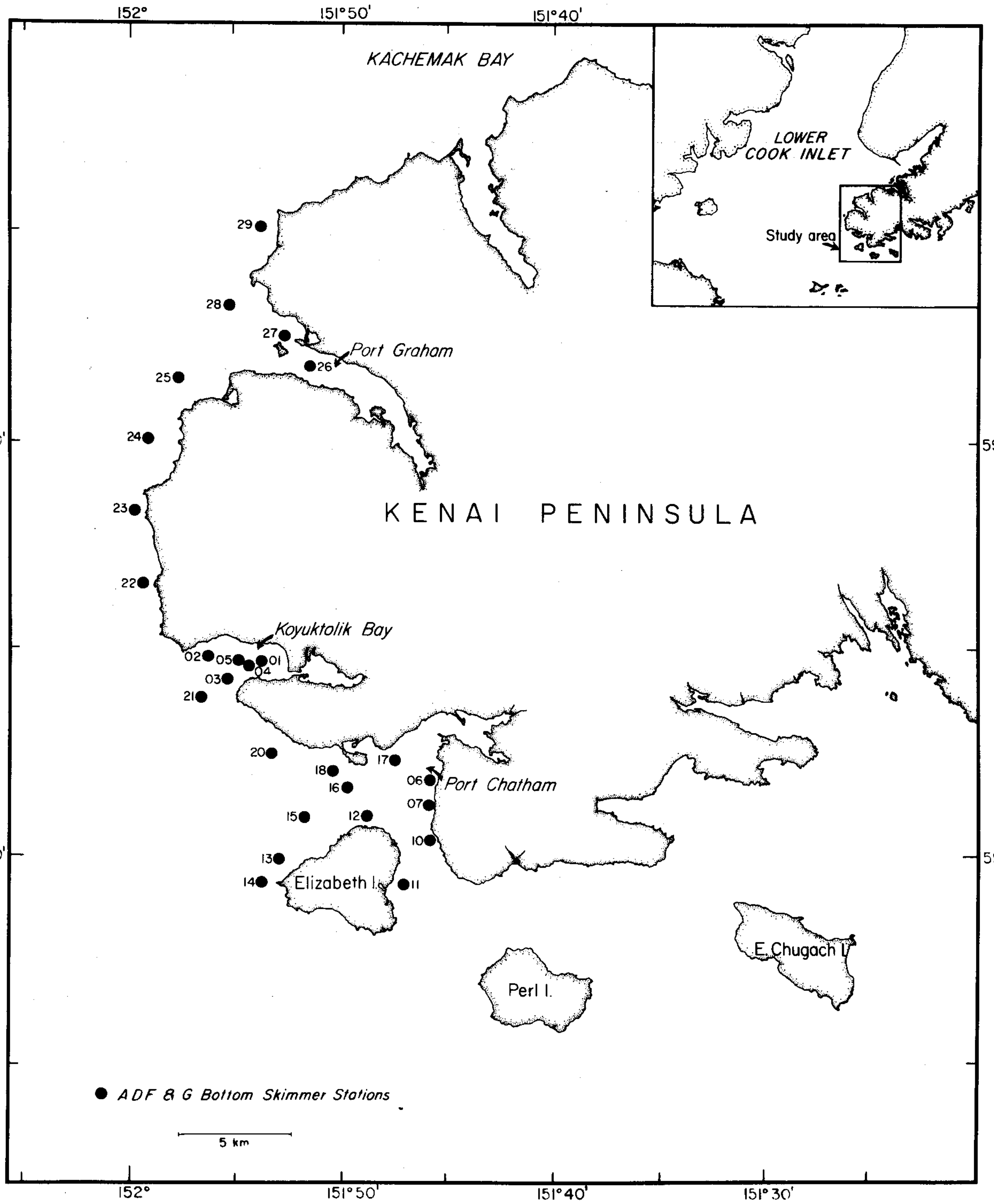

Figure 2. Bottom skimmer stations occupied by Alaska Department of Fish and Game, August 1976.

dredge, try-net, clam dredge, and bottom skimmer were used for qualitative sampling only, while the van Veen grab, Agassiz and Eastern otter trawl data were treated quantitatively. Five or six grabs were generally obtained at selected stations. Sampling time for the Agassiz and Eastern otter trawls was usually 15 and 30 minutes, respectively.

Material from each grab was washed on a 1.0 mm stainless steel screen, and preserved in 10% formalin buffered with hexamine. Labeled samples were returned to the Marine Sorting Center, University of Alaska, where all organisms were identified, counted, and wet-weighed after excess moisture was removed.

The pipe dredge was used to, (1) determine if the van Veen grab was adequately sampling infauna; (2) provide additional infaunal data in areas where van Veen grabs could not penetrate properly; (3) provide specimens for comparison with items found in stomachs of crabs and fishes examined in feeding studies; and (4) collect large numbers of clams for age-growth investigations. Clams were removed from pipe-dredge samples, preserved in 10% buffered formalin, and shipped to the Seward Marine Station for examination. The remainder of the material from the dredge was examined in Fairbanks.

All invertebrates from trawls were sorted on shipboard, given tentative identifications, counted, weighed, and aliquot samples of individual species preserved and labeled for final identification at the Institute of Marine Science, University of Alaska.

After final identification, all invertebrate species were assigned code numbers to facilitate computer analysis of data (Mueller, 1975). Representative and voucher samples of invertebrates were stored at the Institute of Marine Science, University of Alaska, Fairbanks, Alaska.

The stomach contents of snow crab, king crab and selected species of fishes were examined on shipboard. Stomachs were removed immediately, and their contents examined with a dissection microscope when necessary. Prey organisms were counted and identified to the lowest possible taxon. If the number of prey could not be determined, contents were recorded as a single specimen of the food item. This was often the case with barnacles and occasionally bivalves. Crabs were separated by size, sex, and state of maturity. Male snow crabs with carapace widths greater than 110 mm were considered sexually mature (Brown and Powell, 1972). Female snow crabs were classified as immature (pre-reproductive) or mature (reproductive or post-reproductive) based on the enlarged abdomen, modified pleopods, and egg clutch of the adults (Yoshida, 1941).

Food items were recorded as frequency of occurrence, in which prey items were expressed as the percent of the predator containing various food items relative to the total number of the predator analyzed.

Sampling with dredges, grabs and trawls at each station made it possible to obtain information on potential prey (Table II) of snow crab, and facilitated identification of stomach contents.

VI. RESULTS

Invertebrate specimens from 74 OCSEAP stations sampled by the R/V *Moana Wave* and the NOAA Ship *Miller Freeman* were examined as well as specimens from 26 Alaska Department of Fish and Game (ADF&G) stations sampled by the M/V *Puffin*.

Infaunal Program

van Veen Grab

Forty-eight stations were occupied with a van Veen grab in April. Thirteen of these stations were re-occupied in October. Only 13 stations occupied in April were examined in the laboratory; the balance of the samples were archived. Isolation of 211 invertebrate species was made from these stations (Table III). Members of 10 phyla were collected; polychaetous annelids comprised the most important group with 93 species. Mollusca were next in importance with 64 species, and Arthropoda (Crustacea) were next with 33 species. Echinodermata were fourth in importance with 8 species (Table IV).

OCSEAP Station 45 had the highest biomass of 732 g/m^2 (Table V), 80% of which was the sand dollar, *Echinarachnius parma*. Detailed quantitative data for the 13 April stations, as well as qualitative data on the remainder of the grab stations, are on file at NODC (or are included in the Special Data Submission filed with NOAA [Shaw *et al.*, 1976]).

Pipe Dredge

Pipe dredge sampling provided the most comprehensive station coverage.

Text continued on page 75

TABLE II

STATION CHECKLIST OF POTENTIAL PREY ORGANISMS OF *CHIONOECETES BAIRDI* COLLECTED BY VAN VEEN GRAB AND/OR PIPE DREDGE FROM THE LOWER COOK INLET STUDY AREA.

A = abundant, C = common, and R = rate.

	STATION										
	5A	8B	18	23	25	28	40A	41	53	62A	76A
Annelida	-	-	C	C	A	A	-	C	C	C	-
Sipunculida	-	-	-	-	-	C	-	-	-	-	-
Mollusca											
Pelecypoda											
Nuculana tenuis	-	-	C	-	-	C	-	-	C	-	-
Nuculana fossa	C	-	C	-	C	C	-	-	A	R	-
Yoldia hyperborea	-	-	C	-	-	C	-	R	R	C	-
Macoma spp.	C	-	C	C	C	C	-	C	C	C	-
Spisula polynyma	-	-	R	-	-	C	R	C	R	-	-
Tellina nuculoides	-	-	-	C	-	-	-	C	-	-	-
Glycymeris subobsoleta	-	-	-	-	-	C	-	-	-	R	-
Mytilus edulis	-	-	-	-	-	-	-	C	-	-	-
Musculus sp.	-	-	-	-	-	R	-	-	-	C	-
Hiatella arctica	-	-	-	-	-	-	-	C	-	-	-
Serripes groenlandicus	-	-	C	-	-	A	-	-	R	R	-
Astarte spp.	-	-	R	-	C	-	-	-	-	R	-
Pecten caurinus	-	-	-	-	A	-	-	-	-	-	-
Unidentified bivalves	-	-	-	-	-	-	-	C	-	-	-
Gastropoda											
Natica clausa	-	-	-	-	-	C	-	C	-	R	-
Polinices sp.	-	-	C	-	-	C	-	-	-	-	-
Neptunea lyrata	-	C	A	R	C	A	A	-	A	A	-
Nucella lamellosa	-	-	-	-	-	-	A	R	R	-	-
Trichotropis cancellata	-	-	-	-	R	C	-	-	-	-	-
Fusitriton oregonensis	R	C	-	-	R	-	-	-	R	-	-
Unidentified gastropods	-	C	C	C	C	-	C	-	-	-	C
Amphineura	-	-	-	-	-	C	-	-	-	-	-
Arthropoda (Crustacea)											
Cumacea	-	-	C	-	-	-	-	-	C	C	C
Amphipoda	R	R	C	-	A	C	-	R	C	-	-
Shrimps											
Pandalus borealis	R	C	R	-	-	C	-	-	-	-	R
P. hypsinotus	-	-	-	-	-	-	-	-	R	C	-
P. goniurus	-	C	R	-	-	A	-	-	A	-	-
Crangon dalli	-	-	C	-	C	C	R	-	A	A	C
Unidentified Crangonidae	C	C	C	-	C	C	R	-	C	R	C
Crabs											
Paguridae	R	C	C	R	-	R	C	-	C	C	-
Pagurus ochotensis	-	-	C	R	R	C	A	R	A	A	-
P. capillatus	-	C	R	-	-	R	R	-	R	R	R
P. aleuticus	-	A	-	-	-	-	-	-	-	-	-
Hyas lyratus	-	C	-	-	-	-	A	C	-	-	R
Chionoecetes bairdi	A	A	A	A	A	A	A	A	A	A	A
Barnacles											
Balanus spp.	C	C	C	C	C	C	C	C	C	C	C
Echinodermata											
Ophiuroidea	-	C	R	-	-	-	-	-	-	-	-
Echinoidae											
Strongylocentrotus droebachiensis	-	-	-	-	-	C	R	C	-	-	-

TABLE III

SPECIES LIST FOR LOWER COOK INLET VAN VEEN GRAB SAMPLES

Phylum Porifera
    Unidentified species
Phylum Cnidaria
  Class Hydrozoa
      Unidentified species
  Class Anthozoa
    Family Nephtheidae
      Unidentified species
    Family Pennatulidae
      Ptilosarcus gurneyi
Phylum Rhynchocoela
      Unidentified species
Phylum Nematoda
      Unidentified species
Phylum Annelida
  Class Polychaeta
    Family Polynoidae
      Halosydna brevisetosa
      Harmothoe imbricata
      Polynoe canadensis
      Phloe minuta
    Family Euphrosinidae
      Unidentified species
    Family Phyllodocidae
      Anaitides sp.
      Anaitides maculata
      Eteone sp.
      Eteone longa
    Family Syllidae
      Autolytus sp.
      Syllis sp.
      Typosyllis sp.
      Typosyllis alternata
      Langerhansia cornuta
    Family Nereidae
      Nereis pelagica
      Nereis procera
      Nereis zonata
    Family Nephtyidae
      Nephtys sp.
      Nephtys assimilis
      Nephtys ciliata
      Nephtys caeca
      Nephtys cornuta
      Nephtys punctata
      Nephtys rickettsi

TABLE III

CONTINUED

Family Sphaerodoridae
- *Sphaerodoropsis minuta*
- *Sphaerodoropsis sphaerulifer*

Family Glyceridae
- *Glycera capitata*

Family Goniadidae
- *Glycinde picta*
- *Glycinde armigera*
- *Goniada annulata*
- *Goniada maculata*

Family Onuphidae
- *Onuphis* sp.
- *Onuphis conchylega*
- *Onuphis geophiliformis*
- *Onuphis iridescens*

Family Lumbrineridae
- *Lumbrineris* sp.
- *Lumbrineris similabris*
- *Lumbrineris zonata*
- *Lumbrineris luti*
- *Lumbrineris minima*

Family Arabellidae
- *Drilonereis falcata minor*

Family Orbiniidae
- *Haploscoloplos elongatus*
- *Naineris* sp.
- *Naineris dendritica*

Family Paraonidae
- *Aricidea* sp.
- *Aricidea suecica*
- *Aridicea longicornuta*
- *Aridicea jeffreysii*
- *Paraonis gracilis*

Family Spionidae
- *Polydora socialis*
- *Prionopsio* sp.
- *Prionopsio malmgreni*
- *Prionopsio cirrifera*
- *Spio filicornis*
- *Spiophanes* sp.
- *Spiophanes cirrata*

Family Magelonidae
- *Magelona* sp.
- *Magelona saponica*

Family Cirratulidae
- *Tharyx* sp.
- *Chaetozone setosa*

TABLE III

CONTINUED

Family Shpaerodoridae
- *Sphaerodoropsis minuta*
- *Sphaerodoropsis sphaerulifer*

Family Glyceridae
- *Glycera capitata*

Family Goniadidae
- *Glycinde picta*
- *Glycinde armigera*
- *Goniada annulata*
- *Goniada maculata*

Family Onuphidae
- *Onuphis* sp.
- *Onuphis conchylega*
- *Onuphis geophiliformis*
- *Onuphis iridescens*

Family Lumbrineridae
- *Lumbrineris* sp.
- *Lumbrineris similabris*
- *Lumbrineris zonata*
- *Lumbrineris luti*
- *Lumbrineris minima*

Family Arabellidae
- *Drilonereis falcata minor*

Family Orbiniidae
- *Haploscoloplos elongatus*
- *Naineris* sp.
- *Naineris dendritica*

Family Paraonidae
- *Aricidea* sp.
- *Aricidea suecica*
- *Aridicea longicornuta*
- *Aridicea jeffreysii*
- *Paraonis gracilis*

Family Spionidae
- *Polydora socialis*
- *Prionopsio* sp.
- *Prionopsio malmgreni*
- *Prionopsio cirrifera*
- *Spio filicornis*
- *Spiophanes* sp.
- *Spiophanes cirrata*

Family Magelonidae
- *Magelona* sp.
- *Magelona saponica*

Family Cirratulidae
- *Tharyx* sp.
- *Chaetozone setosa*

TABLE III

CONTINUED

Family Scalibregmidae
- *Scalibregma inflatum*

Family Opheliidae
- *Ophelia limacina*
- *Travisia* sp.
- *Travisia brevis*

Family Sternaspidae
- *Sternaspis scutata*

Family Capitellidae
- *Capitella capitata*
- *Notomastus* sp.

Family Maldanidae
- *Asychis similis*
- *Maldane glebifex*
- *Notoproctus* sp.
- *Axiothella rubrocincta*
- *Praxillella gracilis*
- *Praxillella praetermissa*
- *Praxillella affinis*
- *Rhodine birorquata*

Family Oweniidae
- *Owenia fusiformis*
- *Myriochele heeri*

Family Pectinariidae
- *Cistenides hyperborea*

Family Ampharetidae
- *Ampharete arctica*
- *Ampharete acutifrons*
- *Lysippe labiata*
- *Melinna cristata*

Family Terrebellidae
- *Pista cristata*
- *Polycirrus* sp.
- *Artacama coniferi*

Family Trichobranchidae
- *Terebellides stroemii*

Family Sabellidae
- *Chone* sp.
- *Chone gracilis*
- *Chone infundibuliformis*
- *Laonome kroyeri*

Family Serpulidae
- *Chitinopoma groenlandica*
- *Serpula vermicularis*

Class Oligochaeta
- Unidentified species

TABLE III

CONTINUED

Phylum Mollusca
- Class Aplacophora
  - Family Chaetodermatidae
    - *Chaetoderma robusta*
- Class Polyplacophora
  - Family Ischnochitonidae
    - *Ischnochiton albus*
- Class Pelecypoda
  - Family Nuculidae
    - *Nucula tenuis*
  - Family Nuculanidae
    - *Nuculana* sp.
    - *Nuculana fossa*
    - *Yoldia* sp.
    - *Yoldia hyperborea*
    - *Yoldia scissurata*
    - *Yoldia secunda*
  - Family Glycymerididae
    - *Glycymeris subobsoleta*
  - Family Mytilidae
    - *Crenella dessucata*
    - *Musculus corrugatus*
    - *Dacrydium pacificum*
  - Family Astartidae
    - *Astarte* sp.
    - *Astarte borealis*
    - *Astarte alaskensis*
    - *Astarte montagui*
    - *Astarte polaris*
    - *Astarte rollandi*
    - *Astarte esquimalti*
  - Family Carditidae
    - *Cyclocardia ventricosa*
    - *Cyclocardia crebricostata*
    - *Cyclocardia incisa*
    - *Cyclocardia crassidens*
  - Family Thyasiridae
    - *Axinopsida serricata*
    - *Thyasira flexuosa*
  - Family Montacutidae
    - *Mysella* sp.
    - *Mysella tumida*
    - *Odontogena borealis*
  - Family Cardiidae
    - *Clinocardium ciliatum*
    - *Serripes groenlandicus*

TABLE III

CONTINUED

Family Veneridae
- *Liocyma fluctuosa*
- *Psephidia lordi*
- *Protothaca staminea*

Family Mactridae
- *Spisula polynyma*

Family Tellinidae
- *Macoma* sp.
- *Macoma calcarea*
- *Macoma moesta alaskana*
- *Tellina nucleoides*

Family Solenidae
- *Siliqua alta*

Family Myidae
- *Mya elegans*

Family Cuspidariidae
- *Cardiomya* sp.
- *Cardiomya beringensis*

Class Gastropoda

Family Trochidae
- *Margarites* sp.
- *Solariella obscura*
- *Solariella varicosa*

Family Naticidae
- *Polynices* sp.
- *Polynices nanus*
- *Polynices pallida*

Family Olividae
- *Olivella baetica*

Family Turridae
- *Oenopota* sp.
- *Oenopota turricula*
- *Lora* sp.
- *Lora quadra*
- *Lora reticulata*
- *Lora solida*

Family Pyramidellidae
- *Odostomia* sp.
- *Turbonilla* sp.

Family Retusidae
- *Retusa obtusa*

Family Scaphandridae
- *Cylichna alba*

Family Dentaliidae
- *Dentalium dalli*

Family Siphonodentaliidae
- *Cadulus* sp.
- *Cadulus tolmei*

TABLE III

CONTINUED

Phylum Arthropoda
- Class Crustacea
  - Family Balanidae
    - *Balanus crenatus*
  - Family Nebaliidae
    - *Nebalia* sp.
  - Family Leuconidae
    - *Eudorella emarginata*
    - *Eudorella pacifica*
    - *Eudorellopsis integra*
  - Family Diastylidae
    - *Diastylis* sp.
  - Family Campylaspidae
    - *Campylaspis rubicunda*
  - Family Arcturidae
    - *Arcturus beringanus*
  - Family Gnathiidae
    - *Gnathia* sp.
  - Family Anthuridae
    - Unidentified species
  - Family Ampeliscidae
    - *Ampelisca macrocephala*
    - *Byblis eamandi*
  - Family Gammaridae
    - *Melita* sp.
    - *Melita dentata*
  - Family Haustoriidae
    - Unidentified species
  - Family Isaeidae
    - *Photis* sp.
    - *Photis brevipes*
    - *Protomedeia* sp.
    - *Protomedeia epimerata*
  - Family Lysianassidae
    - *Anonyx* sp.
    - *Anonyx nugax*
    - *Anonyx killjeborgi*
    - *Archomene* sp.
    - *Archomene pacifica*
  - Family Oedicerotidae
    - *Pontocrates arenarius*
  - Family Phoxocephalidae
    - *Heterophoxus oculatus*
    - *Paraphoxus* sp.
  - Family Synopiidae
    - Unidentified species

TABLE III

CONTINUED

- Family Caprellidae
  - Unidentified species
- Family Crangonidae
  - *Crangon* sp.
- Family Paguridae
  - *Pagurus* sp.
- Family Majidae
  - *Chionoecetes bairdi*
- Family Pinnotheridae
  - *Pinnixa* sp.

Phylum Sipunculida
- *Phascolion strombi*

Phylum Ectoprocta
- Unidentified species

Phylum Brachiopoda
- Class Articulata
  - Family Cancellothyridae
    - *Terebratulina unguicula*
    - *Terebratulina crossei*
  - Family Dallinidae
    - *Terebratalia* sp.
    - *Terebratalia transversa*
    - *Laqueus californicus*

Phylum Echinodermata
- Class Echinoidea
  - Family Echinarachniidae
    - *Echinarachnius parma*
  - Family Strongylocentrotidae
    - *Allocentrotus fragilis*
    - *Strongylocentrotus* sp.
- Class Ophiuroidea
  - Family Amphiuridae
    - *Diamphiodia craterodmeta*
    - *Unioplus macraspis*
  - Family Ophiuridae
    - *Ophiura* sp.
    - *Ophiura sarsi*
- Class Holothuroidea
  - Family Cucumariidae
    - *Cucumaria calcigera*

TABLE IV

NUMBER AND PERCENT OF SPECIES IN EACH PHYLUM AND CLASS, COOK INLET GRAB SAMPLES, 13 STATIONS

Phylum	Class	Number of Species	Percent of Total Species
Cnidaria	Hydrozoa	1	0.47
	Anthozoa	2	0.94
Rhynchocoela	Anopla	1	0.47
Nematoda	-	1	0.47
Annelida	Polychaeta	93	44.08
	Oligochaeta	1	0.47
Mollusca	Aplacophora	1	0.47
	Polyplacophora	1	0.47
	Pelecypoda	42	19.90
	Gastropoda	20	9.48
Arthropoda	Crustacea	33	15.64
Sipunculida	-	1	0.47
Ectoprocta	-	1	0.47
Brachiopoda	Articulata	5	2.37
Echinodermata	Echinoidea	3	1.42
	Ophiuroidea	4	1.90
	Holothuroidea	1	0.47
	TOTAL	211	

TABLE V

TOTAL COUNT, WEIGHT, AND BIOMASS OF INVERTEBRATE TAXA
FROM 13 LOWER COOK INLET VAN VEEN GRAB STATIONS
APRIL 1976

Station	Total count	Total wet weight (g)	$Count/m^2$	g/m^2
6	1282	98	2137	163
18	667	24	1334	48
27	1120	15	1600	22
31	203	120	406	241
33	1230	77	2050	129
40	1195	27	2988	68
42	226	279	452	558
45	266	365	532	732
46	90	96	300	320
48	63	26	630	261
49	507	42	1014	84
54	960	27	1371	38
69	6	3	15	6

Forty stations were occupied in April and 58 in October (Tables I and VI; Fig. 1). Thirty-seven stations were occupied once (April or October) and 32 were occupied twice (April and October). The most frequently occurring taxa were hydroids, polychaetous annelids, ten species of clams (*Glycymeris subobsoleta, Nuculana fossa, Nucula tenuis, Cyclocardia ventricosa, Astarte esquimalti, A. alaskensis, Psephidia lordi, Macoma calcarea, Spisula polynyma, Tellina nuculoides*) (Appendix I, Tables I and II). A list of species is presented in Table VII.

Clam Dredge

The clam dredge was used at only six stations to sample for large clam specimens. In April, 3.63 kg of the cockle, *Clinocardium californiense*, were obtained at Station 40A (Fig. 1). Also in April, nine large pink neck clams, *Spisula polynyma*, were collected at Station 41. In October, Station 41 yielded 19 blue mussels, *Mytilus edulis*. Sixty-two species, inclusive of clams, were identified from clam dredges (Table VIII).

Bivalve Studies

A total of 76 bivalve species were collected by grab and pipe dredge (see Tables III and VII; Appendix I, Tables I and II).

Deposit-feeding species dominated the fine sediments of the western side of Cook Inlet. Suspension-feeding species increased in importance in the sandier areas examined in outer Kachemak Bay; deposit feeders once again assumed importance in inner Kachemak Bay. The suspension feeder, *Modiolus modiolus*, was important in areas subject to increased water movement (currents), (e.g. Stations 3, 58-60).

Six species of common clams (*Nucula tenuis, Nuculana fossa, Tellina nuculoides, Macoma calcarea, Glycymeris subobsoleta, Spisula polynyma*) were selected for analysis of age and growth patterns, and this analysis is appended to this report (Appendix II, Tables I-XXXVI).

Epifaunal Program

Bottom Skimmer[1]

Although the bottom skimmer did not provide quantitative data, it did

[1]Material made available by Coastal Habitat Protection, ADF&G, Homer, AK.

Text continued on page 96

TABLE VI

LOWER COOK INLET BENTHIC STATIONS OCCUPIED BY R/V *MOANA WAVE*
APRIL 1976, AND NOAA SHIP *MILLER FREEMAN* OCTOBER 1976

Station Name	Latitude	Longitude	Depth (m)
2	59°00.3'	152°11.6'	117
3	59°00.3'	152°21.6'	123
4	59°00.3'	152°30.0'	152
5	59°00.3'	152°42.5'	166
5A	59°00.3'	152°47.5'	181
6	59°00.3'	152°49.7'	166
7	59°00.3'	153°03.1'	150
8	59°00.3'	153°10.6'	121
8B	59°01.0'	153°13.0'	111
9	59°08.4'	152°04.2'	129
11	59°06.0'	152°20.0'	116
12	59°08.9'	152°26.1'	121
14	59°10.3'	152°47.1'	146
15	59°10.0'	152°54.0'	139
16	59°09.8'	153°06.9'	91
17	59°10.0'	153°13.5'	67
18	59°09.3'	153°24.8'	44
19	59°15.5'	152°10.7'	110
21	59°15.3'	152°26.6'	90
23	59°15.3'	152°49.3'	91
25	59°15.9'	153°08.5'	59
26	59°15.8'	153°20.0'	42
27	59°15.6'	153°33.8'	32
28	59°15.4'	153°40.0'	31
29	59°22.6'	152°09.4'	81
30	59°21.5'	152°24.1'	81
31	59°23.3'	152°35.7'	73
33	59°22.3'	153°05.0'	53
35	59°24.9'	153°17.7'	42
36	59°30.0'	153°15.7'	33
37	59°41.3'	151°11.1'	59
39	59°34.9'	151°30.4'	99
40	59°33.1'	151°46.8'	69
40A	59°36.7'	151°51.6'	31
41	59°32.7'	151°55.3'	35
42	59°32.1'	151°04.5'	40
42A	59°33.8'	152°12.5'	32
44	59°33.1'	152°13.7'	68
44A	59°33.1'	152°18.6'	61
45	59°32.7'	152°25.5'	57
46	59°33.5'	152°35.5'	81
47	59°33.9'	152°43.7'	55
48	59°34.0'	152°54.0'	42

TABLE VI

CONTINUED

Station Name	Latitude	Longitude	Depth (m)
49	59°33.1'	153°04.0'	37
51	59°35.0'	153°05.0'	36
52	59°34.0'	153°10.0'	35
53	59°31.8'	153°11.0'	37
54	59°33.4'	153°24.5'	24
55	59°40.0'	151°59.5'	29
56	59°37.0'	153°02.0'	35
57	59°45.1'	152°03.3'	35
58	59°46.1'	152°13.0'	58
59	59°46.2'	152°23.4'	82
60	59°46.8'	152°34.7'	38
61	59°47.0'	152°43.7'	34
62	59°46.2'	152°55.0'	26
62A	59°49.8'	152°52.3'	24
63	59°55.7'	151°58.6'	31
64	59°54.9'	152°08.9'	60
66	60°03.3'	151°48.3'	44
67	60°01.5'	152°01.0'	51
68	60°02.8'	152°13.3'	60
69	60°03.3'	152°20.5'	55
70	60°10.3'	151°39.8'	41
74	60°10.0'	152°23.3'	55
75	60°20.3'	151°34.5'	27
76	60°20.0'	151°46.0'	27
76A	60°18.3'	151°45.2'	47
C	59°07.5'	152°46.1'	147
M	59°32.9'	152°08.2'	48
UWI	58°53.1'	152°51.4'	172
UW2	59°22.7'	152°42.6'	?
UOF	59°21.0'	153°15.2'	44
UOG	59°20.8'	152°43.8'	68

TABLE VII

INVERTEBRATE TAXA OBTAINED BY PIPE DREDGE IN LOWER COOK INLET

Taxon	April	October
Phylum Porifera		
Unidentified species	x	x
Phylum Cnidaria		
Class Hydrozoa		
Unidentified species	x	x
Family Lafoeidae		
Unidentified species	-	x
Family Sertulariidae		
Unidentified species	-	x
Sertularella sp.	-	x
Sertularia sp.	-	x
Abietinaria sp.	-	x
Family Plumulariidae		
Unidentified species	-	x
Family Stylasteridae		
Allopora sp.	x	x
Class Anthozoa		
Family Nephtheidae		
Eunephthya rubiformis	x	-
Family Primnoidae		
Stylatula gracile	-	x
Family Pennatulidae		
Ptilosarcus gurneyi	x	x
Family Actiniidae		
Unidentified species	x	x
Phylum Rhynchocoela		
Unidentified species	x	x
Phylum Annelida		
Class Polychaeta		
Unidentified species	x	x
Family Polynoidae		
Unidentified species	x	x
Family Sigalionidae		
Unidentified species	-	x
Family Nereidae		
Unidentified species	-	x
Nereis sp.	-	x
Family Nephtyidae		
Nephtys sp.	x	x

TABLE VII

CONTINUED

Taxon	April	October
Phylum Annelida (cont'd)		
Family Glyceridae		
Glycera sp.	-	x
Family Goniadidae		
Glycinde sp.	-	x
Family Onuphidae		
Unidentified species	-	x
Family Lumbrineridae		
Lumbrineris sp.	x	-
Family Arabellidae		
Unidentified species	-	x
Family Flabelligeridae		
Unidentified species	-	x
Family Opheliidae		
Unidentified species	-	x
Ophelia limacina	-	x
Family Sternaspidae		
Sternaspis scutata	x	x
Family Maldanidae		
Unidentified species	-	x
Family Pectinariidae		
Cistenides hyperborea	-	x
Family Sabellidae		
Unidentified species	x	x
Family Serpulidae		
Unidentified species	-	x
Class Hirudinea		
Unidentified species	-	x
Phylum Mollusca		
Unidentified species	x	-
Class Polyplacophora		
Family Ischnochitonidae		
Ischnochiton sp.	x	-
Ischnochiton trifidus	x	x
Family Mopaliidae		
Mopalia sp.	-	x
Mopalia ciliata	x	-
Mopalia cirrata	x	-
Mopalia muscosa	x	-
Class Pelecypoda		
Family Nuculidae		
Nucula tenuis	x	x

TABLE VII

CONTINUED

Taxon	April	October
Phylum Mollusca (cont'd)		
Family Nuculanidae		
Unidentified species	-	x
Nuculana minuta	x	x
Nuculana fossa	x	x
Portlandia sp.	-	x
Tindaria kennerlyi	-	x
Yoldia amygdalea	-	x
Yoldia hyperborea	x	-
Yoldia myalis	x	x
Yoldia scissurata	x	x
Yoldia thraciaeformis	-	x
Yoldia secunda	-	x
Family Glycymerididae		
Glycymeris subobsoleta	x	x
Family Mytilidae		
Mytilis edulis	-	x
Crenella decussata	-	x
Musculus discors	x	-
Musculus niger	x	x
Musculus corrugatus	-	x
Musculus marmoratus	-	x
Modiolus modiolus	x	x
Family Pectinidae		
Chlamys sp.	x	x
Chlamys rubida	x	x
Chlamys beringiana	x	-
Cyclopecten sp.	-	x
Propeamussium alaskense	-	x
Family Limidae		
Lima sabauriculata	-	x
Family Anomiidae		
Pododesmus macrochisma	-	x
Family Astartidae		
Astarte sp.	x	-
Astarte borealis	-	x
Astarte alaskensis	x	x
Astarte montagui	x	x
Astarte rollandi	x	x
Astarte bennettii	x	x
Astarte esquimalti	x	x
Family Carditidae		
Cyclocardia sp.	x	-
Cyclocardia ventricosa	x	x
Cyclocardia crebricostata	x	x
Cyclocardia crassidens	x	x

TABLE VII

CONTINUED

Taxon	April	October
Phylum Mollusca (cont'd)		
Family Lucinidae		
Parvilucina tenuisculpta	-	x
Family Thyasiridae		
Axinopsida serricata	-	x
Thyasira flexuosa	x	x
Family Kelliidae		
Kellia laperousi	x	-
Family Montacutidae		
Mysella sp.	-	x
Odontogena borealis	-	x
Family Cardiidae		
Clinocardium sp.	x	-
Clinocardium ciliatum	x	x
Clinocardium nuttallii	-	x
Clinocardium californiense	x	x
Serripes groenlandicus	x	x
Family Veneridae		
Saxidomus gigantea	-	x
Liocyma fluctuosa	x	x
Psephidia lordi	-	x
Humilaria kennerlyi	x	x
Protothaca staminea	x	x
Family Mactridae		
Spisula polynyma	x	x
Family Tellinidae		
Macoma sp.	x	x
Macoma calcarea	x	x
Macoma elimata	-	x
Macoma brota	-	x
Macoma obliqua	x	x
Macoma moesta alaskana	-	x
Macoma balthica	x	-
Tellina nuculoides	x	x
Family Solenidae		
Siliqua alta	x	-
Siliqua sloati	-	x
Family Myidae		
Mya truncata	x	-
Mya priapus	x	x
Family Hiatellidae		
Hiatella arctica	x	x
Family Pandoridae		
Pandora bilirata	-	x
Family Lyonsiidae		
Lyonsia sp.	x	-

TABLE VII

CONTINUED

Taxon	April	October
Phylum Mollusca (cont'd)		
Class Gastropoda		
Unidentified species	x	-
Family Fissurellidae		
Puncturella galeata	x	x
Family Lepetidae		
Cryptobranchia concentrica	-	x
Cryptobranchia alba	x	-
Family Trochidae		
Margarites olivaceus	-	x
Margarites pupillus	x	-
Margarites costalis	x	-
Solariella obscura	x	x
Solariella varicosa	x	x
Family Cocculinidae		
Cocculina casanica	-	x
Family Eulimidae		
Balcis sp.	-	x
Family Calyptraeidae		
Crepidula nummaria	-	x
Family Trichotropididae		
Unidentified species	-	x
Trichotropis cancellata	x	-
Family Naticidae		
Amauropsis purpurea	-	x
Natica clausa	x	x
Polinices pallida	x	x
Family Velutinidae		
Velutina sp.	-	x
Velutina lanigera	x	-
Family Cymatiidae		
Fusitriton oregonensis	x	x
Family Muricidae		
Boreotrophon clathratus	x	-
Boreotrophon stuarti	x	-
Boreotrophon smithii	x	-
Boreotrophon multicostalis	x	-
Boreotrophon pacificus	x	x
Boreotrophon lasius	x	x
Family Thaididae		
Nucella lamellosa	x	x
Family Buccinidae		
Buccinum plectrum	x	x

TABLE VII

CONTINUED

Taxon	April	October
Phylum Mollusca (cont'd)		
Family Neptuneidae		
Beringius sp.	x	-
Beringius kennicotti	-	x
Neptunea sp.	x	-
Neptunea lyrata	x	x
Neptunea ventricosa	x	x
Plicifusus sp.	x	-
Family Columbellidae		
Amphissa columbiana	x	x
Mitrella gouldi	x	x
Family Volutomitridae		
Volutomitra alaskana	x	x
Family Olividae		
Olivella baetica	x	x
Family Cancellariidae		
Admete sp.	-	x
Admete couthouyi	x	-
Family Turridae		
Suavodrillia kennicottii	x	-
Oenopota sp.	x	x
Oenopota decussata	-	x
Oenopota turricula	x	-
Propebela sp.	-	x
Family Pyramidellidae		
Turbonilla torquata	-	x
Family Retusidae		
Retusa sp.	-	x
Family Diaphanidae		
Diaphana sp.	-	x
Family Scaphandridae		
Cylichna alba	-	x
Cylichna attonsa	-	x
Family Dorididae		
Unidentified species	-	x
Class Scaphopoda		
Family Dentaliidae		
Dentalium sp.	-	x
Phylum Arthropoda		
Class Pycnogonida		
Family Pycnogonidae		
Unidentified species	-	x

TABLE VII

CONTINUED

Taxon	April	October
Phylum Arthropoda (cont'd)		
Class Crustacea		
Order Thoracica		
Unidentified species	-	x
Family Balanidae		
Balanus sp.	x	x
Balanus crenatus	x	-
Balanus evermani	x	-
Balanus hesperius	-	x
Balanus rostratus	x	x
Order Cumacea		
Unidentified species	-	x
Order Isopoda		
Family Aegidae		
Rocinela augustata	-	x
Order Amphipoda		
Unidentified species	x	x
Family Ampeliscidae		
Ampelisca birulai	x	-
Byblis gaimandi	x	-
Family Corophiidae		
Ericthonius sp.	-	x
Family Gammaridae		
Anisogammarus sp.	-	x
Melita sp.	-	x
Melita dentata	x	-
Family Lysianassidae		
Anonyx sp.	-	x
Family Ischyroceridae		
Ischyrocerus sp.	x	-
Family Talitridae		
Unidentified species	-	x
Family Caprellidae		
Unidentified species	-	x
Order Decapoda		
Unidentified species	-	x
Family Pandalidae		
Pandalus sp.	-	x
Pandalus borealis	-	x
Pandalus goniurus	-	x
Pandalus hypsinotus	-	x
Pandalopsis dispar	-	x

TABLE VII

CONTINUED

Taxon	April	October
Phylum Arthropoda (cont'd)		
Family Hippolytidae		
Spirontocaris lamellicornis	-	x
Lebbeus groenlandicus	x	x
Eualus sp.	-	x
Eualus herdmani	-	x
Eualus stoneyi	-	x
Heptacarpus tridens	-	x
Family Crangonidae		
Crangon dalli	x	x
Sclerocrangon boreas	x	x
Family Calianassidae		
Unidentified species	-	x
Family Paguridae		
Unidentified species	x	-
Pagurus sp.	x	x
Pagurus ochotensis	x	x
Pagurus aleuticus	-	x
Pagurus capillatus	x	x
Pagurus kennerlyi	x	x
Pagurus beringanus	x	x
Pagurus trigonocheirus	-	x
Elassochirus tenuimanus	x	x
Family Lithodidae		
Paralithodes camtschatica	x	-
Rhinolithodes wosnessenskii	x	-
Family Majidae		
Oregonia gracilis	x	x
Hyas lyratus	x	x
Chionoecetes bairdi	x	x
Family Cancridae		
Cancer sp.	-	x
Cancer magister	-	x
Cancer oregonensis	x	x
Family Pinnotheridae		
Pinnixa sp.	x	-
Pinnixa occidentalis	-	x
Phylum Sipunculida		
Unidentified species	x	-
Golfingia sp.	-	x
Golfingia margaritacea	-	x
Phascolion strombi	-	x

TABLE VII

CONTINUED

Taxon	April	October
Phylum Echiuroidea		
Family Echiuridae		
Echiurus echiurus alaskensis	–	x
Phylum Ectoprocta		
Unidentified species	x	x
Class Cheilostomata		
Family Flustridae		
Unidentified species	–	x
Family Microporidae		
Microporina sp.	–	x
Class Cyclostomata		
Family Diastoporidae		
Unidentified species	–	x
Family Heteroporidae		
Heteropora sp.	–	x
Class Ctenostoma		
Family Alcyonidiidae		
Alcyonidium sp.	x	x
Family Flustrellidae		
Flustrella sp.	x	–
Flustrella gigantea	–	x
Phylum Brachiopoda		
Unidentified species	–	x
Class Articulata		
Family Cancellothyrididae		
Terebratulina unguicula	x	x
Family Dallinidae		
Laqueus californianus	x	x
Terebratalia transversa	x	x
Phylum Echinodermata		
Unidentified species	–	x
Class Asteroidea		
Family Porcellanasteridae		
Ctenodiscus crispatus	x	x
Family Echinasteridae		
Henricia sp.	–	x
Henricia leviuscula	x	x
Family Solasteridae		
Crossaster papposus	x	x

TABLE VII

CONTINUED

Taxon	April	October
Phylum Echinodermata (cont'd)		
Family Asteridae		
Leptasterias sp.	x	-
Leptasterias polaris	x	x
Class Echinoidea		
Family Echinarachniidae		
Echinarachnius parma	x	x
Family Strongylocentrotidae		
Strongylocentrotus droebachiensis	x	x
Strongylocentrotus franciscanus	-	x
Class Ophiuroidea		
Unidentified species	-	x
Family Amphiuridae		
Amphiopholis sp.	x	-
Amphipholis pugetana	-	x
Diamphiodia craterodmeta	-	x
Diamphiodia periercta	-	x
Family Gorgonocephalidae		
Gorgonocephalus caryi	-	x
Family Ophiactidae		
Ophiopholis sp.	x	-
Ophiopholis aculeata	x	x
Family Ophiuridae		
Unidentified species	x	-
Ophiopenia disacantha	-	x
Ophiura sp.	x	x
Ophiura sarsi	x	x
Class Holothuroidea		
Family Synaptidae		
Unidentified species	-	x
Family Cucumariidae		
Unidentified species	x	-
Cucumaria sp.	x	x
Cucumaria calcigera	-	x
Phylum Chordata		
Class Ascidiacea		
Unidentified species	x	x
Family Rhodosomatidae		
Chelyosoma sp.	x	-
Family Styelidae		
Unidentified species	-	x
Family Pyuridae		
Halocynthia igaboja	-	x
Total	145	212

TABLE VIII

INVERTEBRATE TAXA OBTAINED BY AGASSIZ TRAWL, TRY-NET TRAWL, EASTERN OTTER TRAWL AND CLAM DREDGE IN LOWER COOK INLET

Taxon	Agassiz Trawl		Try-Net	Eastern Otter Trawl	Clam Dredge	
	Apr	Oct	Apr	Oct	Apr	Oct
Phylum Porifera						
Unidentified species	x	-	x	x	-	x
Phylum Cnidaria						
Class Hydrozoa						
Unidentified species	x	-	x	x	-	-
Family Campanulariidae						
Campanularia sp.	-	-	-	-	-	x
Family Sertulariidae						
Unidentified species	-	-	-	-	-	x
Sertularia sp.	-	-	-	-	-	x
Sertularella sp.	-	-	-	-	-	x
Abietinaria sp.	-	-	-	-	-	x
Family Plumulariidae						
Unidentified species	-	-	-	-	-	x
Family Stylasteridae						
Allopora sp.	-	-	-	-	-	x
Class Anthozoa						
Family Nephtheidae						
Eunephthya rubiformis	x	-	-	-	-	-
Family Primnoidae						
Stylatula gracile	x	-	-	-	-	-
Family Pennatulidae						
Ptilosarcus gurneyi	x	-	-	x	-	-
Family Actiniidae						
Unidentified species	x	x	-	x	-	x
Tealia crassicornis	x	-	-	x	-	-
Phylum Platyhelmintes						
Class Turbellaria						
Order Polycladia						
Unidentified species	-	-	-	-	-	x
Phylum Annelida						
Class Polychaeta						
Unidentified species	x	x	-	x	-	x
Family Aphroditidae						
Aphrodita japonica	-	x	-	-	-	-

TABLE VIII

CONTINUED

Taxon	Agassiz Trawl Apr	Agassiz Trawl Oct	Try-Net Apr	Eastern Otter Trawl Oct	Clam Dredge Apr	Clam Dredge Oct
Phylum Annelida (cont'd)						
Family Polynoidae						
Unidentified species	x	x	x	x	-	x
Family Nereidae						
Nereis sp.	-	x	-	x	-	-
Class Hirudinea						
Family Piscicolidae						
Notostomobdella sp.	x	x	-	-	-	-
Phylum Mollusca						
Class Polyplacophora						
Family Ischnochitonidae						
Ischnochiton trifidus	-	-	-	-	-	x
Class Pelecypoda						
Unidentified species	-	x	-	-	-	-
Family Nuculidae						
Nucula tenuis	-	x	-	-	-	-
Family Nuculanidae						
Nuculana fossa	-	x	x	-	-	-
Yoldia thraciaeformis	-	x	-	-	-	-
Family Glycymerididae						
Glycymeris subobsoleta	-	-	x	-	x	x
Family Mytilidae						
Mytilis edulis	-	-	-	-	-	x
Modiolus modiolus	x	-	x	-	-	-
Family Pectinidae						
Chlamys rubida	x	x	-	x	-	x
Pecten caurinus	-	-	x	-	-	-
Propeamussium davidsoni	-	x	-	-	-	-
Family Astartidae						
Astarte alaskensis	x	-	-	-	-	-
Astarte rollandi	x	-	-	-	-	-
Family Carditidae						
Cyclocardia sp.	-	-	x	-	-	-
Cyclocardia ventricosa	x	-	-	-	-	x
Cyclocardia crassidens	x	-	-	-	-	-
Family Cardiidae						
Clinocardium sp.	-	-	x	-	-	-
Clinocardium ciliatum	x	-	-	-	x	x
Clinocardium nuttallii	x	-	-	-	-	x
Clinocardium californiense	x	-	-	-	-	x
Serripes groenlandicus	x	x	x	x	-	-

TABLE VIII

CONTINUED

Taxon	Agassiz Trawl Apr	Agassiz Trawl Oct	Try-Net Apr	Eastern Otter Trawl Oct	Clam Dredge Apr	Clam Dredge Oct
Phylum Mollusca (cont'd)						
Family Veneridae						
Humilaria kennerlyi	-	-	-	-	-	x
Protothaca staminea	-	-	-	-	-	x
Family Mactridae						
Spisula polynyma	x	-	-	-	x	-
Family Tellinidae						
Macoma sp.	-	-	x	-	-	-
Macoma calcarea	x	-	x	-	-	-
Tellina nuculoides	-	-	x	-	-	-
Family Hiatellidae						
Hiatella arctica	x	-	-	x	-	x
Class Gastropoda						
Family Trochidae						
Bathybembix sp.	x	-	-	-	-	-
Margarites olivaceus	-	-	-	-	-	x
Margarites costalis	-	x	-	-	-	-
Solariella varicosa	-	x	-	-	-	-
Lischkeia cidaris	-	x	-	-	-	-
Family Epitoniidae						
Epitonium groenlandicum	x	-	-	-	-	-
Family Eulimidae						
Balcis sp.	x	-	-	-	-	-
Family Calyptraeidae						
Crepidula nummaria	x	-	-	-	-	-
Family Naticidae						
Natica clausa	x	-	-	-	-	x
Polinices pallida	x	-	x	-	-	x
Family Cymatiidae						
Fusitriton oregonensis	x	-	x	x	-	x
Family Muricidae						
Boreotrophon clathratus	x	-	-	-	-	-
Boreotrophon stuarti	x	-	-	-	-	-
Boreotrophon pacificus	x	-	-	-	-	-
Boreotrophon lasius	x	-	-	-	-	-
Boreotrophon multicostalis	x	-	-	-	-	-
Family Thaididae						
Nucella lamellosa	x	-	x	x	-	x
Family Buccinidae						
Buccinum cnismatum	-	x	-	-	-	-
Buccinum glaciale	x	-	-	-	-	-
Buccinum plectrum	x	-	x	-	-	x

TABLE VIII

CONTINUED

Taxon	Agassiz Trawl Apr	Agassiz Trawl Oct	Try-Net Apr	Eastern Otter Trawl Oct	Clam Dredge Apr	Clam Dredge Oct
Phylum Mollusca (cont'd)						
Family Neptuneidae						
Beringius kennicotti	x	-	-	x	-	x
Colus sp.	-	x	-	-	-	-
Colus halli	x	-	-	-	-	-
Colus herendeenii	x	-	-	-	-	-
Neptunea lyrata	x	x	x	x	x	x
Neptunea ventricosa	-	-	-	-	-	x
Plicifusus kroyeri	x	-	-	-	-	-
Pyrulofusus harpa	x	-	-	-	-	-
Volutopsius middendorfii	x	-	-	-	-	-
Family Volutomitridae						
Volutomitra alaskana	x	-	-	-	-	-
Family Cancellariidae						
Admete couthouyi	x	-	-	-	-	-
Family Turridae						
Suavodrillia kennicottii	-	x	-	-	-	-
Oenopota decussata	-	x	-	-	-	-
Propebela sp.	-	x	-	-	-	-
Family Dorididae						
Unidentified species	-	x	-	x	-	-
Family Dendronotidae						
Unidentified species	-	x	-	-	-	x
Family Tritoniidae						
Tritonia exsulans	x	-	-	-	-	-
Phylum Arthropoda						
Class Pycnogonida						
Unidentified species	-	x	-	-	-	-
Class Crustacea						
Order Thoracica						
Family Balanidae						
Balanus sp.	x	x	-	x	-	-
Balanus balanus	-	-	-	x	-	-
Balanus evermani	x	-	-	-	-	-
Balanus hesperius	x	x	-	x	-	-
Balanus hoekianus	x	-	-	-	-	-
Balanus rostratus	-	-	x	x	-	x
Order Mysidacea						
Unidentified species	-	x	-	-	-	-
Family Mysidae						
Acanthomysis dybowskii	-	x	-	-	-	-

TABLE VIII

CONTINUED

Taxon	Agassiz Trawl Apr	Agassiz Trawl Oct	Try-Net Apr	Eastern Otter Trawl Oct	Clam Dredge Apr	Clam Dredge Oct
Phylum Arthropoda (cont'd)						
Order Cumacea						
Family Diastylidae						
Diastylis bidentata	-	x	-	-	-	-
Order Isopoda						
Family Aegidae						
Rocinela augustata	-	x	-	-	-	-
Order Amphipoda						
Unidentified species	x	x	-	-	-	x
Family Ampeliscidae						
Ampelisca macrocephala	x	-	-	-	-	-
Ampeliscida birulai	x	x	-	-	-	-
Byblis gaimandi	x	-	-	-	-	-
Family Corophiidae						
Ericthonius sp.	x	-	-	-	-	-
Ericthonius folli	-	x	-	-	-	-
Family Lysianassidae						
Anonyx sp.	-	x	-	-	-	-
Anonyx nugax	-	x	-	-	-	-
Lepidepecreum comatum	-	x	-	-	-	-
Family Oedicerotidae						
Monoculodes zernovi	-	x	-	-	-	-
Family Phoxocephalidae						
Heterophoxus oculatus	x	-	-	-	-	-
Family Caprellidae						
Unidentified species	x	x	-	-	-	-
Order Decapoda						
Family Pandalidae						
Pandalus sp.	-	-	x	-	-	-
Pandalus borealis	x	x	x	x	-	-
Pandalus goniurus	x	x	x	x	-	-
Pandalus hypsinotus	x	x	x	x	-	-
Pandalopsis dispar	x	x	-	-	-	-
Family Hippolytidae						
Spirontocaris lamellicornis	x	x	-	-	-	-
Lebbeus groenlandica	x	-	x	x	-	-
Eualus sp.	x	-	-	-	-	-
Eualus suckleyi	-	x	-	-	-	-
Eualus townsendi	x	-	x	-	-	-
Family Crangonidae						
Crangon sp.	x	-	-	-	-	-
Crangon communis	x	x	x	-	-	-

TABLE VIII

CONTINUED

Taxon	Agassiz Trawl Apr	Agassiz Trawl Oct	Try-Net Apr	Eastern Otter Trawl Oct	Clam Dredge Apr	Clam Dredge Oct
Phylum Arthropoda						
Family Crangonidae (cont'd)						
Crangon resina	-	x	-	-	-	-
Crangon dalli	x	x	x	x	x	x
Sclerocrangon boreas	-	-	x	-	-	x
Argis dentata	x	x	x	x	-	-
Argis crassa	x	-	x	x	-	-
Family Paguridae						
Pagurus sp.	x	-	-	-	-	-
Pagurus ochotensis	x	x	x	x	x	x
Pagurus aleuticus	x	x	x	x	-	-
Pagurus capillatus	x	x	x	x	-	x
Pagurus kennerlyi	x	x	x	x	-	x
Pagurus beringanus	x	-	-	x	-	-
Pagurus confragosus	x	-	-	-	-	-
Pagurus trigonocheirus	x	-	-	-	-	-
Elassochirus tenuimanus	x	x	x	x	x	x
Elassochirus cavimanus	-	-	-	x	-	-
Elassochirus gilli	x	-	-	-	-	-
Labidochirus splendescens	x	-	x	-	-	-
Family Lithodidae						
Paralithodes camtschatica	x	x	x	x	x	-
Rhinolithodes wosnessenskii	x	-	-	-	-	-
Family Majidae						
Oregonia gracilis	x	x	x	x	-	x
Hyas lyratus	x	x	x	x	-	x
Chionoecetes bairdi	x	x	x	x	x	-
Chorilia longipes	-	-	x	-	-	-
Family Cancridae						
Cancer oregonensis	x	-	x	x	-	x
Cancer magister	x	-	-	x	x	-
Family Pinnotheridae						
Pinnixa occidentalis	x	-	-	-	-	-
Phylum Ectoprocta						
Unidentified species	x	-	x	x	-	x
Class Cheilostomata						
Family Membraniporidae						
Membranipora sp.	x	-	-	-	-	-
Family Flustridae						
Unidentified species	-	-	-	-	-	x

TABLE VIII

CONTINUED

Taxon	Agassiz Trawl Apr	Agassiz Trawl Oct	Try-Net Apr	Eastern Otter Trawl Oct	Clam Dredge Apr	Clam Dredge Oct
Phylum Ectoprocta (cont'd)						
Family Microporidae						
Microporina sp.	-	-	-	-	-	x
Class Cyclostomata						
Family Heteroporidae						
Heteropora sp.	x	-	-	-	-	-
Class Ctenostomata						
Family Alcyonidiidae						
Alcyonidium sp.	-	-	-	x	-	-
Family Flustrellidae						
Flustrella sp.	x	-	-	x	-	-
Flustrella gigantea	-	-	-	-	-	x
Phylum Brachiopoda						
Family Dallinidae						
Laqueus californianus	x	-	-	-	-	-
Terebratalia transversa	x	-	-	x	-	-
Phylum Echinodermata						
Class Asteroidea						
Family Goniasteridae						
Ceramaster patagonicus	x	-	-	x	-	-
Ceramaster stellatus	-	x	-	-	-	-
Family Porcellanasteridae						
Ctenodiscus crispatus	x	x	-	-	-	-
Family Echinasteridae						
Henricia sp.	x	x	x	-	-	-
Henricia leviuscula	-	-	-	-	-	x
Family Pterasteridae						
Pteraster tesselatus	x	-	-	x	-	-
Family Asteridae						
Evasterias troschelii	x	-	-	x	-	x
Leptasterias sp.	x	-	-	-	-	-
Leptasterias polaris	x	-	-	x	-	x
Lethasterias sp.	-	-	-	x	-	-
Lethasterias nanimensis	x	-	-	x	-	-
Family Solasteridae						
Crossaster papposus	x	-	-	x	x	x
Crossaster borealis	x	-	-	-	-	-
Solaster dawsoni	x	-	-	-	-	-

TABLE VIII

CONTINUED

Taxon	Agassiz Trawl Apr	Agassiz Trawl Oct	Try-Net Apr	Eastern Otter Trawl Oct	Clam Dredge Apr	Clam Dredge Oct
Phylum Echinodermata (cont'd)						
Class Echinoidea						
Family Echinarachniidae						
Echinarachnius parma	x	-	-	-	x	x
Family Strongylocentrotidae						
Strongylocentrotus droebachiensis	x	x	-	x	-	x
Strongylocentrotus franciscanus	-	-	-	x	-	-
Class Ophiuroidea						
Family Gorgonocephalidae						
Gorgonocephalus caryi	x	-	-	-	-	-
Family Amphiuridae						
Amphipholis pugetana	-	x	-	-	-	-
Family Ophiactidae						
Ophiopholis aculeata	x	-	-	-	-	-
Family Ophiuridae						
Ophiopenia disacantha	-	x	-	-	-	-
Ophiopenia tetracantha	-	x	-	-	-	-
Ophiura sarsi	x	x	-	-	-	x
Class Holothuroidea						
Family Synaptidae						
Unidentified species	-	x	-	-	-	-
Family Cucumariidae						
Cucumaria sp.	x	x	-	-	-	x
Cucumaria calcigera	-	-	-	-	-	x
Phylum Chordata						
Subphylum Urochordata						
Unidentified species	x	-	x	-	-	x
Family Styelidae						
Unidentified species	-	x	-	-	-	-
NUMBER OF SPECIES	149		45	53	62	

show the distribution of selected invertebrate infauna and epifauna in a nearshore region adjacent to OCSEAP deep-water benthic stations in lower Cook Inlet. The stations were relatively diverse with arthropod crustaceans and molluscs leading in species representation. Appendix I, Tables III-XXVIII list the relative abundance of the invertebrate taxa from the 26 stations sampled.

Trawls

The preliminary lower Cook Inlet benthic study, resulted in the successful occupation of 25 different stations by Agassiz trawl and/or try-net, and/or Eastern otter trawl (Tables I and VI; Fig. 1).

Agassiz Trawl - Sampling via Agassiz trawl yielded representatives of nine invertebrate phyla (Table VIII). Ten stations were occupied in April, and seven stations were occupied in October. Arthropod crustaceans were dominant in number, weight, and biomass (Tables IX and X). The major arthropod families were Lithodidae and Majidae (Tables XI and XII) and the dominant species within each family was the king crab, *Paralithodes camtschatica*, and the snow crab, *Chionoecetes bairdi*, respectively. The percent composition of all phyla by family and species is presented in Appendix I, Tables XXIX-XXXII.

Try-Net - Only six stations were sampled with the try-net (Tables I and VI; Fig. 1). The taxonomic list and the occurrence of taxa from these stations appears in Table VIII and Appendix 1, Table XXXIII, respectively. *Chionoecetes bairdi* and the gray shrimp, *Crangon dalli*, were present in all trawls.

Eastern Otter Trawl - Sampling via Eastern otter trawl was only conducted in October 1976 (see Table VIII for species list). The occurrence of taxa in the 16 stations sampled is listed in Appendix Table XXXIV. Arthropoda (Crustacea) once again dominated the number, weight, and biomass of the invertebrate phyla (Table XIII). Mollusca and Echinodermata also contributed significantly. The majid crabs, *Chionoecetes bairdi* and *Hyas lyratus*, made up the bulk of the crustaceans (Appendix 1, Tables XXXV and XXXVI). The gastropod family Neptuneidae, specifically

TABLE IX

NUMBER, WEIGHT, AND BIOMASS (g/m^2) OF EPIFAUNAL INVERTEBRATE PHYLA OF LOWER COOK INLET AS OBTAINED BY AGASSIZ TRAWL, APRIL 1976

Phylum	Number of Organisms	Weight (kg)	% Total Wt.	g/m^2
Porifera	2	0.107	0.094	0.003
Cnidaria	23	0.619	0.542	0.018
Annelida	25	0.031	0.027	0.001
Mollusca	700	17.812	15.588	0.507
Arthropoda: Crustacea	4061	82.414	72.123	2.342
Ectoprocta	5	0.188	0.165	0.005
Brachiopoda	20	0.135	0.118	0.004
Echinodermata	290	12.718	11.130	0.362
Chordata: Urochordata	5	0.245	0.214	0.007
TOTAL	5131	114.269	100	3.249

TABLE X

NUMBER, WEIGHT, AND BIOMASS (g/m^2) OF EPIFAUNAL INVERTEBRATE PHYLA OF LOWER COOK INLET AS OBTAINED BY AGASSIZ TRAWL, OCTOBER 1976

Phylum	Number of Organisms	Weight (kg)	% Total Wt.	g/m^2
Cnidaria	1	0.002	0.003	0.0001
Annelida	17	0.017	0.024	0.0008
Mollusca	60	1.049	1.529	0.0514
Arthropoda: Pycnogonida	8	0.003	0.004	0.0002
Arthropoda: Crustacea	2981	67.354	98.195	3.3049
Echinodermata	78	0.166	0.242	0.0081
Chordata: Urochordata	1	0.001	0.002	0.0001
TOTAL	3146	68.592	100	3.3656

TABLE XI

NUMBER, WEIGHT, AND BIOMASS (g/m^2) OF MAJOR EPIFAUNAL INVERTEBRATE FAMILIES OF LOWER COOK INLET AS OBTAINED BY AGASSIZ TRAWL, APRIL 1976

Family	Number of Organisms	Weight (kg)	% Total Wt.	g/m^2
Pectinidae	62	0.857	0.75	0.024
Cardiidae	49	0.773	0.68	0.022
Cymatiidae	197	4.602	4.04	0.131
Neptuneidae	278	9.745	8.56	0.277
Pandalidae	721	6.561	5.76	0.186
Crangonidae	216	4.291	3.77	0.122
Paguridae	311	5.091	4.47	0.144
Lithodidae	11	3.013	26.49	0.857
Majidae	2757	36.055	31.69	1.026
Solasteridae	8	0.640	0.56	0.018
Asteridae	39	3.623	3.18	0.103
Echinarachniidae	92	4.080	3.58	0.116
Strongylocentrotidae	34	1.998	1.75	0.056
Cucumariidae	12	1.344	1.18	0.038
TOTAL	4787	82.673	96.46	3.120

TABLE XII

NUMBER, WEIGHT, AND BIOMASS (g/m^2) OF MAJOR EPIFAUNAL INVERTEBRATE FAMILIES OF LOWER COOK INLET AS OBTAINED BY AGASSIZ TRAWL, OCTOBER 1976

Family	Number of Organisms	Weight (kg)	% Total Wt.	g/m^2
Pectinidae	11	0.044	0.06	0.002
Cardiidae	1	0.015	0.02	0.001
Neptuneidae	6	0.935	1.36	0.045
Pandalidae	1588	3.257	4.75	0.159
Crangonidae	1221	1.027	1.49	0.050
Paguridae	23	0.239	0.34	0.011
Lithodidae	16	51.070	74.49	2.505
Majidae	45	11.682	17.03	0.573
Strongylocentrotidae	1	0.001	<0.01	<0.001
Cucumariidae	21	0.018	0.02	<0.001
TOTAL	2933	68.288	99.65	3.356

TABLE XIII

NUMBER, WEIGHT, AND BIOMASS (g/m^2) OF EPIFAUNAL INVERTEBRATE PHYLA OF LOWER COOK INLET AS OBTAINED BY EASTERN OTTER TRAWL, OCTOBER 1976

Phylum	Number of Organisms	Weight (kg)	% Total Wt.	g/m^2
Porifera	245	20.046	2.2230	0.06795
Cnidaria	48	14.289	1.5846	0.04844
Annelida	55	0.128	0.0142	0.00043
Mollusca	1623	151.570	16.8082	0.51381
Arthropoda:Crustacea	4902	571.151	63.3374	1.93613
Ectoprocta	14	1.192	0.1322	0.00403
Brachiopoda	1	0.001	0.0001	0.00000
Echinodermata	362	143.383	15.9004	0.48605
TOTAL	7250	901.760	100	3.0569

Neptunea lyrata, dominated the molluscs, and the sea cucumber, *Cucumaria* sp., dominated the echinoderms.

Distribution, Relative Abundance, and Biomass of Invertebrate Epifauna

In general, stations with high relative epifaunal abundance and biomass in lower Cook Inlet were located south of Anchor Point, specifically at western and southwestern stations (Fig. 1). Six species of crabs (*Chionoecetes bairdi, Paralithodes camtschatica, Hyas lyratus, Oregonia gracilis, Pagurus ochotensis, Elassochirus tenuimanus*), two species of gastropods (*Neptunea lyrata, Fusitriton oregonensis*), one species of shrimp (*Crangon dalli*), and one species of sand dollar (*Echinarachnius parma*) were the dominant invertebrate organisms.

The major invertebrate was the snow crab, *Chionoecetes bairdi*, which was mainly obtained by trawling (Figs. 3 and 4). Stations 5 through 8B yielded mainly juvenile crabs ranging from 2 to 26 mm carapace width. Large specimens were obtained at most other western and southwestern stations. Eastern otter trawl Station 25 yielded the highest biomass of snow crabs, 6.5 g/m^2. Other crabs in the same family as *C. bairdi* (Majidae) were *Hyas lyratus* and *Oregonia gracilis*. The highest catch of *H. lyratus* was made in October at Station 40A by Eastern otter trawl (Figs. 5 and 6). At this station 1032 crabs were caught, of which 75% were females with early eggs. *Oregonia gracilis* and *H. lyratus* occurred at many of the same stations (Figs. 7 and 8). The most abundant catch of *O. gracilis*, 29 crabs, came in April at Agassiz trawl Station 8 (Fig. 7).

Catches of king crabs, *Paralithodes camtschatica*, were relatively small during both sampling months. In April, king crabs were found north of Augustine Island and off Anchor Point (Fig. 9). King crabs were more widely distributed in October (Fig. 10). Agassiz trawl Station 6 had the highest biomass with 18.1 g/m^2; however, this comprised only 12 organisms.

Two common hermit crabs in lower Cook Inlet were *Pagurus ochotensis* and *Elassochirus tenuimanus*. Large catches of *P. ochotensis* in April were taken north of Augustine Island, specifically at Agassiz trawl Stations 53 and 54 (Fig. 11). The largest catch in October came from Eastern otter trawl Station 40A, where the biomass and abundance was 0.08 g/m^2 and 54, respectively (Fig. 12). The largest catch of *E. tenuimanus* was in April at Station 44A by Agassiz trawl (Fig. 13). At this station 26 individuals

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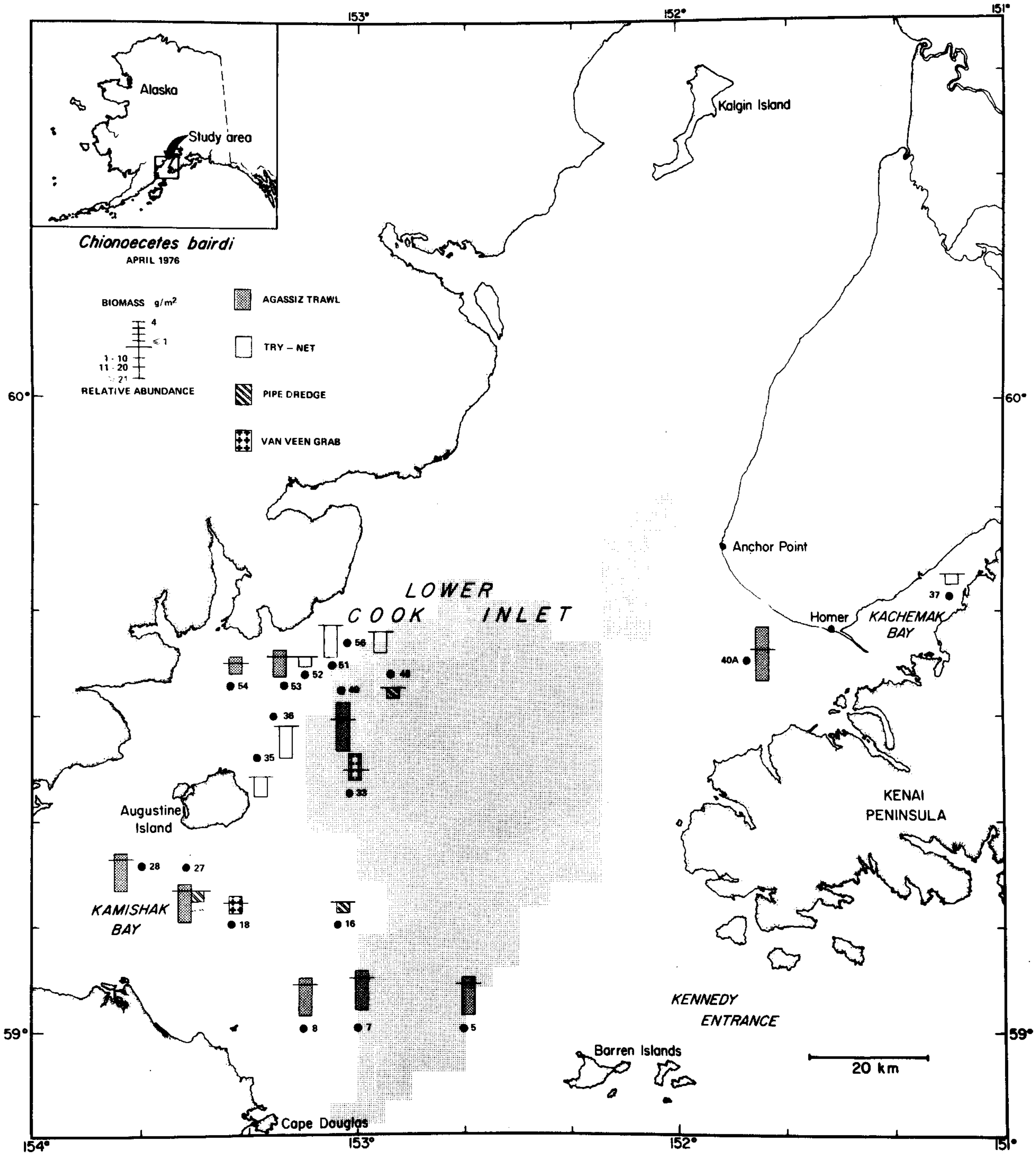

Figure 3. Distribution, relative abundance, and biomass of *Chionoecetes bairdi*, from lower Cook Inlet, April 1976.

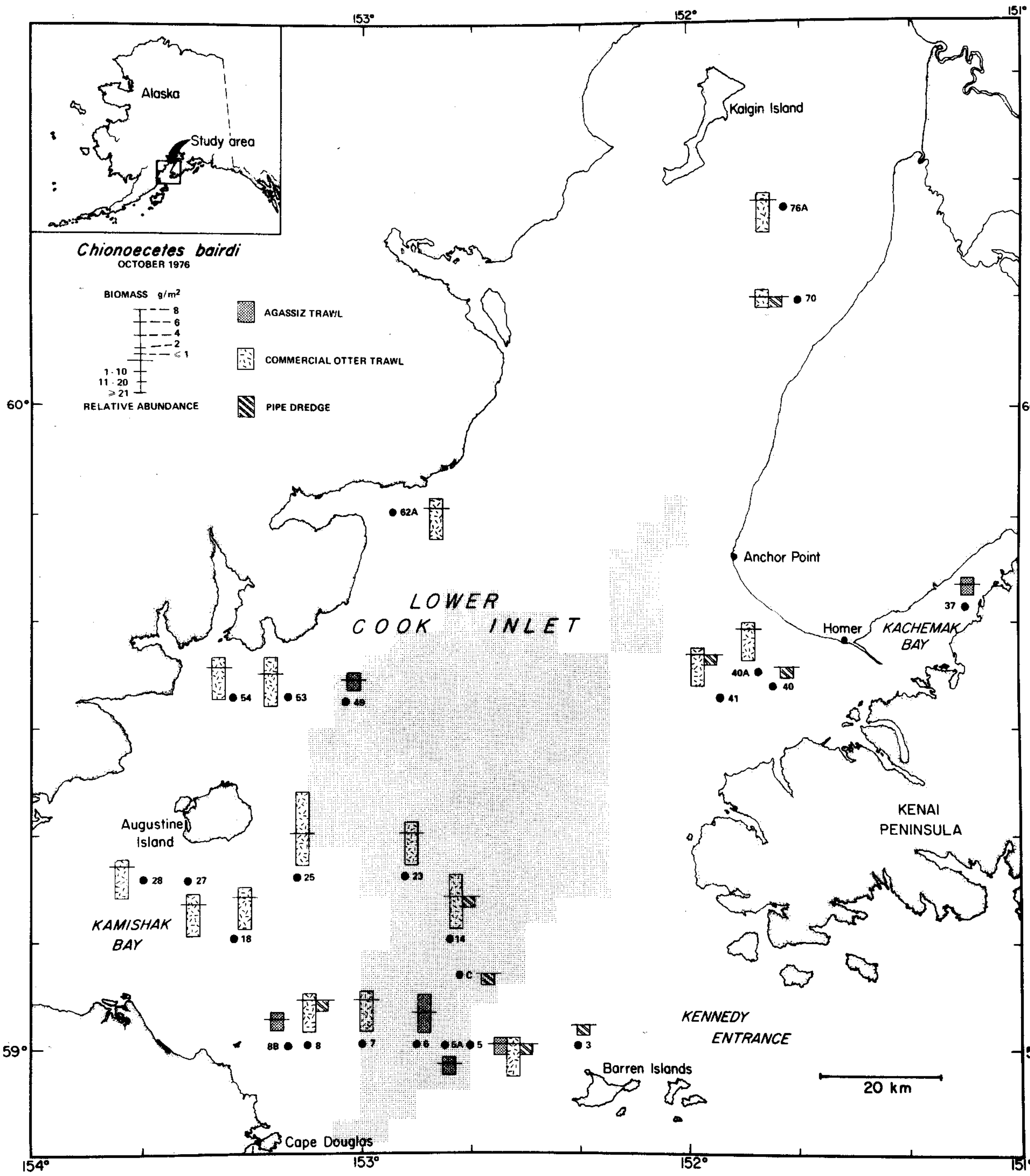

Figure 4. Distribution, relative abundance, and biomass of *Chionoecetes bairdi*, from lower Cook Inlet, October 1976.

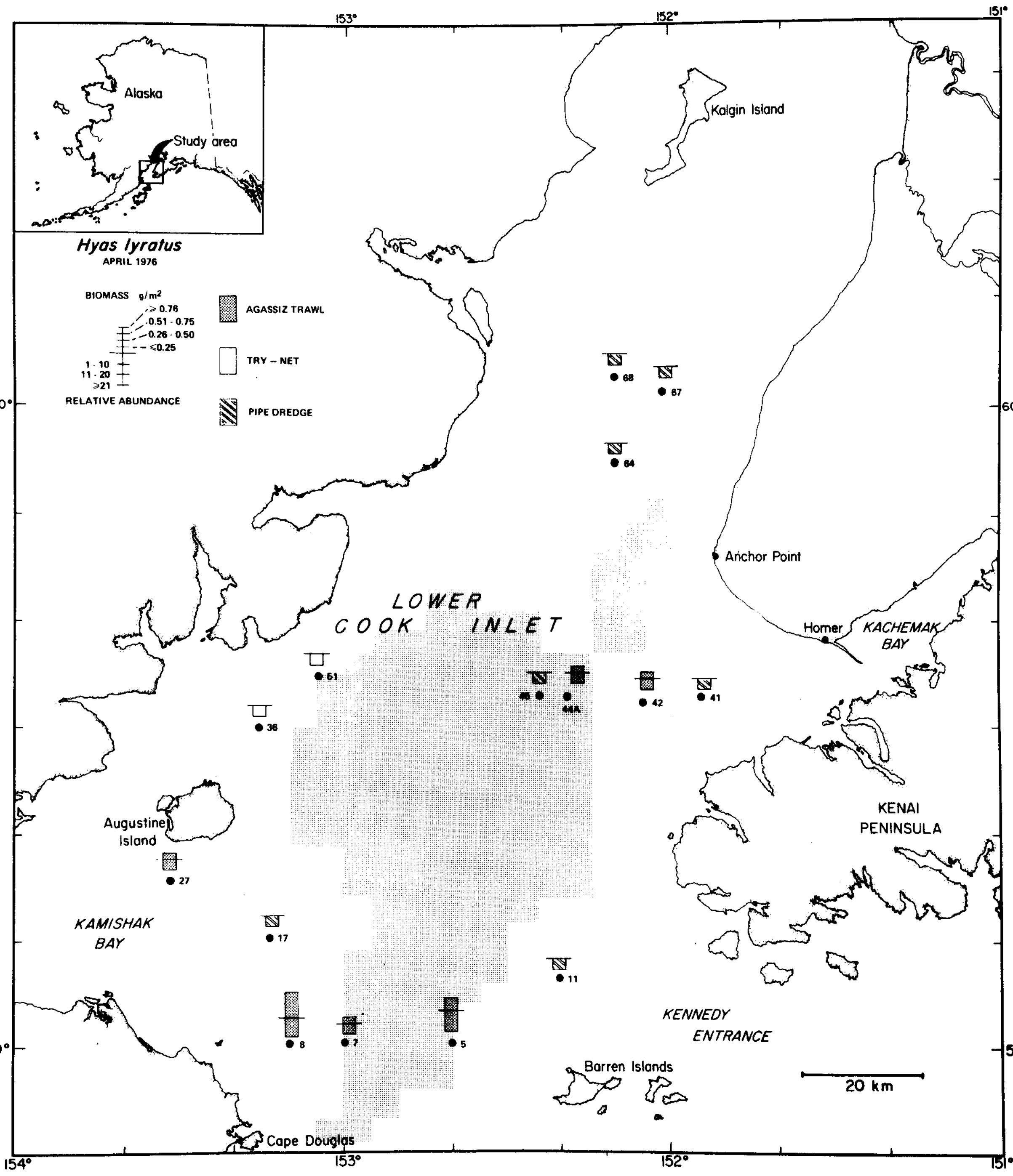

Figure 5. Distribution, relative abundance, and biomass of *Hyas lyratus* from lower Cook Inlet, April 1976.

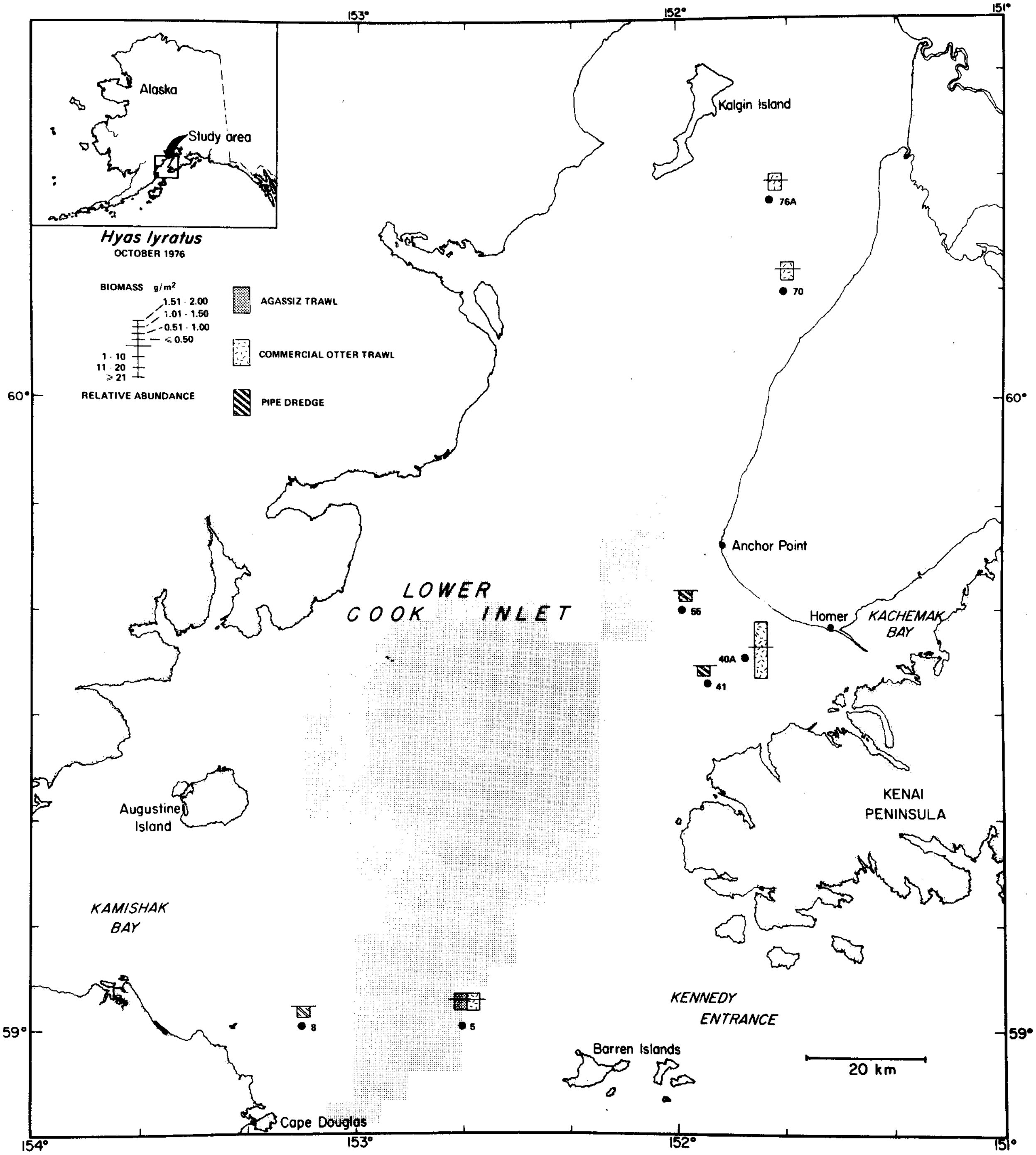

Figure 6. Distribution, relative abundance, and biomass of *Hyas lyratus* from lower Cook Inlet, October 1976.

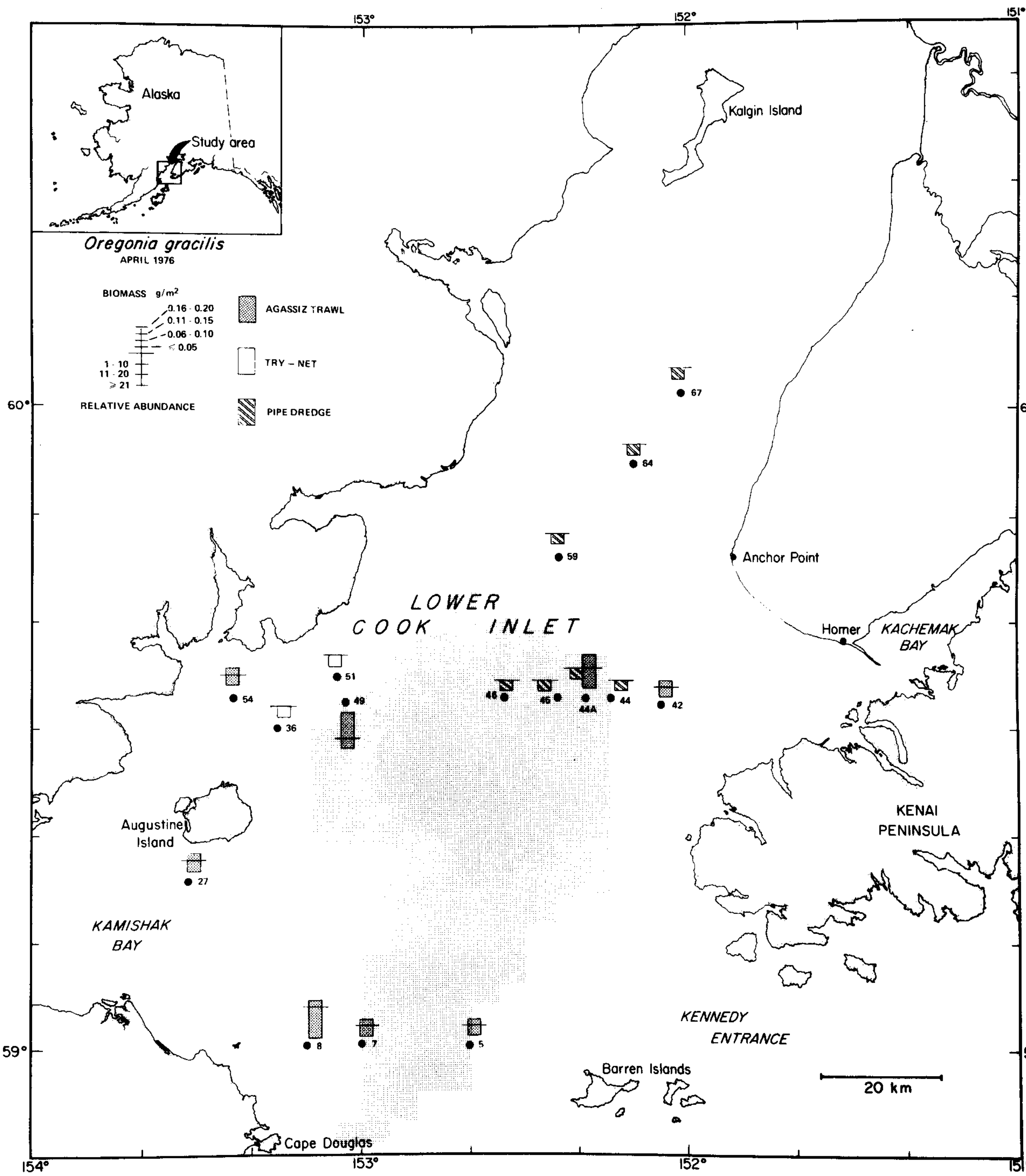

Figure 7. Distribution, relative abundance, and biomass of *Oregonia gracilis* from lower Cook Inlet, April 1976.

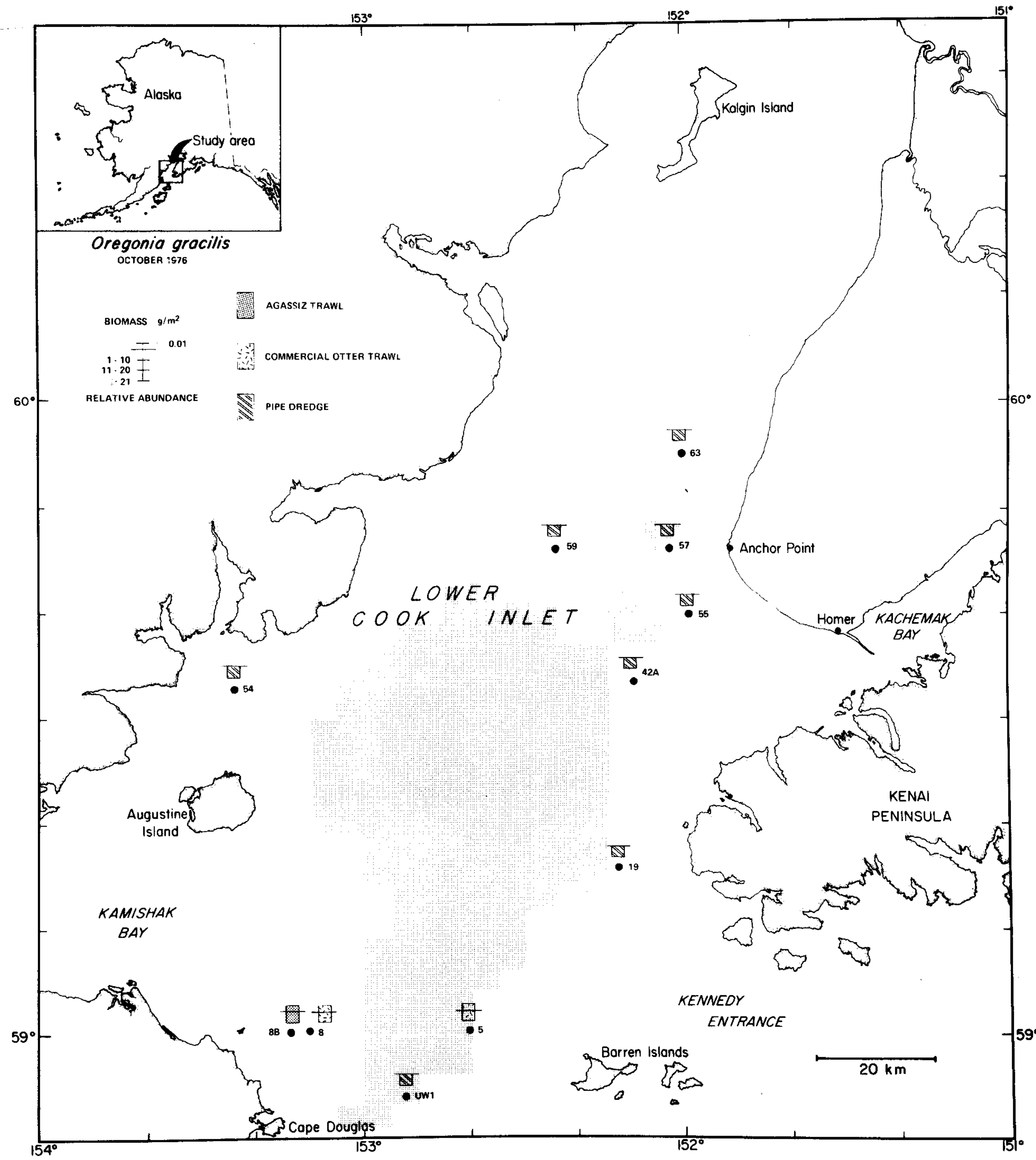

Figure 8. Distribution, relative abundance, and biomass of *Oregonia gracilis* from lower Cook Inlet, October 1976.

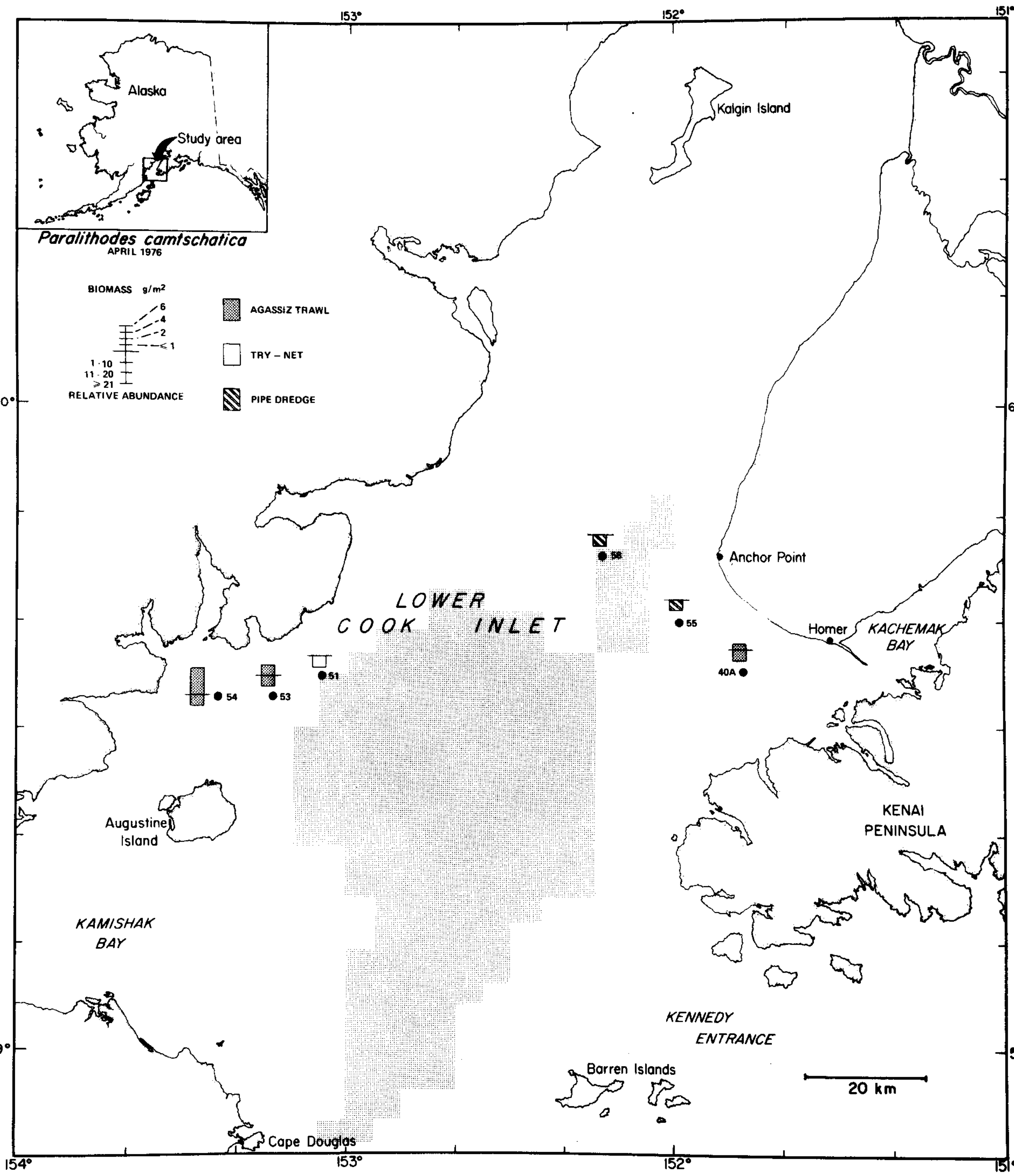

Figure 9. Distribution, relative abundance, and biomass of *Paralithodes camtschatica* from lower Cook Inlet, April 1976.

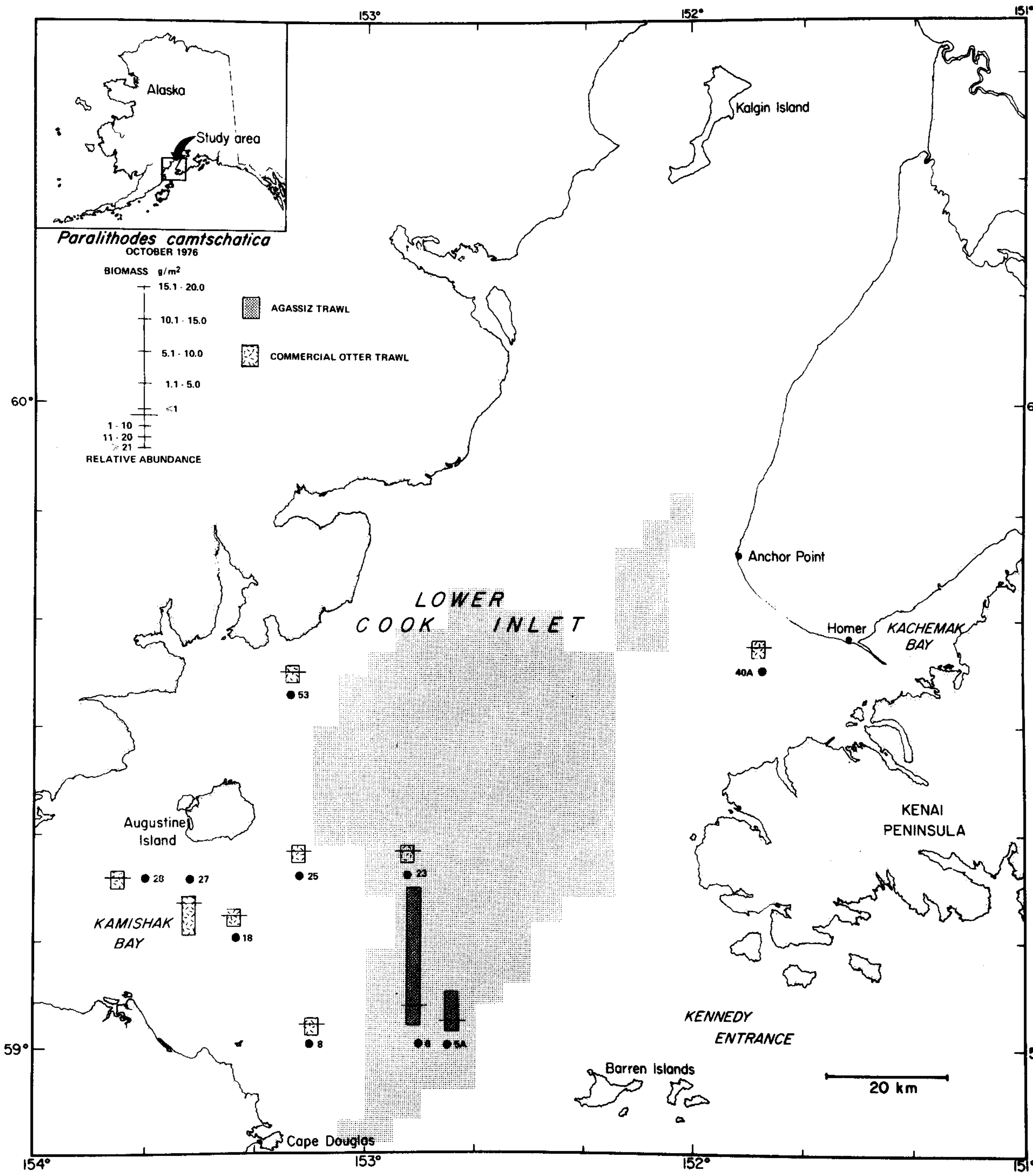

Figure 10. Distribution, relative abundance, and biomass of *Paralithodes camtschatica* from lower Cook Inlet, October 1976.

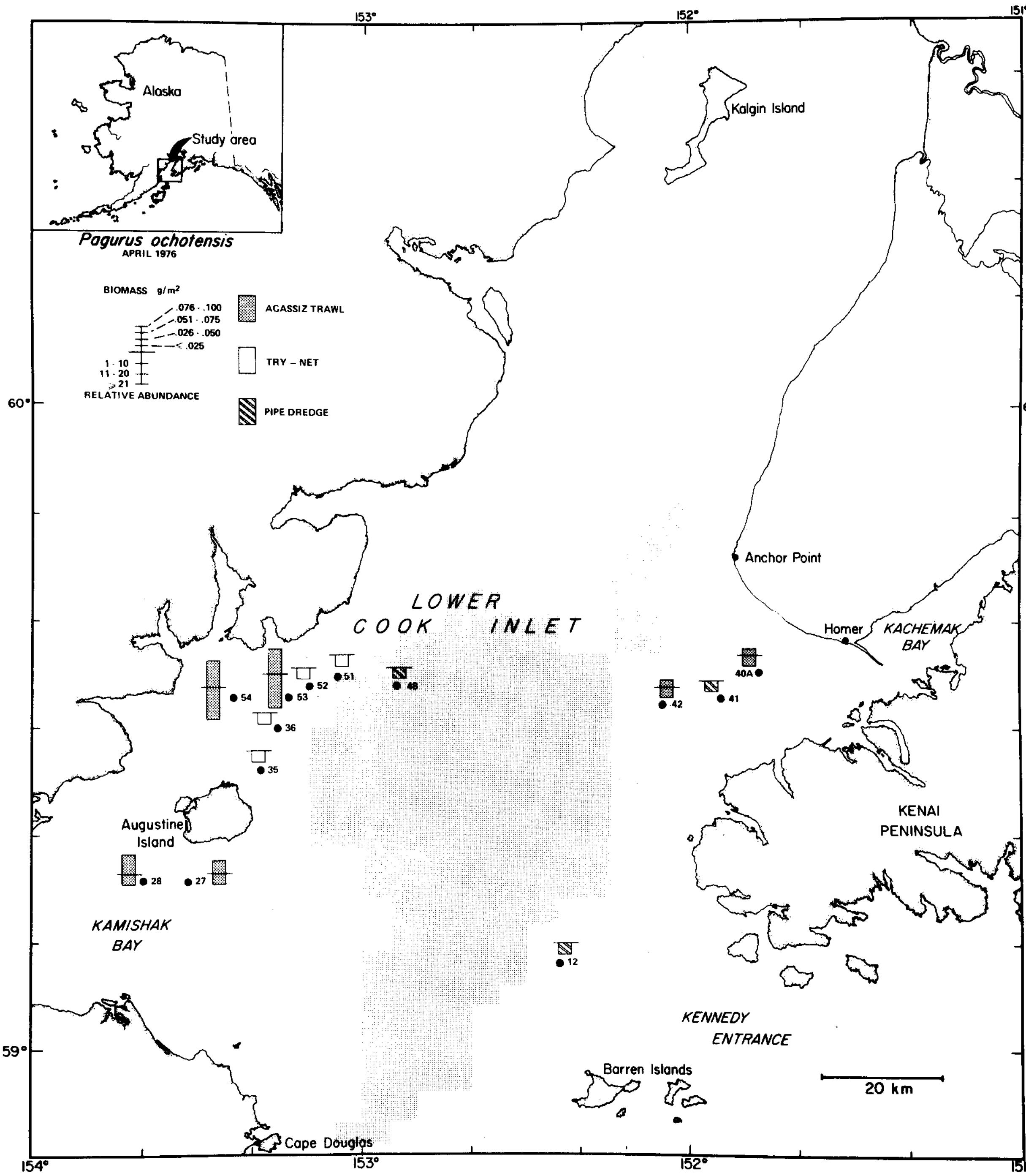

Figure 11. Distribution, relative abundance, and biomass of *Pagurus ochotensis* from lower Cook Inlet, April 1976.

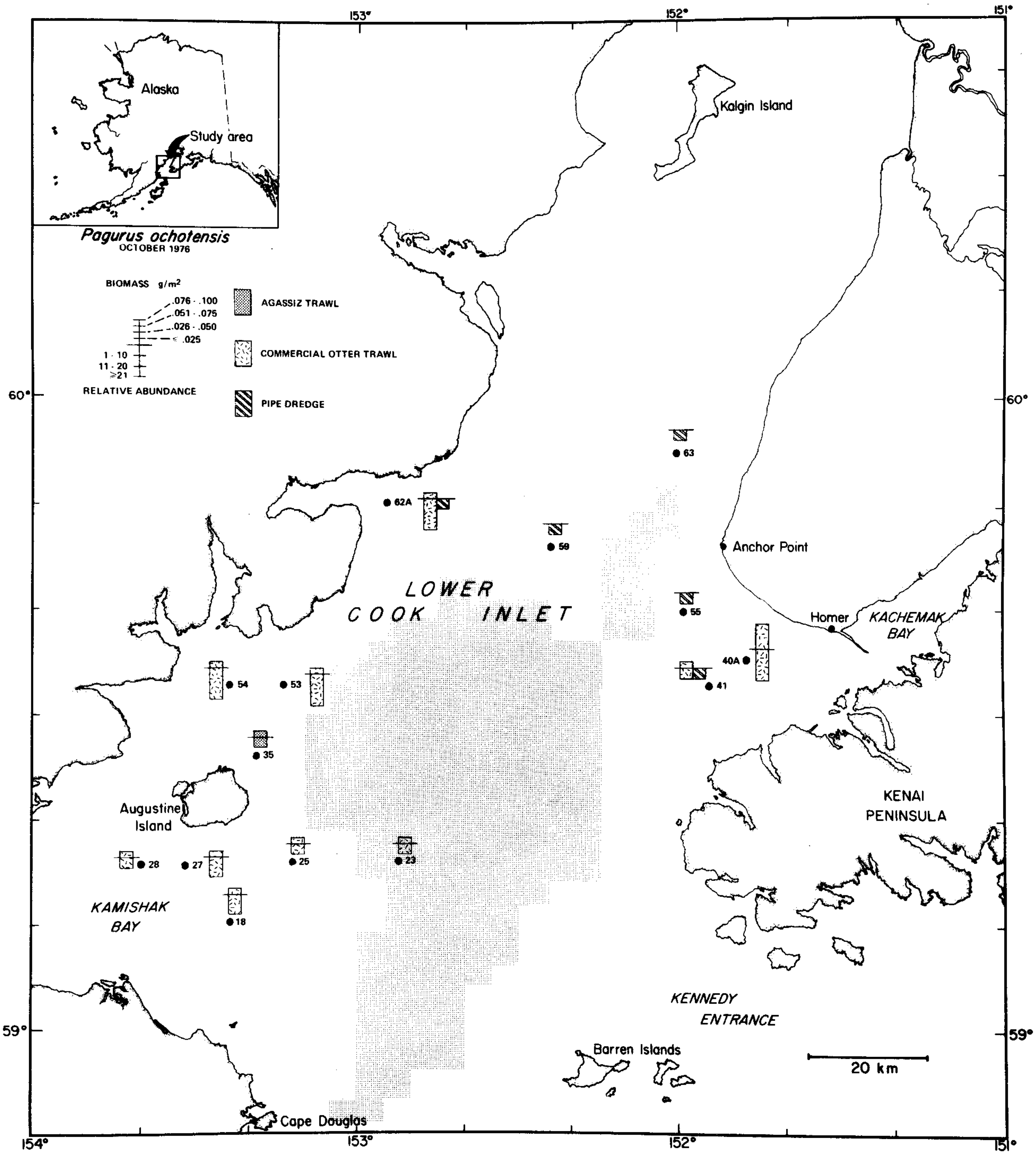

Figure 12. Distribution, relative abundance, and biomass of *Pagurus ochotensis* from lower Cook Inlet, October 1976.

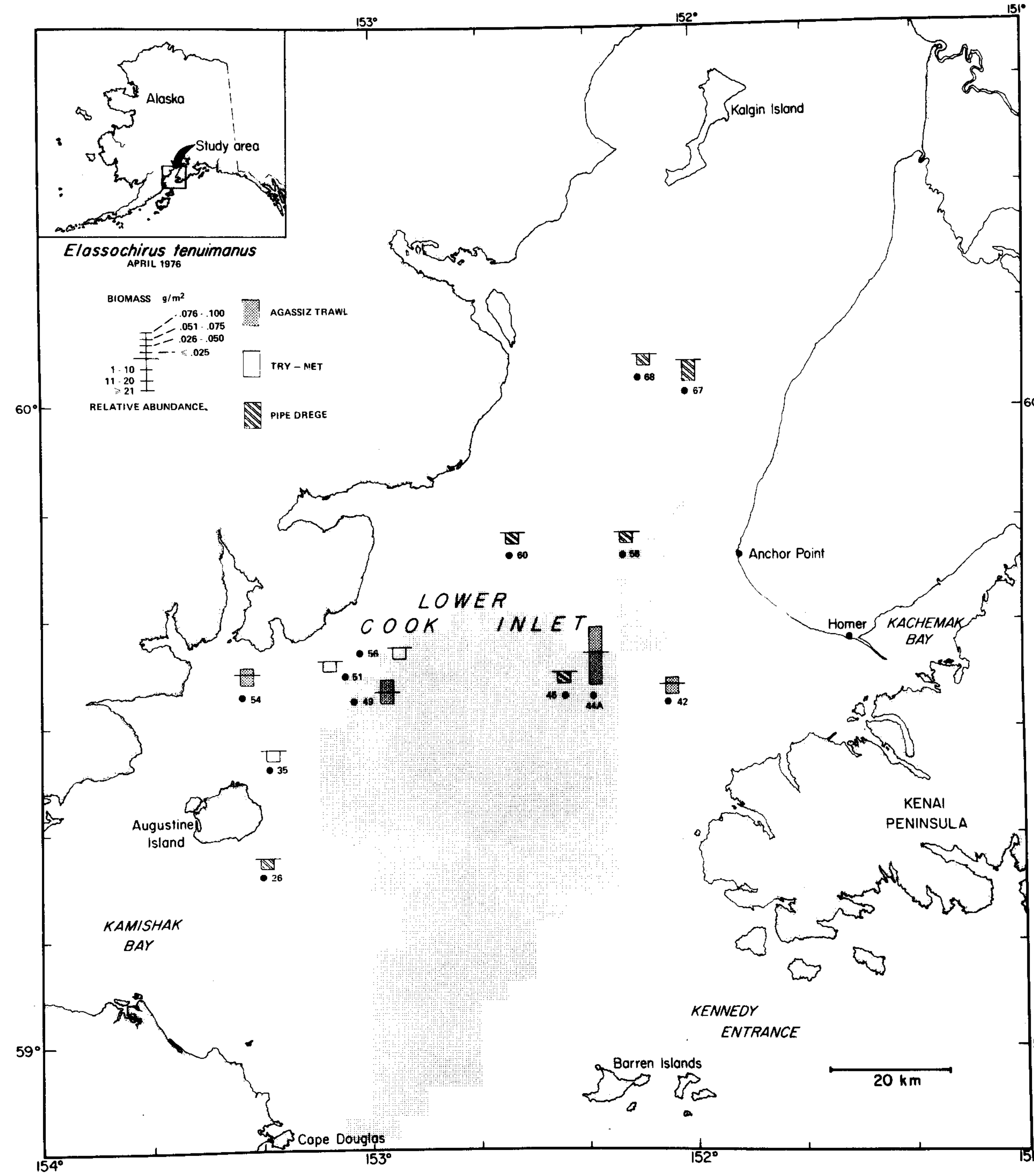

Figure 13. Distribution, relative abundance, and biomass of *Elassochirus tenuimanus* from lower Cook Inlet, April 1976.

were found, and the biomass was 0.09 g/m^2. Catches of this species were small during October (Fig. 14).

Crangon dalli was the dominant shrimp. Although the biomass was never greater than 0.01 g/m^2 at any station in either sampling month, the abundance was often more than 200 individuals (Figs. 15 and 16).

Neptunea lyrata and *Fusitriton oregonensis* were the two most common gastropod molluscs. In April, the biomass of *N. lyrata* was never more than 1 g/m^2 at any station; however, the abundance was high at Agassiz trawl Stations 5, 53 and 54 (Fig. 17). Sampling by Eastern otter trawl in October provided larger catches of *N. lyrata*. Station 53 had the highest biomass with 3.4 g/m^2 (78 individuals). Station 40A had a biomass of only 1.6 g/m^2, but 443 individuals were collected (Fig. 18). In contrast, although the distribution of *F. oregonensis* was similar to *N. lyrata*, the biomass of the former snail was never more than 0.04 g/m^2 at any station (Figs. 19 and 20).

The average invertebrate biomass from the ten Agassiz trawl stations in April and the seven Agassiz trawl stations in October was 3.2 and 3.3 g/m^2 respectively. The average invertebrate biomass from the 16 Eastern otter trawl stations was 3.0 g/m^2. The 13 grab stations had an average biomass of 205.4 g/m^2. The lowest and highest infaunal biomasses were 6.2 g/m^2 at Stations 69 and 731.9 g/m^2 at Station 45.

The sand dollar, *Echinarachnius parma*, was only taken by grab and pipe dredge. In April, the highest biomass stations were grab Stations 30, 42, 45 and 46 (Fig. 21). In grab Station 45 the abundance and biomass were 26 and 585.5 g/m^2, respectively. Grabs were not used in October; sand dollars were only taken by pipe dredge during this period (Fig. 22).

Eastern otter trawl Station 27 was of special interest. Eighty-eight Pacific halibut, of which more than 80 were less than 30 cm (total length), were obtained in a 30 minute tow in October. This abundance of juveniles may indicate a halibut nursery ground.

Distribution, relative abundance, and biomass data on all other benthic invertebrates taken in lower Cook Inlet during April and October are available at NODC.

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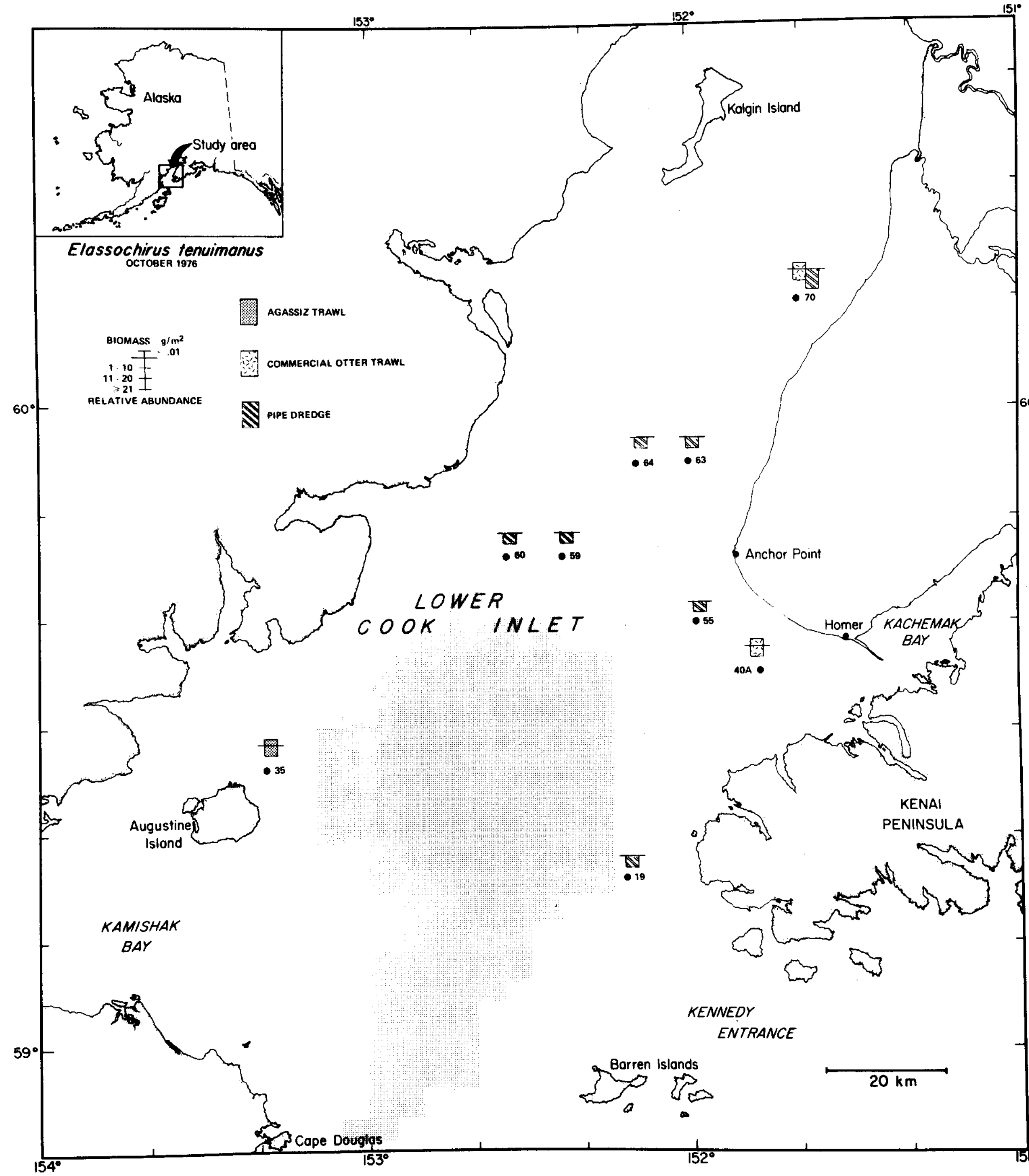

Figure 14. Distribution, relative abundance, and biomass of *Elassochirus tenuimanus* from lower Cook Inlet, October 1976.

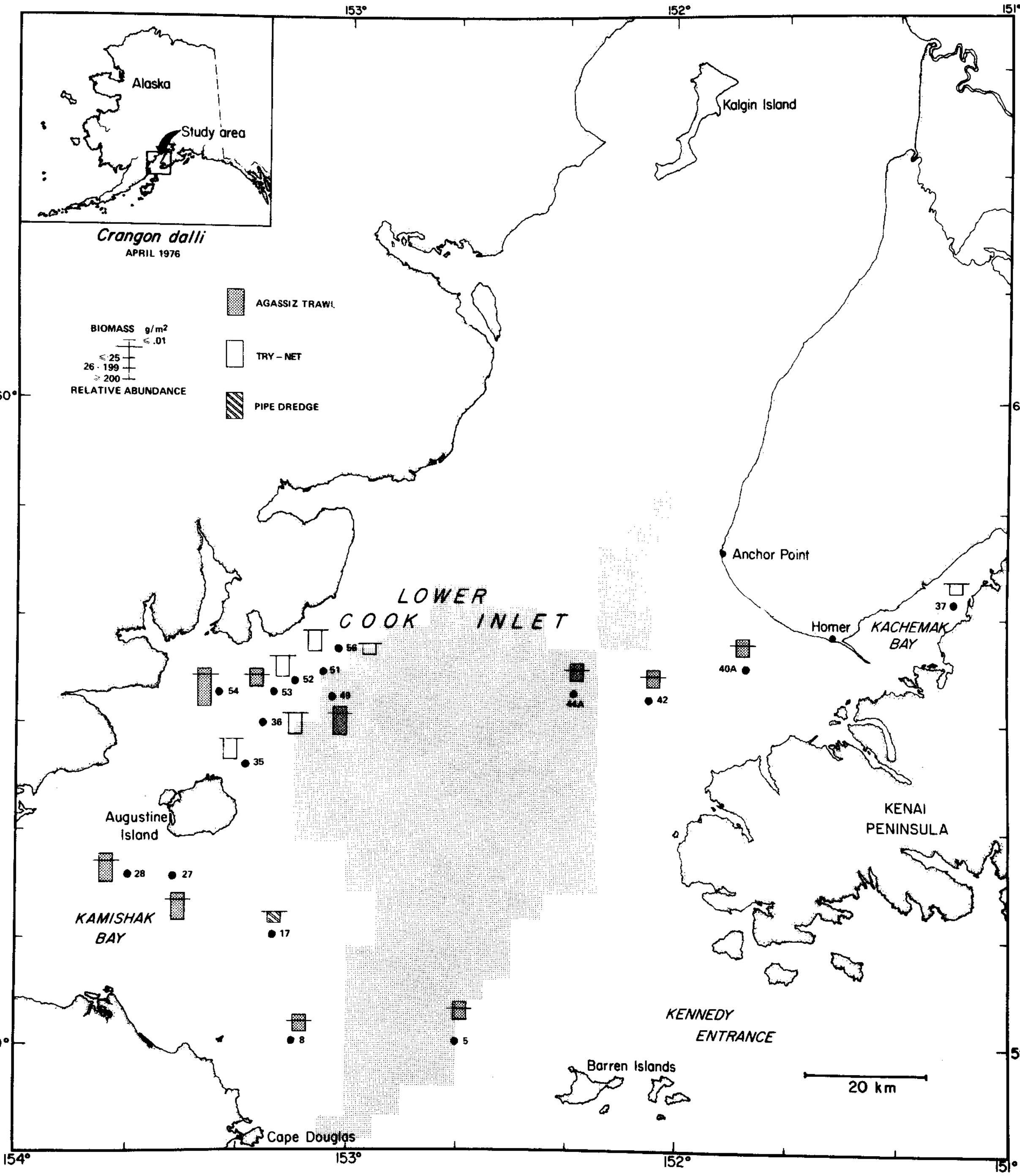

Figure 15. Distribution, relative abundance, and biomass of *Crangon dalli* from lower Cook Inlet, April 1976.

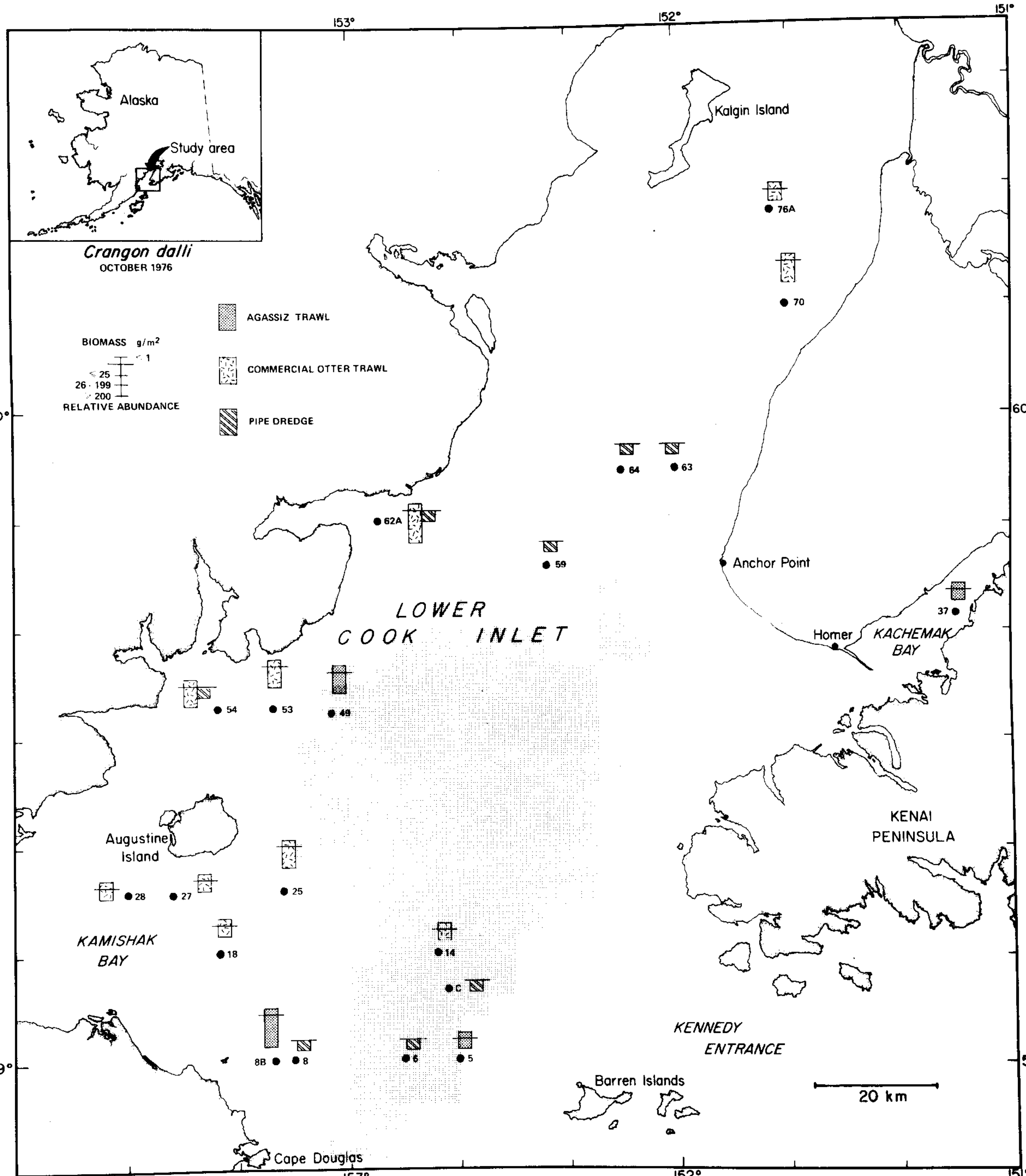

Figure 16. Distribution, relative abundance, and biomass of *Crangon dalli* from lower Cook Inlet, October 1976.

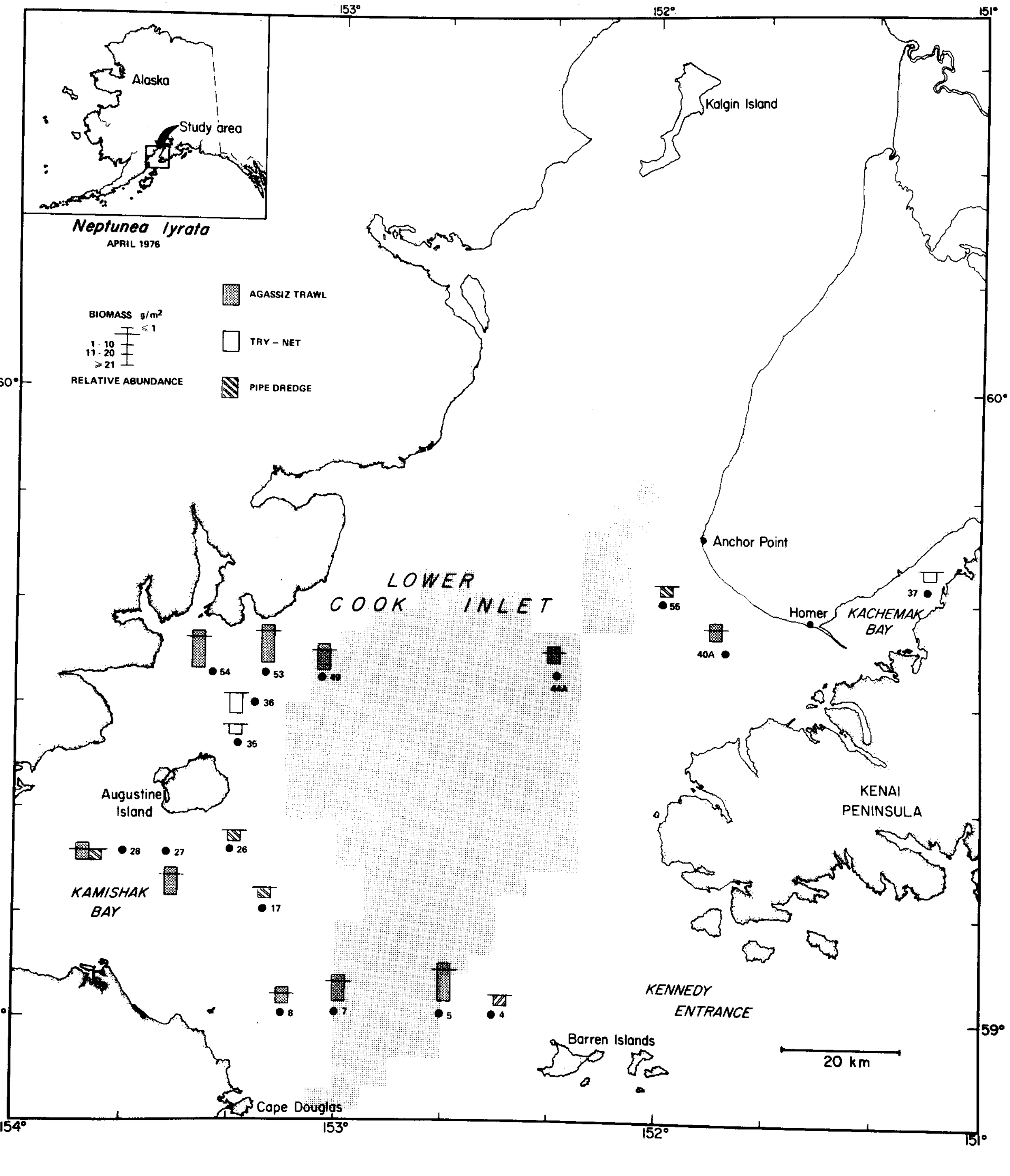

Figure 17. Distribution, relative abundance, and biomass of *Neptunea lyrata* from lower Cook Inlet, April 1976.

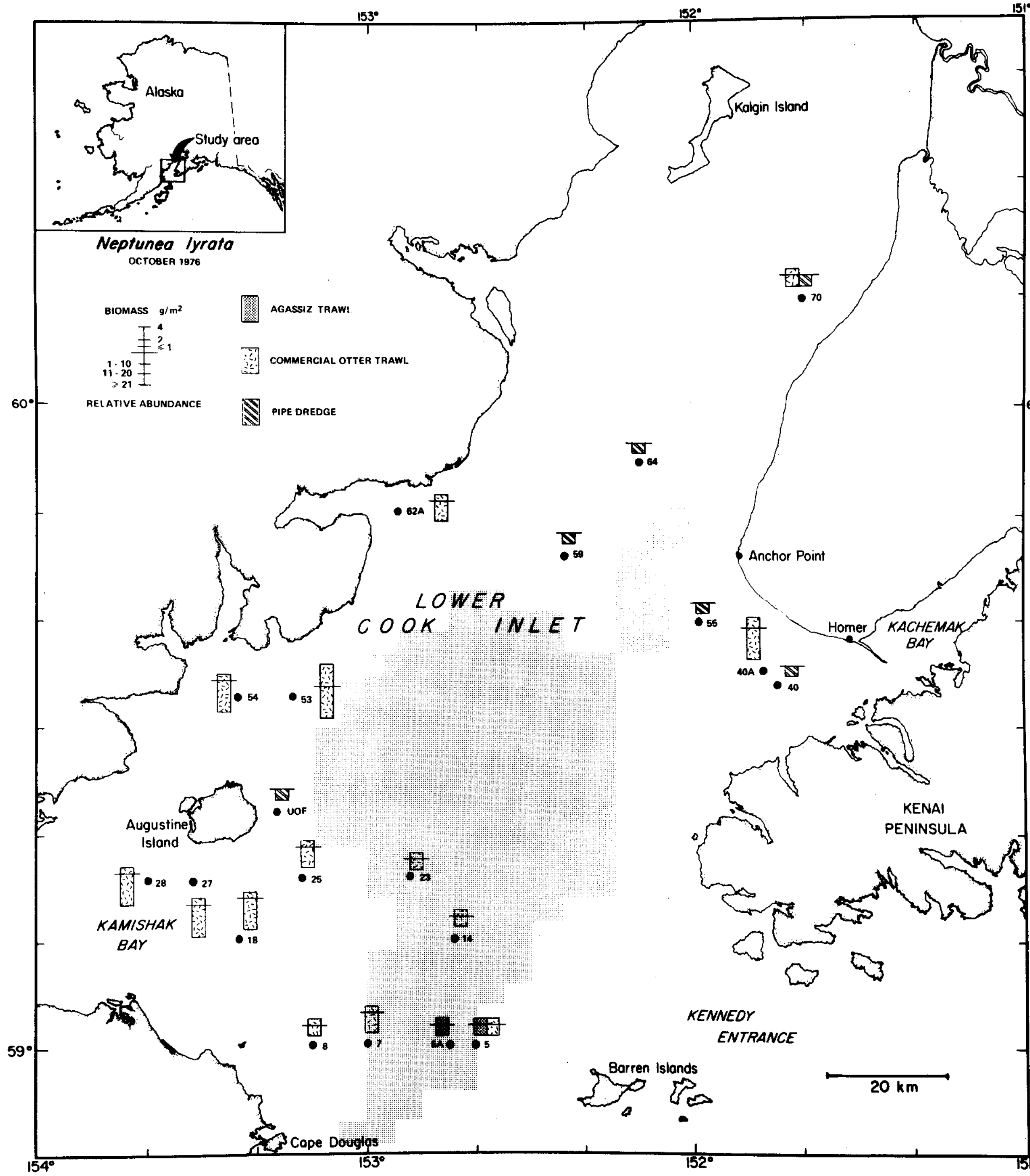

Figure 18. Distribution, relative abundance, and biomass of *Neptunea lyrata* from lower Cook Inlet, October 1976.

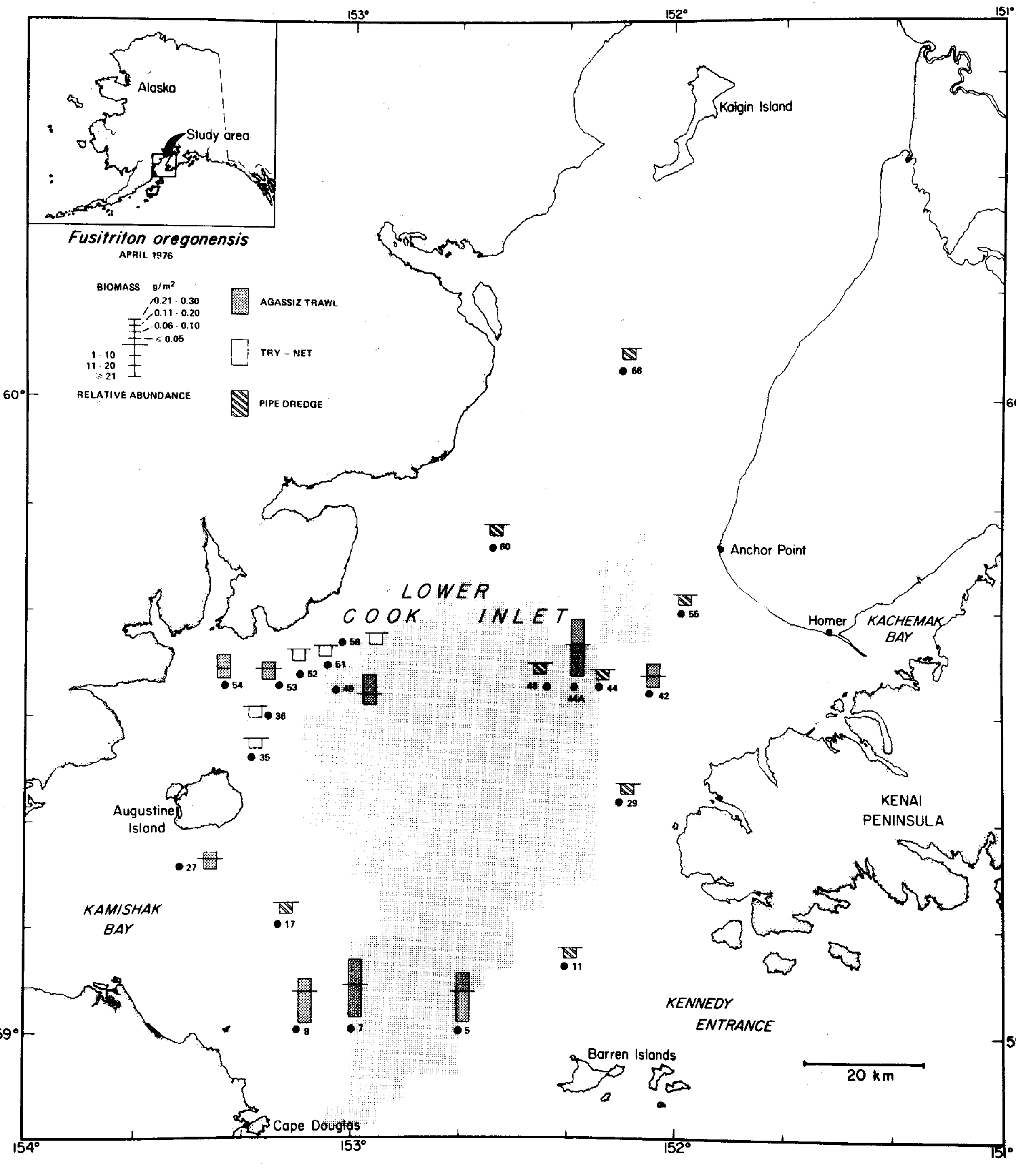

Figure 19. Distribution, relative abundance, and biomass of *Fusitriton oregonensis* from lower Cook Inlet, April 1976.

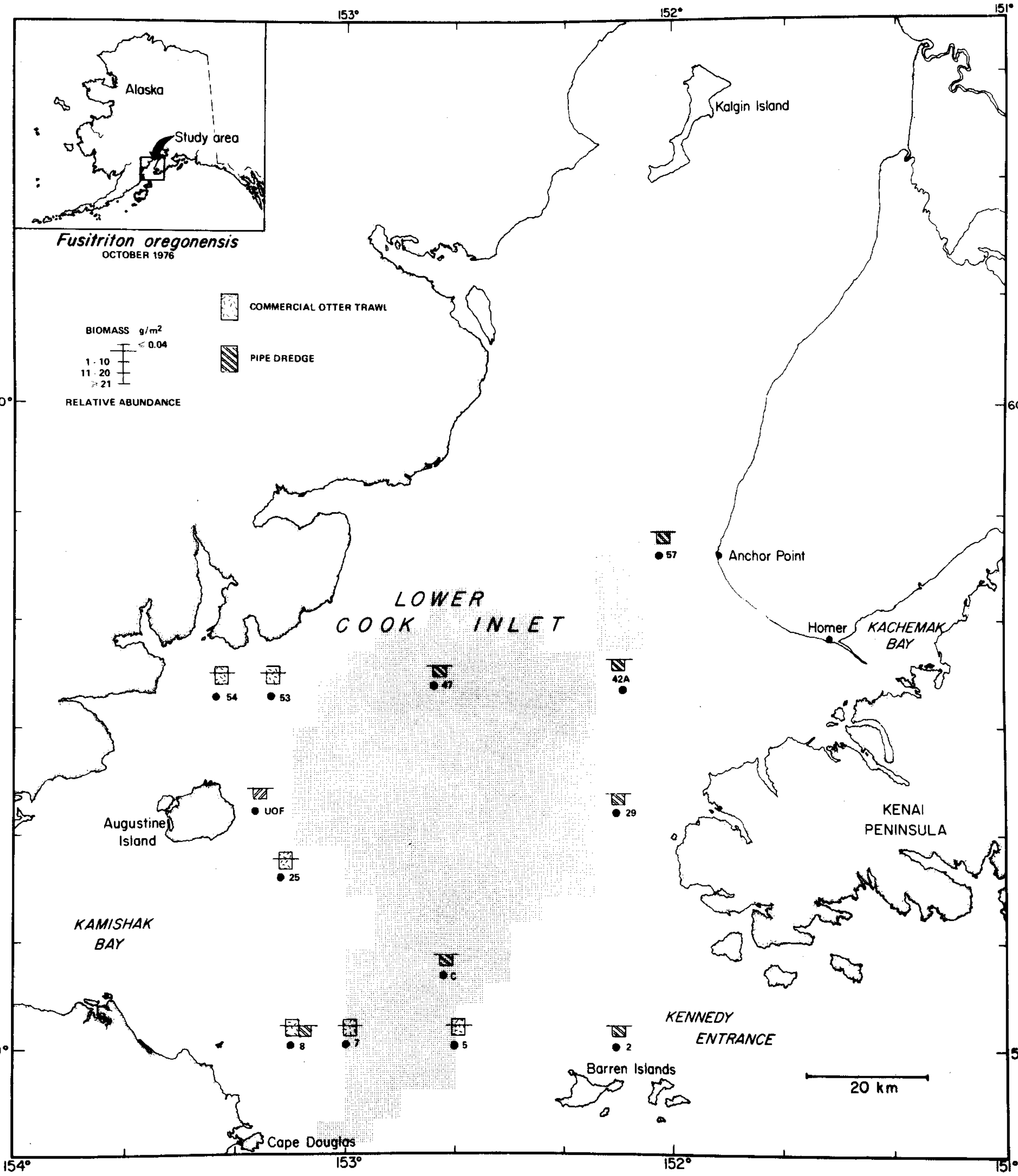

Figure 20. Distribution, relative abundance, and biomass of *Fusitriton oregonensis* from lower Cook Inlet, October 1976.

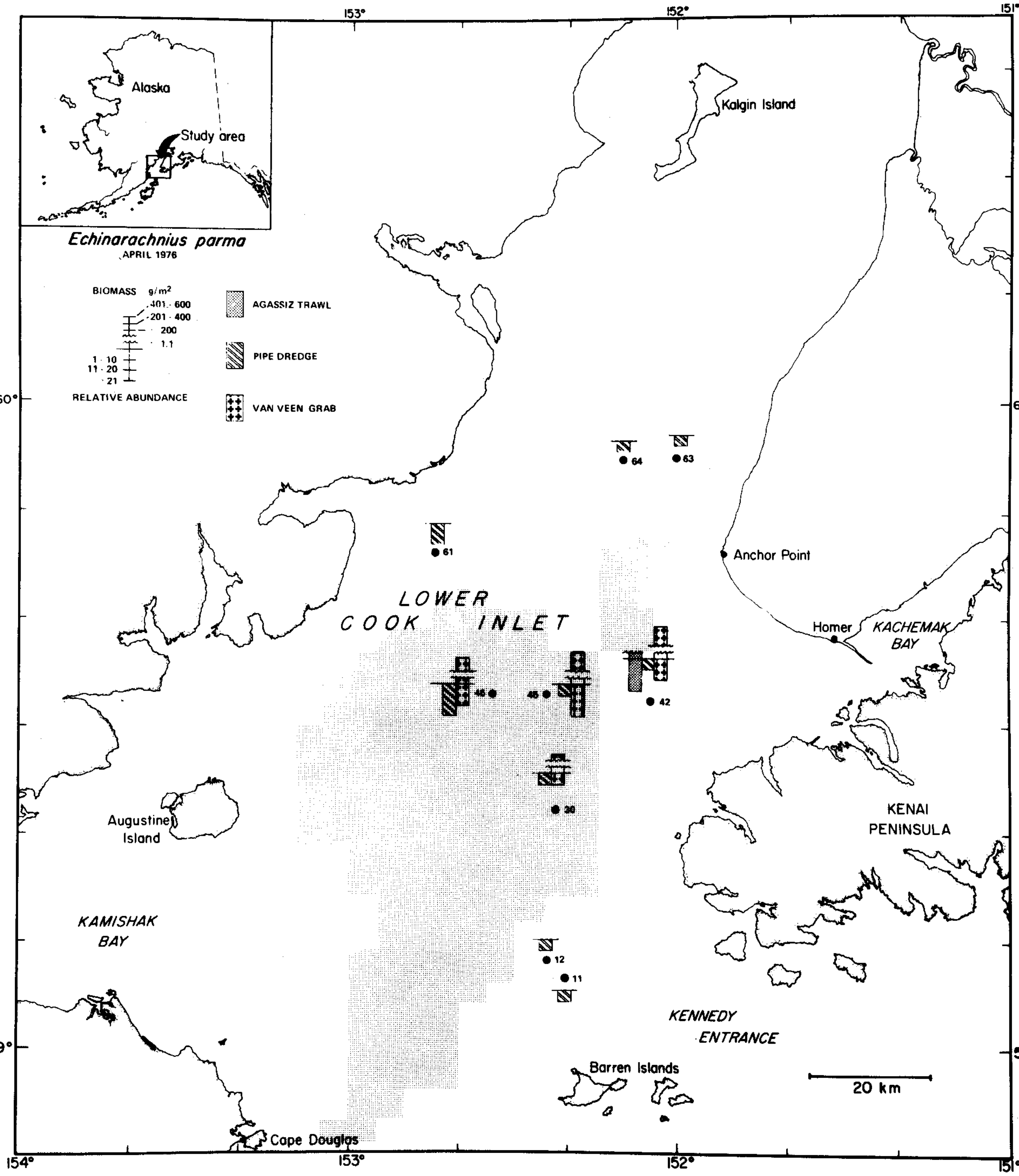

Figure 21. Distribution, relative abundance, and biomass of *Echinarachnius parma* from lower Cook Inlet, April 1976.

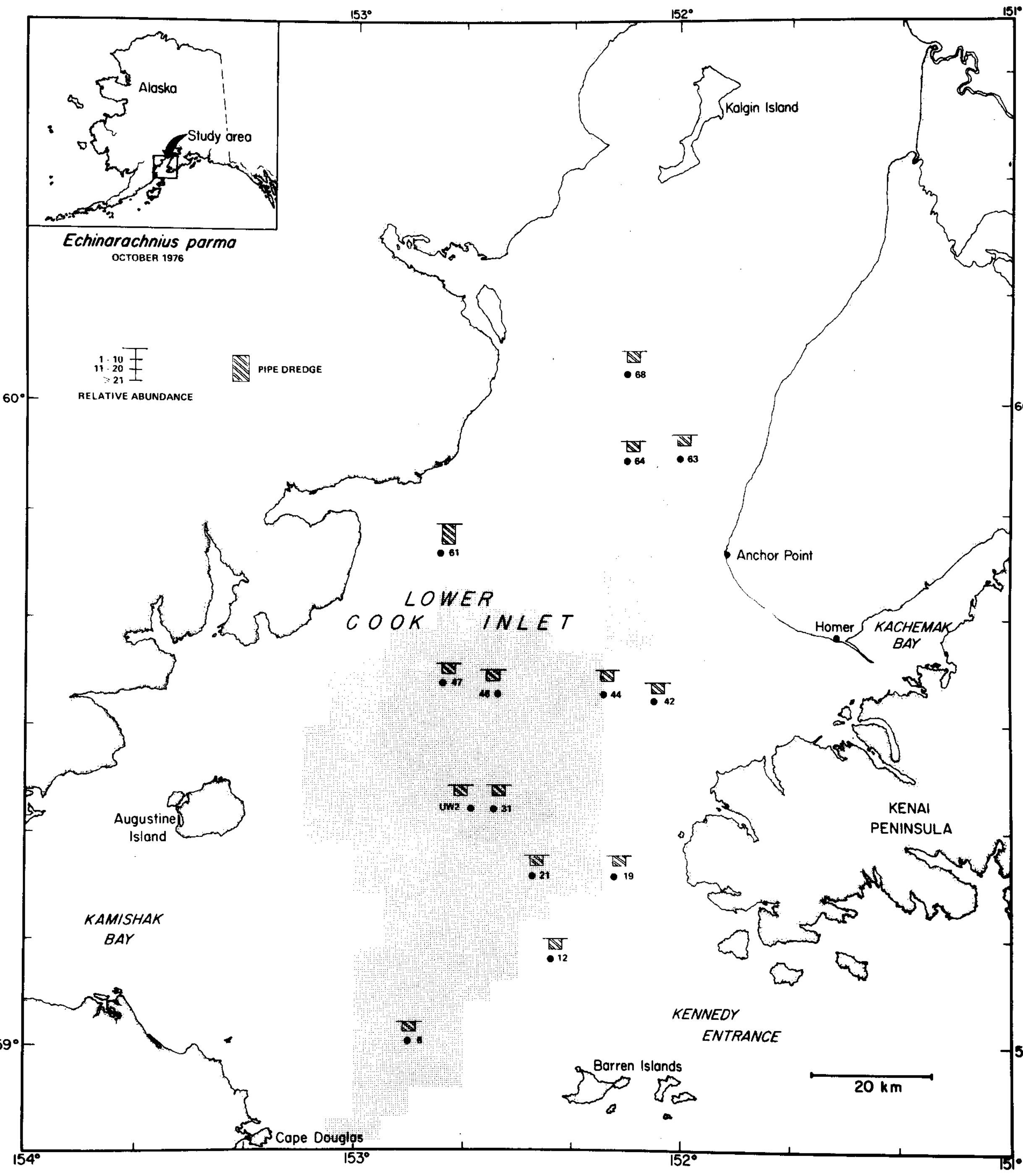

Figure 22. Distribution, relative abundance, and biomass of *Echinarachnius parma* from lower Cook Inlet, October 1976.

Food Studies

Stomach contents were determined for snow crabs (*Chionoecetes bairdi*) (Table XIV), king crabs (*Paralithodes camtschatica*) (Table XV), and selected fishes (Table XV).

Snow Crabs - Food occurred in 428 (60%) of 715 *Chionoecetes bairdi* examined (Table XIV), and included representatives of four phyla and 17 genera (Paul *et al.*, in press). Clams, hermit crabs and barnacles were the dominant food organisms. The most frequently occurring items were small clams, especially *Macoma* spp., with remains of this clam found in 149 stomachs from six of the eleven stations. Hermit crabs (family Paguridae), particularly *Pagurus ochotensis*, were next in importance, and occurred in 147 stomachs from nine of the eleven stations. Shrimps (family Crangonidae) and barnacles (*Balanus* spp.) were found in 37 and 76 stomachs from seven and eight stations respectively. *Chionoecetes bairdi* was found in five stomachs. Polychaetes, amphipods and ophiuroids occurred occasionally. Fifty-one stomachs contained only sediment.

Stomachs with food commonly contained the remains of several barnacles or clams. In one stomach sixteen recently settled *Macoma* spp. were found. Few stomachs contained more than one crab or shrimp. The total number of each prey species found in *C. bairdi* stomachs examined is presented in Table XVI.

No difference was detected in the frequency of occurrence of prey in *C. bairdi* of different size or sex (Table XVII).

Other Species - Other species examined for food contents were king crabs, *Paralithodes camtschatica*, (15 crabs examined) and 19 species of fishes (324 fishes examined) (Table XV).

King crabs were feeding primarily on the clams *Nuculana fossa* and *Macoma* sp.

Seven species of flatfishes were examined. The most frequently occurring food within each of these species was as follows: *Lepidopsetta bilineata* (rock sole) fed on unidentified amphipods; *Hippoglossus stenolepis* (Pacific halibut) fed on unidentified fish and *Chionoecetes bairdi; Platichthys stellatus* (starry flounder) fed on the clam *Spisula polynyma; Hippoglossoides elassodon* (flathead sole) fed on unidentified ophiuroids,

TABLE XIV

FREQUENCY AND PERCENT OF OCCURRENCE OF FOOD ITEMS IN STOMACHS OF 715 *CHIONOECETES BAIRDI*, COLLECTED IN LOWER COOK INLET, OCTOBER 1976. DASH (-) MEANS NO SPECIMENS IN STOMACHS.

Prey Items

Station	Depth m	No. of stomachs examined	No. of stomachs w/food	Polychaeta	*Nuculana fossa*	*Yoldia hyperborea*	*Macoma* spp.	*Spisula polynyma*	*Tellina nuculoides*	*Serripes groenlandicus*	*Astarte* spp.	Unidentified bivalves	Gastropoda	*Nucella lamellosa*	Unidentified Crustaceans	Amphipoda	*Balanus* spp.	*Pandalus* spp.	Crangonidae	Paguridae	*Pagurus ochotensis*	*Chionoecetes bairdi*	Ophiuridae	Sediment	Empty
5A	168	38	23	-	5	-	19	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	15
8B	121	24	14	-	-	-	-	-	-	-	-	-	-	-	1	4	-	2	2	4	-	-	-	-	10
18	44	79	31	-	2	-	1	-	-	6	-	-	-	-	-	-	12	-	5	6	-	-	-	16	48
23	95	141	106	1	-	1	100	-	1	-	1	-	-	-	-	-	5	-	-	15	-	4	-	13	35
25	59	87	67	3	-	-	27	-	-	-	5	2	-	-	-	-	14	-	2	5	14	1	-	5	20
28	32	6	3	-	-	-	1	-	-	-	-	-	-	-	1	-	-	-	-	3	-	-	-	-	3
40A	40	96	64	5	-	-	-	3	-	-	-	1	1	3	-	-	22	-	-	11	23	-	1	9	32
41	32	22	10	-	-	-	-	9	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-	2	12
53	30	78	43	1	-	-	1	-	-	-	-	2	-	-	3	-	13	-	3	6	17	-	-	8	35
62A	20	104	54	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-	14	11	30	-	-	6	50
76A	49	40	13	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	10	-	2	-	-	6	27
TOTAL FREQUENCY OF OCCURRENCE				10	7	1	149	12	1	6	6	5	2	3	6	4	76	2	37	61	86	5	1	65	
PERCENT FREQUENCY OF OCCURRENCE				1.4	1.0	0.1	20.8	1.7	0.1	0.8	0.8	0.7	0.3	0.4	0.8	0.5	10.6	0.3	5.1	8.5	12.0	0.7	0.1	9.1	

TABLE XV

PERCENT FREQUENCY OF OCCURRENCE OF STOMACH CONTENTS OF SELECTED PREDATOR SPECIES FROM LOWER COOK INLET, OCTOBER 1976

Numbers in Parenthesis Indicate the Number of a Specific Predator Containing that Prey

Predators		% Frequency of Occurrence
Paralithodes camtschatica (king crab)		
Stomachs examined:	15	
Stomachs with food:	12	80.0
Stomach contents:	*Nuculana fossa* (10)	66.7
	Macoma sp. (4)	26.7
	Unidentified Crustacea (1)	6.7
Lepidopsetta bilineata (rock sole)		
Stomachs examined:	53	
Stomachs with food:	18	34.0
Stomach contents:	Unidentified Amphipoda (12)	22.6
	Unidentified Crustacea (2)	3.8
	Unidentified Nudibranch (1)	1.9
	Spisula polynyma (1)	1.9
	Crangon dalli (1)	1.9
	Unidentified Pelecypoda (1)	1.9
	Unidentified remains (1)	1.9
Hippoglossus stenolepis (Pacific halibut)		
Stomachs examined:	52	
Stomachs with food:	48	92.3
Stomach contents:	Unidentified fish (17)	32.7
	Chionoecetes bairdi (17)	32.7
	Lumpenus sagitta (7)	13.5
	Trichodon trichodon (7)	13.5
	Crangon dalli (7)	13.5
	Unidentified Crangonidae (5)	9.6
	Pandalus goniurus (4)	7.7
	Cancer magister (4)	7.7
	Pagurus ochotensis (3)	5.8
	Pandalus hypsinotus (2)	3.8
	Unidentified Cottidae (2)	3.8
	Serripes groenlandicus (1)	1.9
	Unidentified Octopus (1)	1.9
	Anonyx sp. (1)	1.9
	Unidentified Amphipoda (1)	1.9
	Pinnixa sp. (1)	1.9
	Pandalopsis dispar (1)	1.9
	Unidentified Stichaeidae (1)	1.9
	Unidentified Zoarcidae (1)	1.9
	Microgadus proximus	1.9

TABLE XV

CONTINUED

Predators		% Frequency of Occurrence
Platichthys stellatus (starry flounder)		
Stomachs examined:	55	
Stomachs with food:	31	56.4
Stomach contents:	*Spisula polynyma* (22)	40.0
	Crangon dalli (7)	12.7
	Chionoecetes bairdi (4)	7.3
	Crangon sp. (2)	3.6
	Pandalus borealis (1)	1.8
	Unidentified Pelecypoda (1)	1.8
Hippoglossoides elassodon (flathead sole)		
Stomachs examined:	6	
Stomachs with food:	6	100.0
Stomach contents:	Unidentified Ophiuroidea (3)	50.0
	Unidentified Crangonidae (3)	50.0
	Nuculana fossa (2)	33.4
	Unidentified Polynoidae (1)	16.7
	Macoma sp. (1)	16.7
Atheresthes stomias (turbot)		
Stomachs examined:	10	
Stomachs with food:	0	0
Glyptocephalus zachirus (rex sole)		
Stomachs examined:	6	
Stomachs with food:	0	0
Limanda aspera (yellowfin sole)		
Stomachs examined:	1	
Stomachs with food:	1	100.0
Stomach contents:	Unidentified Pelecypoda	100.0
Gadus macrocephalus (Pacific cod)		
Stomachs examined:	43	
Stomachs with food:	41	95.3
Stomach contents:	*Chionoecetes bairdi* (27)	62.8
	Unidentified Crangonidae (22)	51.1
	Unidentified fishes (10)	23.2
	Unidentified Polychaeta (5)	17.6
	Pandalus borealis (4)	9.3
	Crangon sp. (4)	9.3
	Crangon dalli (2)	4.7
	Unidentified Isopoda (2)	4.7
	Unidentified Amphipoda (2)	4.7
	Pandalus sp. (1)	2.3
	Hyas lyratus (1)	2.3

TABLE XV

CONTINUED

Predators		% Frequency of Occurrence
Gadus macrocephalus (cont'd)		
	Pinnixa sp. (1)	2.3
	Unidentified Paguridae (1)	2.3
	Anonyx sp. (1)	2.3
	Unidentified Crustacea (1)	2.3
	Unidentified Pelecypoda (1)	2.3
	Nuculana fossa (1)	2.3
	Unidentified Pectinidae (1)	2.3
	Unidentified Naticidae egg collar (1)	2.3
	Echiurus echiurus alaskensis (1)	2.3
	Trichodon trichodon (1)	2.3
	Hippoglossoides elassodon (1)	2.3
	Atheresthes stomias (1)	2.3
Theragra chalcogramma (walleye pollock)		
Stomachs examined:	17	
Stomachs with food:	8	47.1
Stomach contents:	Unidentified Crustacea (4)	23.5
	Pandalus borealis (4)	23.5
	Unidentified Crangonidae (1)	5.9
Microgadus proximus (Pacific tomcod)		
Stomachs examined:	12	
Stomachs with food:	11	91.7
Stomach contents:	*Pandalus borealis* (9)	75.0
	Crangon dalli (2)	16.7
	Pagurus ochotensis (1)	8.3
Bathymaster signatus (searcher)		
Stomachs examined:	21	
Stomachs with food:	4	19.1
Stomach contents:	Unidentified Anthozoa (1)	4.8
	Chionoecetes bairdi (1)	4.8
	Unidentified Crangonidae (1)	4.8
	Unidentified Crustacea (1)	4.8
Trichodon trichodon (Pacific sandfish)		
Stomachs examined:	5	
Stomachs with food:	2	40.0
Stomach contents:	*Mallotus villosus* (2)	40.0
Agonus acipenserinus (sturgeon poacher)		
Stomachs examined:	6	
Stomachs with food:	0	0

TABLE XV

CONTINUED

Predators		% Frequency of Occurrence
Lycodes palearis (wattled eelpout)		
Stomachs examined:	2	
Stomachs with food:	2	100.0
Stomach contents:	*Crangon dalli* (2)	100.0
Lycodes sp. (eelpout)		
Stomachs examined:	1	
Stomachs with food:	1	100.0
Stomach contents:	*Macoma* sp.	100.0
	Unidentified Crangonidae	100.0
Myoxocephalus polyacanthocephalus (great sculpin)		
Stomachs examined:	26	
Stomachs with food:	22	84.6
Stomach contents:	*Chionoecetes bairdi* (8)	30.8
	Crangon dalli (6)	23.1
	Hyas lyratus (4)	15.4
	Unidentified fish (2)	7.6
	Unidentified Cyclopteridae (2)	7.6
	Unidentified Cottidae (1)	3.8
	Lumpenus sagitta (1)	3.8
	Unidentified shrimp (1)	3.8
	Cancer oregonensis (1)	3.8
	Cancer magister (1)	3.8
	Pagurus ochotensis (1)	3.8
	Oregonia gracilis (1)	3.8
Cottidae (sculpin)		
Stomachs examined:	3	
Stomachs with food:	3	100.0
Stomach contents:	*Chionoecetes bairdi* (3)	100.0
Cyclopteridae (snailfish)		
Stomachs examined:	4	
Stomachs with food:	4	100.0
Stomach contents:	*Crangon dalli* (4)	100.0
Squalus sp. (dogfish shark)		
Stomachs examined:	1	
Stomachs with food:	1	100.0
Stomach contents:	Unidentified fish	100.0
	Unidentified leech	100.0

TABLE XVI

THE NUMBER (N) OF PREY FOUND IN THE STOMACHS OF 715 *CHIONOECETES BAIRDI* FROM COOK INLET, ALASKA

$\bar{X}$715=Average Number of Prey per Stomach for all 715 Stomachs.
$\bar{X}$428=Average Number of Prey for the 428 Stomachs Containing Food.

Stomach Content	N	$\bar{X}$715	$\bar{X}$428
Polychaeta	10	0.013	0.023
Nuculana fossa	14	0.019	0.032
Yoldia hyperborea	1	0.001	0.002
Macoma spp.	298	0.416	0.696
Spisula polynyma	9	0.012	0.021
Tellina nuculoides	1	0.001	0.002
Serripes groenlandicus	10	0.013	0.023
Astarte spp.	5	0.006	0.011
Unidentified bivalves	7	0.009	0.016
Unidentified gastropods	1	0.001	0.002
Nucella lamellosa	3	0.004	0.007
Unidentified crustacean	6	0.008	0.014
Pandalus spp.	2	0.002	0.004
Amphipoda	7	0.009	0.016
Balanus spp.	64	0.089	0.149
Crangonidae	23	0.032	0.053
Paguridae	50	0.069	0.116
Pagurus ochotensis	82	0.114	0.191
Chionoecetes bairdi	5	0.006	0.011
Ophiuridae	1	0.001	0.002
Plant material	1	0.001	0.002
Sediment	65	0.090	0.150
Empty stomachs	287	-	-

TABLE XVII

PREY OF COOK INLET *CHIONOECETES BAIRDI* OF DIFFERENT SIZES AND SEXES. DATA IS PRESENTED AS FREQUENCY OF OCCURRENCE. DASH (-) MEANS NO SPECIMENS IN STOMACHS.

	Frequency of Occurrence						
	Males				Females		
	Immature		Mature		Immature		Mature
	CARAPACE WIDTH - MM						
Stomach Contents	5-50	51-109	110-135	136-170	5-50	51-100	51-100
Polychaeta	2	5	1	-	1	1	-
Nuculana fossa	-	2	3	-	-	1	1
Yoldia hyperborea	-	1	-	-	-	-	-
Macoma spp.	2	63	15	-	3	37	29
Spisula polynyma	5	2	2	3	-	-	-
Tellina nuculoides	-	1	-	-	-	-	-
Serripes groenlandicus	-	6	-	-	-	-	-
Astarte spp.	-	1	1	-	1	1	2
Unidentified bivalves	-	1	1	-	-	1	2
Gastropoda	-	-	1	-	-	-	1
Nucella lamellosa	-	1	-	-	2	-	-
Amphipoda	3	-	1	-	1	-	-
Balanus spp.	6	46	6	-	4	10	4
Crangonidae	1	17	5	1	-	4	9
Paguridae (except *Pagurus ochotensis*)	2	36	7	-	3	7	6
Pagurus ochotensis	9	47	8	-	7	7	8
Chionoecetes bairdi	-	3	1	-	-	-	1
Ophiuridae	-	1	-	-	-	-	-
Sediment	6	32	11	2	5	5	4
Empty stomachs	20	103	49	18	32	34	31

unidentified crangonid shrimps, and the clam *Nuculana fossa*; and *Limanda aspera* (yellowfin sole) fed on unidentified clams. The turbot, *Atheresthes stomias*, and the rex sole, *Glyptocephalus zachirus*, were empty.

The Pacific cod, *Gadus macrocephalus*, was mainly feeding on *Chionoecetes bairdi*, while the Pacific tomcod, *Microgadus proximus*, and walleye pollock, *Theragra chalcogramma* were mainly feeding on the pink shrimp, *Pandalus borealis*.

The great sculpin, *Myoxocephalus polyacanthocephalus* was primarily feeding on *Chionoecetes bairdi* and *Crangon dalli*.

Food of other species are listed in Table XV. A Cook Inlet food web was constructed (Fig. 23) from data contained in Tables XIV and XV. Carbon flow through the web is generally from bottom to top or in the direction of the arrows. Heavy lines indicate major food sources based on frequency of occurrence. The major invertebrates in the food web are *Nuculana fossa, Spisula polynyma*, Amphipoda, *Balanus* spp., pandalid and crangonid shrimps, *Chionoecetes bairdi*, Paguridae, and Ophiuroidea. The feeding biology between fishes in Cook Inlet are not well known. The feeding methods used by the invertebrates and fishes included in the Cook Inlet food web are tabulated in Table XVIII.

The portions of the web dealing with snow crab (Fig. 24), king crab (Fig. 25), Pacific cod (Fig. 26), Pacific halibut (Fig. 27), and great sculpin (Fig. 28) have been separated from the overall web to show greater detail.

VII. DISCUSSION

Performance of the van Veen Grab

The van Veen grab typically functioned less effectively in Cook Inlet than it did in the northeast Gulf of Alaska (NEGOA) and Bering Sea stations (Feder, 1977a). A high proportion of sand in the sediments in Cook Inlet generally impeded grab penetration. Lie (1968) indicates that 1 cm penetration of the 0.1 m^2 van Veen grab will collect 1 ℓ of sediment, and he states that a digging depth of at least 4 cm should be attained to assure adequate representation of the fauna. Volumes of 8 to 9 ℓ were collected at some of our stations, and most of the thirteen stations chosen for laboratory analysis were ones with these volumes.

TABLE XVIII

FEEDING METHODS OF INVERTEBRATES AND FISHES INCLUDED IN THE COOK INLET FOOD WEB[1]. PHYLUM ABBREVIATIONS: C=CNIDARIA; A=ANNELIDA; M=MOLLUSCA; ART=ARTHROPODA; CHO=CHORDATA; X=DOMINANT FEEDING METHOD; O=OTHER FEEDING METHOD.

	Phylum	Deposit Feeder	Suspension Feeder	Scavenger	Predator	Unknown
Anthozoa	C	-	-	-	X	-
Polychaeta	A	X	X	X	X	-
Gastropoda	M	X	-	X	X	-
Pelecypoda	M	X	X	-	-	-
Nuculana fossa	M	X	-	-	-	-
Serripes groenlandicus	M	X	X	-	-	-
Tellina sp.	M	X	X	-	-	-
Macoma sp.	M	X	O	-	-	-
Octopus sp.	M	-	-	X	X	-
Crustacea	Art	X	X	X	X	-
Balanus sp.	Art	-	X	-	-	-
Isopoda	Art	X	-	X	X	-
Amphipoda	Art	X	-	X	X	-
Anonyx sp.	Art	-	-	-	-	X
Paguridae	Art	-	-	X	X	-
Pagurus ochotensis	Art	-	-	X	X	-
Paralithodes camtschatica	Art	-	-	X	X	-
Cancer oregonensis	Art	-	-	X	X	-
Cancer magister	Art	-	-	X	X	-
Pinnixa sp.	Art	-	-	-	-	X
Hyas lyratus	Art	-	-	-	-	X
Oregonia gracilis	Art	-	-	-	-	X
Chionoecetes bairdi	Art	-	-	X	X	-
Caridea	Art	-	-	X	X	-
Crangonidae	Art	-	-	-	-	X
Crangon sp.	Art	-	-	-	-	X
Crangon dalli	Art	-	-	-	-	X
Pandalidae	Art	-	-	X	-	-

TABLE XVIII

CONTINUED

	Phylum	Deposit Feeder	Suspension Feeder	Scavenger	Predator	Unknown
Pandalus sp.	Art	–	–	X	–	–
Pandalus borealis	Art	–	–	X	–	–
Pandalus hypsinotus	Art	–	–	X	–	–
Pandalus goniurus	Art	–	–	X	–	–
Pandalopsis dispar	Art	–	–	X	–	–
Teleostei	Cho	–	–	X	–	–
Theragra chalcogramma (pollock)	Cho	–	–	–	X	–
Microgadus proximus (tomcod)	Cho	–	–	–	X	–
Gadus macrocephalus (Pacific cod)	Cho	–	–	–	X	–
Mallotus villosus (capelin)	Cho	–	–	–	X	–
Zoarcidae (eelpouts)	Cho	–	–	–	X	–
Trichodon trichodon (sand fish)	Cho	–	–	–	X	–
Bathymaster sp. (searcher)	Cho	–	–	–	X	–
Stichaeidae (pricklebacks)	Cho	–	–	–	X	–
Lumpenus sagitta (snake prickleback)	Cho	–	–	–	X	–
Cottidae (sculpins)	Cho	–	–	–	X	–
Myoxocephalus sp. (great sculpin)	Cho	–	–	–	X	–
Liparidae (snail fish)	Cho	–	–	–	X	–
Atheresthes stomias (arrowtooth flounder)	Cho	–	–	–	X	–
Hippoglossoides elassodon (flathead sole)	Cho	–	–	–	X	–
Lepidopsetta bilineata (rock sole)	Cho	–	–	–	X	–
Hippoglossus stenolepis (halibut)	Cho	–	–	–	X	–
Platichthys stellatus (starry flounder)	Cho	–	–	–	X	–

[1]Based on Newell, 1970; Barnes, 1968; Pearce and Thorson, 1967; Rasmussen, 1973; Hart, 1973; Skalkin, 1963; and Feder, unpublished data.

LOWER COOK INLET-Food Web

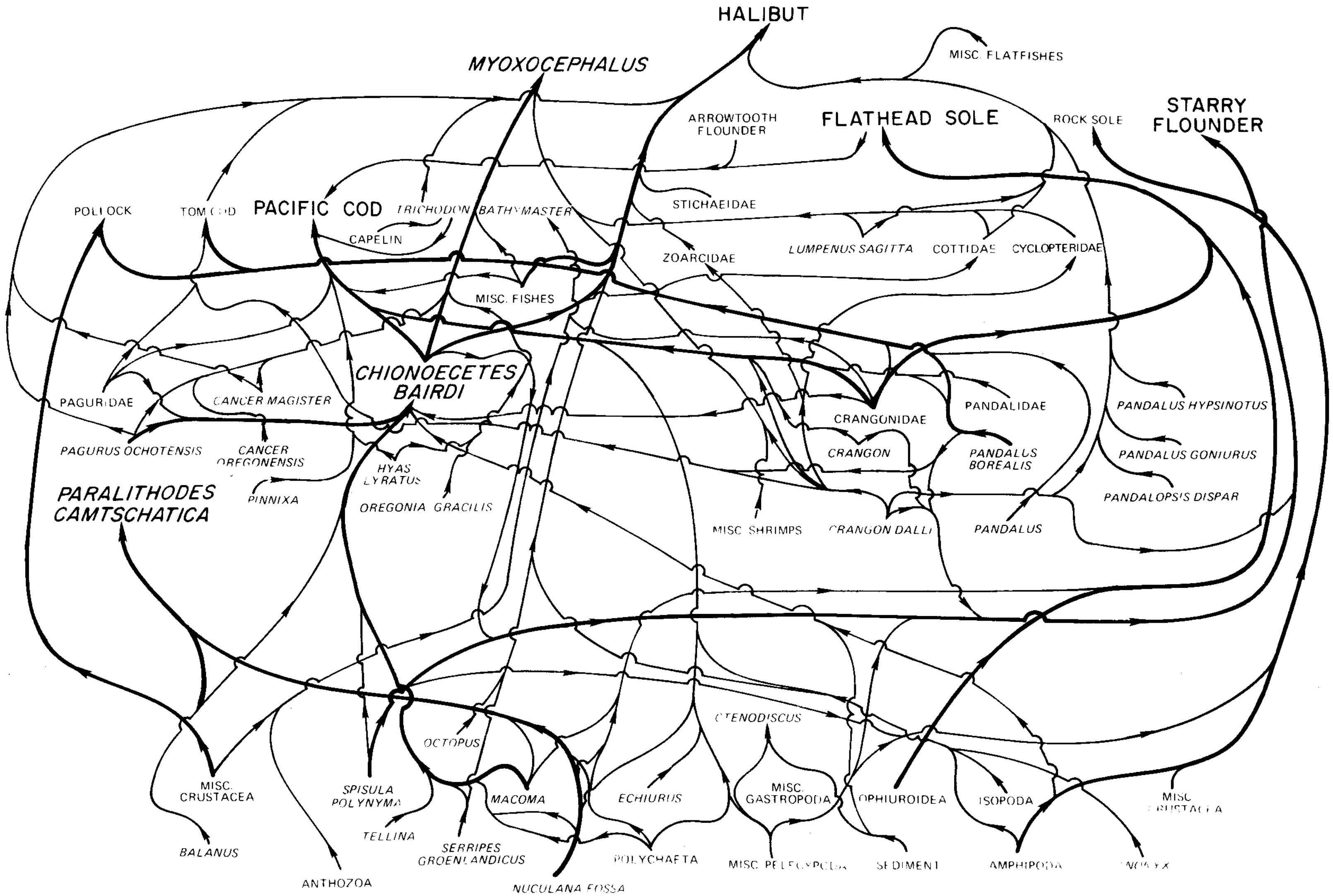

Figure 23. A food web based on the benthic invertebrates of lower Cook Inlet. Carbon flow is in the direction of the arrows. Bold lines indicate major food sources based on frequency of occurrence. *Balanus* sp. was consumed by King Crab in November, 1977 (see Section I of this report).

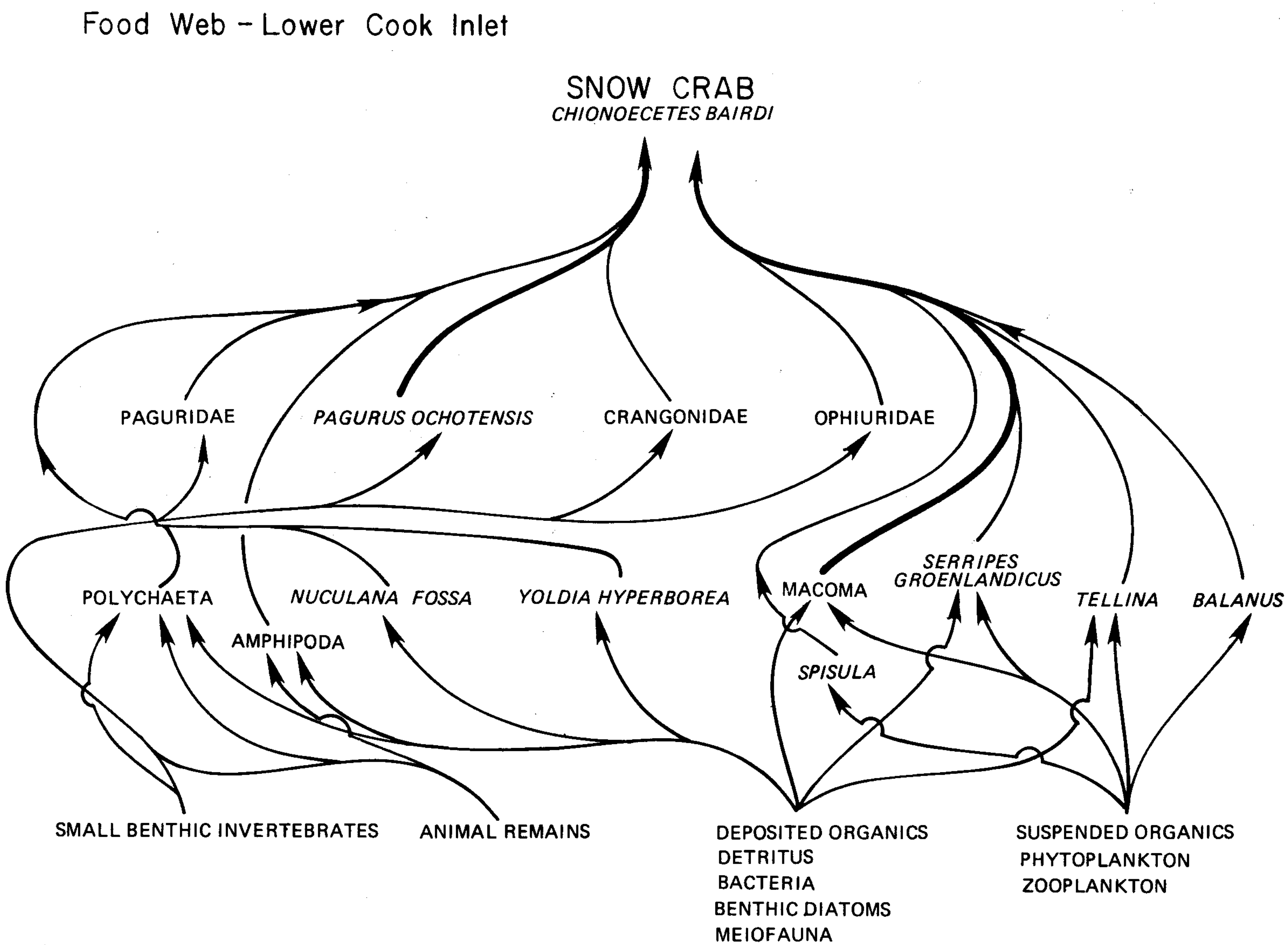

Figure 24. A food web showing carbon flow to snow crab (*Chionoecetes bairdi*) in lower Cook Inlet. Bold lines indicate major food sources based on frequency of occurrence.

Food Web – Lower Cook Inlet

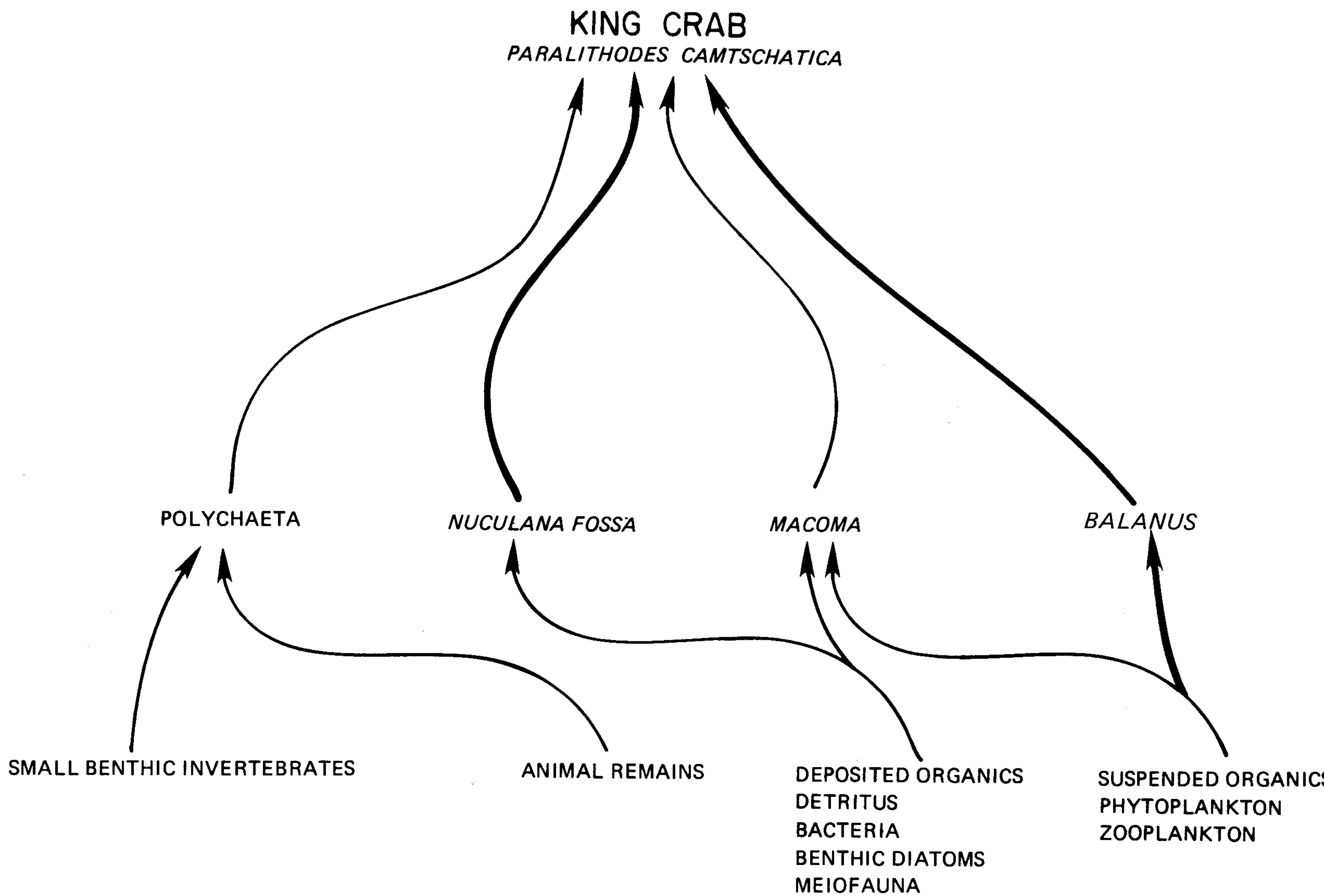

Figure 25. A food web showing carbon flow to King Crab (*Paralithodes camtschatica*) in lower Cook Inlet. Bold line indicates major food sources based on frequency of occurrence. *Balanus* sp. was consumed by King Crab in November, 1977 (see Section I of this report).

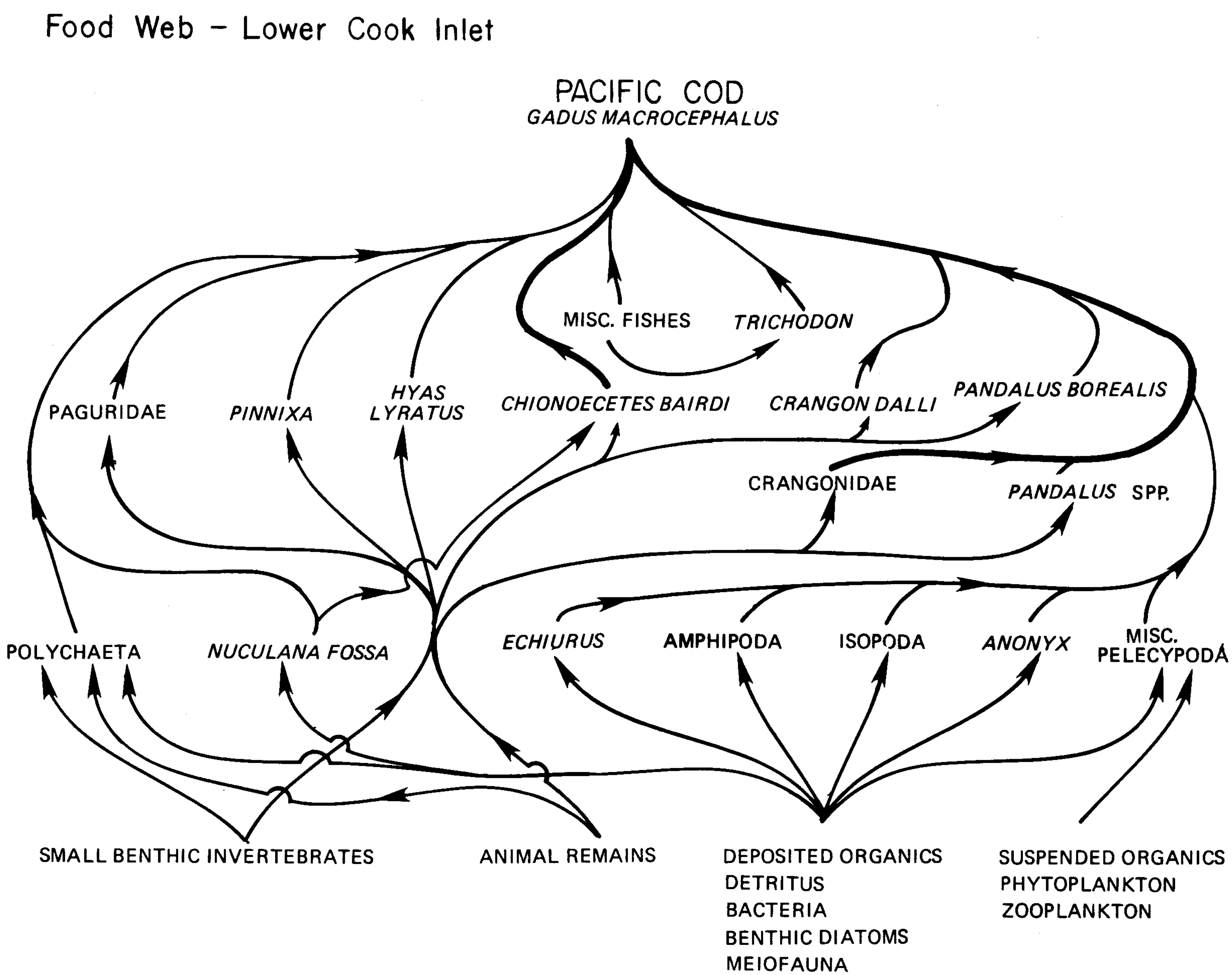

Figure 26. A food web showing carbon flow to Pacific cod *(Gadus macrocephalus)* in lower Cook Inlet. Bold lines indicate major food sources based on frequency of occurrence.

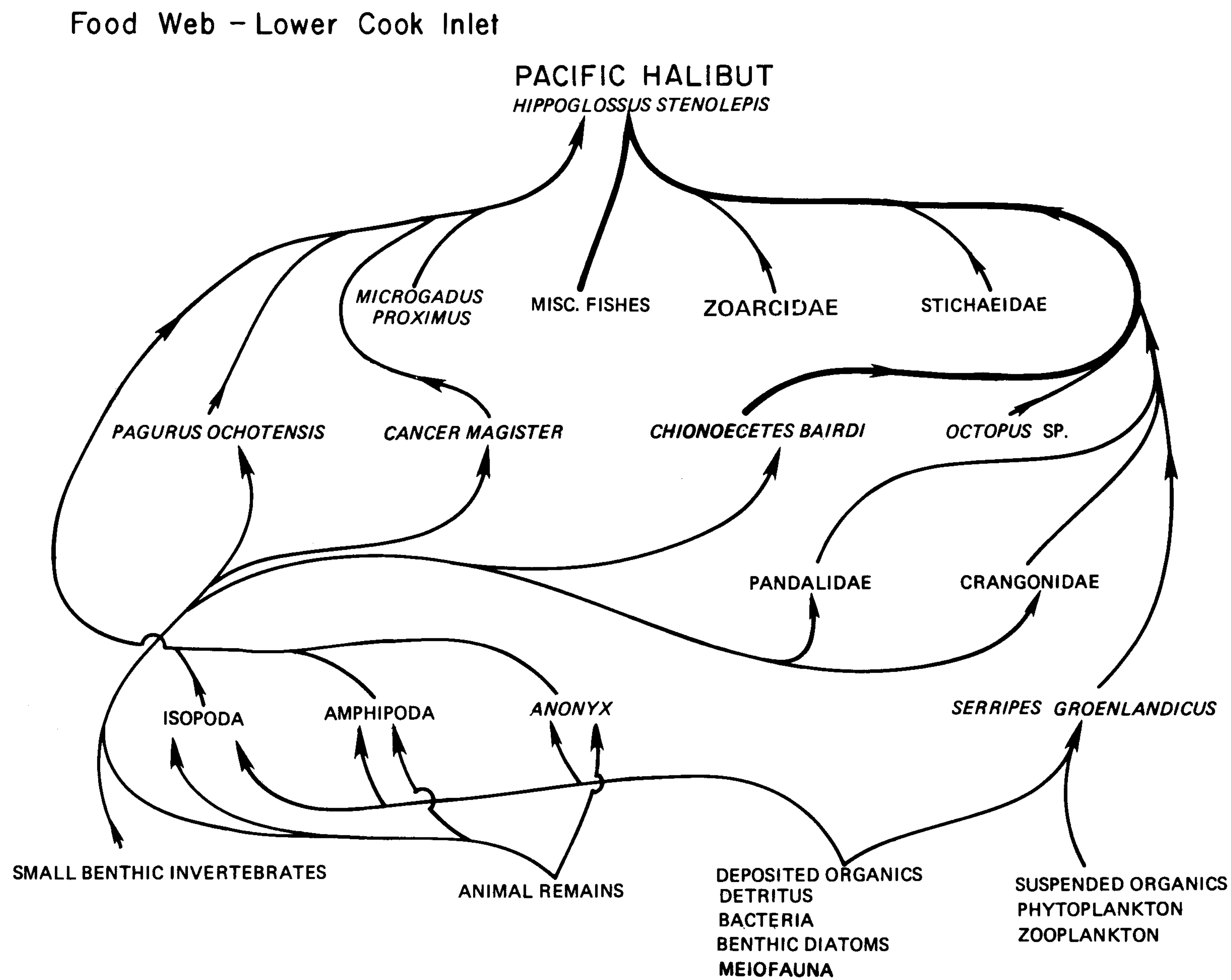

Figure 27. A food web showing carbon flow to Pacific halibut (*Hippoglossus stenolepis*) in lower Cook Inlet. Bold lines indicate major food sources based on frequency of occurrence.

Food Web – Lower Cook Inlet

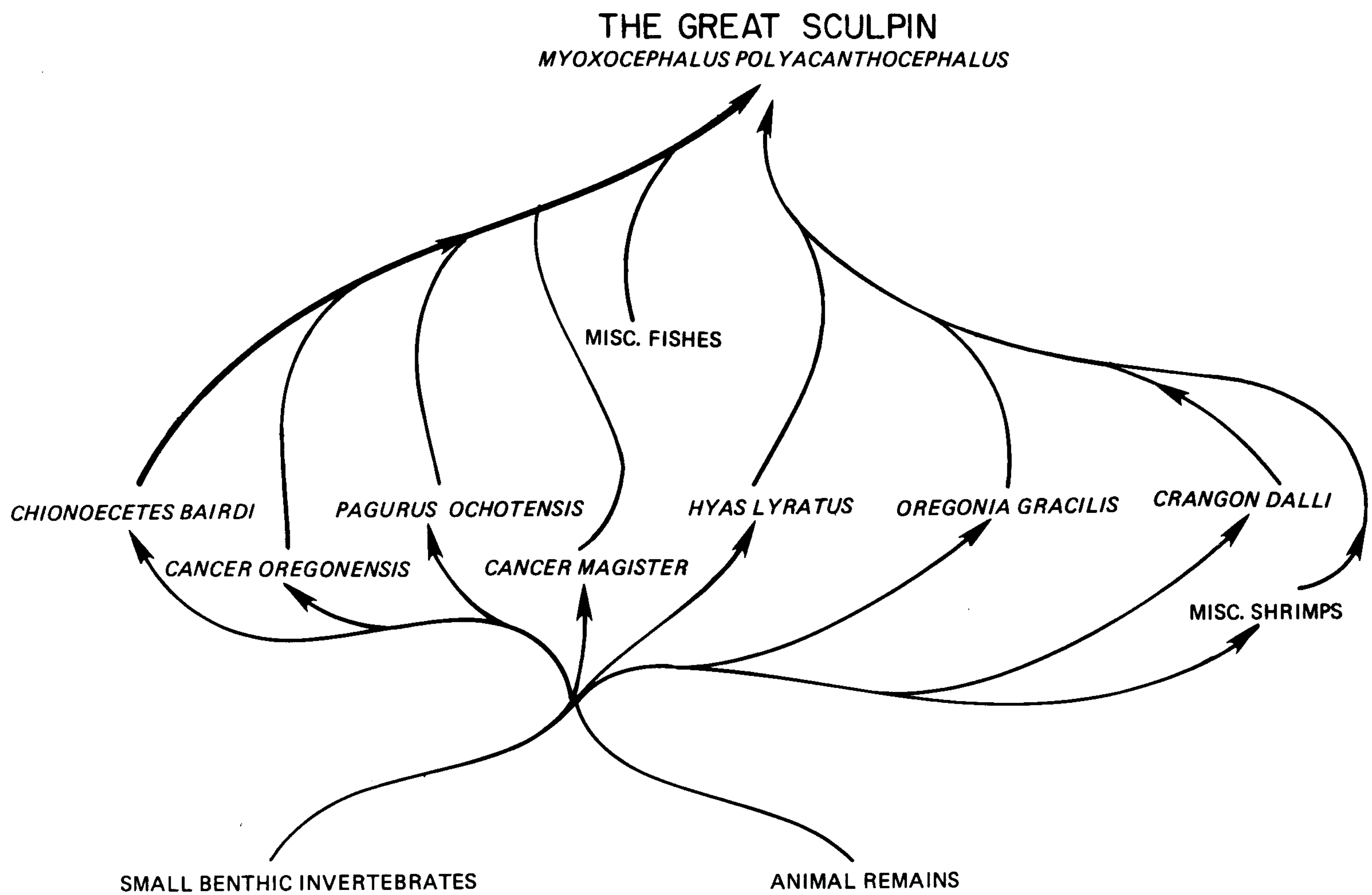

Figure 28. A food web showing carbon flow to the great sculpin (*Myoxocephalus polyacanthocephalus*) in lower Cook Inlet. Bold lines indicate major food sources based on frequency of occurrence.

Number of Grab Samples per Station

Three to five replicates are generally adequate to sample the most abundant species in soft sediments (Feder *et al.*, 1973; Feder, 1977a). However, five replicate samples per station are generally recommended (Longhurst, 1964; Lie, 1968), and this number of replicates has been corroborated in our investigations on a variety of bottom types in NEGOA, Port Valdez, and the Bering Sea (Feder *et al.*, 1973; Feder, 1977a). Thus, five replicate samples were taken routinely at the Cook Inlet stations sampled by grab. However, analysis of the grab samples qualitatively (Special Data Submission to NOAA; Shaw *et al.*, 1976) and quantitatively (Feder, 1977a) soon demonstrated that five replicates were probably insufficient for Cook Inlet. The fauna was obviously very patchy and at some stations replicates were often very dissimilar. However, the thirteen stations chosen for laboratory analysis were ones that had reasonably good replicability from one grab to the next (see data on file at NODC).

Station Coverage

The 100 stations sampled in lower Cook Inlet provided the first intensive coverage for invertebrate infauna and epifauna here. The grab-sampling program initiated in Cook Inlet on board the R/V *Moana Wave* and the NOAA Ship *Miller Freeman* resulted in a wide coverage of the station grid in lower Cook Inlet. However, insufficient funding resulted in analysis of material from only 13 (April cruise) of the stations. The latter stations were selected as ones most likely to be of value to the Bureau of Land Management (BLM) for management decisions. Furthermore, some of the 13 grab stations are likely candidates for continued monitoring after industrial activities are initiated in Cook Inlet. The balance of the grab stations are described qualitatively in the Special Data Submission forwarded to NOAA (Shaw *et al.*, 1976).

Activities utilizing the pipe dredge resulted in a broad coverage of the sampling grid. This type of gear required a minimal effort for deployment, and was usable at most stations. It was especially useful at stations that could not be sampled by any other piece of gear.

Of the 15 Agassiz trawl stations, 16 Eastern otter trawl stations, and six try-net stations, only three stations were trawled north of Anchor Point because of the unsuitability of the substrate there.

Species Composition

The general distribution of infaunal and epifaunal invertebrate species in lower Cook Inlet is now well documented (Figs. 3 through 22; NODC submitted data; Appendices I and II) as a result of sampling accomplished with various types of gear.

In general, species diversity decreased with larger sampling gear. Although only 13 stations were occupied with the van Veen grab, they yielded 211 species. The pipe dredge collections also resulted in a large number of species, i.e. 145 species from 40 stations in April and 212 species from 58 stations in October. The number of species taken by the small Agassiz trawl (149) exceeded the number taken by the try-net (45) and large Eastern otter trawl (53).

The majority of species taken by van Veen grab and pipe dredge were infaunal species, although many small epifaunal organisms were also collected with this gear. Seventy-four percent of the grab species were polychaetous annelids (93 species) and molluscs (64 species); 56% of the pipe dredge species were polychaetes (19 species) and molluscs (129 species).

Snow crabs, *Chionoecetes bairdi*, dominated the catches at most trawl stations,, and the abundance of this species in catches emphasizes the commercial importance of this crustacean in lower Cook Inlet. Based on the large numbers of juvenile snow crabs in Stations 5 through 8B and on the large numbers of these tiny crabs fed upon by fishes from this area, the deep water region immediately east of Cape Douglas appears to be a major snow crab nursery area.

Biomass

The average invertebrate epifaunal biomass values reported (3.0-3.3 g/m^2) in the present study are similar to other biomass estimations made for north Pacific waters. The estimated biomass of epifaunal invertebrates from the northeast Gulf of Alaska was 2.6 g/m^2 (Jewett and Feder, 1976). Similar estimates came from the outer continental shelf of the Bering Sea in 1975 and 1976 with 3.3 g/m^2 and 5.0 g/m^2 reported, respectively (Feder, 1977a).

Russian benthic investigations (Neyman, 1963) provide biomass estimates based on grab samples for infauna and small epifauna from the Bering Sea with values of 55 to 905 g/m^2 reported. The grab biomass from the 13 Cook Inlet stations varied from 6.2 to 731.9 g/m^2.

Biomass from the grabs and trawls are strikingly different. Use of trawls results in the loss of infaunal and small epifaunal organisms which are an important part of the benthic biomass. Therefore, the total benthic biomass value is best expressed by combining both grab and trawl values.

Food Studies

Snow Crabs - Barnacles, hermit crabs, crangonid shrimps, and clams (*Macoma* spp.) are widely distributed throughout lower Cook Inlet (Table I; NODC data), and are fed upon by *Chionoecetes bairdi* in proportion to their abundance. Other species used for food are discontinuous in their distribution in lower Cook Inlet (Table II; NODC data). This discontinuous distribution, probably more than their acceptability as food, explains the infrequent occurrence of these species in snow crab stomachs.

In the Kodiak area the most commonly encountered stomach contents were small clams, shrimps, plant material, and sediment (Feder, 1977a; Feder and Jewett, 1977). In Cook Inlet plant material, possibly eelgrass, was observed in one stomach. Yasuda (1967) examined stomachs of *Chionoecetes opilio elongatus* Rathbun from Japanese waters, and found the most frequently occurring invertebrate prey to be brittle stars (*Ophiura* sp.), young *C. opilio elongatus*, and protobranch clams. Polychaetes, shrimps, gastropods, scaphopods and flatfishes were also taken by *C. opilio elongatus*. *Chionoecetes opilio* from the Bering Sea fed primarily on polychaetes, *Ophiura* sp., and *Macoma* sp. (Feder, 1977a). *Chionoecetes opilio* from the Chukchi Sea fed mainly on polychaetes, bivalve molluscs and crustaceans; sediment was an important component in more than half of the crabs examined (Feder, unpub.). Polychaetes and gastropods were common in lower Cook Inlet but rarely preyed upon. Brittle stars are relatively rare in lower Cook Inlet. Cannibalism was infrequent in Cook Inlet. Scaphopods and fishes were not encountered in *C. bairdi* stomachs. The importance of sediment commonly found in *C. bairdi* and *C. opilio* stomachs is not known.

Other Species - Bivalve molluscs were the major components of the diet of the king crab, *Paralithodes camtschatica*, in Cook Inlet in October 1976, with the protobranch clam, *Nuculana fossa* dominating the diet at this time. A similar reliance on molluscan prey is noted for king crabs in the Bering Sea (Feder, 1977a; McLaughlin and Hebard, 1961). Prior to the eruption of Augustine Volcano in Cook Inlet in January through February 1976, the bottom adjacent to Augustine Island was primarily composed of sediments with little hard substrate present. During the eruption, volcanic debris scattered over several miles of bottom around the island (Feder, unpub. observ.). This hard, widely-dispersed substratum made available new surfaces for attachment of sessile organisms and by November 1977 all volcanic debris recovered in trawls was covered by barnacles (Feder, unpub). Preliminary feeding data on king crabs taken from the Augustine Island area (Stations 35 and 53) in November 1977 indicate that most of these animals are feeding exclusively on this new food item (Feder, unpub. data based on the November 1977 cruise of the NOAA Ship *Surveyor*). A study of the extent of this newly added volcanic, hard substrate on the bottom of Cook Inlet, and the effect of the recently settled barnacles on this substrate on local food webs is currently in progress (see Sect. I, Annual Report for 1978).

Chionoecetes bairdi and crangonid and pandalid shrimps appear to be the most widely utilized food source for many fishes in lower Cook Inlet.

In Kodiak, snow crabs were the single most frequently occurring food species found in Pacific cod stomachs, occurring in nearly 40% of the 4277 cod examined (Jewett, in press). Crangonid and pandalid shrimps were also important in the diet of Pacific cod in the Kodiak area (Jewett, in press). *Chionoecetes bairdi* has become important in the Alaskan and world markets, and has been commercially harvested in Cook Inlet since 1968. The heavy utilization of snow crabs as food by many fishes, inclusive of Pacific cod, in lower Cook Inlet further attests to the commercial abundance of this crab in the Inlet.

Clam Studies

Benthic bivalves are important contributors to the benthic biomass in lower Cook Inlet. The growth-history data generated by this OCSEAP study should provide information on the relative stability of the environment (Appendix II). Age data will also aid in analysis of recruitment success and mortality rates of the clams examined. The combination of growth, recruitment, and mortality rates can be used in determining secondary production for benthic bivalves in Cook Inlet. Recent studies indicate that, in Cook Inlet, benthic bivalves are an important food for the snow crab, *Chionoecetes bairdi*.

The sedentary habits of benthic bivalves prevent them from emigrating from polluted areas; thus, they are excellent species to use in monitoring programs. One or more of the six species examined are suggested for the development of a long-range monitoring study in Cook Inlet.

VIII. CONCLUSIONS

Seventy-four stations have been established in lower Cook Inlet, and samples have been taken by a variety of gear from most of these stations. The grab-sampling programs resulted in a wide coverage of the station grid. The van Veen grab typically functioned less effectively in Cook Inlet than it did in the NEGOA study area; a high proportion of sand in the sediments generally impeded grab penetration. However, despite funding constraints, it was possible to select thirteen stations as likely candidates for monitoring after petroleum activities are initiated in the Inlet.

Use of the pipe dredge and trawls resulted in a broad coverage of the sampling grid, and comprehension of the distributional patterns of the dominant infaunal and epifaunal species in the Inlet. It is apparent that the most common species have been collected in the two cruises completed in 1976 and that only rare or uncommon species will be taken in future surveys.

The dominant infaunal species taken were polychaetous annelids and molluscs. A total of 76 species of bivalve molluscs (clams, mussels, scallops) were collected. Deposit-feeding clams dominated the fine sediments of the western side of the Inlet. Suspension-feeding clams increased in importance in sandier areas of outer Kachemak Bay; deposit feeders assumed importance in inner Kachemak Bay.

Arthropod crustaceans dominated the epifauna in number, weight and biomass; the commercially important snow crab, *Chionoecetes bairdi*, dominated the catch at most trawl stations. Large numbers of juvenile snow crabs occurred in the deep water region immediately east of Cape Douglas. The latter area should be listed as a potentially important snow-crab nursery area, and should be monitored on a continuing basis once oil activity is initiated in the Inlet.

Snow crabs in lower Cook Inlet feed on prey items widely distributed in the area - barnacles, hermit crabs, crangonid shrimps, and clams (primarily *Macoma* spp.). With the exception of barnacles, the prey of snow crabs are (1) deposit feeders, (2) species that take up variable amounts of sediment in the feeding process, and/or (3) ones that utilize prey which occur in or use the sediments as a food source. Furthermore, sediment is commonly found in *C. bairdi* stomachs, and may represent a dominant component of stomach contents.

Deposit-feeding clams are important in the diet of king crabs and some demersal fishes. In addition, many bottom-dwelling fishes in the Inlet utilize snow crab and crangonid and pandalid shrimps in their diet - prey species indirectly or directly dependent on sediments in their food habits. It is apparent from these examples, and others referred to in this report, that in lower Cook Inlet much of the shallow benthos is driven energetically by the sediment-detrital system. Shallow sediment-detrital systems are probably very susceptible to oil contamination, especially in bodies of water like lower Cook Inlet with high suspended loads, if adsorbed oil fractions on settling particles become incorporated into the bottom sediments. It is highly recommended that future activities in lower Cook Inlet center around the benthic boundary layer (sediment-water interface) and that process oriented studies intensively investigate this layer.

Although king crab heavily utilize deposit-feeding clams, suspension-feeding barnacles are also an important prey item for these crustaceans in lower Cook Inlet. The presence of an extensive, new substrate (volcanic debris) for barnacle attachment in the Inlet, after the eruption of

Augustine Volcano in 1976, greatly increased the abundance of barnacles (see data in Section I of this report). The crabs in the vicinity of the volcano (November 1977) were feeding almost exclusively on this new food source. A study of the long-term effects of these recently settled barnacles on food webs in lower Cook Inlet is suggested. Since barnacles in their feeding activities process suspended food particles, they represent another potential reservoir for petroleum hydrocarbons, in this case derived from contaminated plankters. A barnacle-dominated feeding regime for crabs in Kamishak Bay adjacent to Augustine Island could result in tainted or contaminated organisms in the commercial catch if the barnacle resource there were to become impacted by petroleum.

Benthic bivalves are important contributors to the benthic biomass in lower Cook Inlet. The growth-history data derived from this study should provide a method for assessing the stability of the environment. Age data should also aid in analysis of recruitment and mortality rates of dominant species of clams; such analysis would be invaluable as part of a monitoring program in the Inlet.

IX. NEEDS FOR FURTHER STUDIES

Suggestions for further work in Cook Inlet are included in the 1978 Annual Report, Section I of this document.

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APPENDIX I

SUMMARIZATION OF COMPOSITION, DISTRIBUTION, RELATIVE ABUNDANCE, AND BIOMASS OF BENTHIC INVERTEBRATES OF LOWER COOK INLET; FROM THE R/V *MOANA WAVE*, NOAA SHIP *MILLER FREEMAN*, AND THE M/V *PUFFIN*, 1976

APPENDIX I - TABLE I

OCCURRENCE OF TAXA IN 40 LOWER COOK INLET STATIONS AS OBTAINED BY PIPE DREDGE, APRIL 1976

Taxonomic Names Represent Lowest Level of Identification

Taxonomic Name	Cumulative Station Occurrence	% of all[1] Cumulative Station Occurrence	% of all[2] Stations
Porifera (unid. species)	2	0.457	5.000
Hydrozoa (unid. species)	11	2.511	27.500
Allopora sp.	3	0.685	7.500
Eunephthya rubiformis	1	0.228	2.500
Ptilosarcus gurneyi	5	1.142	12.500
Actiniidae (unid. species)	2	0.457	5.000
Rhynchocoela (unid. species)	2	0.457	5.000
Polychaeta (unid. species)	28	6.393	70.000
Polynoidae (unid. species)	3	0.685	7.500
Nephtys sp.	4	0.913	10.000
Lumbrineris sp.	1	0.228	2.500
Sternaspis scutata	1	0.228	2.500
Sabellidae (unid. species)	2	0.457	5.000
Mollusca (unid. species)	1	0.228	2.500
Ischnochiton sp.	1	0.228	2.500
Ischnochiton trifidus	6	1.370	15.000
Mopalia ciliata	1	0.228	2.500
Mopalia cirrata	1	0.228	2.500
Mopalia mucosa	1	0.228	2.500
Nucula tenuis	3	0.685	7.500
Nuculana minuta	1	0.228	2.500
Nuculana fossa	10	2.283	25.000
Yoldia hyperborea	1	0.228	2.500
Yoldia myalis	7	1.598	17.500
Yoldia scissurata	1	0.228	2.500
Glycymeris subobsoleta	11	2.511	27.500
Musculus niger	2	0.457	5.000
Musculus discors	2	0.457	5.000
Modiolus modiolus	8	1.826	20.000
Chlamys sp.	1	0.228	2.500
Chlamys rubida	1	0.228	2.500
Chlamys beringiana	1	0.228	2.500
Astarte sp.	3	0.685	7.500
Astarte alaskensis	2	0.457	5.000
Astarte montegui	9	2.055	22.500
Astarte rollandi	1	0.228	2.500
Astarte bennettii	1	0.228	2.500
Astarte esquimalti	2	0.457	5.000
Cyclocardia sp.	4	0.913	10.000
Cyclocardia ventricosa	3	0.685	7.500
Cyclocardia crebricostata	1	0.228	2.500
Cyclocardia crassidens	3	0.685	7.500
Thyasira flexuosa	2	0.457	5.000
Kellia laperousi	1	0.228	2.500

APPENDIX I - TABLE I

CONTINUED

Taxonomic Name	Cumulative Station Occurrence	% of all[1] Cumulative Station Occurrence	% of all[2] Stations
Clinocardium sp.	1	0.228	2.500
Clinocardium ciliatum	7	1.598	17.500
Clinocardium californiense	4	0.913	10.000
Serripes groenlandicus	2	0.457	5.000
Liocyma fluctuosa	2	0.457	5.000
Humilaria kennerlyi	5	1.142	12.500
Protothaca staminea	1	0.228	2.500
Spisula polynyma	6	1.370	15.000
Macoma sp.	4	0.913	10.000
Macoma calcarea	9	2.055	22.500
Macoma obliqua	3	0.685	7.500
Macoma balthica	3	0.685	7.500
Tellina nuculoides	6	1.370	15.000
Siliqua alta	1	0.228	2.500
Mya truncata	1	0.228	2.500
Mya priapus	1	0.228	2.500
Hiatella arctica	6	1.370	15.000
Lyonsia sp.	1	0.228	2.500
Gastropoda (unid. species)	3	0.685	7.500
Puncturella galeata	4	0.913	10.000
Cryptobranchia alba	1	0.228	2.500
Margarites pupillus	2	0.457	5.000
Margarites costalis	1	0.228	2.500
Solariella obscura	1	0.228	2.500
Solariella varicosa	1	0.228	2.500
Trichotropis cancellata	3	0.685	7.500
Natica clausa	5	1.142	12.500
Polinices pallida	2	0.457	5.000
Velutina lanigera	1	0.228	2.500
Fusitriton oregonensis	8	1.826	20.000
Boreotrophon clathratus	1	0.228	2.500
Boreotrophon stuarti	2	0.457	5.000
Boreotrophon pacificus	2	0.457	5.000
Boreotrophon lasius	5	1.142	12.500
Boreotrophon smithi	1	0.228	2.500
Boreotrophon multicostalis	1	0.228	2.500
Nucella lamellosa	4	0.913	10.000
Buccinum plectrum	3	0.684	7.500
Beringius sp.	1	0.228	2.500
Neptunea sp.	2	0.457	5.000
Neptunea lyrata	5	1.142	12.500
Neptunea ventricosa	1	0.228	2.500
Plicifusus sp.	1	0.228	2.500
Amphissa columbiana	3	0.685	7.500
Mitrella gouldi	2	0.457	5.000
Volutomitra alaskana	1	0.228	2.500
Olivella baetica	1	0.228	2.500

APPENDIX I - TABLE I

CONTINUED

Taxonomic Name	Cumulative Station Occurrence	% of all[1] Cumulative Station Occurrence	% of all[2] Stations
Admete couthouyi	1	0.228	2.500
Suavodrillia kennicottii	1	0.228	2.500
Oenopota sp.	1	0.228	2.500
Oenopota turricula	4	0.913	10.000
Balanus sp.	3	0.685	7.500
Balanus crenatus	1	0.228	2.500
Balanus evermani	2	0.457	5.000
Balanus rostratus	2	0.457	5.000
Amphipoda (unid. species)	6	1.370	15.000
Ampeliscida birulai	1	0.228	2.500
Byblis gaimandi	2	0.457	5.000
Melita dentata	1	0.228	2.500
Ischyrocerus sp.	1	0.228	2.500
Lebbeus groenlandicus	1	0.228	2.500
Crangon dalli	1	0.228	2.500
Sclerocrangon boreas	1	0.228	2.500
Paguridae (unid. species)	1	0.228	2.500
Pagurus sp.	8	1.826	20.000
Pagurus ochotensis	3	0.685	7.500
Pagurus capillatus	1	0.228	2.500
Pagurus kennerlyi	1	0.228	2.500
Pagurus beringanus	1	0.228	2.500
Elassochirus tenuimanus	6	1.370	15.000
Paralithodes camtschatica	2	0.457	5.000
Rhinolithodes wosnessenskii	1	0.228	2.500
Oregonia gracilis	7	1.598	17.500
Hyas lyratus	7	1.598	17.500
Chionoecetes bairdi	3	0.685	7.500
Cancer oregonensis	5	1.142	12.500
Pinnixa sp.	2	0.457	5.000
Sipunculida (unid. species)	3	0.685	7.500
Ectoprocta (unid. species)	11	2.511	27.500
Alcyonidium sp.	1	0.228	2.500
Flustrella sp.	2	0.457	5.000
Terebratulina unguicula	1	0.228	2.500
Laqueus californianus	3	0.685	7.500
Terebratalia transversa	7	1.598	17.500
Ctenodiscus crispatus	1	0.228	2.500
Henricia leviuscula	2	0.457	5.000
Crossaster papposus	3	0.685	7.500
Leptasterias sp.	1	0.228	2.500
Leptasterias polaris	4	0.913	10.000
Echinarachnius parma	9	2.055	22.500
Strongylocentrotus droebachiensis	7	1.598	17.500
Ophiopholis sp.	1	0.228	2.500
Ophiopholis aculeata	3	0.695	7.500

APPENDIX I - TABLE I

CONTINUED

Taxonomic Name	Cumulative Station Occurrence	% of all[1] Cumulative Station Occurrence	% of all[2] Stations
Ophiuridae (unid. species)	1	0.228	2.500
Amphipholis sp.	1	0.228	2.500
Ophiura sp.	1	0.228	2.500
Ophiura sarsi	2	0.457	5.000
Cucumariidae (unid. species)	1	0.228	2.500
Cucumaria sp.	2	0.457	5.000
Urochordata (unid. species)	5	1.142	12.500
Chelyosoma sp.	1	0.228	2.500
TOTAL	438		

1 $\frac{\text{Cumulative station occurrence}}{\text{Total cumulative station occurrence}}$

2 $\frac{\text{Cumulative station occurrence}}{\text{Total number of stations occupied}}$

APPENDIX I - TABLE II

OCCURRENCE OF TAXA IN 58 LOWER COOK INLET STATIONS
AS OBTAINED BY PIPE DREDGE, OCTOBER 1976

Taxonomic Names Represent Lowest Level of Identification

Taxonomic Name	Cumulative Station Occurrence	% of all[1] Cumulative Station Occurrence	% of all[2] Stations
Porifera (unid. species)	11	1.267	18.966
Hydrozoa (unid. species)	11	1.267	18.966
Lafoeidae (unid. species)	2	0.230	3.448
Sertulariidae (unid. species)	7	0.806	12.069
Sertularella sp.	4	0.461	6.897
Sertularia sp.	11	1.267	18.966
Abietinaria sp.	10	1.152	17.241
Plumulariidae (unid. species)	2	0.230	3.448
Allopora sp.	5	0.576	8.621
Stylatula gracile	1	0.115	1.724
Ptilosarcus gurneyi	5	0.576	8.621
Actiniidae (unid. species)	3	0.346	5.172
Rhynchocoela (unid. species)	3	0.346	5.172
Polychaeta (unid. species)	22	2.535	37.931
Polynoidae (unid. species)	5	0.576	8.621
Sigalionidae (unid. species)	1	0.115	1.724
Nereidae (unid. species)	1	0.115	1.724
Nereis sp.	1	0.115	1.724
Nephtys sp.	15	1.728	25.862
Glycera sp.	1	0.115	1.724
Glycinde sp.	4	0.461	6.897
Onuphidae (unid. species)	13	1.498	22.414
Arabellidae (unid. species)	2	0.230	3.448
Flabelligeridae (unid. species)	4	0.461	6.897
Opheliidae (unid. species)	4	0.461	6.897
Ophelia limacina	4	0.461	6.897
Sternaspis scutata	3	0.346	5.172
Maldanidae (unid. species)	10	1.152	17.241
Cistenides hyperborea	4	0.461	6.897
Sabellidae (unid. species)	2	0.230	3.448
Serpulidae (unid. species)	7	0.806	12.069
Hirudinea (unid. species)	1	0.115	1.724
Ischnochiton trifidus	5	0.576	8.621
Mopalia sp.	1	0.115	1.724
Nucula tenuis	13	1.498	22.414
Nuculanidae (unid. species)	1	0.115	1.724
Nuculana minuta	1	0.115	1.724
Nuculana fossa	18	2.074	31.034
Portlandia sp.	1	0.115	1.724
Tindaria kennerlyi	1	0.115	1.724

APPENDIX I - TABLE II

CONTINUED

Taxonomic Name	Cumulative Station Occurrence	% of all[1] Cumulative Station Occurrence	% of all[2] Stations
Yoldia amygdalea	4	0.461	6.897
Yoldia myalis	6	0.691	10.345
Yoldia scissurata	6	0.691	10.345
Yoldia thraciaeformis	1	0.115	1.724
Yoldia secunda	1	0.115	1.724
Glycymeris subobsoleta	13	1.498	22.414
Mytilus edulis	2	0.230	3.448
Crenella decusucata	5	0.576	8.621
Musculus niger	2	0.230	3.448
Musculus corrugatus	2	0.230	3.448
Musculus marmoratus	1	0.115	1.724
Modiolus modiolus	7	0.806	12.069
Chlamys sp.	1	0.115	1.724
Chlamys rubida	7	0.806	12.069
Cyclopecten sp.	1	0.115	1.724
Propeamussium alaskense	1	0.115	1.724
Lima sabauriculata	1	0.115	1.724
Pododesmus macrochisma	2	0.230	3.448
Astarte borealis	4	0.461	6.897
Astarte alaskensis	12	1.382	20.690
Astarte montegui	4	0.461	6.897
Astarte rollandi	7	0.806	12.069
Astarte bennettii	1	0.115	1.724
Astarte esquimalti	14	1.613	24.138
Cyclocardia ventricosa	15	1.728	25.862
Cyclocardia crebricostata	2	0.230	3.448
Cyclocardia crassidens	1	0.115	1.724
Parvilucina tenuisculpta	5	0.576	8.621
Axinopsida serricata	11	1.267	18.966
Thyasira flexuosa	7	0.806	12.069
Mysella sp.	3	0.346	5.172
Odontogena borealis	7	0.806	12.069
Clinocardium ciliatum	7	0.806	12.069
Clinocardium californiense	7	0.806	12.069
Serripes groenlandicus	6	0.691	10.345
Saxidomus gigantea	1	0.115	1.724
Liocyma fluctuosa	4	0.461	6.897
Psephidia lordi	19	2.189	32.759
Humilaria kennerlyi	2	0.230	3.448
Protothaca staminea	4	0.461	6.897
Spisula polynyma	10	1.152	17.241
Macoma sp.	4	0.461	6.897
Macoma calcarea	12	1.382	20.690
Macoma elimata	2	0.230	3.448
Macoma brota	4	0.461	6.897

APPENDIX I - TABLE II

CONTINUED

Taxonomic Name	Cumulative Station Occurrence	% of all[1] Cumulative Station Occurrence	% of all[2] Stations
Macoma obliqua	1	0.115	1.724
Macoma moesta alaskana	7	0.806	12.069
Tellina nuculoides	12	1.382	20.690
Siliqua sloati	1	0.115	1.724
Mya priapus	6	0.691	10.345
Hiatella arctica	4	0.461	6.897
Pandora bilirata	1	0.115	1.724
Puncturella galeata	4	0.461	6.897
Cryptobranchia concentrica	2	0.230	3.448
Margarites olivaceus	2	0.230	3.448
Solariella obscura	11	1.267	18.966
Solariella varicosa	4	0.461	6.897
Cocculina casanica	1	0.115	1.724
Balcis sp.	1	0.115	1.724
Crepidula nummaria	1	0.115	1.724
Trichotropididae (unid. species)	1	0.115	1.724
Amauropsis purpurea	2	0.230	3.448
Natica clausa	12	1.382	20.690
Polinices pallida	8	0.922	13.793
Velutina sp.	1	0.115	1.724
Fusitriton oregonensis	8	0.922	13.793
Boreotrophon pacificus	1	0.115	1.724
Boreotrophon lasius	1	0.115	1.724
Nucella lamellosa	1	0.115	1.724
Buccinum plectrum	2	0.230	3.448
Neptunea lyrata	6	0.691	10.345
Neptunea ventricosa	1	0.115	1.724
Amphissa columbiana	2	0.230	3.448
Mitrella gouldi	6	0.691	10.345
Volutomitra alaskana	2	0.230	3.448
Olivella baetica	2	0.230	3.448
Admete sp.	1	0.115	1.724
Oenopota sp.	8	0.922	13.793
Oenopota decussata	1	0.115	1.724
Propebela sp.	2	0.230	3.448
Turbonilla torquata	2	0.230	3.448
Retusa sp.	1	0.115	1.724
Diaphana sp.	2	0.230	3.448
Cylichna alba	5	0.576	8.621
Cylichna attanosa	1	0.115	1.724
Dorididae (unid. species)	2	0.230	3.448
Dentalium sp.	2	0.230	3.448
Pycnogonidae (unid. species)	1	0.115	1.724
Thoracica (unid. species)	1	0.115	1.724
Balanus sp.	1	0.115	1.724
Balanus hesperius	2	0.230	3.448

APPENDIX I - TABLE II

CONTINUED

Taxonomic Name	Cumulative Station Occurrence	% of all[1] Cumulative Station Occurrence	% of all[2] Stations
Balanus rostratus	15	1.728	25.862
Cumacea (unid. species)	8	0.922	13.793
Rocinela augustata	1	0.115	1.724
Amphipoda (unid. species)	23	2.650	39.655
Ericthonius sp.	1	0.115	1.724
Anisogammarus sp.	1	0.115	1.724
Melita sp.	1	0.115	1.724
Anonyx sp.	2	0.230	3.448
Talitridae (unid. species)	1	0.115	1.724
Caprellidae (unid. species)	1	0.115	1.724
Decapoda (unid. species)	1	0.115	1.724
Pandalus sp.	1	0.115	1.724
Pandalus borealis	1	0.115	1.724
Pandalus goniurus	1	0.115	1.724
Pandalus hypsinotus	1	0.115	1.724
Pandalopsis dispar	1	0.115	1.724
Spirontocaris lamellicornis	1	0.115	1.724
Lebbeus groenlandicus	1	0.115	1.724
Eualus sp.	1	0.115	1.724
Eualus herdmani	1	0.115	1.724
Eualus stoneyi	1	0.115	1.724
Heptacarpus tridens	1	0.115	1.724
Crangon dalli	8	0.922	13.793
Callianassidae (unid. species)	2	0.230	3.448
Pagurus sp.	6	0.691	10.345
Pagurus ochotensis	5	0.576	8.621
Pagurus aleuticus	1	0.115	1.724
Pagurus capillatus	4	0.461	6.897
Pagurus kennerlyi	4	0.461	6.897
Pagurus beringanus	2	0.230	3.448
Pagurus trigonocheirus	2	0.230	3.448
Elassochirus tenuimanus	8	0.922	13.793
Oregonia gracilis	8	0.922	13.793
Hyas lyratus	3	0.346	5.172
Chionoecetes bairdi	8	0.922	13.793
Cancer sp.	1	0.115	1.724
Cancer magister	1	0.115	1.724
Cancer oregonensis	7	0.806	12.069
Pinnixa occidentalis	2	0.230	3.448
Golfingia sp.	1	0.115	1.724
Golfingia margaritacea	5	0.576	8.621
Phascolion strombi	1	0.115	1.724
Echiurus echiurus alaskensis	1	0.115	1.724
Ectoprocta (unid. species)	12	1.382	20.690
Flustridae (unid. species)	11	1.267	18.966

APPENDIX I - TABLE II

CONTINUED

Taxonomic Name	Cumulative Station Occurrence	% of all[1] Cumulative Station Occurrence	% of all[2] Stations
Microporina sp.	3	0.346	5.172
Diastoporidae (unid. species)	2	0.230	3.448
Heteropora sp.	1	0.115	1.724
Alcyonidium sp.	4	0.461	6.897
Flustrella gigantea	2	0.230	3.448
Brachiopoda (unid. species)	1	0.115	1.724
Terebratulina unguicula	5	0.576	8.621
Laqueus californianus	6	0.691	10.345
Terebratalia transversa	7	0.806	12.069
Echinodermata (unid. species)	1	0.115	1.724
Ctenodiscus crispatus	1	0.115	1.724
Henricia sp.	3	0.346	5.172
Crossaster papposus	2	0.230	3.448
Leptasterias polaris	2	0.230	3.448
Echinarachnius parma	15	1.728	25.862
Strongylocentrotus droebachiensis	8	0.922	13.793
Strongylocentrotus franciscanus	1	0.115	1.724
Ophiuroidea (unid. species)	1	0.115	1.724
Amphipholis pugetana	4	0.461	6.897
Diamphiodia craterodmeta	2	0.230	3.448
Diamphiodia periercta	1	0.115	1.724
Gorgonocephalus caryi	1	0.115	1.724
Ophiopholis aculeata	5	0.576	8.621
Ophiopenia disacantha	3	0.346	5.172
Ophiura sp.	2	0.230	3.448
Ophiura sarsi	3	0.346	8.621
Synaptiidae (unid. species)	1	0.115	1.724
Cucumaria calcigera	1	0.115	1.724
Urochordata (unid. species)	5	0.576	8.621
Styelidae (unid. species)	1	0.115	1.724
Halocynthia igaboja	1	0.115	1.724
TOTAL	868	100	

[1] $\frac{\text{Cumulative station occurrence}}{\text{Total cumulative station occurrence}}$

[2] $\frac{\text{Cumulative station occurrence}}{\text{Total number of stations occupied}}$

APPENDIX I - TABLE III

ALASKA DEPARTMENT OF FISH AND GAME (ADF&G)
OUTER KENAI PENINSULA, BOTTOM SKIMMER STATION 01
18.3 METERS - 8/10/76 - TIME 1250

Taxon	Relative Abundance[1]
Cnidaria	
Hydrozoa	F
Annelida	
Serpulidae	A
Polynoidae	C
Nereidae	N
Mollusca	
Tellina nuculoides	C
Glycymeris subobsoleta	C
Hiatella arctica	C
Cyclocardia crebricostata	I
Musculus vernicosus	F
Olivella baetica	F
Psephidia lordi	C
Arthropoda	
Balanus sp.	F
Cumacea	A
Caprellidea	A
Gammaridae (6 species)	A
Pagurus sp.	F
Elassochirus tenuimanus	C
Elassochirus gilli	I
Sclerocrangon boreas	F
Crangon sp.	C
Telmessus cheiragonus	I
Hyas lyratus	I
Oregonia gracilis	I
Ectoprocta	I
Echinodermata	
Ophiuroidea	C
Urochordata	
Solitary ascidian	F
Compound Ascidian	I

Comments: Lots of kelp and pieces of wood

[1]Relative Abundance: I = Infrequent (1-10 organisms)
F = Few (11-20)
C = Common (21-35)
N = Numerous (36-50)
A = Abundant (>51)

APPENDIX I - TABLE IV

ADF&G OUTER KENAI PENINSULA, BOTTOM SKIMMER STATION 02
20.1 METERS - 8/10/76 - TIME 1325

Taxon	Relative Abundance
Porifera	I
Annelida	
Syllidae	I
Polynoidae	I
Mollusca	
Modiolus modiolus	I
Musculus discors	I
Cyclocardia crebricostata	I
Crenella decussata	C
Hiatella arctica	I
Tellina nuculoides	I
Glycymeris subobsoleta	A
Astarte rollandi	C
Limatula subauriculata	I
Olivella baetica	F
Polinices pallida	I
Fusitriton oregonensis	I
Velutina sp.	I
Lacuna sp.	I
Crepidula nummaria	I
Ischnochiton sp.	I
Arthropoda	
Balanus sp.	I
Pentidotea sp.	I
Gammaridae (6 species)	F
Cumacea	I
Hippolytidae	I
Crangon dalli	I
Argis crassa	I
Pagurus ochotensis	I
Pagurus capillatus	I
Pagurus beringanus	I
Elassochirus tenuimanus	F
Hyas lyratus	F
Oregonia gracilis	F
Ectoprocta	
Alcyonidium sp.	I
Flustra sp.	I
Microporina sp.	I

APPENDIX I - TABLE IV

CONTINUED

Taxon	Relative Abundance
Brachiopoda	
Terebratalia transversa	I
Echinodermata	
Ophiuroidea	I
Brisaster townsendi	I
Strongylocentrotus droebachiensis	I
Urochordata	
Compound ascidian	F

Comments: Numerous green, brown and red algal fragments

APPENDIX I - TABLE V

ADF&G OUTER KENAI PENINSULA, BOTTOM SKIMMER STATION 03
25.6 METERS - 8/10/76 - TIME 1350

Taxon	Relative Abundance
Porifera	I
Mollusca	
Astarte rollandi	I
Glycymeris subobsoleta	I
Musculus discors	I
Olivella baetica	I
Arthropoda	
Balanus sp.	F
Pandalus sp.	F
Pandalus borealis	I
Argis crassa	I
Crangon dalli	I
Sclerocrangon boreas	I
Eualus sp.	I
Pagurus kennerlyi	I
Elassochirus tenuimanus	C
Elassochirus gilli	I
Echinodermata	
Lophaster sp.	I

Comments: Large fragments of brown and red algae

APPENDIX I - TABLE VI

ADF&G OUTER KENAI PENINSULA, BOTTOM SKIMMER STATION 04
18.3 METERS - 8/10/76 - TIME 1415

Taxon	Relative Abundance
Porifera	I
Cnidaria	
Hydrozoa	I
Annelida	
Serpulidae	I
Mollusca	
Humilaria kennerleyi	I
Olivella baetica	I
Arthropoda	
Mysidacea	I
Crangon dalli	I
Sclerocrangon boreas	I
Eualus sp.	I
Heptacarpus tridens	I
Pagurus sp.	I
Pagurus trigonochirus	I
Pagurus beringanus	I
Elassochirus tenuimanus	I
Cancer oregonensis	I
Oregonia gracilis	I
Ectoprocta	
Flustrella gigantea	I
Echinodermata	
Strongylocentrotus droebachiensis	I

Comments: Sea grass and brown algae present

APPENDIX I - TABLE VII

ADF&G OUTER KENAI PENINSULA, BOTTOM SKIMMER STATION 05
20.1 METERS - 8/10/76 - TIME 1423

Taxon	Relative Abundance
Annelida	
Glyceridae	I
Ampharetidae	I
Nephtyidae	F
Nereidae	I
Serpulidae	C
Terebellidae	F
Phyllodocidae	F
Mollusca	
Astarte sp.	F
Glycymeris subobsoleta	I
Cyclocardia crebricostata	I
Musculus discors	C
Olivella baetica	F
Cylichna sp.	I
Arthropoda	
Mysidacea	A
Crangon dalli	C
Argis sp.	I
Sclerocrangon boreas	I
Elassochirus tenuimanus	I
Pagurus sp.	I
Spirontocaris sp.	F
Caprellidea	I
Gammaridea (4 species)	N
Lebbeus groenlandicus	I
Ectoprocta	I
Echinodermata	
Strongylocentrotus droebachiensis	I

Comments: Substrate - coarse sand; lots of algae and seaweeds

APPENDIX I - TABLE VIII

ADF&G OUTER KENAI PENINSULA, BOTTOM SKIMMER STATION 06
9.1-18.3 METERS - 8/11/76 - TIME 0900

Taxon	Relative Abundance
Porifera	I
Cnidaria	
Hydrozoa	I
Annelida	
Sabellidae (small)	A
Polynoidae	C
Cistenides sp. (small)	C
Mollusca	
Pododesmus macrochisma	C
Natica sp.	F
Olivella baetica	I
Fusitriton oregonensis	I
Nassarius sp.	F
Trichotropis sp.	I
Calliostoma sp.	I
Nudibranch	I
Mya truncata (dead)	I
Tellina nuculoides (small)	I
Arthropoda	
Isopoda (one Ectoparasitic form)	I
Amphipoda (10 species of Gammaridea)	A
Pagurus sp.	N
Elassochirus tenuimanus	C
Hyas lyratus	C
Oregonia gracilis	C
Sclerocrangon boreas	F
Spirontocaris sp. (small)	N
Megalops of crabs	C

Comments: Two *Pododesmus* occupying dead *Fusitriton* shell along with an *Elassochirus*; one of the *Pododesmus* brooding ∿50 eyed, shelled young.

APPENDIX I - TABLE IX

ADF&G OUTER KENAI PENINSULA, BOTTOM SKIMMER STATION 07
18.3 METERS - 8/11/76 - TIME 1930

Taxon	Relative Abundance
Cnidaria	
Hydrozoa (1 specie)	I
Mollusca	
Glycymeris subobsoleta	I
Diplodonta orbellus	I
Nudibranch	I
Arthropoda	
Hippolytidae	I
Sclerocrangon boreas	I
Argis crassa	I
Oregonia gracilis	I
Elassochirus tenuimanus	I
Pagurus capillatus	I
Echinodermata	
Pteraster tesselatus	I

Comments: Short tow, hung up on rocks

APPENDIX I - TABLE X

ADF&G OUTER KENAI PENINSULA, BOTTOM SKIMMER STATION 10
31.1 METERS - 8/11/76 - TIME 1030

Taxon	Relative Abundance
Porifera (1 type)	I
Cnidaria	
Hydrozoa	F
Annelida	
Polynoidae	C
Terebellidae	I
Serpulidae	C
Nereidae	F
Syllidae	F
Mollusca	
Nudibranch	N
Velutina sp.	I
Placiphorella sp.	I
Micranellum sp.	F
Olivella baetica	I
Oenopota sp.	I
Humilaria kennerleyi	I
Glycymeris subobsoleta	I
Polinices sp.	I
Pododesmus macrochisma	I
Crepidula sp.	I
Arthropoda	
Hippolytidae (small)	F
Cancer sp.	I
Oregonia gracilis (small)	C
Elassochirus tenuimanus	F
Isopoda	I
Gammaridae (∿8 species)	A
Caprellidae	A
Pagurus sp.	C
Sclerocrangon boreas	I
Pycnogonida	I
Ectoprocta (colony)	N
Echonodermata	
Crossaster papposus	I
Ophiuroidea	C
Strongylocentrotus droebachiensis	I

APPENDIX I - TABLE X

CONTINUED

Taxon	Relative Abundance
Urochordata (4 types compound ascidian)	A

Comments: 1 stomach examined from *Gymnocanthus* sp. juvenile; 27 mm total length; contained 2 Pandalid shrimp; 3 Gammarid amphipods

APPENDIX I - TABLE XI

ADF&G OUTER KENAI PENINSULA, BOTTOM SKIMMER STATION 11
27.4 METERS - 8/11/76 - TIME 1105

Taxon	Relative Abundance
Porifera (3 species; one c.f. Grantiidae)	I
Cnidaria	
Hydrozoa (6 species)	A
Annelida	
Polynoidae	I
Nereidae	I
Phyllodocidae	I
Syllidae	I
Serpulidae	I
Rhynchocoela	I
Mollusca	
Hiatella arctica	F
Crepidula nummaria	I
Ischnochiton albus	I
Nudibranch	F
Fusitriton oregonensis	I
Nucella lamellosa	I
Amphissa columbiana	I
Musculus discors	F
Modiolus modiolus	F
Chlamys rubida	I
Velutina sp.	I
Arthropoda	
Balanus balanus	A
Pagurus sp.	C
Elassochirus tenuimanus	I
Cancer oregonensis	F
Hippolytidae	F
Gammaridea (8 species)	A
Caprellidae (♀♀ brooding eggs)	A
Isopoda	N
Oregonia gracilis	C
Lebbeus groenlandicus	I
Pagurus kennerleyi	I
Pugettia gracilis	I
Ectoprocta (colonial)	A

APPENDIX I - TABLE XI

CONTINUED

Taxon	Relative Abundance
Echinodermata	
Ophiopholis aculeata	I
Henricia sp.	I
Urochordata (compound ascidian)	F

Comments: Main bulk of tow consisted of hydrozoans and ectoprocta

APPENDIX I - TABLE XII

ADF&G OUTER KENAI PENINSULA, BOTTOM SKIMMER STATION 12
31.1 METERS - 8/11/76 - TIME 1125

Taxon	Relative Abundance
Foraminifera	A
Porifera	F
Cnidaria	
Hydrozoa (2 species)	A
Anthozoa	F
Annelida	
Owenidae	I
Polynoidae	I
Phyllodocidae	I
Serpulidae	I
Syllidae	I
Nephtys sp.	I
Nereis sp.	N
Lumbrineris sp.	I
Eunoe sp.	F
Nephtyidae	I
Nereidae	N
Sabellidae	N
Serpulidae	A
Rhynchocoela	F
Mollusca	
Musculus discors	F
Modiolus modiolus	F
Natica sp.	I
Fusitriton oregonensis	F
Nucella lamellosa	F
Hiatella arctica	I
Humilaria kennerleyi (dead)	I
Glycymeris subobsoleta (dead)	F
Astarte sp. (dead)	I
Ischnochiton sp.	I
Pododesmus macrochisma	I
Polyplacophora (3 types)	N
Nudibranch	F
Unident. gastropod	N
Scaphopoda	N
Spisula polynyma (dead)	I
Pectinidae (dead)	I
Trophonopsis sp. (dead)	I
Natica sp. (dead)	I
Fusitriton oregonensis (dead)	I
Fissurellidae (dead)	I

APPENDIX I - TABLE XII

CONTINUED

Taxon	Relative Abundance
Arthropoda	
Gammaridae (6 species)	A
Eusiridae	A
Lysianassidae	A
Isopoda (2 species)	N
Balanus sp.	A
*most of decapods were zooea, megalops, and post-megalops juveniles	
Pandalidae	I
Sclerocrangon boreas	I
Elassochirus tenuimanus	F
Hyas lyratus (1 ♀ w/orange eggs)	I
Cancer oregonensis	I
Oregonia gracilis (♀♀ with eggs)	C
Cumacea (2 ♀♀ brooding young)	I
Pycnogonida (2 species)	F
Ectoprocta	
Flustra sp.	F
encrusting	A
leafy	N
Echinodermata	
Asteroidea	I
Echinoidea	I
Ophiuroidea	I
Strongylocentrotus droebachiensis	I
Urochordata	
Compound ascidian	I
Rhodosomatidae	I

Comments: Numerous larval decapods

APPENDIX I - TABLE XIII

ADF&G OUTER KENAI PENINSULA, BOTTOM SKIMMER STATION 13
36.6 METERS - 8/11/76 - TIME 1340

Taxon	Relative Abundance
Porifera	I
Cnidaria	
Hydrozoa (6 species)	A
Annelida	
Polynoidae	I
Polychaeta	I
Serpulidae	C
Mollusca	
Fusitriton oregonensis	I
Olivella baetica	I
Polyplacophora	I
Hiatella arctica	I
Glycymeris subobsoleta	I
Mitrella gouldi	I
Arthropoda	
Cumacea	I
Oregonia gracilis	C
Cancer oregonensis	I
Balanus sp.	I
Hippolytidae	I
Pagurus sp.	C
Pagurus kennerleyi	I
Crangon dalli	I
Gammaridae	
Pycnogonida	
Elassochirus gilli	
Elassochirus tenuimanus	
Lebbeus groenlandicus	
Eualus sp.	
Pagurus capillatus	
Pugettia gracilis	
Ectoprocta	
encrusting	I
Flustra sp.	F
Alcyonidium sp.	I
Echinodermata	
Ophiuroidea	I
Strongylocentrotus droebachiensis	I

APPENDIX I - TABLE XIII

CONTINUED

Taxon	Relative Abundance
Urochordata	
Compound tunicate	I

Comments: Numerous amounts of brown and red algae fragments

APPENDIX I - TABLE XIV

ADF&G OUTER KENAI PENINSULA BOTTOM SKIMMER STATION 14
31.1 METER - 8/11/76 - TIME 1410

Taxon	Relative Abundance
Cnidaria	
Hydrozoa (2 species)	I
Annelida	
Syllidae	I
Mollusca	
Olivella baetica	I
Musculus discors	I
Solariella obscura	I
Tonicella lineata	I
Arthropoda	
Elassochirus tenuimanus	I
Pagurus beringanus	I
Cancer oregonensis	I
Gammaridae	F
Pagurus sp.	F
Hippolytidae	I
Eualus sp.	I
Lebbeus groenlandicus	I
Spirontocaris prionota	I
Spirontocaris lamellicornis	I
Oregonia gracilis	I
Balanus balanus	I
Ectoprocta	
Microporina sp.	F
Flustrellidae	I
Echinodermata	
Ophiopholis aculeata	I
Strongylocentrotus droebachiensis	I
Urochordata	
Compound ascidian	A

APPENDIX I - TABLE XV

ADF&G OUTER KENAI PENINSULA, BOTTOM SKIMMER STATION 15
29.3 METERS - 8/11/76 - TIME 1425

Taxon	Relative Abundance
Foraminifera (3 species)	I
Porifera	I
Cnidaria	
Hydrozoa (by colony)	I
Annelida	
Lumbrineridae	I
Polynoidae	I
Syllidae	I
Serpulidae	I
Arthropoda	
Cumacea	N
Mysidacea	F
Isopoda	F
Crangon sp.	C
Oregonia sp.	F
Amphipoda	A
Hippolytidae	C
Oregonia gracilis	I
Pycnogonidae	I
Balanus sp.	I
Pagurus ochotensis	I
Mollusca	
Olivella baetica	A
Ectoprocta	
Microporina sp.	I
Alcyonidium sp.	I
Urochordata	
Compound ascidian	I

Comments: Numerous remains of pelecypods, gastropods, ectoprocta, crustaceans, hydrozoans, and algae

APPENDIX I - TABLE XVI

ADF&G OUTER KENAI PENINSULA, BOTTOM SKIMMER STATION 16
40.1 METERS - 8/11/76 - TIME 1450

Taxon	Relative Abundance
Porifera (2 species)	I
Cnidaria	
Hydrozoa (by colony)	F
Anthozoa	I
Annelida	
Serpulidae	C
Phyllodocidae	C
Polynoidae	C
Nereidae	I
Syllidae	I
Arthropoda	
Caprellidea (large)	C
Gammaridea (∿10 species)	A
Elassochirus tenuimanus	F
Oregonia gracilis (♀♀ brooding eggs)	C
Hyas lyratus	F
Cancer sp.	F
Pandalidae (small)	F
Hippolytidae	F
Argis sp.	I
Balanus sp.	C
Mollusca	
Fusitriton oregonensis	I
Nudibranchs (small)	C
Cyclocardia crebricostata (dead)	I
Humilaria kennerleyi (dead)	I
Astarte sp. (dead)	I
Polinices sp. (dead; w/*Elassochirus* in them)	F
Crepidula sp.	I
Ectoprocta	C
Echinodermata	
Asteroidea	I
Ophiuroidea	I
Strongylocentrotus droebachiensis	I
Urochordata	
Compound ascidian (1 species)	I

APPENDIX I - TABLE XVII

ADF&G OUTER KENAI PENINSULA, BOTTOM SKIMMER STATION 17
29.3 METERS - 8/11/76 - TIME 1525

Taxon	Relative Abundance
Cnidaria	
Hydrozoa (2 species)	I
Actiniidae	I
Mollusca	
Fusitriton oregonensis	I
Crepidula nummaria	I
Arthropoda	
Elassochirus tenuimanus	I
Balanus sp.	C
Argis crassa	I
Pagurus sp.	I
Elassochirus gilli	I
Eualus sp.	I
Pagurus kennerlyi	I
Pagurus confragosus	I
Ectoprocta (encrusting)	I
Urchordata	
Compound ascidian	I

APPENDIX I - TABLE XVIII

ADF&G OUTER KENAI PENINSULA, BOTTOM SKIMMER STATION 18
27.4 METERS - 8/11/76 - TIME 1550

Taxon	Relative Abundance
Mollusca	
Glycymeris subobsoleta	F
Olivella baetica	I
Cyclocardia crebricostata	I
Tellina nuculoides	I
Arthropoda	
Oregonia gracilis	I
Crangon dalli	I
Hippolytidae	I

Comments: Red and green algae remains

APPENDIX TABLE I - TABLE XIX

ADF&G OUTER KENAI PENINSULA, BOTTOM SKIMMER STATION 20
29.3 METERS - 8/11/76 - TIME 1635

Taxon	Relative Abundance
Porifera	I
Annelida	
Nereis sp.	I
Mollusca	
Glycymeris subobsoleta	A
Humilaria kennerleyi	I
Musculus discors	I
Astarte rollandi	I
Olivella baetica	C
Tellina nuculoides	I
Cyclocardia crebricostata	I
Unident. gastropod	I
Arthropoda	
Hippolytidae	I
Pagurus sp.	I
Gammaridae	I
Echinodermata	
Strongylocentrotus droebachiensis	I
Ectoprocta	
Flustrella gigantea	F
encrusting	I

APPENDIX I - TABLE XX

ADF&G OUTER KENAI PENINSULA, BOTTOM SKIMMER STATION 21
27.5 METERS - 8/11/76 - TIME 0845

Taxon	Relative Abundance
Porifera (many colonies of shell-encrusting type. Also, a form of sponge resembling a "cactus")	N
Hydrozoa (by colony; both leafy and dendroform)	A
Annelida	
Phyllodocidae	F
Nereidae	C
Sabellidae	I
Serpulidae	N
Polynoidae	I
Mollusca	
Hiatella arctica	I
Nudibranchs (small)	F
Pododesmus macrochisma	I
Polyplacophora	I
Glycymeris subobsoleta	I
Chlamys rubida	I
Cyclocardia crebricostata (dead)	I
Humilaria kennerleyi (dead)	I
Mya sp. (dead)	I
Beringius sp. (dead)	C
Nucella lamellosa (dead)	F
Fusitriton oregonensis (dead)	I
Naticidae sp. (dead)	I
Arthropoda	
Pycnogonida	I
Balanus sp.	N
Caprellidae	I
Gammaridae	A
Ischyroceridae	C
Oregonia gracilis	F
Cancer sp.	I
Pagurus sp.	N
Elassochirus tenuimanus	C
Pandalus sp. (small)	N
Spirontocaris sp. (small)	F
Sclerocrangon boreas (small)	F
Ectoprocta (by colony)	A

APPENDIX I - TABLE XX

CONTINUED

Taxon	Relative Abundance
Echinodermata	
Holothuroidea	I
Urochordata (by colony)	N
3 types, all compound ascidians	

Comments: Most shells were dead; 80% had been drilled.

APPENDIX I - TABLE XXI

ADF&G OUTER KENAI PENINSULA, BOTTOM SKIMMER STATION 22
27.5 METERS - 8/12/76 - TIME 0915

Taxon	Relative Abundance
Cnidaria	
Hydrozoa (by colony)	F
Annelida	
Serpulidae	N
Nereidae	F
Sabellidae	F
Mollusca	
Margarites sp.	I
Glycymeris subobsoleta (dead)	N
Astarte sp. (dead)	A
Humilaria kennerleyi (dead)	I
Musculus discors	I
Arthropoda	
Gammaridea (5 species)	N
Pagurus sp. (small)	F
Pandalidae (small)	C
Sclerocrangon boreas	F
Hyas lyratus	I
Balanus sp.	F
Echinodermata	
Holothuroidea (small)	C
Ophiuroidea	F
Strongylocentrotus droebachiensis	F
Asteroidea	I
Urochordata (by colony) (2 types of compound ascidians)	N

Comments: Substrate: "Pea" gravel and smaller; no larger rocks.

APPENDIX I - TABLE XXII

ADF&G OUTER KENAI PENINSULA, BOTTOM SKIMMER STATION 23
23.8 METERS - 8/12/76 - TIME 0940

Taxon	Relative Abundance
Porifera (5 species; 2 of which are encrusting)	C
Cnidaria	
Hydrozoa (coral type and dendroform type)	F
Annelida	
Syllidae	F
Nereidae	I
Pectinariidae	I
Polynoidae	I
Serpulidae	F
Mollusca	
Pododesmus macrochisma	C
Calliostoma sp.	C
Fusitriton oregonensis	I
Beringius sp.	F
Nucella lamellosa	I
Musculus vernicosa (all very small, attached to kelp frond)	N
Astarte montagui	I
Arthropoda	
Pandalus sp.	C
Lebbeus groenlandicus	I
Spirontocaris sp.	N
Eualus sp.	I
Pagurus sp.	N
Elassochirus tenuimanus	F
Pugettia gracilis	I
Hyas lyratus (small)	C
Oregonia gracilis	C
Cancer sp. (small)	F
Amphipoda (5 species)	N
Balanus sp.	A
Ectoprocta (colony)	F
Echinodermata	
Strongylocentrotus droebachiensis	I

APPENDIX I - TABLE XXII

CONTINUED

Taxon	Relative Abundance
Urochordata (short, finger-like compound ascidian dark, grape-like Rhodosomatid, *Chelyosoma* sp.)	F

Comments: High current area

APPENDIX I - TABLE XXIII

ADF&G OUTER KENAI PENINSULA, BOTTOM SKIMMER STATION 24
20.1 METERS - 8/12/76 - TIME 1015

Taxon	Relative Abundance
Porifera	F
(3 types; including shell encrusting form)	
Cnidaria	
Hydrozoa (by colony)	N
(2 types encrusting; 2 dendroform; 1 leafy)	
Nemerteans	I
Annelida	
Serpulidae	C
Polynoidae	I
Nereidae	I
Syllidae	F
Mollusca	
Musculus vernicosa	A
(many 1-2-3 yr. old *Musculus*)	
Nudibranchs (small)	I
Pododesmus macrochisma	I
Calliostoma sp.	I
Glycymeris subobsoleta (dead)	I
Naticidae (dead)	I
Arthropoda	
Caprellidea	I
Gammaridea	A
Pagurus sp.	C
Elassochirus tenuimanus	F
Cancer sp.	I
Cryptolithodes sp.	I
Pandalus sp.	F
Pycnogonida	I
Brachiopoda	I
Ectoprocta (by colony)	F
Echinodermata	
Ophiuroidea	I
Asteroidea	I
Urochordata (compound ascidian)	I

APPENDIX I - TABLE XXIV

ADF&G OUTER KENAI PENINSULA, BOTTOM SKIMMER STATION 25
27.5 METERS - 8/12/76 - TIME 1040

Taxon	Relative Abundance
Porifera	I
Cnidaria	
Hydrozoa (by colonies) ("coral" like forms and leafy dendroform)	A
Annelida	
Gattyana iphionelloides	I
Euphrosine sp.	I
Sabellidae	I
Serpulidae	F
Mollusca	
Polyplacophora	F
Velutinidae	F
Pododesmus macrochisma (both minute and slightly larger)	F
Nudibranchs	I
Naticidae	F
Pelecypoda (very small)	N
Mya sp. (dead shell)	I
Humilaria kennerleyi (all small; dead)	F
Cyclocardia crebricostata (dead)	I
Glycymeris subobsoleta (dead)	F
Musculus discors (dead)	I
Oenopota (dead)	C
"Fusinus" type (dead)	N
Arthropoda	
Isopoda	I
Amphipoda (about 10 species)	
Caprellidae (one ♀♀ brooding eggs)	F
Ischyroceridae	F
Gammaridae	A
Pandalidae	C
Paguridae (mostly small - up to 2 cm long)	N
Cancer sp.	I
Atelecyclidae (post-megalops)	I
Balanus sp. (mostly small, recently	N
settled ones)	I
Majidae	I

APPENDIX I - TABLE XXIV

CONTINUED

Taxon	Relative Abundance
Ectoprocta (by colony)	A
Echinoderms	
Holothurians	I
Ophiuroidea	N
Urochordata (6 types, including 2 types of compound ascidians)	N

APPENDIX I - TABLE XXV

ADF&G OUTER KENAI PENINSULA, BOTTOM SKIMMER STATION 26
29.3 METERS - 8/12/76 - TIME 1115

Taxon	Relative Abundance
Cnidaria	
Hydrozoa	F
Annelida	
Maldanidae	F
Polychaeta	F
Mollusca	
Cyclocardia crassidens	I
Chlamys rubida	I
Kellia laperousii	I
Arthropoda	
Argis dentata	I
Hyas lyratus	I
Balanus sp.	I
Sclerocrangon boreas	F
Oregonia gracilis	I
Elassochirus tenuimanus	I
Pagurus kennerlyi	I
Pagurus sp.	I
Eualus sp.	A
Mysidacea	I
Spirontocaris lamellocornis	F
Spirontocaris prionota	F
Gammaridae	F
Sipunculida	I
Ectoprocta	
Flustra sp.	F
Echinodermata	
Ophiopholis aculeata	I

APPENDIX I - TABLE XXVI

ADF&G OUTER KENAI PENINSULA, BOTTOM SKIMMER STATION 27
20.1 METERS - 8/12/76 - TIME 1130

Taxon	Relative Abundance
Porifera (shell-encrusting type most frequent; 2 other types)	C
Cnidaria	
Hydrozoa (by colony)	A
Annelida	
Polynoidae (3 species)	N
Syllidae	C
Mollusca	
Nudibranch	I
Bathybembix sp. (dead)	F
Musculus discors	I
Nucella lamellosa	F
Arthropoda	
Isopoda	I
Gammaridea (10 species)	A
Pagurus sp.	F
Elassochirus tenuimanus	I
Pandalus sp. (small)	N
Lebbeus groenlandicus (small)	C
Argis sp.	I
Balanus sp. (medium size)	C
Sclerocrangon boreas	I
Ectoprocta (by colony)	F
Brachiopoda	
Terebratalia sp.	I
Echinodermata	
Ophiopholis aculeata	C
Strongylocentrotus droebachiensis	I
Urochordata (compound tunicate)	I

APPENDIX I - TABLE XXVII

ADF&G OUTER KENAI PENINSULA, BOTTOM SKIMMER STATION 28
40.3 METERS - 8/12/76 - TIME 1155

Taxon	Relative Abundance
Porifera	C
(1 encrusting on *Oregonia* sp.	
2 "free living" forms	
1 shell-encrusting form)	
Cnidaria	
Hydrozoa (by colony)	A
Annelida	
Nereidae	C
Polynoidae	N
Sabellidae	F
Syllidae	C
Serpulidae	N
Mollusca	
Glycymeris subobsoleta	I
Chlamys rubida	I
Clinocardium sp.	F
Astarte sp.	I
Fusitriton oregonensis	F
Nucella lamellosa	I
Polinices sp.	C
Arthropoda	
Pycnogonida	C
Caprellidea	C
Gammaridea (∿8 species)	A
Pagurus spp.	N
Elassochirus tenuimanus	F
Cancer oregonensis	F
Cancer magister	C
Hyas lyratus (♀♀ brooding small eggs)	F
Oregonia gracilis	F
Pandalidae (small)	N
Pugettia gracilis	I
	A
Ectoprocta (by colony)	A
(large, leafy, spongy textured form;	
3 other forms)	
Echinodermata	
Strongylocentrotus droebachiensis	F
Crossaster papposus	I
Asteroidea (others)	I
Ophiuroidea	C

APPENDIX I - TABLE XXVII

CONTINUED

Taxon	Relative Abundance
Urochordata (compound ascidians)	F

Comments: 2 stomachs examined from *Anoplarchus* sp. (Stichaeidae)
♂; 91 mm total length; 6 Salp-like Urochordates
♀♀; 74 mm total length; 2 types amphipods; 1 salp-like Urochordate; 1 *Pagurus* sp; 1 *Musculus discors*(?); 1 snail, (c.f. *Tachrynchus* sp.); Remains of 2 crustaceans.

1 stomach from *Anoplagonus inermis* (Agonidae)
♂; 97 mm total length: contents - 1 crab megalops; 1 *Pagurus* sp; 3 amphipods (Gammaridea) 2 Pandalid shrimp.

APPENDIX I - TABLE XXVIII

ADF&G OUTER KENAI PENINSULA, BOTTOM SKIMMER STATION 29
31.1 METERS - 8/12/76 - TIME 1230

Taxon	Relative Abundance
Mollusca	
Tellina nuculoides	A
Glycymeris subobsoleta (dead)	I
Clinocardium sp. (dead)	I
Crepidula sp. (dead)	I
Cyclocardia crebricostata (dead)	I
Beringius sp. (dead)	
Arthropoda	
Majidae	I
Pagurus sp.	I
Echinodermata	
Ophiuroidea	I

Comments: Approximately 75% of substrate in sample composed of broken pieces of Mollusc Shells and *Balanus* sp. Shells.

APPENDIX I - TABLE XXIX

PERCENTAGE COMPOSITION OF ALL PHYLA BY FAMILY FROM LOWER COOK INLET AS OBTAINED BY AGASSIZ TRAWL, APRIL 1976

Taxonomic Name	Number of Organisms (count)	% Total Count	Weight (g)	% Total Weight	g/m^2 All Stations
Porifera (unid. family)	2	0.0390	107	0.0936	0.00304
Hydrozoa (unid. family)	1	0.0195	52	0.0455	0.00148
Alcyonacea (Nephtheidae)	1	0.0195	5	0.0044	0.00014
Pennatulacea (Virgulariidae)	2	0.0390	115	0.1006	0.00327
Pennatulacea (Pennalutidae)	1	0.0195	60	0.0525	0.00171
Actiniidae	18	0.3508	387	0.3387	0.01101
Polychaeta (unid. family)	11	0.2144	8	0.0070	0.00023
Polynoidae	13	0.2534	21	0.0184	0.00060
Piscicolidae	1	0.0195	2	0.0018	0.00006
Mytilidae	2	0.0390	40	0.0350	0.00114
Pectinidae	62	1.2083	857	0.7500	0.02439
Astartidae	5	0.0974	31	0.0271	0.00088
Carditidae	12	0.2339	81	0.0709	0.00231
Cardiidae	49	0.9550	773	0.6765	0.02200
Mactridae	3	0.0585	239	0.2092	0.00680
Tellinidae	1	0.0195	1	0.0009	0.00003
Hiatellidae	1	0.0195	1	0.0009	0.00003
Trochidae	2	0.0390	10	0.0088	0.00028
Epitoniidae	1	0.0195	1	0.0009	0.00003
Eulimidae	6	0.1169	1	0.0009	0.00003
Calyptraeidae	2	0.0390	1	0.0009	0.00003
Naticidae	40	0.7796	694	0.6073	0.01975
Cymatiidae	197	3.8394	4602	4.0273	0.13096
Muricidae	5	0.0974	29	0.0254	0.00083
Thaididae	2	0.0390	20	0.0175	0.00057
Buccinidae	24	0.4677	257	0.2249	0.00731
Neptuneidae	278	5.4180	9745	8.5281	0.27732
Volutomitridae	1	0.0195	50	0.0438	0.00142
Cancellariidae	3	0.0585	9	0.0079	0.00026
Tritoniidae	4	0.0780	370	0.3238	0.01053
Balanidae	16	0.3118	36	0.0315	0.00102
Amphipoda (unid. family)	4	0.0780	3	0.0026	0.00009
Ampeliscidae	4	0.0780	3	0.0026	0.00009
Corophiidae	1	0.0195	1	0.0009	0.00003
Phoxocephalidae	1	0.0195	1	0.0009	0.00003
Caprellidae	1	0.0195	1	0.0009	0.00003
Pandalidae	721	14.0518	6561	5.4717	0.18671
Hippolytidae	14	0.2729	89	0.0779	0.00253
Crangonidae	216	4.2097	4291	3.7552	0.12211
Paguridae	311	6.0612	5091	4.4553	0.14488
Lithodidae	11	0.2144	30139	26.3755	0.85766
Majidae	2757	53.7322	36055	31.5527	1.02604
Cancridae	2	0.0390	50	0.0438	0.00142
Pinnotheridae	2	0.0390	4	0.0035	0.00011

APPENDIX I - TABLE XXIX

CONTINUED

Taxonomic Name	Number of Organisms (count)	% Total Count	Weight (g)	% Total Weight	g/m^2 All Stations
Ectoprocta (unid. Family)	2	0.0390	152	0.1330	0.00433
Membraniporidae	1	0.0195	1	0.0009	0.00003
Heteroporidae	1	0.0195	25	0.0219	0.00071
Flustrellidae	1	0.0195	10	0.0088	0.00028
Dallinidae	20	0.3898	135	0.1181	0.00384
Goniasteridae	1	0.0195	70	0.0613	0.00199
Porcellanasteridae	83	1.6176	121	0.1059	0.00344
Echinasteridae	5	0.0974	165	0.1444	0.00470
Pterasteridae	4	0.0780	540	0.4726	0.01537
Solasteridae	8	0.1559	640	0.5601	0.01821
Asteridae	39	0.7601	3623	3.1706	0.10310
Echinarachniidae	92	1.7930	4080	3.5705	0.11611
Strongylocentrotidae	34	0.6626	1998	1.7485	0.05686
Gorgonocephalidae	2	0.0390	128	0.1120	0.00364
Ophiactidae	7	0.1364	2	0.0018	0.00006
Ophiuridae	3	0.0585	7	0.0061	0.00020
Cucumariidae	12	0.2339	1344	1.1762	0.03825
Urochordata (unid. Family)	5	0.0947	245	0.2144	0.00697
TOTAL	5131		114269		3.24931

APPENDIX I - TABLE XXX

PERCENTAGE COMPOSITION OF ALL PHYLA BY FAMILY FROM LOWER COOK INLET AS OBTAINED BY AGASSIZ TRAWL, OCTOBER 1976

Taxonomic Name	Number of Organisms (count)	% Total Count	Weight (g)	% Total Weight	g/m^2 All Stations
Actiniidae	1	0.0318	2	0.0029	0.00010
Polychaeta (unid. family)	2	0.0636	2	0.0029	0.00010
Polynoidae	12	0.3814	7	0.0102	0.00034
Nereidae	1	0.0318	5	0.0073	0.00025
Aphroditidae	1	0.0318	1	0.0015	0.00005
Piscicolidae	1	0.0318	2	0.0029	0.00010
Pelecypoda (unid. family)	1	0.0318	1	0.0015	0.00005
Nuculidae	2	0.0636	1	0.0015	0.00005
Nuculanidae	2	0.0636	2	0.0029	0.00010
Pectinidae	11	0.3497	44	0.0641	0.00216
Cardiidae	1	0.0318	15	0.0219	0.00074
Trochidae	8	0.2543	4	0.0058	0.00020
Buccinidae	1	0.0318	30	0.0437	0.00147
Neptuneidae	6	0.1907	935	1.3631	0.04588
Turridae	4	0.1271	3	0.0044	0.00015
Dorididae	1	0.0318	1	0.0015	0.00005
Dendronotidae	23	0.7311	13	0.0190	0.00064
Pycnogonida (unid. Family)	8	0.2543	3	0.0044	0.00015
Balanidae	3	0.0954	21	0.0306	0.00103
Mysidacea (unid Family)	3	0.0954	1	0.0015	0.00005
Mysidae	1	0.0318	1	0.0015	0.00005
Diastylidae	1	0.0318	1	0.0015	0.00005
Aegidae	1	0.0318	1	0.0015	0.00005
Amphipoda (unid. Family)	10	0.3179	1	0.0015	0.00005
Ampeliscidae	6	0.1907	1	0.0015	0.00005
Corophiidae	5	0.1589	3	0.0044	0.00015
Lysianassidae	22	0.6993	18	0.0262	0.00088
Oedicerotidae	2	0.0636	1	0.0015	0.00005
Caprellidae	1	0.0318	1	0.0015	0.00005
Pandalidae	1588	50.4769	3257	4.7484	0.15981
Hippolytidae	33	1.0490	29	0.0423	0.00142
Crangonidae	1221	38.8112	1027	1.4973	0.05039
Paguridae	23	0.7311	239	0.3484	0.01173
Lithodidae	16	0.5086	51070	74.4547	2.50589
Majidae	45	1.4304	11682	17.0311	0.57321
Goniasteridae	1	0.0318	50	0.0729	0.00245
Porcellanasteridae	35	1.1125	61	0.0889	0.00299
Echinasteridae	1	0.0318	3	0.0044	0.00015
Strongylocentrotidae	1	0.0318	1	0.0015	0.00005
Amphiuridae	1	0.0318	1	0.0015	0.00005
Ophiuridae	17	0.5404	28	0.4080	0.00137
Synaptidae	1	0.0318	4	0.0058	0.00020
Cucumariidae	21	0.6675	18	0.0262	0.00088
Styelidae	1	0.0318	1	0.0015	0.00005
TOTAL	3146		68592		3.3656

APPENDIX I - TABLE XXXI

PERCENTAGE COMPOSITION OF ALL PHYLA BY SPECIES FROM LOWER COOK INLET AS OBTAINED BY AGASSIZ TRAWL, APRIL 1976

Taxonomic Name	Number of Organisms (count)	% Total Count	Weight (g)	% Total Weight	g/m^2 Occurrence Stations	g/m^2 All Stations	% of Phylum (count)	% of Phylum (weight)
Porifera (unid. species)	2	0.0	107	0.09	0.0072	0.00304	100.00	100.00
Hydrozoa (unid. species)	1	0.0	52	0.05	0.0070	0.00148	0.00	8.40
Eunephthya rubiformis	1	0.0	5	0.00	0.0014	0.00014	0.00	0.81
Stylatula gracile	2	0.0	115	0.10	0.0311	0.00327	9.52	18.58
Ptilosarcus gurneyi	1	0.0	60	0.05	0.0162	0.00171	4.76	9.69
Actiniidae (unid. species)	17	0.3	355	0.31	0.0240	0.01010	80.95	57.35
Tealia crassicornis	1	0.0	32	0.03	0.0086	0.00091	4.76	5.17
Polychaeta (unid. species)	11	0.2	8	0.01	0.0007	0.00023	44.00	25.81
Polynoidae (unid. species)	13	0.3	21	0.02	0.0014	0.00060	52.00	67.74
Notostomobdella sp.	1	0.0	2	0.00	0.0005	0.00006	4.00	6.45
Modiolus modiolus	2	0.0	40	0.04	0.0054	0.00114	0.29	0.22
Chlamys rubida	62	1.2	857	0.75	0.0579	0.02439	8.86	4.81
Astarte alaskensis	4	0.1	30	0.03	0.0041	0.00085	0.57	0.17
Astarte rollandi	1	0.0	1	0.00	0.0003	0.00003	0.14	0.01
Cyclocardia ventricosa	11	0.2	80	0.07	0.0216	0.00228	1.57	0.45
Cyclocardia crassidens	1	0.0	1	0.00	0.0003	0.00003	0.14	0.01
Clinocardium ciliatum	14	0.3	88	0.08	0.0119	0.00250	2.00	0.49
Clinocardium nuttallii	1	0.0	10	0.01	0.0027	0.00028	0.14	0.06
Clinocardium fucanum	26	0.5	55	0.05	0.0149	0.00157	3.71	0.31
Serripes groenlandicus	8	0.2	620	0.54	0.0559	0.01764	1.14	3.48
Spisula polynyma	3	0.1	239	0.21	0.0431	0.00680	0.43	1.34
Macoma calcarea	1	0.0	1	0.00	0.0003	0.00003	0.14	0.01
Hiatella arctica	1	0.0	1	0.00	0.0003	0.00003	0.14	0.01
Bathybembix sp.	2	0.0	10	0.01	0.0027	0.00028	0.29	0.06
Epitonium groenlandicum	1	0.0	1	0.00	0.0003	0.00003	0.14	0.01
Balcis sp.	6	0.1	1	0.00	0.0003	0.00003	0.86	0.01
Crepidula nummaria	2	0.0	1	0.00	0.0003	0.00003	0.29	0.01
Natica clausa	22	0.4	246	0.22	0.0222	0.00700	3.14	1.38
Polinices pallida	18	0.4	448	0.39	0.0404	0.01275	2.57	2.52
Fusitriton oregonensis	197	3.8	4602	4.03	0.1382	0.13096	28.14	25.84

APPENDIX I - TABLE XXXI

CONTINUED

Taxonomic Name	Number of Organisms (count)	% Total Count	Weight (g)	% Total Weight	g/m^2 Occurrence Stations	g/m^2 All Stations	% of Phylum (count)	% of Phylum (weight)
Boreotrophon clathratus	1	0.0	10	0.01	0.0027	0.00028	0.14	0.06
Boreotrophon stuarti	1	0.0	5	0.00	0.0014	0.00014	0.14	0.03
Boreotrophon pacificus	1	0.0	2	0.00	0.0005	0.00006	0.14	0.01
Boreotrophon lasius	1	0.0	10	0.01	0.0027	0.00028	0.14	0.06
Boreotrophon multicostalis	1	0.0	2	0.00	0.0005	0.00006	0.14	0.01
Nucella lamellosa	2	0.0	20	0.02	0.0054	0.00057	0.29	0.11
Buccinum glaciale	1	0.0	20	0.02	0.0054	0.00057	0.14	0.11
Buccinum plectrum	23	0.4	237	0.21	0.0160	0.00674	3.29	1.33
Beringius kennicotti	1	0.0	140	0.12	0.0378	0.00398	0.14	0.79
Colus herendeenii	2	0.0	25	0.02	0.0068	0.00071	0.29	0.14
Colus halli	1	0.0	25	0.02	0.0068	0.00071	0.14	0.14
Neptunea lyrata	270	5.3	9474	8.29	0.2696	0.26961	38.47	53.19
Plicifusus kroyeri	2	0.0	30	0.03	0.0041	0.00085	0.29	0.17
Pyrulofusus harpa	1	0.0	50	0.04	0.0135	0.00142	0.14	0.28
Volutopsius middendorffi	1	0.0	1	0.00	0.0003	0.00003	0.14	0.01
Volutomitra alaskana	1	0.0	50	0.04	0.0135	0.00142	0.14	0.28
Admete couthouyi	3	0.1	9	0.01	0.0012	0.00026	0.43	0.05
Tritonia exsulans	4	0.1	370	0.32	0.1000	0.01053	0.57	2.08
Balanus sp.	9	0.2	15	0.01	0.0041	0.00043	0.22	0.02
Balanus evermani	5	0.1	5	0.00	0.0014	0.00014	0.12	0.01
Balanus hesperius	1	0.0	1	0.00	0.0003	0.00003	0.02	0.00
Balanus hoekianus	1	0.0	15	0.01	0.0041	0.00043	0.02	0.02
Amphipoda (unid. species)	4	0.1	3	0.00	0.0004	0.00009	0.10	0.00
Ampelisca macrocephala	1	0.0	1	0.00	0.0003	0.00003	0.02	0.00
Ampeliscida birulai	2	0.0	1	0.00	0.0003	0.00003	0.05	0.00
Byblis gaimandi	1	0.0	1	0.00	0.0003	0.00003	0.02	0.00
Ericthonius sp.	1	0.0	1	0.00	0.0003	0.00003	0.02	0.00
Heterophoxus sculatus	1	0.0	1	0.00	0.0003	0.00003	0.02	0.00
Caprellidae (unid. species)	1	0.0	1	0.00	0.0003	0.00003	0.02	0.00
Pandalus borealis	241	4.7	1660	1.45	0.2243	0.04724	5.93	2.02
Pandalus goniurus	467	9.1	4780	4.18	0.2584	0.13603	11.50	5.81

APPENDIX I - TABLE XXXI

CONTINUED

Taxonomic Name	Number of Organisms (count)	% Total Count	Weight (g)	% Total Weight	g/m^2 Occurrence Stations	g/m^2 All Stations	% of Phylum (count)	% of Phylum (weight)
Pandalus hypsinotus	12	0.2	106	0.09	0.0143	0.00302	0.30	0.13
Pandalopsis dispar	1	0.0	15	0.01	0.0041	0.00043	0.02	0.02
Spirontocaris lamellicornis	4	0.1	40	0.04	0.0108	0.00114	0.10	0.05
Lebbeus groenlandica	3	0.1	10	0.01	0.0014	0.00028	0.07	0.01
Eualus sp.	1	0.0	2	0.00	0.0005	0.00006	0.02	0.00
Eualus townsendi	6	0.1	37	0.03	0.0050	0.00105	0.15	0.04
Crangon sp.	2	0.0	14	0.01	0.0076	0.00040	0.05	0.02
Crangon dalli	180	3.5	4026	3.52	0.1146	0.11457	4.43	4.89
Crangon communis	5	0.1	40	0.04	0.0108	0.00114	0.12	0.05
Argis dentata	27	0.5	193	0.17	0.0261	0.00549	0.66	0.23
Argis crassa	2	0.0	18	0.02	0.0024	0.00051	0.05	0.02
Pagurus sp.	3	0.1	58	0.05	0.0157	0.00165	0.07	0.07
Pagurus ochotensis	65	1.3	748	0.65	0.0505	0.02129	1.60	0.91
Pagurus aleuticus	59	1.1	420	0.37	0.0378	0.01195	1.45	0.51
Pagurus capillatus	77	1.5	1760	1.54	0.1189	0.05009	1.90	2.14
Pagurus kennerlyi	9	0.2	45	0.04	0.0061	0.00128	0.22	0.05
Pagurus beringanus	1	0.0	1	0.00	0.0003	0.00003	0.02	0.00
Pagurus confragosus	14	0.3	1431	1.25	0.1934	0.04072	0.34	1.74
Pagurus trigonocheirus	1	0.0	1	0.00	0.0003	0.00003	0.02	0.00
Elassochirus tenuimanus	34	0.7	540	0.47	0.0405	0.01281	0.84	0.55
Elassochirus gilli	1	0.0	12	0.01	0.0032	0.00034	0.02	0.01
Labidochirus splendescens	47	0.9	165	0.14	0.0149	0.00470	1.16	0.20
Paralithodes camtschatica	10	0.2	30071	26.32	3.2544	0.85575	0.25	36.53
Rhinolithodes wosnessenskii	1	0.0	67	0.06	0.0181	0.00191	0.02	0.08
Oregonia gracilis	64	1.2	1385	1.21	0.0468	0.03941	1.58	1.68
Hyas lyratus	40	0.8	4905	4.29	0.2209	0.13958	0.98	5.96
Chionoecetes bairdi	2653	51.7	29765	26.05	0.9467	0.84704	65.33	36.16
Cancer magister	1	0.0	40	0.04	0.0217	0.00114	0.02	0.05
Cancer oregonensis	1	0.0	10	0.01	0.0027	0.00028	0.02	0.01
Pinnixa occidentalis	2	0.0	4	0.00	0.0011	0.00011	0.05	0.00
Ectoprocta (unid. species)	2	0.0	152	0.13	0.0103	0.00433	66.67	80.85

APPENDIX I - TABLE XXXI

CONTINUED

Taxonomic Name	Number of Organisms (count)	% Total Count	Weight (g)	% Total Weight	g/m^2 Occurrence Stations	g/m^2 All Stations	% of Phylum (count)	% of Phylum (weight)
Membranipora sp.	1	0.0	1	0.00	0.0003	0.00003	33.33	0.53
Heteropora sp.	1	0.0	25	0.02	0.0034	0.00071	0.00	13.30
Flustrella sp.	1	0.0	10	0.01	0.0027	0.00028	0.0	5.32
Laqueus californianus	14	0.3	90	0.08	0.0122	0.00256	70.00	66.67
Terebratalia transversa	6	0.1	45	0.04	0.0061	0.00128	30.00	33.33
Ceramaster patagonicus	1	0.0	70	0.06	0.0189	0.00199	0.34	0.55
Ctenodiscus crispatus	83	1.6	121	0.11	0.0109	0.00344	28.62	0.95
Henricia sp.	5	0.1	165	0.14	0.0223	0.00470	1.72	1.30
Pteraster tesselatus	4	0.1	540	0.47	0.1459	0.01537	1.38	4.25
Crossaster borealis	1	0.0	220	0.19	0.0595	0.00626	0.34	1.73
Crossaster papposus	6	0.1	200	0.18	0.0270	0.00569	2.07	1.57
Solaster dawsoni	1	0.0	220	0.19	0.0595	0.00626	0.34	1.73
Evasterias troschelii	1	0.0	15	0.01	0.0041	0.00043	0.34	0.12
Leptasterias sp.	6	0.1	35	0.03	0.0047	0.00100	2.07	0.28
Leptasterias polaris	31	0.6	3018	2.64	0.2039	0.08589	10.69	23.73
Lethasterias nanimensis	1	0.0	555	0.49	0.1500	0.01579	0.34	4.36
Echinarachnius parma	92	1.8	4080	3.57	1.1027	0.11611	31.72	32.08
Strongylocentrotus droebachiensis	34	0.7	1998	1.75	0.0900	0.05686	11.72	15.71
Gorgonocephalus caryi	2	0.0	128	0.11	0.0173	0.00364	0.69	1.01
Ophiopholis aculeata	7	0.1	2	0.00	0.0003	0.00006	2.41	0.02
Ophiura sarsi	3	0.1	7	0.01	0.0009	0.00020	1.03	0.06
Cucumaria sp.	12	0.2	1344	1.18	0.1816	0.03825	4.14	10.57
Urochordata (unid. species)	5	0.1	245	0.21	0.0221	0.00697	100.00	100.00
TOTAL	5131		114269			3.24931		

APPENDIX I - TABLE XXXII

PERCENTAGE COMPOSITION OF ALL PHYLA BY SPECIES FROM LOWER COOK INLET AS OBTAINED BY AGASSIZ TRAWL, OCTOBER 1976

Taxonomic Name	Number of Organisms (count)	% Total Count	Weight (g)	% Total Weight	g/m^2 Occurrence Stations	g/m^2 All Stations	% of Phylum (count)	% of Phylum (weight)
Actiniidae (unid. species)	1	0.0	2	0.00	0.0005	0.00010	100.00	100.00
Polychaeta (unid. species)	2	0.1	2	0.00	0.0004	0.00010	11.76	11.76
Polynoidae (unid. species)	12	0.4	7	0.01	0.0009	0.00034	70.59	41.18
Nereis sp.	1	0.0	5	0.01	0.0014	0.00025	5.88	29.41
Aphrodita japonica	1	0.0	1	0.00	0.0003	0.00005	5.88	5.88
Notostomobdella sp.	1	0.0	2	0.00	0.0005	0.00010	5.88	11.76
Pelecypoda (unid. species)	1	0.0	1	0.00	0.0003	0.00005	1.67	0.10
Nucula tenuis	2	0.1	1	0.00	0.0005	0.00005	3.33	0.10
Nuculana fossa	1	0.0	1	0.00	0.0005	0.00005	1.67	0.10
Yoldia thraciaeformis	1	0.0	1	0.00	0.0005	0.00005	1.67	0.10
Chlamys rubida	2	0.1	40	0.06	0.0108	0.00196	3.33	3.81
Propeamussium davidsoni	9	0.3	4	0.01	0.0011	0.00020	15.00	0.38
Serripes groenlandicus	1	0.0	15	0.02	0.0041	0.00074	1.67	1.43
Margarites costalis	1	0.0	1	0.00	0.0003	0.00005	1.67	0.10
Solariella varicosa	6	0.2	2	0.00	0.0003	0.00010	10.00	0.19
Lischkeia cidaris	1	0.0	1	0.00	0.0003	0.00005	1.67	0.10
Buccinum cnismatum	1	0.0	30	0.04	0.0081	0.00147	1.67	2.36
Colus sp.	1	0.0	1	0.00	0.0003	0.00005	1.67	0.10
Neptunea lyrata	5	0.2	934	1.36	0.1262	0.04583	8.33	89.04
Suavodrillia kennicottii	1	0.0	1	0.00	0.0003	0.00005	1.67	0.10
Oenopota decussata	1	0.0	1	0.00	0.0003	0.00005	1.67	0.10
Propebela sp.	2	0.1	1	0.00	0.0003	0.00005	3.33	0.10
Dorididae (unid. species)	1	0.0	1	0.00	0.0005	0.00005	1.67	0.10
Dendronotidae (unid. species)	23	0.7	13	0.02	0.0012	0.00064	38.33	1.24
Pycnogonida (unid. species)	8	0.3	3	0.00	0.0003	0.00015	100.00	100.00
Balanus sp.	2	0.1	11	0.02	0.0020	0.00054	0.07	0.02
Balanus hesperius	1	0.0	10	0.01	0.0027	0.00049	0.03	0.01
Mysidacea (unid. species)	3	0.1	1	0.00	0.0005	0.00005	0.10	0.00
Acanthomysis dybowskii	1	0.0	1	0.00	0.0003	0.00005	0.03	0.00
Diastylis bidentata	1	0.0	1	0.00	0.0003	0.00005	0.03	0.00
Rocinela augustata	1	0.0	1	0.00	0.0003	0.00005	0.03	0.00

APPENDIX TABLE I - TABLE XXXII

CONTINUED

Taxonomic Name	Number of Organisms (count)	% Total Count	Weight (g)	% Total Weight	g/m^2 Occurrence Stations	g/m^2 All Stations	% of Phylum (count)	% of Phylum (weight)
Amphipoda (unid. species)	10	0.3	1	0.00	0.0005	0.00005	0.34	0.00
Ampeliscida birulae	6	0.2	1	0.00	0.0003	0.00005	0.20	0.00
Erichthonius folli	5	0.2	3	0.00	0.0003	0.00015	0.17	0.00
Anonyx sp.	10	0.3	11	0.02	0.0015	0.00054	0.34	0.02
Anonyx nugax	10	0.3	6	0.01	0.0008	0.00029	0.34	0.01
Lepidepecreum comatum	2	0.1	1	0.00	0.0003	0.00005	0.07	0.00
Monoculodes zernovi	2	0.1	1	0.00	0.0003	0.00005	0.07	0.00
Caprellidae (unid. species)	1	0.0	1	0.00	0.0005	0.00005	0.03	0.00
Pandalus borealis	1277	40.6	2610	3.81	0.1761	0.12807	42.84	3.88
Pandalus goniurus	296	9.4	582	0.85	0.0629	0.02856	9.93	0.86
Pandalus hypsinotus	11	0.3	15	0.02	0.0041	0.00074	0.37	0.02
Pandalopsis dispar	4	0.1	50	0.07	0.0054	0.00245	0.13	0.07
Spirontocaris lamellicornis	6	0.2	10	0.01	0.0054	0.00049	0.20	0.01
Euaulus suckleyi	27	0.9	19	0.03	0.0034	0.00093	0.91	0.08
Crangon dalli	367	11.7	636	0.93	0.0491	0.03121	12.31	0.94
Crangon communis	803	25.5	317	0.46	0.0245	0.01555	26.94	0.42
Crangon resina	20	0.6	24	0.04	0.0026	0.00118	0.67	0.04
Argis dentata	31	1.0	50	0.07	0.0045	0.00245	1.04	0.07
Pagurus ochotensis	1	0.0	35	0.05	0.0188	0.00172	0.03	0.05
Pagurus aleuticus	19	0.6	184	0.27	0.0165	0.00903	0.64	0.27
Pagurus capillatus	1	0.0	5	0.01	0.0014	0.00025	0.03	0.01
Pagurus kennerlyi	1	0.0	10	0.01	0.0054	0.00049	0.03	0.01
Elassochirus tenuimanus	1	0.0	5	0.01	0.0027	0.00025	0.03	0.01
Paralithodes camtschatica	16	0.5	51070	74.48	9.1853	2.50589	0.54	76.82
Oregonia gracilis	1	0.0	1	0.00	0.0005	0.00005	0.03	0.00
Hyas lyratus	2	0.1	5	0.01	0.0014	0.00025	0.07	0.01
Chionoecetes bairdi	42	1.3	11676	17.03	0.6305	0.57291	1.41	17.34
Ceramaster stellatus	1	0.0	50	0.07	0.0135	0.00245	1.28	30.1
Ctenodiscus crispatus	35	1.1	61	0.09	0.0082	0.00299	44.87	36.75
Henricia sp.	1	0.0	3	0.00	0.0008	0.00015	1.28	1.81

APPENDIX I - TABLE XXII

CONTINUED

Taxonomic Name	Number of Organisms (count)	% Total Count	Weight (g)	% Total Weight	g/m^2 Occurrence Stations	g/m^2 All Stations	% of Phylum (count)	% of Phylum (weight)
Strongylocentrotus droebachiensis	1	0.0	1	0.00	0.0003	0.00005	1.28	0.60
Amphipholis pugetana	1	0.0	1	0.00	0.0003	0.00005	1.28	0.60
Ophiopenia disacantha	9	0.3	2	0.00	0.0003	0.00010	11.54	1.20
Ophiopenia tetracantha	3	0.1	1	0.00	0.0003	0.00005	3.85	0.60
Ophiura sarsi	5	0.2	25	0.04	0.0068	0.00123	6.41	15.00
Synaptidae	1	0.0	4	0.01	0.0011	0.00020	1.28	2.41
Cucumaria sp.	21	0.7	18	0.03	0.0049	0.00088	26.92	10.84
Styelidae (unid. species)	1	0.0	1	0.00	0.0003	0.00005	100.00	100.00
TOTAL	3146		68592			3.3656		

APPENDIX I - TABLE XXXIII

OCCURRENCE OF TAXA IN SIX LOWER COOK INLET STATIONS
AS OBTAINED BY TRY-NET, APRIL 1976

Taxonomic Names Represent Lowest Level of Identification

Taxonomic Name	Cumulative Stations Occurrence	% of all[1] Cumulative Stations Occurrence	% of all[2] Stations
Porifera (unid. species)	1	1.190	16.667
Hydrozoa (unid. species)	1	1.190	16.667
Polynoidae (unid. species)	2	2.381	33.333
Nuculana fossa	1	1.190	16.667
Glycymeris subobsoleta	1	1.190	16.667
Modiolus modiolus	1	1.190	16.667
Pecten caurinus	1	1.190	16.667
Cyclocardia sp.	1	1.190	16.667
Clinocardium sp.	1	1.190	16.667
Serripes groenlandicus	2	2.381	33.333
Macoma sp.	1	1.190	16.667
Macoma calcarea	1	1.190	16.667
Tellina nuculoides	1	1.190	16.667
Polinices pallida	1	1.190	16.667
Fusitriton oregonensis	5	5.952	83.333
Nucella lamellosa	1	1.190	16.667
Buccinum plectrum	1	1.190	16.667
Neptunea lyrata	3	3.571	50.000
Balanus rostratus	1	1.190	16.667
Pandalus sp.	1	1.190	16.667
Pandalus borealis	1	1.190	16.667
Pandalus goniurus	5	5.952	83.333
Pandalus hypsinotus	3	3.571	50.000
Lebbeus groenlandica	1	1.190	16.667
Eualus townsendi	1	1.190	16.667
Crangon dalli	6	7.143	100.000
Crangon communis	1	1.190	16.667
Sclerocrangon boreas	2	2.381	33.333
Argis dentata	4	4.762	66.667
Argis crassa	1	1.190	16.667
Pagurus ochotensis	4	4.762	66.667
Pagurus aleuticus	1	1.190	16.667
Pagurus capillatus	4	4.762	66.667
Pagurus kennerlyi	1	1.190	16.667
Elassochirus tenuimanus	3	3.571	50.000
Labidochirus splendescens	1	1.190	16.667
Paralithodes camtschatica	1	1.190	16.667
Oregonia gracilis	2	2.381	33.333
Hyas lyratus	2	2.381	33.333
Chionoecetes bairdi	6	7.143	100.000
Chorilia longipes	1	1.190	16.667
Cancer oregonensis	1	1.190	16.667

APPENDIX I - TABLE XXXIII

CONTINUED

Taxonomic Name	Cumulative Stations Occurrence	% of all[1] Cumulative Stations Occurrence	% of all[2] Stations
Ectoprocta (unid. species)	2	2.381	33.333
Henricia sp.	1	1.190	16.667
Urochordata (unid. species)	1	1.190	16.667
TOTAL	84		

[1] $\frac{\text{Cumulative station occurrence}}{\text{Total cumulative station occurrence}}$

[2] $\frac{\text{Cumulative station occurrence}}{\text{Total number of stations occupied}}$

APPENDIX I - TABLE XXXIV

OCCURRENCE OF TAXA IN 16 LOWER COOK INLET STATIONS AS OBTAINED BY EASTERN OTTER TRAWL, OCTOBER 1976

Taxonomic Names Represent Lowest Level of Identification

Taxonomic Name	Cumulative Stations Occurrence	% of all[1] Cumulative Stations Occurrence	% of all[2] Stations
Porifera (unid. species)	8	3.960	50.000
Hydrozoa (unid. species)	1	0.495	6.250
Ptilosarcus gurneyi	1	0.495	6.250
Actiniidae (unid. species)	7	3.465	43.750
Tealia crassicornis	1	0.495	6.250
Polychaeta (unid. species)	1	0.495	6.250
Polynoidae (unid. species)	7	3.465	43.750
Nereis sp.	2	0.990	12.500
Chlamys rubida	2	0.990	12.500
Serripes groenlandicus	3	1.485	18.750
Hiatella arctica	1	0.495	6.250
Fusitriton oregonensis	6	2.970	37.750
Nucella lamellosa	2	0.990	12.500
Beringius kennicotti	1	0.495	6.250
Neptunea lyrata	15	7.426	43.750
Dorididae (unid. species)	1	0.495	6.250
Balanus sp.	7	3.465	43.750
Balanus balanus	2	0.990	12.500
Balanus hesperius	5	2.475	31.250
Balanus rostratus	3	1.485	18.750
Pandalus borealis	5	2.475	31.250
Pandalus goniurus	1	0.495	6.250
Pandalus hypsinotus	1	0.495	6.250
Lebbeus groenlandica	4	1.980	25.000
Crangon dalli	11	5.446	68.750
Argis dentata	4	1.980	25.000
Argis crassa	1	0.495	6.250
Pagurus ochotensis	11	5.446	68.750
Pagurus aleuticus	3	1.485	18.750
Pagurus capillatus	9	4.455	56.250
Pagurus kennerlyi	1	0.495	6.250
Pagurus beringanus	1	0.495	6.250
Elassochirus tenuimanus	2	0.990	12.500
Elassochirus cavimanus	1	0.495	6.250
Paralithodes camtschatica	8	3.960	50.000
Oregonia gracilis	2	0.990	12.500
Hyas lyratus	4	1.980	25.000
Chionoecetes bairdi	16	8.416	100.000
Cancer magister	3	1.485	18.750
Cancer oregonensis	1	0.495	6.250
Ectoprocta (unid. species)	2	0.990	12.500
Alcyonidium sp.	3	1.485	18.750
Flustrella sp.	3	1.485	18.750

APPENDIX I - TABLE XXXIV

CONTINUED

Taxonomic Name	Cumulative Stations Occurrence	% of all[1] Cumulative Stations Occurrence	% of all[2] Stations
Terebratalia transversa	1	0.495	6.250
Ceramaster patagonicus	1	0.495	6.250
Pteraster tesselatus	1	0.495	6.250
Crossaster papposus	1	0.495	6.250
Evasterias troschelii	5	2.475	31.250
Leptasterias polaris	6	2.970	37.500
Lethasterias sp.	1	0.495	6.250
Lethasterias nanimensis	4	1.980	25.000
Strongylocentrotus droebachiensis	3	1.485	18.750
Strongylocentrotus franciscanus	1	0.495	6.250
Cucumaria sp.	4	1.980	25.000
TOTAL	202	100	

1 $\frac{\text{Cumulative station occurrence}}{\text{Total cumulative station occurrence}}$

2 $\frac{\text{Cumulative station occurrence}}{\text{Total number of stations occupied}}$

APPENDIX I - TABLE XXXV

PERCENTAGE COMPOSITION OF ALL PHYLA BY FAMILY FROM LOWER COOK INLET AS OBTAINED BY EASTERN OTTER TRAWL, OCTOBER 1976

Taxonomic Name	Number of Organisms (count)	% Total Count	Weight (g)	% Total Weight	g/m^2 All Stations
Porifera (unid. family)	245	3.3793	20046	2.2230	0.06795
Hydrozoa (unid. family)	1	0.0138	200	0.0222	0.00068
Pennatulacea (Pennatulidae)	8	0.1103	2270	0.2517	0.00770
Actiniidae	39	0.5379	11819	1.3107	0.04006
Polychaeta (unid. family)	12	0.1655	20	0.0022	0.00007
Polynoidae	40	0.5517	96	0.0106	0.00033
Nereidae	3	0.0414	12	0.0013	0.00004
Pectinidae	38	0.5241	15431	1.7112	0.05231
Cardiidae	25	0.3448	2418	0.2683	0.00820
Hiatellidae	1	0.0138	1	0.0001	0.00000
Cymatiidae	20	0.2759	964	0.1069	0.00327
Thaididae	818	11.2828	4136	0.4587	0.01402
Neptuneidae	720	9.9310	128580	14.2588	0.43587
Dorididae	1	0.0138	40	0.0044	0.00014
Balanidae	314	4.3310	7418	0.8226	0.02515
Pandalidae	477	6.5793	1984	0.2200	0.00673
Hippolytidae	6	0.0828	53	0.0059	0.00018
Crangonidae	709	9.7793	2853	0.3165	0.00967
Paguridae	304	4.1931	6658	0.7383	0.02257
Lithodidae	67	0.9241	33497	3.7146	0.11355
Majidae	3010	41.5172	512918	56.8797	1.73873
Cancridae	15	0.2069	5770	0.6399	0.01956
Ectoprocta (unid. Family)	2	0.0276	2	0.0002	0.00001
Alcyonidiidae	9	0.1241	865	0.0959	0.00293
Flustrellidae	3	0.0414	325	0.0360	0.00110
Dallinidae	1	0.0138	1	0.0001	0.00000
Goniasteridae	1	0.0138	70	0.0078	0.00024
Pterasteridae	1	0.0138	40	0.0044	0.00014
Solasteridae	1	0.0138	30	0.0033	0.00010
Asteridae	93	1.2828	40438	4.4843	0.13708
Strongylocentrotidae	31	0.4276	3473	0.3851	0.01177
Cucumariidae	235	3.2414	99332	11.0153	0.33672
TOTAL	7250		901760		3.0569

APPENDIX I - TABLE XXXVI

PERCENTAGE COMPOSITION OF ALL PHYLA BY SPECIES FROM LOWER COOK INLET AS OBTAINED BY EASTERN OTTER TRAWL, OCTOBER 1976

Taxonomic Name	Number of Organisms (count)	% Total Count	Weight (g)	% Total Weight	g/m^2 Occurrence Stations	g/m^2 All Stations	% of Phylum (count)	% of Phylum (weight)
Porifera (unid. species)	245	3.4	20046	2.22	0.1730	0.06795	100.00	100.00
Hydrozoa (unid. species)	1	0.0	200	0.02	0.0089	0.00068	2.08	1.40
Ptilosarcus gurneyi	8	0.1	2270	0.25	0.1257	0.00770	16.67	15.89
Actiniidae (unid. species)	38	0.5	10669	1.18	0.1020	0.03617	79.17	74.67
Tealia crassicornis	1	0.0	1150	0.13	0.0524	0.00390	2.08	8.05
Polychaeta (unid. species)	12	0.2	20	0.00	0.0009	0.00007	21.82	15.63
Polynoidae (unid. species)	40	0.6	96	0.01	0.0008	0.00033	72.73	75.00
Nereis sp.	3	0.0	12	0.00	0.0004	0.00004	5.45	9.38
Chlamys rubida	38	0.5	15431	1.71	0.5248	0.05231	2.34	10.18
Serripes groenlandicus	25	0.3	2418	0.27	0.0428	0.00820	1.54	1.60
Hiatella arctica	1	0.0	1	0.00	0.0001	0.00000	0.06	0.00
Fusitriton oregonensis	20	0.3	964	0.11	0.0118	0.00327	1.23	0.64
Nucella lamellosa	818	11.3	4136	0.46	0.0916	0.01402	50.40	2.73
Beringius kennicotti	2	0.0	300	0.03	0.0166	0.00102	0.12	0.20
Neptunea lyrata	718	9.9	128280	14.23	0.4981	0.43485	44.24	84.63
Dorididae (unid. species)	1	0.0	40	0.00	0.0035	0.00014	0.06	0.03
Balanus sp.	16	0.2	500	0.06	0.0039	0.00169	0.33	0.09
Balanus balanus	255	3.5	5190	0.58	0.1150	0.01759	5.20	0.91
Balanus hesperius	14	0.2	78	0.01	0.0010	0.00026	0.29	0.01
Balanus rostratus	29	0.4	1650	0.18	0.0400	0.00559	0.59	0.29
Pandalus borealis	47	0.6	1125	0.12	0.0121	0.00381	0.96	0.20
Pandalus goniurus	172	2.4	343	0.04	0.0190	0.00116	3.51	0.06
Pandalus hypsinotus	258	3.6	516	0.06	0.00229	0.00175	5.26	0.09
Lebbeus groenlandica	6	0.1	53	0.01	0.0007	0.00018	0.10	0.01
Crangon dalli	701	9.7	2812	0.31	0.0143	0.00953	14.30	0.49
Argis dentata	5	0.1	21	0.00	0.0003	0.00007	0.10	0.00
Argis crassa	3	0.0	20	0.00	0.0011	0.00007	0.06	0.00
Pagurus ochotensis	197	2.7	5273	0.58	0.0239	0.01787	4.02	0.92
Pagurus aleuticus	18	0.2	490	0.05	0.0163	0.00166	0.37	0.09
Pagurus capillatus	60	0.8	470	0.05	0.0028	0.00159	1.22	0.08

APPENDIX I - TABLE XXXVI

CONTINUED

Taxonomic Name	Number of Organisms (count)	% Total Count	Weight (g)	% Total Weight	g/m^2 Occurrence Stations	g/m^2 All Stations	% of Phylum (count)	% of Phylum (weight)
Pagurus kennerlyi	16	0.2	220	0.02	0.0097	0.00075	0.33	0.04
Pagurus beringanus	3	0.0	20	0.00	0.0009	0.00007	0.06	0.00
Elassochirus tenuimanus	9	0.1	155	0.02	0.0038	0.00053	0.18	0.03
Elassochirus cavimanus	1	0.0	30	0.00	0.0026	0.00010	0.02	0.01
Paralithodes camtschatica	67	0.9	33497	3.71	0.2091	0.11355	1.37	5.96
Oregonia gracilis	2	0.0	45	0.00	0.0024	0.00015	0.04	0.01
Hyas lyratus	1043	14.4	43867	4.86	0.6561	0.14870	21.28	7.68
Chionoecetes bairdi	1965	27.1	469006	52.01	1.5899	1.58987	40.09	82.12
Cancer magister	14	0.2	5725	0.63	0.0954	0.01941	0.29	1.00
Cancer oregonensis	1	0.0	45	0.00	0.0020	0.00015	0.02	0.01
Ectoprocta (unid. species)	2	0.0	2	0.00	0.0000	0.00001	14.29	0.17
Alyconidium sp.	9	0.1	865	0.10	0.0156	0.00293	64.29	72.57
Flustrella sp.	3	0.0	325	0.04	0.0051	0.00110	21.43	27.27
Terebratalia transversa	1	0.0	1	0.00	0.0001	0.00000	100.00	100.00
Ceramaster patagonicus	1	0.0	70	0.01	0.0096	0.00024	0.28	0.05
Pteraster tesselatus	1	0.0	40	0.00	0.0035	0.00014	0.28	0.03
Crossaster papposus	1	0.0	30	0.00	0.0013	0.00010	0.28	0.02
Evasterias troschelii	42	0.6	34949	3.88	0.3472	0.11847	11.60	24.37
Leptasterias polaris	32	0.4	2788	0.31	0.0214	0.00945	8.84	1.94
Lethasterias sp.	3	0.0	315	0.03	0.0143	0.00107	0.83	0.22
Lethasterias nanimensis	16	0.2	2386	0.26	0.0266	0.00809	4.42	1.66
Strongylocentrotus droebachiensis	30	0.4	3019	0.33	0.0667	0.01023	8.29	2.11
Strongylocentrotus franciscanus	1	0.0	454	0.05	0.0400	0.00154	0.28	0.32
Cucumaria sp.	235	3.2	99332	11.02	1.5568	0.33672	64.92	69.28
TOTAL	7250		901760					

APPENDIX II.

BIOLOGY OF SIX SELECTED SPECIES OF CLAMS (*NUCULA TENUIS, NUCULANA FOSSA, MACOMA CALCAREA, TELLINA NUCULOIDES, GLYCYMERIS SUBOBSOLETA, SPISULA POLYNYMA*) FROM LOWER COOK INLET

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INTRODUCTION

Bivalve molluscs are a widely distributed and important component of the lower Cook Inlet subtidal benthic system. Seventy-six species of bivalves were collected on the OCSEAP-sponsored cruises discussed in the body of this report, and both deposit-feeding and suspension-feeding species are represented in the collections. Each of the modes of feeding (i.e., deposit or suspension) used by bivalve molluscs is susceptible to contamination by oil fractions in polluted waters. Suspension feeders take up oil fractions from particulate material in the water column (i.e., contaminated small organisms, fecal pellets, general debris, sediment, and oil droplets). Deposit feeders are subject to contamination through the sediment-detrital materials that they process in the course of their feeding activities. Varying amounts of petroleum hydrocarbons will be accumulated in bivalve tissues in polluted waters, and the measurable quantities of hydrocarbons in these tissues should reflect the level of pollution in the water column and/or the sediment. Such tissue contamination is detectable by suitable analytical techniques (e.g. see Shaw, 1977). However, tissue contamination should also be detectable by a continuing field program designed to monitor clam condition (see Westley, 1961 for condition index measurement technique), and, in fact, a decrease in clam condition has been noted for the clam *Macoma balthica* maintained in oil-contaminated laboratory tanks at the Seward Marine Laboratory (A. J. Paul, personal communication). Furthermore, clams in Alaskan waters deposit annual rings of shell growth and many species can be readily aged and their growth histories determined by the measurements of these annual rings (Feder and Paul, 1974; Feder *et al.*, 1976; Paul and Feder, 1973; Nickerson, 1975). These growth history data can be used to detect abnormal growth resulting from environmental alteration. Assessment of the growth histories and examination of growth curves of six species of subtidal clams from lower Cook Inlet (*Nucula tenuis, Nuculana fossa, Macoma calcarea, Tellina nuculoides, Glycymeris subobsoleta, Spisula polynyma*) serve as bases for comprehending shell growth patterns in years free of major oil contamination. The distribution of these six species of clams is also shown in Figures included in this Appendix.

Bivalve molluscs represent a rather important food source for the snow crab (*Chionoecetes bairdi*), king crab (*Paralithodes camtschatica*), and some bottom fishes (rock sole; *Lepidopsetta bilineata*; flathead soles; *Hippoglossoides elassodon*; starry flounder; *Platichthys stellatus*). Oil contamination of clams could be reflected by a reduction in the number and/or loss of these important prey species. Furthermore, based on known trophic interactions in lower Cook Inlet (Feder, 1977), contamination of many trophic components, via clams, is probable once intensive oil production is initiated. Ingestion of oil-contaminated molluscs could ultimately result in a broad spectrum of biochemical and behavioral changes in predator species (see Malins, 1977 for a general discussion on the effect of oil on predators).

This Appendix is a compilation of distributional, age, growth, and mortality data from the six subtidal species of clams noted above, and serves as a data base for growth-mortality studies currently underway in lower Cook Inlet.

METHODS

The samples were collected in lower Cook Inlet in April and October 1976 mainly with a 0.1 m^2 van Veen grab, and pipe dredge (36 x 91 cm) on the R/V *Moana Wave* and NOAA Ship *Miller Freeman*. Occasionally, clams were obtained with a trawl or clam dredge. A try-net was used to collect empty shells of *Spisula polynyma*. Alaska Department of Fish and Game, Homer Office, supplied samples of fresh, frozen *S. polynyma* from four Cook Inlet (Kachemak Bay) stations sampled with an anchor dredge.[1] Grab and pipe dredge samples were washed on a 1 x 1 mm mesh screen, and bivalve species were separated from other benthic organisms. The screen retained all but recently settled clams.

Six relatively abundant species - *Nucula tenuis, Nuculana fossa, Glycymeris subobsoleta, Spisula polynyma, Macoma calcarea* and *Tellina nuculoides* - were selected for detailed study. Some of the clams collected could not be aged due to their damaged condition. Not all stations were used in the clam aging studies; however, all stations at

[1]See Alaska Department of Fish and Game, Homer, for station locations.

which a species was collected are included in the distribution maps. All clams used for aging were pooled, i.e. clams from all sampling gear and all collection dates. Aging was accomplished by the annular method (Weymouth, 1923) using a Nikon dissection microscope with a 2x lens. Annuli, a series of closely spaced concentric growth rings, are the result of slow growth at low winter temperatures (Paul and Feder, 1973). The term 0 age group refers to individuals of the settling year class that have undergone one growing season (5 to 6 months) before forming their first winter annulus. Thus, individuals referred to as 1 year of age are actually 17 or 18 months old, and have lived through two growing seasons. The 0 annulus was not measured, except on 0 age clams, because of abrasion of the umbo on most of the older shells. Two types of measurements were made on all clams: total shell length (in millimeters) of each specimen and length (in millimeters) at each annulus. Growth history tables were generated from the measurements of length at each annulus. The last annulus on all specimens in the collection was formed in the winter of 1975-1976, and length values for this annulus were assigned to the year 1976 in growth-history tables. Selected growth history tables for each clam species are included in this report.

Age-structure tables were generated; only stations with 10 or more specimens of a given species are included in individual station tables. In addition, tables are presented that include a summary of age-structure for each species from all stations where it was collected.

All data were processed by a Honeywell 66/40 computer. To test the accuracy of the annular method, a one-way analysis of variance (Snedecor, 1956) was applied to the data for each species. Mean shell length, range, standard deviation, and standard error of the mean (Hubbs and Hubbs, 1953) were plotted to show the relationship between shell length and age. The horizontal line in the latter plot is the mean, the vertical line is the range, the white box is the standard deviation, and the black box the standard error of the mean. The standard error of the mean and the standard deviation are not shown for age classes with a sample size of five or less.

RESULTS

Nucula tenuis

Two hundred and two *Nucula tenuis* were aged. The collection locations are listed in Table I and shown in Figure 1. The annual increase in shell length for each of the size classes was typically 0.6 to 1.0 mm. Growth rates were similar at all stations, and varied only slightly from year to year (Figs. 2-4). The calculated F ratio indicates that age classes, as defined by shell lengths, are statistically distinguishable (α=0.01; Table II). The integrity of the age classes is further illustrated in Figures 5 and 6 where it can be observed that none of the standard errors of the mean overlap (Hubbs and Hubbs, 1953). The majority of the 202 specimens examined were between 0 and 4 years of age. However, differential recruitment and mortality at the eleven stations sampled resulted in a variable age composition in the collections (Tables III-VIII). For example, 89% of the *N. tenuis* from Station 28 were between 0 and 2 years of age while 100% of the clams from Station 49 were between 2 and 4 years of age. Calculations using the age structure tables (Tables III-VIII) indicate that extensive mortality occurred after 4 years of age (96% of the clams were from 0 to 4 years of age). The oldest and largest *N. tenuis* collected were 7 years of age and 9.7 mm in length, respectively. The growth data are summarized in Tables III-VIII and Figures 2-6.

The mean shell length at any given annular age, from 1970 to 1976, showed some variation (Figs. 2-4), but at any given age the size fell within 1 mm of the standard deviations calculated for each age class (Tables III-VIII).

Nuculana fossa

Six hundred and three *Nuculana fossa* were aged. The collection locations are listed in Table I and shown in Figure 7. The annual increase in shell length for each of the size classes in Cook Inlet was typically 1 to 3 mm. Growth rates were similar at all stations, and varied only slightly from year to year (Figs. 8-11). The calculated F ratio indicates that age classes, as defined by shell lengths, are statistically distinguishable (α=0.01; Table II).

Text continued on page 229

TABLE I

NUMBER OF CLAMS COLLECTED BY VAN VEEN GRABS (VV) AND PIPE DREDGE (PD) IN LOWER COOK INLET, APRIL (A) AND OCTOBER (O), 1976.

Δ Indicates Additional Clams from Various Qualitative Sources

	Nucula tenuis				*Nuculana fossa*					*Glycymeris subobsoleta*					*Spisula polynyma*					*Macoma calcarea*					*Tellina nuculoides*			
	VV		PD		VV		PD		Δ	VV		PD		Δ	VV		PD		Δ	VV		PD		Δ	VV		PD	
Station	A	O	A	O	A	O	A	O		A	O	A	O		A	O	A	O		A	O	A	O		A	O	A	O
3[1]																												
5	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-	212[2]	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
7[1]																												
8[1]																												
12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
16	-	-	-	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18	-	-	-	16	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	22	-	-	-	-	-
19[1]																												
23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	4
25	-	-	-	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
27	-	-	-	9	2	2	8	-	-	-	-	-	-	1	-	-	-	-	1	5	-	-	18	19	-	-	-	-
28	-	92	-	29	-	144	-	31	4	376	-	-	179	-	-	-	-	-	1	4	348	-	-	-	-	-	-	-
29	-	-	-	-	-	-	-	-	-	-	-	22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30	-	-	-	-	-	-	-	-	-	-	-	24	-	-	-	-	-	1	1	-	-	-	-	-	7	-	-	-
31	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	-	-	-	-	-	19	77	-	-
32	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	2	-	-	-	-	-	-	-	-
33	-	-	-	12	1	1	3	-	-	-	-	-	-	-	-	-	-	-	1	5	-	17	7	-	-	-	-	-
35	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	-
37	-	-	-	5	-	-	-	-	191[3]	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	1
39	-	-	-	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	25	-	-	-	-	-
40[1]																												
40A	-	-	-	-	-	-	-	-	-	-	-	-	152	-	-	-	-	-	36[5]	-	-	-	-	-	-	-	-	8
41	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	184	43[5]	-	-	-	-	-	-	-	-	8
42	-	-	-	-	-	-	-	-	-	8	-	38	10	-	-	-	-	1	-	-	-	-	-	-	57	-	113	89
44	-	-	-	-	-	-	-	-	-	-	-	44	5	8[4]	-	-	-	-	-	-	-	-	-	-	200	-	-	19
44A[1]																												
45	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
47[1]																												
48[1]																												
49	-	-	14	8	-	-	5	-	-	-	-	-	-	1	-	-	-	-	1	-	-	-	11	-	-	-	-	-

TABLE I

CONTINUED

Station	*Nucula tenuis*				*Nuculana fossa*					*Glycymeris subobsoleta*					*Spisula polynyma*					*Macoma calcarea*					*Tellina nuculoides*			
	VV		PD		VV		PD		Δ	VV		PD		Δ	VV		PD		Δ	VV		PD		Δ	VV		PD	
	A	O	A	O	A	O	A	O		A	O	A	O		A	O	A	O		A	O	A	O		A	O	A	O
53	–	–	1	9	–	–	–	–	1	–	–	–	–	–	–	–	–	1	–	–	–	–	4	–	–	–	–	–
54	–	–	1	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	15	–	–	–	–	–
62A	–	–	–	4	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	1	–	–	–	–
63	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	31	–	–	–
66[1]																												
70[1]																												
C	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	3	–	–	–	–	–
M	–	–	–	–	–	–	–	–	–	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
UOG[1]																												
UW1[1]																												
UW2	–	–	–	–	–	–	–	–	–	–	–	–	4	–	–	–	–	–	–	–	–	–	–	–	–	–	49	45
DG1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	135[6]	–	–	–	–	–	–	–	–	–
DG2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	119	–	–	–	–	–	–	–	–	–
DG3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	18	–	–	–	–	–	–	–	–	–
DG4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	19	–	–	–	–	–	–	–	–	–
SUBTOTALS	0	92	16	94	4	147	16	31	415	384	0	129	357	12	0	0	0	188	378	16	348	17	120	20	314	77	162	175
TOTALS	203				613					882					566					521					728			

[1]Clams present but not enumerated - see distribution maps (Figs. 1, 7, 16, 27, 36, 47)
[2]Agassiz trawl, October
[3]Try-net, April
[4]Clam dredge, October
[5]Eastern otter trawl, October
[6]All DG stations sampled were obtained by ADF&G via anchor dredge, September 1976.

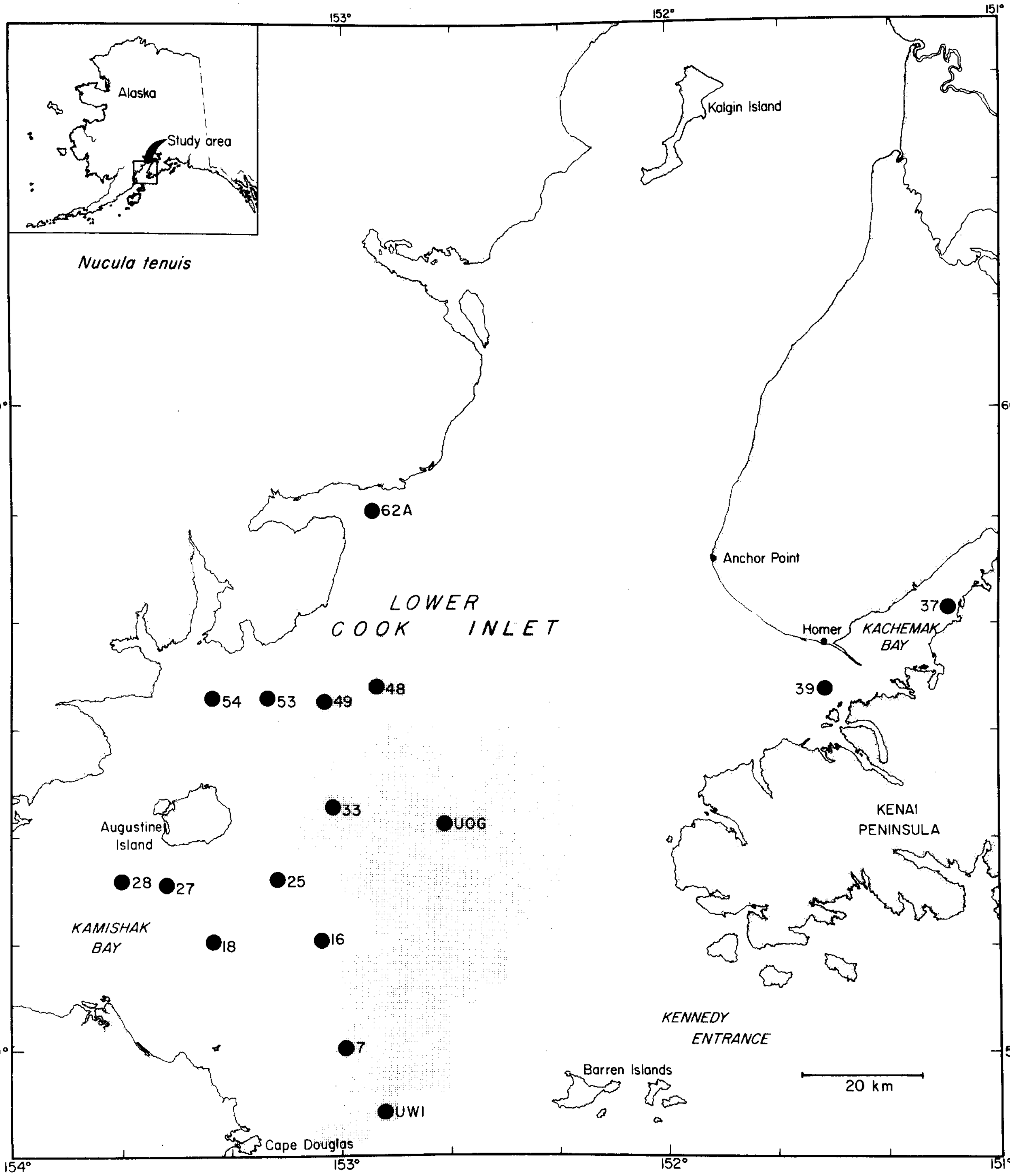

Figure 1. Distribution map of *Nucula tenuis* collected at lower Cook Inlet stations. The shaded region represents the tract selection area.

All Stations (Cook Inlet) *Nucula tenuis*

Year Class	*M S L at Annulus 1	M S L at Annulus 2	M S L at Annulus 3	M S L at Annulus 4	M S L at Annulus 5	M S L at Annulus 6	M S L at Annulus 7	Number in Age Class
1	2.3							55
2	2.4	3.4						44
3	2.4	3.4	4.3					34
4	2.3	3.4	4.4	5.3				30
5	2.5	3.5	4.4	5.3	6.2			7
6								0
7	2.6	3.5	4.8	6.1	7.0	8.4	9.4	2
	1970	1971	1972	1973	1974	1975	1976	Total
	YEAR OF ANNULUS FORMATION							172

* M S L = Mean Shell Length, mm

Figure 2. Growth history of *Nucula tenuis* from eleven stations in Cook Inlet.

Station 28 (Cook Inlet) *Nucula tenuis*

Year Class	*M S L at Annulus 1	M S L at Annulus 2	M S L at Annulus 3	M S L at Annulus 4	M S L at Annulus 5	Number in Age Class
1	2.3					52
2	2.4	3.3				26
3	2.4	3.4	4.2			8
4	2.3	3.3	4.5	5.6		4
5	2.7	4.0	4.6	5.7	6.3	1
	1972	1973	1974	1975	1976	Total
	* Y A F					91

* M S L = Mean Shell Length, mm
* Y A F = Year of Annulus Formation

Figure 3. Growth history of *Nucula tenuis* from Cook Inlet Station 28.

Station 49 (Cook Inlet) *Nucula tenuis*

Year Class	*M S L at Annulus 1	M S L at Annulus 2	M S L at Annulus 3	M S L at Annulus 4	Number in Age Class
1					0
2	2.3	3.5			5
3	2.3	3.3	4.5		7
4	2.3	3.5	4.3	5.3	10
	1973	1974	1975	1976	Total
	*Y A F				22

* M S L = Mean Shell Length, mm
* Y A F = Year of Annulus Formation

Figure 4. Growth history of *Nucula tenuis* from Cook Inlet Station 49.

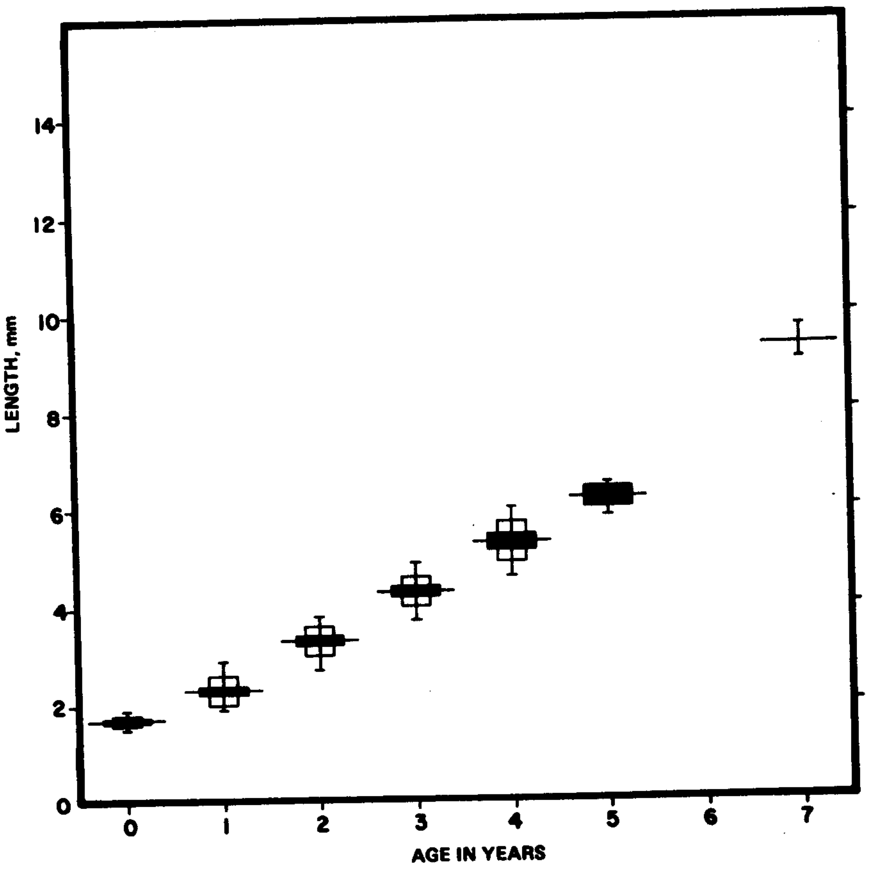

Figure 5. Growth curve for *Nucula tenuis* from eleven stations in Cook Inlet.

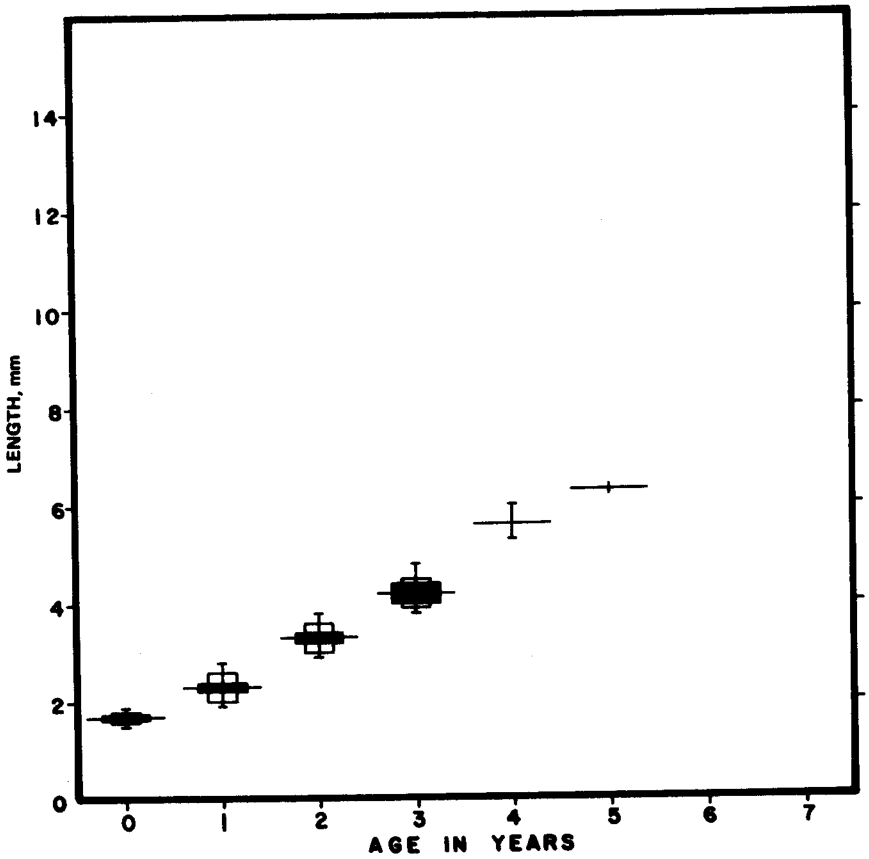

Figure 6. Growth curve for *Nucula tenuis* from Cook Inlet Station 28.

TABLE II

ONE-WAY ANALYSIS OF VARIANCE OF SHELL LENGTH FOR THE ANNULAR AGE CLASSES OF SIX SPECIES OF BIVALVE MOLLUSCS FROM LOWER COOK INLET

Species	Source of Variation	Degrees of Freedom	Mean Square	F Ratio	Significant Difference (P = 0.01)
Nucula tenuis	Sample means	1	410.526		
	individuals	200	0.105	3,901.749	Yes
Nuculana fossa	Sample means	1	10,782.465		
	individuals	601	1.120	9,625.123	Yes
Glycymeris subobsoleta	Sample means	1	15,840.503		
	individuals	876	0.603	26,249.800	Yes
Spisula polynyma	Sample means	1	527,157.188		
	individuals	554	25.223	20,899.578	Yes
Macoma calcarea	Sample means	1	15,115.871		
	individuals	518	0.381	36,698.482	Yes
Tellina nuculoides	Sample means	1	5,581.457		
	individuals	670	2.114	2,640.185	Yes

TABLE III

AGE STRUCTURE OF *NUCULA TENUIS* FROM ELEVEN LOWER COOK INLET STATIONS (16, 18, 27 28, 33, 37, 39, 49, 53, 54, and 62A) (See Table I and Fig. 1)

N = Number of Clams; ML = Mean Length of Clams; SD = Standard deviation; SEM = Standard Error of the Mean; R = Range

Year Class (Age of Clams)	N	ML (mm)	SD (mm)	SEM (mm)	R (mm)
0	30	1.7	0.1	0.04	1.5-1.9
1	55	2.3	0.3	0.07	1.9-2.9
2	44	3.3	0.3	0.08	2.7-3.8
3	34	4.3	0.3	0.12	3.7-4.9
4	30	5.3	0.4	0.15	4.6-6.0
5	7	6.2	0.2	0.21	5.8-6.5
6	0	--	--	--	--
7	2	9.3	0.5	1.02	9.0-9.7
	Total = 202				

TABLE IV

AGE STRUCTURE OF *NUCULA TENUIS* FROM LOWER COOK INLET STATION 18.

N = Number of Clams; ML = Mean Length of Clams; SD = Standard Deviation; SEM = Standard Error of the Mean; R = Range

Year Class (Age of clams)	N	ML (mm)	SD (mm)	SEM (mm)	R (mm)
0	0	--	--	--	--
1	0	--	--	--	--
2	3	3.5	0.3	0.37	3.3-3.8
3	9	4.2	0.4	0.27	3.7-4.9
4	4	5.1	0.4	0.50	4.7-5.7
	Total = 16				

TABLE V

AGE STRUCTURE OF *NUCULA TENUIS* FROM LOWER COOK INLET STATION 28.

N = Number of Clams; ML = Mean Length of Clams; SD = Standard Deviation; SEM = Standard Error of the Mean; R = Range

Year Class (age of clams)	N	ML (mm)	SD (mm)	SEM (mm)	R (mm)
0	30	1.7	0.1	0.04	1.5-1.9
1	52	2.3	0.3	0.07	1.9-2.8
2	26	3.3	0.3	0.11	2.9-3.8
3	8	4.2	0.3	0.22	3.8-4.8
4	4	5.6	0.3	0.39	5.3-6.0
5	1	6.3	0.0	0.00	6.3
	Total = 121				

TABLE VI

AGE STRUCTURE OF *NUCULA TENUIS* FROM LOWER COOK INLET STATION 33.

N = Number of Clams; ML = Mean Length of Clams; SD = Standard Deviation
SEM = Standard Error of the Mean; R = Range

Year Class (Age of clams)	N	ML (mm)	SD (mm)	SEM (mm)	R (mm)
0	0	--	--	--	--
1	1	2.9	0.0	0.00	2.9
2	5	3.4	0.3	0.29	3.1-3.7
3	4	4.1	0.3	0.41	3.8-4.5
4	2	5.4	0.6	1.31	5.0-5.9
	Total = 12				

TABLE VII

AGE STRUCTURE OF *NUCULA TENUIS* FROM LOWER COOK INLET STATION 49.

N = Number of Clams; ML = Mean Length of Clams; SD = Standard Deviation;
SEM = Standard Error of the Mean; R = Range

Year Class (Age of clams)	N	ML (mm)	SD (mm)	SEM (mm)	R (mm)
0	0	--	--	--	--
1	0	--	--	--	--
2	5	3.5	0.2	0.24	3.3-3.8
3	7	4.5	0.3	0.27	4.0-4.8
4	10	5.2	0.3	0.22	4.7-5.8
	Total = 22				

TABLE VIII

AGE STRUCTURE OF *NUCULA TENUIS* FROM LOWER COOK INLET STATION 53.

N = Number of Clams; ML = Mean Length of Clams; SD = Standard Deviation; SEM = Standard Error of the Mean; R = Range

Year Class (Age of clams)	N	ML (mm)	SD (mm)	SEM (mm)	R (mm)
0	0	--	--	--	--
1	0	--	--	--	--
2	1	3.4	0.0	0.00	3.4
3	3	4.4	0.3	0.47	4.2-4.8
4	5	5.2	0.6	0.58	4.6-5.8
5	1	6.1	0.0	0.00	6.1
	Total = 10				

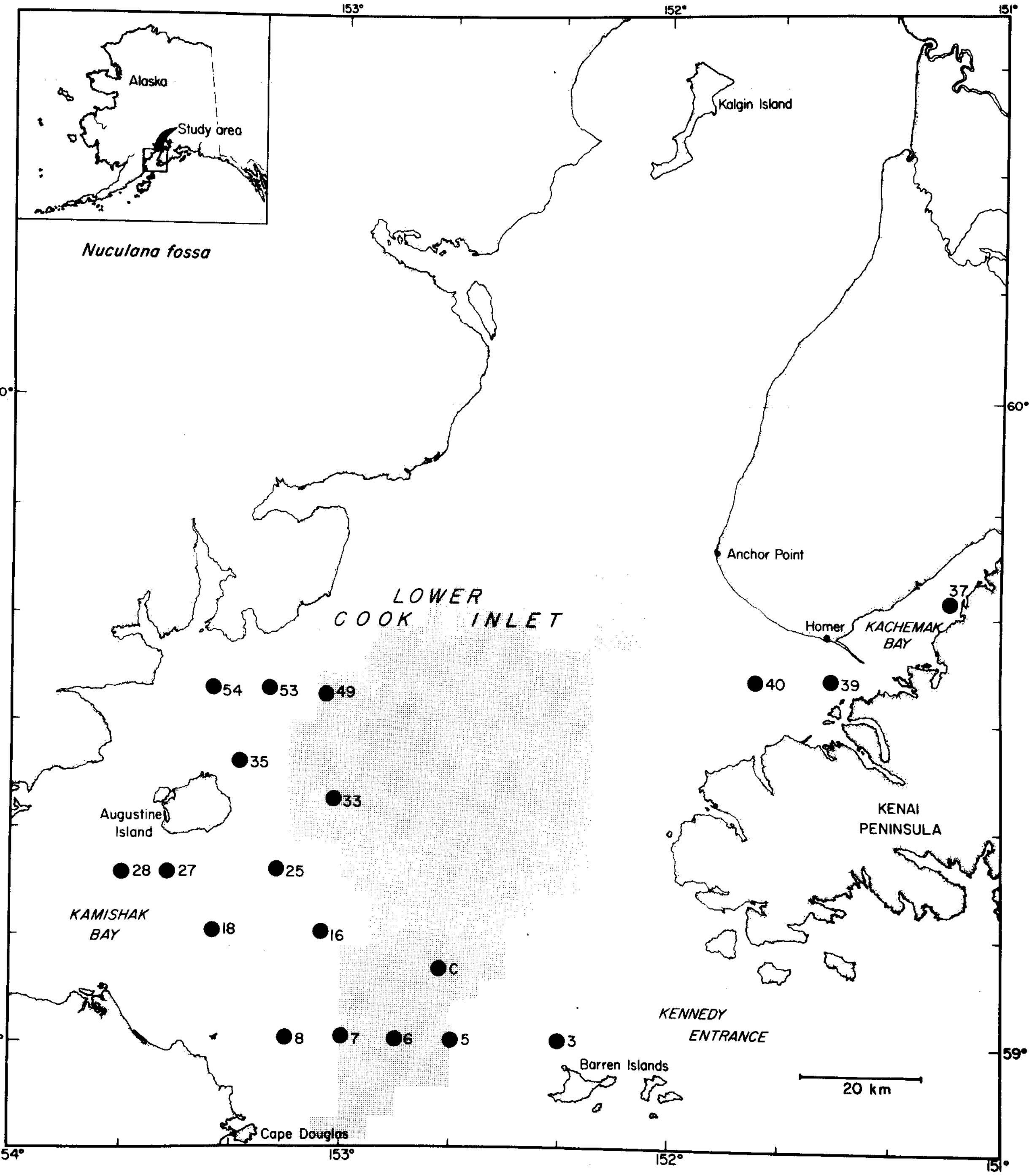

Figure 7. Distribution map of all *Nuculana fossa* from Cook Inlet stations. The shaded region represents the tract selection area.

All Stations (Cook Inlet) *Nuculana fossa*

Year Class	*M S L at Annulus 1	M S L at Annulus 2	M S L at Annulus 3	M S L at Annulus 4	M S L at Annulus 5	M S L at Annulus 6	M S L at Annulus 7	Number in Age Class
1	3.7							67
2	3.8	6.7						97
3	3.6	6.1	9.0					88
4	3.5	5.9	8.5	10.9				60
5	3.6	6.4	9.0	11.0	12.9			106
6	3.6	5.8	8.8	11.0	12.5	14.0		60
7	3.5	5.7	8.5	11.4	13.6	15.0	16.2	6
YEAR OF ANNULUS FORMATION	1970	1971	1972	1973	1974	1975	1976	Total 484

* M S L = Mean Shell Length, mm

Figure 8. Growth history of *Nuculana fossa* from eight Cook Inlet stations.

Station 6 (Cook Inlet) *Nuculana fossa*

Year Class	*M S L at Annulus 1	M S L at Annulus 2	M S L at Annulus 3	M S L at Annulus 4	M S L at Annulus 5	M S L at Annulus 6	M S L at Annulus 7	Number in Age Class
1								0
2	3.4	6.2						11
3	3.6	6.0	9.0					34
4	3.3	5.6	8.2	10.8				39
5	3.6	6.4	9.0	10.9	12.8			77
6	3.6	5.7	8.7	10.9	12.3	13.8		48
7	3.4	5.6	7.7	10.4	12.3	13.5	14.9	3
YEAR OF ANNULUS FORMATION	1970	1971	1972	1973	1974	1975	1976	Total 212

*M S L = Mean Shell Length

Figure 9. Growth history of *Nuculana fossa* from Cook Inlet Station 6.

Station 28 (Cook Inlet) *Nuculana fossa*

Year Class	*M S L at Annulus 1	M S L at Annulus 2	M S L at Annulus 3	M S L at Annulus 4	M S L at Annulus 5	Number in Age Class
1	3.6					32
2	4.0	6.7				11
3	3.4	5.4	7.9			12
4	3.4	5.2	7.3	9.5		3
5	3.4	5.4	7.6	9.9	12.1	2
	1972	1973	1974	1975	1976	Total
	**Y A F					60

*M S L = Mean Shell Length

**Y A F = Year of Annulus Formation

Figure 10. Growth history of *Nuculana fossa* from Cook Inlet Station 28.

Station 37 (Cook Inlet) *Nuculana fossa*

Year Class	*M S L at Annulus 1	M S L at Annulus 2	M S L at Annulus 3	M S L at Annulus 4	M S L at Annulus 5	M S L at Annulus 6	M S L at Annulus 7	Number in Age Class
1	3.6							26
2	3.8	6.7						73
3	3.7	6.3	9.3					34
4	3.8	6.7	9.1	11.4				18
5	3.6	6.5	9.3	11.2	13.4			26
6	3.7	6.5	9.1	11.6	13.2	15.0		12
7	3.3	5.2	9.3	12.8	15.5	17.0	18.3	2
	1970	1971	1972	1973	1974	1975	1976	Total
	YEAR OF ANNULUS FORMATION							191

*M S L = Mean Shell Length

Figure 11. Growth history of *Nuculana fossa* from Cook Inlet Station 37.

The integrity of the age classes is further illustrated in Figures 12-15 where it can be observed that none of the standard errors of the mean overlap (Hubbs and Hubbs, 1953). The majority of the 603 specimens examined were between 0 and 6 years of age. However, differential recruitment and mortality between the eight stations sampled resulted in a variable age composition in the collections (Tables IX-XII). For example, 93% of the *N. fossa* from Station 6 were between 3 and 6 years of age, while 67% of the clams from station 28 were in the 0 age class. Calculations using the age structure tables (Tables IX-XII) indicate that extensive mortality occurred after 6 years of age (99% of the clams were between 0 and 6 years of age). The oldest and largest *N. fossa* collected were 7 years of age and 19.5 mm in length, respectively. The growth data are summarized in Tables XII-XV and Figures 8-15.

The mean shell length at any given annular age, from 1970 to 1976, showed some variation (Fig. 8-11), but at any given age the size typically (94 of the 97 mean annual lengths, Fig. 8-11) fell within 1 mm of the standard deviations calculated for each age class (Tables IX-XII).

Glycymeris subobsoleta

Eight hundred and seventy-eight *Glycymeris subobsoleta* were aged. The collection locations are listed in Table I and shown in Figure 16. The annual increase in shell length for each of the size classes in Cook Inlet was typically 1 to 3 mm. Growth rates were similar for all stations, and varied only slightly from year to year (Figs. 17-23). The calculated F ratios indicates that age classes, as defined by shell lengths, are statistically distinguishable (α=0.01; Table II). The integrity of the age classes is further illustrated in Figures 24-26 where it can be observed that none of the standard errors of the mean overlap (Hubbs and Hubbs, 1953). The majority of the 878 specimens examined were between 0 and 4 years of age. However, differential recruitment and mortality between the ten stations sampled resulted in a variable age composition in the collections (Tables XIII-XIX). For example, stations 30, 42 and 44 had very few clams in the 0, 1 and 2 year classes, while station 28 had a predominance of 0 and 1 year old clams. Calculations using the age structure tables (Tables XIII-XIX) show that extensive mortality occurs

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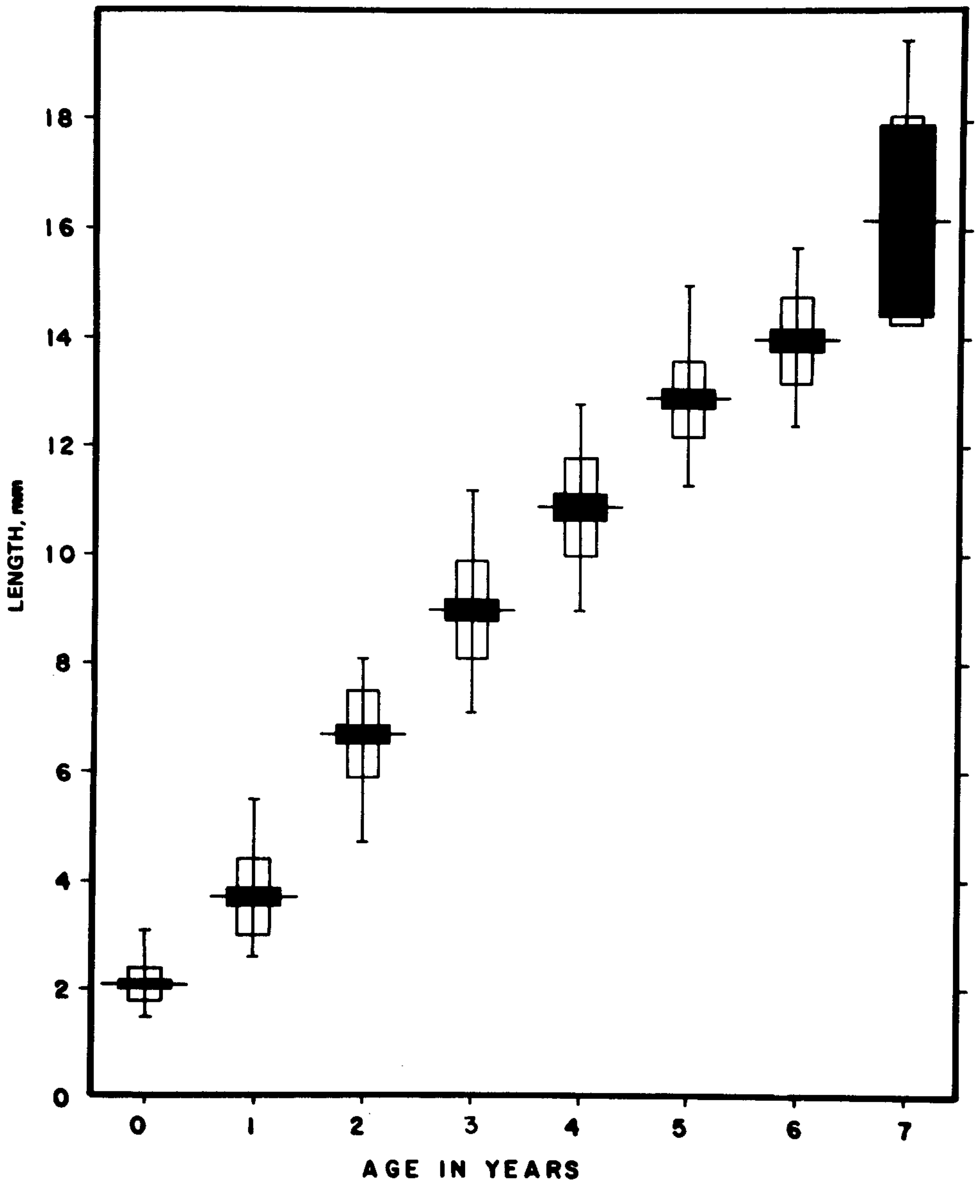

Figure 12. Growth curve for *Nuculana fossa* from eight Cook Inlet stations.

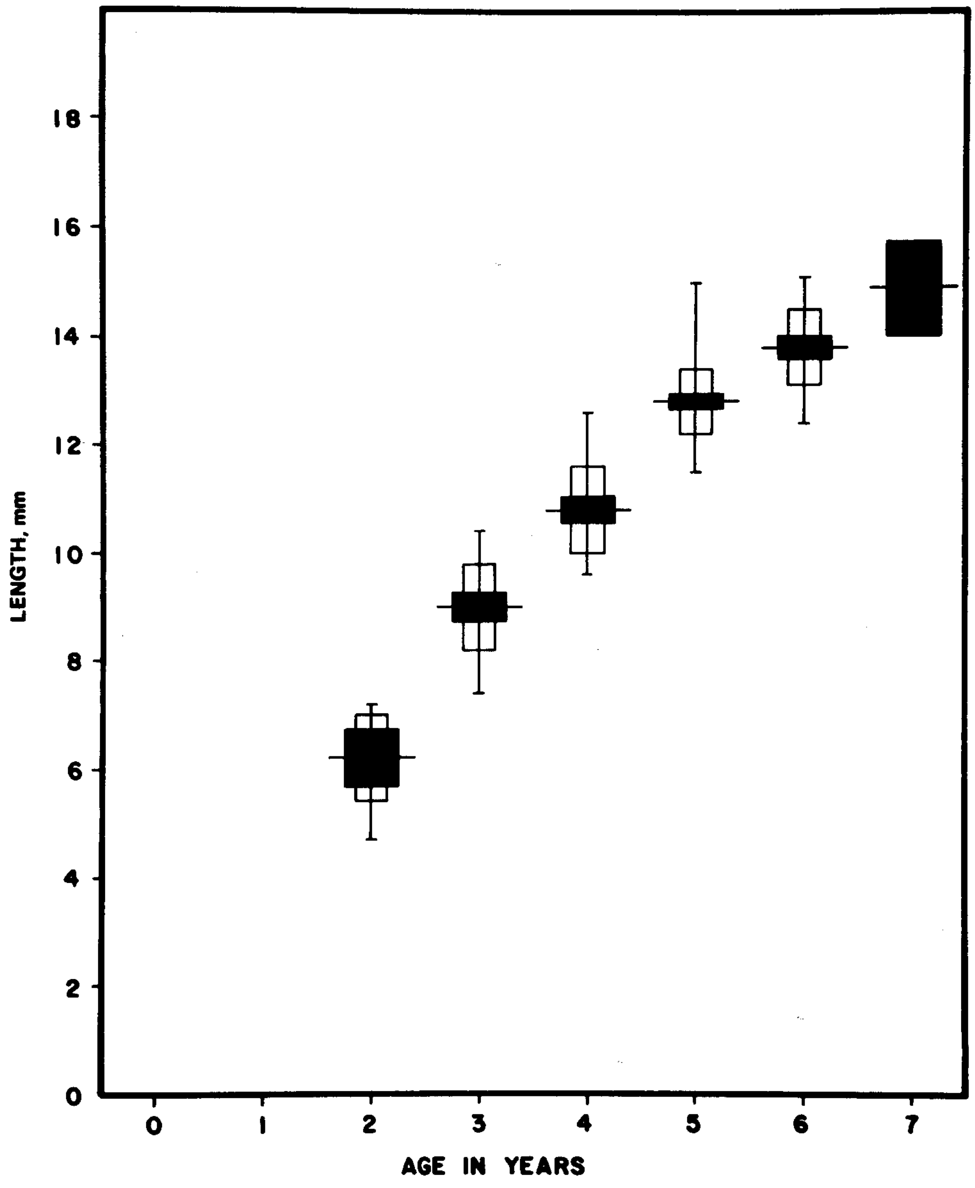

Figure 13. *Nuculana fossa* from Cook Inlet Station 6.

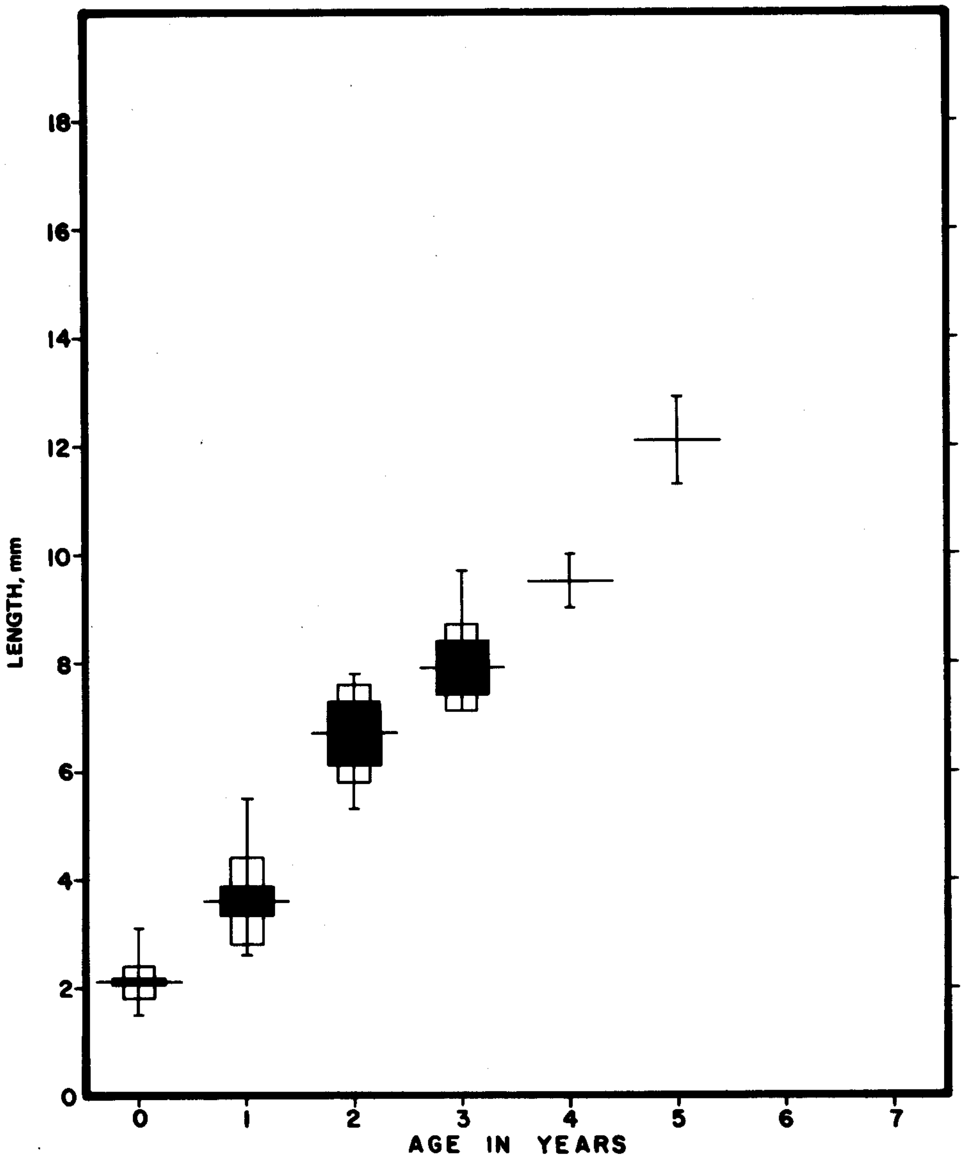

Figure 14. *Nuculana fossa* from Cook Inlet Station 28.

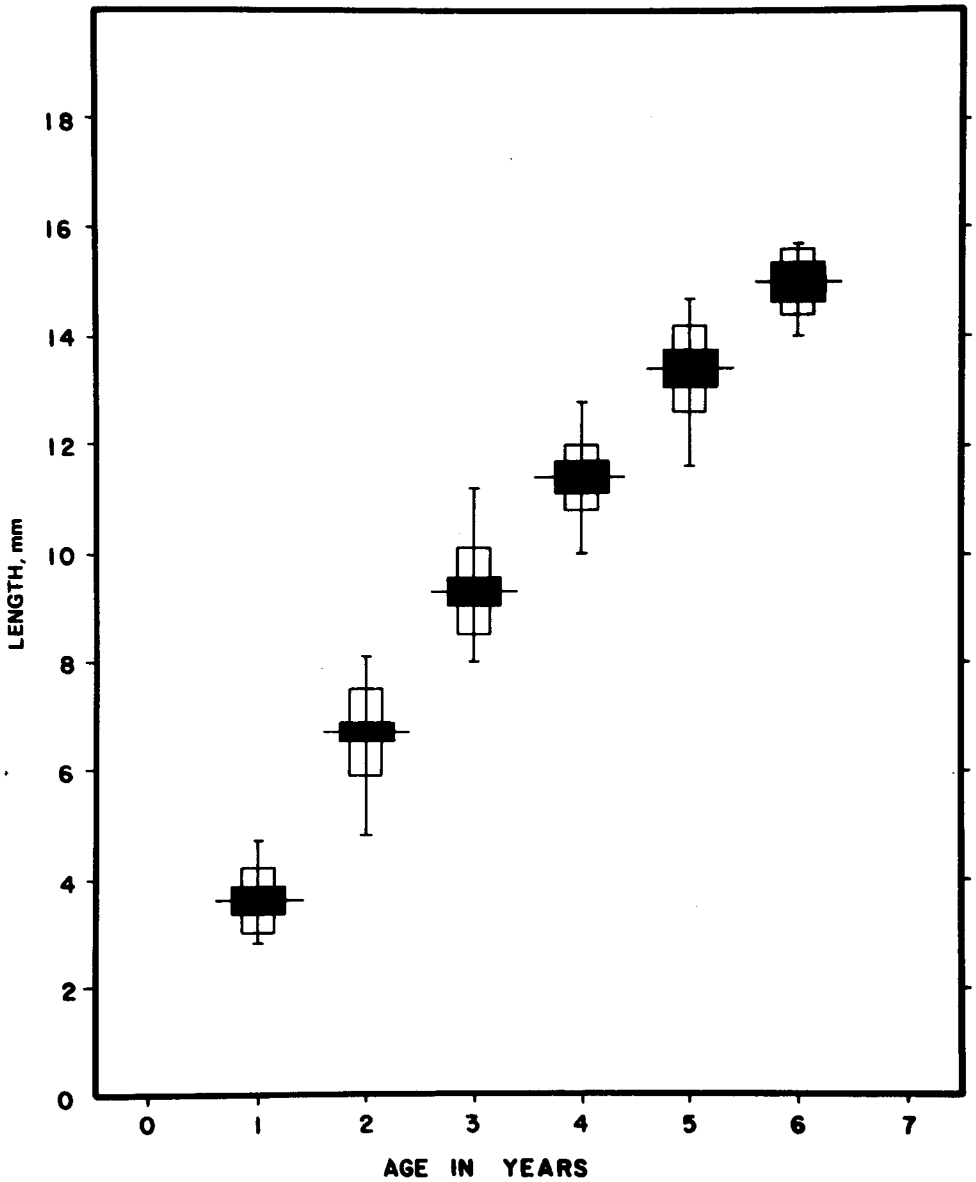

Figure 15. *Nuculana fossa* from Cook Inlet Station 37.

TABLE IX

AGE STRUCTURE OF *NUCULANA FOSSA* FROM THE EIGHT LOWER COOK INLET STATIONS (5, 6, 27, 28, 33, 37, 49, 54) WHERE THE CLAMS WERE COLLECTED (SEE FIG. 15).

N = Number of Clams; ML = Mean Length of Clams; SD = Standard Deviation; SEM = Standard Error of the Mean; R = Range

Year Class (Age of clams)	N	ML (mm)	SD (mm)	SEM (mm)	R (mm)
0	119	2.1	0.3	0.05	1.5-3.1
1	67	3.7	0.7	0.17	2.6-5.5
2	97	6.7	0.8	0.16	4.7-8.1
3	88	9.0	0.9	0.19	7.1-11.2
4	60	10.9	0.9	0.23	9.0-12.8
5	106	12.9	0.7	0.13	11.3-15.0
6	60	14.0	0.8	0.20	12.4-15.7
7	6	16.2	1.9	1.75	14.5-19.5
	Total = 603				

TABLE X

AGE STRUCTURE OF *NUCULANA FOSSA* FROM LOWER COOK INLET, STATION 6.

N = number of clams. ML = mean length of clams. SD = standard deviation. SEM = standard error of the mean. R = range.

Year Class (Age of clams)	N	ML (mm)	SD (mm)	SEM (mm)	R (mm)
0	0	--	--	--	--
1	0	--	--	--	--
2	11	6.2	0.8	0.52	4.7- 7.2
3	34	9.0	0.8	0.27	7.4-10.4
4	39	10.8	0.8	0.25	9.6-12.6
5	77	12.8	0.6	0.13	11.5-15.0
6	48	13.8	0.7	0.20	12.4-15.1
7	3	14.9	0.6	0.88	14.5-15.6
	Total = 212				

TABLE XI

AGE STRUCTURE OF *NUCULANA FOSSA* FROM LOWER COOK INLET, STATION 28.

N = number of clams. ML = mean length of clams. SD = standard deviation. SEM = standard error of the mean. R = range.

Year Class (Age of clams)	N	ML (mm)	SD (mm)	SEM (mm)	R (mm)
0	119	2.1	0.3	0.05	1.5- 3.1
1	32	3.6	0.8	0.28	2.6- 5.5
2	11	6.7	0.9	0.59	5.3- 7.8
3	12	7.9	0.8	0.50	7.1- 9.7
4	3	9.5	0.5	0.73	9.0-10.0
5	2	12.1	1.1	2.27	11.3-12.9
	Total = 179				

TABLE XII

AGE STRUCTURE OF *NUCULANA FOSSA* FROM LOWER COOK INLET, STATION 37.

N = number of clams. ML = mean length of clams. SD = standard deviation. SEM = standard error of the mean. R = range.

Year Class (Age of clams)	N	ML (mm)	SD (mm)	SEM (mm)	R (mm)
0	0	--	--	--	--
1	26	3.6	0.6	0.25	2.8- 4.7
2	73	6.7	0.8	0.18	4.8- 8.1
3	34	9.3	0.8	0.27	8.0-11.2
4	18	11.4	0.6	0.30	10.0-12.8
5	26	13.4	0.8	0.33	11.6-14.7
6	12	15.0	0.6	0.37	14.0-15.7
7	2	18.3	1.8	3.72	17.0-19.5
	Total = 191				

TABLE XIII

AGE STRUCTURE OF *GLYCYMERIS SUBOBSOLETA* FROM LOWER COOK INLET, THE TEN STATIONS (M, UW2, 28, 29, 30, 40A, 42, 44, 45, and 63) WHERE THE CLAMS WERE COLLECTED (Fig. 16).

N = Number of Clams. ML = Mean Length of Clams. SD = Standard Deviation. SEM = Standard Error of the Mean. R = Range.

Year Class (Age of clams)	N	ML (mm)	SD (mm)	SEM (mm)	R (mm)
0	128	2.1	0.4	0.07	1.3- 2.8
1	475	3.6	0.5	0.04	2.2- 4.9
2	92	5.0	0.7	0.14	4.0- 6.5
3	45	8.3	0.8	0.23	6.3- 9.7
4	65	10.8	0.8	0.20	9.5-12.3
5	26	13.6	0.9	0.37	12.0-15.6
6	16	16.3	1.2	0.64	13.8-18.6
7	8	18.4	1.4	1.09	17.1-21.2
8	14	19.8	1.4	0.80	17.9-22.3
9	6	21.8	1.2	1.11	20.2-23.7
10	2	26.0	0.6	1.24	25.6-26.5
11	1	27.0	0.0	0.00	27.0

Total = 878

TABLE XIV

AGE STRUCTURE OF *GLYCYMERIS SUBOBSOLETA* FROM LOWER COOK INLET, STATION 28.

N = Number of Clams. ML = Mean Length of Clams. SD = Standard Deviation. SEM = Standard Error of the Mean. R = Range.

Year Class (Age of clams)	N	ML (mm)	SD (mm)	SEM (mm)	R (mm)
0	123	2.1	0.4	0.07	1.3 - 2.7
1	430	3.6	0.5	0.05	2.2 - 4.9
2	2	5.1	0.4	0.83	4.8 - 5.3
Total =	555				

TABLE XV

AGE STRUCTURE OF *GLYCYMERIS SUBOBSOLETA* FROM LOWER COOK INLET, STATION 29.

N = number of clams. ML = mean length of clams. SD = standard deviation. SEM = standard error of the mean. R = range.

Year Class (Age of clams)	N	ML (mm)	SD (mm)	SEM (mm)	R (mm)
3	3	8.5	0.3	0.44	8.1- 8.7
4	1	10.9	0.0	0.00	10.9
5	2	13.2	1.7	3.51	12.0-14.4
6	5	16.5	1.1	1.13	15.4-18.3
7	3	19.8	1.2	0.85	18.9-21.2
8	4	19.8	0.8	0.95	19.2-20.9
9	2	22.0	0.6	1.24	21.6-22.4
10	2	26.0	0.6	1.24	25.6-26.5
Total =	22				

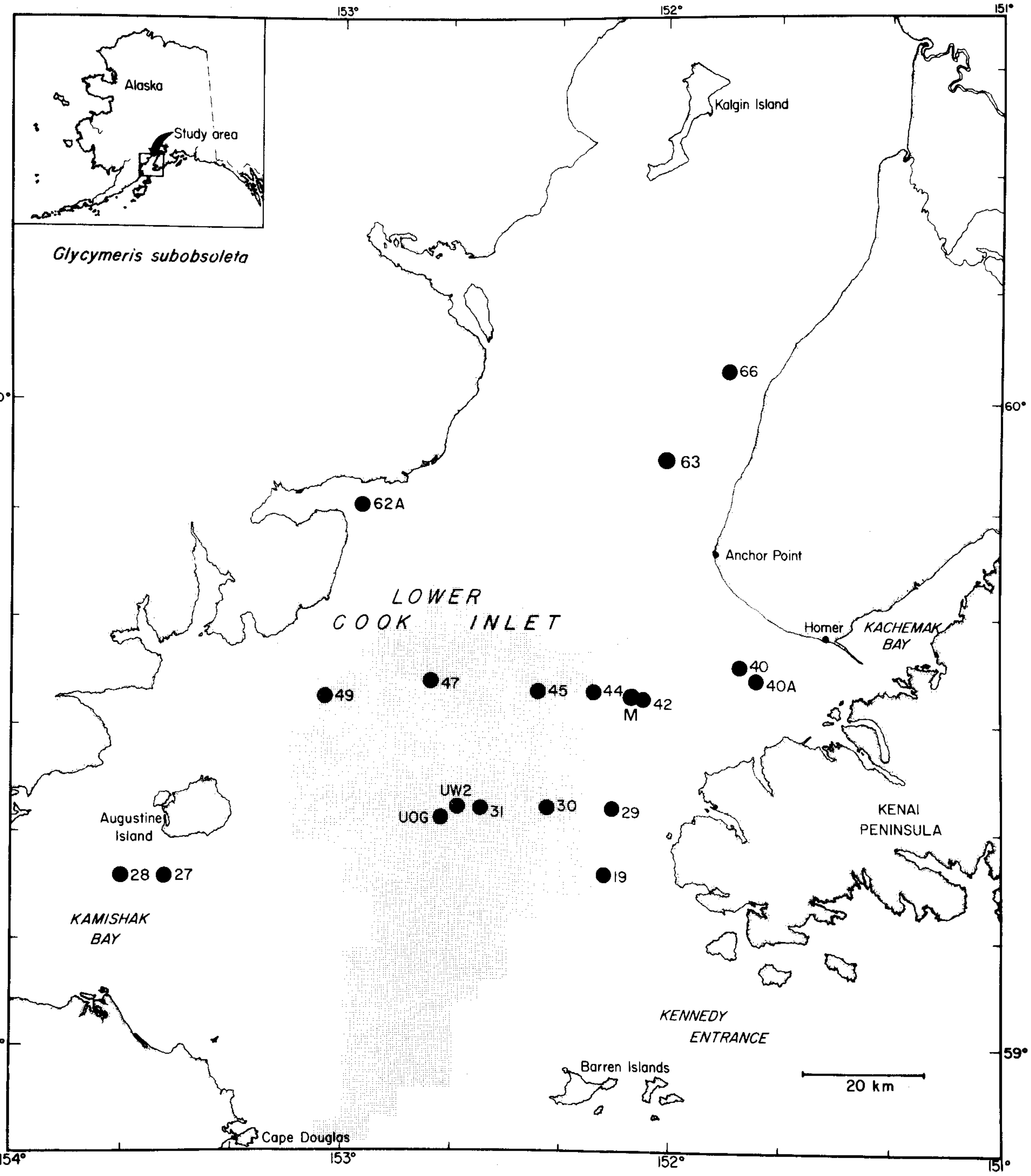

Figure 16. Distribution map of all *Glycymeris subobsoleta* from Cook Inlet stations. The shaded region represents the tract selection area.

All Stations (Cook Inlet) *Glycymeris subobsoleta*

Year Class	*M S L at Annulus 1	M S L at Annulus 2	M S L at Annulus 3	M S L at Annulus 4	M S L at Annulus 5	M S L at Annulus 6	M S L at Annulus 7	M S L at Annulus 8	M S L at Annulus 9	M S L at Annulus 10	M S L at Annulus 11	Number in Age Class
1	3.6											475
2	3.3	5.0										92
3	3.5	5.6	8.3									45
4	3.4	5.5	8.0	10.8								65
5	3.5	5.5	8.1	10.8	13.6							26
6	3.6	5.9	8.4	11.4	13.7	16.3						16
7	3.6	5.7	8.5	11.3	13.9	16.2	18.4					8
8	3.7	5.5	8.0	10.9	13.6	15.9	18.0	19.8				14
9	3.5	5.5	7.8	10.2	12.9	15.7	18.0	20.0	21.8			6
10	3.7	5.8	7.8	11.1	14.4	17.5	20.3	22.3	24.2	26.0		2
11	3.0	5.3	7.2	10.4	13.2	15.6	17.4	21.5	23.4	25.0	27.0	1
	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	Total
	YEAR OF ANNULUS FORMATION											750

* M S L = Mean Shell Length, mm

Figure 17. Growth history of *Glycymeris subobsoleta* from ten Cook Inlet stations.

Station 28 (Cook Inlet)
Glycymeris subobsoleta

Year Class	*M S L at Annulus 1	M S L at Annulus 2	Number in Age Class
1	3.6		430
2	3.7	5.1	2
	1975	1976	Total
	**Y A F		432

* M S L = Mean Shell Length
** Y A F = Year of Annulus Formation

Figure 18. Growth history of *Glycymeris subobsoleta* from Cook Inlet Station 28.

Station 29 (Cook Inlet) *Glycymeris subobsoleta*

Year Class	*M S L at Annulus 1	M S L at Annulus 2	M S L at Annulus 3	M S L at Annulus 4	M S L at Annulus 5	M S L at Annulus 6	M S L at Annulus 7	M S L at Annulus 8	M S L at Annulus 9	M S L at Annulus 10	Number in Age Class
1											0
2											0
3	3.8	6.3	8.5								3
4	3.8	5.7	8.2	10.9							1
5	3.7	5.8	8.2	10.9	13.2						2
6	3.7	6.1	8.8	11.7	14.0	16.5					5
7	3.7	5.8	8.9	12.1	14.5	17.3	19.8				3
8	3.7	5.6	7.7	10.7	13.4	15.6	18.2	19.8			4
9	3.2	4.9	7.1	10.0	13.2	16.3	18.7	20.5	22.0		2
10	3.7	5.8	7.8	11.1	14.4	17.5	20.3	22.3	24.2	26.0	2
	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	Total
	YEAR OF ANNULUS FORMATION										22

*M S L = Mean Shell Length

Figure 19. Growth history of *Glycymeris subobsoleta* from Cook Inlet Station 29.

Station 30 (Cook Inlet) *Glycymeris subobsoleta*

Year Class	*M S L at Annulus 1	M S L at Annulus 2	M S L at Annulus 3	M S L at Annulus 4	M S L at Annulus 5	Number in Age Class
1						0
2	3.5	5.3				2
3	3.4	5.7	8.7			10
4	3.4	5.5	7.9	10.6		11
5	3.3	5.6	8.2	10.2	12.2	1
	1972	1973	1974	1975	1976	Total
	**Y A F					24

*M S L = Mean Shell Length
**Y A F = Year of Annulus Formation

Figure 20. Growth history of *Glycymeris subobsoleta* from Cook Inlet Station 30.

Station 40A (Cook Inlet) *Glycymeris subobsoleta*

Year Class	*M S L at Annulus 1	M S L at Annulus 2	M S L at Annulus 3	M S L at Annulus 4	M S L at Annulus 5	Number in Age Class
1	3.6					42
2	3.3	4.9				84
3	3.5	5.2	7.6			12
4	3.4	5.2	7.7	10.5		9
5	3.7	5.2	7.0	10.4	12.2	1
**Y A F	1972	1973	1974	1975	1976	Total 148

*M S L = Mean Shell Length
**Y A F = Year of Annulus Formation

Figure 21. Growth history of *Glycymeris subobsoleta* from Cook Inlet Station 40A.

Station 42 (Cook Inlet) *Glycymeris subobsoleta*

Year Class	*M S L at Annulus 1	M S L at Annulus 2	M S L at Annulus 3	M S L at Annulus 4	M S L at Annulus 5	M S L at Annulus 6	M S L at Annulus 7	M S L at Annulus 8	Number in Age Class
1	4.1								1
2	3.8	5.9							4
3	3.5	5.8	8.6						13
4	3.4	5.6	8.1	10.9					21
5	3.6	5.7	8.4	11.0	13.9				10
6	3.7	6.1	8.6	11.1	13.3	16.2			4
7	3.4	5.7	8.4	11.0	14.1	15.9	17.5		2
8	3.6	5.8	8.8	11.8	14.1	16.5	19.8	22.0	1
YEAR OF ANNULUS FORMATION	1969	1970	1971	1972	1973	1974	1975	1976	Total 56

*M S L = Mean Shell Length

Figure 22. Growth history of *Glycymeris subobsoleta* from Cook Inlet Station 42.

Station 44 (Cook Inlet) *Glycymeris subobsoleta*

Year Class	*M S L at Annulus 1	M S L at Annulus 2	M S L at Annulus 3	M S L at Annulus 4	M S L at Annulus 5	M S L at Annulus 6	M S L at Annulus 7	M S L at Annulus 8	M S L at Annulus 9	M S L at Annulus 10	M S L at Annulus 11	Number in Age Class
1												0
2												0
3	3.4	5.5	8.2									6
4	3.5	5.7	8.1	10.9								20
5	3.3	5.4	8.0	10.6	13.5							11
6	3.6	5.6	8.2	11.7	14.1	16.8						5
7	3.6	5.7	8.1	10.7	13.1	15.3	17.5					3
8	3.8	5.5	8.2	11.2	14.0	16.3	18.1	20.0				7
9	3.7	5.8	8.1	10.3	12.8	15.4	17.6	19.8	21.7			4
10												0
11	3.0	5.3	7.2	10.4	13.2	15.6	17.4	21.5	23.4	25.0	27.0	1
YEAR OF ANNULUS FORMATION	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	Total 57

*M S L = Mean Shell Length

Figure 23. Growth history of *Glycymeris subobsoleta* from Cook Inlet Station 44.

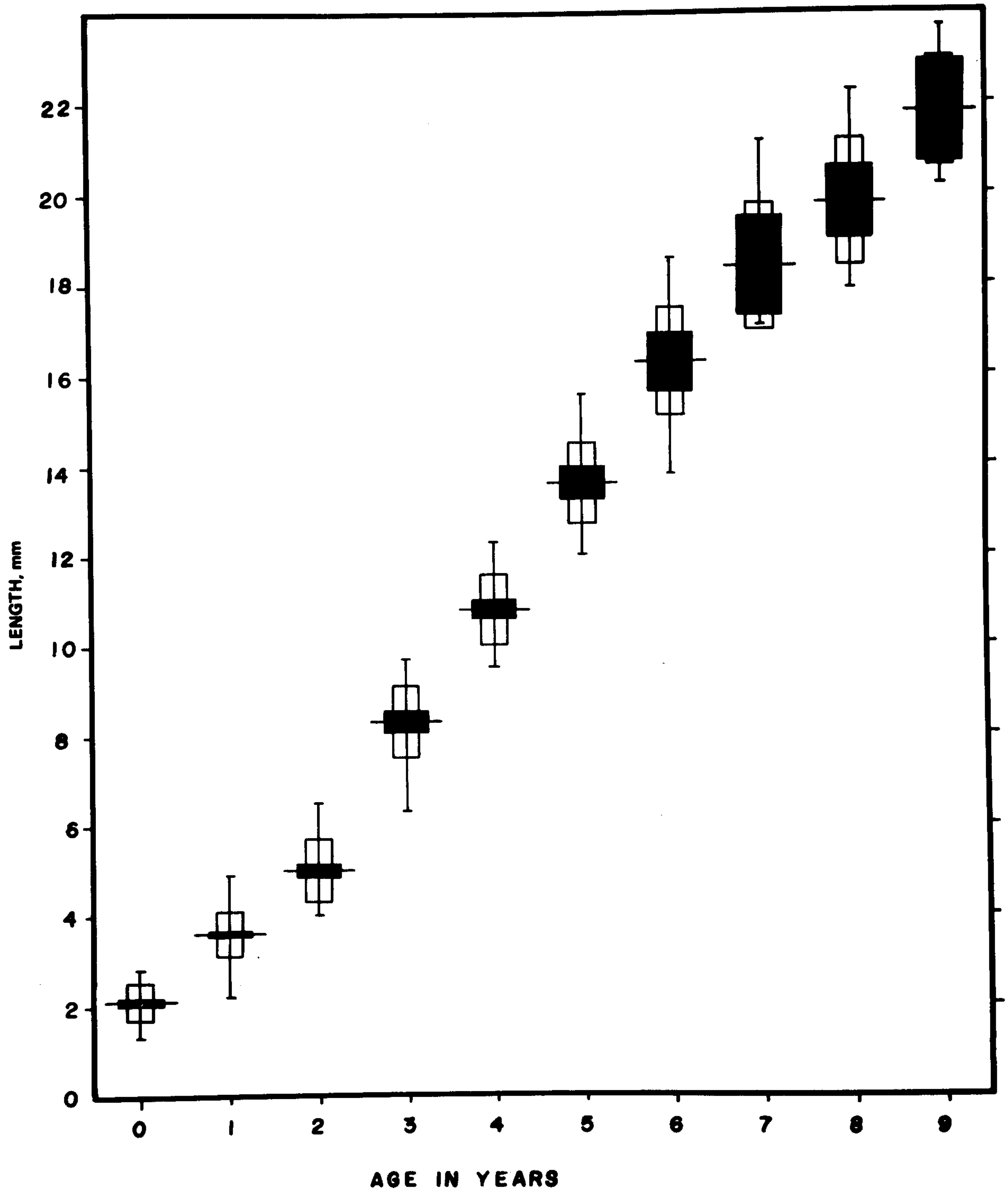

Figure 24. Growth curve for *Glycymeris subobsoleta* from ten Cook Inlet stations.

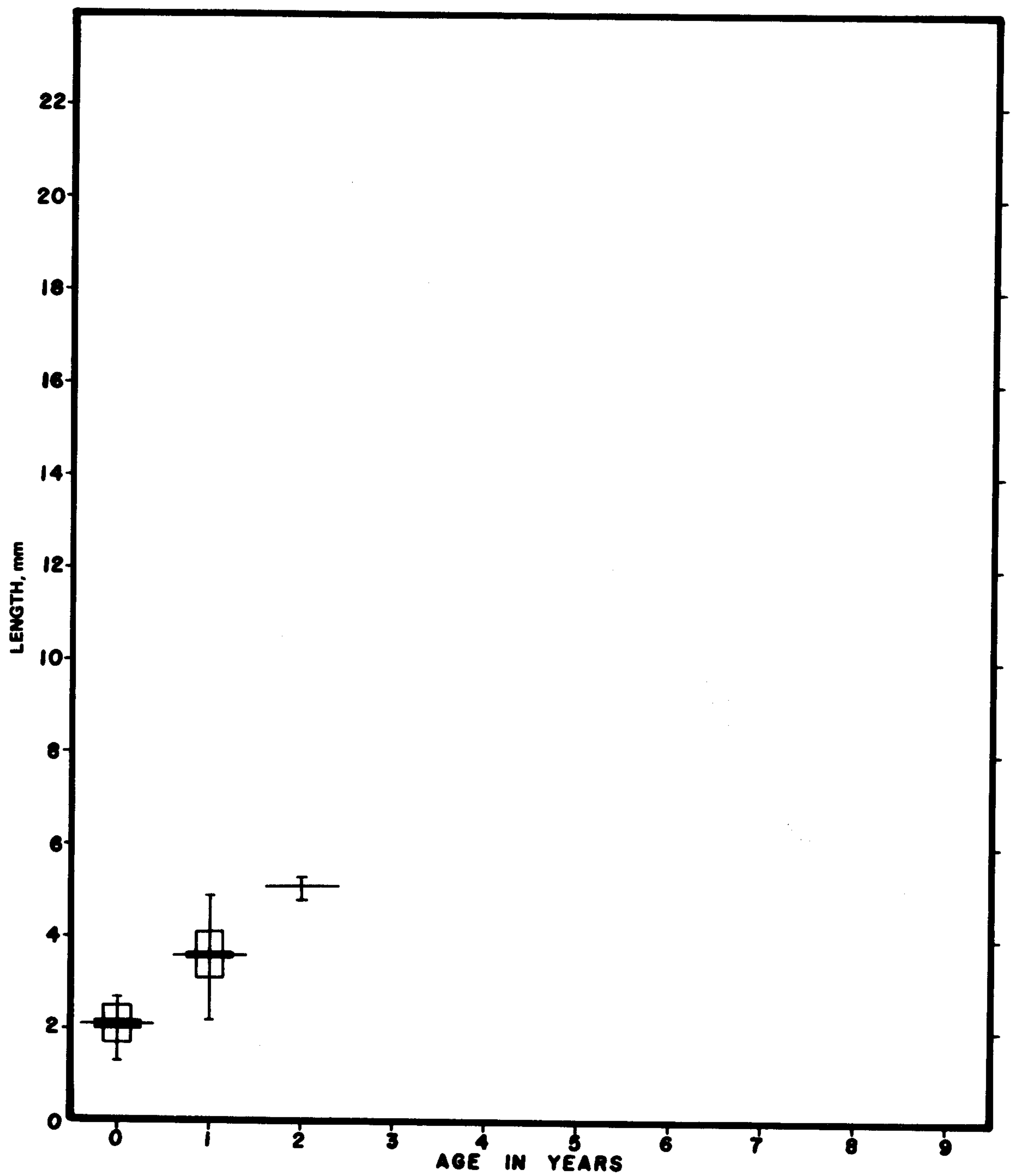

Figure 25. Growth curve for *Glycymeris subobsoleta* from Cook Inlet Station 28.

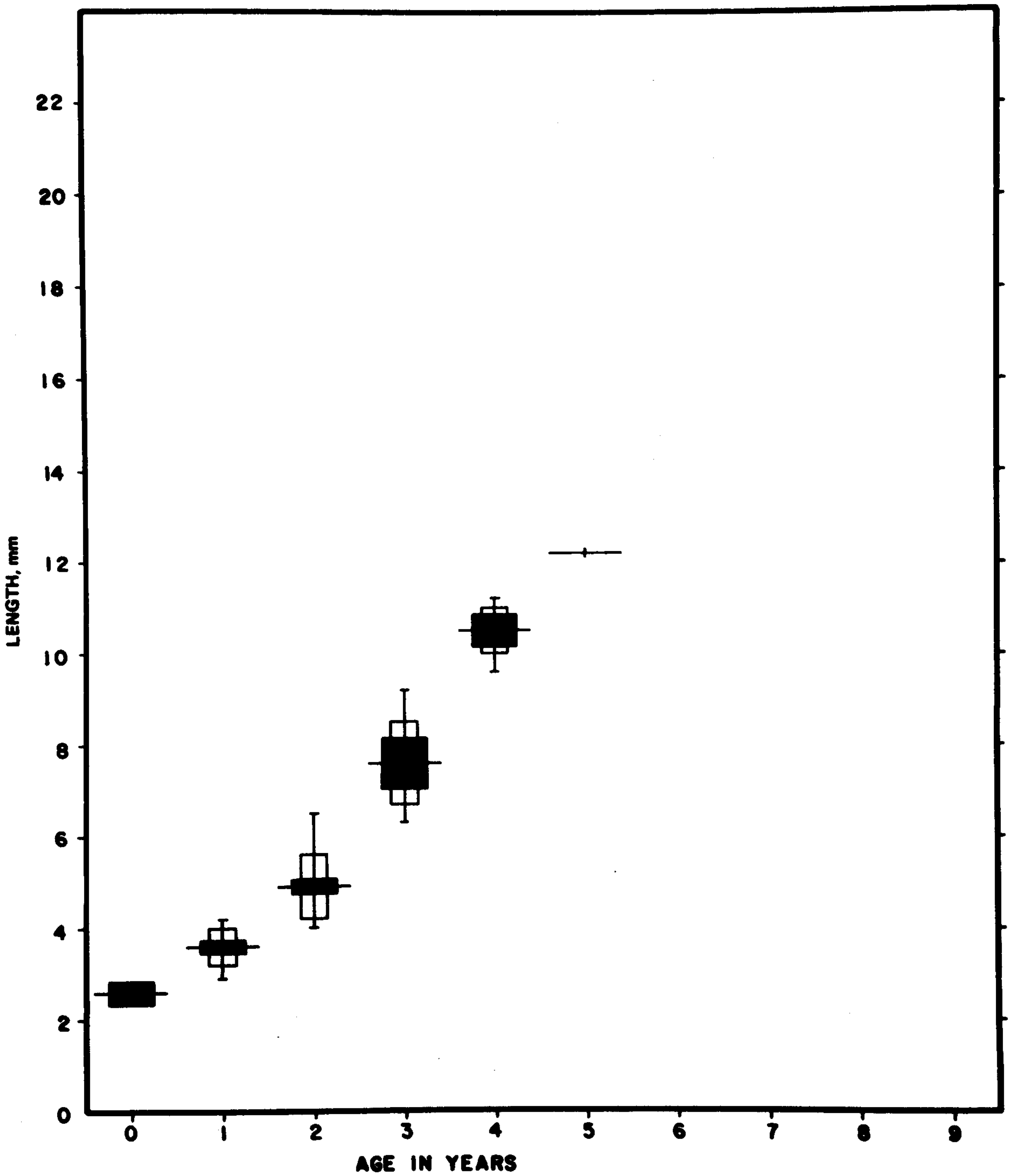

Figure 26. Growth curve for *Glycymeris subobsoleta* from Cook Inlet Station 40A.

TABLE XVI

AGE STRUCTURE OF *GLYCYMERIS SUBOBSOLETA* FROM LOWER COOK INLET, STATION 30.

N = number of clams. ML = mean length of clams. SD = standard deviation. SEM = standard error of the mean. R = range.

Year Class (Age of clams)	N	ML (mm)	SD (mm)	SEM (mm)	R (mm)
0	0	--	--	--	--
1	0	--	--	--	--
2	2	5.3	0.6	1.24	4.8- 5.7
3	10	8.7	0.3	0.21	8.2- 9.1
4	11	10.6	0.6	0.39	10.0-12.0
5	1	12.2	0.0	0.00	12.2
Total =	24				

TABLE XVII

AGE STRUCTURE OF *GLYCYMERIS SUBOBSOLETA* FROM LOWER COOK INLET, STATION 40A.

N = number of clams. ML = mean length of clams. SD = standard deviation. SEM = standard error of the mean. R = range.

Year Class (Age of clams)	N	ML (mm)	SD (mm)	SEM (mm)	R (mm)
0	4	2.6	0.2	0.24	2.4- 2.8
1	42	3.6	0.4	0.12	2.9- 4.2
2	84	4.9	0.7	0.15	4.0- 6.5
3	12	7.6	0.9	0.56	6.3- 9.2
4	9	10.5	0.5	0.36	9.6-11.2
5	1	12.2	0.0	0.00	12.2
Total =	152				

TABLE XVIII

AGE STRUCTURE OF *GLYCYMERIS SUBOBSOLETA* FROM LOWER COOK INLET, STATION 42.

N = number of clams. ML = mean length of clams. SD = standard deviation. SEM = standard error of the mean. R = range.

Year Class (Age of clams)	N	ML (mm)	SD (mm)	SEM (mm)	R (mm)
0	0	--	--	--	--
1	1	4.1	0.0	0.00	4.1
2	4	5.9	0.4	0.48	5.4- 6.3
3	13	8.6	0.8	0.48	7.4- 9.7
4	21	10.9	0.9	0.43	9.5-12.3
5	10	13.9	0.9	0.62	12.8-15.6
6	4	16.2	0.6	0.71	15.5-16.7
7	2	17.5	0.6	1.24	17.1-18.0
8	1	22.0	0.0	0.00	22.0

Total = 56

TABLE XIX

AGE STRUCTURE OF *GLYCYMERIS SUBOBSOLETA* FROM LOWER COOK INLET, STATION 44.

N = number of clams. ML = mean length of clams. SD = standard deviation. SEM = standard error of the mean. R = range.

Year Class (Age of clams)	N	ML (mm)	SD (mm)	SEM (mm)	R (mm)
0	0	--	--	--	--
1	0	--	--	--	--
2	0	--	--	--	--
3	6	8.2	0.9	0.83	7.1- 9.4
4	20	10.9	0.9	0.43	9.6-12.2
5	11	13.5	0.8	0.52	12.6-15.0
6	5	16.8	1.2	1.24	15.6-18.6
7	3	17.5	0.4	0.58	17.1-17.8
8	7	20.0	1.4	1.18	18.0-22.3
9	4	21.7	1.6	1.91	20.2-23.7
10	0	--	--	--	--
11	1	25.0	0.0	0.00	25.0
Total = 57					

after 4 years of age. Ninety-two percent of the samples were in the 0 to 4 year classes. The oldest and largest *G. subobsoleta* collected were 11 years of age and 27.0 mm in length, respectively. The growth data are summarized in Tables XIII-XIX and Figures 17-26.

The mean shell length at any given annular age, from 1966 to 1976, showed some variation (Figs. 17-23), but at any given age the size typically (235 of the 239 mean annular lengths, Figs. 17-23) fell within 1 mm of the standard deviations calculated for each age class (Tables XIII-XIX).

Spisula polynyma

Five hundred and fifty-six *Spisula polynyma* were aged. The collection locations are listed in Table I and shown in Figure 27 (excluding DG stations). Of the specimens over 30 mm in length, five were fresh-frozen specimens provided by the Alaska Department of Fish and Game and 74 were empty shells from otter trawls. The sampling gear used in the present survey did not adequately sample all size classes of *S. polynyma*. Therefore, observations on the biology of this clam were restricted to age and growth. The annual increase in shell length for various size classes in Cook Inlet was typically 5 to 9 mm, which is slightly less than the 6 to 11 mm reported by Feder *et al.* (1976) for Prince William Sound. Growth was similar at all stations, and varied only slightly from year to year for age groups 0 through 4 (Figs. 28-31). The calculated F ratio indicates that age classes, as defined by shell lengths are statistically distinguishable (α=0.01; Table II). The integrity of the age classes is further illustrated in Figures 32-35 where it can be observed that none of the standard errors of the mean overlap (Hubbs and Hubbs, 1953). Beyond 4 years of age, samples sizes were small and comparisons could not be made. The majority of the 556 specimens examined were between 1 and 4 years of age. The oldest clams were 16 years of age at a variety of sizes; the largest clam was 128 mm in length and 13 years of age. The growth data are summarized in Tables XX-XXIII and Figures 28-35.

The growth histories for the mean shell lengths at annuli 1 through 3 (Figs. 28-31) were similar, only 11 out of 126 mean annular lengths exceeded the standard deviations included in Tables XX-XXIII by more than

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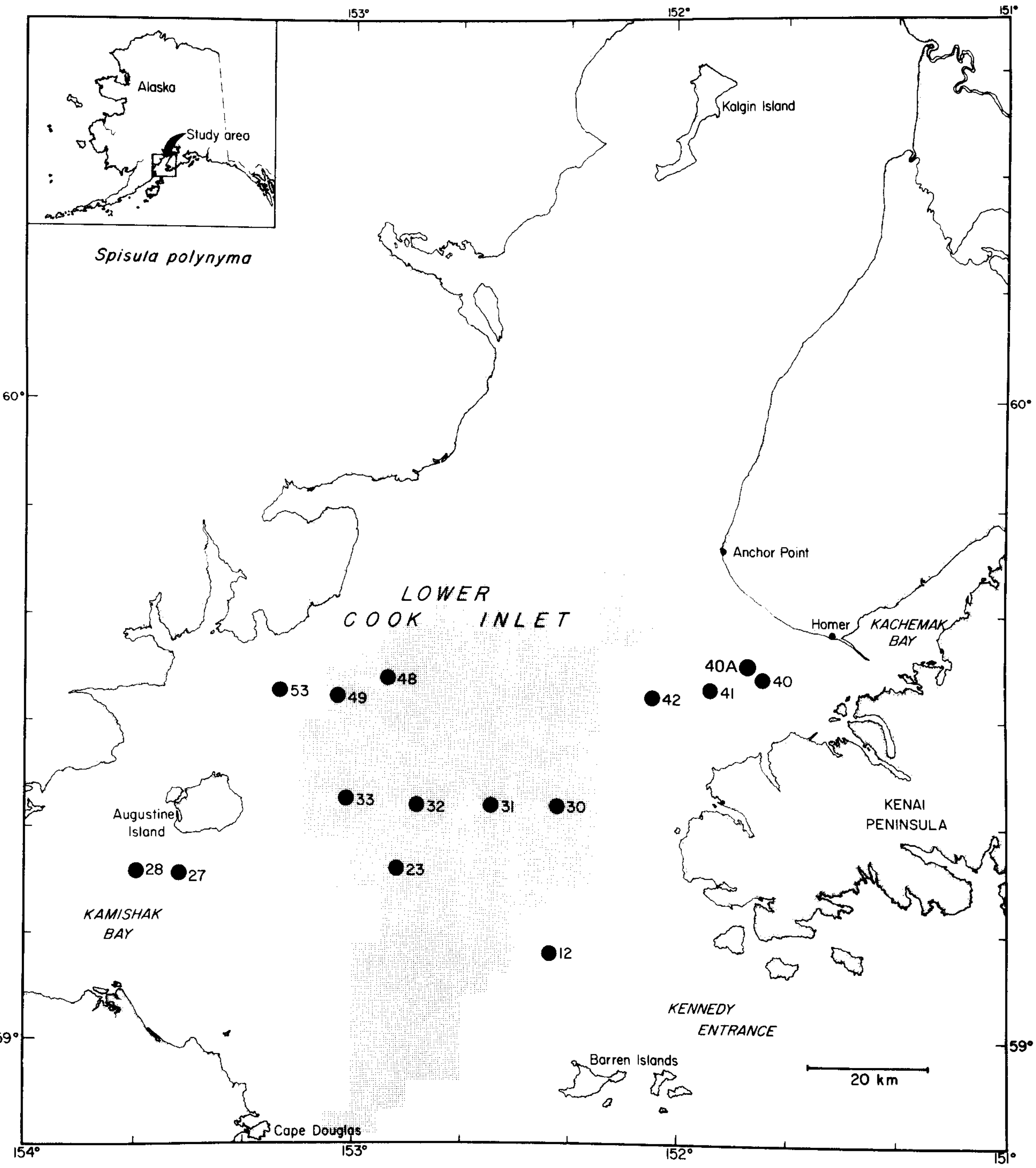

Figure 27. Distribution map of all *Spisula polynyma* from Cook Inlet stations. The shaded portion represents the tract selection area.

All Stations (Cook Inlet) *Spisula polynyma*

Year Class	*M S L at Annulus 1	M S L at Annulus 2	M S L at Annulus 3	M S L at Annulus 4	M S L at Annulus 5	M S L at Annulus 6	M S L at Annulus 7	M S L at Annulus 8	M S L at Annulus 9	M S L at Annulus 10	M S L at Annulus 11	M S L at Annulus 12	M S L at Annulus 13	M S L at Annulus 14	M S L at Annulus 15	M S L at Annulus 16	Number in Age Class
1	10																128
2	9	15															117
3	8	15	21														175
4	7	12	20	26													56
5																	0
6																	0
7																	0
8																	0
9																	0
10																	0
11																	0
12																	0
13	10	16	22	34	42	48	55	65	77	90	100	110	118				2
14	7	13	20	29	36	46	54	66	78	85	95	104	109	117			2
15																	0
16	6	12	19	28	33	40	49	56	64	74	82	91	103	110	119	123	1
	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	Total
	YEAR OF ANNULUS FORMATION																481

*** M S L = Mean Shell Length, mm**

Figure 28. Growth history of *Spisula polynyma* from seven Cook Inlet stations.

Station 41
(Cook Inlet)

Spisula polynyma

Year Class	*M S L at Annulus 1	M S L at Annulus 2	M S L at Annulus 3	M S L at Annulus 4	Number in Age Class
1	9				4
2	8	15			21
3	9	16	22		108
4	7	12	20	26	56
**Y A F	1973	1974	1975	1976	Total 189

*M S L = Mean Shell Length
**Y A F = Year of Annulus Formation

Figure 29. Growth history of *Spisula polynyma* from Cook Inlet Station 41.

Station DG1 (Cook Inlet) *Spisula polynyma*

Year Class	*M S L at Annulus 1	M S L at Annulus 2	M S L at Annulus 3	M S L at Annulus 4	M S L at Annulus 5	M S L at Annulus 6	M S L at Annulus 7	M S L at Annulus 8	M S L at Annulus 9	M S L at Annulus 10	M S L at Annulus 11	M S L at Annulus 12	M S L at Annulus 13	M S L at Annulus 14	Number in Age Class
1	10														6
2	9	16													70
3	7	13	19												56
4															0
5															0
6															0
7															0
8															0
9															0
10															0
11															0
12															0
13	11	16	21	36	45	51	59	69	80	90	99	113	122		1
14	7	13	20	29	36	46	54	66	78	85	95	104	109	117	2
YEAR OF ANNULUS FORMATION	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	Total 135

*M S L = Mean Shell Length

Figure 30. Growth history of *Spisula polynyma* from Cook Inlet Station DG1.

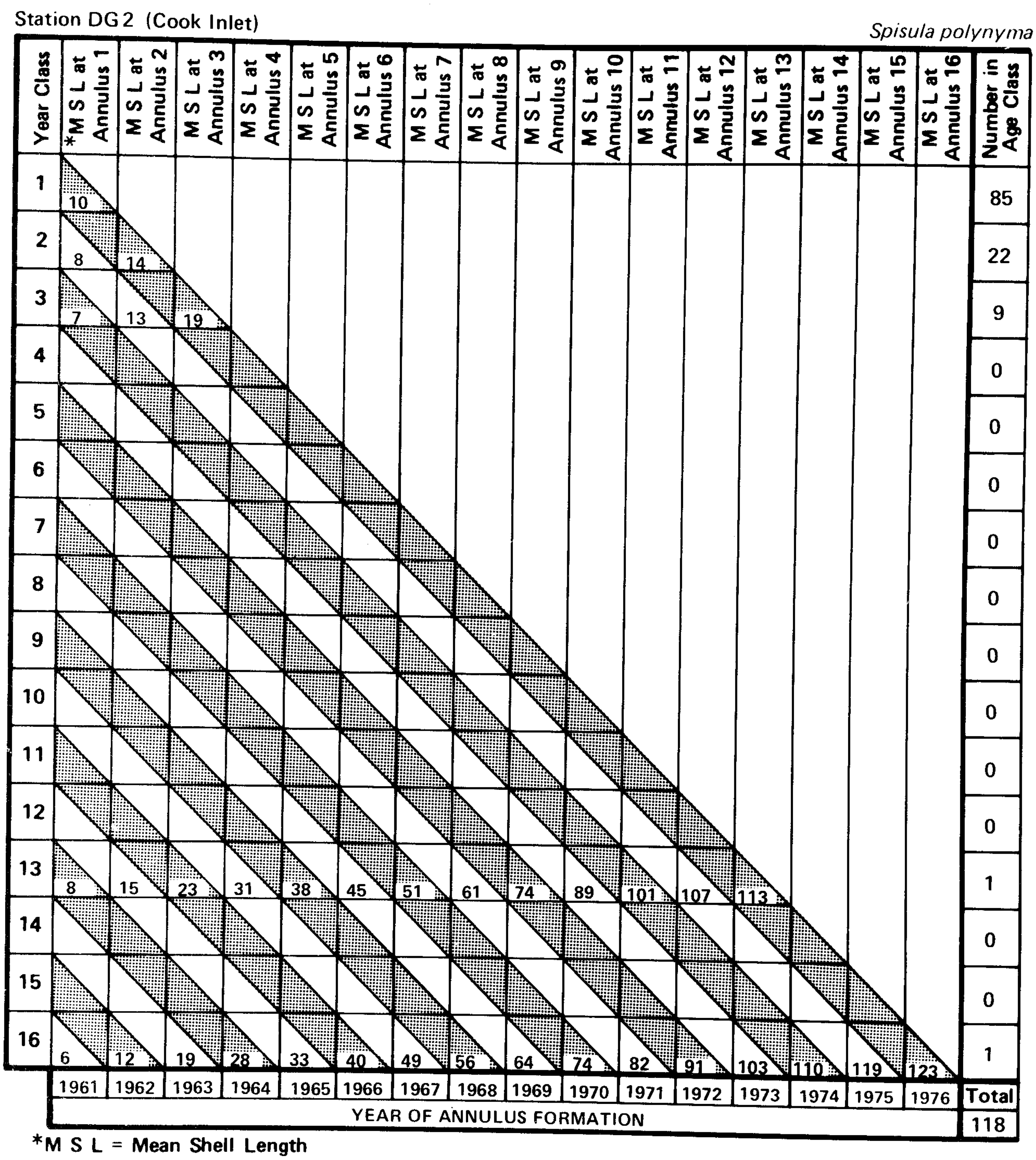

Figure 31. Growth history of *Spisula polynyma* from Cook Inlet Station DG2.

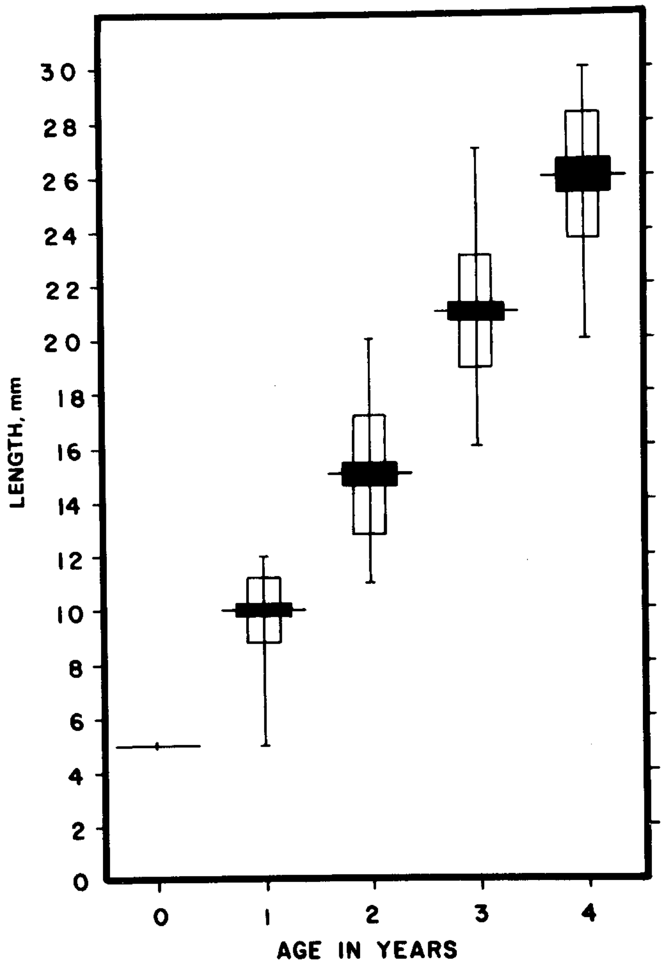

Figure 32. Growth curve for *Spisula polynyma* from seven Cook Inlet stations.

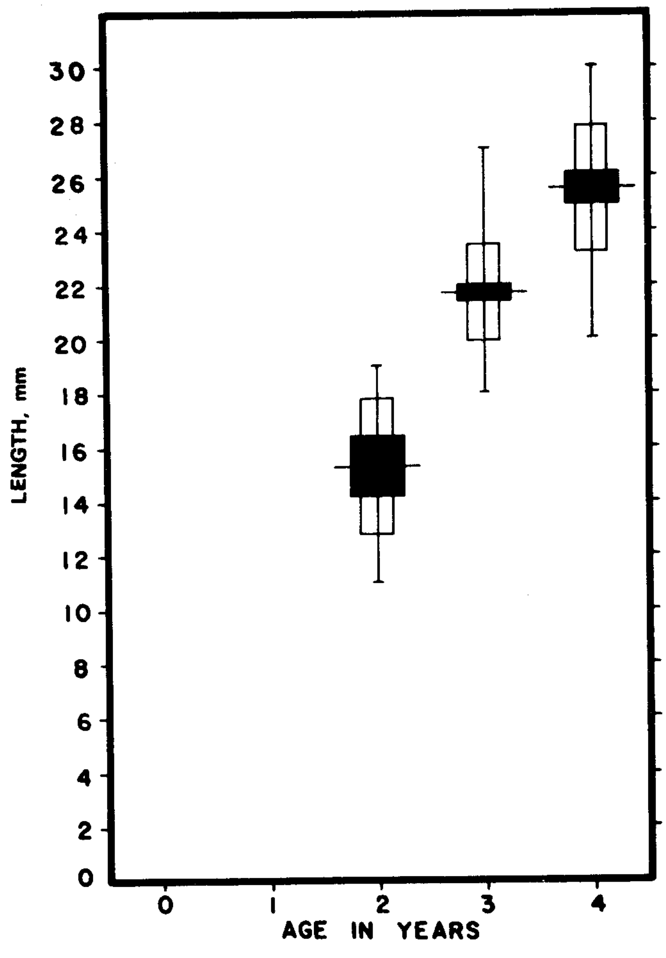

Figure 33. Growth curve for *Spisula polynyma* from Cook Inlet Station 41.

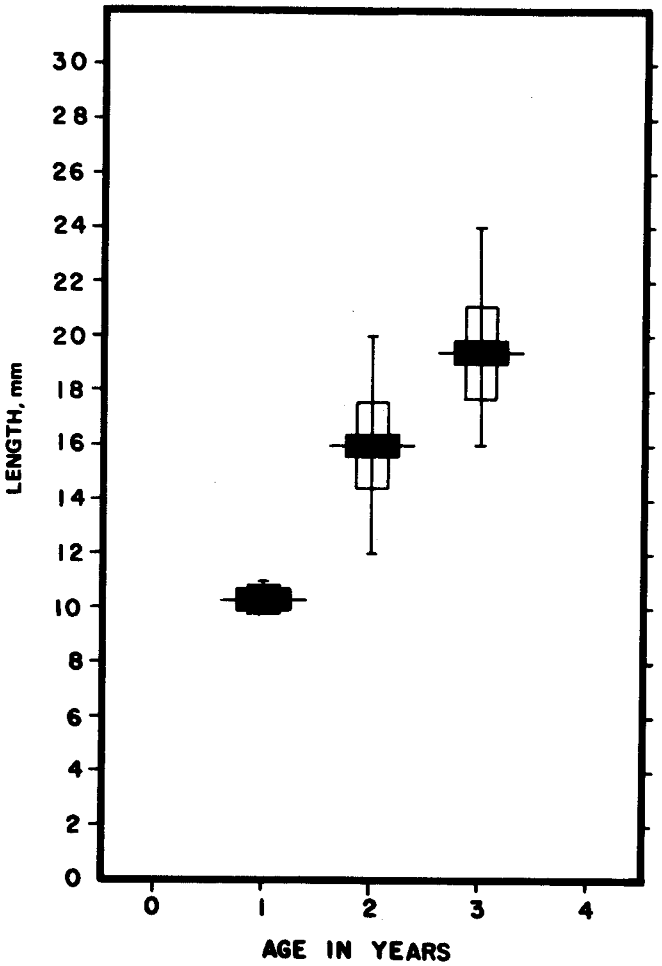

Figure 34. Growth curve for *Spisula polynyma* from Cook Inlet Station DG1.

Figure 35. Growth curve for *Spisula polynyma* from Cook Inlet Station DG2.

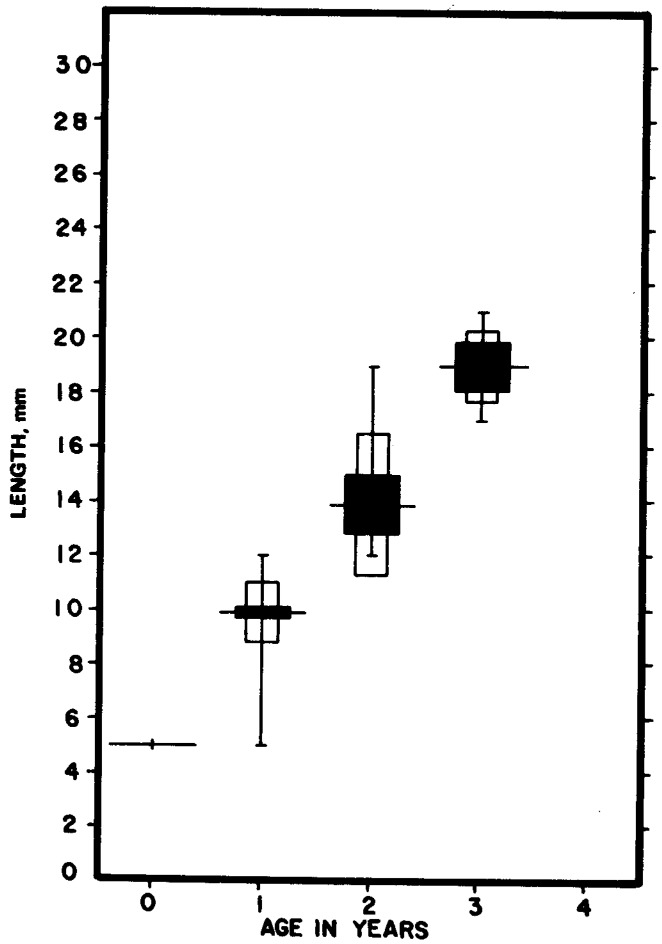

TABLE XX

AGE STRUCTURE OF *SPISULA POLYNYMA* FROM LOWER COOK INLET FROM SEVEN STATIONS (40A, 41, 42, DG 1, DG 2, DG 3, and DG 4)[1] (See Table I and Fig. 27)

N = number of clams. ML = mean length of clams. SD = standard deviation. SEM = standard error of the mean. R = range.

Year Class (Age of clams)	N	ML (mm)	SD (mm)	SEM (mm)	R (mm)
0	1	5	0	0	5
1	128	10	1.2	0.2	5- 12
2	117	15	2.2	0.4	11- 20
3	175	21	2.1	0.3	16- 27
4	56	26	2.3	0.6	20- 30
5	1*	38	0	0	38
6	1*	43	0	0	43
7	0	--	--	--	--
8	1*	82	0	0	82
9	3*	80	5.9	7.0	73- 84
10	5*	92	6.6	6.1	82- 99
11	16*	98	5.1	2.6	90-107
12	16*	107	5.3	2.7	96-113
13	14*	112	7.3	4.0	100-128
14	14*	114	4.0	2.2	107-120
15	4*	120	6.2	6.4	112-127
16	4*	118	4.0	2.0	114-123
	Total = 556				

[1] DG station locations can be obtained from ADF&G, Homer, Alaska.

* Empty shells

TABLE XXI

AGE STRUCTURE OF *SPISULA POLYNYMA* FROM LOWER COOK INLET, STATION 41.

N = number of clams. ML = mean length of clams. SD = standard deviation. SEM = standard error of the mean. R = range.

Year Class (Age of clams)	N	ML (mm)	SD (mm)	SEM (mm)	R (mm)
0	0	--	--	--	--
1	4	9	1.8	1.9	7- 11
2	21	15	2.5	1.1	11- 19
3	108	22	1.8	0.3	18- 27
4	56	26	2.3	0.6	20- 30
5	1*	38	0	0	38
6	1*	43	0	0	43
7	0	--	--	--	--
8	1*	82	0	0	82
9	3*	80	5.9	7.0	73- 84
10	5*	92	6.6	6.1	82- 99
11	14*	97	4.3	2.4	90-106
12	8*	106	5.3	3.9	96-113
13	2*	103	3.5	7.3	100-105
14	3*	112	3.0	3.6	109-115
	Total = 227				

* Empty shells.

TABLE XXII

AGE STRUCTURE OF *SPISULA POLYNYMA* FROM LOWER COOK INLET (DG 1).

N = number of clams. ML = mean length of clams. SD = standard deviation. SEM = standard error of the mean. R = range.

Year Class (Age of clams)	N	ML (mm)	SD (mm)	SEM (mm)	R (mm)
0	0	--	--	--	--
1	6	10	0.5	0.4	10- 11
2	70	16	1.6	0.4	12- 20
3	56	19	1.7	0.4	16- 24
4	0	--	--	--	--
5	0	--	--	--	--
6	0	--	--	--	--
7	0	--	--	--	--
8	0	--	--	--	--
9	0	--	--	--	--
10	0	--	--	--	--
11	0	--	--	--	--
12	0	--	--	--	--
13	1	122	0	0	122
14	2	117	4.2	8.8	114-120
Total = 135					

TABLE XXIII

AGE STRUCTURE OF *SPISULA POLYNYMA* FROM LOWER COOK INLET (DG 2).

N = number of clams. ML = mean length of clams. SD = standard deviation.
SEM = standard error of the mean. R = range.

Year Class (Age of clams)	N	ML (mm)	SD (mm)	SEM (mm)	R (mm)
0	1	5	0	0	5
1	85	10	1.1	0.2	5-12
2	22	14	2.6	1.1	12-19
3	9	19	1.3	0.9	17-21
4	0	--	--	--	--
5	0	--	--	--	--
6	0	--	--	--	--
7	0	--	--	--	--
8	0	--	--	--	--
9	0	--	--	--	--
10	0	--	--	--	--
11	0	--	--	--	--
12	0	--	--	--	--
13	1	113	0	0	113
14	0	--	--	--	--
15	0	--	--	--	--
16	1	123	0	0	123
Total = 119					

1 mm. Sixty-eight percent of the mean shell lengths for annulus 4 (Figs. 28-31) exceeded the standard deviations by more than 1 mm. No live *S. polynyma* older than 4 years of age occurred in the samples (Table XX).

Macoma calcarea

Five hundred and twenty *Macoma calcarea* were aged. The collection locations are listed in Table I and shown in Figure 36. The annual increases in shell length for each of the size classes in Cook Inlet was typically 1.3 to 2.7 mm. Growth was similar at all stations, and varied only slightly from year to year (Figs. 37-42). The calculated F ratio indicates that age classes, as defined by shell lengths, are statistically distinguishable (α=0.01; Table II). The integrity of the age classes is further illustrated in Figures 43-46 where it can be observed that none of the standard errors of the mean overlap (Hubbs and Hubbs, 1953). The majority of the 520 specimens examined were between 0 and 5 years of age. However, differential recruitment and mortality between the thirteen stations sampled resulted in a variable age composition in the collections (Tables XXIV-XXXII). For example, 90% of the *M. calcarea* from Station 28 were in the 0 year class, while 79% of the clams from Station 53 were between 3 and 5 years of age. Calculations using the age structure tables (Tables XXIV-XXXII) indicate that extensive mortality occurred after 5 years of age (94% of the clams were between 0 and 5 years of age). The oldest and largest *M. calcarea* collected was 14 years of age and 31.4 mm in length, respectively. The growth data are summarized in Tables XXIV-XXXII and Figures 37-46.

The mean shell length of any given annular age, from 1963 to 1976, showed some variation (Figs. 37-42), but of any given age the size typically (294 of the 300 mean annular lengths, Figs. 37-42) fell within 1 mm of the standard deviations calculated for each age class (Tables XXIV-XXXII).

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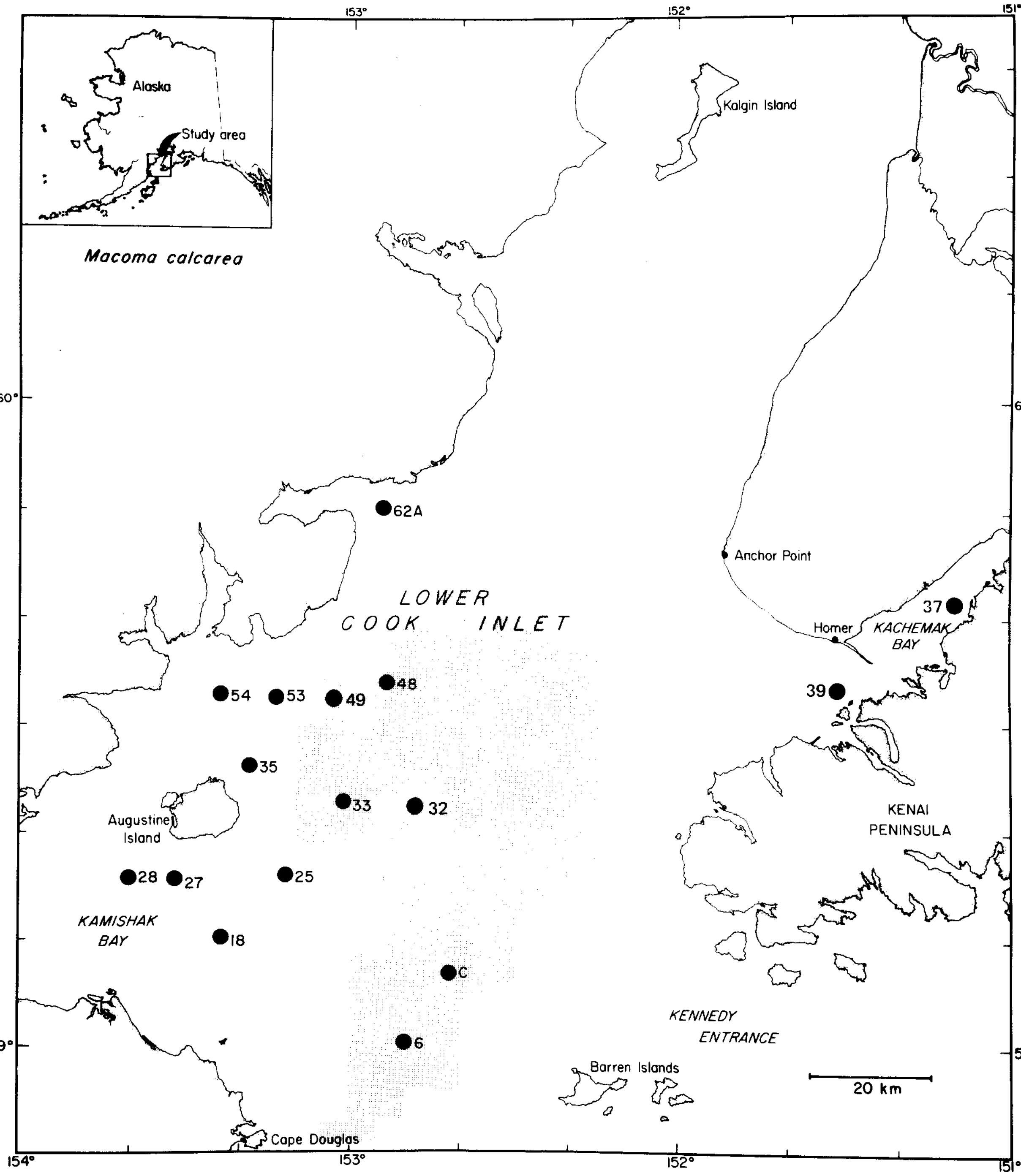

Figure 36. Distribution map of all *Macoma calcarea* from Cook Inlet stations. The shaded portion represents the tract selection area.

All Stations (Cook Inlet) *Macoma calcarea*

Year Class	*M S L at Annulus 1	M S L at Annulus 2	M S L at Annulus 3	M S L at Annulus 4	M S L at Annulus 5	M S L at Annulus 6	M S L at Annulus 7	M S L at Annulus 8	M S L at Annulus 9	M S L at Annulus 10	M S L at Annulus 11	M S L at Annulus 12	M S L at Annulus 13	M S L at Annulus 14	Number in Age Class
1	3.4														29
2	3.7	5.3													15
3	3.7	5.6	7.4												49
4	3.6	5.6	7.4	9.2											49
5	3.7	5.8	8.0	10.1	11.9										27
6	3.9	6.0	7.9	10.6	12.4	14.3									9
7	3.9	6.0	8.4	10.7	12.4	14.9	16.9								3
8	3.9	5.5	7.9	9.8	11.9	13.9	16.1	18.2							2
9	3.9	5.8	8.0	9.9	12.2	14.1	16.1	18.3	20.1						4
10	3.7	5.6	8.0	9.9	12.6	13.9	16.3	19.0	20.7	22.4					4
11	3.7	6.0	8.6	10.8	12.7	14.6	16.6	18.5	20.2	22.3	24.2				4
12	4.3	6.1	8.3	10.1	12.5	15.2	17.4	19.5	21.1	22.7	24.6	26.7			3
13	3.4	5.7	8.2	10.9	12.1	14.0	17.0	19.3	21.1	22.8	24.6	26.3	28.3		3
14	3.8	5.7	7.5	9.7	12.8	14.4	15.5	18.3	21.4	23.4	25.0	27.1	29.3	31.4	1
YEAR OF ANNULUS FORMATION	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	Total 202

* M S L = Mean Shell Length, mm

Figure 37. Growth history of *Macoma calcarea* from thirteen Cook Inlet stations.

Station 18 (Cook Inlet) *Macoma calcarea*

Year Class	*M S L at Annulus 1	M S L at Annulus 2	M S L at Annulus 3	M S L at Annulus 4	M S L at Annulus 5	M S L at Annulus 6	Number in Age Class
1	4.2						3
2	4.4	6.0					1
3	3.9	5.8	7.9				8
4	3.9	6.4	8.0	9.7			5
5	3.6	6.4	8.5	10.9	12.3		3
6	4.4	6.5	8.4	10.8	12.9	14.8	2
	1971	1972	1973	1974	1975	1976	Total
	YEAR OF ANNULUS FORMATION						22

*M S L = Mean Shell Length, mm

Figure 38. Growth history of *Macoma calcarea* from Cook Inlet Station 18.

Station 27 (Cook Inlet) *Macoma calcarea*

Year Class	*M S L at Annulus 1	M S L at Annulus 2	M S L at Annulus 3	M S L at Annulus 4	M S L at Annulus 5	M S L at Annulus 6	M S L at Annulus 7	M S L at Annulus 8	M S L at Annulus 9	M S L at Annulus 10	M S L at Annulus 11	Number in Age Class
1	4.3											4
2	3.6	5.0										4
3	3.9	5.6	7.1									10
4	3.5	5.4	6.9	8.6								18
5	3.5	5.3	7.3	9.4	11.3							3
6												0
7												0
8												0
9	3.8	5.4	7.1	8.7	11.0	13.6	16.1	17.9	19.4			1
10	3.8	5.2	6.9	9.9	12.1	13.6	16.3	18.1	20.2	22.8		1
11	3.9	6.6	8.7	10.8	12.3	14.7	16.3	17.9	19.3	21.2	23.5	1
	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	Total
	YEAR OF ANNULUS FORMATION											42

*M S L = Mean Shell Length, mm

Figure 39. Growth history of *Macoma calcarea* from Cook Inlet Station 27.

Station 28 (Cook Inlet) *Macoma calcarea*

Year Class	*M S L at Annulus 1	M S L at Annulus 2	M S L at Annulus 3	M S L at Annulus 4	M S L at Annulus 5	M S L at Annulus 6	M S L at Annulus 7	Number in Age Class
1	2.9							15
2	3.2	5.4						2
3	3.6	5.6	7.2					7
4	3.5	5.4	7.6	9.6				7
5	3.7	5.5	8.2	10.4	12.6			3
6								0
7	3.8	6.2	8.2	10.2	12.1	14.8	15.5	1
YEAR OF ANNULUS FORMATION	1970	1971	1972	1973	1974	1975	1976	Total 35

* M S L = Mean Shell Length, mm

Figure 40. Growth history of *Macoma calcarea* from Cook Inlet Station 28.

Station 33 (Cook Inlet) *Macoma calcarea*

Year Class	*M S L at Annulus 1	M S L at Annulus 2	M S L at Annulus 3	M S L at Annulus 4	M S L at Annulus 5	M S L at Annulus 6	M S L at Annulus 7	M S L at Annulus 8	Number in Age Class
1	3.2								3
2	3.9	5.6							2
3	3.6	5.6	7.2						10
4	3.6	5.6	7.4	9.0					8
5	3.7	5.9	8.3	10.4	12.1				5
6									0
7									0
8	3.2	5.3	7.6	9.9	12.3	14.7	16.9	19.4	1
YEAR OF ANNULUS FORMATION	1969	1970	1971	1972	1973	1974	1975	1976	Total 29

*M S L = Mean Shell Length, mm

Figure 41. Growth history of *Macoma calcarea* from Cook Inlet Station 33.

Station 39 (Cook Inlet) *Macoma calcarea*

Year Class	*M S L at Annulus 1	M S L at Annulus 2	M S L at Annulus 3	M S L at Annulus 4	M S L at Annulus 5	M S L at Annulus 6	M S L at Annulus 7	M S L at Annulus 8	M S L at Annulus 9	M S L at Annulus 10	M S L at Annulus 11	M S L at Annulus 12	M S L at Annulus 13	M S L at Annulus 14	Number in Age Class
1	3.9														4
2	3.9	5.5													1
3	3.7	5.8	7.5												4
4	4.2	6.7	8.1	10.7											1
5	3.6	5.4	7.6	9.5	11.9										5
6	3.8	5.9	7.8	10.5	12.5	14.8									2
7	4.0	6.0	8.5	10.9	12.6	15.0	17.7								2
8															0
9	4.5	6.7	8.4	10.1	12.8	14.5	16.1	18.7	21.2						1
10	3.8	5.4	8.7	9.4	13.1	14.3	16.0	18.2	20.2	22.2					1
11	3.5	6.7	8.9	11.2	12.8	15.0	16.6	18.6	20.6	23.5	26.0				1
12	4.2	5.7	9.3	10.8	12.3	14.8	16.9	19.1	21.1	22.7	25.4	28.1			1
13															0
14	3.8	5.7	7.5	9.7	12.8	14.4	15.5	18.3	21.4	23.4	25.0	27.1	29.3	31.4	1
	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	Total
	YEAR OF ANNULUS FORMATION														24

*M S L = Mean Shell Length, mm

Figure 42. Growth history of *Macoma calcarea* from Cook Inlet Station 39.

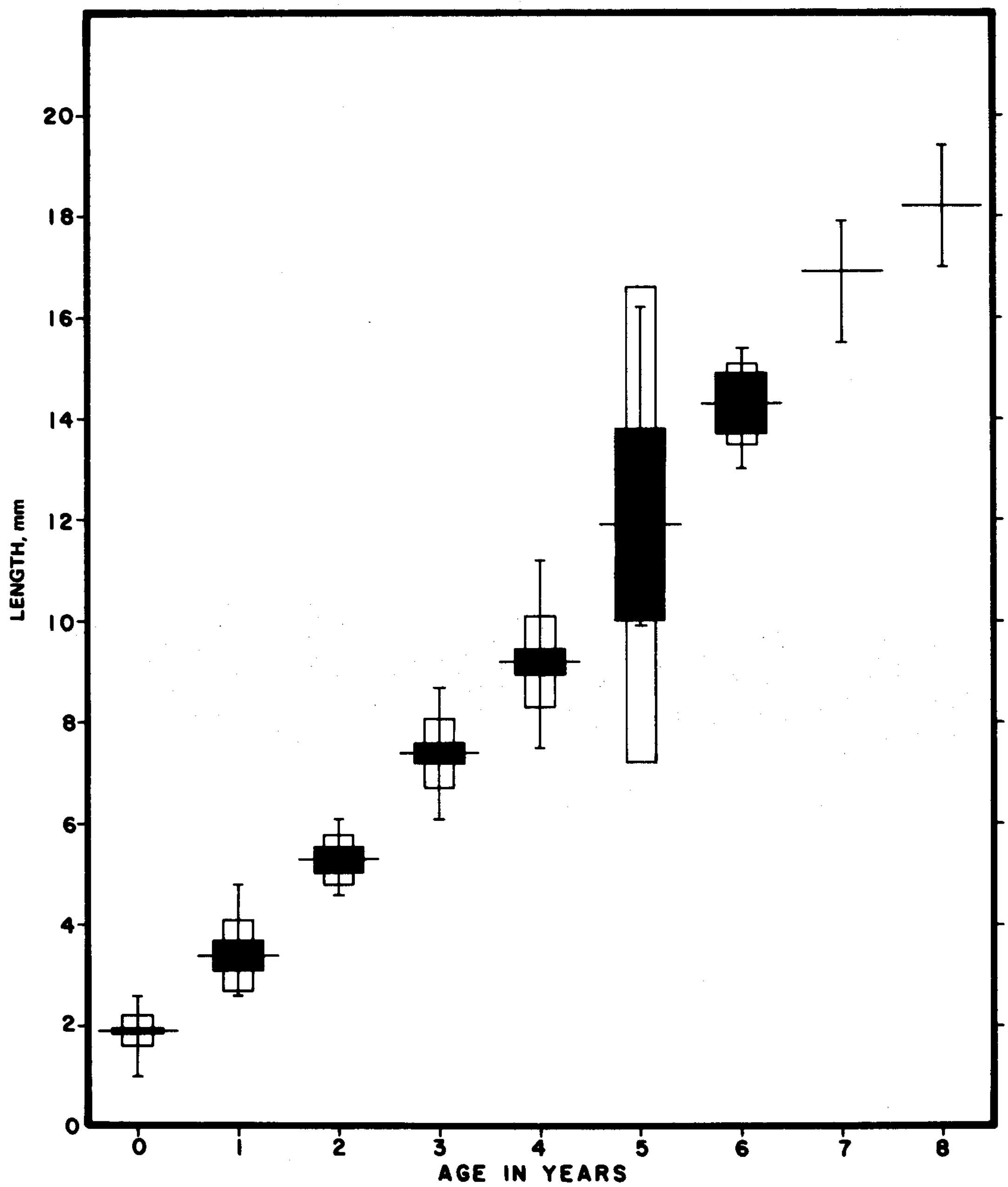

Figure 43. Growth curve for *Macoma calcarea* from thirteen Cook Inlet stations.

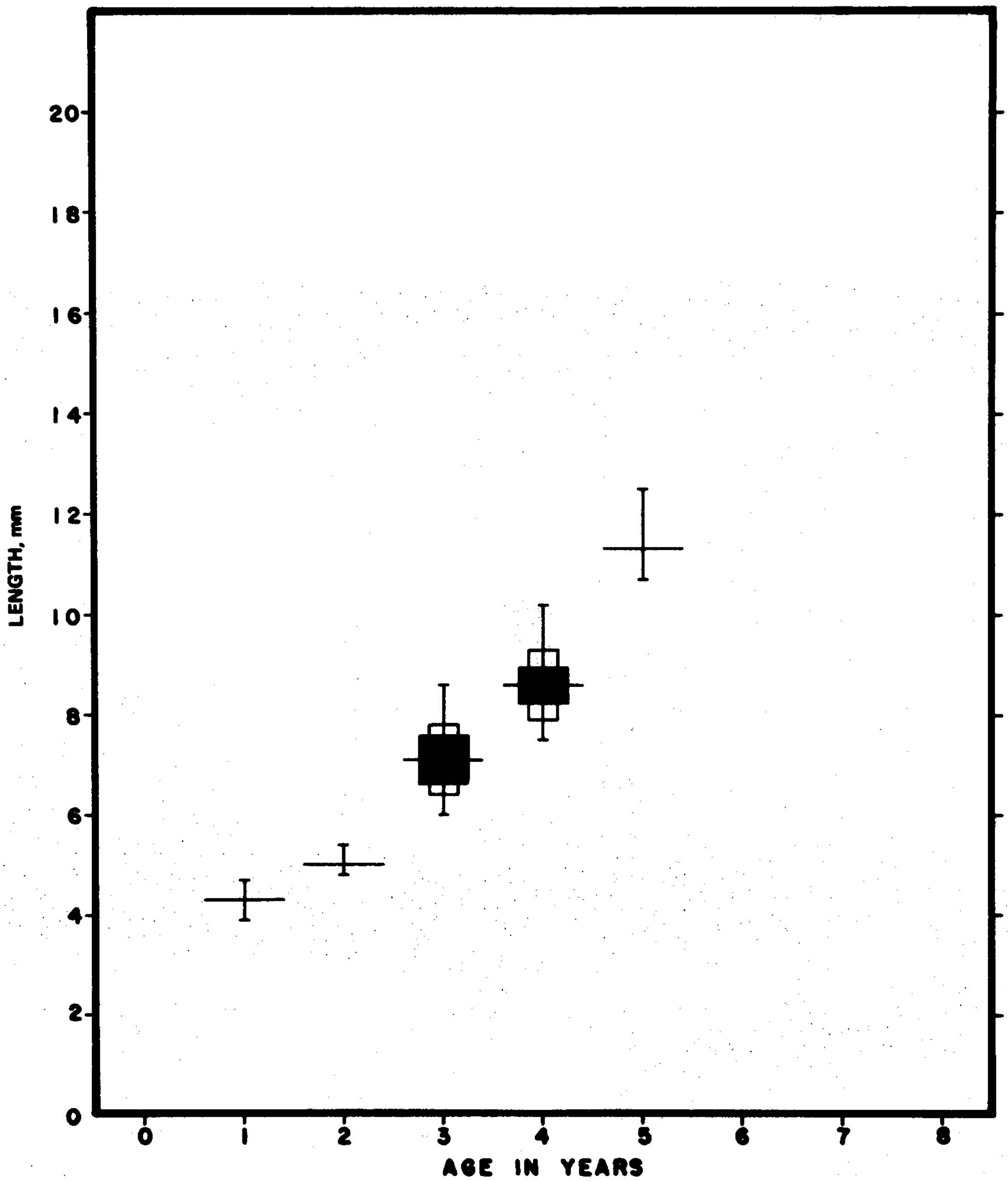

Figure 44. Growth curve for *Macoma calcarea* from Cook Inlet Station 27.

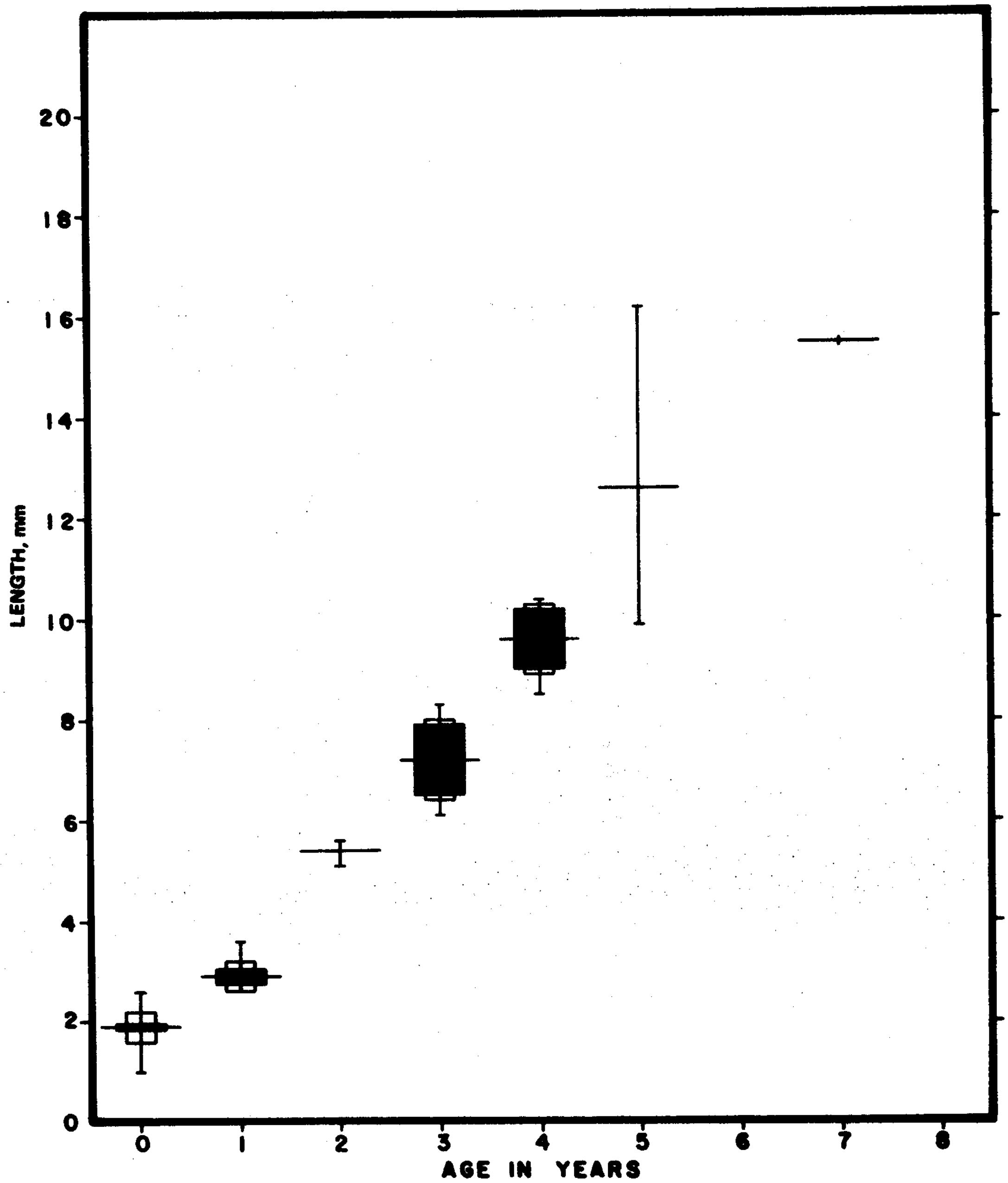

Figure 45. Growth curve for *Macoma calcarea* from Cook Inlet Station 28.

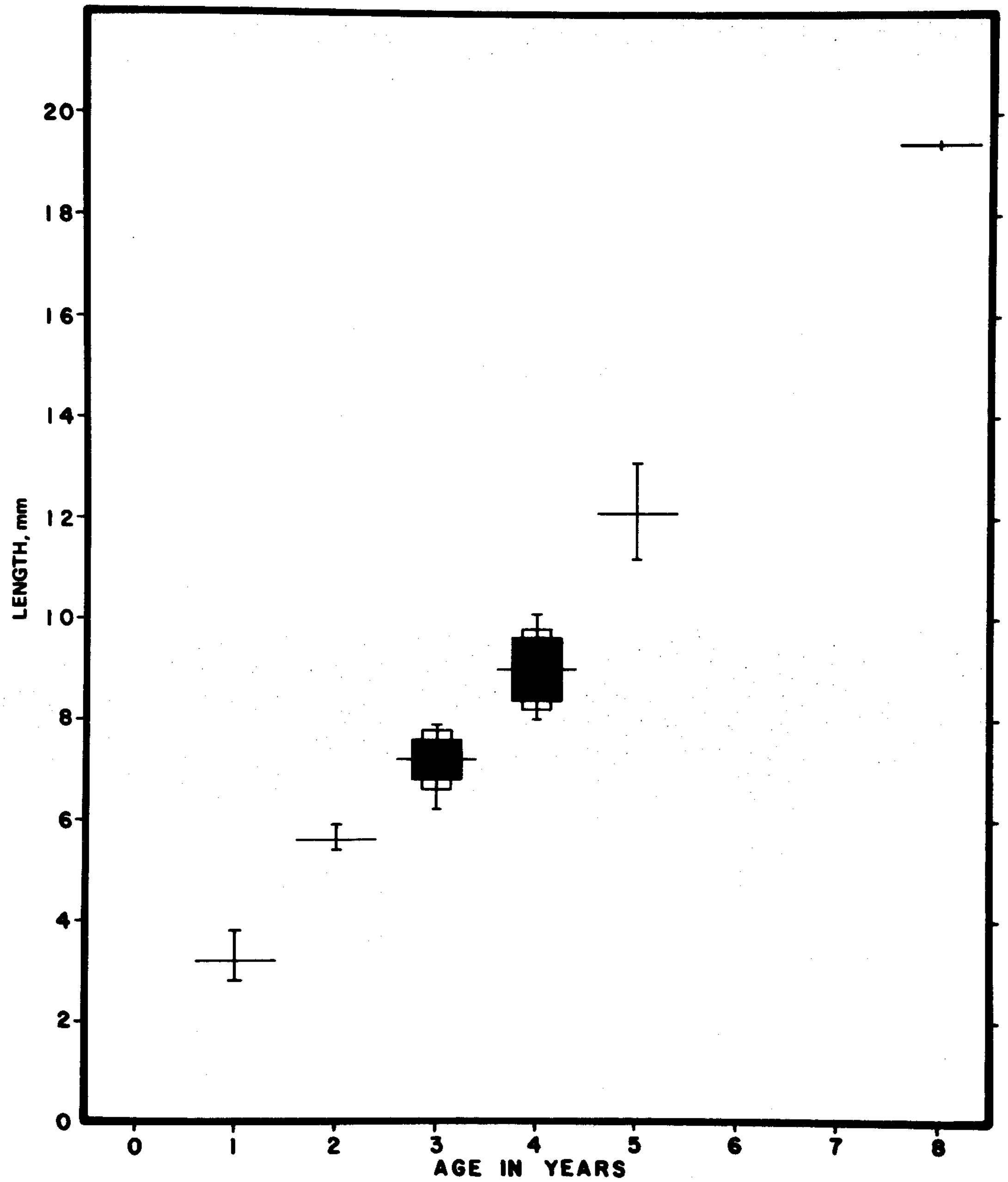

Figure 46. Growth curve for *Macoma calcarea* from Cook Inlet Station 33.

TABLE XXIV

AGE STRUCTURE OF *MACOMA CALCAREA* FROM THIRTEEN LOWER COOK INLET STATIONS (C, 18, 25, 27, 28, 32, 33, 35, 37, 39, 49, 53, and 54) (See Table I and Fig. 36).

N = number of clams. ML = mean length of clams. SD = standard deviation. SEM = standard error of the mean. R = range.

Year Class (Age of clams)	N	ML (mm)	SD (mm)	SEM (mm)	R (mm)
0	318	1.9	0.3	0.03	1.0- 2.6
1	29	3.4	0.7	0.28	2.6- 4.8
2	15	5.3	0.5	0.25	4.6- 6.1
3	49	7.4	0.7	0.19	6.1- 8.7
4	49	9.2	0.9	0.26	7.5-11.2
5	27	11.9	4.7	1.89	9.9-16.2
6	9	14.3	0.8	0.59	13.0-15.4
7	3	16.9	1.3	1.85	15.5-17.9
8	2	18.2	1.7	3.50	17.0-19.4
9	4	20.1	0.8	0.94	19.4-21.2
10	4	22.4	0.4	0.46	22.0-22.8
11	4	24.2	1.2	1.47	23.3-26.0
12	3	26.7	1.3	1.85	25.7-28.1
13	3	28.3	0.8	1.13	27.7-29.2
14	1	31.4	0.0	0.00	31.4

Total = 520

TABLE XXV

AGE STRUCTURE OF *MACOMA CALCAREA* FROM LOWER COOK INLET STATION 18.

N = number of clams. ML = mean length of clams. SD = standard deviation. SEM = standard error of the mean. R = range.

Year Class (Age of clams)	N	ML (mm)	SD (mm)	SEM (mm)	R (mm)
0	0	--	--	--	--
1	3	4.2	0.7	0.95	3.5- 4.8
2	1	6.0	0.0	0.00	6.0
3	8	7.9	0.5	0.38	7.3- 8.7
4	5	9.7	0.9	0.91	8.9-11.2
5	3	12.3	1.3	1.92	11.6-13.1
6	2	14.8	0.1	0.29	14.7-14.9
Total = 22					

TABLE XXVI

AGE STRUCTURE OF *MACOMA CALCAREA* FROM LOWER COOK INLET STATION 27.

N = number of clams. ML = mean length of clams. SD = standard deviation. SEM = standard error of the mean. R = range.

Year Class (Age of clams)	N	ML (mm)	SD (mm)	SEM (mm)	R (mm)
0	0	--	--	--	--
1	4	4.3	0.3	0.39	3.9- 4.7
2	4	5.0	0.3	0.34	4.8- 5.4
3	10	7.1	0.7	0.47	6.0- 8.6
4	18	8.6	0.7	0.34	7.5-10.2
5	3	11.3	1.6	2.37	10.7-12.5
6	0	--	--	--	--
7	0	--	--	--	--
8	0	--	--	--	--
9	1	19.4	0.0	0.00	19.4
10	1	22.8	0.0	0.00	22.8
11	1	23.5	0.0	0.00	23.5
Total = 42					

TABLE XXVII

AGE STRUCTURE OF *MACOMA CALCAREA* FROM LOWER COOK INLET STATION 28.

N = number of clams. ML = mean length of clams. SD = standard deviation. SEM = standard error of the mean. R = range.

Year Class (Age of clams)	N	ML (mm)	SD (mm)	SEM (mm)	R (mm)
0	317	1.9	0.3	0.03	1.0- 2.6
1	15	2.9	0.3	0.16	2.6- 3.6
2	2	5.4	0.4	0.73	5.1- 5.6
3	7	7.2	0.8	0.70	6.1- 8.3
4	7	9.6	0.7	0.62	8.5-10.4
5	3	12.6	5.7	8.36	9.9-16.2
6	0	--	--	--	--
7	1	15.5	0.0	0.00	15.5

Total = 352

TABLE XXVIII

AGE STRUCTURE OF *MACOMA CALCAREA* FROM LOWER COOK INLET STATION 33.

N = number of clams. ML = mean length of clams. SD = standard deviation. SEM = standard error of the mean. R = range.

Year Class (Age of clams)	N	ML (mm)	SD (mm)	SEM (mm)	R (mm)
0	0	--	--	--	--
1	3	3.2	0.5	0.77	2.8- 3.8
2	2	5.6	0.4	0.73	5.4- 5.9
3	10	7.2	0.6	0.39	6.2- 7.9
4	8	9.0	0.8	0.63	8.0-10.1
5	5	12.1	1.2	1.20	11.2-13.1
6	0	--	--	--	--
7	0	--	--	--	--
8	1	19.4	0.0	0.00	19.4

Total = 29

TABLE XXIX

AGE STRUCTURE OF *MACOMA CALCAREA* FROM LOWER COOK INLET STATION 35.

N = number of clams. ML = mean length of clams. SD = standard deviation. SEM = standard error of the mean. R = range.

Year Class (Age of clams)	N	ML (mm)	SD (mm)	SEM (mm)	R (mm)
0	0	--	--	--	--
1	0	--	--	--	--
2	1	5.5	0.0	0.00	5.5
3	0	--	--	--	--
4	5	10.3	0.4	0.46	9.9-10.9
5	2	12.3	0.5	1.03	12.0-12.5
6	2	13.1	0.1	0.15	13.0-13.1
	Total = 10				

TABLE XXX

AGE STRUCTURE OF *MACOMA CALCAREA* FROM LOWER COOK INLET STATION 39.

N = number of clams. ML = mean length of clams. SD = standard deviation. SEM = standard error of the mean. R = range.

Year Class (Age of clams)	N	ML (mm)	SD (mm)	SEM (mm)	R (mm)
0	1	1.5	0.0	0.00	1.5
1	4	3.9	0.7	0.88	3.1- 4.8
2	1	5.5	0.0	0.00	5.5
3	4	7.5	0.6	0.74	6.6- 8.0
4	1	10.7	0.0	0.00	10.7
5	5	11.9	2.1	2.15	10.3-13.5
6	2	14.8	0.9	1.90	14.1-15.4
7	2	17.7	0.4	0.73	17.4-17.9
8	0	--	--	--	--
9	1	21.2	0.0	0.00	21.2
10	1	22.2	0.0	0.00	22.2
11	1	26.0	0.0	0.00	26.0
12	1	28.1	0.0	0.00	28.1
13	0	--	--	--	--
14	1	31.4	0.0	0.00	31.4
Total = 25					

TABLE XXXI

AGE STRUCTURE OF *MACOMA CALCAREA* FROM LOWER COOK INLET STATION 49.

N = number of clams. ML = mean length of clams. SD = standard deviation.
SEM = standard error of the mean. R = range.

Year Class (Age of clams)	N	ML (mm)	SD (mm)	SEM (mm)	R (mm)
0	0	--	--	--	--
1	0	--	--	--	--
2	0	--	--	--	--
3	2	7.1	0.6	1.31	6.6- 7.5
4	2	10.0	1.2	2.48	9.1-10.8
5	0	--	--	--	--
6	1	14.7	0.0	0.00	14.7
7	0	--	--	--	--
8	1	17.0	0.0	0.00	17.0
9	1	19.7	0.0	0.00	19.7
10	1	22.0	0.0	0.00	22.0
11	1	23.3	0.0	0.00	23.3
12	2	26.0	0.4	0.73	25.7-26.2
	Total = 11				

TABLE XXXII

AGE STRUCTURE OF *MACOMA CALCAREA* FROM LOWER COOK INLET STATION 54.

N = number of clams. ML = mean length of clams. SD = standard deviation.
SEM = standard error of the mean. R = range.

Year Class (Age of clams)	N	ML (mm)	SD (mm)	SEM (mm)	R (mm)
0	0	--	--	--	--
1	0	--	--	--	--
2	3	4.9	0.3	0.45	4.6- 5.2
3	4	7.3	0.6	0.69	6.8- 8.1
4	2	9.3	0.1	0.29	9.2- 9.4
5	4	11.7	1.4	1.72	10.7-12.7
6	2	14.5	0.4	0.73	14.2-14.7
	Total = 15				

Tellina nuculoides

Six hundred and seventy-three *Tellina nuculoides* were aged. The collection locations are listed in Table I and shown in Figure 47. The annual increase in shell length for each of the size classes in Cook Inlet was typically 0.5 to 2.0 mm. Growth was similar at all stations, and varied only slightly from year to year (Figs. 48-53). The calculated F ratio indicates that age classes, as defined by shell lengths, are statistically distinguishable (α=0.01; Table II). The integrity of the age classes is further illustrated in Figures 54-57 where it can be observed that none of the standard errors of the mean overlap (Hubbs and Hubbs, 1953). The majority of the 673 specimens examined were between 5 and 10 years of age. Station UW2 had a different age structure from that found at all other stations; 71% of the *T. nuculoides* from UW2 were in the 1 year class (Tables XXXIII-XXXVI). Calculations using the age structure tables (Tables XXXIII-XXXVI) indicate extensive mortality occurs after 9-10 years of age. The oldest and largest *T. nuculoides* collected were 13 years of age and 16.4 mm in length, respectively. The growth data are summarized in Tables XXXIII-XXXVI and Figures 48-57.

The mean shell length at any given annular age, from 1964 to 1976, showed some variation (Figs. 48-53), but at any given age the size typically (326 of the 336 mean annular lengths, Figs. 48-53) fell within 1 mm of the standard deviations calculated for each age class (Tables XXXIII-XXXVI).

DISCUSSION

Nucula tenuis

Survival within each year class varied from station to station (Tables III-VIII). However, when specimens from all stations are combined (Table III) it is apparent that the number of individuals in year classes 0 through 4 are relatively abundant in comparison to year classes 5 through 7. This difference is attributed to increased natural mortality in clams older than 4. The similarity in year class strengths of clams 0 through 4 years of age suggests that annual recruitment and survival, while patchy at individual stations, were relatively stable for Cook Inlet.

Text continued on page 291

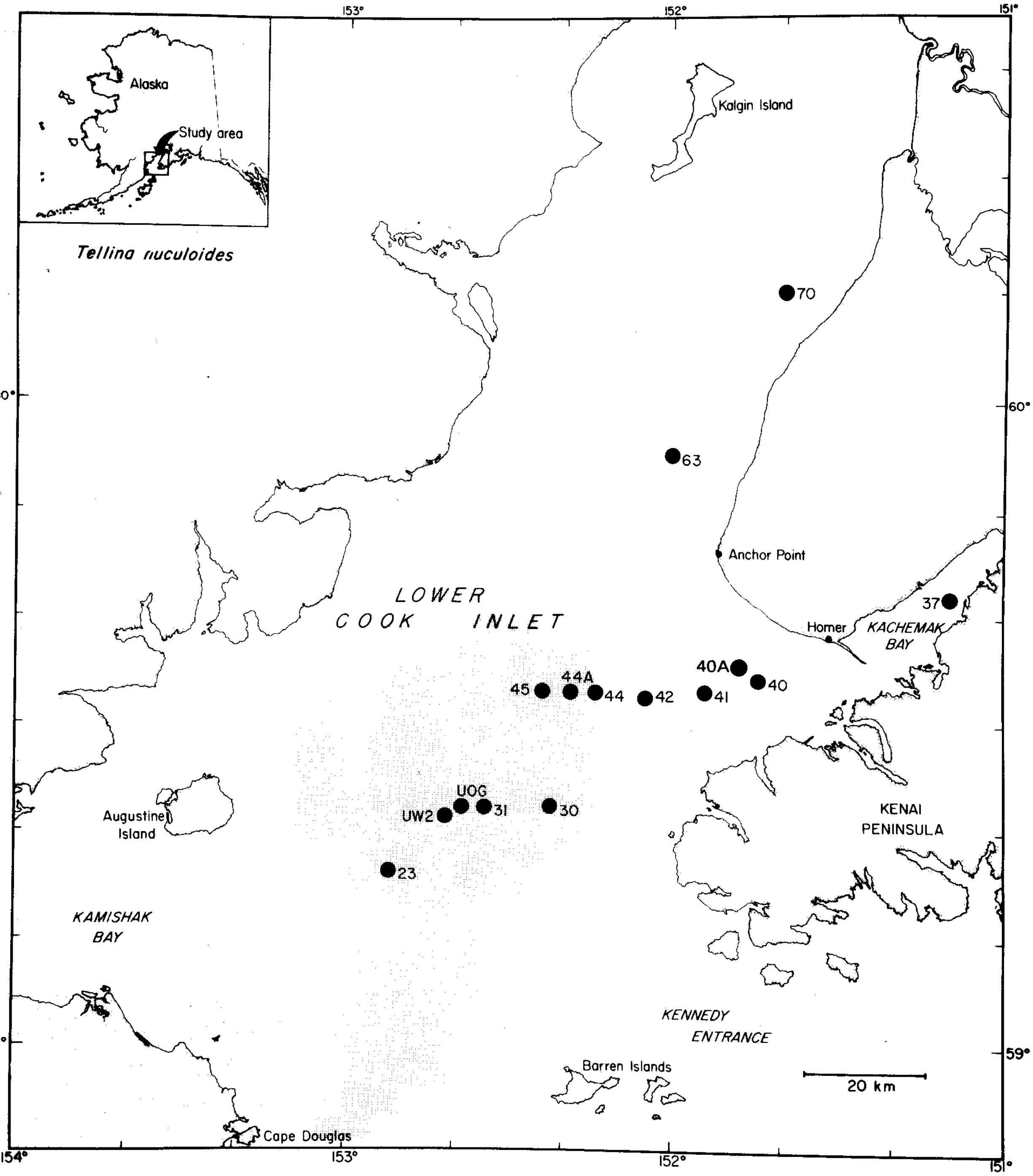

Figure 47. Distribution map of all *Tellina nuculoides* from Cook Inlet stations. The shaded portion represents the tract selection area.

All Stations (Cook Inlet) *Tellina nuculoides*

Year Class	*M S L at Annulus 1	M S L at Annulus 2	M S L at Annulus 3	M S L at Annulus 4	M S L at Annulus 5	M S L at Annulus 6	M S L at Annulus 7	M S L at Annulus 8	M S L at Annulus 9	M S L at Annulus 10	M S L at Annulus 11	M S L at Annulus 12	M S L at Annulus 13	Number in Age Class
1	3.6													70
2	3.6	5.4												20
3	3.6	5.8	7.5											43
4	3.4	5.5	7.4	8.8										48
5	3.6	5.4	7.4	9.0	10.2									95
6	3.6	5.5	7.2	8.8	9.9	10.7								120
7	3.4	5.4	7.2	8.6	9.8	10.7	11.4							112
8	3.4	5.5	7.6	9.1	10.2	11.2	11.9	12.4						79
9	3.3	5.3	7.4	9.0	10.1	10.9	11.6	12.3	12.8					38
10	3.2	5.2	7.6	9.5	10.7	11.4	12.0	12.7	13.1	13.5				20
11	3.3	5.5	7.9	9.8	11.2	12.0	12.4	12.9	13.5	13.9	14.2			11
12	3.2	4.7	7.7	10.6	11.6	12.5	13.0	13.7	14.3	14.5	14.8	15.0		2
13	3.3	6.0	9.0	11.6	13.3	14.1	14.5	14.8	14.9	15.4	15.7	16.0	16.4	1
	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	Total
	YEAR OF ANNULUS FORMATION													659

* M S L = Mean Shell Length, mm

Figure 48. Growth history of *Tellina nuculoides* from nine Cook Inlet stations.

Station 31 (Cook Inlet) *Tellina nuculoides*

Year Class	*M S L at Annulus 1	M S L at Annulus 2	M S L at Annulus 3	M S L at Annulus 4	M S L at Annulus 5	M S L at Annulus 6	M S L at Annulus 7	Number in Age Class
1								0
2	4.0	6.0						3
3	3.0	5.5	7.2					1
4	3.1	4.8	6.6	7.3				1
5	4.1	6.0	7.6	9.1	10.5			4
6	3.8	5.5	6.8	7.8	9.1	10.0		6
7	3.7	5.2	6.4	7.8	9.0	9.8	10.4	4
	1970	1971	1972	1973	1974	1975	1976	Total
	YEAR OF ANNULUS FORMATION							19

*M S L = Mean Shell Length

Figure 49. Growth history of *Tellina nuculoides* from Cook Inlet Station 31.

Station 42 (Cook Inlet) *Tellina nuculoides*

Year Class	*M S L at Annulus 1	M S L at Annulus 2	M S L at Annulus 3	M S L at Annulus 4	M S L at Annulus 5	M S L at Annulus 6	M S L at Annulus 7	M S L at Annulus 8	M S L at Annulus 9	M S L at Annulus 10	M S L at Annulus 11	M S L at Annulus 12	M S L at Annulus 13	Number in Age Class
1														0
2	3.3	5.2												5
3	3.5	6.0	7.9											15
4	3.3	5.6	7.5	8.9										28
5	3.6	5.4	7.4	9.0	10.3									47
6	3.5	5.5	7.3	9.0	10.1	10.9								54
7	3.3	5.5	7.3	8.7	9.9	10.9	11.6							52
8	3.5	5.6	7.7	9.3	10.5	11.5	12.2	12.8						41
9	3.3	5.5	7.8	9.3	10.4	11.2	12.0	12.7	13.2					22
10	3.4	5.4	8.0	10.2	11.4	12.0	12.7	13.3	13.8	14.3				10
11	3.3	5.6	8.3	10.3	11.6	12.3	12.7	13.2	13.8	14.2	14.6			9
12	3.2	4.7	7.7	10.6	11.6	12.5	13.0	13.7	14.3	14.5	14.8	15.0		2
13	3.3	6.0	9.0	11.6	13.3	14.1	14.5	14.8	14.9	15.4	15.7	16.0	16.4	1
	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	Total
	YEAR OF ANNULUS FORMATION													286

*M S L = Mean Shell Length

Figure 50. Growth history of *Tellina nuculoides* from Cook Inlet Station 42.

Station 44 (Cook Inlet) *Tellina nuculoides*

Year Class	*M S L at Annulus 1	M S L at Annulus 2	M S L at Annulus 3	M S L at Annulus 4	M S L at Annulus 5	M S L at Annulus 6	M S L at Annulus 7	M S L at Annulus 8	M S L at Annulus 9	M S L at Annulus 10	M S L at Annulus 11	Number in Age Class
1												0
2	3.9	6.0										2
3	3.6	5.8	7.4									22
4	3.5	5.6	7.7	9.1								10
5	3.6	5.4	7.4	9.1	10.3							33
6	3.6	5.5	7.3	8.7	9.9	10.7						55
7	3.5	5.3	7.3	8.8	9.9	10.8	11.4					49
8	3.4	5.4	7.4	9.0	10.1	10.9	11.6	12.1				34
9	3.3	5.0	6.9	8.7	9.8	10.6	11.2	11.8	12.3			10
10	3.5	5.6	7.9	10.1	11.3	11.8	12.3	12.8	13.1	13.4		2
11	3.4	4.8	6.2	7.7	9.4	10.5	11.1	11.6	11.9	12.2	12.6	2
YEAR OF ANNULUS FORMATION	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	Total 219

*M S L = Mean Shell Length

Figure 51. Growth history of *Tellina nuculoides* from Cook Inlet Station 44.

Station 63 (Cook Inlet) *Tellina nuculoides*

Year Class	*M S L at Annulus 1	M S L at Annulus 2	M S L at Annulus 3	M S L at Annulus 4	M S L at Annulus 5	M S L at Annulus 6	M S L at Annulus 7	M S L at Annulus 8	M S L at Annulus 9	M S L at Annulus 10	Number in Age Class
1											0
2											0
3	3.6	4.9	6.4								2
4	3.2	4.3	6.0	7.8							2
5	3.7	5.0	6.6	7.8	8.8						4
6	3.3	4.9	6.4	7.7	8.8	9.6					4
7	3.6	5.3	6.4	7.6	8.6	9.4	10.3				4
8	3.6	5.1	6.9	8.4	9.5	10.4	11.0	11.7			3
9	3.6	5.3	6.9	8.5	9.7	10.5	11.3	11.8	12.2		5
10	3.0	5.0	7.2	8.9	9.9	10.9	11.4	11.8	12.3	12.6	7
YEAR OF ANNULUS FORMATION	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	Total 31

*M S L = Mean Shell Length

Figure 52. Growth history of *Tellina nuculoides* from Cook Inlet Station 63.

Station UW2 (Cook Inlet) *Tellina nuculoides*

Year Class	*M S L at Annulus 1	M S L at Annulus 2	M S L at Annulus 3	M S L at Annulus 4	M S L at Annulus 5	Number in Age Class
1	3.6					67
2	3.6	5.2				9
3	3.9	5.6	7.0			2
4						0
5	4.1	5.7	8.0	9.7	10.3	2
**Y A F	1972	1973	1974	1975	1976	Total 80

*M S L = Mean Shell Length
**Y A F = Year of Annulus Formation

Figure 53. Growth history of *Tellina nuculoides* from Cook Inlet Station UW2.

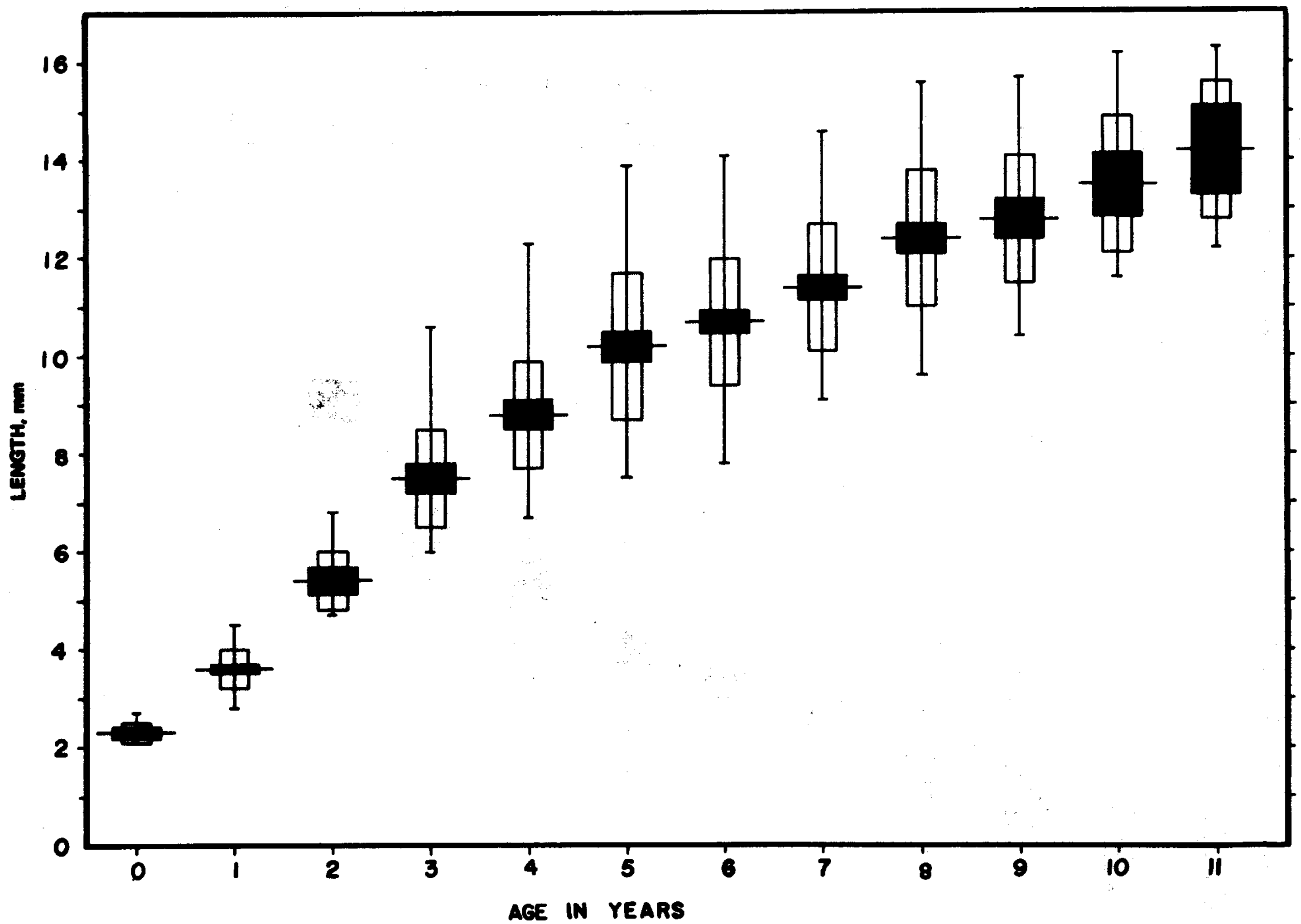

Figure 54. Growth curve for *Tellina nuculoides* from nine Cook Inlet stations.

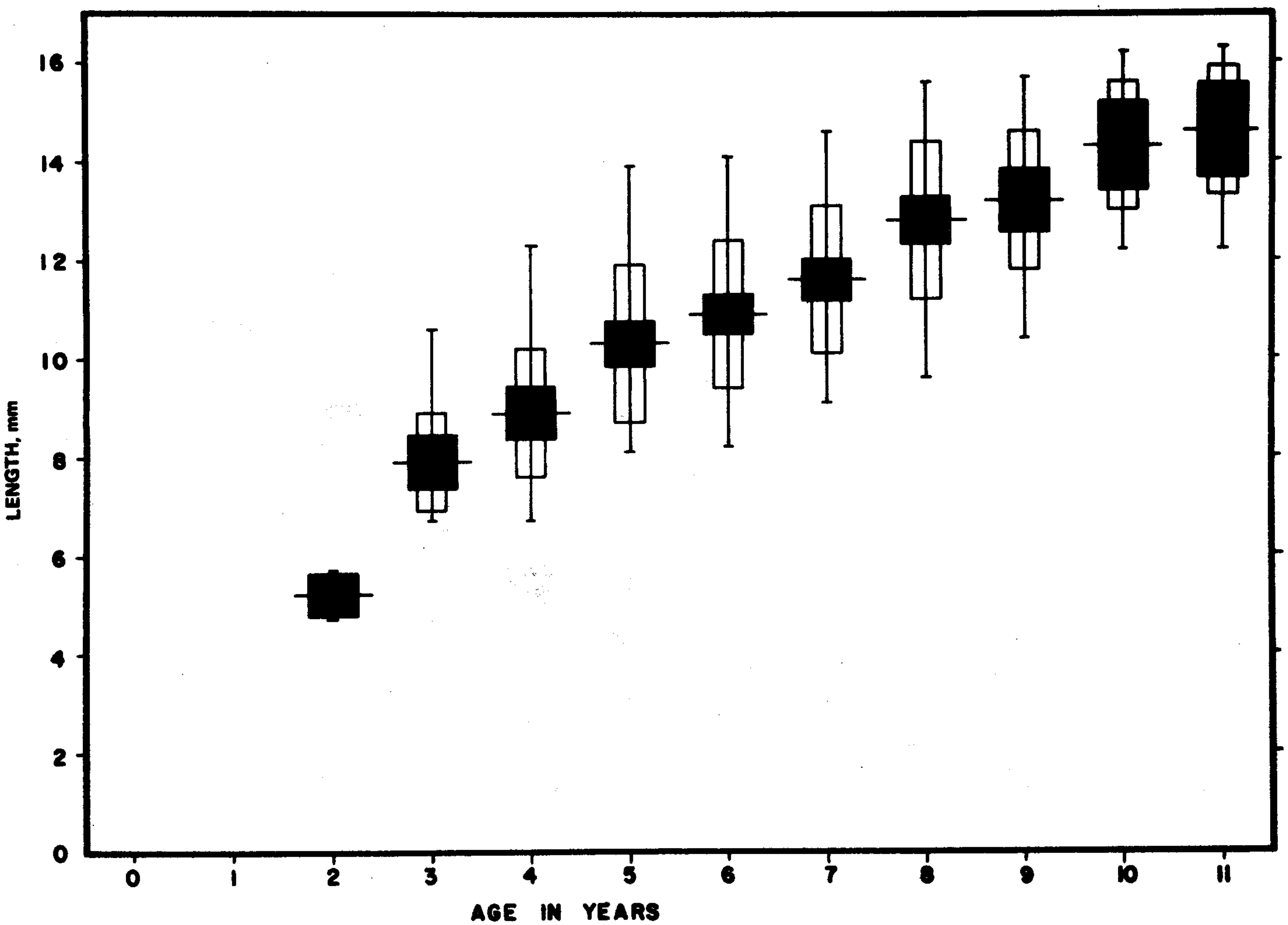

Figure 55. Growth curve for *Tellina nuculoides* from Cook Inlet Station 42.

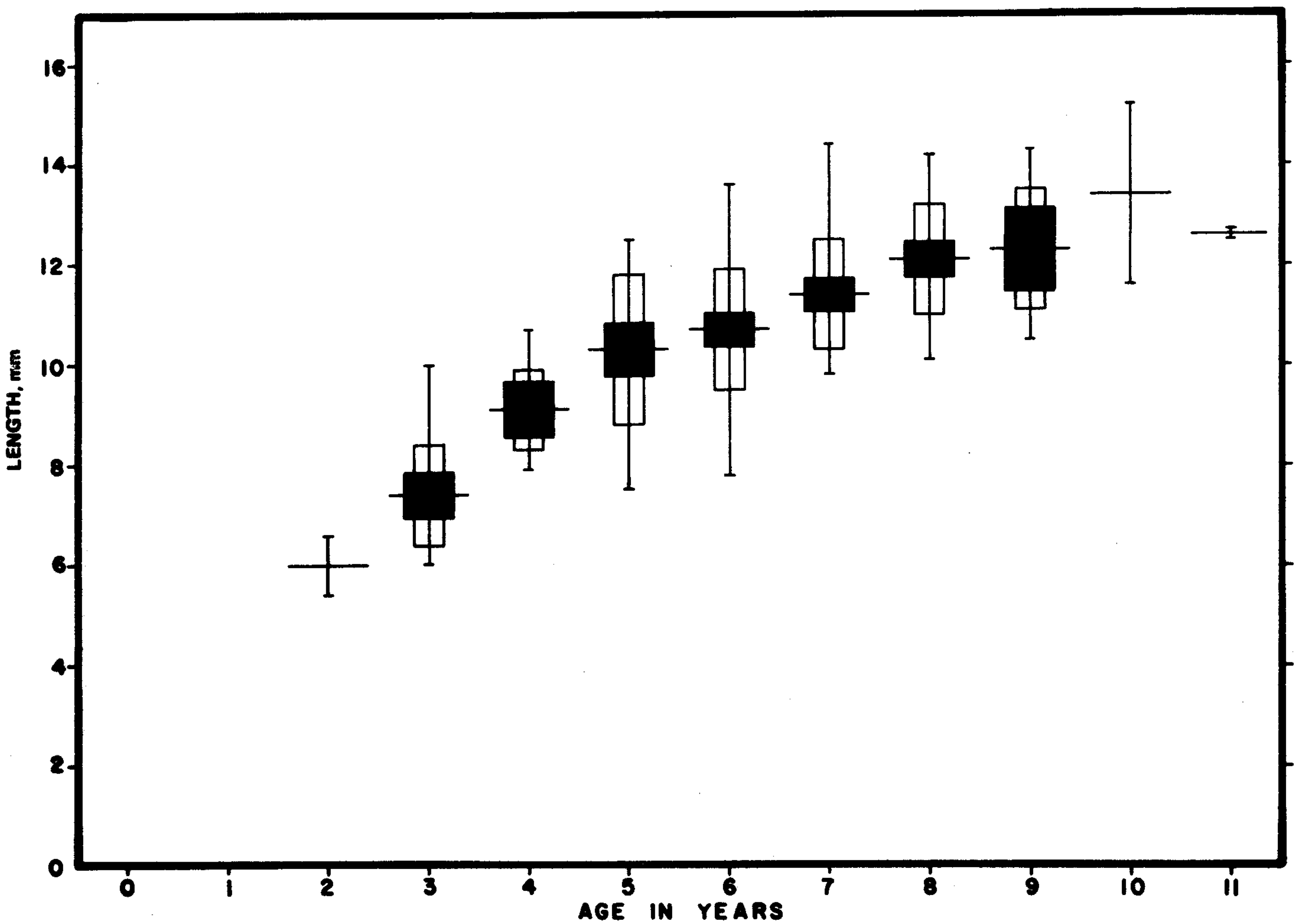

Figure 56. Growth curve for *Tellina nuculoides* from Cook Inlet Station 44.

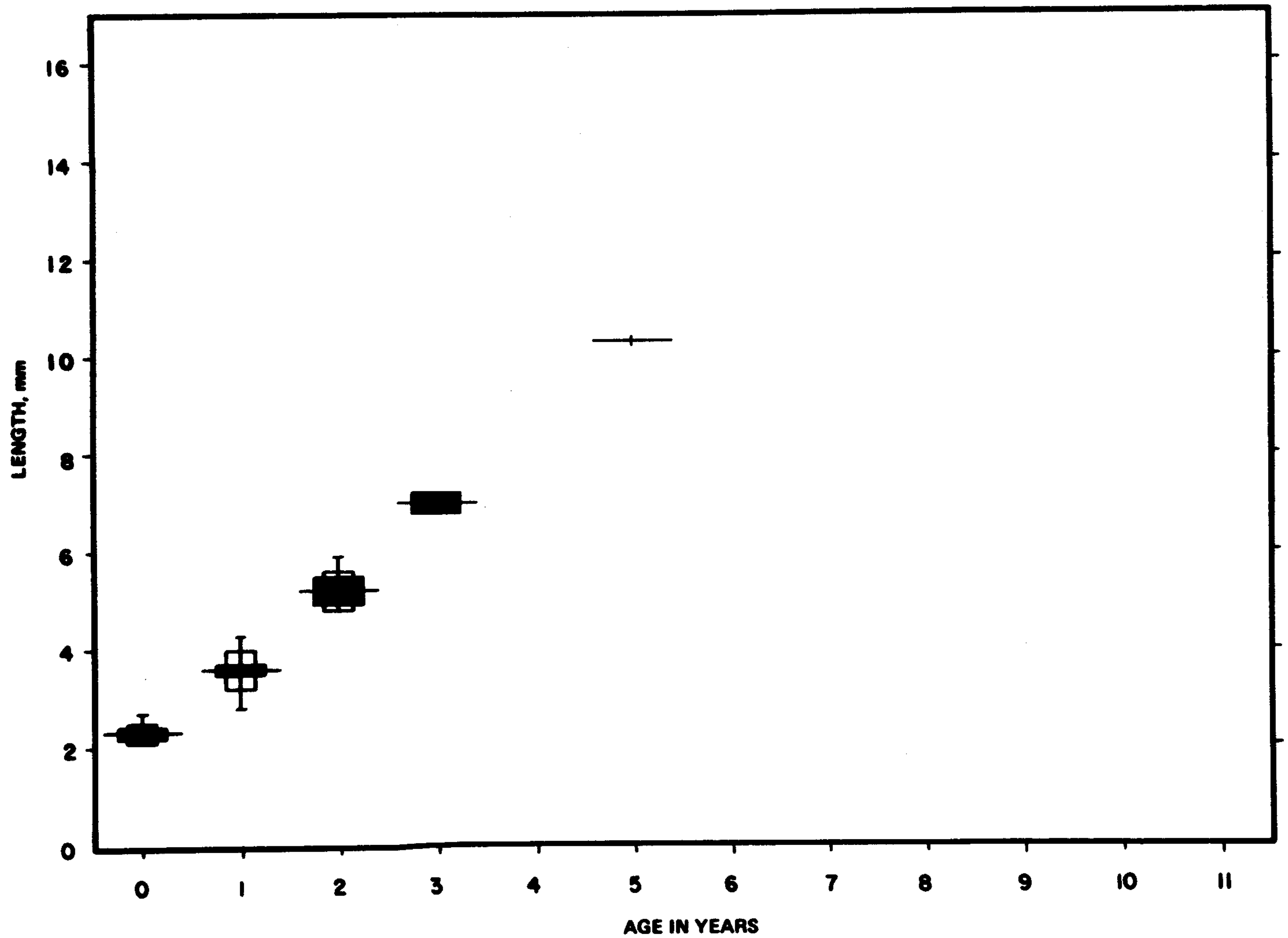

Figure 57. Growth curve for *Tellina nuculoides* from Cook Inlet Station UW2.

TABLE XXXIII

AGE STRUCTURE OF *TELLINA NUCULOIDES* FROM NINE LOWER COOK INLET STATIONS (UW2, 30, 31, 40A, 41, 42, 44, 45, and 63) (See Table I and Fig. 47).

N = number of clams. ML = mean length of clams. SD = standard deviation. SEM = standard error of the mean. R = range.

Year Class (Age of clams)	N	ML (mm)	SD (mm)	SEM (mm)	R (mm)
0	14	2.3	0.2	0.11	2.1- 2.7
1	70	3.6	0.4	0.09	2.8- 4.5
2	20	5.4	0.6	0.28	4.7- 6.8
3	43	7.5	1.0	0.30	6.0-10.6
4	47	8.8	1.1	0.31	6.7-12.3
5	95	10.2	1.5	0.30	7.5-13.9
6	120	10.7	1.3	0.23	7.8-14.1
7	112	11.4	1.3	0.24	9.1-14.6
8	79	12.4	1.4	0.31	9.6-15.6
9	38	12.8	1.3	0.41	10.4-15.7
10	20	13.5	1.4	0.66	11.6-16.2
11	11	14.2	1.4	0.91	12.2-16.3
12	2	15.0	0.6	1.24	14.6-15.4
13	1	16.4	0.0	0.00	16.4
	Total = 672				

TABLE XXXIV

AGE STRUCTURE OF *TELLINA NUCULOIDES* FROM LOWER COOK INLET, STATION 42.

N = number of clams. ML = mean length of clams. SD = standard deviation. SEM = standard error of the mean. R = range.

Year Class (Age of clams)	N	ML (mm)	SD (mm)	SEM (mm)	R (mm)
0	0	--	--	--	--
1	0	--	--	--	--
2	5	5.2	0.4	0.41	4.7- 5.7
3	15	7.9	1.0	0.55	6.7-10.6
4	28	8.9	1.3	0.52	6.7-12.3
5	47	10.3	1.6	0.46	8.1-13.9
6	54	10.9	1.5	0.40	8.2-14.1
7	52	11.6	1.5	0.41	9.1-14.6
8	41	12.8	1.6	0.49	9.6-15.6
9	22	13.2	1.4	0.63	10.4-15.7
10	10	14.3	1.3	0.90	12.2-16.2
11	9	14.6	1.3	0.95	12.2-16.3
12	2	15.0	0.6	1.24	14.6-15.4
13	1	16.4	0.0	0.00	16.4

Total = 286

TABLE XXXV

AGE STRUCTURE OF *TELLINA NUCULOIDES* FROM LOWER COOK INLET, STATION 44.

N = number of clams. ML = mean length of clams. SD = standard deviation. SEM = standard error of the mean. R = range.

Year Class (Age of clams)	N	ML (mm)	SD (mm)	SEM (mm)	R (mm)
0	0	--	--	--	--
1	0	--	--	--	--
2	2	6.0	0.9	1.86	5.4- 6.6
3	22	7.4	1.0	0.45	6.0-10.0
4	10	9.1	0.8	0.54	7.9-10.7
5	33	10.3	1.5	0.51	7.5-12.5
6	55	10.7	1.2	0.32	7.8-13.6
7	49	11.4	1.1	0.31	9.8-14.4
8	34	12.1	1.1	0.37	10.1-14.2
9	10	12.3	1.2	0.82	10.5-14.3
10	2	13.4	2.6	5.37	11.6-15.2
11	2	12.6	0.1	0.21	12.5-12.7

Total = 219

TABLE XXXVI

AGE STRUCTURE OF *TELLINA NUCULOIDES* FROM LOWER COOK INLET, STATION UW2.

N = number of clams. ML = mean length of clams. SD = standard deviation. SEM = standard error of the mean. R = range.

Year Class (Age of clams)	N	ML (mm)	SD (mm)	SEM (mm)	R (mm)
0	14	2.3	0.2	0.11	2.1-2.7
1	67	3.6	0.4	0.10	2.8-4.3
2	9	5.2	0.4	0.29	4.8-5.9
3	2	7.0	0.1	0.21	6.9-7.1
4	0	--	--	--	--
5	2	10.3	0.0	0.00	10.3

Total = 94

Although no *N. tenuis* older than 7 years of age were found in Cook Inlet, the species can survive at least 9 years in Alaska as indicated by data from the Bering Sea (Feder, unpublished OCSEAP data). There was no apparent gear bias in age sampling of this species, as the age classes were well represented in the collections as shown in age structure Table III.

Similar growth, size at age (Tables III-VIII; Figs. 5-6) and growth histories (Figs. 2-4) were observed for *N. tenuis* from the Cook Inlet stations examined. Neyman (1964) reported mean shell lengths of 1.0, 1.5, 3.9, 5.3, 6.9 and 9.3 mm for *N. tenuis* from the eastern Bering Sea for age classes 0 to 5, respectively. These shell lengths compare with 1.7, 2.3, 3.3, 4.3, 5.3 and 6.2 mm for our Cook Inlet specimens; therefore, this clam appears to grow slightly faster in the eastern Bering Sea.

Nuculana fossa

Survival within each year class varied from station to station (Tables IX-XII). However, when specimens from all stations are combined (Table IX), it is apparent that the number of individuals in year classes 0 through 6 are relatively abundant in comparison to year class 7. This difference is attributed to increased natural mortality in clams older than 6. The similarity in year class strengths of clams 0 through 6 years of age suggests that annual recruitment and survival, while patchy at individual stations, were relatively stable for Cook Inlet. Although no *N. fossa* older than 7 years of age were found in Cook Inlet, the species can survive at least 9 years in Alaska as indicated by data from the Bering Sea (Feder, unpub. OCSEAP data). There was no apparent gear bias in age sampling of this species, as all age classes were well represented in the collection as shown in age structure Table IX.

Similar growth, size at age (Tables IX-XII; Figs. 12-15), and growth histories (Figs. 8-11) were observed for *N. fossa* from the Cook Inlet stations examined. Neyman (1964) reported mean shell lengths of 1.3, 4.4, 6.8, 9.1, 12.4 and 16.1 mm for *N. fossa* (called *Leda pernula* by the author; see Abbott, 1974) from the eastern Bering Sea for age classes 0 through 5, respectively. These shell lengths compare with 2.1, 3.7, 6.7, 9.0, 10.9 and

12.9 mm for our Cook Inlet specimens; therefore, this clam appears to grow slightly faster in the eastern Bering Sea.

Glycymeris subobsoleta

Relatively stable recruitment and/or survival is suggested for year classes 0-4 (Tables XIII-XIX). The very large number of one-year old clams observed at only one station (Sta. 28) is indicative of the patchiness of the infauna frequently observed in lower Cook Inlet (Feder, unpub. OCSEAP data). Ninety-one percent of the *G. subobsoleta* sampled were in the 0 to 4 year classes; however, this species may survive for at least 11 years (Table XIII). There was no gear bias apparent in the collection of *G. subobsoleta*, and all age classes were well represented in the samples as shown in age structure Table XIII. Natural mortality explains the marked decrease in numbers after age 4. No data are available on mortality of this clam for other areas.

Similar growth, size at age (Tables XIII-XIX; Figs. 24-26) and growth histories (Figs. 17-23) were observed at all of the Cook Inlet stations examined. No growth data are available for this species from other areas.

Spisula polynyma

The van Veen grab and pipe dredge did not penetrate the substrate sufficiently to collect clams over 30 mm in length; therefore, no data on recruitment and survival for this species are available. The anchor dredge used by the Alaska Department of Fish and Game in Kachemak Bay provided the only large (greater than 30 mm in length), fresh specimens of *S. polynyma* available to this investigation. It is suggested that a hydraulic clam dredge is necessary to adequately sample this species.

Growth data are available for intertidal *S. polynyma* from Hartney Bay, Prince William Sound, Alaska (Feder *et al.*, 1976), and mean shell lengths of 8, 13, 22 and 32 mm are reported for clams aged 1 through 4, respectively. These shell lengths at age are similar to those noted for *S. polynyma* from Cook Inlet (Table XX). However, in older clams, growth appears to be somewhat greater in Prince William Sound than in Cook Inlet. For example, at 10 and 16 years of age Hartney Bay clams averaged 98 mm and 139 mm, respectively. This compares with 92 mm and 118 mm, respectively, for Cook Inlet clams (Table XX). The size difference between the two areas may be the result of small sample sizes for clams older than 4 years in the Cook Inlet material. A gear bias was apparent in the collection of *S. polynyma*.

Macoma calcarea

Survival within each year class varied from station to station (Tables XXIV-XXXII). However, when specimens from all stations are combined (Table XXIV) it is apparent that the number of individuals in year classes 0 through 5 are relatively abundant in comparison to year classes 6 through 14. This difference is attributed to increased natural mortality in clams older than 5. The similarity in year class strengths 1 through 5 suggests that annual recruitment and survival, while patchy at individual stations, were relatively stable for Cook Inlet. There was no apparent gear bias in age sampling of *M. calcarea*, as all age classes were well represented in the collection as shown in age structure Table XXIV.

Similar growth, size at age (Tables XXIV-XXXII; Figs. 43-46), and growth histories (Figs. 37-42) were observed for *M. calcarea* from the Cook Inlet stations examined. Neyman (1964) reported mean shell lengths of 2.0, 4.1, 6.4, 10.7, 16.9 and 17.9 mm for *M. calcarea* from the eastern Bering Sea for age classes 0 through 5, respectively. These shell lengths compare with 1.9, 3.4, 5.3, 7.4, 9.2 and 11.9 mm for our Cook Inlet specimens; therefore, this clam appears to grow faster in the eastern Bering Sea.

Tellina nuculoides

Survival within each year class varied considerably from year to year (Table XXXIII). For example, the 6 and 7 year old clams were most abundant while there was a paucity of 0 and 2 year old clams. Sixty percent of the *T. nuculoides* examined were in the 5 through 8 year classes (Table XXXIII). These strong year classes indicate variable recruitment and/or survival. This species is capable of living 13 years, with natural mortality low until age 8 is reaches. There was no gear bias apparent in the collection of *T. nuculoides*, and all age classes were well represented in the samples as shown in age structure Table XXXIII. No data on mortality of this clam are available from other areas.

Similar growth, size at age (Tables XXXIII-XXXVI; Figs. 54-57), and growth histories (Figs. 48-53) were observed for *T. nuculoides* at the Cook Inlet stations examined. No growth data are available for this species from other areas.

GENERAL CONCLUSIONS

If the age structure of the six species from all stations (Tables VI, XII, XXII and XXXV) are considered, it is evident that in lower Cook Inlet there are no years when zero recruitment occurs. This is not the case for individual stations where the number of clams at a given age is variable. As a result of this variability, population monitoring at individual stations may not be feasible, but use of pooled data from a number of stations should be possible. No data concerning recruitment or survival of other Alaskan subtidal clams are available for comparison (data from additional clam species from the Bering Sea will be available in the final report for that area: Feder, unpub. OCSEAP data). However, complete year class failures on individual beaches have been observed for the Alaskan intertidal clams *Protothaca staminea* (Paul *et al.*, 1976a) and *Saxidomus gigantea* (Paul *et al.*, 1976b). Distinct year classes, yearly growth, and growth histories of these clams can be measured by the annular aging method. Measurement of growth and growth history, provides a promising technique for detecting changes in the environment which affect the growth rates of bivalves. These data are also necessary for the determination of mortality rates and secondary production.

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